TUS Midlands Midwest

The Contribution of Gaelic Football Participation to Physical Activity in Irish Youth

Kevin Gavin, BSc

Supervisors:

Dr. Kieran Dowd

Dr. Aoife Lane

A thesis submitted to the Technological University of the Shannon: Midlands in fulfilment of the requirement for the degree of Doctor of Philosophy

Submitted to the Technological University of the Shannon: Midlands,

March 2022

Abstract

Background: Physical activity (PA) provides a range of health benefits for adolescents. However, approximately 80% of adolescents internationally fail to meet the PA guidelines. Organised sport (OS) participation is recognised as one of the "eight investments that work" for increasing PA. Yet, evidence highlights low levels of PA achieved in OS practice sessions, while coaches employ approaches that do not maximise PA attainment.

Aim: This research aimed to: (i) determine the contribution of Gaelic football participation to adolescents' overall daily PA levels; (ii) describe the coaching practices applied by youth Gaelic games coaches and their awareness, knowledge, and perceptions of PA; and (iii) examine the impact an alternative approach to coaching, a Game Based Approach (GBA), may have on PA levels in a youth Gaelic football setting.

Methods: The total PA levels attained by 130 adolescents (males: n=65; females; n=65) during two different nine-day measurement periods and during Gaelic football participation was determined using activPAL^{3M} accelerometers. A mixed-methods design using quantitative (survey; n=1660) and qualitative (semi-structured interviews; n=22) methods was utilised to assess the current coaching practices of youth Gaelic games coaches in the context of coaching approaches that best promote PA. Finally, an intervention was employed to investigate the impact of a GBA on players' PA levels and perceptions of practice sessions in two youth Gaelic football teams (U17 boys; n=18; U16 girls: n=20).

Results: Gaelic football participation provided 25-38 minutes of MVPA and significantly increased participants' likelihood of meeting the PA guidelines. However, approximately 50% of Gaelic football practice session time was spent inactive or in light intensity PA. Coaches reported to spend the majority of practice session time in training from activities (e.g., drills), arranged in a linear format. Coaches also appreciated the importance of their players accumulating PA, yet a low proportion could accurately identify the PA guidelines. When implemented within Gaelic football coaching sessions, the GBA intervention led to a significant increase in practice session PA levels and daily PA levels, while also positively impacting players experiences of the practice sessions.

Conclusion: The evidence presented in this thesis highlights the substantial PA contribution of youth Gaelic football participation. However, it was apparent that considerable proportions of time during Gaelic football participation were spent inactive, while coaches maintain approaches which limit PA attainment. An alternative approach, a GBA, holds considerable potential to positively impact the coaching environment and enhance the contribution of participation in youth Gaelic football to participants' daily PA levels.

Authors Declaration

I hereby declare that this research is entirely the result of my own investigation, and that appropriate credit has been given where reference has been made to the work of others. This work has not been submitted for any academic award, or part thereof, at this or any other educational establishment.

Signed:_____ **Date:**_____

Kevin Gavin

Acknowledgments

Numerous people have helped make my PhD journey a possibility, providing invaluable help, support and encouragement, and to those people I am extremely thankful.

Firstly, I would like to thank my fantastic supervisors, Dr. Kieran Dowd and Dr. Aoife Lane. You have both displayed an unwavering confidence in my work and have always put my needs first. The level of commitment and dedication that you have shown as my supervisors and mentors is unparalleled, and very much appreciated. Thank you!

To all the staff in the Department of Sport and Health Sciences who have created such a friendly and supportive environment for all the postgraduates. Special shout out to Chris Coombes for all of our early morning rugby chats in the clinic!

To all of my fellow postgraduate students in the Research Hub for your friendship, guidance and hilarious night outs over the years. Unfortunately our time in the hub was cut short in 2020, but I am sure we will make up for it in the near future.

To my fellow PhD candidate and great mate Lorcan Daly. Thanks for all the great times in the hub canteen talking nonsense, but especially for the craic we had when we worked from home. We lived in each other's pocket's for the best part of two years there was never a dull moment.

To my Mardyke Street boys, Andrew, Jack and Sam. I will never ever forget the memories we made together in that apartment and beyond. Thanks for the constant laughs and slagging.

To my sister, Sarah who I must admit is the best sister I could have asked for. Even if I don't always show it.

A special thank you to my parents, Pat and Martina. Without your unconditional support and belief in me none of this would have been possible. All you ever ask is that I do my best-I hope my best makes you proud. Thank you from the bottom of my heart for everything.

Lastly, I'd like to dedicate this thesis to my Granny and Grandad Gavin, who sadly passed away before they could see me finish my PhD journey. You both were always so interested in how I was getting on. I know you would have been proud.

Table of Contents

List of Tables

List of Figures

Dissemination of Research

This research has been disseminated through peer-reviewed publications, and via oral and poster presentations at national and international conferences and applied sports settings.

Peer Reviewed Publications

- Gavin, K.W., Lane, A. and Dowd, K.P., (2020). The contribution of Gaelic football participation to youth physical activity levels. *Journal of Sports Science & Medicine*, 19(4), 652–661, available: https://www.jssm.org/jssm-19-652.xml%3EFulltext.
- Gavin, K.W., Lane, A. and Dowd, K.P., (2021). Seasonal changes in the physical activity levels of youth Gaelic football players. *Journal of Sports Sciences*, 39(17), 2023-2029, available: doi: 10.1080/02640414.2021.1923204.

Conference Oral Presentations

- Gavin, K. W., & Lane, A., & Dowd, K. P. (2021). Support for Organised Sport as a Strategy to Close the Gender Gap in Physical Activity in Youth. *8th ISPAH Virtual Congress, Vancouver 2021.*
- Games Coaches' Awareness, Knowledge and Perceptions of Physical Activity and Physical Activity Guidelines. *Women in Sport & Exercise (WISE) Conference* hosted by the University of Worcester.
- Gavin, K. W., & Lane, A., & Dowd, K. P. (2020). A game-based coach education intervention to increase the contribution of Gaelic football participation to overall daily physical activity levels in youth. *Postgraduate Research Connect Seminar Series* hosted by the University of Lincoln.
- Gavin, K. W., & Lane, A., & Dowd, K. P. (2019). The contribution of Gaelic football participation to adolescent's physical activity levels. *All Ireland Postgraduate Conference in Sport Science, Physical Activity and Physical Education*, Athlone Institute of Technology, Ireland.
- Gavin, K. W., & Lane, A., & Dowd, K. P. (2019). The contribution of organised sport to overall physical activity levels among adolescents. *HEPA Europe Conference*, The University of Southern Denmark, Odense, Denmark.

Conference Poster Presentations

- Gavin, K. W., Lane, A., & Dowd, K. P. (2020). Utilising stakeholder engagement to develop a coach education programme to increase physical activity levels during youth Gaelic football participation. *AIT Showcase Postgraduate Research Poster Event*, Athlone Institute of Technology, Ireland

- Gavin, K. W., Lane, A., & Dowd, K. P. (2019). Seasonal changes in the physical activity levels of youth Gaelic football players. *AIT Postgraduate Research Day*, Athlone Institute of Technology, Athlone, Ireland.
- Gavin, K. W., Lane, A., & Dowd, K. P. (2018). The contribution of Gaelic football participation to adolescent's physical activity levels. *AIT Research Presentation, Poster & Network Day*, Athlone Institute of Technology, Athlone, Ireland.

Media

- Gavin, K. W., Lane, A., & Dowd, K. P. (2020). The contribution of Gaelic football participation to adolescent's physical activity levels. *Ladies Gaelic Football Association Research Pod.* Available at: https://www.youtube.com/watch?v=U4gopbptw_s&t=91s

Chapter 1. Introduction

1.1. Introduction

1.1.1 Rationale for the Thesis

Physical inactivity, defined as an insufficient physical activity (PA) level to meet current PA guidelines (Tremblay et al. 2017), has been identified as the fourth leading risk factor for mortality across the world (Kohl et al. 2012). Evidence shows that physical inactivity contributes to many adverse health conditions, including major non-communicable diseases (NCDs) such as coronary heart disease and type 2 diabetes (Kohl et al. 2012). Lee et al. (2012) determined that 6-10% of all deaths from NCDs can be attributed to physical inactivity, equating to 5.3 million deaths per year globally. Further, global estimates suggest that physical inactivity has a direct economic cost of $53.8 billion annually (Ding et al. 2016). In Ireland, physical inactivity is estimated to cause 8.8% of coronary heart disease, 10.9% of type 2 diabetes, 15.2% of breast cancer and 15.7% of colon cancer (Lee et al. 2012), resulting in an estimated annual cost of €132 million (Ding et al. 2016). Considering that the current global PA prevalence averts approximately 3.9 million deaths annually (Strain et al. 2020), the promotion of PA is a public health priority (Katzmarzyk et al. 2022, Klepac Pogrmilovic et al. 2020).

1.1.2. Physical Activity and Health

Physical activity has been defined as any bodily movement produced by skeletal muscle which results in an increase in energy expenditure above resting levels (Caspersen et al. 1985). Physical activity is a complex, multi-dimensional and highly variable behaviour that can include activities of daily living, sport, volitional exercise, or active transport. The health-related components of PA include cardiorespiratory fitness, muscular endurance, muscular strength, body composition and flexibility (Caspersen et al., 1985). The benefits of PA to health are widely accepted (World Health Organization 2010c) and there is a wealth of evidence supporting these benefits in children and youth (Janssen and LeBlanc 2010, Poitras et al. 2016). Specifically, participation in regular PA during adolescence has a positive impact on a range of health markers, including adiposity, cardiometabolic biomarkers and bone health (Janssen and LeBlanc 2010, Poitras et al. 2016). Research in youth indicates engagement in higher intensity PA, such as moderate physical activity (MPA) and vigorous physical activity (VPA), have more consistent and robust relationships with health indicators than lower intensity PA (Poitras et al. 2016). Moreover, a dose-response relationship has been observed between PA intensity and health outcomes among youth, with studies reporting that VPA may be more strongly related to reduced adiposity and decreased risk factors for disease than MPA (Gralla et al. 2019, Owens et al. 2017).

The accumulation of evidence on the positive impact of increased PA participation on health resulted in the development of national and international PA guidelines. In Ireland, the current national guidelines state that children and adolescents should engage in at least 60 minutes of moderate-to-vigorous physical activity (MVPA) daily (Healthy Ireland 2016). In 2020, the World Health Organisation (WHO) released updated global guidelines, which now recommend that children and adolescents engage in at least an average of 60 minutes per day of MVPA across the week (World Health Organisation 2020). Furthermore, due to the recent findings further supporting a dose-response relationship between PA intensity and health (Gralla et al. 2019), the latest guidelines have also included a recommendation to incorporate VPA on at least three days per week (World Health Organisation 2020).

1.1.3. Physical Activity in Youth

Despite PA guidelines being well established and implemented internationally as the standard for PA promotion, global estimates show that over 80% of adolescents are insufficiently active (Guthold et al. 2020, Sallis et al. 2016). In 2010, the global prevalence of adolescents meeting the PA guidelines was 78.4% for boys and 84.4% for girls aged 11-17 years (Sallis et al. 2016). In 2016, an updated analysis of 1.6 million adolescents worldwide found that 77.6% of boys and 84.7% of girls were insufficiently active (Guthold et al. 2020). Results from Irish research are comparable, with the most recent Children's Sports Participation and Physical Activity (CSPPA) Study concluding that 83% of boys and 91% of girls aged 10-18-years failed to meet the national PA guidelines (Woods et al. 2018).

Research consistently shows that throughout adolescence, PA levels and the prevalence of achieving PA guidelines decreases significantly (Corder et al. 2015, Dumith et al. 2011, Harding et al. 2015). Across the adolescent years, PA levels decline by a mean of 7% per annum, equating to a total PA decline of 60-70% throughout this period (Dumith et al. 2011). Moreover, the age-related decline in PA participation is steeper for girls than for boys, with Farooq et al. (2020) reporting annual declines in MVPA of 3.4% in males and 5.3% in females. This was also evident in the CSPPA study, as the percentage of boys meeting the PA guidelines declined from 23% in primary school age groups to 14% in post-primary school age groups. In girls, the PA levels were consistently lower and declined from 13% to 7% in the same age brackets (Woods et al. 2018). Considering that PA behaviours adopted during adolescence are likely to be maintained into adulthood (Hayes et al. 2019, Tammelin et al. 2014), the promotion of adequate PA participation during this early developmental stage is essential (Camacho-Miñano et al. 2011, Hallal et al. 2006).

1.1.4. Physical Activity and Organised Sport

In response to the low levels of PA attained throughout adolescence, the promotion of PA has been become a public health priority (Klepac Pogrmilovic et al. 2020). The WHO has recently published the Global Action Plan on Physical Activity (GAPPA) 2018–2030, which aims to reduce global levels of physical inactivity in adults and adolescents by 15% by 2030 (World Health Organization 2018). In order to achieve this goal, this document recommended the creation of appropriate and supportive environments for PA and increasing opportunities for PA in a variety of settings, including schools, health care, transport and sport (World Health Organization 2018). To date, most research in youth PA promotion has focused on opportunities offered within the school setting (e.g., physical education, school breaks) (Lonsdale et al. 2013, Ridgers et al. 2012a). However, adolescents are active within a variety of settings, thus there is a need for research focused on investigating the relevance of contexts outside the school environment (Fenton et al. 2015).

Organised sport (OS) has been identified as one of the "eight investments that work" for increasing PA (The International Society for Physical Activity and Health 2020), and is particularly relevant to youth given the existing cultural norms and infrastructure that encourages sports participation amongst this cohort (Howie et al. 2020). Indeed, OS is the most popular form of leisure-time PA for youth, with at least one third of children and adolescents participating worldwide (Aubert et al. 2018). Research has demonstrated that adolescents who participate in OS are significantly more physically active (Hebert et al. 2015, Kokko et al. 2018, Marques et al. 2016), and more likely to meet the PA guidelines than their non-participating peers (Sprengeler et al. 2019). Moreover, OS participants accumulate more MVPA on sports days than on non-sports days (Mooses and Kull 2019).

While it is encouraging that OS participation increases the likelihood of being sufficiently active, the specific role of OS in youth daily PA levels remains unclear (Howie et al. 2020). Firstly, participation alone does not ensure youth will achieve the PA guidelines (Ridley et al. 2018), with one study reporting that less than 20% of OS participating youth met the recommendations (Vella et al. 2016). Also, studies consistently demonstrate that irrespective of the sport type, sport context (practice or game), age or gender, youth OS participants spend most of their sport time inactive or in light intensity physical activity (LIPA) (Cohen et al. 2014, Kanters et al. 2015, Leek et al. 2011, Ridley et al. 2018, Sacheck et al. 2011, Schlechter et al. 2017). Also, a gender disparity in PA behaviour persists in an OS setting, with females accumulating significantly less time in MVPA during OS participation compared to males (Leek et al. 2011, Mooses and Kull 2019, Ridley et al. 2018, Sprengeler et al. 2019). It is important that better insights into how youth OS participation

can facilitate higher engagement in PA, to ultimately progress youth OS as a setting for PA promotion (Fenton et al. 2015).

1.1.5. Gaelic Games Context

The promotion of OS participation as a setting for PA promotion has underpinned the National Sport Policy and Sport Action Plan recently launched by Irish government, which aims for at least 60% of the population to be actively participating in sport by 2027 (Department of Tourism 2021). Gaelic games, inclusive of Gaelic football, Ladies Gaelic football, Hurling and Camogie, are the national sports of Ireland (Duignan et al. 2021). The national governing bodies (NGBs) for Gaelic games comprise of the Gaelic Athletic Association (GAA), Ladies Gaelic Football Association (LGFA) and Camogie Association. With approximately 3,000 affiliated clubs which oversee one million members, 500,000 players and 100,000 coaches, Gaelic games form the largest community and sporting organisation in Ireland (Horgan 2021, Lane et al. 2017). Given its reach and role within Irish society, the Gaelic games club delivers many health benefits through the promotion of sport and PA (Lane et al. 2021). In particular, Gaelic football plays an important role in the promotion of PA among Irish youth, as it is the most popular team-based sport, with 32% of adolescents participating regularly (Woods et al. 2018). However, to the best of the authors knowledge, no research has examined the PA contribution of Gaelic football participation. In addition, despite considerable health promotion activity being delivered through the GAA Healthy Club Project, research has identified limited efforts to incorporate health promotion thinking into the core on-field activity of playing sport and promoting PA through sport (Lane et al. 2021).

1.1.6. Coaching Pedagogy

Coaches have been described as one of the primary factors influencing the quantity of PA levels attained in OS contexts (Howie et al. 2020), as they are viewed as experts, have regular direct involvement, and carry considerable influence over participants and the environment (Conroy and Coatsworth 2006, Howie et al. 2020). Consequently, there have been calls to investigate and improve the current quality of youth OS coaching and to determine efficient ways of optimising the dose of PA accumulated during youth OS (Leek et al. 2011, Pate and O'Neill 2011, Vella et al. 2016). One possible strategy to increase the PA levels obtained during Gaelic football participation is the implementation of specific coaching approaches.

Coaching literature has reported two commonly implemented coaching approaches within field-based sports, a "traditional" approach and a "game-based approach" (GBA) (Kinnerk et al. 2018). In invasion team sports, the traditional approach is the predominant approach utilised by coaches (Stone et al. 2021). This traditional approach is characterised by (i) highly structured coaching

sequences which start with the introduction of technical skills in isolation; (ii) players repeatedly attempt to replicate the coach-prescribed technical skills in various progressive activities; (iii) the coach provides regular corrective feedback; and (iv) a concluding game-related activity where players attempt to apply the technical skills learned (Moy et al. 2016). While it is considered effective at facilitating skill development in the early stages of learning, research has identified several concerns relating to traditional coaching methods, such as limiting player's ability to develop decision-making skills and perform technical skills in context (Stone et al. 2021).

A game-based approach has emerged as an alternative pedagogical approach to the coaching of team sports. In contrast to traditional coaching methods, GBAs contextualise learning within game-related activity, which mimics the demands a player will encounter in competitive play (Ford et al. 2010, Pinder et al. 2011). Furthermore, GBAs require the coach to act as a facilitator, being less directive and using questioning to stimulate thinking and interaction (Cushion 2013, Harvey et al. 2010a). Notwithstanding the many forms of GBAs that exist within the literature (e.g., Tactical Games Approach, Game Sense), Light (2013) argues that all GBAs share four fundamental features: (i) the design and manipulation of games; (ii) the use of questioning; (iii) the provision of opportunities for dialogue; and (iv) building a supportive socio-moral environment.

A recent review of the GBA literature within team sport settings found that GBAs have a positive effect on numerous player outcomes including, tactical awareness and decision-making, personal and social development, motivation and enjoyment (Kinnerk et al. 2018). Despite such positive findings, however, employment of GBAs by coaches remains limited (Harvey and Jarrett 2014). Lyle (2018) has highlighted the lack of available research examining the effect of GBAs on outcomes critical to successful performance as a major reason for the lack of adoption of GBAs in OS settings. There is also a noted scarcity of studies investigating PA in GBAs, with just three studies demonstrating that players in GBA-focused practice sessions had significantly higher levels of PA than those who participated in traditional sessions (Miller et al. 2016, Nathan 2017, Sierra-Ríos et al. 2020). It has been proposed that future GBA research should investigate the relationships between GBAs and improved PA levels within adolescents (Miller 2015).

1.2. Aims of the Research

Given the background described above, this thesis has three primary aims which organised the research into three distinct studies. The aims of this research are;

1. To determine the contribution of Gaelic football participation to PA in youth.
2. To describe youth Gaelic Games coaches' current coaching practices in the context of PA promotion.
3. To investigate the effect of a GBA intervention in a youth Gaelic football setting on players' PA levels.

1.3. Research Methodology

Data collection will be detailed in full within each chapter, but a concise preliminary overview is provided here. Firstly, the PA levels of youth Gaelic football participants were quantitatively assessed using the activPAL^{3M} activity monitor (n=130), a valid and reliable measure of adolescent PA. Secondly, a mixed-methods design using quantitative and qualitative methods was employed to evaluate Gaelic games coaches and coaching and games (C&G) personnel's current coaching practices. Quantitative data relating to coaches' current practices was first obtained through a self-report survey on Gaelic games coaches (n=758). Qualitative data in the form of semi-structured interviews was gathered from Gaelic football coaches (n=10) and C&G personnel (n=12). Finally, a quasi-experimental design was implemented to investigate the impact of a GBA. First, quantitative data of youth Gaelic football participants' PA during traditional and GBA practice sessions assessed using the activPAL^{3M} (n=38) and compared to determine the impact of a GBA on PA. Second, session characteristics were obtained through the systematic observation and coding of practice sessions. Lastly, data in the form of post-session questionnaires were collected to determine the players perceptions of the practice sessions.

1.4. Thesis Structure

The thesis is organised into seven chapters and additional appendices. An overview of the thesis structure and research methodology is provided below in Figure 1.1. **Chapter 1** provides a brief overview of the research topic, the key research aims and an outline of the thesis. **Chapter 2** provides a comprehensive narrative literature review on a broad range of research areas, including the relationship between PA and indices of health, methods of PA assessment, national and international prevalence of PA in adolescent populations, the PA contribution of youth OS participation, development of GBA pedagogy and GBA interventions. Study 1 is detailed in Chapters 3 and Chapter 4. **Chapter 3**, published in the *Journal of Sports Science and Medicine*, objectively quantifies the overall daily PA levels of Irish adolescents and determines the PA

contribution of Gaelic football participation. **Chapter 4**, which has been published in the *Journal of Sports Sciences*, investigates the longitudinal changes in PA levels attained by adolescents during Gaelic football participation across a competitive season and determines if these changes influenced the overall daily PA levels of the participants. Study 2 is detailed in **Chapter 5**, which examines the current coaching practices of youth Gaelic games coaches and assesses to what extent they align with GBA pedagogy, which can optimise PA accumulation. Study 3 is detailed in **Chapter 6** and reports on the effects of a GBA intervention on players' PA levels, practice session characteristics and players' perceptions of the practice sessions. **Chapter 7** presents an overall discussion of the research findings, conclusions, limitations, implications and recommendations for future research. Supplementary material (e.g. surveys, consent forms etc.) are available in the subsequent **Appendices**.

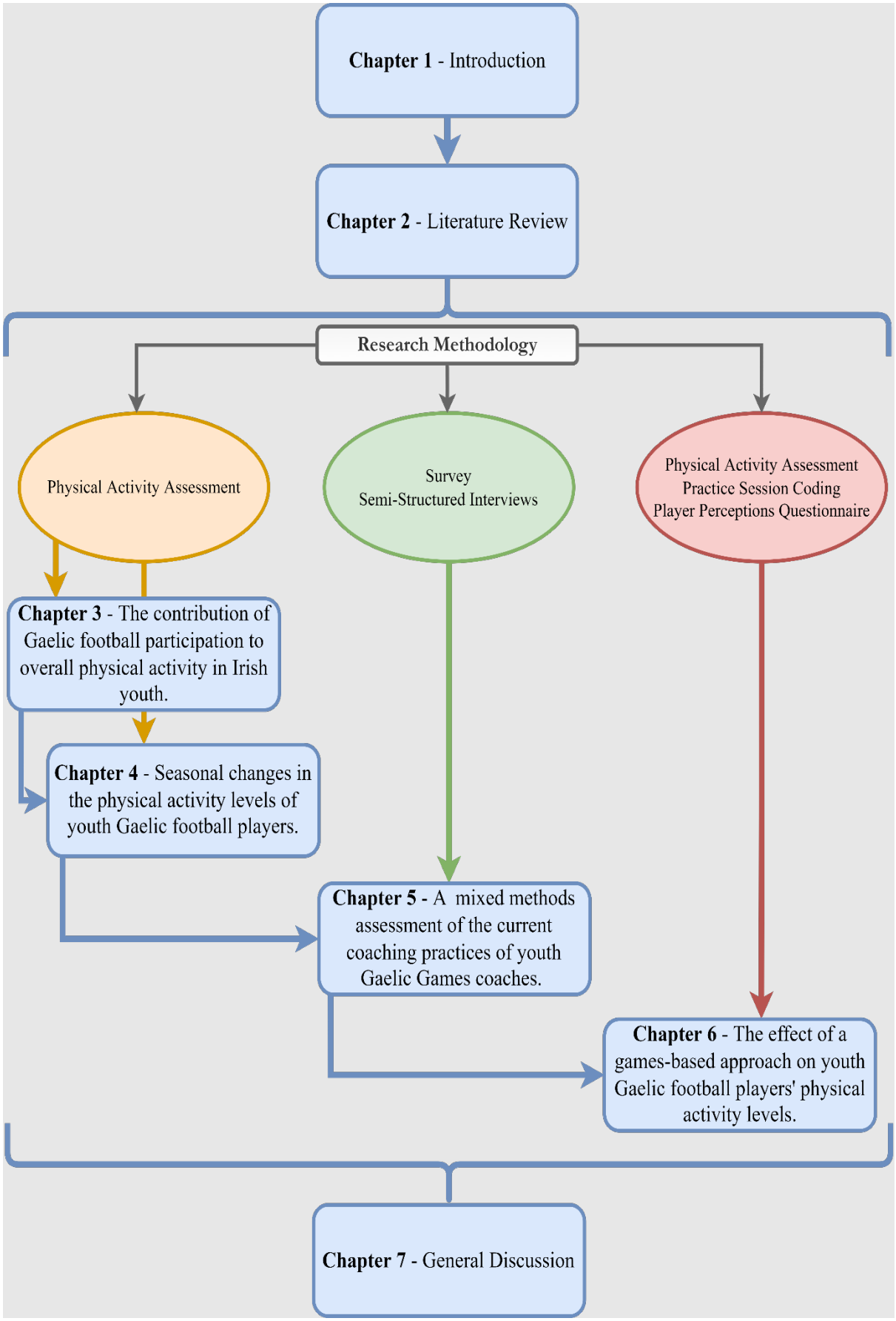


Figure 1.1 Overview of thesis structure and research methodology.

Chapter 2. Literature Review

2.1. Introduction

Across five sections, Chapter 2 provides a critical analysis of the current literature pertaining to this body of research. In section A, the literature review will describe the key concepts regarding PA, examine the history of PA guidelines and present the current guidelines for adolescents. The relationship between PA and indices of health in children and adolescents will also be reviewed. In section B, methods of assessing PA will be discussed, with a particular focus on accelerometry and on the use of accelerometers with inclinometer functions when examining free-living PA. Methodological issues with the assessment of PA measures will be considered, and the validity and reliability of these measures will be assessed. Section C will review the Irish and international context for PA in adolescents. Section D will examine OS participation levels, the PA levels attained during organised sport (OS) participation and its impact on participants' daily PA levels. Finally, in section E, this review will examine coaching pedagogy research, with a particular focus on the development of game-based approach (GBA) pedagogy, and its impact on player outcomes critical to performance.

2.2. Section A: Physical Activity

2.2.1. Physical Activity Background and Key Concepts

The physical activity continuum (Figure 2.1.) identifies sedentary behaviour (SB), light intensity physical activity (LIPA) and moderate-to-vigorous physical activity (MVPA) as three distinct constructs (Tremblay et al. 2010) eliciting different physiological responses. A rapid growth of SB and PA related research in the health science field resulted in confusion over the definition of SB, PA and other related terms (Tremblay et al. 2017). In 2012, the Sedentary Behaviour Research Network (SBRN) published a letter proposing definitions aimed at clarifying differences between "sedentary behaviour" and "physical inactivity" (Sedentary Behaviour Research Network 2012). Despite this clarification being widely accepted, a need for further refinement and consensus on a variety of emergent terms was apparent (Thivel et al. 2018). To address this and definitively differentiate SB from PA and physical inactivity, the SBRN created a new terminology consensus that aimed to develop and standardise definitions for terms routinely used in research related to SB (Tremblay et al. 2017). The following sections provides a summary of the most recent and accepted terminology and definitions of the various activity behaviours which will be referenced throughout this thesis.

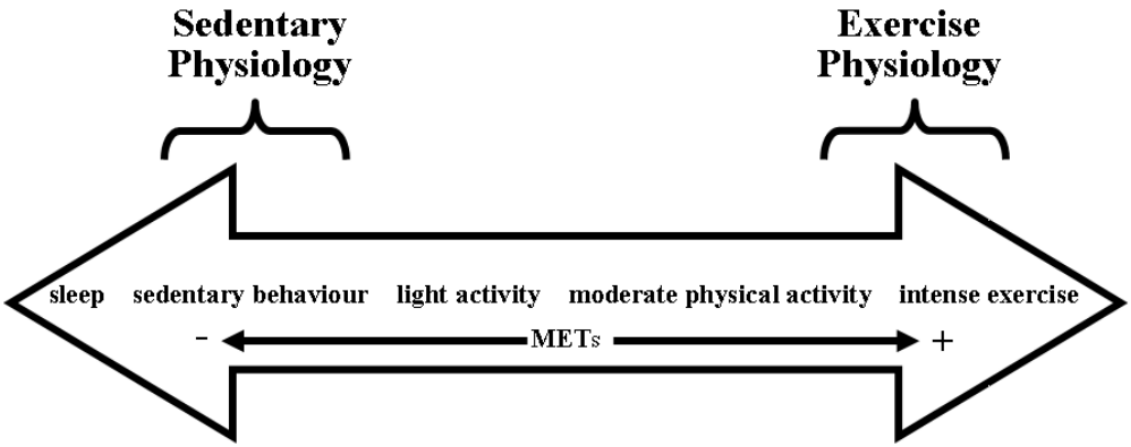


Figure 2.1 The physical activity continuum (Tremblay et al. 2010)

2.2.1.1. Sedentary Behaviour

The SBRN defined SB as any waking behaviour characterised by an energy expenditure (EE) of ≤ 1.5 METs while in a sitting, lying or reclining posture (Tremblay et al. 2017). Sedentary time is defined as the time spent for any duration (e.g., minutes per day) or in any context (e.g., at school or work) in SB. A sedentary bout is defined as period of uninterrupted sedentary time and a sedentary break is defined as a non-sedentary bout in between two sedentary bouts (Tremblay et al. 2017). Finally, SB patterns were defined as the way SB is accumulated throughout the day or week while awake (e.g., the timing, duration and frequency of sedentary bouts and breaks) (Tremblay et al. 2017).

2.2.1.2. Standing Behaviour

Independent of SB, standing was defined as a position in which one has or is maintaining an upright position while supported by one's feet (Tremblay et al. 2017). A distinction is made between active and passive standing, whereby passive standing is any waking activity in a standing posture characterised by an EE ≤2.0 METs (e.g., use of a phone while standing), and active standing is any waking activity in a standing posture characterised by an EE >2.0 METs (e.g., standing while washing dishes) (Tremblay et al. 2017). Standing time is defined as the time spent for any duration (e.g., minutes per day) or in any context (e.g., at school or work) while standing. A standing bout is defined as a period of uninterrupted time while standing, while a standing break is defined as a non-standing bout in between two standing bouts (Tremblay et al. 2017).

2.2.1.3. Physical Activity

Physical activity is defined as any bodily movement produced by the skeletal muscles that results in a substantial increase over resting EE (Caspersen et al. 1985). Physical activity dose is defined

as the amount or volume of PA performed by an individual over a specified period (Powell et al. 2011). To comprehensively assess PA dose, three components must be measured: frequency, duration and intensity. Frequency relates to the number of sessions or bouts of PA undertaken in each period (e.g., per day or per week), while duration describes the total time spent in activity during that bout (e.g., 30 minutes per day) and intensity relates to the rate of EE required to perform any PA (Kruk 2009). When referring to PA intensity, more specific descriptors should be used. Light intensity physical activity refers to all movements with a metabolic cost >1.5 and <3.0 MET (e.g., activities of daily living). Moderate physical activity (MPA) refers to those activities that have a metabolic cost ≥3 and <6 METs, while vigorous physical activity (VPA) refers to any activity behaviours with a metabolic cost >6 METs. Collectively, MPA and VPA are referred to as MVPA (Thivel et al. 2018, Tremblay et al. 2010). In addition to the components of frequency, duration and intensity, the domains within which PA occurs is central to the accurate assessment of PA levels. The most common domains of PA are occupational, transportation, and leisure-time (Strath et al. 2013).

2.2.1.4. Physical Inactivity

Physical inactivity is defined as an insufficient PA level to meet the present PA guidelines for the relevant age group (Tremblay et al. 2017). The current PA guidelines for children and adolescents, which will be described in detail in Section 2.2.3, can vary across country and organisation. Therefore, children and adolescents may be described as physically inactive if they fail to achieve 60 minutes of MVPA per day (Physical Activity Guidelines Advisory Committee 2018) or an average of 60 minutes of MVPA across the week (World Health Organization 2020).

While an individual is considered physically active when they meet the relevant PA guideline, this does not preclude them from spending a significant portion of their waking hours in SB (Tremblay et al., 2010). Thus, it is possible for an individual to be considered as both active and sedentary (Pate et al. 2008). In addition, while PA and SB are regarded as distinct constructs (Tremblay et al. 2017), they are also interdependent as any change in behaviour will result in an increase in one activity variable and a subsequent decrease in others (Chastin et al. 2015).

2.2.2. The Relationship between Physical Activity and Health

Strong evidence shows that physical inactivity increases the risk of many adverse health conditions, including major non-communicable diseases (NCDs) (Lee et al. 2012) and substantial economic costs on a global scale (Ding et al. 2016). Physical inactivity has been estimated to account for 5.3 million deaths per year (Lee et al. 2012) and has a direct economic cost of $53.8 billion annually worldwide (Ding et al. 2016). In Ireland, physical inactivity is accountable for 9% of the burden of

coronary heart disease, 11% of type 2 diabetes, 15% of breast cancer and 16% of colon cancer (Lee et al. 2012), while the direct costs are estimated at €132 million, accounting for approximately 0.74% of total health-care costs (Ding et al. 2016). physical inactivity is recognised as a global pandemic (Kohl et al. 2012), but most of the evidence to substantiate this has come from studies in adult populations, where effects on NCDs become apparent (Lee et al. 2012, Physical Activity Guidelines Advisory Committee 2018, Sallis et al. 2016). While adolescence is generally considered a time when disease burden is low (Gore et al. 2011), many NCDs that manifest later in life are, partly, the result of modifiable risk behaviours established during this time, including low levels of PA (Gore et al. 2011, van Sluijs et al. 2021). It has also become increasingly apparent that the prevalence of NCDs (e.g., type 2 diabetes) and NCD risk factors (e.g., hypertension and obesity) in adolescence are increasing (Johnson et al. 2015, Lascar et al. 2018, Song et al. 2019).

2.2.2.1. Physical Activity and Indices of Health in Childhood and Adolescence

Given that NCDs tend to manifest themselves in adulthood, the most effective method to assess the relationship between youth PA and health is to examine indicators of health including cardiometabolic biomarkers, adiposity and bone health (Poitras et al. 2016). To date, several reviews have reported associations between PA behaviours and indices of health among youth populations (Carson et al. 2016, Janssen and LeBlanc 2010, Tremblay et al. 2011). Most of these reviews, however, have presented evidence that assessed PA through self-report measurement methodologies. Poitras and colleagues (2016) significantly advanced this field of research and synthesised peer-reviewed evidence from 162 studies that examined the associations between device-based measured PA and health indicators in school-aged children and youth aged between 5-17 years. The review included data on 204,171 participants from 31 countries. Overall, the findings of this review showed favourable associations between device-based measured PA and indicators of health, which are discussed below in combination with more recently published relevant literature.

2.2.2.1.1. Physical Activity and Cardiometabolic Biomarkers

Extensive research has examined the relationship between PA and a range of cardiometabolic biomarkers (e.g., blood pressure (BP), blood lipids, insulin) within children and adolescent populations (Poitras et al. 2016). Most of the available research has examined relationships between PA and cardiometabolic biomarkers cross-sectionally, with a number of these studies specifically examining a composite cardiometabolic disease risk score (Poitras et al. 2016). Of these studies, a majority have determined that total PA, MPA, VPA and MVPA were associated with lower cardiometabolic disease risk score (Carson and Janssen 2011, Ekelund et al. 2009, Holman

et al. 2011, Jiménez-Pavón et al. 2013, Nguyen et al. 2010, Stabelini Neto et al. 2014). Regarding individual cardiometabolic biomarkers, many studies have also determined total PA, MPA, VPA and MVPA to be positively associated with hypertension, diastolic and systolic BP, triglycerides, cholesterol, insulin, and glucose (Carson and Janssen 2011, Carson et al. 2014, Carson et al. 2019, Chaput et al. 2013, Hay et al. 2012, Holman et al. 2011, Janssen et al. 2013, Jiménez-Pavón et al. 2013, Stabelini Neto et al. 2014). For example, Verswijveren et al. (2021) examined the effects of reallocating time spent sedentary with time spent in varying PA intensities on the cardiometabolic biomarkers of 169 eight-year-olds. The findings determined that replacing sedentary time with MPA and VPA was associated with significantly lower HDL cholesterol, triglycerides and insulin resistance (Verswijveren et al. 2021).

In a school-based randomised controlled trial (RCT), Kriemler et al. (2010) found that increased MVPA in the intervention group resulted in larger reductions in cardiometabolic disease risk score, triglycerides, and glucose, and a greater increase in high-density lipoprotein (HDL) cholesterol compared with the control group. In addition, in a longitudinal study of 8–11-year-olds (n=723), Hjorth et al. (2014) reported that total PA and MVPA was favourably associated with HDL cholesterol. Additional longitudinal studies demonstrated that total PA was also favourably associated with diastolic BP in children aged 5-8 years (Knowles et al. 2013) and adolescents aged 11-14 years (Hallal et al. 2011). Overall, there is strong and consistent evidence that PA is favourably associated with cardiometabolic biomarkers (Poitras et al. 2016).

2.2.2.1.2. Physical Activity and Adiposity

The correlation between PA and adiposity in school-aged children and youth has been extensively studied (Janssen and LeBlanc 2010). Primarily, waist circumference (WC), body mass index (BMI) centiles and body fat percentage are the most frequently utilised adiposity measures within the literature (Poitras et al. 2016). There is a large body of cross-sectional evidence reporting positive associations between PA and indices of adiposity (Poitras et al. 2016). Jiménez-Pavón et al. (2013) reported significant positive relationships between device-based measured PA, especially VPA, with measures of body composition in a group of 2,200 European adolescents aged 14 years. After adjusting for several confounding variables (including indices of fat mass and muscle mass), total PA, VPA and MVPA were negatively associated with all measured indices of body composition (BMI, % fat mass, sum of skinfolds; $p<0.05$). Similarly, in a sample of 342 adolescents aged 10–16 years, Kracht et al. (2020) concluded that attaining 60 minutes of MVPA daily was associated with lower BMI percentile ($p=0.001$) and body fat percentage ($p=0.006$) compared with those who did not meet the recommended amount of PA.

Evidence from RCTs have concluded that increasing total PA resulted in decreased adiposity compared with a control condition for at least one body composition measure (Eather et al. 2013, Ford et al. 2013, Kriemler et al. 2010, Verstraete et al. 2007). For example, Eather et al. (2013) highlighted that an 8-week multi-component school-based PA intervention had a significant effect on intervention participants' BMI (-0.96 kg/m2, $p<0.001$). Ford et al. (2013) also reported that increased MPA following a 15-week brisk walking intervention had a significant positive effect on participants' body fat percentage (-1.95±2.6%, $p<0.001$) and fat mass (-0.49±1.0 kg, $p<0.001$), with no change in the control group.

Among longitudinal research, associations between PA and adiposity are mixed (Poitras et al. 2016), with approximately half of the identified longitudinal studies that examined VPA and/or MVPA reporting a favourable association with at least one measure of adiposity. Carson et al. (2014) examined the longitudinal associations between different PA intensities and cardiometabolic risk factors among a sample of 315 Canadian youth aged 9–15 years. The results highlighted that at two years follow-up, time spent in VPA was positively associated with WC (-6.4cm, $p=0.04$). Similarly, Oh et al. (2021) examined the associations of MVPA in adolescence through young adulthood with adiposity in young adults. This study utilised device-based measured PA data obtained at five assessments over nine years (15, 17, 19, 21, and 23 years of age) from a subset of 221 participants from the Iowa Bone Development Study. The authors concluded that individuals who are consistently physically active during adolescence through early young adulthood are less likely to accumulate total body fat in young adulthood (Oh et al. 2021). In contrast, in a sample of 4103 Brazilian adolescents, Hallal et al. (2012b) reported null associations between device-based measured PA and sum of skinfolds ($p>0.05$). Ultimately, there is substantial evidence that PA is favourably associated with adiposity (Poitras et al. 2016).

2.2.2.1.3. Physical Activity and Bone Health

Many observational studies have examined the relation between device-based measured PA and indicators of bone health, including bone mineral content (BMC) and bone mineral density (BMD) (Janssen and LeBlanc 2010, Poitras et al. 2016). Cross-sectional research has consistently demonstrated positive associations between PA and indicators of bone health (Bland et al. 2020, Poitras et al. 2016). For example, Osborn et al. (2018) indicated that time spent in MVPA was more positively associated with bone health than SB in a sample of 1357 11–12-year-old children. Interestingly, a recent systematic review of cross-sectional literature indicated that VPA was associated more consistently with greater bone health than MPA/MVPA (Brailey et al. 2022), indicating that lower-intensity exercise has a lesser osteogenic effect (Rønne et al. 2019). For example, Marin-Puyalto et al. (2019) examined the cross-sectional relationship between BMC and

BMD and device-based measured time spent in PA among 180 12-year-olds. When adjusted for body mass and skeletal age, the skeletal site that showed the highest correlation with PA participation was the femoral neck, where both BMC and BMD presented significant correlations with MPA and VPA ($p<0.05$). Nonetheless, VPA presented the strongest relation with bone mineral indictors; being the only PA intensity with statistically significant relationships with whole body and lumbar spine BMC values (Marin-Puyalto et al. 2019). In a randomised crossover trial conducted by Gutin et al. (1999), a four-month physical training program resulted in larger increases in BMD during the intervention period compared with the control period in both groups of 7–11-year-old children ($p=0.045$). In relation to the longitudinal associations between PA and bone health, findings are less clear with a mix of favourable and null results observed depending on intensity of PA and skeletal site (e.g., spine, femoral neck) (Poitras et al. 2016). Rønne et al. (2019) examined longitudinal associations of BMC with PA levels among 663 participants between the ages of 10 and 17 years. A positive association was found between percent time spent in VPA and BMC ($\beta=5.8$, $p=0.002$), whereas MVPA was not significantly associated with BMC (Rønne et al. 2019). Overall, the literature has consistently demonstrated a positive association between PA and bone health, with results indicative of greater benefits of VPA over lower PA intensities (Brailey et al. 2022, Poitras et al. 2016).

2.2.2.2. Tracking of Physical Activity from Childhood and Adolescence into Adulthood

Increasing PA levels in childhood and adolescence might reduce the risk of mortality and chronic illness in adults by increasing the chance of people being more active in adulthood (Telama 2009). It is believed that if good activity behaviours are developed early in life, there is a higher likelihood they will persist later in life (Jones et al. 2013). This concept, known as tracking, has previously been defined as a tendency of individuals to maintain their rank or position within a group over time (Malina 2001) or the ability to predict subsequent observations based on earlier values (Pühse 2005). Research by Tammelin et al. (2014) measured the baseline PA levels of 3596 children and adolescents aged 3-18 years old, with four separate follow-up measurements across a 27-year period. The study concluded that a physically active lifestyle begins to develop early in childhood and that the tracking of PA from youth to adulthood is moderate to high (Tammelin et al. 2014).

Recently, Hayes and colleagues (2019) conducted a review of the evidence for the tracking of both PA and SB from adolescence through to young adulthood (defined as 19-25 years), citing this as a critical period for establishing lifestyle behaviours. It is speculated that understanding how PA and SB track between these time periods may highlight adolescent determinants of adult activity behaviours (McVeigh et al. 2016). In general, this review found evidence that PA and SB show

low-to-moderate tracking during the transition from adolescence to young adulthood. The findings showed a weakening of the strength of tracking over longer periods and increased tracking stability with increasing baseline age. Generally, PA declined with age, whereas SB tended to increase, although the evidence for this is weaker (Hayes et al. 2019).

2.2.3. Physical Activity Guidelines

As outlined in the previous section, research demonstrates that children and adolescents who attain higher levels of PA have more favourable health outcomes (Poitras et al. 2016). Such evidence was foundational in the development of age-specific PA guidelines and recommendations that promote the optimal dose of PA required to maintain and improve indices of health.

2.2.3.1. Development of Physical Activity Guidelines

The development of PA guidelines for clinicians and physicians originated in the early 1970's, as several epidemiologic and experimental studies had revealed that physically active individuals had better health outcomes than those who were less active. The American Heart Association (AHA) published the first guidelines in 1972 and 1975, which were focused on reducing cardiovascular risk by performing moderate-to-vigorous intensity exercise (American Heart Association 1972, American Heart Association 1975). At the same time, several organisations and government agencies began issuing recommendations, guidelines, and position stands on PA. This led to the development of the first American College of Sports Medicine (ACSM) position statement, which recommended individuals perform an endurance-type activity for 15 to 60 minutes, 3 to 5 days per week (American College of Sports Medicine 1978). In 1993, the Centers for Disease Control and Prevention (CDC) in collaboration with the ACSM published "Physical Activity and Public Health: A Recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine" (Pate et al. 1995). The primary recommendation of this publication was that all adults should accumulate 30 minutes or more of MPA on most, preferably all, days of the week. Around the same time the World Health Organisation (WHO) issued a report on the health benefits of regular PA, also recommending that adults attain 30 minutes or more of MPA on most days (WHO/FIMS Committee on Physical Activity for Health 1995).

It is from these earlier position stands and public recommendations that the current PA guidelines were developed. In 2008, the U.S. Department of Health and Human Services issued the Physical Activity Guidelines Advisory Committee Report, outlining recommendations for both adults and adolescents (Physical Activity Guidelines Advisory Committee 2008), representing a major milestone in addressing the health burden of physical inactivity (Lee and Shiroma 2014). The report provided a comprehensive and thorough summary of a large volume of scientific research relating

to the relationship between PA, PA dose and health, and converted these findings into practical guidelines for the public (Powell et al. 2011). The guidelines recommended that children and adolescents should attain 60 minutes of PA daily for optimal health benefits. Most of the 60 minutes should be either moderate or vigorous aerobic activity; and as part of the 60 minutes of activity, inclusion of VPA, muscle-strengthening, and bone-strengthening PA was recommended on at least 3 days of the week (Physical Activity Guidelines Advisory Committee 2008). The development and implementation of these 2008 PA guidelines and the subsequent Word Health Organisation's (WHO) PA guidelines in 2010 were a fundamental step in enabling the general population to make informed decisions on their level of PA participation (World Health Organization 2010a). These recommendations were consequently adopted by other countries globally, including the Irish Department of Health and Children (Department of Health and Children 2012, World Health Organisation 2011).

2.2.3.2. Current Physical Activity Guidelines for Children and Youth

The Physical Activity Guidelines Advisory Committee issued a new scientific report in 2018, (Physical Activity Guidelines Advisory Committee 2018) that recommended bouts of PA of any duration can be accumulated and can contribute to health benefits for the individual (Physical Activity Guidelines Advisory Committee 2018). This update reflected research showing that PA accumulated in less than 10-minute bouts had positive effects on outcomes of body composition, blood pressure, blood lipids, and metabolic syndrome (Loprinzi and Cardinal 2013, White et al. 2015, Wolff-Hughes et al. 2015). Nonetheless, in this latest report the committee maintained the recommendation that children and adolescents should attain 60 minutes of PA daily (Physical Activity Guidelines Advisory Committee 2018).

In 2019, the UK Chief Medical Officers released an updated version of the 2011 UK PA Guidelines. The 2019 UK guidelines suggest children and young people should engage in MVPA for *an average* of at least 60 minutes per day across the week (Department of Health and Social Care 2019). The report stated that the current evidence base does not support a specific minimum daily threshold of 60 minutes of MVPA for health benefits, therefore, they recommended a shift to an average of 60 minutes across the week. In addition, the recommendation includes a guideline advocating that children and young people should participate in a range of types and intensities of PA across the week to develop movement skills, muscular fitness and bone strength (Department of Health and Social Care 2019).

In line with the UK guidelines, the WHO recently published updated PA guidelines, which suggest that children and adolescents should achieve at least an average of 60 minutes per day of moderate-

to-vigorous intensity, mostly aerobic, PA across the week (World Health Organization 2020). The new guidelines also recommend children and adolescents to include vigorous-intensity aerobic activities, as well as activities that strengthen muscle and bone at least three days per week. Lastly, the WHO have incorporated a recommendation for SB which states that children and adolescents should limit the about of time spent being sedentary, particularly the amount of recreational screen time (World Health Organization 2020).

The updated UK and WHO PA guidelines are supported by the most up-to-date scientific evidence on the benefits of PA for health. They also include specific recommendations for frequency, intensity, duration and volume of aerobic and muscle strengthening activities. The guidelines provide the most recent advances in the evidence base for PA and SB and associated selected health consequences and thus the guidelines should be used to inform national health policies (Bull et al. 2020). It should be noted, however, that these new guidelines are yet to be adopted by many countries, including Ireland, which continue to recommend the earlier PA guideline of 60 minutes of MVPA daily (Department of Health and Children 2012).

2.2.4. Summary: Section A

The research presented here highlights that there are favourable relationships between PA and a wide range of health indicators. Overall, there is strong, consistent evidence that PA was favourably associated with adiposity, cardiometabolic biomarkers, and bone health. In general, higher intensity PA (i.e., MVPA and VPA) had more consistent and robust relationships with health indicators than lower intensity PA (i.e., LIPA and MPA) (Poitras et al. 2016). These findings were integral in the establishment of the current PA guidelines. The ability to accurately assess PA using valid and reliable tools is imperative to increasing the knowledge of the quantity of PA required to elicit favourable health outcomes (Loprinzi and Cardinal 2011).

2.3. Section B: Assessment of Physical Activity Levels

Presently, a wide variety of assessment tools are used to measure activity behaviours, including self-report measures (Ainsworth et al. 2015) and objective and device-based measures such as direct observations (DO), doubly labelled water (DLW), calorimetry, heart rate (HR) monitors, pedometers and accelerometers (Migueles et al. 2017). Physical activity is a complex construct, making measurement difficult (Butte et al. 2012), particularly among adolescents as, unlike adults, their PA patterns are intermittent rather than occurring in continuous time periods (Baquet et al. 2007). This section will provide an outline of existing PA measurement tools, with a particular focus on accelerometery which will be utilised within subsequent chapters of this thesis. This

section will also provide an overview of the national and international levels of PA in youth populations.

2.3.1. Subjective Measures of Physical Activity

The use of subjective measurements tools, such as self-administered recalls, interviewer administered recalls, diaries, and proxy reports completed by parents and teachers (Ainsworth et al. 2015), has supported and developed researchers understanding of links between PA and health indices (Sylvia et al. 2014). The self-report method is the most commonly used approach in the assessment of PA in epidemiological research due to their low burden, ease of administration, cost effectiveness and ability to provide information on the type and context of PA in a large sample of individuals (Loprinzi and Cardinal 2011, Sylvia et al. 2014). Nevertheless, numerous limitations of self-report measures have been identified, which include difficulties in determining/recalling the frequency, duration and intensity of PA, as well as the influence of social desirability bias, recall bias, age and seasonal variation (Ndahimana and Kim 2017, Sylvia et al. 2014). Among adolescents, recall bias is particularly common, as this group find it extremely difficult to accurately recall their PA behaviours due to the sporadic activity patterns and short duration of PA bouts (Colley et al. 2019, Mattocks et al. 2008).

As with any PA measurement tool, the quality of information gathered using self-report is dependent on its methodological effectiveness (e.g., validity and reliability) (Chinapaw et al. 2010, Sallis and Saelens 2000). Chinapaw et al. (2010) performed a systematic review of the reliability and validity of 61 PA questionnaires developed for use in youth. Reliability results were reported for 35 different instruments, with the study quality rated as positive if the study population was >50 and the reliability intraclass correlation coefficient (ICC) was >0.70 (Chinapaw et al. 2010). Of the 35 reviewed questionnaires just seven received a positive rating, with the reliability ranging from ICC=0.02 to ICC=0.96. Construct validity was mostly evaluated by correlations between the questionnaire and accelerometers (n = 46), with results ranging from r=<0.01 to r=0.77. More recently, Hidding et al. (2018) published an updated review of the reliability and validity of 89 PA questionnaires for youth. Like the previous review (Chinapaw et al. 2010), just five questionnaires were identified as reliable, while just one questionnaire was found to be valid (Hidding et al. 2018). The authors concluded that no questionnaires were identified with conclusive evidence for both acceptable validity and reliability, partly due to the low methodological quality of the studies. This highlights a need for high-quality methodological studies examining the measurement properties of the most promising PA questionnaire (Hidding et al. 2018).

2.3.2. Objective Measures of Physical Activity

2.3.2.1. Direct Calorimetry

Energy expenditure as a result of PA is a complex series of biochemical processes that result in the transfer of metabolic energy to generate skeletal muscle contraction (Brooks et al. 1996). Consequently, a large amount of heat energy is produced which is directly proportional to the net activity related EE. Energy expenditure can then be directly quantified by measuring body heat at rest or during exercise (Montoye 1996). The direct measurement of body heat production using a calorimeter is known as direct calorimetry and is considered the gold standard for measuring human metabolic rate (Kenny et al. 2017). Typically, direct calorimetry is performed within a laboratory setting and the participant is required to be sealed in an airtight chamber, where the total heat dissipated through evaporation, radiation, conduction, and convection is recorded (Levine 2005, Pettee et al. 2009). Although a valid and reliable measure of EE, calorimetry systems are extremely expensive and difficult to operate, while also confining the participant to a laboratory over the 24-hour period, making direct calorimetry generally impractical to examine realistic free-living behaviours (Brychta et al. 2010, Kenny et al. 2017).

2.3.2.2. Indirect Calorimetry

Due to the restrictive nature of direct calorimetry, indirect calorimetry is the most used method to measure rates of energy production. Indirect calorimetry measures the difference in oxygen (O_2) and carbon dioxide (CO_2) contents between expired and inspired air, which allows for the quantification of O_2 consumption and CO_2 production (Kenny et al. 2017, Montoye 1996). Energy expenditure can then be calculated from the volume of oxygen consumed (VO_2) and carbon dioxide produced (VCO_2) with a standard equation (Rosenbaum et al. 1997). Indirect calorimetry was initially performed under similar laboratory conditions to direct calorimetry, with the participant confined to a respiratory chamber within an air-tight, insulated, and temperature- and humidity-controlled room (Montoye 1996). Methods to perform indirect calorimetry outside of the respiratory chamber have been developed, which include metabolic carts and mobile, wearable metabolic devices (Pettee et al. 2009). These techniques use a measurement system comprised of an O_2 and CO_2 analyser, a ventilation flow-volume meter, while processing expired air collected through a fitted hood, face mask or mouthpiece (Davis 1996). These indirect calorimetry techniques are commonly used to assess activities such as treadmill walking or running, household work and occupational work (Strath et al. 2002).

Indirect calorimetry has been identified as a valid and reliable measure of EE and has been commonly used as a criterion measure of PA intensity (Freedson et al. 2012, Trost 2007). This

measurement technique has also been used as a method of validating accelerometers (Powell et al. 2017), pedometers (Smith et al. 2019) and HR monitors (García-Prieto et al. 2017). However, the restrictive nature of the laboratory setting does not allow for accurate measures of free-living EE (Seale and Rumpler 1997). The mobile metabolic devices have also been shown to be burdensome over extended periods, particularly with child and adolescent populations (Sirard and Pate 2001).

2.3.2.3. Doubly Labelled Water

The DLW technique is a method of measuring PA related EE (Park et al. 2014). This method of measurement is determined by the chemical reactions of two stable isotopes, heavy hydrogen or deuterium (^{2}H) and heavy oxygen (^{18}O) (Trost 2007, Westerterp 2017). A typical protocol requires the participant to provide a baseline urine sample prior to ingesting a standardised dosage of DLW containing both stable isotopes ($^{2}H_2{}^{18}O$) (Ndahimana and Kim 2017). Over the measurement period, ^{2}H is lost from the body through the usual routes of water loss (e.g., urine, sweat), while ^{18}O is lost at a slightly faster rate due to it also being lost via CO_2 production (Ndahimana and Kim 2017, Westerterp 2017). After the measurement period, a final urine sample is examined using a mass spectrometer to identify the difference between the rates of elimination of ^{2}H and ^{18}O (Ndahimana and Kim 2017, Westerterp 2017). The difference between the rate of elimination of the isotopes reflects the rate at which CO_2 is produced which can be used to determine EE (Ainslie et al. 2003). The DLW technique has been validated in comparison to indirect calorimetry, and has been shown to be highly accurate, within 5-10% (Goran 1994, Trost 2007). Due to its precision and accuracy, the DLW technique has been deemed "gold-standard" for the assessment of free-living EE in humans (Park et al. 2014). Despite the high level of measurement accuracy, the DLW technique is not applicable to large-scale studies due to the large cost of the stable isotopes and the burden that is placed on the participant to provide urine samples regularly within a laboratory setting (Welk et al. 2000). Moreover, despite accurately measuring PA related EE over a given period, DLW cannot provide estimates of energy expended during varying intensities or durations (Trost 2001). Due to the DLW technique being extremely accurate at measuring EE, yet impracticable for large scale studies, it has been used to examine the validity of measures of PA including self-report (Conway et al. 2002, Hill and Davies 2001), accelerometery (Leenders et al. 2006, Murakami et al. 2019, Plasqui and Westerterp 2007), HR monitoring (Brage et al. 2015, Davidson et al. 1997) and pedometers (Komura et al. 2017).

2.3.2.4. Direct Observation

Direct observation involves the observation and recording of participants' PA behaviour over a specific period (Trost 2007). There are varying protocols implemented throughout research,

however, the majority require a trained observer to monitor the participants, while simultaneously recording an instantaneous rating of the participants' activity type/intensity into a log or handheld device (Lyden et al. 2014). Specific activities and locations are recorded on a momentary time-sampling basis at time intervals which can range from 5 seconds to 1 minute (Trost 2007). Direct observation has an advantage over other methods of measurement when examining PA in children and adolescents as the protocols are often more flexible. This allows the observer to not just quantify the total PA level of the participant, but also records factors such as behavioural cues and environmental conditions (Trost 2007). Despite this advantage, DO is often not a feasible method of measuring PA, as it is both labour intensive and expensive to implement (Kohl et al. 2000, Lyden et al. 2014). The time required to train observers with a specific protocol is considerable and observation is commonly only possible with a small sample in specific environments such as during school breaks or sporting events. This limits DO's use in large-scale epidemiological studies (Lyden et al. 2014, Trost 2007).

The DO method of PA measurement has been identified as both valid and reliable (Trost 2007). Kohl and colleagues (2000) identified ten studies examining the reliability of DO in children and adolescents, with six of the studies assessing inter-observer variability, while the remaining studies evaluated test–retest (time-dependent) reliability. The studies evaluating inter-observer variability reported extremely high levels of agreement (> 90%), while the four other studies found moderate to high levels of test-retest reliability. Lyden et al. (2014) conducted the most recent research, investigating the validity of DO as a measure of SB and PA among adults. The study concluded that DO accurately and precisely measures low intensity activity and MVPA when compared to indirect calorimetry. Overall, DO is a valid and reliable measure of PA, however, due to limitations, its use within PA research is limited.

2.3.2.5. Wearable Monitors

Within PA research, the use of wearable monitors to directly measure various components of PA has become increasingly prevalent (Ainsworth et al. 2015). In comparison to self-report methods, wearable monitors provide more accurate measurements of the physiological and biomechanical parameters that correspond to PA (Westerterp 2009). It should be noted that in recent literature the use of wearable monitors has been primarily described as a "device-based" measure of PA instead of an "objective" measure, due to the subjective decisions needed on how the output is processed and analysed (Aunger and Wagnild 2022).

2.3.2.5.1. Heart Rate Monitoring

In free-living settings, HR monitors are one of the most used device-based measurement tools for EE and PA (Sylvia et al. 2014) due to their versatility, low cost, and unobtrusive nature (Hills et al. 2014). The use of HR monitoring as a device-based measure of PA relies on the linear relationship between the increase in HR and the increase in EE during exercise (Strath et al. 2013). The number of commercially available HR monitors has increased considerably over the past decade, with the development of both chest-worn and small wrist-worn monitors (Gillinov et al. 2017). These relatively inexpensive and unobtrusive monitors have the capacity to store minute-by-minute HR for several days, providing an indirect assessment of the intensity, frequency and duration of adolescent's PA (Loprinzi and Cardinal 2011, Trost 2007). Heart rate monitors have also demonstrated an ability to measure EE during activities that do not involve vertical trunk displacement, such as rowing or cycling, that accelerometers and pedometers may miss (Crouter et al. 2004, Sylvia et al. 2014).

Despite this, there has been several well-documented limitations regarding the use of HR monitors to assess PA levels, which have led to concerns regarding their use in free-living studies in youth populations (Ndahimana and Kim 2017). Logan et al. (2000) identified large variability across studies in the definition of resting HR and the protocol used to measure HR. A total of five different definitions of resting HR were identified and used in the measurement of children's PA via HR monitoring and depending on the definition used, estimates of PA varied 10-65% (Logan et al. 2000). Another issue evident with the use of HR monitoring is the weak relationship between HR and EE during SB and LIPA, as HR can also be influenced by factors that cause sympathetic reactivity such as emotional stress, environmental conditions and temperature (Ndahimana and Kim 2017). Riddoch and colleagues (2007) indicated that this may introduce measurement error when measuring adolescent PA, as most adolescents spend a large percentage of their day in SB and LIPA. Another limitation of HR monitoring as a measurement tool of PA is the tendency of HR to remain elevated after activity has ceased (Trost 2001). Such discrepancies between HR and PA may mask the sporadic activity patterns of children and adolescents (Loprinzi and Cardinal 2011). Overall, HR is an important physiological marker for PA, but is influenced by a large range of factors unrelated to the activity being monitored. Therefore, HR monitoring provides an overview of PA, but estimates could be enhanced if used in conjunction with other methods (Hills et al. 2014).

2.3.2.5.2. Pedometers

Pedometers are small, lightweight and inexpensive devices that measure the number of steps taken and distance walked/run over a specified time period (Warren et al. 2010). The early models of

pedometers were typically hip-worn, and utilised a gear-driven mechanical technology, which identified a step based on the force generated from a typical heel-strike during ambulation. However, this form of pedometer was shown to have large errors in accuracy (Meijer et al. 1991). More recently available pedometers have utilised a microelectromechanical systems (MEMS) technology and algorithm-based processing of the MEMS signal to identify steps, which has subsequently significantly improved their accuracy (Berlin et al. 2006).

The validity of pedometers has been investigated in children and adolescent populations. Beets and colleagues (2005) examined the accuracy of four models of pedometers in 20 children aged between 5 and 11 years during self-paced walking and treadmill-based walking at different speeds. Two models of pedometers were used for the self-paced walking trials (Digiwalker SW-200 and Walk4Life 2502) and an additional two models were utilised during the treadmill-based walking trials (Sun TrekLINQ and Digiwalker 701). The two pedometers implemented during the self-paced walking trials showed a high level of agreement (ICC=0.985-0.997). During the slower paced treadmill-based walking trials (1.5–2.0 mph), all four pedometer models showed low levels of agreement (ICC≤0.746). However, at the faster, more conventional walking speeds (2.5–3.5 mph) the agreement between all models increased significantly (ICC>0.90). Moreover, McNamara et al. (2010), reviewed the validity and reliability of pedometers to measure PA in youth, and concluded that pedometers correlated highly in terms of criterion validity (ICC=0.74-0.99), while reliability was also consistently high (ICC=0.51-0.92).

The generally high levels of validity and reliability, coupled with their size, low cost and simplicity make them an attractive device for use in research (Ainslie et al. 2003; Ainsworth et al. 2015), however, they do have limitations (Trost 2007). Pedometers are insensitive to some forms of activity such as upper body activities, cycling and rowing and are unable to identify the magnitude of the movement detected (Trost 2001). Also, most pedometers do not provide real-time data storage or the ability to download recorded activity (Trost 2007). Pedometer brands use various proprietary algorithms to determine step count, thus making data harmonisation challenging (Ainsworth et al. 2015, Corder et al. 2008). Despite these limitations, the output from pedometers may be best used to document relative changes in activity levels and/or as an effective intervention instrument when used a motivational tool for individuals (Ndahimana and Kim 2017).

2.3.2.5.3. Activity/Fitness Trackers

Consumer wearable devices, referred to as "activity trackers" or "fitness trackers", have become popular for the monitoring of PA (Evenson et al. 2015). All modern activity trackers are wrist worn and utilise an accelerometer to estimate the type of movement, count steps, calculate energy

expenditure and energy intensity and estimate sleep patterns (Ainsworth et al. 2015). In addition to the accelerometer, many devices have utilised other types of sensors including barometers and altimeters to improve accuracy (Henriksen et al. 2018). The popularity of these devices has risen as they have become more affordable, unobtrusive, while also providing real time feedback, enabling the wearer to self-monitor against PA recommendations or set goals (Ridgers et al. 2016). Research by Henriksen et al. (2018) identified a total of 423 unique fitness tracker style devices from 132 different brands available on the consumer market, all of which utilised different sensors and algorithms. However, within PA research, Fitbit® was used in twice as many validation studies as other brands and 10 times as often as other brands in registered clinical trial studies (Henriksen et al. 2018).

Evenson et al. (2015) published the earliest review of the validity of Fitbit activity trackers within adult populations. The criterion measures of validity for counting steps included comparison against accelerometers or direct step counting. During laboratory-based studies, the correlation with both accelerometers and step counting was generally high (≥ 0.80), however, some studies did indicate this relationship decreased at lower speeds. The validity of the Fitbit as a measure of EE was compared with a range of criterion measures, including direct and indirect calorimetry. The review reported that regardless of the criterion used, EE was underestimated by the Fitbit devices (Adam Noah et al. 2013, Diaz et al. 2015). In addition, just two studies were reported to compare accelerometry-assessed PA to the Fitbit trackers, with one study finding higher correlation (ICC=0.86), while another study found a wide range in correlation (ICC=0.36–0.70).

While the aforementioned review provides support for the use of Fitbit activity trackers as a valid tool for measuring step count within adult populations (Evenson et al. 2015), there is little published data on validation studies conducted among children and youth (Mooses et al. 2018). Of the limited research available, the Fitbit activity trackers did not provide acceptable validity when measuring adolescent's step counts across three different walking conditions (incidental, controlled, and treadmill) when compared with observer counts within a laboratory setting (Sun et al. 2021). In free-living conditions, a strong correlation (r=0.85–0.96) was identified between school-time step counts recorded by the Fitbit and ActiGraph accelerometer among 147 9–10-year-olds who wore the device for 5 days (Mooses et al. 2018). In addition, a weak to strong correlation (r=0.24-0.80) was observed for MVPA time between the two devices, depending on the school period (i.e. class time, recess) (Mooses et al. 2018). Similarly, a study of 87 adolescents who wore a Fitbit tracker and the ActiGraph accelerometer simultaneously for seven days confirmed moderate to high correlations between the two devices for step counts (r=0.72-0.96) and MVPA (r=0.67-0.94).

While the area of activity trackers within research is continually growing, several interoperability challenges related to the collection and processing of data from activity trackers have been identified (Arriba-Pérez et al. 2016). Different activity tracker brands and models employ different sensors and algorithms in the detection and processing of the data. (Henriksen et al. 2018). Sensor data are, in most devices, reduced to a limited set of metrics before being transferred to the user's mobile phone. As the algorithms are not made available as open-source code, the degree of accuracy and similarity of these algorithms generated by the activity tracker companies remains ambiguous (Chan et al. 2022). In addition, limited space affects how long the device can collect data before data transfer is needed. Data are stored locally, and in many cases, uploaded to brand specific or open cloud–based health repositories. Accessing these data by third-party apps and comparing them is not always possible (Henriksen et al. 2018). These interoperability challenges may limit the use of activity trackers within research to measure PA behaviours beyond step counts.

2.3.2.5.4. Accelerometers

Accelerometry has become the preferred device-based measure of the PA levels of both youth and adult populations (Stewart et al. 2018), with the number of studies using accelerometers increasing dramatically since 2002 and more than 1100 papers published in 2017 (Montoye et al. 2018, Rowlands 2018). Accelerometers are small wearable monitors that detect and measure accelerations of the body in gravitational units. Acceleration is defined as the rate of change of velocity with respect to time. Through examining the resultant acceleration from body worn accelerometers, the frequency, intensity, and duration of PA can be assessed as a function of body movement (Ridgers and Fairclough 2011). Accelerometry works on the basis that the muscular forces responsible for body movement are directly proportional to the accelerations produced, and in turn, related to EE (Warren et al. 2010). Most accelerometer-based PA monitors consist of one or more piezoelectric accelerometers that consist of a horizontal cantilevered piezoelectric element with a seismic mass. When the sensor undergoes acceleration, the seismic mass causes the piezoelectric element to bend or compress, which produces an electrical signal that is directly proportional to the applied acceleration. The raw acceleration signal is analog/digital converted, filtered and summarised into discrete epochs to produce an indication of movement (Butte et al. 2012, Chen and Bassett 2005, Ridgers and Fairclough 2011).

2.3.2.5.4.1. Accelerometer Types

There are currently a wide range of commercially available accelerometers used within research, the most employed being the ActiGraph (ActiGraph, Fort Walton Beach, FL), the activPAL™ (PAL technologies Ltd., Glasgow, UK), the GENEActiv (Activinsights, Cambridgeshire, UK), the

Axivity (Axivity Ltd, Newcastle Upon Tyne, UK), and the Sensewear Armband (Bodymedia, Pittsburgh, PA, USA) (Broderick et al. 2014). Depending on the model of accelerometer, it may measure acceleration in one plane (uni-axial), two planes (bi-axial) or three planes (tri-axial) that represent vertical, anteroposterior and mediolateral directions (Hills et al. 2014). Most early PA accelerometers were uniaxial and typically worn in a manner that allows the sensitive axis to be oriented in the vertical plane. Omnidirectional accelerometers are most sensitive in one plane, generally the vertical, but are also sensitive to movement in other directions, with the output being a composite of the signals (Hills et al. 2014, Ridgers and Fairclough 2011). Over recent decades, technological advancements have led to the development of triaxial accelerometers that have the capabilities to measure accelerations in the three orthogonal planes separately (X, Y and Z), providing an output for each plane and a composite measure. To compute the composite measure, triaxial accelerometers sum the accelerations from the three planes to provide a sum of the vector magnitude (SVM) (Chen and Bassett 2005, Ndahimana and Kim 2017). Some research has indicated that triaxial accelerometers may provide a more valid assessment of PA when compared to uniaxial accelerometers (Hills et al. 2014, Ridgers and Fairclough 2011, Welk 2005). It has been suggested that the ability of triaxial devices to measure acceleration in three planes may be more sensitive to detect free-living activities, which may be particularly advantageous in children and adolescent populations where activity is multidirectional and sporadic (Trost 2007). However, the research indicates high correlations between uniaxial and triaxial output, indicating that both models of accelerometer provide comparable results (Smith et al. 2018, Trost et al. 2005).

2.3.2.5.4.2. Assessment of Accelerometer Output

An important challenge regarding the use of accelerometers to measure PA lies in the interpretation of the raw outputs generated by the devices, which are dimensionless units and need to be translated into measurements with PA behavioural meaning (de Almeida Mendes et al. 2018). The two primary methods of assessing accelerometer output will be discussed below.

2.3.2.5.4.2.1. Count-to-Activity Thresholds

Traditionally, the accelerometer device utilised proprietary algorithms to arrange the accelerometer output into an arbitrary score, or accelerometer activity counts (Bassett et al. 2012, Migueles et al. 2017). These arbitrary accelerometer counts are dependent on the specific proprietary algorithms of the accelerometer, consequently not allowing direct comparison between accelerometer models (Chen and Bassett 2005, Rowlands and Eston 2007). As a result, the most utilised method of analysing accelerometer output is through count-to-activity thresholds or cut-points, which allows for accelerometer counts to be classified into PA levels or EE using predetermined values (Freedson et al. 2005, Trost et al. 2011).

Threshold development is the method by which the arbitrary accelerometer counts are converted into EE to give biological meaning to the output (Freedson et al. 2005). This process involves representative samples of a specific population performing a range of free-living activities while wearing the chosen accelerometer to be calibrated (Welk 2005). During these activities, a criterion measure of EE is utilised, most commonly indirect calorimetry. The data collected from both the accelerometer and indirect calorimetry devices are examined and applied to predict EE (Rowlands 2007). This predicted level of EE has also been used to provide a variety of count thresholds to distinguish between sedentary, light, moderate and vigorous activity intensities (Butte et al. 2012, Rowlands 2007). These different intensity thresholds have been determined using different methods including linear regression equations (Freedson et al. 1998, Trost et al. 1998), two-regression equations (Crouter et al. 2006) and random coefficients models (Mattocks et al. 2007).

Accelerometer activity counts are summed and stored over a specific time period called an epoch (Rowlands and Eston 2007). Epoch lengths often range from as low as 1 second, up to several minutes depending on the model of accelerometer and the target participant population (Rowlands 2007). In earlier research, epoch length was regularly set at 1 minute, due to the limited memory storage of the accelerometer models. However, as the technology of the accelerometers improved and memory storage size increased, it was possible for researchers to implement shorter epoch lengths from 1 second to 15 seconds (Rowlands 2007). The ability to capture PA in shorter length epochs, such as 15 seconds, is particularly important when measuring children and adolescent populations as their PA patterns are characterized by short bursts of rapidly changing activity (Loprinzi and Cardinal 2011).

A major advantage of this approach to processing accelerometer output is the ability to quantify time spent in activities of different intensities. However, despite several proposed thresholds for some devices, there is currently no consensus how to select the appropriate cut-off points to define activity intensities (Hills et al. 2014). This makes it difficult to make meaningful comparisons between the findings of different studies (Corder et al. 2009). In essence, if different thresholds were utilised on the same data set, it is possible to define the same group of adolescents as sufficiently or insufficiently active based on the current PA guidelines.

2.3.2.5.4.2.2. Machine Learning

Due to the larger storage capacity of modern accelerometer models, there has been a call within the research to move away from the use of activity counts, instead collecting and analysing PA data as raw acceleration signals (Rowlands 2018). However, this raw data can be difficult to interpret in terms of meaningful outcomes (Jones et al. 2021). Machine learning has received

increased attention as a new alternative to the previously mentioned count-to-activity threshold method of classifying accelerometer output into meaningful PA behaviours (Bassett et al. 2012, de Almeida Mendes et al. 2018). Machine learning techniques use pattern recognition, whereby a significant amount of labelled PA data is required to 'train' the classification algorithm (Preece et al. 2009, Sasaki et al. 2016). Once the training phase is complete, the classifier can assign an activity label to an unknown window of raw sensor data (Bassett et al. 2012, Preece et al. 2009).

The implementation of machine learning in early research laboratory studies using commercially available accelerometers were able to estimate activity type (e.g., walking, running, cycling) with recognition rates higher than 80% (Mannini et al. 2013, Zhang et al. 2012a, Zhang et al. 2012b). In a recent comprehensive review of raw accelerometer data calibration studies, de Almeida Mendes et al. (2018) reported that machine learning was the most frequently applied calibration approach. This review concluded that machine learning approaches presented promising validity, as the mean values of accuracy for sedentary (e.g., lying down), household (e.g., washing dishes) and locomotive (e.g., walking) activities were 82.9%, 55.4% and 89.7%, respectively (de Almeida Mendes et al. 2018).

While these results are promising, most studies that have used these techniques have been conducted in controlled laboratory settings, and thus have not been validated in free-living settings (de Almeida Mendes et al. 2018, Preece et al. 2009). As free-living activity is multifaceted, it remains relatively unclear how a machine learning approach would work under free-living conditions. Atkin et al. (2012) propose that more validation work is needed on large samples in free-living environments to test the utility of this approach in free-living conditions (Atkin et al. 2012). Moreover, the machine learning technique is in an early phase of development and requires considerable analytical expertise, which may limit its widespread use in research (An et al. 2017).

2.3.2.5.4.2.3. Length of Measurement Protocol and Measured Day

There is a lack of uniformity within the research with regards to what constitutes a valid day of measured PA (Rowlands 2007). This lack of consistency has limited the ability to compare results across studies (Masse et al. 2005). For example, Anderson et al., (2005) states that 600 minutes of data are needed to constitute a valid day and a period of 20 minutes of consecutive zeros indicated that the monitor had been removed. Eiberg et al. (2005) implemented a different set of requirements, indicating that a valid day needed at least eight hours of accumulated activity and just 10 minutes of consecutive zeros indicated removal of the monitor. Van Coevering et al. (2005) implemented different criterion for weekdays and weekend days in adolescent populations, due to the differing sleep patterns for weekend days. It has been suggested that ensuring the accelerometer

is worn both during waking and sleeping hours would reduce the inconsistency between studies regarding valid days and remove the need to make arbitrary decisions as to the waking period of the children (Loprinzi and Cardinal 2011).

The total number of days of measurement required to accurately reflect the participants habitual PA behaviour is also an important factor for researchers to consider. When dealing with youth populations, it is particularly important to consider the burden placed on the participant (Loprinzi and Cardinal 2011). Trost et al. (2000) investigated the minimum number of days required to capture children's usual PA patterns, before concluding that a seven-day monitoring protocol provides reliable estimates of usual PA behaviour in children and adolescents. In contrast, Dowd and colleagues (2016) concluded that a minimum of nine days was required to achieve a reliability of ≥ 0.7. when using the activPAL.

2.3.2.5.4.3. Accelerometer Validity

A large number of early studies examined the validity of different accelerometers under both laboratory and field conditions (Trost 2007). Laboratory-based studies commonly implement indirect calorimetry as the criterion measure of validity, while field-based studies utilise both DLW and DO (Bassett et al. 2012, Sirard and Pate 2001, Trost et al. 2005). While no study has simultaneously compared all accelerometer models (Rowlands and Eston 2007), Trost and colleagues (2005) reviewed the validity of several different accelerometers among both adult and youth populations. Within this review, validation studies yielded moderate-to-strong correlations (r=0.45-0.93) between accelerometer counts and oxygen consumption, EE, and MET in adults and similar correlations (r=0.53-0.92) in children (Trost 2007).

In a more recent systematic review, Lynch et al. (2019) demonstrated that triaxial and omnidirectional accelerometers accurately measure SB and PA in children and adolescents, when using indirect calorimetry as the criterion measure. Across the included studies, accelerometers' median sensitivity ranged from 46% to 96% and median specificity ranged from 71% to 96%. In particular, the findings were consistent with a previous systematic review that showed that accelerometers had greater than 80% sensitivity and specificity for detecting SB (Lubans et al. 2011a). The evidence in this review demonstrated that sensitivity and specificity was greatest when detecting SB (>95%) and lowest when detecting LIPA (46-83%). In addition, the sensitivity and specificity of accelerometers was >83% for both MPA and VPA (Lynch et al. 2019).

2.3.2.5.4.4. Potential Limitations of Accelerometers

Accelerometers, like all methodologies, have some limitations. The inability of accelerometers to provide contextual information (Sylvia et al. 2014), the potential of participant reactivity (Rowlands

2007), and compliance issues due to wear position are the most common issues with their use (Butte et al. 2012). Monitor placement has received increased interest as a means of increasing wear time and participant compliance. Hip-worn accelerometers were previously considered to be the most accurate way of determining normal ambulation (Ainsworth et al. 2015). However, recent comparative results have observed only minimal differences in the accuracy between hip-worn or wrist-worn devices (Shiroma et al. 2016). As a result, many studies have switched wear position of the device to the wrist. Indeed, Troiano et al. (2014) reported to observe a 30-40% increase in adherence rates after changing the accelerometer wear position from the hip to the wrist.

2.3.2.5.4.5. The activPAL Physical Activity Monitor

There has been an increased interest in the use of wearable monitors to detect changes in postural allocation, due to the emergence of SB as a potentially independent risk factor for disease (Owen et al. 2010). In particular, the ability of accelerometers to detect seated and standing postures and transitions between these postures is key to improving our understanding of the impact of SB and PA accumulation on health (Ainsworth et al. 2015, Edwardson et al. 2017). However, most accelerometers have technical limitations and infer sedentary time from a lack of movement (Henson et al. 2013). This can lead to misclassification of low-intensity non-sedentary behaviours as SBs (Kozey-Keadle et al. 2011b). A prime example of this misclassification occurs with standing, as it involves minimal movement and low energy expenditure, like sitting and lying. However, unlike sitting or lying, this behaviour is characterised by its upright posture which elicits higher muscle contractile activity and may result in increased EE (Tikkanen et al. 2013). Although these differences in EE may be considered negligible, the accumulation of these differences may have implications for energy balance over time (Levine et al. 2005). This higher muscle contractile activity has also been associated with a range of beneficial impacts on physiological processes such as glucose metabolism (Buckley et al. 2013).

Innovative accelerometer-based devices with inclinometers use sensors which are sensitive to both static and dynamic accelerations and therefore make it possible to differentiate between postures (Edwardson et al. 2017, Janssen et al. 2014). The activPAL PA monitor was the first inclinometer that was developed for large-scale use and is now generally considered the "gold standard" for the measurement of SB in free-living contexts (Aunger and Wagnild 2022, Edwardson et al. 2017, Kozey-Keadle et al. 2011a, Lyden et al. 2017). The activPAL monitor is a small (24x45x5mm), lightweight (9g) triaxial accelerometer device worn on the mid-line of the anterior aspect of the thigh. The activPAL incorporates Intelligent Activity Classification™ based on information obtained from MEMS. Via this Intelligent Activity Classification™, accelerometer-derived information about thigh position and acceleration are used to determine body posture

(sitting/lying and standing), transitions between these postures (sit-to-stand, stand-to-sit), stepping, and stepping cadence to estimate EE (Edwardson et al. 2017).

Within laboratory studies, the activPAL device has demonstrated high levels of agreement with DO for estimating the time spent in different postures and stepping within adult populations (An et al. 2017, Bassett et al. 2014). Bassett et al. (2014) reported that the activPAL accurately classified time spent in lying, sitting, standing and stepping (>90%). Similarly, An et al. (2017) examined the accuracy of the activPAL in 62 adults while completing 15 different types of activities (e.g., sitting typing, throwing ball) which were classified into 3 different postures (sitting, standing, and stepping). The results confirmed that the activPAL was reasonably accurate for detecting sitting, standing, and stepping and very accurate for classifying stepping (An et al. 2017). In free-living conditions, the activPAL has also demonstrated high levels of agreement with DO for the measurement of total sedentary time (Kozey-Keadle et al. 2011b). Moreover, Lyden et al. (2017) observed that when compared with DO as a criterion, the activPAL's overall accuracy rate for time spent in LIPA and MVPA was 96.2%.

While research investigating the validity of the activPAL3™ within youth is limited, Sellers and colleagues (2016) examined the validity of this device for measuring posture and stepping during standardised activities and activities of daily living (ADL) in both adults and adolescent populations (Sellers et al. 2016). The activPAL measured sedentary and upright times for standardised activities were within 5% of video observation for both adults and young people. Ridley et al. (2016) validated the accuracy of the activPAL for assessing free-living sitting and standing time of 40 children in a classroom setting. Against a criterion measure of DO, the activPAL demonstrated good accuracy for sitting and standing time, with a mean bias of -1.9 min and +1.8 min, respectively. Moreover, the study determined that the activPAL accurately detects postural sit-to-stand transitions (mean diff = 0.24) (Ridley et al. 2016). More recently, Hayes and colleagues (2021) published the first study to develop and cross-validate count-to-activity thresholds for a range of activity monitors, including the activPAL, in a mixed adolescent population. The study concluded that the activPAL had higher levels of sensitivity and specificity for the developed SVM MPA thresholds, supporting its use as an accurate measure of MPA in a mixed adolescent population (Hayes et al., 2021). Overall, through a combination of postural detection and using counts information to derive activity intensity, the activPAL has the potential to accurately measure the amount of time spent in sitting/lying, standing, LIPA and MVPA behaviours.

2.3.3. Summary: Section B

In summary, the valid and reliable measurement of PA is important when examining the associations between activity variables and indices of health (Loprinzi and Cardinal 2011). Device-based measures have become the preferred method of choice when assessing activity behaviour due to the inherent limitations of subjective measurement methods (Owen et al. 2010). The examination of PA using accelerometers has increased considerably, due to their relatively low cost, ease of administration and ability to accurately and precisely measure activity behaviours (Bassett et al. 2012, Rowlands and Eston 2007). In particular, the activPAL has been identified as a suitable accelerometer device to accurately detect both SB and PA.

2.4. Section C: Physical Activity Levels in Youth

As outlined previously in section 2.3.1, the most recent global PA guidelines published by the WHO recommends children and adolescents achieve at least an average of 60 minutes per day of MVPA *across the week* (Bull *et al.* 2020). However, this updated guideline has yet to be widely adopted by many countries, including within Ireland, where the national guideline recommends children and adolescents achieve at least 60 minutes of MVPA *daily* (Department of Health and Children and The Health Service Executive 2009). Similarly, most current published research has utilised the former WHO guideline of a minimum of 60 minutes of MVPA *daily* to determine if the participants are physically active (Physical Activity Guidelines Advisory Committee 2018, World Health Organization 2010b). Therefore, unless otherwise stated, the following reviewed literature considers an individual to have achieved the PA guidelines if they attained this recommended *daily* amount.

2.4.1. Physical Activity Levels in Irish Youth

2.4.1.1. Subjectively Measured Physical Activity and Inactivity in Irish Youth

Most of the research examining the levels of PA among children and adolescents within Ireland has been conducted using subjective measures. The Survey of Lifestyle Attitudes and Nutrition (SLÁN, 1998 and 2003) followed by the Irish Health Behaviour in School-Aged Children survey (HBSC, 2006, 2010, 2014 and 2018) were the first studies to comprehensively and continuously examine and monitor PA levels of Irish adolescents (Friel et al. 1999, Gavin et al. 2015, Gavin et al. 2021, Kelleher et al. 2003, Kelly et al. 2012, Nic Gabhainn et al. 2007). Survey data from the 1998-2018 SLÁN and HBSC studies, which focused on the health behaviours of school-aged children between the ages of 10-17 years, are presented in Table 2.1. When determining the PA patterns of children and adolescents throughout the surveys, participants were asked the frequency with which they "exercised so much that they get out of breath or sweat". The findings indicated an age-related decline in exercise participation, as the proportion of boys and girls participating in

exercise on four or more times a week is higher during childhood (9-11 years) than the mid- (12-14 years) and late- adolescent period (15-17 years). This age-related decline was most prominent in females, with an average decrease of 30.7% from 9-11 years to 15-17 years. While these studies provide important information on PA participation, they should be interpreted with caution as all data was collected using self-reported measures.

Table 2.1 Percentage of boys and girls who report participating in vigorous exercise four or more times per week.

	9-11yrs		12-14yrs		15-17yrs	
	Boys (%)	**Girls (%)**	**Boys (%)**	**Girls (%)**	**Boys (%)**	**Girls (%)**
SLÁN 1998	68	59	67	50	54	26
SLÁN 2003	64	56	65	43	49	25
HBSC 2006	72	58	68	51	55	28
HBSC 2010	66	60	64	42	55	28
HBSC 2014	63	57	57	46	56	33
HBSC 2018	66	62	56	44	51	28

The Growing Up in Ireland Study is a national longitudinal study of children and youth in Ireland designed to inform Government policy. Starting in 2006, a cross-sequential longitudinal design was adopted and followed a cohort of 8,568 children (Cohort '98) across three waves at nine years, 13 years, and 17/18 years, respectively (Williams et al. 2009). This study examined self-reported data provided from the children themselves and proxy-reported data from parents, teachers and other regular caregivers of the selected children, with the aim of identifying what is both typical and atypical during a child's development. A key objective of this study was to examine the progress and well-being of children at critical periods, which included an examination of their PA levels. The first wave of the study indicated that 31% of boys and 21% of girls met the recommended daily PA guideline (Growing Up in Ireland Study Team 2009). At wave two, the 13-year-olds were asked to report the frequency with which they participated in light exercise (defined as activity which did not result in being out of breath) and hard exercise (defined as sufficiently vigorous activity as to make the heartbeat faster). The result indicated that 68% of boys and 52% of girls participated in light or hard exercise on 6 or more of the last 14 days (Growing Up in Ireland Study Team 2012). Similarly, at wave three 74% of boys and 58% of girls reported to participate in light or hard exercise on 6 or more of the last 14 days (Growing Up in Ireland Study Team 2016). Around the same time, Breslin and colleagues (2012) also carried out a self-report questionnaire on a representative sample of 1,424 children (male: n=643; female: n=781) 9–11-

year-olds in Northern Ireland and concluded that only 24% of the participants had achieved the recommended level of 60 minutes of MVPA per day. There was also a significant difference between males and females, with 27.9% of males achieving the PA guidelines, compared to 21.0% of females.

One of the largest and most comprehensive research studies into the PA levels of Irish children and adolescents is the Children's Sports Participation and Physical Activity (CSPPA) study (Woods et al. 2010, Woods et al. 2018). Woods and colleagues used both self-report questionnaires and qualitative interviews to assess the PA levels of participants aged 10-18 years. A total of 5,397 children and adolescents from primary schools (n=1275) and post-primary schools (n=4122) participated in the first CSPPA study in 2010 (Woods et al. 2010). In the follow-up CSPPA study in 2018, the total number of participants increased to 6,651 (primary: n=1549; post-primary: n=5102). Table 2.2 presents the proportion of children and adolescents that achieved 60 minutes or more of MVPA on all days of the week from both CSPPA reports. The CSPPA 2018 study indicated that just 13% of participants met the daily PA guideline of at least 60 minutes of MVPA (17% primary; 10% post-primary). These proportions have decreased slightly since 2010 when 14% of participants met the guidelines (19% primary: 12% post-primary). The gender difference evident in 2010 remained, with 17% of boys and 9% of girls attaining the guidelines. The difference between males and females was also evident across both primary (13% vs. 23%) and post-primary (7% vs. 14%) schools. As in the 2010 study, there was a significant decrease in PA levels as the adolescents increased in age and transitioned from primary to post-primary school (23% to 14% Males; 13% to 7% females) (Woods et al. 2018).

Table 2.2 Proportion of children by gender and school level who met the physical activity guidelines in the CSPPA studies.

	Males (%)	**Females (%)**
CSPPA 2010: Primary	27	13
CSPPA 2018: Primary	23	13
CSPPA 2010: Post-Primary	15	9
CSPPA 2018: Post-Primary	14	7

(Woods et al. 2010, Woods et al. 2018)

Comparisons of the CSPPA data with data reported from the HBSC studies should be interpreted with caution. While all studies have reported low levels of PA within Irish youth, some of the reported differences could be the result of the use of different PA categorisation criteria, variation in the sampling methods and methodological approaches undertaken. This emphasises the need for more standardised and precise measurement methodologies.

2.4.1.2. Device-Based Measured Physical Activity and Inactivity in Irish Youth

Shiely and MacDonncha (2009) conducted the earliest research within Ireland to utilise device-based PA measures. The study measured the PA levels of 27 students (14 male; 13 female) aged between 12 and 15 years, from a single post-primary school using heart rate monitors. This research also measured the PA levels of the participants using PA questionnaires to make comparisons between the device-based and subjective measurement tools. When examining PA data collected using the recall questionnaire, just 11.1% of the participants accrued 60 minutes of moderate intensity PA on all four days. In comparison, no participant reached 60 minutes of moderate intensity PA on all four days when measured using a heart rate monitor. When examining vigorous PA, data indicated 18.5% of the participants accumulated ≥20 minutes on four days. Again, when measured using the heart rate monitor no participant reached ≥20 minutes of vigorous PA on all four days (Shiely and MacDonncha 2009).

Harrington and colleagues (2010) used the activPAL accelerometer to measure the sedentary patterns of adolescent females. While doing so, the percentage of time spent in LIPA and MVPA was also determined. A total of 56 adolescent females wore the activPAL accelerometer for a total of seven days. The results revealed that the female adolescents spent 0.9 hours in MVPA on a weekday and 0.8 hours during a weekend day (Harrington et al. 2010). Dowd and colleagues (2014) also provided activPAL measured data from 195 females aged between 13 and 18 years. The results found that the adolescent female participants spent 65.3% (9.6 hrs) of the waking day in sitting/lying, 23.0% (3.4 hrs) in standing, 5.6% (0.9 hrs) in LIPA and just 6.1% (0.4 hrs) in MVPA (Dowd et al. 2014).

Belton et al. (2016) have conducted the most recent Irish based research using accelerometers aiming to identify the daily patterns of PA in early adolescent youth. As part of the "Y-PATH; Youth Physical Activity Towards Health" initiative, a total of 413 adolescents, aged between 12 and 14 years, provided ActiGraph accelerometer over a total of nine days. The data showed that overall, 32.4% of the valid sample met the 60 minutes of daily MVPA guideline. A significant difference was observed between genders as 41.4% of males met the daily PA guideline, in

comparison to just 22.7% of females. Males were also shown to accumulate significantly more MVPA on both weekdays and weekend days than their female counterparts.

Accelerometer data was obtained in a sub-sample of youth within the previously mentioned CSPPA 2010 study (n=293, 70% female, 12.5±2.1 years). According to the device-based measurement analysis, approximately 19% of the population achieved the daily PA guideline. The sole purpose for including the device-based measure was to validate the self-report PA questionnaire and so detailed accelerometer methodologies or detailed accelerometer output have not been reported (Woods et al. 2010). While device-based measures have been used to determine whether participants meet the PA guidelines, the original PA guidelines were based on self-report data. As a result, researchers must exercise caution when interpreting surveillance data. Use of device-based measures that are deemed accurate and reliable will remove some of the imprecision and biases that exist when using self-reported measures to inform PA guidelines (Dowd et al. 2018).

2.4.2. International Physical Activity Levels in Youth

2.4.2.1. International Subjectively Measured Physical Activity and Inactivity in Youth

The PA levels of adolescents has been examined extensively internationally, with several large-scale reports being conducted using subjective measures. The HBSC, a WHO cross-national study, constitutes the most comprehensive self-report PA surveillance studies in youth, conducted in 42 countries and regions across the WHO European region and North America (Inchley and Currie 2013). Hallal et al. (2012a) provided the first global estimate of adolescent PA data, combining available data from both the global school-based student health survey (GSHS) and the HBSC survey from across 105 different countries. Results indicated that just 19.7% of adolescents reported reaching 60 minutes of MVPA daily (Hallal et al. 2012a).

Publicly available data from the HBSC surveys of different countries was utilised by Kalman et al. (2015). This article examined country specific trends in MVPA from three HBSC surveys, from 2002 to 2010, across 32 countries from Europe and North America. The total sample consisted of 479,674 adolescents (49% boys), aged 11 years, 13 years and 15 years. Results indicated a slight overall increase in the percentage of adolescents achieving 60 minutes of MVPA daily from 2002 (17%) to 2010 (18.6%). A significant difference between the genders was also observed as 23.1% of males were reported to have obtained at least 60 minutes of MVPA daily in comparison to 14.0% of females. When the results are examined between age groups, adolescents aged 11 years were reported to obtain a significantly greater amount of daily MVPA than those aged 15 years (23.2% v 14.0%) (Kalman et al. 2015).

Building upon the report published in 2012 (Hallal et al. 2012a), Sallis et al. (2016) provided updated global PA estimates from 120 countries for adolescents aged 11–17 years.

Consistent with the 2012 data, inactivity prevalence continued to be extremely high, with a global average of 18.6% of adolescents or 21.6% of males and 15.6% of females successfully achieving the recommended level of activity (Sallis et al. 2016). More recently, Guthold et al. (2020) utilised the data from both the GSHS and the HBSC surveys from 146 countries, representing 1.6 million participants aged 11–17 years. Overall, just 19% of adolescents, or 22% of males and 15% of females were reported to meet the PA guidelines. This study also highlighted that between 2001 and 2016 the prevalence of meeting the PA guidelines decreased by 2.5% for boys (80.1% to 77.6%), whereas there was no significant change for girls (85.1% to 84.7%), leading to a significant global difference of 7.1% in physical inactivity between genders in 2016 (Guthold et al. 2020).

2.4.2.2. International Device-Based Measured Physical Activity and Inactivity in Youth

Over the past 20 years, accelerometers have been successfully utilised in large-scale population-based surveillance studies (Trost et al. 2005). The National Health and Nutrition Examination Survey (NHANES) is a large-scale ongoing study conducted by the CDC in the United States of America, which employs interviews and a physical exam to assess the health and nutritional status of a nationally representative sample of adults and children (Fuezeki et al. 2017, Ryu et al. 2020). Since the 2003/2004 NHANES wave, PA has also been assessed using the ActiGraph accelerometer, providing a largescale database which has been utilised by researchers to determine the PA and SB of different populations (Fuezeki et al. 2017). However, the 2003-2004 and 2005-2006 NHANES cycles are the only cycles where the accelerometry data has been made available to researchers (Ryu et al. 2020).

Troiano et al. (2008) examined the NHANES 2003/2004 data collection to determine the PA levels of children aged 6-11 years (males: n=309; females: n=288) and adolescents aged 12-19 years (males: n=570; females: n=611). The proportion of children aged 6-11 achieving the PA guideline of 60 minutes of MVPA daily was 48.9% and 34.7% for males and females, respectively. This declined significantly for both sexes between the ages of 12-15 years with 11.9% of males and only 3.4% of the female participants achieving the guidelines. Finally, 10% of males and 5.4% of females aged between 16-19 years attained sufficient MVPA to achieve the guidelines (Troiano et al. 2008). Carson and Janssen (2011) combined the NHANES accelerometery data from 2003-2004 and 2005-2006 to examine the volume and patterns of SB and MVPA in a cohort of 2527 (50.8% males) children and adolescents aged 6-19 years. The findings of this study highlighted that

participants spent 50.8%, 43.8% and 4.1% of their waking hours in SB, LIPA and MVPA, respectively (Carson and Janssen 2011).

Ekelund et al. (2012) published one of the largest investigations into children and adolescent PA levels using accelerometer data pooled from 14 studies between 1998 and 2009, comprising 20,871 children and adolescents aged between 4 and 18 years. Males were shown to achieve significantly higher counts (642±226 cpm/day) than females (540±193 cpm/day). Males were also found to accumulate significantly more minutes of MVPA daily (37±23 min/day) than their female counterparts (24±17 min/day).

Within the European context, The DEDIPAC (DEterminants of DIet and Physical ACtivity) Knowledge Hub was established in 2013 by twelve European Union Member States. One of the aims of DEDIPAC is to "enable a more continuous cross-European monitoring of PA behaviours and changes in these behaviours across the life course and within populations" (Lakerveld et al. 2014). Thus, within DEDIPAC a systematic review of 30 articles was performed to provide an overview of existing cross-European studies on PA in European youth (Van Hecke et al. 2016). Overall, the review concluded that there is substantial variability between countries in overall levels of PA and in the prevalence of compliance to recommended PA guidelines in youth. Depending on the intensity thresholds that were used, measured data ranged from 0-60% of youth meeting the PA guidelines. Consistent with previous literature, the device-based data also highlighted that boys were more active than girls and younger children were more active than adolescents (Van Hecke et al. 2016).

One of the more recent examinations of the PA levels of adolescents using accelerometers was conducted as part of the Canadian Health Measures Survey (Colley et al. 2017). Accelerometer data was collected from a total of 5,608 adolescents aged between 6 to 17 years. The results from this study highlighted that just 7% of the adolescents achieved at least 60 minutes of MVPA on at least 6 out of 7 days. Males were once again found to accumulate more MVPA than females, while adolescents aged 6-11 years were also accumulating significantly more MVPA than those aged 12-17 years. An interesting observation of this study indicated that the MVPA levels of Canadian adolescents was unchanged over the 9-year period of the study.

While the information presented in the preceding sections is useful in determining device-based measured levels of PA, it must be acknowledged that true PA behaviours are difficult to determine, especially in cross-country comparisons. As alluded to earlier by Van Hecke et al. (2016), the use of various count-to-activity thresholds across studies may hinder and/or distort the ability to accurately determine if participants are regarded as physically active. Indeed, in a review of

European children and adolescents' PA levels, Guinhouya et al. (2013) highlighted that the use of a threshold of >1000-1500 counts per minute resulted in up to 100% of youth being deemed as physically active. In contrast when a threshold of >3000 counts per minute was used across studies, only 3-5% of the population were considered physically active (Guinhouya et al. 2013).

2.4.3. Summary: Section C

Despite the substantial and wide-ranging benefits of PA, both subjective and device-based research has consistently shown low levels of PA among Irish and international youth populations, with the majority not reaching the PA guidelines (Guthold et al. 2020, Kalman et al. 2015, Woods et al. 2018). It is also evident that females are less active than males and PA levels decline throughout adolescence, which is paralleled with increased inactivity. This is particularly evident among female adolescents as they transition from mid-to-late adolescence.

2.5. Section D: Physical Activity: The Role of Organised Sport

For the past several decades, national governments, international organisations, public health researchers and non-governmental organisations have produced various initiatives and policies to make the promotion of PA a public health priority (Klepac Pogrmilovic et al. 2020). In 2016, the Irish government launched the National Physical Activity Plan for Ireland (NPAP), with a key aim to increase the proportion of children and adolescents achieving at least 60 minutes of daily MVPA by 1% per annum and decrease the proportion who do not achieve the recommendations by 0.5% per annum (Healthy Ireland 2016). While many countries have developed and implemented similar policies to tackle physical inactivity, global prevalence has remained relatively static over the past 20 years (Guthold et al. 2018), emphasising the need for greater investment and cross-sectoral action (Milton et al. 2021)

In 2018, the WHO published the Global Action Plan on Physical Activity (GAPPA) 2018–2030 (World Health Organization 2018). This document set a new target to reduce global levels of physical inactivity in adults and adolescents by 15% by 2030 and outlined 20 recommended policy actions and interventions. These included the creation of appropriate and supportive environments for PA and increasing opportunities for PA in a variety of settings, including schools, health care, transport, urban planning, public education and sport (World Health Organization 2018). However, advocacy efforts are required to engage each of these sectors and settings and encourage implementation of the actions outlined in the plan (Milton et al. 2020). Thus, the International Society for Physical Activity and Health (ISPAH), a leading global organisation working to advance research, policy, and practice to promote PA, established the "8 investments that work for physical activity" (The International Society for Physical Activity and

Health 2020). This ISPAH document categorised organised sport (OS) as one of these eight investment areas that work for changing PA behaviour (Milton et al. 2021). The NPAP also outlined participation in OS as one of the eight action points to encourage greater PA engagement within Ireland (Healthy Ireland 2016).

2.5.1. Organised Sports Participation and Health Outcomes

To date, several reviews have reported associations between OS participation and health outcomes among youth populations (Bean et al. 2014, Clark et al. 2015, Diehl et al. 2012, Kwan et al. 2014, Mansfield et al. 2018, Nelson et al. 2011, Vella 2019, Venetsanou et al. 2015). These reviews have associated OS participation with higher levels of PA, favourable motor development, and healthier eating habits (Nelson et al. 2011), yet the potentially beneficial effects on weight development, bone health, and cardiometabolic health are less well documented (Venetsanou et al. 2015). Furthermore, there have been reports of positive associations with psychological and social health factors (Clark et al. 2015, Mansfield et al. 2018), while potentially negative effects include increased consumption of alcohol and smokeless tobacco, and higher levels of stress, maltreatment, burnout, eating disorders, and overuse injuries (Bean et al. 2014, Vella 2019).

Bjørnarå et al. (2021) recently conducted a review of reviews to assess the systematically reviewed associations between OS participation in children and adolescents and health. Overall, inconclusive relationships between OS participation and obesity status were reported with low-to-moderate quality of evidence. A moderate positive effect on weight loss based on OS interventions was reported with moderate-to-high quality of evidence for causal relationships, with this positive effect accentuated in team sports compared with individual sports. In addition, a positive and consistent dose–response relationship between OS participation and bone health was reported (Bjørnarå et al. 2021).

Participation in OS was found to have a primarily positive association with a range of psychological and social variables, including mental health, perceived health and well-being, self-concept, self-esteem, self-regulation, self-efficacy, competence, social skills, enjoyment, satisfaction, connectedness, belonging, interdependence, and group cohesion (Bjørnarå et al. 2021). Nevertheless, OS participation was also negatively associated with some variables, including social maladjustment and depression, which increased at very high levels of involvement in OS. Finally, OS participation was reported to have a strong positive dose–response relationship with PA levels (Bjørnarå et al. 2021).

2.5.2. Organised Sports Participation and Physical Activity Levels

Several peer-reviewed studies have investigated the influence of OS participation on youth PA levels. These studies provide insight into: (1) PA levels of OS participants compared to nonparticipants, and (2) the PA levels attained during OS participation. These identified articles and their findings are summarised below in Table 2.3 and Table 2.4.

Table 2.3 Summary of the studies that have examined the physical activity levels of organised sport participants compared to non-participants.

Authors	Purpose	Country	Study Design	Sample size (n)	Age (years)	Sports	Key findings
Silva et al. (2010)	To determine the impact of OS on boys' and girls' MVPA.	Portugal	Cross-sectional	208 (79 boys, 129 girls)	14-16	N/A	OS increased participants' likelihood of achieving PA guidelines.
Machado-Rodrigues et al. (2012)	To investigate how much OS participation contributes to the total daily MVPA.	Portugal	Cross-sectional	165 (boys)	13-16	Range of individual and team sports (e.g., soccer, marital arts)	OS participants accumulated significantly more MVPA than non-participants (18min).
Silva et al. (2013)	To examine the associations between OS participation and levels of MVPA.	Portugal	Cross-sectional	310 (127 boys, 183 girls)	11-18	N/A	OS participants accumulated significantly more MVPA than non-participants (22min).
Hebert et al. (2015)	To explore the associations of OS participation with overall PA levels and PA guideline concordance.	Denmark	Quasi-experimental trial	1124 (528 boys, 596 girls)	8.4 (mean)	Soccer, handball, gymnastics, basketball and volleyball	Soccer and handball participants accumulated significantly more MVPA than non-participants (5-20min).

Marques et al. (2016)	To examine whether participation in OS is related to achieving PA recommendations, and objectively measured PA intensity.	Portugal	Cross-sectional	973 (427 boys, 546 girls)	10-18	N/A	OS participants were more likely to achieve PA guidelines and accumulated significantly more MVPA (5min) than non-participants.
Telford et al. (2016)	To investigate the longitudinal effect of OS participation in PA during childhood and adolescence.	Australia	Longitudinal	289 (134 boys, 155 girls)	8-16	N/A	OS participants accumulated significantly more MVPA than non-participants (6-9min).
Koorts et al. (2019)	To examine the contribution of OS participation to overall MVPA among adolescents.	Australia	Cross-sectional	358 (146 boys, 212 girls)	15.3 (mean)	N/A	OS participants accumulated significantly more MVPA than non-participants (7min).
Sprengeler et al. (2019)	To evaluate the proportion of different PA levels during PE and OS in children and adolescents as well as the contribution of PE or OS to the achievement of the PA guidelines.	Germany	Longitudinal	396 (200 boys, 196 girls)	6-17	N/A	OS participants were 2.57 times more likely to meet the PA guidelines than non-participants.
Mooses and Kull (2019)	To determine the contributing role of OS participation to daily PA.	Estonia	Cross-sectional	492 (226 boys, 266 girls)	7-12	N/A	OS participants were 1.6-4.0 times more likely to meet the PA guidelines than non-participants.

Table 2.4 Summary of the studies that have examined the physical activity levels attained during youth organised sport.

Authors	Purpose	Country	Study Design	Sample size (n)	Age (years)	Sports	Key findings
Leek et al. (2011)	To examine PA levels during youth OS practices.	USA	Cross-sectional	200 (105 boys, 95 girls)	7-14	Soccer and baseball/ softball	Participants on soccer teams (13.7mins, 10.6% practice time), boys (10.7mins, 7.8% practice time), and those aged 7-10 years (7.0mins, 5.8% practice time) had significantly more MVPA than their counterparts (i.e. baseball/softball participants, girls and those aged 11-14 years).
Cohen et al. (2014)	To use the accelerometer data to estimate the proportion of practice time spent in MVPA.	USA	Cross-sectional	29 (15 boys, 14 girls)	5-10	Soccer	On average, children spent 23mins or 36.8% of practice time engaged in MVPA.
Schlechter et al. (2017)	To report PA levels during practice time for youth flag football participants.	USA	Cross-sectional	111 (boys)	5-11	Flag football	Participants spent 19.9 mins (34%) of practice time in MVPA.
Ridley et al. (2018)	To measure the PA levels of children during practice sessions of OS.	Australia	Cross-sectional	141 (72 boys, 69 girls)	9-13	Soccer, netball and Australian rules football	Participants spent an average of between 22-41 minutes (40-50%) of practice time in MVPA.

Guagliano et al. (2013)	To objectively examine PA levels of girls during OS, and to compare the levels between games and practices for the same participants.	Australia	Cross-sectional	94 (girls)	11-17	Soccer, netball and basketball	Participants spent a significantly higher percentage of time in MVPA during practices compared to games (33.8% or 20min/hr vs. 30.6% or 18min/hr).
van den Berg and Kolen (2015)	To measure the amount and intensity of PA achieved by children during an organised ice hockey practice and game.	Canada	Cross-sectional	17 (16 boys, 1 girl)	9-10	Hockey	Participants spent significantly more time in MVPA (30.2 mins or 43.1%) during a practice session than during a game (22.3 mins or 28.2%).
(Tomlin et al. 2015)	To investigate the contributions of children's soccer practices and games to recommended PA levels.	Canada	Cross-sectional	62 (33 boys, 29 girls)	8.5 (mean)	Soccer	Participants spent significantly more time in MVPA during practices than games (74.1% versus 67.7%). No gender differences in PA levels were observed.
Wickel and Eisenmann (2007)	To examine how youth OS, recess, and PE each contribute to total daily PA time.	USA	Cross-sectional	119 (boys)	6-12	Soccer, basketball and flag football	Boys accumulated 110 min MVPA daily with youth OS contributing 23% of the total MVPA (26min).
Fenton et al. (2015)	To determine minutes of MVPA accrued in youth soccer and the contribution towards daily MVPA.	England	Cross-sectional	184 (boys)	9-16	Soccer	Football MVPA (51mins) contributed 60% towards overall daily MVPA.

2.5.2.1. Physical Activity Levels of Sports Participants Compared to Non-Participants

Several studies have found that youth who participate in OS attain significantly higher levels of PA and are more likely to meet the PA guidelines than those who do not participate. For example, Telford and colleagues (2016) conducted a longitudinal study examining the effect of OS participation on PA levels of Australian youth aged 8–16 years. The data collection was carried out annually from 8-12 years and again at age 16 years. Males who participated in OS were shown to accumulate an extra nine minutes of MVPA per day, with OS participating females also accumulating an additional six minutes of MVPA daily when compared to their non-sport participating peers (Telford et al. 2016). Similarly, Marques et al. (2016) found that participation in OS was related to significantly more time spent in MVPA daily for both boys (5.6 mins) and girls (5.7 mins). This study also highlighted that OS participants were 1.6 times more likely to achieve the PA guidelines than their nonparticipating counterparts. This increased likelihood of meeting the PA guidelines for OS participants was reported in other studies. Mooses and Kull (2019) found that OS participating youth were 1.6-4.0 times more likely to meet the PA guidelines than their non-participating peers. Likewise, Sprengeler et al. (2019) found that OS participating youth were 2.57 times more likely to meet the PA guidelines than those who did not participate in sport. Kokko et al. (2018) determined that OS participants across six European countries (Belgium, Czech Republic, Finland, France, Ireland and Sweden) were 2-6.4 times more likely to meet the PA guidelines.

However, it should be noted that a large percentage of OS participants still fail to meet the PA guidelines. Telford et al. (2016) concluded that despite increased levels of daily PA, just 22% of OS participating boys and 28% of OS participating girls achieved the recommended amount of PA daily. Vella and colleagues (2016) also found that despite 64-85% of Australians aged 5–17 years regularly participating in OS, less than 20% met the daily PA recommendations. Both Marques et al (2016) and Sprengeler et al., (2019) concluded that between 24% and 37% of OS participating adolescents met the PA recommendations. Evidently, OS presents an important opportunity for increasing PA in youth, but OS alone might be insufficient for meeting PA guidelines. At the same time, it has been suggested that there is room for improvement in terms of increasing PA levels in OS (Guagliano et al. 2013, Leek et al. 2011). Thus, the quality of time spent in OS should be considered to optimise PA attainment in OS (Guagliano et al. 2013, Janssen 2014).

2.5.2.2. Levels of Physical Activity Accumulated During Organised Sport

2.5.2.2.1. Practice Sessions

A limited number of studies have investigated the intensity and duration of PA attained during youth sport, reporting considerable variation depending on sport type, context (practice or game), gender and age (Schlechter et al. 2017). Most of these previous studies have utilised accelerometery to measure the PA levels of a practice session. Leek and colleagues (2011) quantified PA of boys and girls aged 7-10 and 11-14 years during either a soccer or baseball practice session, focusing primarily on the level of MVPA attained (Leek et al. 2011). Overall, participants spent 45.1 minutes (46.1% of practice time) in MVPA. Interestingly, participants on the soccer teams, boys and those aged 7-10 years accumulated significantly more MVPA than their counterparts, highlighting significant differences between gender, age group and sport type. Additionally, this study found that participants were reported as sedentary/inactive for about 30 minutes during the average practice (Leek et al. 2011). Cohen and colleagues (2014) found that boys and girls, aged 5-10 years, spent an average of 23 minutes (36%) of soccer practice time engaged in MVPA, while also engaging in SB for 15 minutes (24%) of practice time. This study, however, did not investigate the differences, if any, between genders in PA levels attained during practice. In line with the previous two studies, Schlechter et al. (2017) examined the PA levels attained by boys aged 5-11 years during flag football and found that an average of 19.9 minutes (34%) of practice time was spent in MVPA, while an average of 7.7 minutes (13%) of practice time was spent in SB. More recently, Ridley et al. (2018) measured the PA levels of 9–13-year-old boys and girls during practice sessions of three different organised sports in Australia (Australian rules football, soccer and netball). Participants spent an average of between 22-41 minutes (40-50%) of practice time in MVPA, with boys' soccer participants accumulating significantly more MVPA than the other groups. As with the previously mentioned studies, a large amount of practice, ranging from 11-19 minutes (12-23%), was spent in SB.

2.5.2.2.2. Practice Sessions vs. Games

Existing research measuring the PA levels of youth OS practices and games is limited to three studies (Guagliano et al. 2013, Tomlin et al. 2015, van den Berg and Kolen 2015). Guagliano et al. (2013) examined the PA levels of different female sports (netball, basketball, soccer), and reported that 20.3 minutes (33.8%) of a practice session was spent in MVPA, compared to 18.4 minutes (30.6%) of a game (Guagliano et al. 2013). Tomlin and colleagues (2015) also investigated the PA levels of both youth soccer games and practices, concluding that participants spent a significantly greater amount of time in MVPA during a practice session than a game (74.1% versus 67.7%). In agreement with the previous two studies, van den Berg and Kolen (2015) found adolescents

participating in ice hockey accumulated significantly more time in MVPA (30.2 minutes or 43.1%) during a practice session than during a game (22.3 minutes or 28.2%). Across all these three studies, irrespective of sport type or context, a significantly large proportion of OS time was spent in either SB or LIPA.

2.5.2.2.3. Contribution of Organised Sport Participation to Daily Physical Activity

To our knowledge, only two studies have measured both adolescents' daily PA levels and the PA levels they attain during OS participation using device-based measures (Fenton et al. 2015, Wickel and Eisenmann 2007). Wickel and Eisenmann (2007) investigated the PA levels of youth OS and its contribution to the overall daily PA levels of male participants aged 6 to 12 years. The resulting data highlighted that youth sport contributed to approximately 26 minutes (23%) of the total daily MVPA. Interestingly, approximately 51% of OS time was spent in either sedentary or light-intensity activities, whereas moderate and vigorous PA accounted for approximately 27 and 22% of the time, respectively (Wickel and Eisenmann 2007). Fenton and colleagues (2015) also investigated the contribution of soccer to daily PA levels in adolescent males and concluded that participants accumulated an average of 51.5 minutes of MVPA, accounting for a total of 60% of the overall daily MVPA levels.

2.5.3. Irish Organised Sports Participation Levels

The Irish government has recently launched the National Sport Policy and Sport Action Plan, which aims for at least 60% of the population to be actively participating in sport by 2027 (Department of Tourism 2021). Sport is commonly defined as being organised, is usually competitive and played in a team or as an individual (Khan et al. 2012). Organised sport is one of the most popular forms of leisure-time activities worldwide, with at least one-third of children and adolescents participating in most countries (Aubert et al. 2018).

In 2007, The Irish Sports Council published a report entitled "Ballpark figures: Key research for Irish sports policy", examining the levels of sports participation by schoolchildren (Irish Sports Council 2007). The data utilised in this report originated from a survey of more than 3,000 primary and 3,000 post-primary students in a nationally representative sample of over 200 Irish schools conducted by the ESRI. This report highlighted that school children accumulated sport in three separate areas: physical education (PE), extracurricular school sport and OS. A total of 62% of primary schools provided PE at least once a week, with soccer and Gaelic football the most popular sports played. It was also highlighted that 56% of primary school children play club sports more than twice a week, with Gaelic football again identified as the most popular sport. Both extra-curricular sport and OS were also highlighted as very popular for post-primary adolescents,

with participation levels for both between 70-80% for males and 50-70% for females (Irish Sports Council 2007).

The CSPPA Study 2010 aimed to provide a national database of cross-sectional PA, physical education and sport participation levels of children and youth aged 10-18 years in Ireland (Woods et al. 2010). The findings identified that 63% of primary school pupils and 73% of post-primary school pupils participate in sport outside of school (i.e., OS) on at least one day per week. Boys had higher participation rates than girls in OS, with traditional team-based invasion sports the most popular for both primary and post-primary schools. Interestingly, Gaelic football was again the most popular OS for both males (38%) and females (32%) at primary school, while being the overall third most popular sport at post-primary level. In addition, this study observed that participants became members of their chosen sports clubs at an early age. By the age of four, 37% of the participants were members of a sports club, this increased to 80% by age 7 and 93% by age 9, highlighting the popularity of OS clubs among youth within Ireland (Woods et al. 2010). In the more recent CSPPA 2018 Study, the popularity of OS continued, with 80% of primary and 58% of post primary school pupils reported participating in OS at least once per week compared to 79% and 64% respectively in 2010 (Woods et al. 2018). In addition, 75% of primary and 67% of post primary pupils reported belonging to at least one OS club. As with the 2010 study, Gaelic football was the most popular team-based sport among both primary (34%) and post-primary (32%) pupils (Woods et al. 2018).

The Irish Sports Monitor (ISM) is an ongoing large-scale population-based survey that measures both physical and social participation in sport in Ireland (Irish Sports Council 2015). The Irish Sports Council (now Sport Ireland) published updated reports annually between 2007 and 2009 as well as in 2011, 2013, 2015, 2017, with the most recent report published in 2019 (Sport Ireland 2017). Across these published reports, participation in sport has remained consistently high across the total population. Participation among both genders has increased since 2017, but a slightly larger increase among women has meant that the gender gap has narrowed from 4.5% to 3.4% (Sport Ireland, 2019). Throughout these reports a large gap in participation exists between younger and older age groups, with those in the youngest age group (16-19-year-olds) approximately three times more likely to participate in sport than those in the oldest age group (65 years and older) (Sport Ireland, 2019).

2.5.4. Gaelic Games Context

Gaelic football, Ladies Gaelic football, hurling and camogie (Gaelic games) are the national sports of Ireland (Duignan et al. 2021). The Gaelic games national governing bodies (NGB) of the Gaelic Athletic Association (GAA), Ladies Gaelic football Association (LGFA) and Camogie Association form Ireland's largest community and sporting organisations, with up to one million members, equating to almost 1 in 4 of the national population (Lane et al. 2017). With approximately 3,000 affiliated clubs in Ireland and overseas, Gaelic games are also the largest amateur sporting body in the world (Crampsie 2016). Gaelic games has at least three times the number of club members, event attendance, and volunteer hours than any other team sport in Ireland (Sport Ireland 2017).

To support its almost 500,000 playing members, participation in Gaelic games is guided by the "Gaelic Games Player Pathway", which encompasses three main phases; Foundation, Talent and Elite/High Performance (Gaelic Athletic Association 2021). Through the foundation phase, the pathway promotes the club as the central tenet in the player development process. In this phase, participation begins at nursery (4-6 years) and child (7-11 years) levels, where the focus is primarily on the development of fundamental movement skills (FMS) and the early acquisition of the specific skills of Gaelic games. After the consolidation of these skills, the focus for the subsequent youth level (12-17 years) is the commencement of formal competition which extends to adult level (18+ years). The Talent phase is focused on youth player's involvement with development opportunities outside of the club environment (i.e., development/academy/county squads). Finally, players at the Elite/High Performance stage achieve elite status through selection and representation on their adult inter-county team (Gaelic Athletic Association 2021).

As outlined previously in section 2.5.3, Gaelic football is the most popular of the Gaelic games sports, with 32% of youth aged 12-18 years participating regularly (Woods et al. 2018). Gaelic football is a field-based invasive team sport, which is contested by two opposing teams of 15 players on a rectangular grass pitch approximately 145 m long and 90 m wide Cullen et al. (2017). Competitive game play lasts 60 minutes and is characterised by intermittent periods of high-intensity, multidirectional running, where players are required to perform several skills, such as hand passing, kick passing, shooting, blocking and tackling (Shovlin et al. 2018). The aim of the sport is to outscore the opposition at H-shaped goal posts positioned at both end lines, with one point awarded for striking or kicking the ball over a crossbar and one goal (three points) awarded for striking or kicking the ball under the crossbar past a goalkeeper (Roe et al. 2016).

Given its popularity and role within Irish society, the Gaelic games club delivers many health benefits through the promotion of sport and PA (Lane et al. 2021). However, to the authors

knowledge, no research has quantitively examined the PA contribution of Gaelic games participation. Nevertheless, in the most recent 2018-2021 strategic plan, the GAA highlighted their willingness to improving the health and wellbeing of players, members, coaches and administrators through education and policy development (Gaelic Athletic Association 2018). The GAA Healthy Clubs Project (HCP) has developed as a flagship sports club-based health promotion initiative to achieve this goal (Lane et al. 2017). It is working well to extend the health promotion message into many aspects of the GAA club, such as policy and governance, and ideology around respect and lifelong participation. However, evaluation of the HCP has indicated that health promotion practice is least apparent in the day-to-day business of coaching and providing PA for all (Lane et al. 2021). Indeed there is a conflict of sorts between coach education, coaching practice and the GAA's ethos for maximising youth participation in games, as well as a failure to incorporate health promotion thinking into the core on-field activity of playing sport (Lane et al. 2021).

There are over 100,000 coaches in Gaelic games, supported by a coach development system that provides education opportunities for beginner to high performance coaches. A first national engagement with over 11,000 Gaelic games coaches through the "Gaelic Games Coach Survey" has indicated success for this system with over 91% of participants reporting to possess a coaching qualification (Horgan 2021). However, like many formal coach education programmes in invasion game sports, these courses are delivered over short periods of time in on-line and classroom settings, making it unlikely that coaches' practices will be positively influenced (Cassidy et al. 2015, Piggott 2012). Indeed, the Gaelic games coach survey also highlighted that 80% of coaches prefer learning through other coaches, 60% through coaching courses and 32% through engagement with a mentor. Further, 95% of coaches are highly interested in future learning opportunities (Horgan 2021). While acknowledging the positive steps OS coaching bodies such as the GAA have made as regards promoting best practice coaching methods, much is still unknown about the coaching approaches implemented within Gaelic games.

2.5.5. Summary: Section D

Overall, Irish OS participation levels are high, with team-based sports such as Gaelic football being the most popular sport for adolescents. This research also highlighted that adolescents who participate in OS attain higher levels of MVPA and are more likely to achieve the PA guidelines than their non-participating peers (Marques et al. 2016). However, it appears that OS alone does not provide sufficient MVPA to meet the PA guidelines (Ridley et al. 2018). Nonetheless, irrespective of sport type, sport context, age group, or gender, a large proportion of OS practice time is spent in low intensity activity. Although recovery, coaching instruction, questioning and discussion are all important factors for coaches within practice sessions, these findings still suggest

that there remains potential for coaches to increase the amount of MVPA accumulated during practice sessions, and displace some of the time spent inactive. This may be particularly relevant within a Gaelic games context, as coaches fail to promote PA or prioritise maximum participation for all youth players (Lane et al. 2021).

2.6. Section E: Coaching Research

Coaches are regarded as central figures in the youth OS setting, as they are uniquely positioned to deliver specific strategies and activities that support the development of proficient players (Sherwin et al. 2017). Considering they have regular direct involvement and carry considerable influence over players and the environment, the coach has been described as one of the primary factors influencing the quantity of PA levels attained in OS contexts (Howie et al. 2020). Accordingly, there have been calls to investigate and improve the current quality of youth OS coaching and to establish how to maximise the dose of PA attained during youth OS (Pate and O'Neill 2011, Vella et al. 2016). Therefore, examining coaches' practice is essential, as it provides insight into how coaches conduct their coaching sessions and how closely they align with different coaching approaches or pedagogies.

2.6.1. Coaching Pedagogy

Pedagogy, defined as 'any conscious activity by one person designed to enhance learning in another' (Watkins and Mortimore 1999), has tended to operate outside of the traditional sports coaching paradigm (Jones 2006). Nonetheless, over the last 15 years there has been an increase in coaching research that has recognised coaching as a complex process that involves more than just the transfer of a set of discrete skills to players (Light et al. 2014). This suggests that player learning is central to coaching and that pedagogy, therefore, should play a more central role in preparing coaches (Morgan and Sproule 2012). However, while receiving more attention within the literature, coaches and coach developers have yet to be influenced by pedagogy, who appear to be largely unaware of it (Light and Evans 2010, Light et al. 2014).

2.6.2. Traditional Approach

In competitive team sports, one of the primary goals for coaches is to improve the performance of their players (Harvey et al. 2013). As a result, the traditional approach has been observed as the most dominant approach adopted by coaches in invasion sports (Stone et al. 2021). This traditional approach is characterised by (i) conventional, highly structured coaching sequences which start with the introduction of technical skills in isolation from the competitive performance environment; (ii) players' repetitive attempts to reproduce coach-prescribed movements in drills; (iii) the coach providing regular, corrective verbal feedback; and (iv), a concluding game or

performance activity where players attempt to apply the motor skills learned (Moy et al. 2016). This approach is considered effective at facilitating skill development in the early stages of learning. This can be attributed to its emphasis on initially teaching simple skills in a relatively 'predictable' environment, but also to a more regimented and instructor-driven approach that keeps the participants 'on task' and ensures the maximum use of practice time (Sierra-Ríos et al. 2020). However, the traditional approach has faced criticisms from a skill acquisition perspective, as it is performed in isolation from the performance setting, which could limit players' ability to perform technical skills in context (Moy et al. 2016, Renshaw et al. 2010). Research has identified additional concerns relating to this approach, such as limiting player's ability to develop decision-making skills, develop thinking players, ownership, and personal and social skills (García López et al. 2009, Stone et al. 2021). Hence, alternative contemporary approaches to learning have been proposed and utilised, which encourage a more player-centred, non-linear perspective on player learning and development in sub-elite and elite sports organisations (Stone et al. 2021).

2.6.3. Game-Based Approach

A GBA has emerged as an alternative pedagogical approach to coaching of team sports. This approach is characterised by a shift from a coach-centred and skills-based approach to a player-centred approach aimed at developing skills in the context of games (Wang and Ha 2012). A GBA focuses on learning through game appreciation, tactical awareness, decision-making and skills execution (Light and Fawns 2003), with a core belief of empowering learners and placing the coach as a partner in learning (Cushion 2013). Notwithstanding the many forms of GBAs that exist, Light (2013) argues that all GBAs share four immutable features: (i) the design and manipulation of games; (ii) the use of questioning; (iii) the provision of opportunities for dialogue; and (iv) building a supportive socio-moral environment. Therefore, the collective term GBA has been adopted to describe pedagogical approaches that adhere to such features and to avoid any misunderstanding among practitioners who are unfamiliar with the nuanced differences (Harvey and Light 2015, Jarrett and Harvey 2016, Light et al. 2013, Serra-Olivares et al. 2015).

2.6.3.1. Origin of the Game-Based Approach

In the late 1960's and 1970's, the work of Mahlo (1969) and Deleplace (1979) recognised the importance of developing an understanding of both technique and tactics within the one model of games teaching (Jarrett and Harvey 2016). Essentially, their recognition that cognitive processes were important aspects of effective game play performance helped to stimulate and inform further research (Harvey et al. 2010a). Indeed, the publication of Bunker and Thorpe's (1982) Teaching Games for Understanding (TGfU) Model for physical education (PE) teachers to develop

students' game appreciation and tactical awareness stimulated the current global interest into how sport and games are taught (Jarrett and Harvey 2016).

2.6.3.2. Teaching Games for Understanding

The traditional game learning pedagogy within PE, pre-1980, was primarily focused on teaching specific motor skills or technique competence before the introduction of the game context, typically within closed skill learning environments and breaking the skills down into their component parts (Bunker and Thorpe 1983). This approach was applied because it was widely believed that mastering the skills and techniques of an activity was required before engaging in games. Bunker and Thorpe identified several problems with the traditional, technique-focused instruction that students were receiving (Griffin and Patton 2005). They believed that because of the structure, many students struggled to make decisions, frequently relying on an instructor for assistance, and left school dissatisfied in terms of their perceptions of their ability to play games (Bunker and Thorpe 1986, Hopper 2011). In response to the failings of the traditional approach, Bunker and Thorpe developed their new instructional model, TGfU (Bunker and Thorpe 1982). Later, Bunker and Thorpe published their curriculum model which provided a more detailed explanation and description of the model, justifications for the creation of the model, and instructions on how it can be adopted and implemented (Bunker and Thorpe 1986).

2.6.3.2.1. Teaching Games for Understanding Theory

Teaching Games for Understanding is a learner-centred, game-centred approach to teaching PE and sport, which can be used both in the school setting and in the extracurricular sport setting (Harvey and Jarrett 2014). As a learner-centred approach to teaching games, TGfU focuses on the players by ensuring that their needs are met, both instructionally and by creating an appropriate environment by modifying the original, formal version of a game to one that is more age appropriate (Light 2002, Sproule et al. 2011). The theoretical model which underpins the TGfU model is a constructivist approach to teaching/learning, as the learner is given more responsibility and becomes more involved in the learning process (Griffin and Patton 2005, Light 2002). Regardless of the significant differences in baseline knowledge and experience, a constructivist approach uses the learner's previous knowledge as a starting point (Turner 2005), while actively engaging with the subject through exploration, experimentation and discussions with others to draw new conclusions and create new knowledge in themselves (Richard and Wallian 2005). This type of learning is possible within TGfU, as it shifts the role of the teacher to facilitator, placing more responsibility and emphasis on the students to create knowledge for themselves and their peers (Dyson 2005). The teacher is not removed from TGfU instruction; however, the role of the

learner becomes more important than in a traditional approach to learning as they must create the knowledge, not simply receive it from the teacher (Light 2002).

Teaching Games for Understanding has also been determined to align with Situated Learning Theory (Dyson 2005, Richard and Wallian 2005), which proposes that learning occurs when the learner is an active participant within the learning environment (Kirk and MacPhail 2002, Richard and Wallian 2005). It is through this active engagement that an individual can adapt knowledge to suit their needs and extend their prior knowledge to apply at a later stage (Kirk et al. 2000, Kirk and MacPhail 2002). This approach situates learning within environments which are constantly changing, placing students into situations where they must adapt, building upon their prior knowledge (e.g., rules of game) to create new knowledge and learning (Hopper 2011, Kirk and MacPhail 2002).

2.6.3.2.2. Teaching Games for Understanding Model

The TGfU model follows a cyclic, six-step process which includes playing the game, recognising and understanding useful tactics, development of skills and decision-making abilities (Bunker and Thorpe 1986). This progression is designed to follow the evolution of learning any game (Werner et al. 1996), as students are provided information at the most opportune and appropriate times to aid them in learning (Hopper 2011). The steps, in order, as proposed by Bunker and Thorpe are (1) Game, (2) Game Appreciation, (3) Tactical Awareness, (4) Making Appropriate Decisions, (5) Skill Execution, and (6) Performance (Bunker and Thorpe, 1986) (Figure 2.2).

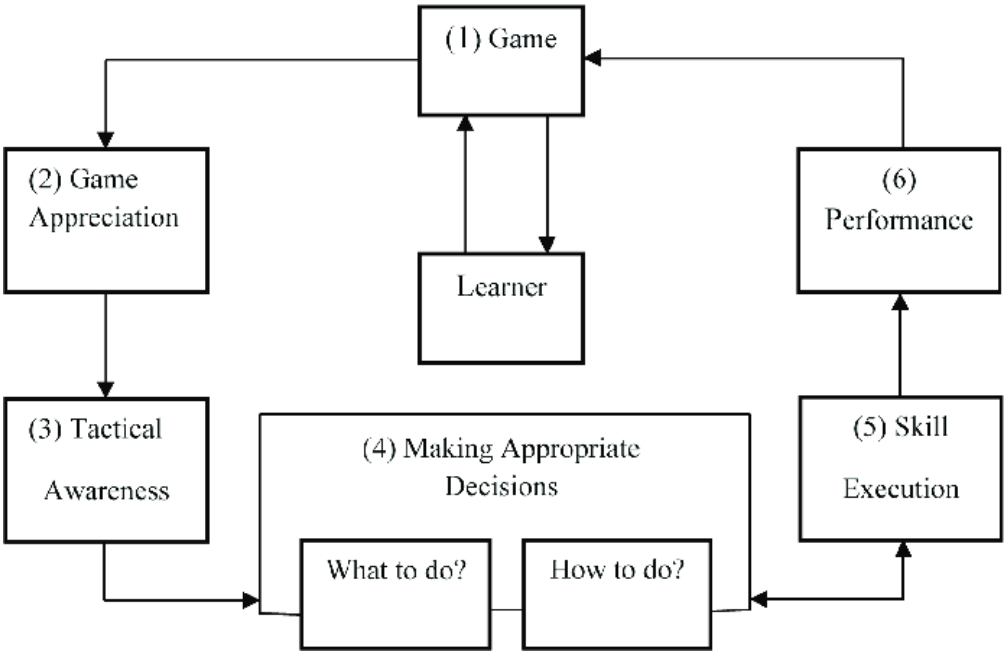


Figure 2.2 Teaching Games for Understanding Model Steps (Brunker and Thorpe, 1986)

Step one of the TGfU model is *Game,* which introduces the learners to a modified version of a game (Griffin and Patton 2005), but must represent a close approximation of the adult version of the game. The game must be modified to match the learners' developmental needs, which may entail manipulating different factors, such as the playing area, player numbers or equipment. This first step of playing the game immerses the learners in the game, exposing them to the game's unique challenges, allowing them to recognise them and possibly generate their own answers within the context of the game (Werner et al. 1996). This initial game also provides context to learners as they later begin to recognise tactics and develop skills necessary for game play (Mandigo et al. 2007b). Learners will have a better idea of why they are acquiring the skill and when it would be helpful to utilise throughout the game as opposed to if it had been developed in isolation (Kirk et al. 2000, Light 2002).

Step two, *Game Appreciation,* presents the modified game in a manner that ensures players understand the rules and methods of scoring, and appreciate the role that rules play in informing the skills, tactics and strategies which will be implemented during gameplay (Holt et al. 2002, Mandigo et al. 2007a, Werner et al. 1996). During this step, the learner should begin to recognise that a change in the modified game's rules or parameters necessitates a new strategy for success, making the learner more engaged in the learning process.

Step three, *Tactical Awareness*, requires the modified game to be presented in a context where the learners develop an understanding of the various tactics which can be employed within the parameters of the game. Understanding and using both offensive (i.e., maximising scoring opportunities) and defensive (i.e., restricting opponents scoring opportunities) game tactics is important because it gives learners flexibility as tactics may need to vary during the game to suit the scenario.

The fourth step in the TGfU model is *Making Appropriate Decisions,* where the learner considers what they must do in certain situations and how it should be performed. In this step, students use the information they've gathered in the previous steps to determine when it's the optimal time to perform specific activities or deploy various tactics in the game (Holt et al. 2002, Mandigo et al. 2007a). During game play, players must collect all sensory information available to them, identify which cues are relevant and significant, and analyse probable consequences before deciding what must be done and how to carry out this decision (Bunker and Thorpe 1986, Holt et al. 2002).

Step five, *Skill Execution*, focuses on how the learner executes specific skills and movements within the context of the game rather than in isolation, making them effective game players (Bunker and Thorpe 1986, Holt et al. 2002). This stage will teach the learners how to perform the skill itself,

however it is important to recognise that this is not performance, as during game play, technique might need to be more flexible to suit the situation; the teaching and learning which occurs during this stage should be done with the context of the game in mind (Griffin and Patton 2005).

All the other steps culminate in the final *Game Performance* step (Bunker and Thorpe 1986), which provides the learners with a chance to apply what they have learned thus far within the context of game that is a more advanced version of the game that has been the focus previously (Mandigo et al. 2007a). This step also allows the instructor to examine the participants' learning visually and offer feedback as needed and appropriate (Holt et al. 2002, Mandigo et al. 2007a). Performance evaluations must be based on the game's goals, as well as the lesson and unit in which the learning took place, to determine if a participant is a successful and competent player (Bunker and Thorpe 1986, Griffin and Patton 2005).

2.6.3.2.3. Teaching Games for Understanding Pedagogical Principles

To accompany and supplement the TGfU model, Bunker and Thorpe created four pedagogical principles: sampling, representation, exaggeration and tactical complexity (Bunker and Thorpe 1986, Griffin and Patton 2005, Holt et al. 2002, Stolz and Pill 2014). The first pedagogical concept of *Sampling* is predicated on the notion that the games selected for learning should provide a diversity of experiences, with opportunities to demonstrate similarities and differences between apparently dissimilar and similar games, respectively (Bunker and Thorpe 1986, Thorpe et al. 1984). By utilising many different games, individuals are more likely to be exposed to situations in which they might recognise the transferability of tactics and skills between games, helping make them more proficient game players (Mandigo et al. 2007a).

A key component of the TGfU model is the use of modified games to teach players about the formal game. This modification of the games is facilitated through the second and third pedagogical principles of *representation*, and *exaggeration* (Holt et al. 2002). *Representation* involves breaking down the formal game into a developmentally appropriate game or scenario which still maintains the tactics present in the formal game (Griffin and Patton 2005, Hopper 2011, Stolz and Pill 2014). The aim of representation is for learners to experience opportunities for developing tactical awareness, making appropriate decisions, and practicing skills in manageable practice environments (Tan et al. 2012). Closely related to representation, the principle of *Exaggeration* involves exaggerating or emphasising a specific tactical problem within the game through the modification of rules (Griffin and Patton, 2005), equipment or playing area (Stolz and Pill, 2014). Games should keep the core rules of the full game for this process to occur, while components of the games can be modified to exaggerate a tactical concept to be investigated (Tan et al. 2012).

The fourth principle of *Tactical Complexity* suggested by Bunker and Thorpe, involves designing and matching the game forms to the developmental level of the student, so that the tactical problems presented are not too complex for the learners to understand (Tan et al. 2012). As the players' understanding of the game and their ability to recognise tactics and implement strategies develops, the instructors can adjust the game's complexity to meet the needs of their learners (Sproule et al. 2011). Hopper (2011) suggested an additional pedagogical principal of *Adaption* as an extension to tactical complexity, which refers to increasing the challenge to the players as they achieve success. An example of adaption would involve increasing the area a player must defend every time they score a point, therefore increasing the demands and challenges they encounter, while still maintaining the capability to interact with an individual of a differing ability (Hopper 2011).

Finally, an additional pedagogical principle of *Questioning* has been suggested by Stolz and Pill (2014). This principle promotes the idea that by asking players questions and encouraging them to think and solve problems, they will become more involved in the creation of knowledge and the learning process. This innately occurs throughout the TGfU model, but it is critical for educators to become skilled at asking questions; asking students the right questions at appropriate times to elicit responses and getting them to think (Stolz and Pill, 2014).

2.6.3.3. Game-Based Approach Models

Since the development of TGfU by Bunker and Thorpe, several other GBAs have emerged, all with slight variations on the original TGfU model based on the needs of different cultures (Harvey and Jarrett 2014). As outlined previously, Light (2013) proposed GBAs include four common features. More specifically, in the first feature coaches are encouraged to design and deliver coaching sessions based upon game-related scenarios and modified games to illicit specific technical or tactical problems. The second feature requires coaches use a questioning approach to develop player understanding and promote learning through reflection. Connected with questioning, the third feature involves coaches providing players with opportunities for dialogue and debate. Finally, the fourth feature requires the coach to provide a supportive learning environment where athletes are encouraged to take risks, be creative and engage in active learning (Light 2013). Research on these various cultural versions of GBAs has been largely concentrated on investigations in PE environments (Harvey and Jarrett 2014).

2.6.3.3.1. Tactical Games Model

Developed by Griffin et al. (1997), the Tactical Games Model attempted to make TGfU more user-friendly by simplifying the original six-step model into a model containing just three stages.

The three-component model, consisting of 1) Game form, 2) Tactical awareness, and 3) Skill execution (Figure 2.3), creates an organised framework to help motivate students by providing clear student-oriented objectives (Griffin et al. 1997, Mitchell et al. 2006). A novel aspect within the *Tactical Games Model* is the integration of different levels of tactical complexity to help player progression. The authors emphasised that although many teachers focus on both tactical and technical aspects, they often have problems linking them (Mitchell et al. 2006). They emphasised that by linking skills and tactics, the players can learn more about the game and enhance their performance by using tactics as a platform to practice game-related motor skills (Griffin et al., 1997).

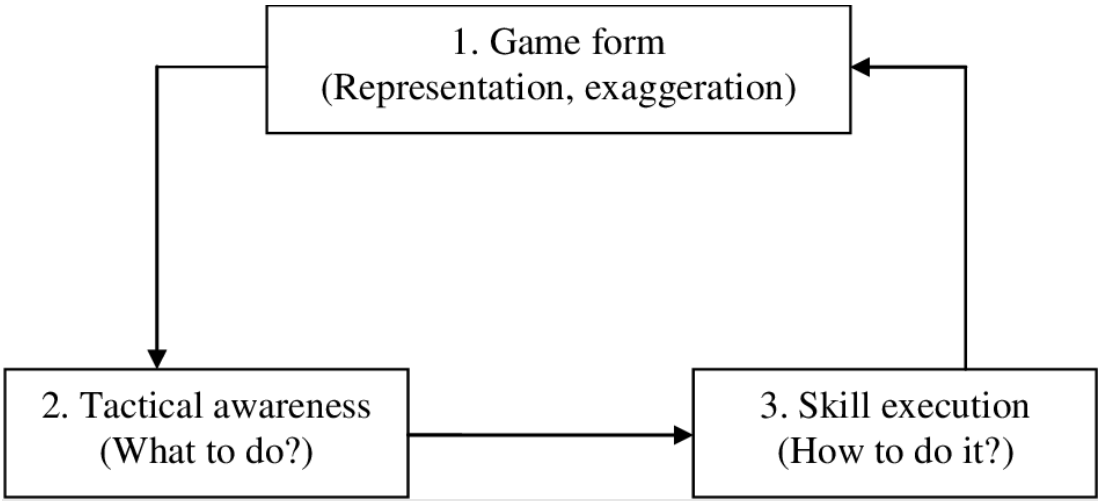


Figure 2.3 Tactical Games Model (Mitchell et al. 2006)

2.6.3.3.2. Play Practice

Despite Launder stating that Play Practice is not based on TGfU (Launder and Piltz 2013), the similarities are obvious, as a principal purpose of this approach is the learning of skills within (modified) games, which direct learners to skills that they need to develop (Launder 2001). Play Practice promotes the principles of shaping play, focusing play, and enhancing play to progress these games. Play Practice also primarily aims to provide a fun playing experience and to teach the ability to play the game for beginners, creating a game environment which allows the players freedom to try new game movements and skills without fear of failure (Launder and Piltz 2013, Stolz and Pill 2014). In contrast to TGfU, which focuses on the game as the setting for learning, Play Practice's major purpose is to create ways to engage and motivate children (Launder & Piltz, 2013). To achieve this, Launder and Piltz (2013) proposed that before establishing which components of skilled play are most relevant for the learners in question, a detailed examination

of the activity should be conducted. Regarding the pedagogy used by practitioners, Play Practice encourages a wide range of so-called instructional strategies (Stolz and Pill 2014). However, unlike TGfU, this model does not explicitly promote questioning as a pedological tool (Stolz & Pill, 2014).

2.6.3.3.3. Game Sense

Since it was primarily created by Rod Thorpe, in partnership with the Australian Sports Commission, in the mid-1990s, Game Sense is often referred to as the Australian version of TGfU (Australian Sports Commission 1999, Stolz and Pill 2014). Like TGfU, Game Sense is focused on the game and not the technique, contextualizing learning within games or game-like situations (Light 2004). This approach has lately garnered attention within invasion team sports such as rugby and football, leading to multiple sport NGBs to incorporate it within their coach education programmes (Karagiannis and Pill 2017, Reid and Harvey 2014). Light et al. (2014) assert that among the different variations of TGfU, Game Sense is the most appropriate approach for sports coaching, as unlike TGfU, it is concerned with athletes' tactical understanding development rather than their acquaintance with new games within PE. Indeed, Light (2013) clarified that the six pedagogical steps presented in the original TGfU model do not have to be followed in *Game Sense*.

Instead, the central focus of the Game Sense approach is the development of thinking players (den Duyn 1997). This objective for sport coaching is pursued via the coupling of movement technique to game context as skilled performance; or, as den Duyn (1997) described "Technique + Game Context = Skill" (Figure 2.4). This was a subtle distinction, but a departure from the six-step TGfU cycle of learning where game appreciation occurs before technique development (Soltz & Pill, 2014). Light (2013) also states that Game Sense sessions should include activities built on the knowledge developed in the previous game, in a logical sequence from the simple to the complex. Consistent with TGfU, this approach possesses a focus on questioning to stimulate players to think.

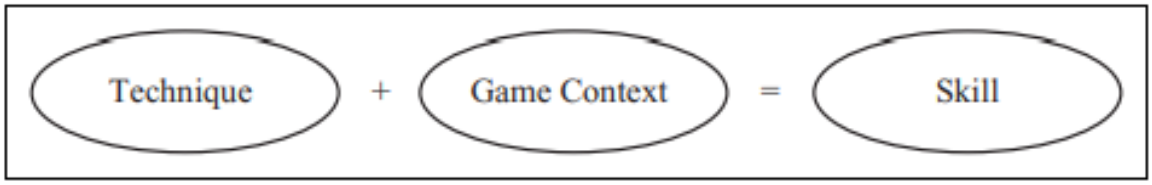


Figure 2.4 Game Sense (den Duyn, 1997)

2.6.3.3.4. Tactical Decision Learning Model

The Tactical Decision Learning Model (TDLM) (Figure 2.5), developed by Gréhaigne and Godbout (1995), shares the TGfU constructivist principle that demands an active role for the

learner in the creation of models of play (Light et al., 2014b). However, TDLM primarily focusses on student exploration of the various possibilities of game play and on the construction of adequate movement responses in small-sided invasion games (Gréhaigne et al. 2005). After experiencing the game, teams propose game plans in which four components are considered: cooperation with teammates, opposition to opponents, attacking opponents' space, and defending a team's own space (Gréhaigne et al. 2005). These game plans are then tested in play and progressively refined as players develop better understanding of the relationship between the game plan and the game rules (Stolz & Pill, 2014). Like the Tactical Games approach, TDLM places a strong emphasis on data collection, observational evaluation, and the gathering of qualitative and quantitative feedback (Stolz & Pill, 2014).

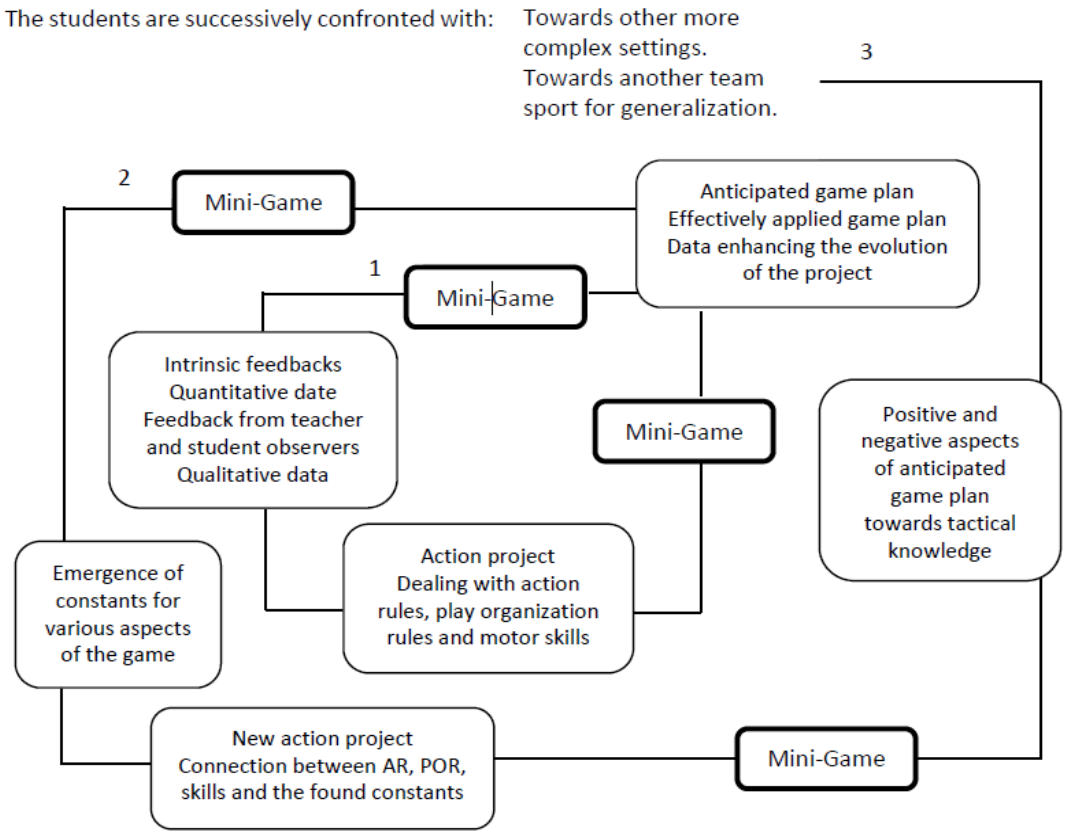


Figure 2.5 The Tactical Learning Decision Model (Gréhaigne and Godbout 1995)

2.6.3.3.5. Constraints-Led Approach

A pedagogical approach that has often been associated and miscategorised with GBAs is the Constraints-Led Approach (CLA). According to Renshaw et al. (2016), such confusion derives from an early focus of CLA literature on team games (Renshaw et al. 2010) and published research that have integrated aspects of GBAs and the CLA (Storey and Butler 2013). Nonetheless, the two approaches are somewhat harmonious and key similarities include the design of practice session

tasks and the proposed role of the coach (Renshaw et al. 2016). Specifically, both GBAs and the CLA support a holistic approach that attempts to engage learners on physical and cognitive levels (Renshaw et al. 2016). To promote this, the CLA advocates modified game-activities framed by the manipulation of task, performer, and environment constraints (Renshaw et al. 2010). Similarly, GBAs propose modifying the aspects of the game-activities by implementing the pedagogical principles of exaggeration, representation, and tactical complexity (Stolz and Pill 2014). In addition, the role of the coach in both GBAs and the CLA is to act as a facilitator that guides the players' learning (Renshaw et al. 2016). Thus, coach practitioners are advised to not provide players with the answers to a problem, instead encouraging players to explore and take responsibility for their own learning (Butler 2014).

However, these similarities have been described as being at an operational level, whilst the pedagogical principles that underpin both approaches are quite distinct (Renshaw et al., 2016). While a GBA was originally developed as a model for PE teachers (i.e., TGfU), it has been described as emerging from practice rather than being explicitly based upon theoretically based motor learning principles (Butler 2014). In contrast, the CLA emerged from the theoretical framework of ecological dynamics (Harvey et al. 2018). Another key difference between GBAs and the CLA is the use of questioning as a pedagogical tool. As outlined previously, the use of questioning and the reflective activity of the players form a core component of the learning processes within GBAs (Light 2013). Within the CLA, however, the use of questioning is only viewed as another method to constrain emergent learning behaviours, while a specific focus on players reflection to the questions is not a feature (Renshaw et al. 2016, Renshaw et al. 2010).

2.6.3.4. Game-Based Approaches in Team Sport Settings

As outlined earlier, investigations in PE contexts have dominated research on the many cultural versions of GBAs (Harvey and Jarrett 2014). While research findings in teaching PE are helpful resources for coaches, there are nonetheless critical differences between the PE and coaching environment (Blair and Capel 2013). For example, a primary expectation for coaches is to improve game performance in competition as a team (Light and Evans 2010), while teachers in PE focus more on individual students' development in a class (Drewe 2000). Furthermore, teachers attend to many pupils of varied abilities in PE classes, all of whom are required to participate in PE as a subject in the school curriculum (Kwon and Kim 2010). In contrast, in a sport setting, the coach's goal is to support players who have chosen to engage in the sport and are typically highly driven to improve their abilities and reach their full potential (Kwon & Kim, 2010). Given these notable differences, research conducted in both settings is likely to provide different findings. It has been

encouraging that reviews of the literature on GBAs in the past decade (Cushion 2013, Harvey and Jarrett 2014, Miller 2015) have noted the emergence of research investigating GBAs in competitive coaching settings (Kidman and Hanrahan 2010).

2.6.3.4.1. Tactical Development in Game-Based Approaches

Competent sports performance, particularly during team sports, is dependent on the execution of tactical skills concerned with obtaining and using information present within the game environment (Miller et al., 2016). The available research examining GBAs in competitive team sport environments provides strong support for the development of tactical components associated with effective game performance, including decision making and support play (Harvey et al. 2010b, Miller et al. 2016, Práxedes et al. 2016). Utilising TGfU, adolescent male soccer players were assessed pre and post intervention (12 sessions over 8 weeks) within a modified 3 vs. 3 assessment game (Harvey et al. 2010b). Analysis of the data demonstrated that the GBA intervention, which was centred on defensive aspects of game performance, highlighted positive changes between baseline and intervention phases in players' off-the-ball movements (Harvey et al. 2010b). Similarly, Práxedes et al. (2016) examined the impact of a TGfU intervention, implemented in 21 sessions over 12 weeks, on adolescent male soccer players' decision making when passing and dribbling. Results showed that after applying the intervention program, the players in the experimental group showed better decision making in both the pass and dribbling actions, compared with the players from the control group (Práxedes et al. 2016). Miller et al. (2016) also highlighted positive changes in decision making and support play amongst female adolescent netball players following a 9-week long GBA intervention.

2.6.3.4.2. Technical Skill Development in Game-Based Approaches

In contrast to the positive findings for tactical development in GBAs, there is little evidence to support the development of technical skills because of coaches using a GBA (Harvey and Jarrett 2014). Of the limited studies which have investigated technical skill execution in a competitive sport setting, just two reported significant improvements in this area (Pizarro et al. 2017, Práxedes et al. 2016). Interestingly, both Práxedes et al., (2016) and Pizarro et al., (2017) concluded that a 12-week (22 session) TGfU intervention resulted in male adolescent soccer players demonstrating significant improvements in the execution of passing actions, yet no significant improvements were observed for the execution of dribbling actions. Nevertheless, Light and Harvey (2017) states that because GBAs are holistic in nature, requiring the interaction of skill, decision-making, and tactical awareness, it is difficult to pinpoint specific technical skill improvements without breaking the game down into component sections. This challenge may underlie the limited evidence to date for the development of technical skills through GBAs (Kinnerk et al. 2018). However, it should

also be noted that in the remaining studies which explored technical skill execution (Nathan 2015, Nathan 2017), there was no evidence to suggest that coaches utilising a GBA resulted in reduced technical skill development amongst the players.

2.6.3.4.3. Affective Domain Development in Game-Based Approaches

A growing proportion of research has focused on the potential of GBAs to promote learning in the affective domain (e.g., emotion, motivation and fun) (Davis and Sumara 1997, Evans and Light 2007, Thomas et al. 2013) The findings of Thomas and colleagues (2013) provide an excellent summary of the player perceptions seen across the previous research studies, as players experienced greater enjoyment, increased game involvement through small-sided games, and increased motivation through tactical goal setting. Game-based approach research in PE supports these findings, with researchers discovering that GBA sessions are beneficial in keeping player task focussed and, as a result, ensuring players remain motivated and interested (Gray et al. 2009). Positive reports were also noted across the reviewed studies with respect to the strength of the player-coach relationship because of GBA pedagogy (Evans and Light 2007, Pill 2016), as players reported to be appreciative of the coaches' efforts to engage them in the process. Therefore, the coach repositioning themselves as facilitator enhances the learning environment (Davis and Sumara 1997, Light 2008).

2.6.3.4.4. Personal and Social Development of Players in Game-Based Approaches

Research has also examined the ability of GBAs to facilitate personal and social development (e.g., cooperation, fair play, responsibility and ownership). For example, Harvey (2009) described evidence of improved social cohesion, interaction, communication and teamwork when using Games Sense within a youth soccer setting. Pill (2016) also reported Australian Rules football players being confident in the team's game plan when the coach used Game Sense. Researchers have also reported that the heightened sense of player autonomy and empowerment provided by the coach during a GBA was well received by the players. For example, Koekoek et al. (2014) demonstrated that players felt a sense of responsibility to solve tactical problems themselves rather than been given the answer by the coach. Atkinson and Harvey (2017) directly linked an improvement in players' communication skills and team cohesion to the coaches' use of the Tactical Games Model. Overall, the reviewed studies demonstrate a positive association between the coach adopting a facilitative approach, which encourages player empowerment and responsibility, and this should therefore be considered a key strength of GBAs (Kinnerk et al. 2018).

2.6.3.4.5. Physical Activity and Fitness Development in Game-Based Approaches

Published studies directly investigating PA and fitness development in GBAs are scarce (Harvey and Jarrett 2014). While some qualitative evidence has highlighted a view amongst coaches and players that GBA-focused practice sessions were of a high intensity (Evans and Light 2007, Thomas et al. 2013), there is limited quantitative evidence to support these perceptions. Indeed, to the authors knowledge, there is no quantitative evidence that GBAs facilitated players developing and/or maintaining fitness levels. However, some emerging evidence from three studies has demonstrated the use of GBAs resulted in players attaining higher levels of PA in practice sessions (Miller et al. 2016, Nathan 2017, Sierra-Ríos et al. 2020). Miller and colleagues (2016) concluded that a GBA intervention was efficacious in increasing female adolescents' involvement during netball sessions, as they were observed to accumulate significantly more steps per minute than their peers in the control group. Nathan (2017) also demonstrated that adolescent field hockey players that participated in TGfU aligned practice sessions had significantly higher HR measurements than those who participated in traditional skills practice sessions. Similarly, Sierra-Ríos et al. (2020) revealed that TGfU practice sessions promoted significantly higher levels of LIPA (28.96% of practice time) compared to traditional/direct instruction practice sessions (27.55% of practice time) for under-12 male soccer players. Interestingly, this study also examined the percentage of practice time spent in PA during specific tactical principles, such as attacking the goal and keeping possession. The results concluded that for the tactical principle of keeping possession, significantly more time was spent in MVPA during TGfU practice sessions (43.60%) compared to the traditional practice sessions (38.05%) (Sierra-Ríos et al. 2020).

Despite the dearth of research investigating PA attainment via GBAs (Kinnerk et al 2019), studies have investigated the impact of "game-based training", whereby coaches utilise game-related activities, such as small-sided games in their practice sessions, but the pedagogical features necessary for a GBA (i.e. questioning, dialogue) are not apparent (Light, 2013). For example, a review of the game-based training literature by Gabbett et al. (2009) supported the value of game-related activities in maintaining physical fitness for team sport players. Furthermore, Van Acker et al. (2010) found that using modified game forms with simplified rules (arguably reflective of a GBA) resulted in players attaining significantly increased levels of MVPA. Thus, additional studies that objectively investigate a validated GBA in relation to its impact on multiple domain-specific variables, including players' PA and fitness levels are warranted (Kinnerk et al., 2018).

2.6.4. Summary: Section F

Evidence presented within this section demonstrated that the amount of quantitative research undertaken to evaluate the efficacy of a GBA in a coaching context could be improved to

strengthen the empirical basis of the pedagogical approach. While collective findings displayed no association between the use of a GBA and improvement in technical skill outcomes, it should be noted that there was no evidence that technical skill development declined due to coaches using a GBA. Game-based approaches were observed to significantly improve players' tactical awareness and decision-making where games and questioning are effectively employed. Players' affective domain outcomes (e.g., motivation) and personal and social development outcomes (e.g., communication) were also positively affected through GBAs. Finally, limited research explored the relationship between the application of GBAs and players' PA engagement, albeit coaches and athletes qualitatively reported progress in this domain. Thus, the literature presented highlights the need for future research investigating GBAs and their influence on PA.

2.7. Summary of Literature Review

This literature review highlights that PA provides multiple health-related benefits in adolescence, including improved cardiometabolic biomarkers, body composition, physical fitness, bone health and mental health (Poitras et al. 2016). For the measurement of free-living PA behaviour, device-based measurement tools have become the primary method of choice. Wearable monitors that are capable of measuring both PA and postural position (i.e. activPAL) have the potential to advance the accurate measurement of sedentary time, standing time, LIPA and MVPA (Edwardson et al. 2017). Despite the substantial and wide-ranging benefits of PA, however, the adherence rates to the well-established PA guidelines are poor and decline across the lifespan, with just 19% of adolescents regarded as physically active globally (Guthold et al. 2020). In response to the consistently low PA levels attained throughout adolescence, increased efforts have been placed on identifying effective settings to increase engagement (Fenton et al. 2015).

Considering the high participation rates amongst adolescents, OS was recognised as one of the "eight investments that work" for increasing PA (Milton et al. 2021). Indeed, research has demonstrated that adolescents who participate in OS are significantly more physically active and more likely to meet the PA guidelines than their non-participating peers (Marques et al. 2016). Yet, an opportunity remains for coaches to replace a large proportion of practice session time spent inactive with time spent in MVPA, in turn improving the contribution of OS participation to overall daily PA levels. A GBA has been identified as an effective coaching pedagogy to increase several critical player performance outcomes (Kinnerk et al. 2018) while some emerging evidence has demonstrated positive associations between GBAs and PA levels (Miller et al. 2016, Nathan 2017, Sierra-Ríos et al. 2020). Within an Irish context, no research has investigated the PA contribution of Gaelic football participation, despite it being the most popular OS amongst adolescents (Woods et al. 2018). Moreover, there is a dearth of research investigating the coaching

approaches of Gaelic games coaches at club level, while no research has investigated the impact of a GBA within this setting. The aim of this thesis is to address these research gaps.

Chapter 3. The Contribution of Gaelic Football Participation to Youth Physical Activity Levels

Publications from this chapter:

Gavin, K.W., Lane, A. and Dowd, K.P., (2020). The contribution of Gaelic football participation to youth physical activity levels. *Journal of Sports Science & Medicine*, 19(4), 652–661.

3.1. Introduction

Regular participation in physical activity (PA) during childhood and adolescence has a positive impact on a range of health markers, including adiposity, cardiometabolic biomarkers and bone health (Poitras et al. 2016). Physical activity in adolescence indirectly affects adult health status by increasing the probability of becoming more active in adulthood, which in turn is linked to more favourable health outcomes (Hallal et al. 2006). In Ireland, the current national PA guidelines recommend youth achieve a minimum of 60 minutes of moderate-to-vigorous physical activity (MVPA) daily for disease prevention and maintenance of health (Healthy Ireland 2016). The latest guidelines for PA from the World Health Organization (WHO) recommend youth achieve at least an average of 60 minutes per day of moderate-to-vigorous physical activity (MVPA) across the week to attain these health benefits (World Health Organisation 2020). Despite these guidelines being implemented as the standard for PA promotion, international research indicates that approximately 80% of youth fail to meet the minimum daily PA guidelines (Guthold et al. 2020, Sallis et al. 2016). Such high levels of physical inactivity are a public health concern, given the important role PA plays in the prevention of overweight and obesity during childhood and adolescence (Hills et al. 2011). This is particularly relevant considering that the number of adolescents classified as obese globally has increased substantially from 11 million in 1975, to 125 million in 2016 (Abarca-Gómez et al. 2017).

Organised sport (OS) participation has been identified as a key tool for the provision of MVPA in youth (Ridley et al. 2018, Trost et al. 2014), given it is the most popular form of leisure-time PA, with at least one third of children and adolescents participating worldwide (Aubert et al. 2018). Research has demonstrated that adolescents who participate in OS are significantly more physically active (Hebert et al. 2015, Kokko et al. 2018, Marques et al. 2016), and more likely to meet the PA guidelines than their non-participating peers (Sprengeler et al. 2019). Additionally, OS participants accumulate more MVPA on sports days than on non-sports days (Mooses and Kull 2019). However, evidence also suggests that OS makes a relatively small contribution to the daily PA levels of adolescents (Koorts et al. 2019), with 72-80% of sport participating youth failing to achieve the minimum recommended amount of PA daily (Telford et al. 2016, Vella et al. 2016).

Research investigating the PA contribution of OS in youth using device-based measures is limited to a small range of sports, including soccer (Cohen et al. 2014, Sacheck et al. 2011), netball (Guagliano et al. 2013), basketball (Wickel and Eisenmann 2007), flag football (Schlechter et al. 2017), ice hockey (Kanters et al. 2015), baseball/softball (Leek et al. 2011) and Australian Rules football (Ridley et al. 2018). Most of these studies determined the PA contribution of practice sessions, with participants spending between 30-55% of practice time in MVPA (Cohen et al. 2014,

Kanters et al. 2015, Leek et al. 2011, Ridley et al. 2018, Schlechter et al. 2017, Wickel and Eisenmann 2007). In a further analysis of the PA contribution of youth sport in practice and games, it was highlighted that participants spend between 3-14% (2-8 minutes) more time in MVPA during a practice session than during a game (Guagliano et al. 2013, Tomlin et al. 2015, van den Berg and Kolen 2015). These findings suggest that the level of MVPA accumulated during youth OS varies greatly depending on the sport type and context (practice or game).

Gaelic football is the most popular team-based sport in Ireland, with 10.4% of the population holding membership in one of almost 3000 registered clubs (Sport Ireland 2017), and 32% of Irish youth aged 12-18 years participating regularly in the sport (Woods et al. 2018). Gaelic football is a field-based invasive team sport, played between two teams of 15 active players on a rectangular grass surface (Cullen et al. 2017). Similar to Australian Rules football and soccer, Gaelic football is characterized by unpredictable bursts of high intensity anaerobic activity interspersed with sustained light to moderate aerobic activity (Cullen et al. 2013, Malone et al. 2017). This suggests that high levels of MVPA may be accumulated during Gaelic football practice and game settings. However, to the best of the authors knowledge, no research is available on the level of MVPA accumulated during youth Gaelic football practice sessions and games, or the contribution of Gaelic football participation to overall daily PA levels and the attainment of PA guidelines.

The primary aim of this study was to quantify the overall daily PA levels of Gaelic football participating youth using a body-worn device. Secondary aims of this study were to determine the percentage of participants achieving the PA guidelines and to compare the PA contribution of Gaelic football participation between males and females and across age groups.

3.2. Methods

3.2.1. Participants

A total of 165 adolescents (90 male, 75 female) aged 12-18 years (14.3±1.6 years) were recruited from across three age groups (Under 14, Under 16 and Under 18) in accordance with the structure of competitions for Gaelic football. A convenience sample of five Gaelic football clubs in the Midwest of Ireland were identified and approached to take part in the study. The chairperson of each club was first contacted by phone to outline the purpose of the study, and then provided with an information sheet (Appendix B), which outlined what was involved, what was required from the club and players and to request permission to recruit participants at the club. Three of the clubs expressed an interest in partaking in the study and the club executive committees provided the primary researcher with informed written consent (Appendix B) and the contact details of the coaches for each relevant age group. Following contact with the coaches, the primary investigator

was given an opportunity to deliver a detailed description of the study to the adolescent players, outlining the study protocol, purpose of the study and the risks and benefits associated with participation. At this point parental and participant information sheets and consent and assent forms were distributed (Appendix C), and all participants were invited to return the completed consent forms at their next practice session. Ethical approval for this research study was granted by the TUS Research Ethics Committee (#20180207).

3.2.2. Study Protocol

Data collection was conducted at the participating Gaelic football clubs, where the primary researcher made two separate visits to the practice sessions of all participating teams. On the first visit, the completed parental/guardian consent and participant assent forms were returned to the primary researcher. Participants were then brought to a semi-private measurement area where height and weight measures were obtained from each participant. The activPAL3 micro activity monitor (activPAL^{3M}; PAL Technologies Ltd., Glasgow, UK) was the device-based measurement tool used to assess free-living PA levels in this study. The activPAL^{3M} device was distributed to each participant, who were given a detailed instruction sheet (Appendix D) and a full demonstration of how the device was to be attached, when the device was to be worn and what to do if the device was misplaced. Participants were instructed to wear the activPAL^{3M} for a total of seven consecutive days, while maintaining their normal daily routines. The coaches of each participating team were provided with a diary to record the date, start time, finish time of each practice session and game over the measurement period (Appendix E). In addition, the coaches were requested to detail the type of activities (e.g., drills, modified games) performed during each component of the practice sessions. After the seven-day measurement period, the primary researcher returned to the participating teams and the activPAL^{3M} devices were collected.

3.2.2.1. Anthropometry

Height and weight were measured following standard procedures. Participants were instructed to remove their shoes, socks and any heavy clothing prior to measurement. Height was measured to the nearest 0.1cm using a portable stadiometer (Seca model 213, Seca Corporation, Hanover MD). During height measurement, participants were instructed to stand with their feet flat on the base plate of the stadiometer and positioned slightly apart, in line with their hips, arms loosely by their side and to stand with their back as straight as possible against the vertical measuring rod while looking straight ahead. Each participant was then asked to take a deep breath and hold, while the investigator ensured the head plate was resting on top of the crown of the head and the measurement was recorded. Weight was measured to the nearest 0.1kg using a portable electronic

scale (Seca model 213, Seca Corporation, Hanover MD). During weight measurement, participants were instructed to stand on the electronic scale, with their feet hip width apart, arms loosely by their side while look straight ahead.

3.2.2.2. Physical Activity Assessment

The activPAL^{3M} activity monitor, measuring 24x45x5mm and weighting 9g, is a triaxial accelerometer that uses information about static and dynamic acceleration to distinguish body posture (sitting, lying, standing and stepping) and to estimate energy expenditure (Lyden et al. 2017). The device has been established as a valid measure of body posture and for quantifying sedentary time and PA in youth (Dowd et al. 2012b, Hayes et al. 2021, Ridgers et al. 2012b). The activPAL software (PALanalysis Software™, version 8.11.9), was used to initialise the devices. Prior to initialisation, the activPAL devices were connected to a PC via a USB interface and charged for a period of five hours. The software allows immediate initialisation or future initialisation of the devices. For this study, all monitors were pre-initialised to begin recording an hour before their scheduled practice session start time and were set to stop recording at the same time seven days later. The monitors were set to record data in 15s epochs, which aids in the effective capture of the intermittent patterns of children and adolescents PA behaviour (Trost et al. 2005).

The activPAL^{3M} device was first waterproofed by placing it into a small flexible nitrile sleeve. To ensure standard operating procedures across all data collections, under the supervision of the primary investigator, the participants attached the activPAL^{3M} directly to the skin on the midline of the anterior aspect of the right thigh using a transparent dressing (Tegaderm™ Foam Adhesive Dressing). Participants were encouraged to wear the activPAL device for 24-hours a day of the seven-day measurement period and were asked to only remove the device if they were bathing or swimming, or when playing high-impact contact sports such as rugby. The use of the 24-hour continuous wear protocol enabled the identification of the first rise time and last movements of each participant. It permitted the examination of sedentary patterns and time spent in bed which subsequently provided a more accurate estimation of waking time. A 24-hour period was defined from 5 am to 5 am the following day. If a participant experienced skin irritation, they were advised to attach the device to the opposite leg. This enabled the participant to keep the device in the same optimal location (mid-thigh) rather than a sub-optimal position on the same leg. Participants were provided with extra nitrile sleeves and dressings, an elasticated tubular support bandage to secure the device when engaging in PA (Sterogrip™ Elasticated Tubular Bandage) and were instructed to change the dressing every 2-3 days. Any time the participants removed the device they were

instructed to document the time they removed the monitor, the time they replaced it and the reason for removal in a non-wear diary (Appendix D). Completion of the non-wear diary enabled the researcher to investigate non-wear time that could not be inferred from the monitor output alone.

Following data collection, the activPAL devices were connected to a PC via a USB interface and the recoded activPAL epoch data was accessed and downloaded into a separate coded folder for each participant using the PALanalysis Software™. This software provided the researcher with a pre-classified graphical illustration of the amount of time spent sitting, standing, stepping and lying. Each individual file could be viewed by hour, by day or by week, which enabled the researcher to check if the device was worn for the duration of the wear protocol. To enable further analysis the data from the activPAL stored in proprietary data format was converted to a Microsoft Excel Format File (Microsoft Corporation, Microsoft Excel 2020, One Microsoft Way, Redmond, WA, USA). The protocol used for data collection and reduction is described in detail elsewhere (Dowd et al. 2012a). Briefly, recorded participant data was determined acceptable for analysis if there was a minimum of four valid days of activity recorded (including one weekend day). A valid day was determined as a measured day with ≤4 hour's non-wear time during waking hours. Non-wear time was defined as a period with ≥60 minutes of consecutive zero activity counts. The amount of waking time was calculated by subtracting bedtime from rise time. To estimate bed hours, the first registered non-sedentary epoch each day was identified as the rise time while the last registered non-sedentary epoch followed by an uninterrupted sedentary period (>2h) was identified as the time participants went to bed (Dowd et al. 2012a). Breaks in bed hours (e.g., small breaks between bedtime and rise time for visits to the bathroom etc.) were identified by manual assessment of the data, and bed hours and sedentary hours were adjusted accordingly.

The output files were examined to produce daily PA variables, which include sitting/lying time, standing time, light intensity physical activity (LIPA), moderate intensity physical activity (MPA), VPA and MVPA. Total sitting/lying time and standing time was calculated by summing the total number of seconds spent in sitting/lying and standing postures over the 24-hour measurement period, as determined by the activPAL^{3M} algorithms. Previously developed and validated thresholds for the determination of MPA (9282 counts per 15 second epoch) and VPA (16100 counts per 15 second epoch) were utilised (Hayes et al. 2021). Moderate-to-vigorous PA was calculated by summing the time spent in MPA and VPA. Light intensity physical activity was categorised as all time spent in a stepping behaviour at an intensity of less than 3 metabolic equivalents (METS). A sports day was defined as any day that the participants took part in an organised Gaelic football practice session or game, as recorded in the coach's diary.

In addition, the start and finish times of each practice session and game were identified within the output files and the PA variables during these periods were also quantified. To control for the variation in duration time between practices and games, the PA variables during these Gaelic football sessions were defined as minutes per hour (min/hr). This was achieved by dividing the amount of time spent in each PA variable by the duration of each practice or game and then multiplying by 60.

3.2.2.3. Attainment of Physical Activity Guidelines

To determine the number of participants that meet the current WHO PA guideline of an average of 60 minutes of MVPA per day across the week (World Health Organization 2020), participants were required to achieve a daily average of 60 minutes of MVPA across all measured days.

3.2.3. Statistical Analysis

All outcome variables were tested to meet the assumptions for normal distribution using the Kolmogorov-Smirnov test of normality. In the case of data that did not demonstrate a normal distribution, the parametric conclusion was confirmed using non-parametric equivalent tests. Descriptive statistics for normally distributed variables for the study sample are presented as means and standard deviations (SD). The homogeneity of variance of data was investigated using the Levene's test. Differences in means of each PA intensity (sitting/lying, standing, LIPA, MPA, VPA and MVPA) with respect to gender (male and female) and age group (Under 14, Under 16 and Under 18) were established using a two-way analysis of variance (ANOVA). Tukey post-hoc analysis was completed to identify where differences were observed across the age groups. Partial eta squared values (η_p^2) of 0.01, 0.06 or 0.14, represented small, medium and large effect sizes respectively (Cohen 1988). Differences in means of each PA intensity (sitting/lying, standing, LIPA, MPA, VPA and MVPA) between OS practice and games and between sports days and non-sports days were assessed using paired samples t-tests or Wilcoxon Signed ranks tests. To reduce the likelihood of Type I error, p-values were subjected to Benjamini–Hochberg adjustment. Effect sizes were calculated using Cohen's d where d=0.2, 0.5 and 0.8 represented small, medium and large effect sizes respectively (Cohen 1988). A logistic regression was performed to determine the effect of a sports day and a non-sports day on the likelihood that participants would achieve the 60 minutes MVPA. Data was presented as adjusted odds ratios and 95% confidence intervals. Statistical analyses were performed using IBM SPSS 24.0 (SPSS, Inc; Chicago, IL) and the level of statistical significance was set at $p<0.05$.

3.3. Results

3.3.1. Participant Characteristics

Descriptive characteristics of the participants are displayed in Table 3.1. On average, males were taller (167.8±8.7 cm) and heavier (58.1±8.8 kg) than females (161.1±4.3 cm; 53.1±6.6 kg). A total of 32 participants provided four valid days of accelerometer data (20%), with 82 participants providing five valid days (51%), 35 participants providing six valid days (22%) and 11 participants providing seven valid days (7%). Five participants were excluded from the analysis due to failure to achieve the minimum number of valid days or lost accelerometer devices. The final sample included 160 participants (87 male, 73 female; mean age 14.5±1.8 yrs).

Table 3.1 Descriptive characteristics of the total population and each participant group.

	Overall (n=160)	**U14 Males (n=29)**	**U14 Females (n=29)**	**U16 Males (n=29)**	**U16 Females (n=30)**	**U18 Males (n=28)**	**U18 Females (n=15)**
Age (yrs.)	14.5 (1.8)	12.4 (0.5)	12.6 (0.4)	14.6 (0.4)	14.4 (0.5)	16.7 (0.4)	16.2 (0.5)
Height (cm)	164.4 (8.4)	157.1 (4.5)	155.6 (4.1)	167.8 (3.4)	161.6 (3.1)	178.6 (2.6)	166.1 (2.4)
Weight (kg)	57.6 (8.3)	48.5 (3.1)	46.6 (3.9)	62.5 (3.1)	59.6 (4.7)	68.1 (2.7)	60.5 (4.3)

Values are presented as mean (SD); Abbreviations: n = number of participants, yrs. = years, cm = centimetres, kg = kilograms

3.3.2. Overall Daily Physical Activity Levels

The distribution of waking time spent sitting/lying, standing, in LIPA, MPA, VPA and MVPA across gender and age are displayed in Figure 3.1. The average waking daily minutes (proportion of day) spent sitting/lying was 558.7±79.3 min (64%), spent standing was 178.6±52.3 (21%), spent in LIPA was 70.2±18.2 min (8%), spent in MPA was 36.6±13.2 min (4%), spent in VPA was 21.9±13.1 min (3%), and spent in MVPA was 58.5±23.6 min (7%).

There was a statistically significant interaction effect between gender and age on sitting/lying ($F_{2,154}$=3.339; p=0.38; η_p^2=0.042), standing ($F_{2,154}$=3.583; p=0.30; η_p^2=0.044), LIPA ($F_{2,154}$=5.540; p=0.005; η_p^2=0.067), and VPA ($F_{2,154}$=5.301; p=0.006; η_p^2=0.064). No statistically significant interaction effect was found between gender and age on MPA ($F_{2,154}$=1.348; p=0.263; η_p^2=0.017) and MVPA ($F_{2,154}$=2.075; p=0.129; η_p^2=0.026).

There was a statistically significant main effect of gender on sitting/lying, standing, MPA, VPA and MVPA. Males spent significantly more time than their female counterparts in sitting/lying ($F_{1,154}$=9.910; p=0.002; η_p^2=0.060), MPA ($F_{1,154}$=55.494; p<0.001; η_p^2=0.265), VPA ($F_{1,154}$=84.791; p<0.001; η_p^2=0.355) and MVPA ($F_{1,154}$=103.014; p<0.001; η_p^2=0.401). Statistically significant main effects of age were also observed, with time spent sitting/lying significantly increasing with age ($F_{2,154}$=7.409; p=0.001; η_p^2=0.088), while time spent in MPA ($F_{2,154}$=18.133; p<0.001; η_p^2=0.191), VPA ($F_{2,154}$=25.925; p<0.001; η_p^2=0.252) and MVPA ($F_{2,154}$=32.873; p<0.001; η_p^2=0.299) significantly decreased with age.

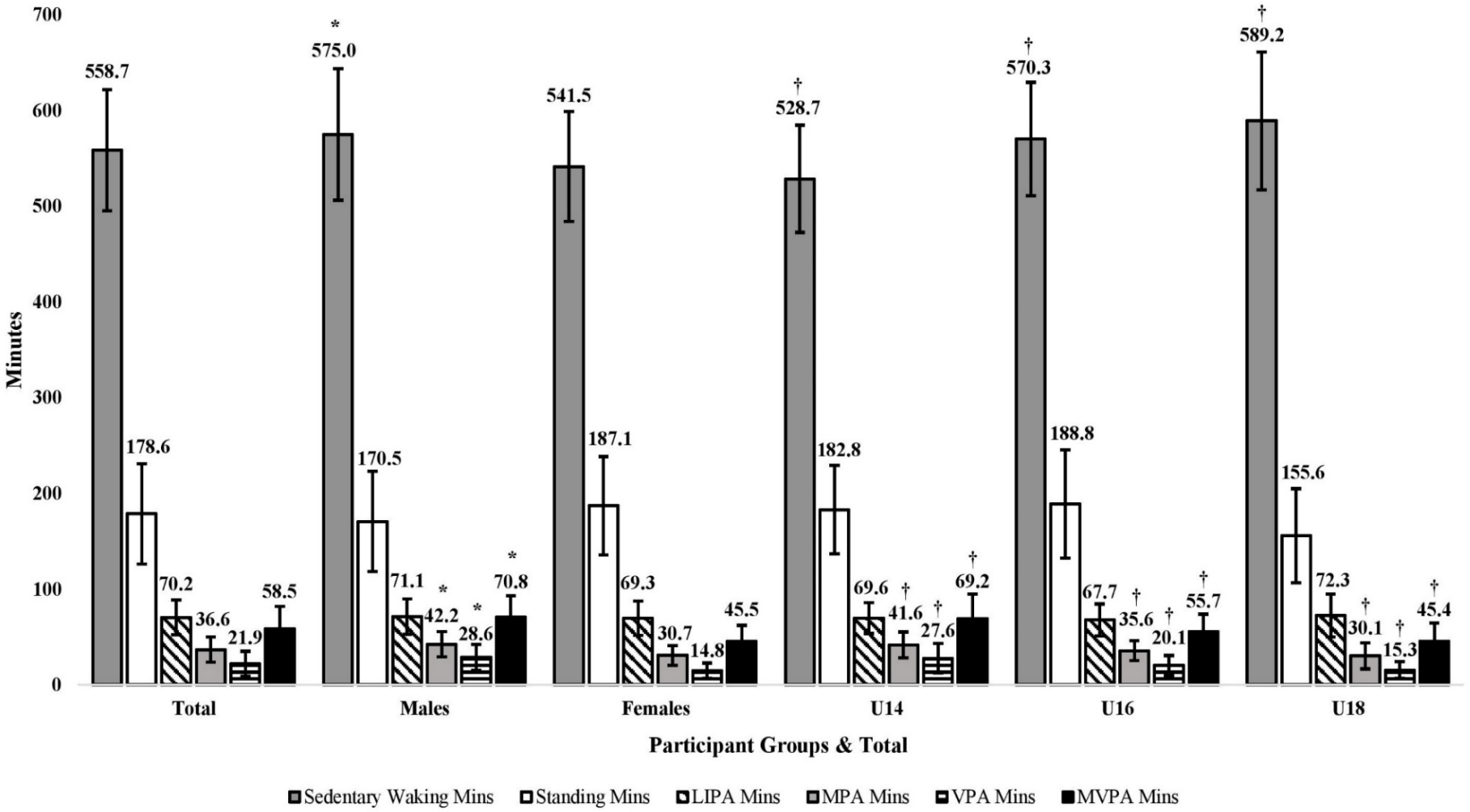


Figure 3.1 Mean daily physical activity intensity (minutes) across all participant groups.

** Significant difference between male and female participants ($p < 0.05$); † Significant difference between age groups ($p < 0.05$)*

3.3.3. Physical Activity Levels during Gaelic Football

The distribution of time spent sitting/lying, standing, in LIPA, MPA, VPA and MVPA during practice sessions and games are described in Table 3.2. Overall, significantly more time was spent in MPA (Practice=21%; Games=23%; $t(187)=-2.559$; $p=0.006$; $d=0.38$), VPA (Practice=28%; Games=37%; $t(187)=-4.410$; $p<0.001$; $d=0.64$) and MVPA (Practice=48%; Games=60%; $t(187)=-5.264$; $p<0.001$; $d=0.80$) during games than during practices. Conversely, during practice sessions, participants spent significantly more time in standing (Practice=28%; Games=19%; $t(187)=6.063$; $p<0.001$, $d=0.91$) and LIPA (Practice=18%; Games=15%; $t(187)=3.674$; $p<0.001$, $d=0.53$) than during games.

Significant differences for time spent in each PA intensity between practices and games were observed across gender and age groups. The mean amount of time spent in MVPA during games was significantly greater than during practices across all groups (Males: $p=0.040$, $d=0.50$; Females: $p=0.014$, $d=0.81$; U14: $p<0.001$, $d=1.13$; U16: $p=0.030$, $d=0.49$; U18: $p=0.006$, $d=1.49$). The mean amount of time spent standing during practices was significantly greater than during games across all groups (Males: $p=0.046$, $d=0.43$; Females: $p=0.012$, $d=0.92$; U14: $p<0.001$, $d=1.18$; U16: $p<0.001$, $d=0.79$; U18: $p=0.011$, $d=1.17$).

Table 3.2 Physical activity intensity (minutes per hour) during practice sessions and games for the total population and each participant group.

	Total (n=160)			Males (n=86)			Females (n=74)			U14 (n=58)			U16 (n=59)			U18 (n=43)		
	Practice	Game	p	Practice	Game	p	Practice	Game	p	Practice	Game	p	Practice	Game	p	Practice	Game	p
Sitting/lying	3.5 (4.9)	3.8 (4.8)	0.321	4.2 (4.0)	4.0 (4.5)	0.382	3.9 (5.4)	2.9 (6.4)	0.326	4.7 (6.3)	3.1 (4.3)	0.161	**2.3 (2.9)**	**4.4 (5.6)**	**0.045**	3.6 (4.7)	3.7 (1.1)	0.484
Standing	**16.7 (5.5)**	**11.5 (5.9)**	**<0.001**	**13.0 (4.5)**	**10.7 (5.9)**	**0.046**	**19.3 (4.6)**	**15.2 (4.3)**	**0.012**	**18.2 (5.0)**	**12.6 (4.4)**	**<0.001**	**16.3 (5.8)**	**11.2 (7.0)**	**<0.001**	**15.2 (5.4)**	**9.4 (4.4)**	**0.011**
LIPA	**10.7 (3.5)**	**8.7 (4.0)**	**0.001**	**10.0 (2.8)**	**8.4 (3.9)**	**0.048**	11.2 (3.9)	10.0 (4.5)	0.240	**10.5 (2.9)**	**8.3 (3.7)**	**0.009**	10.6 (4.4)	8.8 (4.3)	0.051	11.3 (2.8)	9.0 (3.9)	0.057
MPA	**12.5 (3.7)**	**13.9 (3.6)**	**0.006**	13.5 (3.0)	14.2 (3.5)	0.165	11.8 (3.9)	12.3 (3.6)	0.326	14.0 (3.6)	14.5 (2.9)	0.309	12.0 (3.9)	13.3 (3.6)	0.077	**10.9 (2.5)**	**14.9 (5.2)**	**0.005**
VPA	**16.6 (7.5)**	**22.1 (9.4)**	**<0.001**	**19.3 (7.3)**	**22.6 (9.8)**	**0.045**	**13.8 (6.3)**	**19.6 (7.4)**	**0.018**	**12.5 (6.3)**	**21.5 (9.4)**	**<0.001**	**18.7 (8.3)**	**22.3 (9.9)**	**0.044**	19.0 (5.3)	23.0 (7.7)	0.061
MVPA	**29.0 (8.3)**	**36.0 (9.2)**	**<0.001**	**32.8 (6.2)**	**36.8 (9.3)**	**0.040**	**25.6 (7.8)**	**32.0 (7.9)**	**0.014**	**26.5 (8.2)**	**36.0 (8.6)**	**<0.001**	**30.7 (9.5)**	**35.6 (10.4)**	**0.030**	**29.9 (5.8)**	**38.0 (5.0)**	**0.006**

Values are presented as mean (SD); n = number of participants, p = significance value; Statistically significant (p<0.05) values are identified in bold.

3.3.4. Contribution of Gaelic Football to Meeting Physical Activity Guidelines

Overall, 41% of participants (n=66) were compliant with the current WHO PA guidelines, as they achieved a daily average of at least 60 minutes of MVPA across all measured days. Gender differences were apparent, with 61% of males (n=50) and 21% of females (n=16) meeting the current WHO guidelines.

A description of waking time spent sitting/lying, standing, in LIPA, MPA, VPA and MVPA during sports days and non-sports days are presented in Table 3.3. On sports days, participants accumulated significantly more time in MPA ($t(877)=3.885$; $p<0.001$; $d=0.29$), VPA ($t(877)=6.787$; $p<0.001$; $d=0.48$) and MVPA ($t(877)=6.086$; $p<0.001$; $d=0.45$) than on non-sports days. Significantly more time was spent in MVPA during sports day than non-sports day for all participant groups ($p<0.05$) with the exception of the U18 group ($t(189)=1.062$; $p=0.145$; $d=0.18$). After adjustment for age and gender, logistic regression identified that participants were 2.16 times more likely to attain 60 minutes of MVPA on a sports day than on a non-sports day (OR=2.16; 95% CI=1.60–2.92; Table 3.4).

Table 3.3 Physical activity intensity (minutes) during sport day and non-sport day for the total population and across both age and gender.

	Total (n=160)			Males (n=86)			Females (n=74)			U14 (n=58)			U16 (n=59)			U18 (n=43)		
	Sports Day	Non-Sports Day	p	Sports Day	Non-Sports Day	p	Sports Day	Non-Sports Day	p	Sports Day	Non-Sports Day	p	Sports Day	Non-Sports Day	p	Sports Day	Non-Sports Day	p
Sitting/lying	549.1 (134.4)	551.3 (144.2)	0.502	573.6 (147.3)	565.9 (130.4)	0.355	517.9 (110.5)	533.2 (152.6)	0.156	510.5 (133.8)	517.6 (147.7)	0.345	555.8 (88.2)	566.3 (137.0)	0.196	613.6 (104.6)	585.0 (138.0)	1.224
Standing	183.0 (92.0)	177.8 (84.3)	0.320	168.7 (100.5)	171.8 (85.5)	0.371	201.1 (79.9)	184.8 (78.4)	0.046	195.1 (104.0)	180.9 (75.8)	0.129	195.4 (78.7)	185.9 (94.4)	0.213	**120.7 (75.5)**	**160.2 (79.5)**	**0.007**
LIPA	70.1 (26.1)	69.9 (31.1)	0.459	69.0 (27.6)	71.4 (32.8)	0.362	71.1 (24.7)	67.9 (28.6)	0.148	71.7 (23.0)	69.7 (25.2)	0.304	71.7 (23.1)	66.2 (33.1)	0.082	**62.0 (37.5)**	**75.8 (35.8)**	**0.033**
MPA	**40.9 (21.2)**	**34.9 (19.9)**	**<0.001**	44.0 (19.9)	41.0 (21.8)	0.175	**35.4 (20.0)**	**29.3 (15.5)**	**0.001**	**46.5 (21.3)**	**39.8 (20.4)**	**0.009**	**39.9 (17.2)**	**33.5 (17.7)**	**0.001**	31.5 (27.6)	29.1 (20.3)	0.449
VPA	**29.2 (22.2)**	**19.3 (18.2)**	**<0.001**	**36.7 (24.8)**	**26.2 (20.8)**	**<0.001**	**20.5 (15.3)**	**12.8 (12.1)**	**<0.001**	**37.7 (26.1)**	**23.9 (19.8)**	**<0.001**	**26.6 (19.0)**	**17.5 (11.4)**	**<0.001**	18.4 (13.4)	15.0 (14.9)	0.115
MVPA	**70.1 (36.0)**	**54.2 (34.0)**	**<0.001**	**80.7 (36.7)**	**67.2 (37.2)**	**0.001**	**55.9 (29.3)**	**42.1 (24.7)**	**<0.001**	**84.2 (37.9)**	**63.7 (36.3)**	**<0.001**	**66.5 (30.7)**	**51.0 (31.6)**	**<0.001**	49.9 (34.5)	44.1 (30.2)	0.145

Values are presented as mean (SD); n = number of participants; p = significance value; Statistically significant (p<0.05) values are identified in bold.

Table 3.4 Odds ratios for sports participation as a predictor of attaining 60 minutes MVPA.

	Attaining 60 Minutes MVPA %	Attaining 60 Minutes MVPA %	OR (95% CI)
Non-Sports Day	36.2%	63.8%	1.00
Sports Day	55.1%	44.9%	2.16 (1.60 – 2.92) *

*Note. Odds ratios adjusted for age and gender; * Odds ratio is significant (p <0 .05); Abbreviations: PA = physical activity, OR = odds ratio*

3.4. Discussion

To the author's knowledge, this is the first study to quantify the contribution of Gaelic football participation to the overall daily PA levels in youth using device-based measures. These findings highlight that participants achieve an average of 58 minutes of MVPA daily. Males were shown to accumulate significantly more MVPA than their female counterparts, while MVPA significantly decreased as age increased. Participants accumulated 25-38 minutes of MVPA during practice sessions and games and were twice as likely to achieve 60 minutes of MVPA on sports days than non-sports days, indicating that Gaelic football provides a supportive environment for PA accumulation. Nonetheless, most participants failed to meet the current PA guidelines.

It has been stated that OS have multifaceted outcome goals and PA attainment is not the sole objective, thus making it unrealistic to expect participants to achieve the PA guidelines in one session (Ridley et al. 2018). However, data from this analysis shows demonstrates there is potential to improve the contribution of youth Gaelic football participation to overall daily MVPA. A limited number of studies have investigated the levels of PA attained during youth sport, reporting considerable variation in MVPA based on sport type and context (practice or game) (Schlechter et al. 2017). Previous studies of similar invasion field-based sports to Gaelic football, such as Australian rules football (Ridley et al. 2018) and soccer (Cohen et al. 2014, Leek et al. 2011, Wickel and Eisenmann 2007) have highlighted that 30-55% of practice time was spent in MVPA. The findings in this study are comparable to these earlier studies, with 48% (29 min/hr) of practice time in this analysis spent in MVPA. Also, in this study, participants spent a considerable proportion of practice sessions sitting/lying, standing and in LIPA (6%, 28% and 18%

respectively), which is consistent with previous studies that have identified large proportions of practice time spent in either sedentary or low intensity activities (Guagliano et al. 2013, Leek et al. 2011, Wickel and Eisenmann 2007). More recently, the PA levels accumulated in practice sessions and games in a variety of different sports (soccer (Tomlin et al. 2015), ice hockey (van den Berg and Kolen 2015), netball and basketball (Guagliano et al. 2013)) have been examined and compared. Across all sports studied, the amount of time spent in MVPA during practice sessions was significantly greater than during games (3-14% or 2-8mins). This contrasts with the findings of this analysis, which found that a significantly greater amount of time was spent in MVPA during games in comparison to practice (12% or 7min/hr).

Coaches have been identified as leaders in the youth OS setting (Schlechter et al. 2017), and carry considerable influence over their players (Conroy and Coatsworth 2006). Therefore, a possible explanation for the lower amount of MVPA accumulated during Gaelic football practice sessions in this study is a tendency of coaches to overemphasise skill development, competition strategies or other non-active instruction, thereby limiting the amount of time that participants engage in MVPA (Kanters et al. 2015, Leek et al. 2011). Alternatively, the greater amount of time spent in MVPA during practice sessions in other sports may be due to the ability of coaches to better dictate the intensity of a practice session and the increased opportunity for players to participate simultaneously (Guagliano et al. 2013). Given large proportions of practice time are spent inactive or in low intensity activities, this provides coaches with an ideal opportunity to reallocate this time to MVPA. Guagliano and colleagues demonstrated that a coach education program successfully increased time spent in MVPA in youth OS practice sessions by 15% and reduced practice time spent inactive by 14% (Guagliano et al. 2015). Furthermore, Miller et al. highlighted that both MVPA and other OS outcomes, such as decision-making and skill execution, can be achieved simultaneously during OS practices using an evidenced based, game-centred coaching approach (Miller et al. 2016). Evidently, coaches are capable of influencing PA intensity during practice sessions (Guagliano et al. 2015) and should be considered in any interventional approach to increase MVPA during OS practice sessions.

A growing body of research has highlighted the importance of OS participation to the overall daily PA levels of adolescents. Indeed, OS participants have been shown to accumulate 5-20 minutes more MVPA daily (Hebert et al. 2015), and are 1.6-6.4 times more likely to achieve the recommended PA guidelines than their non-participating peers (Kokko et al. 2018, Mooses and Kull 2019, Sprengeler et al. 2019). Moreover, an additional 7-25 minutes of MVPA is accumulated by OS participants on sports days in comparison to non-sports day (Koorts et al. 2019, Mooses and Kull 2019, Sprengeler et al. 2019). In the current study, findings confirm that Gaelic football

also provides a good opportunity to accumulate a considerable amount of MVPA, as adolescents accumulated an average of an additional 16 minutes MVPA on sports days when compared to non-sports days. Furthermore, on sports days, participants were more than twice as likely (OR = 2.16) to accumulate 60 minutes of MVPA than on non-sports days.

Despite Gaelic football providing a supportive environment for the accumulation of PA, almost 60% of participants failed to achieve the new recommendations as defined by the WHO (World Health Organisation 2020) Interestingly, other research has also observed that 72-80% of OS participating youth do not achieve the PA guidelines (Telford et al. 2016, Vella et al. 2016). Furthermore, in this analysis, males accumulated an average of 25 minutes more MVPA daily compared to females, while daily MVPA levels decreased as age increased, supporting previous findings around gender and age-related PA (Corder et al. 2015, Harding et al. 2015, Marques et al. 2016, Silva et al. 2013). The low proportions of youth achieving the PA guidelines is of public health significance within Ireland, with reports currently estimating that physical inactivity has a direct economic cost of €132 million annually (Ding et al. 2016). Given the importance of achieving the PA guidelines for health maintenance and disease prevention in adolescents (Poitras et al. 2016), and the potential negative implications this may have in adulthood (Hallal et al. 2006), a greater emphasis must be placed on increasing these low levels of Gaelic football participating youth achieving 60 minutes of MVPA daily.

It has been established that VPA has a stronger effect than lower intensity activities on health outcomes, including adiposity, cardiovascular fitness and bone health (Gralla et al. 2019, Owens et al. 2017). In turn, OS has been identified as an ideal opportunity for youth to accumulate VPA (Guagliano et al. 2015, Schlechter et al. 2017). In this analysis, on average, participants accumulated significantly more time in VPA on sports days than on non-sports days and spent a larger percentage of both practice and game time in VPA in comparison to LIPA and MPA. Unlike the adult recommendations, vigorous PA is not considered an independent behaviour when examining the success in attaining public health recommendations in youth (Physical Activity Guidelines Advisory Committee 2018). This makes determining the beneficial effect of VPA in youth difficult, and limits researcher ability to interpret the potential increased benefit of VPA accumulated in OS. The consequences of this are the miscategorising of youth who participate in OS as not achieving the recommendations, even though high levels of VPA are regularly being accumulated.

3.5. Strength and Limitations

This research study had a number of strengths. To the author's knowledge, this is the first study to use a device-based measure to record PA data in a youth Gaelic football setting. This study

aimed to recruit an equal number of male and female adolescents across three different age groups of youth Gaelic football. Due to the low numbers of active players in the clubs, only fifteen participants were recruited from the under 18 female group. Finally, this is the first study that has examined the full range of PA intensities and body posture, using the activPAL^{3M} activity monitor, providing data on time spent sitting/lying, standing and in LIPA, MPA, VPA and MVPA when investigating youth in a Gaelic football setting. A few potential limitations to the current study should be considered when interpreting the results. Firstly, due to the convenience sampling method used and the small number of Gaelic football teams investigated, there is the potential for sampling bias. Consequently, the results obtained may not be representative of the wider population of youth Gaelic football teams and participants. However, this study tried to address these issues through the recruitment of participants from Gaelic football clubs that were in both rural and urban areas and from different socio-economic settings. Secondly, the PA findings presented were measured during the preseason phase of the youth Gaelic football calendar and may not be representative of the entire youth Gaelic football season. In spite of these limitations, the merits of this study should be considered.

3.6. Conclusion

While participation in youth Gaelic football provides an ideal opportunity for adolescents to accumulate MVPA, a majority of participants failed to achieve the PA guidelines. A gender disparity was also observed, as males accumulated significantly more time in MVPA daily and during Gaelic football participation. Considerable proportions of time during Gaelic football practice sessions were spent in low intensity PA behaviours, presenting an opportunity to increase time spent in MVPA and displace some of the time spent inactive, in turn improving the contribution. Future research should utilise this information in the development of coaching approaches and interventions to increase the amount of MVPA attained by adolescents during youth Gaelic football, thus enhancing the contribution of Gaelic football participation to overall daily PA levels.

3.7. Summary

The findings of this study highlight the positive contribution that Gaelic football participation makes to youth players' daily PA levels. However, considering that this investigation was conducted at one time point across a competitive season and the associated limitations which have been outlined, a longitudinal assessment would provide a more thorough examination of the PA contribution of youth Gaelic football participation. Therefore, to address these limitations, Chapter 4 will examine the longitudinal changes in PA levels attained by adolescents during Gaelic football participation across two timepoints of a competitive season.

Chapter 4. Seasonal Changes in the Physical Activity Levels of Youth Gaelic Football Players

Publications from this chapter:

Gavin, K.W., Lane, A. and Dowd, K.P., (2021). Seasonal changes in the physical activity levels of youth Gaelic football players. *Journal of Sports Sciences*, 39(17), 2023-2029.

4.1. Introduction

The importance of regular physical activity (PA) to the healthy development of children and adolescents is well established, with evidence highlighting links between PA and improved health markers (Janssen and LeBlanc 2010, Poitras et al. 2016). Furthermore, PA behaviours adopted during adolescence are likely to be maintained into adulthood (Hayes et al. 2019, Tammelin et al. 2014), demonstrating the importance of promoting adequate PA participation during this developmental stage (Camacho-Miñano et al. 2011, Hallal et al. 2006). To achieve these benefits, the current national guidelines call for adolescents to achieve 60 minutes of moderate-to-vigorous physical activity (MVPA) daily (Healthy Ireland 2016), while the latest guidelines from the World Health Organization (WHO) recommend youth achieve at least an average of 60 minutes per day of MVPA across the week (World Health Organisation 2020). Despite this, research has reported that up to 90% of Irish adolescents fail to meet the relevant national guidelines for PA (Woods et al. 2018). Moreover, a gender disparity in PA participation has been widely reported, as females are consistently less physically active throughout youth (Sallis et al. 2016), and experience a steeper age-related decline in PA when compared to males (Farooq et al. 2020, Owen et al. 2017).

In response to the low levels of PA attained throughout adolescence, increased efforts have been placed on identifying effective settings to increase engagement in MVPA (Fenton et al. 2015). Participation in organised sport (OS) has been identified as one of the "eight investments that work" for increasing PA (The International Society for Physical Activity and Health 2020), and is particularly relevant to youth given the existing cultural norms and infrastructure that encourages sports participation amongst this cohort (Howie et al. 2020). Indeed, research indicates that 58-80% of Irish youth participate in at least one OS per week, while Gaelic football, with 32% of youth participating regularly, is the most popular OS among this cohort (Woods et al. 2018). This could have positive implications for public health, as participation in youth OS is associated with increased daily PA levels (Hebert et al. 2015, Sprengeler et al. 2019), increased likelihood of attaining the PA guidelines (Kokko et al. 2018, Mooses and Kull 2019) and psychological benefits such as lower levels of anxiety and depressive symptoms (McMahon et al. 2017, Murphy et al. 2020).

However, the specific role of OS in youth daily PA levels remains unclear. Participation alone does not ensure youth will achieve the PA guidelines (Ridley et al. 2018), with one study reporting that less than 20% of OS participating youth met the recommendations (Vella et al. 2016). This was also evident in Chapter 3 of this thesis, as Gaelic football participants' compliance with the PA guidelines ranged from 21% to 61% (See Section 3.3.4). Research consistently demonstrates that irrespective of the sport type, sport context (practice or game), age or gender, youth OS

participants spend most of their sport time inactive or in light intensity physical activity (LIPA) (Cohen et al. 2014, Kanters et al. 2015, Leek et al. 2011, Ridley et al. 2018, Sacheck et al. 2011, Schlechter et al. 2017). Notably, the gender disparity in PA behaviour persists in an OS setting, with females accumulating significantly less time in MVPA during OS participation when compared to males (Leek et al. 2011, Mooses and Kull 2019, Ridley et al. 2018, Sprengeler et al. 2019). These findings corroborate those of Chapter 3, as participants were observed to spend more than 50% of Gaelic football practice session time in PA behaviours below a moderate intensity, while gender differences in time spent in MVPA during participation were also observed.

Adolescents' PA levels consistently exhibit a seasonal pattern (Harrison et al. 2015). It is suggested that this pattern is predominantly driven by changes in hours of daylight and weather conditions (Rich et al. 2012). Indeed, recent reviews examining the impact of seasonality on PA indicated increased PA levels in the spring and summer months and lower levels in the autumn and winter months (Garriga et al. 2021, Turrisi et al. 2021). Although seasonal conditions are not acutely modifiable, they are important to understand because of their ability to alter opportunities for PA (Turrisi et al. 2021). Rainfall has been identified as the predominant weather-related barrier to being physically active (Chan and Ryan 2009), operating primarily by inhibiting outdoor PA opportunities which are typically of a higher intensity (Harrison et al. 2015). Despite the potential impact of weather on PA behaviours, no research to date has examined the PA levels of OS participants across a competitive season, restricting data collection to one often undisclosed time point, which may potentially introduce bias in the assessment of habitual PA levels (Rich et al. 2012).

A limited number of studies have also demonstrated that the approach and activities implemented by OS coaches changes significantly across a competitive season (Harvey et al. 2013, Kinnerk et al. 2019). For example, Hall et al. (2016) determined that one elite rugby coach significantly increased the amount of time spent in game-related or "playing form" activities by 25% as the season moved towards it competitive stage. Similarly, Kinnerk et al. (2019) determined that intercounty level Gaelic football coaches predominately utilised skill related or "training form" activities early in the season (57%), while playing form activities featured prominently during peak season (63%). Considering that training form activities have been demonstrated to result in lower PA levels when compared to playing form activities (Cohen et al. 2014), changes in coaching approaches across a competitive season may have a significant effect on the PA levels of the participants.

Overall, the impact of seasonal and coaching variations on PA levels attained during OS is unclear in any youth OS context. Therefore, the purpose of this study was to investigate longitudinal changes in PA levels attained by adolescents during Gaelic football participation across a competitive season and to determine if these changes influenced the overall daily PA levels of the participants.

4.2. Methods

4.2.1. Participants

Participants were recruited from a convenience sample of three local Gaelic football clubs in the Midwest of Ireland. Written informed consent was first obtained from club executive committees, followed by written informed parental consent and participant assent prior to the commencement of the study (Appendix C). A total of 138 adolescents (71 male, 67 female) between the ages of 12 and 18 years (mean age=14.4±1.7) took part in data collection at both the first time point (T1) between the months of January-March, and second time point (T2) between the months of June–August. It should be noted that the sample of participants included at T1 of this study are the same sample that was included in Chapter 3 of this thesis. Ethical approval for this research study was granted by the TUS Research Ethics Committee (#20180207).

4.2.2. Study Protocol

As data collection for this study followed the same protocol that was employed in Chapter 3 (Section 3.2.2), it will only be briefly outlined here. Data collection was conducted at two distinct time points, scheduled in line with the preseason (T1) and in-season (T2) period of the youth Gaelic football calendar. Data was collected at the participating Gaelic football clubs prior to an organised practice session. Participant's height and weight were first recorded following standard procedures. Height was measured to the nearest 0.1cm using a portable stadiometer (Marsden model HM-250P, Marsden weighing machine group, UK). Weight was measured to the nearest 0.1kg using a portable electronic scale (Seca model 813, Seca Corporation, Hanover MD).

To assess the free-living PA levels, the activPAL3 micro activity monitor (activPAL^{3M}) was utilised. The activPAL^{3M} device was first waterproofed by placing it into a small flexible nitrile sleeve and under the supervision of the primary researcher, the participants attached the device directly to the skin on the midline of the anterior aspect of the right thigh using a transparent dressing (Tegaderm™ Foam Adhesive Dressing). Participants were instructed to wear the activPAL^{3M} 24 hours per day (except while swimming or bathing) for a total of seven consecutive days and were required to partake in a minimum of one practice session and one game during both measurement periods. The participants were also provided with additional adhesive dressings, instructions

detailing how to change the dressings, and a non-wear diary to record any time the device was removed and reapplied (Appendix D). In addition, the coaches were provided with a journal to record the start and finish time of each practice session and game, and to detail the activities performed during the practice sessions (Appendix E). Following the seven-day measurement period, the primary investigator collected the activity monitors.

The protocol used for PA reduction and analysis is described in detail in Section 3.2.2.2, and thus will only be briefly described here. The primary researcher accessed the recorded epoch data using the PALanalysis Software™ (version 8.11.9), before exporting it to a Microsoft Excel (Redmond, WA, USA) file format to be processed. The activPAL output was individually screened to ensure that each participant had provided enough valid days of accelerometer recording. Participants were included in this free-living analysis only if they achieved at least four full days of accelerometer recording (3 weekdays and 1 weekend day) (Trost et al. 2005) across each seven-day period. The output files were then examined to produce daily PA variables, which include sitting/lying time, standing time, LIPA, moderate physical activity (MPA), vigorous physical activity (VPA) and MVPA. The start and finish times of each recorded practice session and game were identified within the output files and the PA variables during these periods were also quantified. To control for the variation in the amount of time spent in practice sessions and games, the PA variables during these sessions were defined as minutes per hour (min/hr). This was achieved by dividing the amount of time spent in each PA variable by the duration of each practice session and then multiplying by 60.

4.2.3. Statistical Analysis

All outcome variables were tested to meet the assumptions for normal distribution using the Kolmogorov-Smirnov test of normality. The homogeneity of variance of data was investigated using the Levene's test. In the case of data that did not demonstrate a normal distribution, the parametric conclusion was confirmed using non-parametric equivalent tests. For ease of interpretation, the parametric result is reported within. In the case where the parametric test did not confirm the non-parametric result, the non-parametric test statistic is reported.

Descriptive statistics for normally distributed variables for the study sample are presented as means and standard deviations (SD). Paired sample t-tests or Wilcoxon Signed ranks tests were utilised to compare the amount of daily time spent in PA behaviours between T1 and T2 for the total sample and males and females separately. Paired sample t-tests and Wilcoxon Signed ranks tests were also utilised to compare the amount of time spent in PA behaviours on sports days and non-sports days and in practice sessions and games at T1 and T2 for the total sample and males and

females separately. Finally, gender differences in the means of each PA behaviour during practice sessions and games, and on total measured days at T1 and T2 were established using independent samples t-tests or Mann-Whitney U tests. To reduce the likelihood of Type I error, p-values were subjected to Benjamini–Hochberg adjustment. Effect sizes were calculated using Cohen's d where d=0.2, 0.5 and 0.8 represented small, medium and large effect sizes respectively (Cohen 1988).

4.3. Results

4.3.1. Daily Physical Activity Levels

Eight participants were excluded from the analysis due to failure to achieve the minimum number of valid days at both timepoints. The final sample included 130 participants (65 male, 65 female). Descriptive characteristics and overall daily PA data of the participants are presented in Table 4.1.

Females significantly increased time spent in daily MPA ($t(64)=-5.211$; $p<0.001$; $d=0.85$), VPA ($t(64)=-4.877$; $p<0.001$; $d=0.80$) and MVPA ($t(64)=-5.887$; $p<0.001$; $d=1.05$) between T1 and T2. In contrast, no statistically significant differences were observed between the timepoints for any of the PA behaviours in male participants ($p>0.005$).

Statistically significant gender differences were observed at T1, with males spending significantly more time than their female counterparts in MPA ($t(128)=5.491$; $p<0.001$; $d=0.96$), VPA ($t(128)=6.870$; $p<0.001$; $d=1.20$) and MPVA ($t(128)=7.070$; $p<0.001$; $d=1.24$). At T2, no statistically significant differences were observed between males and females for daily time spent in each PA intensity ($p>0.05$).

At T1, the overall compliance with the current WHO PA guidelines was 42%, while differences in compliance with the guidelines were apparent across gender with 62% of males and 23% of females successfully meeting the guidelines. During round 2, the overall compliance with the PA guidelines was 54%, with 57% of males and 51% of females successfully meeting the guidelines.

Table 4.1 Participant characteristics and daily physical activity measures.

Measure	Total		Males		Females	
Participants (n)	130		65		65	
Age (years)	15.3 (1.5)		15.4 (1.5)		15.2 (1.7)	
Height (cm)	165.0 (9.1)		168.4 (8.2)		161.6 (6.5)	
Weight (kg)	58.1 (8.7)		60.5 (9.4)		55.6 (7.3)	
Total Daily PA (min/day)	**T1**	**T2**	**T1**	**T2**	**T1**	**T2**
MPA	36.7 (13.8)	39.8 (13.8)	**42.7 (13.9)†**	39.3 (16.0)	**30.7 (10.9)†**	**40.2 (11.4)***
VPA	21.3 (12.3)	**24.4 (13.8)***	**27.6 (12.5)†**	26.0 (15.9)	**14.9 (8.2)†**	**22.8 (11.2)***
MVPA	58.0 (23.4)	**64.2 (23.8)***	**70.3 (22.5)†**	65.4 (28.3)	**45.6 (17.0)†**	**63.0 (18.3)***
Achieved PA Guidelines % (n)	42 (55)	54 (70)	62 (40)	57 (37)	23 (15)	51 (33)

*Values are mean (SD), * Significant difference between T1 and T2 ($p < 0.05$) † Significant difference between genders ($p < 0.05$) , Statistically significant ($p<0.05$) values are identified in bold.*

4.3.2. Sport Days and Non-Sports Days Physical Activity Levels

Table 4.2. describes participants' waking time spent in MPA, VPA and MVPA during sports days and non-sports days. During both T1 and T2, time spent in MVPA on a sports day was significantly greater than on a non-sports day for total participants (T1: $t(674)=4.876$, $p<0.001$, $d=0.42$; T2: $t(694)=3.601$, $p<0.001$, $d=0.30$), males only (T1: $t(305)=2.969$, $p=0.004$, $d=0.38$; T2: $t(310)=2.639$, $p=0.013$, $d=0.33$) and females only (T1: $t(367)=4.438$, $p<0.001$, $d=0.50$; T2: $t(382)=2.688$, $p=0.012$, $d=0.31$).

Between T1 and T2, females significantly increased time spent in MPA ($t(552)=-4.023$; $p<0.001$; $d=0.34$), VPA ($t(552)=-4.655$; $p<0.001$; $d=0.40$) and MVPA ($t(552)=-5.021$; $p<0.001$; $d=0.43$) on non-sports days. Additionally, between T1 and T2, females significantly increased time spent in VPA ($t(197)=-2.185$; $p=0.045$; $d=0.31$) and MVPA ($t(197)=-2.108$; $p=0.036$; $d=0.30$) on sports days. In contrast, for male participants, no statistically significant differences were observed between the timepoints for any of the PA behaviours on sports days or non-sports days ($p>0.005$).

On both sports days and non-sports days during T1, males accumulated significantly more time in MPA (Sports Day: $p=0.004$; $d=0.42$; Non-Sports Day: $p<0.001$; $d=0.56$), VPA (Sports Day: $p<0.001$; $d=0.72$; Non-Sports Day: $p<0.001$; $d=0.70$), and MVPA (Sports Day: $p<0.001$; $d=0.72$; Non-Sports Day: $p<0.001$; $d=0.71$) than their female counterparts. At T2, no statistically significant gender differences were observed for time spent in each PA intensity on sports days or non-sports days ($p>0.05$).

Table 4.2 Physical activity intensity (minutes) during sports day and non-sports day for the total population and across gender.

Measure	Total		Males		Females	
	T1	**T2**	**T1**	**T2**	**T1**	**T2**
Sports Day PA (min/day)						
MPA	40.4 (19.3)	41.6 (23.5)	44.7 (17.3) **†**	42.4 (23.6)	36.8 (20.1) **†**	40.8 (22.1)
VPA	28.5 (21.3)	29.3 (21.5)	36.4 (24.4) **†**	32.5 (23.3)	21.7 (15.4) **†**	27.0 (19.0) *****
MVPA	68.9 (33.0)	70.5 (37.6)	81.1 (33.3) **†**	74.9 (40.3)	58.5 (29.0) **†**	67.8 (33.8) *****
Non-Sports Day PA (min/day)						
MPA	35.8 (18.8) ***Φ***	37.9 (20.8)	41.5 (21.1) **†**	38.6 (21.6)	31.2 (15.2) **† *Φ***	37.3 (20.5) *****
VPA	19.4 (17.8) ***Φ***	21.6 (19.9) ***Φ***	26.0 (21.0) **† *Φ***	23.6 (21.8)	13.9 (12.4) **† *Φ***	20.1 (18.3) *** *Φ***
MVPA	55.2 (32.8) ***Φ***	59.5 (35.1) ***Φ***	67.5 (37.3) **† *Φ***	62.2 (37.8)	45.1 (24.4) **† *Φ***	57.4 (32.8) *** *Φ***

*Values are mean (SD), * Significant difference between T1 and T2 ($p < 0.05$); Φ Significant difference between sports days and non-sports days; † Significant difference between genders ($p < 0.05$).*

4.3.3. Physical Activity Levels During Gaelic Football Participation

The distribution of time spent in MPA, VPA and MVPA during practice sessions and games for the total population and gender across both timepoints is presented in Table 4.3. During both T1 and T2, time spent in MVPA during games was significantly greater than during practice sessions for total participants (T1: $t(187)=-5.924$, $p<0.001$, $d=0.89$; T2: $t(240)=-4.019$, $p<0.001$, $d=0.51$), males only (T1: $t(103)=-2.420$, $p=0.045$, $d=0.47$; T2: $t(118)=-1.854$, $p=0.049$, $d=0.33$) and females only (T1: $t(82)=-2.508$, $p=0.014$, $d=0.79$; T2: $t(120)=-3.983$, $p<0.001$, $d=0.72$).

Overtime, total participants significantly increased time spent in MPA ($t(244)=-4.143$, $p<0.001$, $d=0.54$), VPA ($t(244)=-2.788$, $p=0.004$, $d=0.35$) and MVPA ($t(244)=-4.616$, $p<0.001$, $d=0.59$) during practice sessions at T2. In contrast, during games no significant differences were observed across the timepoints for time spent in each PA intensity ($p>0.05$). When examined in more detail by gender, female participants significantly increased time spent in MPA ($t(118)=-2.263$, $p=0.015$, $d=0.57$), VPA ($t(118)=-4.752$, $p<0.001$, $d=0.74$) and MVPA ($t(118)=-5.261$, $p<0.001$, $d=0.95$) during practice sessions, and significantly increased time spent in MVPA ($t(69)=-2.053$, $p=0.044$, $d=0.66$) during games. In contrast, no statistically significant differences were observed over time in male participants for any of the PA behaviours during practice sessions or games ($p>0.05$).

In addition, at T1, statistically significant gender differences were observed, with males spending significantly more time than their female counterparts in MVPA during practice sessions ($t(121)=6.428$, $p<0.001$, $d=1.21$). In contrast, at T2, no statistically significant gender differences were observed for time spent in each PA intensity during practice sessions or games ($p>0.05$).

Table 4.3 Physical activity intensity (minutes per hour) during Gaelic football practice sessions and games for the total population and across gender.

Measure	Total		Males		Females	
	T1	**T2**	**T1**	**T2**	**T1**	**T2**
Practice Session (min/hr)						
MPA	12.4 (3.7)	14.4 (3.7) *****	13.5 (3.0)	15.0 (3.8)	11.7 (3.9) **†**	13.8 (3.5) *****
VPA	16.6 (7.5)	19.0 (6.2) *****	20.6 (7.3)	19.7 (6.4)	13.8 (6.3) **†**	18.3 (5.8) *****
MVPA	29.0 (8.3)	33.4 (6.5) *****	34.1 (6.2)	34.7 (6.8)	25.5 (7.9) **†**	32.1 (5.8) *****
Game (min/hr)						
MPA	13.9 (3.6) **Φ**	14.7 (3.6)	14.2 (3.5)	14.4 (3.4)	12.1 (3.6)	14.9 (3.8)
VPA	22.1 (9.4) **Φ**	22.3 (8.5) **Φ**	22.6 (9.8)	22.8 (8.8) **Φ**	19.7 (7.4) **Φ**	21.9 (8.4) **Φ**
MVPA	36.8 (9.2) **Φ**	37.0 (7.5) **Φ**	37.8 (9.2) **Φ**	37.2 (7.9) **Φ**	31.8 (7.9) **Φ**	36.8 (7.2) *** Φ**

*Values are mean (SD), * Significant difference between T1 and T2 ($p < 0.05$); Φ Significant difference between practice sessions and games; † Significant difference between genders ($p < 0.05$).*

4.4. Discussion

To the author's knowledge, this is the first study to quantify changes in the PA levels attained during OS participation across two time points of a competitive season and to determine the effect of these changes on the overall daily PA levels of the participants. Findings revealed that female participants demonstrated a significant increase in time spent in MVPA during Gaelic football participation and on both sports days and non-sports days between T1 and T2, resulting in a significant increase in overall daily PA levels and compliance with the PA guidelines. Consequently, gender differences in daily PA levels and PA levels during Gaelic football, which were apparent at T1, did not persist at T2.

A gender disparity in adolescent PA levels has consistently been demonstrated within the literature, whereby both OS participating and non-OS participating females accumulate significantly less MVPA daily than their male counterparts (Marques et al. 2016, Telford et al. 2016). Due to these pronounced gender differences in PA during adolescent years, females have been identified as a high priority group for PA promotion (Camacho-Miñano et al. 2011). In response, a new body of literature on girls' PA promotion has emerged, including targeted policies and intervention strategies that are designed specifically to address the unique needs of girls (Camacho-Miñano et al. 2011). Contrary to expectations, female participants' daily MVPA levels increased across time points in this analysis, resulting in no significant gender differences being observed for daily time spent in PA at T2. Female participants were also observed to accumulate significantly more time in MVPA on both sports days and non-sports days at this timepoint, which may explain this novel finding.

The influences on PA participation during adolescence are multifactorial, while there is some indication of gender differences between these factors (Telford et al. 2016). Overall, female adolescents have reported to experience significantly higher levels of perceived barriers to PA in comparison to their male peers (Rosselli et al. 2020). Females cite many school-related barriers to their participation, including increased importance of education, parental expectations, negative physical education (PE) experiences, unsupportive PE teachers and negative peer influence (Corr et al. 2019). Given that T2 of data collection in this study was recorded during the summer months, the removal of these school-related barriers to PA participation during the summer holidays may, in part, explain the increase in female participants PA levels on non-sports days. Other research has concluded that increased levels of PA in youth during spring and summer months were explained by greater discretionary time, resulting in increased time spent in leisure activities, out-of-home play or involvement in additional OS (Goodman et al. 2012, Staiano et al. 2015).

Together, these findings present a possible justification for the overall increase in MVPA among females between T1 and T2.

As well as gender disparities in daily PA, research also consistently shows that males are more physically active than their female counterparts during OS participation, accumulating between 6-9% more time in MVPA (Leek et al. 2011, Mooses and Kull 2019). In this analysis, however, female participants significantly increased the amount of time spent in MVPA during both Gaelic football practice sessions (7min/hr) and games (5min/hr; see Table 4.2.) over time, resulting in no significant differences being observed between genders for time spent in MVPA during Gaelic football participation at T2. The impact of increased PA during Gaelic football participation contributes to increased PA levels on sports days, where females accumulated an additional 9 minutes of MVPA at T2, which in turn removed the gender disparity in MVPA on sports days. Furthermore, the proportion of female participants that achieved the PA guidelines increased by 28% across the timepoints. This may have public health implications, given the multiple health benefits associated with achieving sufficient levels of PA (Poitras et al. 2016).

Coaches have been recognised as one of the primary factors influencing the intensity of PA attained during OS participation (Howie et al. 2020). It has been previously highlighted that the structure, content and focus of OS practice sessions may vary across a season (Emmonds et al. 2020, Harvey et al. 2013). This has been demonstrated within a Gaelic football context, as Kinnerk et al. (2019) determined that inter-county coaches dedicated preseason practice sessions to the development of skills, through the predominate use of drill-based or "training form" activities, before implementing more game-related or "playing from" activities during the regular season. This may provide a possible explanation for the variation in PA attained by female participants during Gaelic football across the season, given that training from activities have been shown to limit PA attainment in comparison to playing form activities (Cohen et al. 2014). Further, research reports gender differences in fundamental movement skill (FMS) proficiency, with female adolescents performing lower in object control skills, involving catching, kicking, and throwing, in comparison to males (Barnett et al. 2016, Eather et al. 2018). Consequently, there may have been a need for the coaches of female teams in this analysis to dedicate a larger percentage of T1 practice session time to training from activities to develop player's technical skills. Thus, this provides a possible justification for the gender disparity in PA levels attained during T1 practice sessions.

4.5. Strength and Limitations

This study had several strengths. Firstly, to the author's knowledge, this is the first study to measure PA in an OS setting across two distinct time points of a competitive season, which provides a

more complete analysis of both the daily PA levels and PA levels attained during OS participation. Secondly, the use of a device-based measure permitted the accurate assessment of the PA levels of Irish OS participating adolescents, where data was previously limited. However, there are limitations to this study. Firstly, due to poor adherence of the coaches to outline the activities performed during practice sessions within the provided journal, it was not possible to clearly indicate if coaching strategies had changed across the season. Secondly, this study did not require the participants to record if/when they were physically active within other settings outside of Gaelic football, such as other OS, which may have impacted PA levels on non-sports days. Finally, the convenience sampling method used, and the small number of Gaelic football teams investigated, means that these findings may not be generalisable across all youth that participate in Gaelic football.

4.6. Conclusion

Across a competitive season, significant changes in the amount of time spent in MVPA on sports days, non-sports days and during Gaelic football participation were observed for females. This had a positive impact on the overall daily PA levels of female participants, accumulating equivalent amounts of MVPA daily to their male counterparts. These positive changes may be a result of the implementation of different coaching strategies and reduced barriers to PA over time. Further research should explore how coaching approaches could improve female PA levels during Gaelic football participation throughout a season and assist in reducing the deficit in overall PA accumulated by females.

4.7. Summary

In accordance with the findings of Chapter 3, this research confirmed the positive PA contribution of Gaelic football participation. In addition, this chapter highlighted the ability of Gaelic football participation to remove the gender disparity in PA levels typically observed in adolescents. While it was hypothesised that the significant increase in PA levels attained by female participants during Gaelic football practice sessions was due to changes in coaching approaches across the season, there is currently no available research examining the coaching approaches implementeed at youth Gaelic football level. Therefore, Chapter 5 aims to address this gap in the literature by describing the current coaching approaches of youth Gaelic games coaches.

Chapter 5. A Mixed-Methods Assessment of the Current Coaching Practices of Youth Gaelic Games Coaches

5.1. Introduction

Youth organised sport (OS) is a structured leisure-time physical activity (PA) setting that is governed by the rules of the sport being played (Janssen 2014). In OS, players attend practice sessions and games under supervision of one or more adults, who typically assume the role of team coach (Janssen 2014, Smoll and Smith 2002). Coaches are recognised as playing an integral role in players' development (Fraser-Thomas and Côté 2009), as they have regular direct involvement with them and they carry considerable influence and control over the sporting environment (Cushion 2010, Howie et al. 2020). In particular, the coach has been described as one of the primary factors influencing the quantity of PA levels attained in OS contexts (Howie et al. 2020), particularly during practice sessions where coaches are better able to dictate the intensity of PA (Guagliano et al. 2014). However, it remains unclear whether coaches are aware of this important role in PA provision or if they consider this in their coaching practices. Consequently, there have been calls to investigate coaches' knowledge of PA provision in OS settings (Guagliano et al. 2014) and to determine efficient ways of optimising the dose of PA accumulated during youth OS through coaching (Vella et al. 2016).

Currently, youth OS coach education programmes do not emphasise achieving moderate-to-vigorous physical activity (MVPA) as an important outcome of youth sport (Schlechter et al. 2017) and they generally do not provide coaches with direction on how to create structured environments that promote increased MVPA provision (Vella et al. 2016). A possible explanation for this is that OS is often aimed at improving players' physical fitness for competitive play and therefore it is associated with high intensity PA (Guagliano et al. 2014). Secondly, coaches likely believe that their players are performing adequate amounts of PA during OS practice sessions (Schlechter et al. 2017). Guagliano et al. (2014) observed that although coaches perceived themselves as role models for players' PA, they also believed that their players were accumulating sufficient PA during practices. However, research has consistently shown that youth OS participants, including Gaelic football participants, spend most practice time inactive or in light intensity physical activity (LIPA) (Gavin et al. 2020, Guagliano et al. 2013, Wickel and Eisenmann 2007).

One possible strategy to increase the PA levels obtained during Gaelic football participation is modifying the way the practices sessions are conducted through the implementation of specific coaching approaches (Leek et al. 2011, Pate and O'Neill 2011). Coaching literature has reported two commonly implemented coaching approaches within field-based sports; a "traditional approach" (Ford et al. 2010) and a "game-based approach" (GBA) (Light 2013). These two coaching approaches may be differentiated by the main practice activity type and the timing of the

activities within a coaching session (Kinnerk et al. 2019). These activity types are broadly classified as training form and playing form. Training form activities are focused on motor-skill performance in isolation or in small-group scenarios, devoid of competition-like context (i.e., isolated skills and fitness practice) (Miller et al. 2016), while playing form activities replicate the technical, tactical and physical aspects of game play (i.e., conditioned or small-sided games) (Ford et al. 2010, Hall et al. 2016).

The traditional approach is characterised by a large amount of time spent in progressively complex training form activities (Pill 2016). This traditional approach promotes a linear sequence of activities, whereby technical skills need to be mastered, usually through multiple repetitions of a training form activity with limited opponents, prior to entering game play (Evans 2006). Research has highlighted concerns relating to a traditional approach, including limiting players' ability to attain significant levels of PA (Cohen, et al., 2014) and develop decision-making skills (Garcia Lopez et al., 2009). The GBA has emerged as an alternative pedagogical approach to the coaching of team sports (Kirk 2010), which advocates predominant use of playing form activities within coaching sessions (Ford et al. 2010, Pinder et al. 2011). In relation to the timing of activities, coaches who employ GBAs utilise a playing form activity as the starting point or "organising centre" of the session from which the rest of the session is built around (Pill, 2016). A recent review of the GBA literature within team sport settings found that GBAs have a positive effect on many player outcomes including decision-making, motivation and enjoyment (Kinnerk et al. 2018). Further, as GBAs promote the predominate use of playing form activities, which have been highlighted to be more conducive to PA than training from activities (Cohen et al. 2014), it has been suggested that this approach may also have a positive effect on players' PA levels (Kinnerk et al. 2018). Indeed, emerging evidence has highlighted that during GBA practice sessions, players accumulated significantly higher levels of PA than during traditional practice sessions (Miller et al. 2016, Nathan 2017, Sierra-Ríos et al. 2020).

To offer insight into the coaching approach implemented by coaches, previous research has assessed the practice activity preferences (i.e., training form or playing form) and sequencing of these practice activities within their coaching sessions (Cushion 2013). Of the limited research available, coaches across a variety of sports (e.g., soccer, field hockey, cricket, basketball, volleyball) at different age grades (e.g., youth, collegiate) and competition levels (e.g., elite, sub-elite, non-elite) were observed to align with a traditional approach, as they spent most of the practice session time in training form activities (Ford et al., 2010; Partington & Cushion, 2013; Harvey et al., 2013; Low et al., 2013). However, more recent research has shown a significant trend towards a GBA within

invasion team sports, as coaches in elite and sub-elite youth soccer (O'Connor et al. 2018, Roca and Ford 2020), elite adult rugby (Hall et al. 2016) and intercounty youth and adult Gaelic football (Kinnerk et al. 2019) were observed to spend most of the practice session time in playing form activities. Furthermore, to date, just two studies have investigated coaches sequencing of practice activities, as O'Connor et al. (2018) and Kinnerk et al. (2019) found soccer and intercounty Gaelic football coaches, respectively, implemented a traditionally linear practice session format. Given the importance of context within coaching (Côté and Gilbert 2009), additional studies are required to investigate activity type and session sequencing in different sporting contexts and across different times of the season (Kinnerk et al. 2019).

Investigating coaches' practice has also been conducted through the examination of the coaching strategies implemented within their coaching sessions (Kinnerk et al. 2019, Light and Evans 2013). Attaining an insight into the conscious strategies that coaches apply within their coaching setting may reveal their affinity with a specific pedagogical approach (Cushion 2013). Specifically, coaches who position themselves in a facilitator role, utilise questioning and encourage player dialogue within coaching sessions demonstrate player-centred strategies which are embedded in GBA pedagogy (Kinnerk et al. 2019). In comparison, traditional coaches typically demonstrate a preference towards a more coach-centred and directive methods of instruction, thereby limiting player involvement (Kidman 2005, Partington and Cushion 2013). Light and Evans (2013) determined rugby union coaches' alignment with GBA pedagogy by exploring coaches' strategies relating to player involvement, player learning and coach behaviours. Additionally, Vinson et al. (2016) examined soccer coaches' alignment with GBA pedagogy through both the examination of their coaching behaviours and coaching strategies implemented. Despite demonstrating some application of GBA aligned strategies, such as questioning, the coaches in both Light and Evans (2013) and Vinson et al. (2016) research displayed a predominate use of traditional coaching strategies.

Despite the available evidence highlighting the potential positive impact of a GBA oriented coaching practice on a range of player outcomes, including PA levels (Kinnerk et al. 2018), the application of GBAs by coaches remains minimal (Ford et al., 2010; Harvey et al., 2013). Interestingly, some NGBs of different sports have adopted GBA benchmarks within their coach education models, including within the GAA (Coach10/MVA–Game Based Model, (Horgan & Daly, 2015). However, there is currently no evidence to indicate whether youth club Gaelic games coaches are employing GBAs or the principles of GBA pedagogy in their practice. Furthermore, no research has explored this coaching populations' awareness of the PA guidelines or their role

in PA provision. Therefore, the primary aim of this chapter was to determine the current coaching practices of youth Gaelic games coaches and assess to what extent they align with GBA pedagogy, and therefore potentially conducive to higher PA levels. A secondary aim of this study was to evaluate youth Gaelic games coaches' awareness, knowledge, and perceptions of PA and the PA guidelines.

5.2. Methods

5.2.1. Design

This study employed a mixed-methods design using quantitative and qualitative methods to assess the current coaching practices of youth Gaelic games coaches, and to evaluate to what extent they align with GBA pedagogy. Firstly, quantitative data using an online survey was obtained to describe (i) youth Gaelic games coaches' current practice activities, session sequencing and coaching strategies across either an entire standard season or across early and summer phases of a season, (ii) coaches' knowledge and understanding of GBA pedagogy, and (iii) coaches knowledge and awareness of guidelines for PA. Survey study designs have been previously utilised to gain insight into sports coaches' perceptions on a larger scale (Stoszkowski and Collins 2016). Secondly, qualitative data were gathered in the form of semi-structured interviews with Gaelic football coaches and coaching and games (C&G) personnel to provide a detailed description and interpretation of coaches' current practices, their knowledge of GBA pedagogy, and to corroborate the quantitative information obtained. Semi-structured interviews were selected as the primary qualitative data collection technique, as they afford the flexibility for the attainment of relevant information from the interviewee, to better understand the process of coaching (Elliott and McCullick 2019, Vinson et al. 2017). Ethical approval for this research study was granted by the TUS Research Ethics Committee (#20200604).

5.2.2. Quantitative Study: Survey

5.2.2.1. Participants

Gaelic games, inclusive of Gaelic football, Ladies Gaelic football, Hurling and Camogie, are the national sports of Ireland (O'Connor et al. 2021). The national governing bodies (NGB) for Gaelic games, the Gaelic Athletic Association (GAA), Ladies Gaelic Football Association (LGFA) and Camogie Association form Ireland's largest community and sporting organisation, with up to one million members, equating to almost 1 in 4 of the national population (Gaelic Athletic Association 2016, Ladies Gaelic Football Association 2011, Sport Ireland 2019a). With approximately 3000 Gaelic games clubs in existence, the NGBs oversee and support over 100,000 coaches (Horgan 2021, Roe et al. 2016). In a first national engagement survey with over 11,000 Gaelic games

coaches, over 90% of respondents indicated that they coach at club level (Horgan, 2021). At the time of this research, youth age grades at club level encompass Under 12, Under 14, Under 16 and Under 18 teams. As this study aimed to recruit youth, club level Gaelic games coaches, the inclusion criteria for participation in the survey was a coach currently coaching or having coached a club level Gaelic football or Hurling/Camogie team, between Under 12 and Under 18 age grades, in the past five years. These criteria were adopted, as data collection took place during Covid-19 restrictions, during which time many coaches may not have been actively involved in coaching for up to a two-year period.

5.2.2.2. Survey Selection and Adaptation

The survey employed in this study was an adapted version of Kinnerk and colleagues (2019) survey, which was developed and validated for use in an inter-county Gaelic football setting across both youth and adult levels. The purpose of this survey was to investigate inter-county Gaelic football coaches' current practices and their knowledge and perceptions of GBAs. The development of this survey is described in detail elsewhere (Kinnerk et al. 2019). Briefly, survey development was guided by steps outlined in educational research (Artino Jr et al. 2014), and consisted of five initial phases: (1) an extensive review of the GBA literature, (2) systematic search of previous survey studies exploring coaches' perceptions of their practice, (3) reviewing benchmarks of GBA practice sessions, (4) observation of Gaelic football coaching sessions and field notes to establish practice activities, and (5) assessing practicing coaches' session plans for practice activity types and definitions. Using this information, and previously established academic activity type definitions (Cushion et al. 2012), Gaelic games activity type terms and their accompanying definitions were developed. In addition, two pilot studies were conducted to ensure content and face validity of the final version of the survey, which comprised of three sections and 36 items.

Permission was granted from the authors to utilise and adapt the survey to suit a youth club Gaelic games coach population. This process resulted in the following modifications:

- Due to the Covid-19 guidelines and the restrictions implemented on team sports during this data collection phase, coaches may not have actively coached within the previous year. To ensure all potential coaches were recruited, the inclusion criteria was expanded to include coaches who are currently coaching or have coached within the last 5 years. To highlight this, an additional question was included in the *Participant Characteristics* component of Section 1, which asked coaches if they were a current coach or a former coach (within the last 1-5 years).
- As this survey aimed to recruit coaches of male and female teams, from both codes of Gaelic football and Hurling/Camogie, two additions were made in the *Describing The Team You Are*

Coaching component of Section 1. Coaches were asked to outline both the gender (Male or Female) and code of the team they were coaching (Gaelic football or Hurling/Camogie).

- In the *Describing Your Typical Coaching Approach* component of Section 2, there was one adaptation and one addition. The Peak Season phase and its description was adapted to Summer Season and described as "the period of the year when a team are preparing for and playing championship matches. Players are finished in school during this time period." This provided a more suitable description of that phase of the youth Gaelic games calendar. An additional phase, Standard Season was included to describe the entire length of a standard Gaelic games season. This provided coaches with an option to detail their coaching sessions if they did not change significantly from Early to Summer Phases.
- An additional section, Section 4, was included to evaluate coaches' awareness, knowledge, and perceptions of PA and the PA guidelines. Questions previously employed by Vaara et al. (2019) were utilised to assess coaches' awareness and knowledge of the PA guidelines. Similarly, to assess coaches' perceptions of PA, questions employed Guagliano et al. (2014) were adapted and utilised.

Following these changes, the adapted survey was reviewed by the authors, resulting in minor modifications to the description of some practice activities. Next, the adapted survey was evaluated for clarity and comprehensibility though a pilot study with a small convenience sample of youth club coaches (n=11). Feedback obtained from the coaches via email and phone was deliberated on by the research team to determine if editing was warranted within the survey. As a result, minor modifications to the phrasing of some questions were made to ensure that they were understandable and applicable to the youth, club level Gaelic games context. The final version of the adapted survey was created using the Survey Monkey platform and comprised of four sections and 38 questions in total.

5.2.2.3. Survey Content

Section 1 comprised of 14 questions relating to coaches' background (i.e., age, gender experience, coach education) and particulars of the team they currently coach/most recently coached (i.e., code, age group, number of practice sessions). Section 2 focused on the coaches' current approach to practice sessions by allowing them to outline the activity types, structure, and strategies they typically employ. As a preface to this section, coaches were asked if their coaching practices change significantly between "Early" and "Summer" phases of a typical Gaelic games season (see Table 5.1). If their coaching practices did change significantly, they were asked to complete the subsequent questions for both phases of a "Split Season". If their coaching practices did not change significantly, they were asked to answer the questions for the entire length of a "Standard

Season". Asking coaches to provide details of their coaching practices for two distinct phases of the season gave greater context to the coach and allowed the researcher to highlight any changes which may occur across a season.

Information regarding session activity content was ascertained by requesting the coaches to estimate the typical amount of time spent per session in individual practice activities (e.g., drills, modified games; see Table 5.1). If a coach did not use a particular practice activity, they did not enter a value for that activity. In a following question, coaches were asked to sequence the order of their session by selecting the activity that came first, second, third and so on. In addition, Likert scale questions were included in this section which explored coaches' perceptions of strategies employed in coaching practice. The questions in this section consisted of statements referring to the employment of GBA and traditional coaching strategies. Section 3 consisted of nine multiple choice and open-ended questions to investigate coaches' awareness, understanding and application of GBA models, along with identifying their confidence and potential challenges in applying a GBA. Section 4 consisted of three questions which aimed to evaluate coaches' awareness, knowledge, and perceptions of PA and the PA guidelines. To assess coaches' awareness, they were asked whether they had seen, heard or read about the PA guidelines. To assess coaches' knowledge, they were asked to select the PA guidelines from a list of six options. Finally, Likert scale questions were included in this section which explored their perceptions of PA in coaching. The survey in its entirety can be found in Appendix F.

Table 5.1 Definitions of Activity Types and Seasons

Activity Type	Definition
Training Form	
Drills	Exercises practiced unopposed in lines that require the repetition of skills and prescribed directional movement.
Skills in Isolation	Similar to drills but don't occur in lines and are often completed with little or no movement allowing the player to solely concentrate on the skill being practiced.
Conditioning	Exercises completed without the ball that usually focuses on improving fitness, speed, and agility etc.
Playing Form	
Applied Skill Practice	Activities that involve some level of opposition and where technique is exposed to pressure and elements of decision making are required (1vs1/2vs2/4vs2).
Modified Games	Match-like activities with reduced numbers (6vs6/7vs7) where space/rule restrictions may be employed (e.g., conditioned games, small-sided games).
Full-Sided Games	Game played with the full complement of players present at a training session. Regulation rules with two goals.
Season	
Early Phase	The first phase of the Gaelic games season when a team starts training and are playing league games. Players are still in school during this time.
Summer Phase	The phase of the Gaelic games season when a team are preparing for and playing championship matches. Players are finished in school during this time.
Standard Season	Represents a Gaelic games season when coaches *do not* significantly change their coaching practices between early and summer phases of the season.
Split Season	Represents a Gaelic games season when coaches *do* significantly change their coaching practices as the season progresses.

5.2.2.4. Procedure

Prior to distribution of the survey, the primary investigator presented the details of the study to coaching leaders in the GAA, LGFA and the Camogie Association. The NGBs agreed to support the research by circulating the survey on their relevant social media platforms, and by emailing it to their appropriate Coaching and Games (C&G) personnel at provincial and county level. However, a known database of emails is a more effective recruitment strategy than most and typically generates a high response rate (Schillewaert et al. 1998). As no database existed for youth club Gaelic games coaches or their clubs, the primary investigator gathered the names and email addresses of the secretary from over 1,400 clubs across Ireland. An email was then sent to all club secretaries explaining the background and purpose of the research and requested them to forward the link to the online survey to their youth club coaches. The survey was delivered online, to enhance participant experience and facilitate greater access in comparison to paper-based methods (Ward et al. 2014), while also complying with public health guidelines during the Covid-19 pandemic. Online surveys have also shown increased response rates as well as equally valid scores compared to traditional survey methods (Lonsdale et al. 2006). To utilise snowball sampling (Given 2008), the email also encouraged participants to circulate the survey link to their own personal networks and coaching peers. The first page of the survey provided participants with study information and requested informed consent to continue. Following recommendations to generate higher response rates in online surveys (Ryan and Clopton 2009), the club secretaries were sent reminder emails four weeks after the initial email. In addition, the primary investigator circulated the survey link via their online social networks (e.g., Twitter, Instagram).

5.2.2.5. Survey Analysis

Coaches were required to complete all 38 questions of the survey to be included in the final analysis. Descriptive statistics (means, standard deviation, frequencies, and percentages) were used to summarise coach demographic information, the amount of time coaches spent in each of the practice activity types, sequencing of sessions, awareness/utilisation of GBA models, and the proportion of responses to Likert scale questions. Dichotomous variables were created for coaches' responses to the frequency of implementation of coaching strategies (1=Often/Sometimes; 2=Rarely/Never). Homogeneity of variance of data was investigated using Levene's test. All relevant outcome variables were tested to meet the assumptions for normal distribution using the Kolmogorov-Smirnov test of normality. In the case of data that did not demonstrate a normal distribution, the parametric conclusion was confirmed using non-parametric equivalent tests. The amount of time coaches reported spending in training from and playing form activity types was determined as a percentage of the total duration of the practice session. This was

calculated by dividing the time spent in each of the activities by the total time of the practice session and then multiplying this number by 100. Independent sample t-tests and Mann-Whitney U tests were utilised to examine the differences in the percentage of time spent in each practice activity type (i.e., training form and playing form) and individual practice activities (i.e., drills, conditioned games etc.) between a standard season and the early and summer phases of a split season. Finally, differences in the percentage of time spent in each practice activity type and individual practice activities between early and summer phases of a split season were established using paired samples t-tests and Wilcoxon Signed ranks tests. To reduce the likelihood of Type I error, p-values were subjected to Benjamini–Hochberg adjustment. Cohen's d effect sizes (d) denoted a small (d=0.2), medium (d=0.5) and large (d=0.8) effect (Cohen 1988) and the alpha level required for significance for all tests was set at $p<0.05$.

5.2.3. Qualitative Study: Semi-Structured Interviews and Focus Groups

5.2.3.1. Participants

A stakeholder is defined as 'individuals and organisations that have a direct interest in the process and outcomes of a project, research or policy endeavour'. Stakeholder engagement is 'an iterative process of actively soliciting the knowledge, experience, judgment and values of individuals selected to represent a broad range of direct interests in a particular issue, for the dual purposes of creating a shared understanding and making relevant, transparent and effective decisions" (Deverka et al. 2012). Utilising a framework developed by Schiller et al. (2013), the key stakeholders identified for this study were Gaelic football coaches and C&G personnel. Sampling is the process of selecting or searching for situations, context and/or participants who provide rich data of the phenomenon of interest (Polit and Beck 2017). This study incorporated purposive sampling, whereby participants that are the most informative and most likely to generate meaningful discussions are selected (Moser and Korstjens 2018). Unfortunately, it was beyond the scope of this study to select coach participants from across both codes of Gaelic games, thus just Gaelic football coaches were selected.

5.2.3.1.1. Coaches

A purposive sampling technique was used to select a broad range of coaches, including male and female coaches, coaches of male and female teams, coaches from different provinces, and coaches with varying years of experiences. Coach participants were required to have at least one year of coaching experience and to be currently coaching a youth club level Gaelic football team. Coaches were recruited through direct contact from the primary investigator via email (Appendix G), which

included a detailed information sheet and consent form (Appendix H). Ten Gaelic football coaches (5 male and 5 female) coaching at youth club level were recruited to participate.

5.2.3.1.2. Coaching and Games Personnel

Coaching and games personnel are deployed at national, provincial, and county level, and comprise of a range of positions, including games development managers, games development administrators/officers and games promotion officers. A purposive sample of 12 C&G personnel (11 male and 1 female; 8 GAA and 4 LGFA) were recruited to participate as they are key informants, most knowledgeable about coaching and coach education and can act as representatives in revealing and interpreting the current coaching practices within youth club level Gaelic football. Coaching and games personnel were recruited using the same methods as the coaches (See Section 5.2.3.1.1).

5.2.3.2. Procedure

Prior to the qualitative data collection, an interview guide (Appendix I-J) was developed by the research team, which consisted of a list of open-ended questions used to guide the interviews. These questions aimed to explore participants' perceptions on a range of topics, including current coaching practices and strategies, practice activity type preferences and knowledge and understanding of GBA pedagogy. Although the interview guide was not always followed in strict chronological order, it acted as a natural progression and allowed further questions to be asked when required. Probing questions were used to provoke more discussion and to ensure participants had discussed everything before the primary investigator proceeded on to the subsequent question (Sparkes and Smith 2013). The questions were developed based on a review of the relevant coaching pedagogy literature and the guide was informed by guidelines for qualitative research and interviewing (Rubin and Rubin 2011, Sparkes and Smith 2013). Semi-structured interviews with the coaches and C&G personnel were conducted one-to-one with the primary investigator over the phone at a time that was convenient to the participants. Interviews were recorded using a digital voice recorder (Olympus VN-540PC, Shinjuku City, Japan). Prior to the commencement of the interview, the researcher provided a short briefing detailing the background of the study, information on the questions, the potential outcomes of the results, while also ensuring complete confidentiality and anonymity (Appendix K). Demographic information (age, gender and years coaching/involvement in Gaelic football) was also recorded.

5.2.3.3. Data Analysis

Qualitative data analysis was informed by previous coaching research in youth organised sport (OS) settings, where an open coding, deductive approach was utilised (Morales-Belando and Arias-

Estero 2017a, 2017b, Morales-Belando et al. 2018). A deductive approach to data coding and analysis is a top-down approach where the researcher brings to the data a series of concepts, ideas, or topics that they use to code and interpret the data (Braun and Clarke 2012). The recorded interviews were transcribed verbatim, producing 78,262 words or 126 single-spaced pages of transcript. The transcripts were then uploaded to NVivo 12 software (QSR International Pty Ltd., Doncaster, VIC, Australia) which facilitated the organisation and coding of the dataset. The primary investigator reviewed the transcripts on numerous occasions to become familiar with the depth and breadth of the data and detect recurring topics. Open coding of the transcripts was then conducted line by line at a descriptive level (Taylor 2014). This process of open coding involved the identification and organisation of meaning units into initial codes in the dataset to organise the data and facilitate its retrieval (Patton 2002). Meaning units are words or phrases used by the participants which were potentially important (Vinson et al. 2016). Deductive analysis was then conducted, where the codes generated from open coding were organised under five pre-existing categories used in the quantitative data: (a) training form activities, (b) playing form activities, (c) session sequencing, (d) coaching strategies and (e) GBA knowledge.

5.3. Results

5.3.1. Quantitative Results

5.3.1.1. Participant Characteristics

Background information was completed by a total of 1660 coaches (1267 males, 393 females), however, just 758 (614 males, 144 females) of these coaches completed all sections of the survey up to question 38, equating to a completion rate of 46%. Table 5.2. presents the demographic information of these coaches across the total sample and across gender. Overall, most respondents were current coaches (90.0%), aged between 45-54 years (49.5%), had 6-10 years of coaching experience (30.7%), previously coached at club level (88.8%) and had a foundation award coaching qualification (78.4%). In relation to their current team, a majority were coaching a male (59.0%), Gaelic football team (66.0%), at under 11/12 age grade (28.6%). Distinct differences between male and female coaches were observed for several characteristics. Most male coaches had 6-10 years of coaching experience (31.5%), while most female coaches had 0-5 years of coaching experience (45.1%). Further, a larger percentage of male coaches reported to possess Award 1 (60.8%) and Award 2 (18.5%) coaching qualifications than female coaches (Award 1: 47.9%; Award 2: 13.2%). Finally, in relation to the gender of the team they currently coach, a large majority of female coaches reported to currently coach a female team (90.2%), while a larger percentage of male coaches were observed to coach across genders (male team: 70.6%; female team: 29.4%).

Table 5.2 Demographic characteristics of Gaelic games coaches.

		Total (n=758)		Males (n=614)		Females (n=144)	
Variable		**%**	**n**	**%**	**n**	**%**	**n**
Coaching status	Current	90.0	682	91.1	559	85.1	123
	Former	10.0	76	8.9	55	14.9	21
Age (yrs)	18-24	5.3	40	2.8	17	16.0	23
	25-34	8.0	61	6.3	39	15.3	22
	35-44	28.5	216	29.1	179	25.7	37
	45-54	49.5	375	52.5	322	36.8	53
	55-64	8.0	61	8.5	52	6.3	9
	65+	0.7	5	0.8	5	0.0	0
Coaching experience (yrs)	0-5	27.6	209	23.5	144	45.1	65
	6-10	30.7	233	31.5	193	27.7	40
	11-15	14.5	110	16.3	100	7.0	10
	16-20	12.4	94	12.2	75	13.2	19
	21+	14.0	106	15.6	96	7.0	10
Levels of Gaelic games previously coached	Club	88.8	673	90.0	553	83.3	120
	College/University	8.3	63	8.9	55	5.6	8
	County	26.5	201	28.2	173	19.4	28
	Schools	23.0	174	22.1	136	26.4	38
Current team's code	Gaelic Football	66.0	500	66.4	408	63.6	92
	Hurling /Camogie	34.0	258	33.6	206	36.4	52
Current team's gender	Male	59.0	447	70.6	433	9.8	14
	Female	41.0	311	29.4	181	90.2	130
Current team's age grade	Under 11/12	28.6	217	25.8	158	41.1	59
	Under 13/14	26.1	198	26.6	163	24.1	35
	Under 15/16	24.0	182	24.4	150	22.0	32
	Under 17/18	21.1	160	23.2	142	12.8	18
Current level of coaching qualification	No formal coach education	2.9	22	2.8	17	3.5	5
	Foundation Award / Fundamentals / Camán and Coach	78.4	594	77.4	475	82.6	119
	Award 1 / Level 1	58.3	442	60.8	373	47.9	69
	Award 2 / Level 2	17.5	133	18.5	114	13.2	19
	Coach Education Tutor Award	6.9	52	6.8	42	6.9	10
	Coach Education Tutor Trainer Award	2.6	20	3.0	18	1.4	2
	Gaelic games Coaching Workshops	63.1	478	65.4	402	52.8	76
	Diploma of Sport Coaching (or equivalent)	3.4	26	3.5	21	3.5	5
	Sports coaching related 3rd level degree (e.g., Sports Science)	10.2	77	7.6	47	20.8	30
	Sports coaching related Masters (e.g., Sports Performance)	2.8	21	2.8	17	2.8	4
	Sports coaching related PhD	0.3	2	0.3	2	0.0	0
	Other education / accreditation (e.g., NSCA, CSCS)	6.3	48	6.1	37	7.6	11

5.3.1.2. Time Spent in Practice Activity Types

Table 5.3. presents the percentage of practice session time spent in training form and playing form activity types during both a standard season and the individual early and summer phases of a split season. Overall, coaches reported spending a significantly greater amount of practice session time in training form activities than in playing form activities throughout a standard season ($z=-4.815$; $p<0.001$) and the early phase ($z=-16.832$; $p<0.001$). In contrast, during the summer phase, the percentage of practice session duration spent in training form and playing form activities was equivalent ($z=-0.748$; $p=0.454$).

5.3.1.2.1. Standard Season vs Split Season Phases

During a standard season, coaches reported spending significantly less time in training form activities and significantly more time in playing form activities when compared to the early phase ($z=-10.488$, $p<0.001$, $d=0.71$). In contrast, when compared to the summer phase, coaches reported spending significantly more time in training form activities and significantly less time in playing form activities ($z=-3.398$, $p=0.001$, $d=0.22$) during a standard season**.**

5.3.1.2.2. Early Phase vs Summer Phases

When comparing across a split season, there was a significant increase in the time spent in playing form activities between early and summer phases, equating to approximately 14.3% ($z=-13.484$, $p<0.001$, $d=0.94$).

Table 5.3 Percentage of practice session duration spent in training form and playing form activity types across a standard season and early and summer phases of a split season.

	Standard Season	**Split Season**	
	Total	**Early Phase**	**Summer Phase**
Training Form (%)	53.6 Φ ***†**	64.7 Φ**†**	50.4 *****
Playing Form (%)	46.4 ***†**	35.2 **†**	49.6 *****

Φ *Significant difference between training from and playing form ($p < 0.05$); * Significant difference to Early Phase ($p < 0.05$); † Significant difference to Summer Phase ($p < 0.05$).*

5.3.1.3. Time Spent in Individual Practice Activities

Figure 5.1 presents a breakdown of the percentage of time spent in each of the seven individual practice activities (e.g., drills, modified games) during both a standard season and the individual early and summer phases of a split season.

5.3.1.3.1. Standard Season vs Split Season Phases

Compared to the early phase, coaches spent significantly less time in the training from activities of warm-up/cool down ($z=-6.641$, $p<0.001$, $d=0.37$), drills ($z=-2.237$, $p=0.013$, $d=0.10$) and conditioning ($z=-9.832$, $p<0.001$, $d=0.71$) during a standard season. In terms of playing form activities, coaches reported spending significantly more time in applied skills practice ($z=-3.615$; $p<0.001$, $d=0.23$), modified games ($z=-5.046$; $p<0.001$, $d=0.37$) and full-sided games ($z=-5.216$; $p<0.001$, $d=0.33$) during a standard season.

Compared to the summer phase, coaches spent less time in the training from activities of warm-up/cool down ($z=-3.438$, $p=0.001$, $d=0.15$), but significantly more time in drills ($z=-6.330$, $p<0.001$, $d=0.43$) during a standard season. In terms of playing form activities, coaches reported spending significantly more time in modified games ($z=-3.242$; $p<0.001$, $d=0.22$), but significantly less time in full-sided games ($z=-6.258$; $p<0.001$, $d=0.42$) during a standard season.

5.3.1.3.2. Early Phase vs Summer Phase

The percentage of practice time spent in the training form activities of warm-up/cool down ($z=-4.323$; $p<0.001$, $d=0.25$), drills ($t(1107)=9.420$; $p<0.001$, $d=0.56$) and conditioning ($z=-8.451$; $p<0.001$, $d=0.57$) were significantly larger during the early phase. Coaches spent a significantly larger amount of time in playing form activities of applied skills practice ($z=-5.521$; $p<0.001$, $d=0.28$), modified games ($z=-2.343$; $p=0.008$, $d=0.15$) and full-sided games ($z=-10.631$; $p<0.001$, $d=0.76$) during the summer phase.

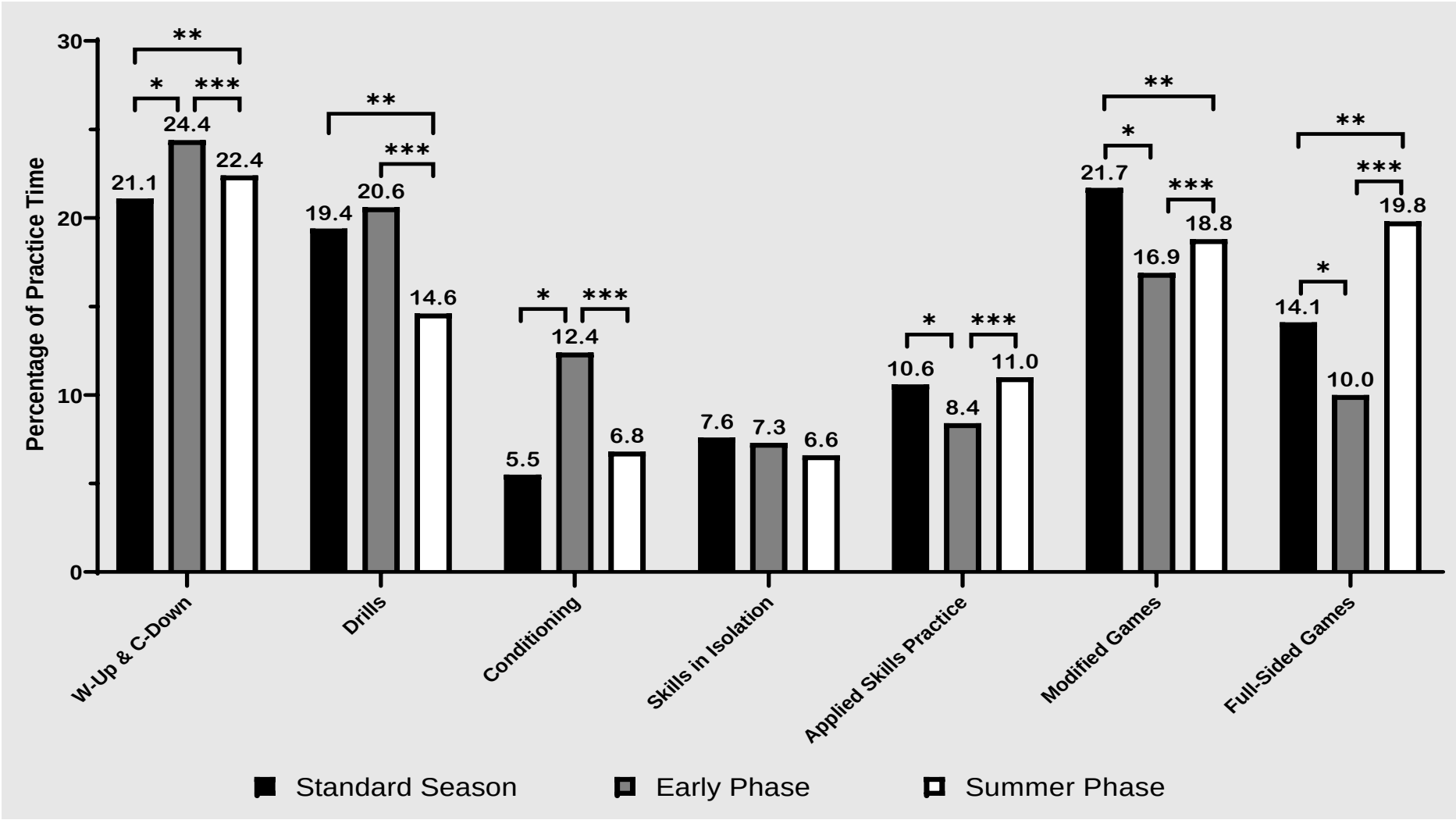


Figure 5.1 Percentage of practice session duration spent in training form and playing form activities in standard season, early and summer phase.
** Significant difference between Standard Season and Early Phase; ** Significant difference between Standard Season and Summer Phase; *** Significant difference between Early and Summer Phases ($p<0.005$)*

5.3.1.4. Session Sequencing

With respect to the sequencing of practice activities over a session, Figures 5.2 highlights that, regardless of season type (standard or split) or phase of a split season (early or summer), coaches sequenced their sessions by selecting the training form activities of drills, skills in isolation and conditioning in the first third of their practice session (activity 1 & activity 2). However, as the session progressed (activity 3-6), there was a decrease in the training form activities, counteracted by an increase in the use of playing form activities, in particular the use of modified and full-sided games. Overall, coaches sequenced their practice activities in a linear format, where technical skills practice (i.e., drills) is performed prior to entering game-related activity (i.e., modified games).

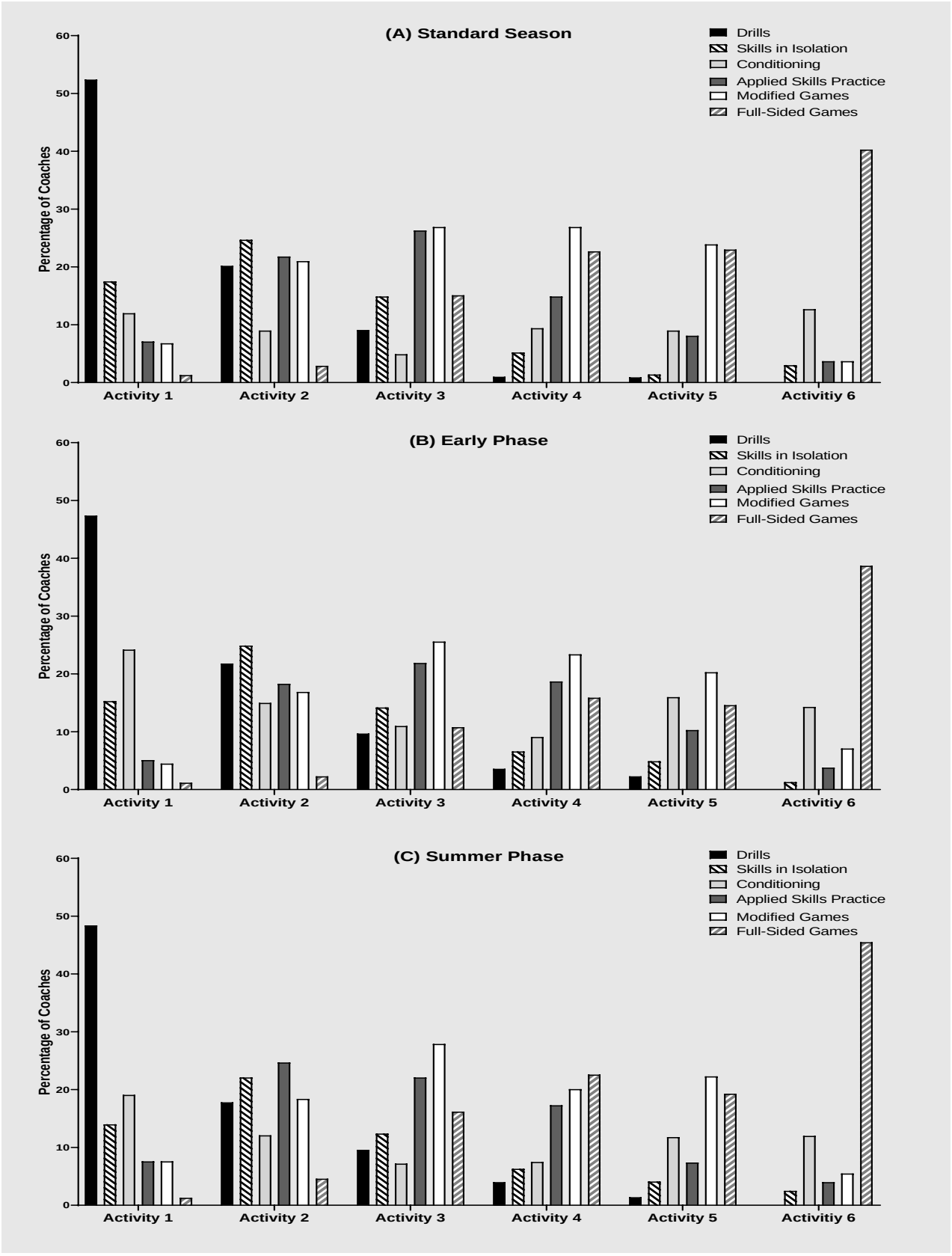


Figure 5.2 Coaches' sequencing of activities within a typical practice session in (A) Standard Season, (B) Early Phase and (C) Summer Phase. Activity percentage represents the popularity of that activity type for that stage of a practice session (e.g., over 50% of coaches use drills as activity 1 in a standard season practice session).

5.3.1.5. Coaching Strategies

Table 5.4 describes how often coaches implement traditional (n=2) and GBA (n=4) aligned coaching strategies within their practice sessions. When ranked on a 4-point Likert scale (1=always to 4=never), coaches reported regularly implementing each of the traditional coaching strategies. Specifically, a large majority of coaches stated that they always or often provide players with all the instructions necessary to perform an activity (94.4%) and regularly stop an activity if the players are not completing it to their expectations (80.9%). Similarly, in terms of GBA coaching strategies, over 90% of coaches reported to always or often encouraging input from the players (94.4%) and asking players questions mid-session to stimulate thinking (91.7%). However, coaches were less engaged with the two remaining GBA coaching strategies, with most participants stating that they rarely or never provide opportunities for discussion and debate (68.1%) or ensure players are included in decision making (65.8%).

Table 5.4 Percentage of coaches who report employing a range of traditional and GBA aligned coaching strategies within practice sessions.

Traditional Strategies	**Always / Often**	**Rarely / Never**
I give players all the instructions, direction and tools they need to perform a task.	**94.4%**	**5.7%**
I regularly stop an activity if the players aren't completing it to my expected standards.	**80.9%**	**19.1%**
GBA Strategies		
I encourage input and feedback from the players throughout the session.	**92.3%**	**7.6%**
I provide opportunities for players to discuss and debate their own strategies in upcoming sections of training.	**31.9%**	**68.1%**
I ask players questions mid-session to stimulate thinking and interaction.	**91.7%**	**8.3%**
I ensure players are included in the decision-making process regarding team tactics and strategies.	**34.3%**	**65.8%**

5.3.1.6. Coach Awareness, Confidence and Utilisation of GBA Models

Overall, 83.5% of youth Gaelic games coaches reported to be aware of the term GBA in coaching. When asked to outline their level of confidence in implementing a GBA, most coaches reported having either complete (8.5%), high (34.1%) or moderate (44.0%) confidence. However, when asked to outline to what extent their formal Gaelic games coach education had prepared them to apply a GBA within their sessions, coaches primarily reported to be only 'Somewhat Prepared' (40%).

Figure 5.3 outlines the percentage of Gaelic games coaches who were aware of and implement seven different academic GBA models as their predominant coaching approach. Overall, Gaelic games coaches were largely unaware of the majority of the formal GBA models, with 22.6% of coaches reporting to not recognise any of the GBAs presented. The GAA's MVA/Coach10 model was the most recognised GBA model (25.6%), while less than 14% of coaches claimed to be aware of the remaining six GBA models.

Despite coaches reporting to be largely unaware of the formal GBA models, a cumulative 77.7% of coaches reported to implement one of these models as the predominant approach within their coaching sessions. Of these models, the most frequently implemented by coaches were Game Sense (23.2%) and Play Practice (16.2%). Despite being the most recognised GBA model, just 11.4% of coaches reported to predominantly implement the GAA's MVA/Coach10 model. Interestingly, 11.5% of coaches reported that they did not use any of the GBAs outlined above, while just 10.7% claimed to not use a GBA of any kind within their sessions (Figure 5.3).

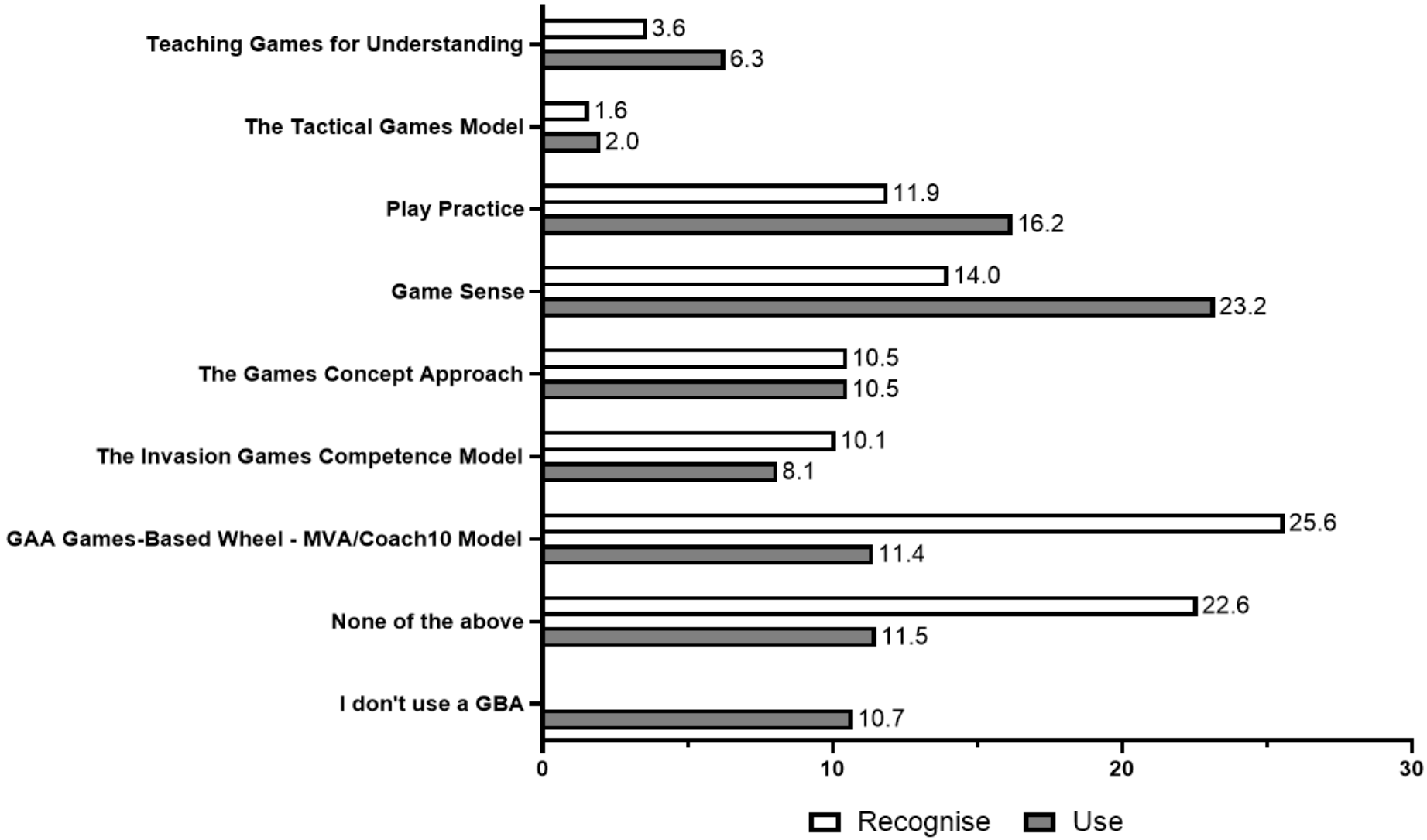


Figure 5.3 Percentage of coaches who reported to recognise and utilise different academic GBA models within their practice sessions

5.3.1.7. Coach Awareness, Knowledge and Perceptions of PA Levels and PA Guidelines

Overall, most coaches reported that they were either not aware (45.1%) or unsure (22.8%) of the current national PA guidelines for youth, with just 32.1% of coaches reporting awareness of the relevant guidelines. When asked to select the current national PA guideline for youth from six options, only 15.5% of coaches correctly selected *60 Minutes per Day, 7 Days a Week*, while most coaches indicated 'Don't Know/Unsure' (23.7%). The remaining 53.5% of coaches selected one of the five incorrect options.

Table 5.5 displays the proportion of coaches who agree, disagree or are unsure with eight statements related to PA and their role as coaches. In total, over 90% of coaches were in agreement on 5 of the statements, agreeing that; it is the responsibility of Gaelic games to promote PA among its youth members (92.8%), they ensure players are always physically active throughout a session (93.2%), they limit the amount of time players spend standing during training sessions (95.0%), it is important players are physically active outside of sport (96.9%), and that it is important that training sessions make a significant contribution to players' daily PA levels (90.4%). Of the remaining three statements, a larger variation in coach responses was observed, with 22.5% of coaches unsure if Gaelic games coach education addresses the promotion of PA, 19.1% of coaches unsure if they see themselves as role models for players in terms of PA, and 14.2% of coaches stating that they disagree that they are responsible for influencing the PA behaviours of the players outside sport.

Table 5.5 Percentage of coaches who reported to agree, disagree or were unsure in relation to PA related statements.

Statement	Agree (%)	Unsure (%)	Disagree (%)
It is a responsibility for Gaelic games to promote physical activity among its youth members.	92.8	4.3	2.8
The Gaelic games coach education addresses the promotion of physical activity.	63.3	22.5	14.2
I ensure players are always physically active throughout the session.	93.2	3.7	3.1
I limit the amount of time players spend standing during training sessions.	95.0	3.1	1.9
It is important players are physically active outside of sport.	96.9	2.6	0.5
I am responsible for influencing the physical activity behaviours of my players outside sport.	67.0	18.8	14.2
In terms of physical activity, I see myself as a role model for the players.	73.5	19.1	7.3
It is important that training sessions make a significant contribution to players' daily PA levels	90.4	5.8	3.8

5.3.2. Qualitative Results

During the qualitative data collection phase, information was sought from the coaches and C&G personnel regarding the current coaching practices employed within youth Gaelic football practice sessions. Based on the pre-determined categories of training form activities, playing form activities, session sequencing, coaching strategies and GBA knowledge, Table 5.6 presents some examples of the coaches' and C&G personnel's responses.

5.3.2.1. Training Form Activities, Playing Form Activities and Session Sequencing

Specifically, it was noted within the interviews that coaches predominately utilised training form activities, such as drills and skills in isolation within their practice sessions. Nonetheless, coaches also reported to regularly implement playing form activities, such as small-sided games, conditioned games, and full-sided games, describing an increase in this practice activity type within their sessions as the season progressed. While C&G personnel demonstrated a clear understanding of the advantages of playing form activities for the development of youth players, they also reported to observe a predominant use of training form activities by coaches within youth Gaelic games settings. In relation to session sequencing, coaches outlined a traditional linear sequencing of activities, where they implemented training form activities prior to entering game play. Despite advocating for a GBA aligned practice session sequence, the C&G personnel confirmed a linear sequencing of activities exists amongst club coaches.

5.3.2.2. Coaching Strategies and GBA Knowledge

Qualitative data indicated that coaches regularly utilise both traditional and GBA strategies. Coaches were highlighted as adopting some aspects of a player-centred approach, as they regularly utilise questioning and promote a supportive, encouraging and fun environment for their players. However, coaches also demonstrated some alignment with traditional strategies, as they were less supportive of providing opportunities for dialogue and debate, instead adopting a more direct instructional approach. Interestingly, C&G personnel consistently reported to promote the use of GBA aligned strategies amongst their coaching cohorts, including the use of questioning and the need to reposition into a facilitator role. Finally, the qualitative data demonstrated a general lack of knowledge or understanding of GBA pedagogy amongst coaches, as they consistently equated the use of games within their practice sessions as successfully implementing a GBA. These findings were reiterated within the C&G personnel's responses, as they reported to observe a similar misinterpretation of a GBA as the utilisation of games within their practice sessions.

Table 5.6 Example of coaches' and C&G personnel's responses to each category in the interviews.

Category	Quotes
Training Form Activities	**Coaches:** • "I would typically use a lot of drills in training, usually to work on a movement and a skill, just so they're not breaking down with the skill later on." – **Coach 4.** • Some days we might work on a skill like kick passing or catching, so I usually like to get the players lined up in groups of four, and you just want straight lines first of all, hop solo, hop solo, punch pass back and forth, all in straight lines." – **Coach 1.** • "Early on in the year we would focus on doing some running or conditioning to build a base of fitness. So maybe something along the lines of interval runs across the pitch" – **Coach 9.** • "I think it's important to focus on the basics, especially if we have a few weaker girls on the team, so we would try and make sure they get a lot of time in things like kick passing or soloing drills and just make sure they have those skills nailed down." – **Coach 6.** **C&G Personnel:** • "Coaches want to show the skill in a kind of linear format where you have 10 people behind one cone and 10 people behind another cone, they are getting them into line format. " – **C&G Personnel 1.** • "It is happening a lot where the coaches have all the balls inside the bag, there's only one ball out and a player is running out in a line and getting to go one at a time and then back to the end of the line." - **C&G Personnel 13.** • "Club coaches, especially at underage level, tend to use a lot of drills where they can have it planned out and organised, so working on something like hand passing or kick passing between two players at two different cones" - **C&G Personnel 5.** • "I have seen sessions in clubs where 12 kids are lined up one side of the goal and 12 kids on the other and two footballs and they are kicking points." – **C&G Personnel 2.**
Playing Form Activities	**Coaches:** • "I would include some games during training too, maybe a conditioned game and bringing in some different conditions, maybe one handpass or one solo. The conditioned game could be at any size, if there's big numbers, you could go 5 vs 5, or maybe 6 vs 4." – **Coach 1.** • "We do use games, probably mostly focusing on small group games, with a maximum of like teams of four just to make sure everybody got a touch of the ball." – **Coach 7.** • "Because in preseason you are working on all the skills in different drills, because I am a firm believer in being able to handpass left and right, working on kick passing even on your weak foot" – **Coach 2.**

	• "Later on in the year, once the matches are up and running, we focus more on game scenarios, maybe trying to set up scoring opportunities with a man advantage or something like that." – **Coach 6.** **C&G Personnel:** • You can go a lot more game-based or small-sided or conditioned games, where the players are getting a lot more time to make their own decisions." – **C&G Personnel 1.** • "I think coaches are starting to use games more now, especially small-sided games, with maybe 4 v 4 or 8 v 8 games." – **C&G Personnel 6** • "We are trying to get coaches away from using drills all the time and getting players into a conditioned game or a game-based scenario where they are making the decisions, as opposed to us making the decisions for them." – **C&G Personnel 12.**
Session Sequencing	**Coaches:** • "Do it in a drill scenario first, and then stop, explain and then maybe over your second or third session, introduce it into that, into the conditioned game." – **Coach 10.** • "Especially with the underage, do the drills first. Work on the drills first, and then bring it into the game scenarios" – **Coach 8.** • "So, we learn the skill, we refine it, we get good at it and then bring it into a small mini games situation where it becomes competitive." – **Coach 5.** • "So, what we would be doing in the skills, we would be implementing it in a game-based scenario then afterwards. So, if we were working on kick pass, we would use different kinds of kick passing drills, and then running an actual kind of kick passing game, or conditioned game after that then." – **Coach 6.** **C&G Personnel:** • "I think across the local clubs, coaches are usually very focused on perfecting skills first, ensuring that the kids can kick and catch before then bringing that into a game or game scenarios". – **C&G Personnel 2.** • "A lot of coaches are thinking very structured, I do this drill for 3 or 4 minutes and then I do another drill and another drill" – **C&G Personnel 11.** • "I think [that] is what we would be trying to promote. Start with the game, identify where the weaknesses are, work on that particular skill, and then get back into a game." – **C&G Personnel 6.**
Coach Strategies	**Coaches:** • "And then another way to engage players is just by asking open questions, try and get them talking, you know, why are we doing this? What could we do?" – **Coach 4** • "I simply ask the players, where do you think we need to work? What do you think we need to do?" – **Coach 10.** • "We try and give a reason for it [an activity] and you ask them their opinion on it and what do they feel about it and we take that on board as well." – **Coach 2.**

	• "With under sixteens maybe not [providing opportunities for dialogue], because you're trying to maybe tell them what you want off them more so" – **Coach 1.** **C&G Personnel:** • "I think one of the biggest things we have to do is to encourage the coach to give the player ownership for what they are doing. But I think that coaches struggle with that, I see a lot of coaches who always have to interrupt during drills and correct problems straight away. "– **C&G Personnel 3.** • "We promote this open questioning. We always say its instead of 70% the coach telling and 30% the players talking or open questions, we like to reverse that. So, its players are talking 70% and the coach is talking 30% of the session." – **C&G Personnel 8.** • "I try and promote the concept of all they need to know is the rules of the game, let them off then stand back and observe. It could be chaos, if it's chaos great, because then you see the improvement the second time you play it." – **C&G Personnel 1.**
GBA Knowledge	**Coaches:** • "Yes, I would say we are using a game-based approach with the lads. We always try and bring in different types of games into training, whether that's conditioned games or 2 v 2 games." **– Coach 1.** • "Nearly everything really, we do will be a game-based approach if you kind of knuckle it down and I suppose look at it from that term. We always try and use games throughout a session to improve the players." – **Coach 5.** **C&G Personnel:** • "I think if you asked most coaches they would say that they use a game-based approach because they use things like conditioned games. But there is a lot more to it than just using games in trainings." – **C&G Personnel 11.** • "A coach could know why they are using games, but they don't know how to bring the players learning into it then you're wasting your time." – **C&G Personnel 4.**

5.4. Discussion

The primary aim of this research was to investigate the current coaching practices employed by youth Gaelic games in the context of coaching approaches that may best promote PA. This aim was achieved through the assessment of coaches' practice activity types, session sequencing, coaching strategies, knowledge of GBA pedagogy and knowledge and perceptions of PA and the PA guidelines. The findings from this chapter revealed that coaches implement a range of training form and playing form activities, while the amount of time spent in these different types of activities change across a season. Coaches reported sequencing practice activities in a linear format, by arranging training form activities in the initial stages of the practice session followed by playing form activities. There was variation in the use of coaching strategies, as coaches reported frequently employing both traditional and GBA aligned strategies. Additionally, despite claiming to use a GBA within their sessions, coaches demonstrated a general lack of knowledge and understanding of GBA pedagogy. Finally, coaches appreciate the importance of their players accumulating PA and recognise the impact Gaelic games can have on players' PA levels, yet a low proportion are aware of or can accurately identify the PA guidelines.

The examination of coaches' practices through the assessment of their activity preferences has previously been utilised to offer insight into their pedagogical approach (Cushion 2013, Turner and Martinek 1999). A key focus of this study was to examine youth Gaelic football coaches' practice sessions through the assessment of the activity types implemented. Of the limited studies which have investigated coaches' practice according to activity type, most appear to be in line with a traditional pedagogy, as coaches spent a larger percentage of the practice session in training form activities (Ford et al. 2010, Harvey et al. 2013, Low et al. 2013, Partington and Cushion 2013). Consistent with these findings, the quantitative data in this analysis revealed that coaches spent the majority of practice session time in training form activities during both standard (TF: 54%; PF: 46%) and split (TF: 58%; PF: 42%) seasons. Training form activities are typically used by coaches to increase the number of skill execution repetitions, resulting in more rapid short-term performance gains (Gabbett et al. 2009). This was supported within the qualitative data, as coaches and C&G personnel reported the frequent use of training form activities within coaching sessions, primarily to facilitate players' development of specific skills in isolated situations:

> *"I would typically use a lot of drills in training, usually to work on a movement and a skill, just so they're not breaking down with the skill later on."* – Coach 4.

When examining across the phases of a split season, the quantitative data revealed that, during the summer phase, coaches estimated dedicating an equal percentage of practice session time to

training form and playing form activities (TF: 50.4%; PF: 49.6%). Playing form activities have been deemed more relevant to competitive game play than training form activities, as they provide decision making opportunities and facilitate retention and transferability of skills (Cushion et al., 2012a). In more recent studies, coaches in the invasion team sports of rugby (TF: 41.5%, PF: 58.5% (Hall et al. 2016)), soccer (TF: 22.3%, PF: 40.9% (O'Connor et al. 2018)) and intercounty Gaelic football (TF: 37%; PF: 63% (Kinnerk et al., 2019) have been observed to spend more time in the playing form activity type. The use of playing form activities within practice sessions was emphasised within the qualitative data, as coaches and C&G personnel outlined the value they place in playing form activities to facilitate the transfer of skills to recreate the intensity and decision-making conditions of competitive gameplay:

> *"You can go a lot more game-based or small-sided or conditioned games, where the players are getting a lot more time to make their own decisions."* – C&G Personnel 1.

In view of these findings, the coaching approach of Gaelic games coaches does vary depending on time of the season. Specifically, the increase in the playing form activity type by 14% during the summer phase was a direct result of significantly reducing time spent in drills and conditioning and replacing it with time in applied skills practice, modified games and full-sided games (Figure 5.1). Indeed, these findings are consistent with Kinnerk and colleagues research, where intercounty Gaelic football coaches significantly reduced time spent in conditioning and increased time spent in modified and full-sided games during peak season (Kinnerk et al. 2019). Furthermore, Hall et al. (2016) highlighted that one elite rugby coach increased the amount of time spent in playing form activities during peak season by 25%. Coaches' reporting significant time being spent in conditioning and drills in early season in this analysis infers a traditional belief of ensuring players attain adequate levels of fitness and skill development prior to utilising games (Kinnerk et al. 2019). This significant shift in time spent in playing form activities between early and summer phases was corroborated within the qualitative data:

> *"Because in preseason you are working on all the skills in different drills, because I am a firm believer in being able to handpass left and right, working on kick passing even on your weak foot"* – Coach 2.

The sequencing of activities within practice sessions was another key focus of this research, as it is considered a distinguishing feature between traditional and GBA pedagogies (Cushion 2013). The quantitative data revealed that, irrespective of season type or phase of a season, coaches indicated sequencing training from activities such as drills, skills in isolation and conditioning, in the first third of their coaching sessions, before implementing playing form activities in the

remaining time (Figure 5.2). These findings support previous research, whereby soccer (O'Connor et al. 2018) and Gaelic football coaches (Kinnerk et al. 2019) prescribed drills early in their practice sessions before employing playing form activities. The structure of sessions in this manner strongly demonstrates a link to a traditional approach, with coaches believing that technical skills must be mastered before these skills can be applied in game situations (Evans 2006). This trend of sequencing was also noted in the qualitative data, as coaches repeatedly reported implementing training form activities prior to entering game play:

> *"Do it in a drill scenario first, and then stop, explain and then introduce it into the conditioned game."* – Coach 10.

In addition to practice activity types and session sequencing, the strategies implemented within practice sessions are a critical component to understanding the pedagogical approach of coaches (Cushion 2013). The traditional role of a coach has been to enhance players' physical, technical and tactical skills to ensure they succeed in competitive situations (Romar et al. 2016). Consequently, coaches aligned with a traditional approach, typically adopting "coach-centred" strategies, where the coach makes all the decisions and adopts a significant instructional behaviour that allows little opportunity for player input (Martens 2004, Partington and Cushion 2013, Romar et al. 2016). In contrast, GBA literature promotes the adoption of "player-centred" strategies (Harvey et al. 2010a, Pill 2016), where the coaches are repositioned as facilitators and are less directive, while the players are given autonomy and responsibility within sessions (Harvey et al. 2010a, Romar et al. 2016). Within the quantitative data, most coaches indicated support of some GBA aligned strategies, as they encouraged input and feedback from the players (92.3%),) and ask players questions to stimulate thinking and interaction (91.7%). These player-centred strategies were also identified within the qualitative data, as coaches frequently reported utilising questioning as a primary method to increase player engagement, and obtain feedback within the practice sessions:

> "*And then another way to engage players is just by asking open questions, try and get them talking, you know, why are we doing this? What could we do?"* – Coach 4

However, it should also be noted that coaches were less supportive of providing opportunities for dialogue and debate (31.9%) or including players in decision making (34.3%). Instead, coaches indicated a strong alignment with coach-centred strategies, where they provide the players with all the instruction, direction, and tools they need to perform a task (94.4%) and regularly stop an activity if the players aren't completing it to their expectations (80.9%). This was reiterated within

the qualitative data, as coaches described being unsupportive of providing opportunities for dialogue:

> "*With under sixteens maybe not [providing opportunities for dialogue], because you're trying to maybe tell them what you want off them more so"* – Coach 1.

The coaches' reluctance to use group dialogue and discussion within their sessions, instead favouring direct instruction, reflects the traditional view of learning that the coach holds the knowledge and athletes are passive receivers (Cassidy et al. 2015, Partington and Cushion 2013). Cushion (2013) states that these beliefs and assumptions are often by-products of the tradition or culture of coaching within the sport. Indeed, within many invasion team sports, the tradition and culture of coaching is categorised by high levels of instruction where coaches spend significant time in demonstrating, instructing and feedback (O'Connor et al. 2018).

Lyle (2007) states that coaching practice and knowledge is largely uninformed by pedagogy research, instead being developed overwhelmingly by informal sources, such as observation and experience. Light and Evans (2010) observed that elite rugby coaches were unfamiliar with the basic terminology and principles relating to pedagogy, while also failing to recognise the names of formal GBA models. The minimal impact of pedagogy on coaches' practice was also observed within this study, as GBAs, which we believe to be supportive of PA, are misunderstood and implemented inconsistently amongst youth Gaelic games coaches. In this analysis, coaches reported being largely unaware of the formal GBA models proposed in the academic literature (22.6%, Figure 5.3). Despite this, a cumulative 78% of coaches reported to implement one of these GBA models as the predominant approach within their coaching sessions, while just 10.7% of coaches claimed to not use a GBA of any kind within their sessions (Figure 5.3).

This contradiction, whereby coaches demonstrate a confidence in the application of GBAs within their sessions, but are largely unaware of the formal models, and fail to support it with tangible examples in their practice, is illustrative of an "epistemological gap". Light (2008) describes an epistemological gap as the use of the language of an approach, but with limited conceptual or practical understanding of it. For example, Evans (2012) highlighted that despite utilising playing form activities within their sessions and the term GBA becoming part of the coaching discourse, it was an approach that was not well understood and had limited influence on elite level rugby coaches practice sessions. In addition, previous qualitative research has depicted a common view of GBA amongst coaches as just involving the use of games in practice sessions without any consideration of its pedagogy (Evans 2012, Light and Evans 2010). This epistemological gap was also noted within the qualitative data, as coaches claimed to implement a GBA based solely on

their use of playing form activities, despite describing a more traditional approach throughout the discussion:

> *Yes, I would say we are using a game-based approach with the lads. We always try and bring in different types of games into training, whether that's conditioned games or 2 v 2 games."* – Coach 1.

The failure to integrate pedagogy research into coaching practice leads to coaches implementing a self-referenced anecdotal approach or "folk pedagogy", whereby coaches abstract some elements of a GBA and insert these within a traditional coaching session (Cushion 2013). Ultimately, both the quantitative and qualitative findings demonstrate that youth Gaelic games coaches are applying their own folk pedagogies. This is highlighted by the coaches' use of playing form activities and some GBA aligned strategies within their sessions yet reporting a predominate use of training form activities within a linear sequence, while favouring direct instruction. These findings support previous research where elements of GBA pedagogy, such as the limited use of playing form activities and questioning, were identified within primarily traditional sessions consisting of most of the time spent in training form activities (Ford et al. 2010, Light and Evans 2010, Partington and Cushion 2013). Roberts (2011) states that the implementation of these folk pedagogies results in a distorted understanding of a GBA and a range of "conceptual, pedagogical and cultural dilemmas" in its application.

To overcome these dilemmas and facilitate the development of coaching and the realisation of GBAs in practice, coaches require knowledge, understanding, practices, strategies, coherent arguments and critical thinking (Cushion, 2013), all of which are noticeably absent from formal coach education (Cushion, 2011; Piggott, 2011). Indeed, recent research has identified the limitations of large-scale formal coach education courses (Trudel et al., 2010; Piggott, 2012). This apparent failure of formal coach education was supported within this analysis as, despite NGBs adopting some GBA benchmarks within their coaching models (Coach10/MVA–Game Based Model, (Horgan & Daly, 2015)), over 50% of coaches reported that their formal Gaelic games coach education had either not prepared them or only somewhat prepared them to apply a GBA within their sessions. This was reiterated within the qualitative data, as C&G personnel, who are responsible for the implementation of the NGBs' coach education objectives and policies nationally and provincially, promoted some elements of a GBA within youth Gaelic games settings. However, examples of real-life implementation of this approach amongst youth Gaelic games coaches was absent. For example, despite not featuring amongst the coach participants, C&G personnel advocated for the sequencing of practice sessions in line with GBA literature:

"I think [that] is what we would be trying to promote. Start with the game, identify where the weaknesses are, work on that particular skill, and then get back into a game." – C&G Personnel 6.

Consistent with previous research, it was evident in this analysis that the formal Gaelic games coach education does not effectively promote the PA guidelines (Schlechter et al. 2017). Over 67% of coaches reported to be either unaware or unsure of the current national PA guidelines for youth, while just 15.5% of coaches correctly selected this guideline from six options. Furthermore, over 36% of coaches either disagreed or were unsure whether the Gaelic games coach education addressed the promotion of PA. Nevertheless, despite coaches' inability to accurately identify the PA guidelines, they demonstrated an awareness of the importance of PA and their role in providing PA for their players. A majority of coaches reported that it is important that practice sessions make a significant contribution to players' daily PA levels, that they consciously ensure players are physically active throughout their sessions, while also perceiving themselves as role models for PA. These findings are consistent with the only other study to examine whether coaches perceive themselves as influential on players' PA (Guagliano et al. 2014). Through qualitative interviews, Guagliano et al. (2014) found that youth OS coaches perceived themselves as role models for players' PA, that they were conscious of players PA levels during practice sessions and that they could accurately gauge how physically active players were. Coaches also perceived their practice sessions to provide sufficient PA and thus did not feel the need to try to increase PA during practices (Guagliano et al. 2014). Overall, Guagliano et al. (2014) concluded that coaches may underestimate the impact they can have on players' PA levels, and to further enhance the PA promoting capabilities of OS, there should also be an emphasis placed on educating coaches to capitalise on the opportunity they have to promote PA to their players.

5.5. Strength and Limitations

This research study had a number of strengths. First, to address the limitations of the self-report survey data collection, this study employed interviews with coaches and C&G personnel to confirm the findings. This qualitative data collection increases the richness of quantitative data collected and offers consideration of the context and situation within which these data were collected (Harvey et al., 2013). Second, this is a novel study as, to the authors knowledge, it is the first to examine the practices of male and female coaches across both codes of Gaelic football and Hurling/Camogie at a youth club level. In addition, the self-report method used in this survey for gathering information relating to practice activity type and session sequencing will provide coaches, researchers, and coach education curriculum developers with detailed information regarding coaching practices. Lastly, utilising the NGBs support in circuiting the survey, this research

successfully obtained a large nationwide sample of coaches across the different genders, codes and age grades.

The limitations of this study must be acknowledged. Firstly, as outlined by Kinnerk et al., (2019), no reliability tests were conducted on the questions used within the survey. While content and face validity measures were adopted, reliability tests would have increased the rigour of the survey design. Future studies may address this limitation by conducting a specific reliability study on this survey. Secondly, the self-report data obtained in the survey section of this study should be interpreted cautiously, as evidence suggests that coaches have a limited awareness of their coaching behaviours and approaches (Partington & Cushion, 2013; Cushion, 2010). Therefore, a coaches' perception of their practice may not present the true reality of how they conduct their practice. In addition, it is possible that coaches may state they use player-centred approaches, such as providing opportunities for discussion and debate, yet these strategies might not be used or coaches' understanding of what these terms mean and the frequency of their occurrence may differ from coach to coach (Denison, Mills, & Konoval, 2017).

5.6 Conclusion

The current study offered a unique insight into the coaching practices of youth Gaelic games coaches and their perceptions of their role in the provision of PA. This study found that while coaches were unable to identify the PA guidelines, they were aware of their role in providing PA for their players. Coaches predominately utilise training form activities within a traditionally linear sequence. Playing form activities were utilised within coaches' practice sessions, with the amount of time spent in this activity type increasing as a season progresses. There was variation in coaches' reporting of strategies used in practice sessions, with both traditional and GBA aligned strategies receiving support from coaches. However, an epistemological gap was apparent amongst coaches, as they reported to utilise a GBA within their sessions, despite having little awareness or knowledge of GBA pedagogy or its formal models. This was reinforced by qualitative data, in which coaches equated the use of game-related activity within their sessions to successfully implementing a GBA. In conclusion, the findings of this research reveal that while coaches demonstrated some alignment with GBA pedagogy, it is unlikely that coaches are employing authentic GBAs as promoted in the academic GBA literature, instead appearing to implement their own folk pedagogies.

5.7. Summary

The findings of this chapter identify the need for further education and engagement with PA and coaching pedagogy related literature to develop skilled coaches equipped to successfully apply a GBA, which may be supportive of increased PA. Furthermore, the effect of a GBA on players'

PA levels, particularly in a youth Gaelic football setting, is an important question which requires further assessment. Consequently, Chapter 6 will investigate the impact of a GBA intervention on youth Gaelic football practice sessions.

Chapter 6. The Effect of a Game-Based Approach Intervention on Players' Physical Activity Levels

6.1. Introduction

Organised sport (OS) is the most popular form of leisure-time physical activity (PA), with at least one third of children and adolescents participating worldwide (Aubert et al., 2018). Participation in OS is associated with improved psychological and social health, above and beyond other forms of leisure-time PA (Eime et al. 2013, Murphy et al. 2020). Gaelic games and their respective national governing bodies (i.e. GAA, LGFA and Camogie Association) form Ireland's largest community and sporting organisations, supporting approximately 500,000 playing members and 100,000 coaches (Horgan 2021). Given its prominent position and reach, the Gaelic games club has been highlighted as a suitable setting for the promotion and accumulation of PA amongst Irish youth (Lane et al. 2021). Gaelic football has the highest participation rates amongst Irish adolescents, with 32% of 12-18 years olds participating regularly (Woods et al. 2018). Notwithstanding the popularity of Gaelic football among this cohort, evidence from Chapter 3 and 4 suggests that approximately 50% of practice session time in this OS is spent sedentary or in light intensity physical activity (LIPA). This highlights opportunities to increase the contribution of Gaelic football to overall daily PA levels.

Coaches can develop a wide range of player outcomes through the activities and behaviours they use in their learning environment (Ford et al. 2010, O'Connor et al. 2018, Partington and Cushion 2013). The coach has been described as one of the primary factors influencing the quantity of PA levels attained in OS contexts (Howie et al. 2020). However, coaches in invasion team sports have typically placed a large emphasis on developing player performance through prescriptive technical skills practice (e.g., drills) (Ford et al. 2010, Low et al. 2013, Partington et al. 2014), while adopting significant instructional behaviour (Partington & Cushion, 2013). Research has shown that the implementation of such practices, commonly referred to as a traditional coaching approach, results in limited PA attainment (Cohen et al. 2014, Miller et al. 2016). For example, Cohen et al., (2014) demonstrated that youth soccer players spent just 37% (23 mins) of practice session time engaged in MVPA when coaches allocated a majority of practice duration to drills (46%), while also predominantly implementing direct tactical instruction. Consequently, there have been calls to further investigate youth OS coaching and to determine efficient ways of optimising the dose of PA accumulated by youth during OS (Leek et al. 2011, Pate and O'Neill 2011, Vella et al. 2016).

Improving PA during OS must be considered in the context of developing and enhancing successful performance, which is dependent on players' ability to display high levels of competency in technical and tactical skills (Farrow et al. 2008, Ford et al. 2010). A game-based approach (GBA) has emerged within coaching research as an improved pedagogical approach to address such needs,

by prioritising learning through game appreciation, tactical awareness, decision-making and skills execution (Cushion 2013). Additional to the development of technical and tactical skills, the implementation of a GBA also offers a way of simultaneously preparing athletes for the physical demands of competition (Hoffmann Jr et al. 2014). However, despite emerging evidence which has found that GBAs have a positive effect on player's PA levels (Miller et al. 2016, Nathan 2017, Sierra-Ríos et al. 2020), there is generally a dearth of intervention-based research in coaching settings to substantiate such findings (Kinnerk et al. 2018).

There are several forms of GBAs that exist within research and practice (e.g., Game Sense, TGfU), with common features including session characteristics (e.g., practice activities, sequence of activities) and pedagogical techniques (e.g., use of questioning/discussion). First, GBA pedagogy advocates the predominant use of playing form activity, also referred to as game-related activity, within coaching sessions (Bunker and Thorpe 1982, Light 2013), and typically includes activities such as phases of play, conditioned games, and small-sided games (Ford et al. 2010, Hall et al. 2016, Harvey et al. 2013). To promote the development of the skills necessary for success in competitive sport, research recommends that players spend greater amounts of time in this activity type, as it replicates the technical, tactical and physical aspects of match play (Ford et al., 2010; Hall et al., 2016). However, player involvement in game–related activity alone does not guarantee improvement in performance, and some form of guidance is required (i.e., conditions/rules within the game) (Cushion 2013). Therefore, the inclusion of GBA principles (e.g., sampling, tactical complexity) in the design of game-related activity has been suggested as a framework for coaches to create effective learning environments (Práxedes et al. 2019, Tan et al. 2012).

In addition to the employment of game-related activities as the primary activity type (Bunker & Thorpe, 1982; Light, 2013), GBA pedagogy promotes sequencing these activities in a structured format (Metzler 2005). Specifically, a GBA practice session should begin with an initial game to establish context for players and to assess players' competencies (Metzler, 2005), before progressing to additional playing form activities (Turner 2005). It is hypothesised that the sequencing of activities in this format stimulates players to interpret their experiences from previous games (Light, 2013). However, the presence of a sequence of game-related activities alone will not ensure learning (Rink 2014, Ward and Ayvazo 2016), as there must be connections present between these activities (Mitchell et al. 2013). Therefore, the potential for players to experience learning within sequencing is predicated on the coaches' ability to link all practice activities within a session to a common theme (Rink, 2014). Hence, tactical themes and principles of play are employed to guide session planning in GBAs (Mitchell et al. 2013, Pill 2016).

Another characteristic of GBAs is the targeted utilisation of the significant periods within practice sessions when players are not engaged in a practice activity (O'Connor et al., 2018). During these periods, players are occupied in water breaks, transitioning from activities, and in huddles with coaches. Few studies have captured the amount of time players spend in these periods, referred to as "inactivity" or "other" periods (Harvey et al. 2013, Low et al. 2013, O'Connor et al. 2018). However, the instructional behaviours used by coaches during these periods are central to player development (Ford et al. 2010), as GBA pedagogy promotes this time as an opportunity for learning and proposes that coaches utilise questioning and provide opportunities for players to discuss and debate ideas (Light 2013). These methods empower players to take responsibility for their own learning and explore critical components required to successfully perform in tactical and technical situations (Práxedes et al. 2016). Indeed, studies have shown that, when skilfully employed, questioning and opportunities for debate can improve player performance (García-González et al. 2014, Garcia-Gonzalez et al. 2013, Light and Harvey 2017).

Despite research demonstrating the potential benefits of GBAs to player development, uptake of this pedagogical approach by practitioners in coaching settings remains sparse (Harvey et al. 2013, Harvey and Jarrett 2014). Instead, coaches in invasion team sports consistently implement their own "folk pedagogies" (Harvey and Jarrett 2014), whereby they present playing form activities within a traditional coaching session structure (i.e. using direct instruction after a series of training form activities) (O'Connor et al. 2018). These findings were corroborated in Chapter 5, as Gaelic games coaches reported an awareness of GBAs and an appreciation for playing form activities, yet predominantly implemented training form activities and coach-centred strategies within their practice sessions. Lyle (2018) states that a major contributor to this lack of transfer and adoption of evidence-based coaching research to OS settings is a failure to produce in-situ intervention-based studies. A dearth of research investigating the effect of interventions on outcomes critical to successful performance (i.e. technical skills, PA) and minimal reporting on the acceptability of GBAs to players and coaches may have contributed to GBAs receiving little attention from coaches and coach developers (Cushion 2013, Harvey and Jarrett 2014).

As a result, the need for research to investigate GBA interventions across a broader scope of geographical areas, OS types and coaching context has been emphasised (Kinnerk et al. 2018). Considering previous research has demonstrated its positive effect on players' PA levels (Sierra-Ríos et al. 2020), and its existing position within the Gaelic games coaching discourse (Horgan and Daly 2015), a GBA was identified as a suitable approach to potentially impact youth Gaelic football players' PA levels. Moreover, Kinnerk and colleagues (2018) specified that studies which

investigate the impact of a GBA on players' PA using device-based measures are warranted. Thus, the aim of this current study is to investigate the effect of a GBA in a youth Gaelic football setting, on youth players' PA levels in comparison to their standard practice sessions. The study also aims to investigate the effects of the GBA on youth players' daily PA levels, practice session characteristics, such as practice activities, and determine players perceptions of the GBA practice sessions.

6.2. Methods

6.2.1. Design

This research study employed a quasi-experimental design to investigate the impact of a 2-week GBA intervention within a youth Gaelic football setting. Following a 1-week baseline measurement period (which included practice sessions delivered by their usual coach), specialist GBA coaches implemented the GBA intervention across four practice sessions with an U17 boys team and 2 practice sessions with an U16 girls team. The lower number of GBA intervention practice sessions conducted with the U16 girls team was due to a number of unforeseen scheduling conflicts and rearranged fixtures

There were three components to this study. Firstly, quantitative data of youth Gaelic football participants' PA levels during baseline and GBA practice sessions, and across two nine-day measurement periods was assessed using an activPAL accelerometer. Secondly, practice session characteristics were determined through the systematic observation of baseline and GBA practice sessions. Lastly, player perceptions of the baseline and GBA practice sessions were gathered using post-session questionnaires.

6.2.2. Participants

Using a convenience sampling method, one Gaelic football club in the Midwest of Ireland, with an active U17 boys and U16 girls team, was selected to participate in this study. Written informed consent was first obtained from the club executive committee (Appendix L), followed by written informed consent from the coaches of the U17 boys (n=2) and U16 girls teams (n=2) (Appendix M). Finally, written informed parental consent and participant assent was obtained prior to the commencement of the study (Appendix N-O). A total of 46 adolescents (22 male, 24 female) were recruited from their respective club teams. Participant inclusion criteria for the players were: (a) present for two baseline and two GBA practice sessions; and (b) provide the minimum number of valid days of PA measurement at both timepoints. Ethical approval for this research study was granted by the TUS Research Ethics Committee (#20210501).

6.2.3. Study Protocol / Procedures

Data collection for this study was conducted over three consecutive weeks, represented as three different timepoints (Figure 6.1). As highlighted in Chapter 6, youth Gaelic football coaches do not tend to employ authentic GBAs within their practice sessions, instead utilising their own folk pedagogies. Thus, timepoint 1 (T1) represented a baseline period of assessment where the coaches of the participating teams were encouraged to continue with their typical coaching approach. At this timepoint, two "baseline" practice sessions and the related quantitative (session characteristics & PA behaviours) and qualitative (player perceptions) outcome measures were recorded for both the U17 boys (n=2) and U16 girls (n=2) teams. While the coaches did not claim to have an explicit theme for these baseline practice sessions, they were observed to have a primary focus on "attacking" or "scoring" situations. In addition, daily PA data was also recorded across a nine-day measurement period during this timepoint.

Timepoint 2 (T2) and timepoint 3 (T3) represented the GBA intervention period, as both the U17 boys (n=4) and U16 girls (n=2) teams participated in GBA practice sessions. At both T2 and T3, data collection included a total of three GBA practice sessions (U17 Boys: n=2; U16 Girls: n=1) and the related quantitative (session characteristics & PA) and qualitative (player perceptions) outcome measures. At T2, PA data collection was limited to the recorded practice sessions only. At T3, PA data was also recorded across a nine-day measurement period to determine the impact of the GBA intervention on participant's daily PA levels. The reason for this was to limit the burden on the participants to wear the activPAL device for a total of three consecutive weeks.

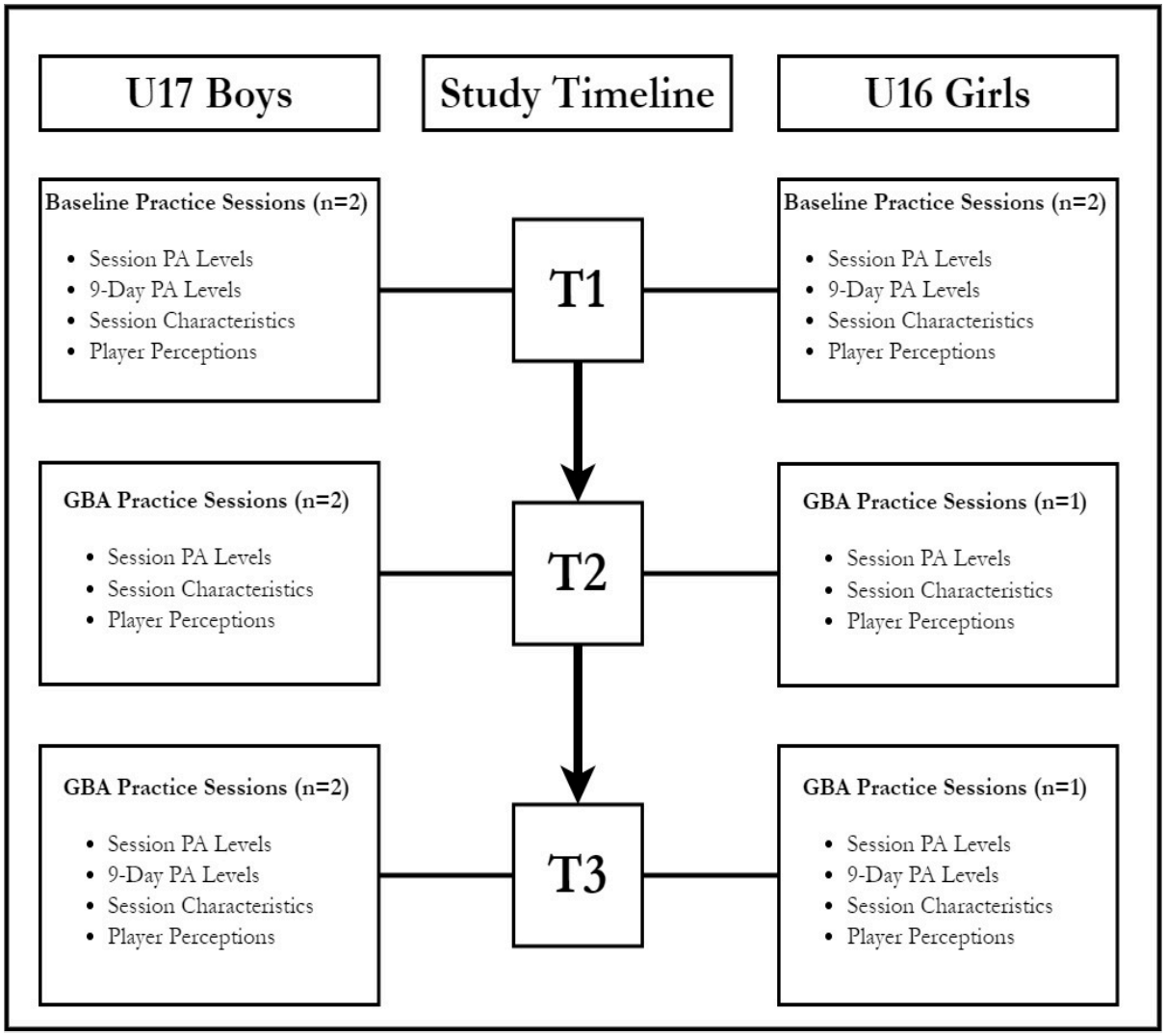


Figure 6.1 Study design timeline for the U17 boys' and U16 girls teams.

6.2.3.1. GBA Practice Session Delivery

The research team agreed that coaches with experience in employing authentic GBAs were required to assume the role of "specialist coaches" and deliver the GBA practice sessions in the club setting. A leading GBA expert in Gaelic games in Ireland provided a recommendation and access to two coaches to support the delivery of the study. These coaches had previously participated in a 26-week training intervention in GBA pedagogy (Kinnerk 2020), are experienced GBA practitioners and are acknowledged as advocates for GBA. Subsequently, these coaches were contacted by the research team and provided with the information related to the study, including what would be required of them if they were to agree to undertake the position of specialist coaches (i.e. number of sessions, travel requirements etc.). To streamline the delivery of these GBA practice sessions and limit the burden on the specialist coaches to travel to the selected club, the boys and girls practice sessions were run consecutively at each visit to the club. Following engagement and confirmation of study dates, the coaches agreed to partake in the study in the specified role.

6.2.3.2. GBA Practice Sessions

Prior to the commencement of data collection at T2 and T3, both the U17 boys and U16 girls coaches were provided with the opportunity to request a specific tactical theme (e.g. attack, keeping possession) which they wanted to be the central focus within the GBA practice sessions. The participating coaches requested that the tactical theme of the GBA practice sessions be decided by the specialist coaches. Thus, a total of four separate practice sessions aligned with Light's (2013) four features of GBAs and linked to the theme of "Understanding Width" were developed by the specialist coaches. The structure of each practice session reflected a format previously utilised within GBA research (Mitchell et al. 2013, Kinnerk 2020):

1. **Initial game:** Players are introduced to an activity which presents a tactical problem and sets the focus for the remainder of the session. This game is typically played one to two times for between 3-5 minutes before progressing.
2. **Questions and setting new challenges:** After the initial game, a coach-player huddle is organised where players are asked questions regarding this activity. Questions for this section can be pre-planned and aim to promote discussion about the theme of the session and identify concepts to improve in this area.
3. **Modified game:** This game-related activity is designed to assist players in developing concepts or factors identified in the initial game form. This activity is typically performed for between two to five sets over a predetermined length of time, ranging from 2-3 minutes (i.e.5x2mins). At the end of each completed set, coaches utilise both player huddles and coach-player huddles to allow for discussion and debate.
4. **Skills practice (if necessary):** During the initial game and modified games, the specialist coaches may determine that players' performances are being inhibited by a failure to execute skills. In such circumstances, the coaches may prescribe training form activities (i.e. skills in isolation, drills) to emphasise a particular technical skill with a view to facilitate improved game performance. The amount of time afforded to this type of activity is limited to until the players can successfully perform the skill before returning to game-related activities.
5. **Progressive game:** The aim of this activity is to target the associated theme of the session, but with conditions that increase the complexity of the task. Like the modified game activity, this activity is typically performed over several predetermined sets and lengths of time (i.e.5x2mins). Opportunities for questioning, discussion and debate are also provided using coach-player huddles in between games.

6. **Return to initial game:** The final activity sees the players return to the initial game they performed at the beginning of the practice session. The emphasis in play and conditions within this activity should be on elements covered within the previous activities.
7. **Session review:** Summary of the session through discussions and questioning around the tactical concepts identified and worked on within the session.

Figure 6.2 presents one of the utilised GBA practice sessions as an example of all sessions conducted in this intervention.

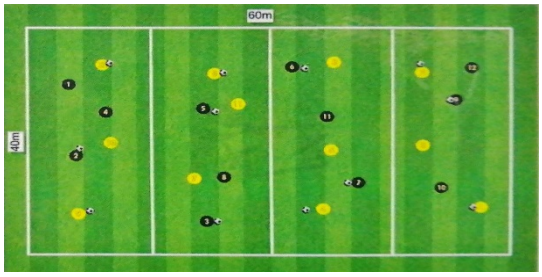
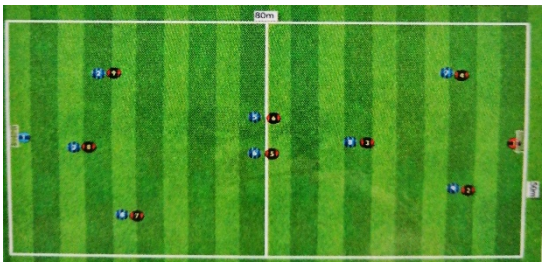
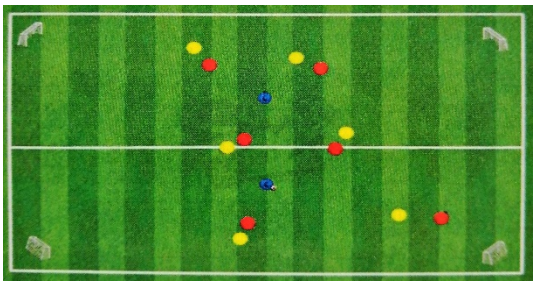
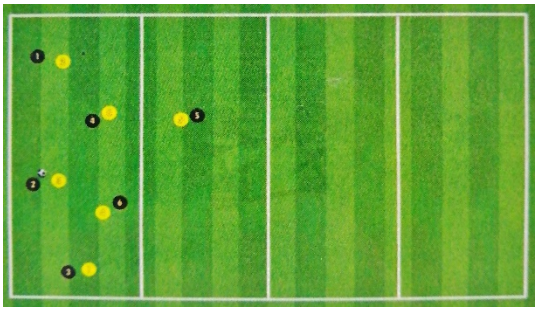
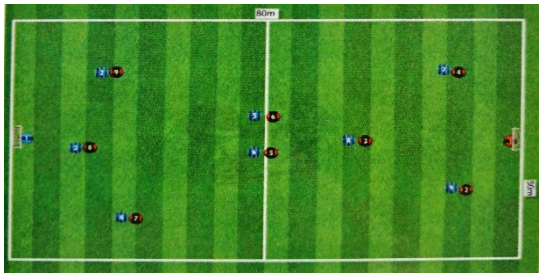
Warm Up (10 mins) 	**Kick Pass and Go** 1. Players take 2 solos before they kick pass. 2. Once they kick pass they must move zones. 3. To progress to long kicks the player must skip a zone when they kick pass.
Initial Game (2x3 mins) 	**20 Seconds** 1. Game starts with a throw in 2. Team in possession has 20 seconds to build the ball past half way. If they do so, any score they get is doubled. 3. Team defending must keep at least one player up in attack.
Modified Game (3x3 mins) 	**Double Lanes** 1. Players can score in either plane. 2. Coach (in blue) decides which side of the pitch the players can score in by moving to that side. 3. Option is there for the coach to play as floater if needed. **Questions** Why do we have to have players in both halves? How does this relate to a real game? How would communication help in this game?
Progressive Game (3x3 mins) 	**Give and Go** 1. Team in passion must try to work the ball through the zones by kick pass. 2. They can use the coach as a floater. 3. Once they hand pass in the first zone, they must move to the next zone. 4. They can re-enter the first zone after they've none this or they can look for a kick pass. **Questions** How can we create depth in this game after we pass? Explain that more. How important is movement when I'm receiving a pass? Why is this game important? Explain.
Return to Initial Game (2x3 mins) 	**20 Seconds** **Questions** Why are steps important? Can you expand on that? Why do we have more time when we move past halfway? Why is it important to move the ball quickly from defence? How can we use the lanes when we move past halfway?

Figure 6.2 Example of the specialist coaches' session plan for one of the GBA practice sessions.

6.2.4. Data Collection

Data were collected in this study in relation to: (1) PA of players, (2) session characteristics, and (3) players' perceptions of practice sessions.

6.2.4.1. Physical Activity

6.2.4.1.1. Physical Activity Assessment

The activPAL3 micro activity monitor (activPAL^{3M}, PAL Technologies Ltd., Glasgow, UK) was the device-based measurement tool used to assess free-living PA levels in this study. As a detailed description of the activPAL^{3M} and the wear protocol employed in this research has been previously provided in Section 3.2.5, it will only be briefly outlined here.

Following the study design schedule as outlined above in Section 7.2.1, participants were provided with their activPAL^{3M} devices prior to the selected practice sessions. Under the supervision of the primary investigator, the participants attached the device directly to the skin on the midline of the anterior aspect of the right thigh using a transparent dressing (Tegaderm™ Foam Adhesive Dressing). To further secure the device in place during the practice sessions, participants were also provided with an elasticated tubular support bandage (Sterogrip™ Elasticated Tubular Bandage).

At T1 and T3, participants were instructed to wear the activPAL^{3M} device 24 hours per day (except while swimming or bathing) for a total of nine consecutive days (including two practice sessions). The participants were also provided with additional adhesive dressings, instructions detailing how to change the dressings, and an activity log to record any time the device was removed and reapplied, or any time they participated in an additional OS over the nine-day period. In contrast, during T2, participants were only required to wear the activPAL device during the practice sessions. Following the data collection periods, the primary investigator collected the activPAL devices, and downloaded the activity information to a laptop.

6.2.4.1.2. Data Processing

The protocol used for data collection and reduction is described in detail in Section 3.6, and thus will only be briefly described here. The primary investigator accessed the recorded epoch data using the PALanalysis Software™ (version 8.11.9), before exporting it to a Microsoft Excel (Redmond, WA, USA) file format to be processed. The activPAL output was individually screened to ensure that each participant had provided a sufficient number of valid days of accelerometer recording. Participants were included in this free-living analysis only if they achieved at least four full days of accelerometer recording (3 weekdays and 1 weekend day) (Trost et al. 2005) across each nine-day period. The output files were then examined to produce daily PA variables, which

include sitting/lying time, standing time, LIPA, moderate physical activity (MPA), vigorous physical activity (VPA) and MVPA. The start and finish times of each recorded practice session were identified within the output files and the PA variables during these periods were also quantified. To control for the variation in the amount of time spent in practice sessions, the PA variables during these sessions were defined as minutes per hour (min/hr). This was achieved by dividing the amount of time spent in each PA variable by the duration of each practice session and then multiplying by 60.

6.2.4.2. Baseline and GBA Practice Session Characteristics

6.2.4.2.1. Practice Session Recording

A total of 4 baseline practice sessions (U17 Boys: n=2; U16 Girls: n=2) and 6 GBA practice sessions (U17 Boys: n=4; U16 Girls: n=2) were recorded during this study. Each of these practice sessions were recorded using a digital video camera (Panasonic HC-V100, Panasonic Co., Japan) mounted on a stationary tripod (SLIK U9800, SLIK Corporation, Japan). To provide an unobstructed view of all practice activities, the camera was positioned at either the left or right corner of the training pitch. The video footage of each practice session was then uploaded to a laptop computer (Dell Latitude 5410, Dell Computer Corporation, Texas, USA) and coded.

6.2.4.2.2. Coding System

To assess the structure of the coaching sessions in this study, a coding system developed by Kinnerk and colleagues (2020) was employed. The development of this coding system is described in detail elsewhere (Kinnerk 2020). Briefly, to code the practice activities implemented by coaches in practice sessions, Kinnerk and colleagues (2020) developed terms and definitions for training form activities (i.e. drills) and playing form activities (i.e. modified games) in a Gaelic football context. In addition, periods within practice sessions when players are not actively participating in a practice activity were included in the coding system. To code these periods, previously referred to as "inactivity or "other" (Harvey et al., 2013; O'Connor et al., 2018), terms and definitions used by O'Connor et al. (2018) were proposed (i.e. player huddle).

To ensure content validity, a review process of the coding system was conducted, which resulted in a number of modifications. Kinnerk and colleagues' (2020) final coding system included three training form activities (drills, skills in isolation, fitness), five playing from activities (applied skills practice, small-sided games, conditioned games, phase of play, full-sided games) and five "inactivity" terms (freeze in position, coach-player huddle, player huddle, drink break, transition).

Prior to implementation within this research, one modification to this coding system was made, where the descriptor "inactivity", was modified to "other" activity. Given that the measurement

of PA data is a primary aim of this research study, the use of "inactivity" to describe these times would conflict with the accepted PA research terminology. The final coding system utilised in this study is presented in Table 6.1.

Table 6.1 Practice session coding terms and definitions.

Training Form	
Drills	Exercises practiced unopposed in lines that require the repetition of skills and prescribed directional movement.
Skills in Isolation	Similar to drills but do not occur in lines/use of cones and are often completed with little movement/no pressure thus allowing the player to solely concentrate on the skill being practiced (e.g., random practice exercises such as 3 players kick passing to each other randomly throughout field with no pressure).
Fitness	Exercises completed without the ball that usually focus on improving fitness, speed and agility etc. (e.g., warm-up/cool down non-ball exercises, stretching, timed runs, conditioning)
Playing Form	
Applied Skills Practice	Activities that involve some level of opposition and where technique is exposed to pressure and elements of decision-making are required. Typically, uneven or low number activities (1vs1/2vs2/4vs2).
Small-Sided Games	Match-play with reduced number of players and two goals (No conditions imposed)
Conditioned Games	As per small-sided games, but includes variations to rules and areas of play (e.g., Players cannot cross halfway, X number of passes needed before shooting, possessions, steps only)
Phase of Play	Unidirectional match-like play, toward one goal (e.g., One team always attacks)
Full-Sided Games	Actual match-play. Game played with the full complement of players present at a training session. Regulation rules with two goals.
"Other" Activities	
Freeze in Position	Coach stops the activity to talk to the players and the players remain in their current position during the activity (i.e., "stop and hold there…")
Coach-Player Huddle	Coach stops the activity and gets the players to come together for a discussion in a certain area (i.e., "stop and bring it in..")
Player Huddle	Coach stops the activity and asks players to lead a discussion without coach's presence (i.e., "attackers have a chat amongst yourselves…")
Drink Break	Periods of time where the players have been told by the coach to have a rest and a drink (i.e., "stop there and go get a drink…")
Transition	Periods of time where the players are moving (or transitioning) between activities or inactivity periods such as the players moving back into position following a player huddle or drink break

6.2.4.2.3. Coding Process

The coding of practice activities (i.e. training form and playing form) and "other" activities followed a distinct process. Firstly, coding of a practice activity (e.g., drill) began once instruction/conversation in relation to that specific practice activity was initiated by the coach. A practice activity was then regarded to end once the coach commenced instruction/conversation on the next practice activity. Within these practice activity types, the start and end times for coding "other" activities were initiated by the coach. The moment the coach stopped the practice activity temporarily, this signalled the beginning of the "freeze in position" code and once the coach initiated the play again, this signalled the end of this specific "other" activity. The start and end times for transitions were coded by focusing on one player within the group and identifying the moment they left a stationary position within a drink break or huddle as the start time for the transition. The moment that the selected player reached a stationary point again for the commencement of a huddle or practice activity was identified as the end time for a transition (Miller et al., 2016).

"Other" activities often occurred during an individual training from or playing form activity. For example, coaches would often implement "freeze in position" or "coach-player huddles" throughout the duration of a conditioned game. As a result, this study did not subtract these "other" activity periods from the practice activity type in which they occurred. Instead, "other" activities were coded simultaneously to practice activities when such periods occurred, resulting in separate values for both. (Kinnerk 2020). As a result, within each practice session all training form and playing form activities added to the total session duration and percentages added to 100.

6.2.4.3. Player Perceptions of Practice Sessions

After each of the baseline and GBA practice sessions, a short questionnaire was completed by the players (Appendix P). Informed by previous research which has examined the attitudes and perceptions of adolescents towards PE and OS (Beni et al. 2017, Lubans et al. 2011b, Rikard and Banville 2006, Säfvenbom et al. 2015, Zeng et al. 2011), the aim of this questionnaire was to assess the players' perceptions of both the baseline and GBA practice sessions. The questionnaire consisted of a 4-point Likert scale question, which asked players to indicate to what extent they agreed or disagreed with 10 different statements (Table 6.5). The included statements related to topics such as the players enjoyment, and whether they perceived the practice sessions to have improved several outcomes (e.g., skills, fitness, decision making). The Likert scale responses ranged from strongly agree to strongly disagree.

6.2.5. GBA Intervention Validation

Ragan and Smith (1999) suggest that when conducting any research involving pedagogical models, it is necessary to validate that the methods of instruction are aligned with the framework set out by that specific approach. Furthermore, Harvey and Jarrett (2014) maintain that a greater acceptance of GBAs would be secured by greater reporting of intervention and validation procedures. Therefore, to ensure the GBA practice sessions were employed by the specialist coaches as stipulated in the GBA literature, context specific validation protocols and benchmarks were utilised (Harvey and Jarrett 2014). Firstly, following video recording, each practice session was coded using a validation protocol (Appendix Q) (Turner and Martinek 1999). This validation protocol requires the coder (primary investigator) to make several judgements on each practice session based on the following criteria:

a) The players spent most of the practice in game-related situations.

b) The players spent the practice learning specific skills taught by the coach before playing the game.

c) The coach started the session with skill instruction.

d) The coach intervened in game-related situations to discuss strategies with players.

e) The coach based their practice on observations of an initial game.

f) The major emphasis of the practice was skill development.

g) The major emphasis of the practice was tactical instruction in game-related situations.

Successful implementation of the practice sessions as outlined in the GBA research would yield a 'yes' response to items a, d, e, and g, and a 'no' response to items b, c, and f. To assist the primary investigator in making the correct judgements, the coding instrument (see Table 6.1.) utilised to describe coach practices according to activity type was referenced during this validation process. For example, the amount of time players spent in playing form and training form activities and what sequence these activities were implemented within the practice sessions was recorded using the coding instrument. This enabled the primary investigator to make a confident decision in relation to criteria 'a', 'b' and 'c' in the validation protocol.

Secondly, to determine the pedagogical behaviours necessary for the accurate delivery of a GBA practice session, a benchmark observational instrument was designed based on (Metzler 2011) benchmarks for coaches (Appendix R). The coaches' benchmark checklist included the following seven benchmarks:

1) The coach uses a tactical problem as the organising centre for learning tasks/practice activities.

2) The coach begins each session with a game form to assess player knowledge and to provide context for the remainder of the session.
3) The coach identifies needed tactical and skill areas from game form.
4) The coach uses deductive questions to get players to solve tactical problem.
5) The coach uses clear communications for situated learning tasks.
6) The coach uses high rates of guides and feedback during practice activities.
7) The coach provides a review that includes the tactical problems of the session.

Following coding of the recorded practice sessions, successful implementation of a GBA was confirmed if a 'yes' response to all 7 benchmarks was noted. Ultimately, the results of both the validation protocol (Turner and Martinek 1999) and benchmark validation (Metzler 2011) indicated that the GBA was validly implemented by the specialist coaches within all sessions.

6.2.6. Data Analysis

6.2.6.1. Physical Activity

The activPAL output was summed and averaged over the measured data collection periods for the male and female participants. The total time spent sitting/lying, standing, in LIPA, MPA, VPA and MVPA during waking hours was examined. All outcome variables were tested to meet the assumptions for normal distribution using the Shapiro-Wilks test of normality. The homogeneity of variance of data was investigated using the Levene's test. In the case of data that did not demonstrate a normal distribution, the parametric conclusion was confirmed using non-parametric equivalent tests. For ease of interpretation, the parametric result is reported within. In the case where the parametric test did not confirm the non-parametric result, the non-parametric test statistic is reported.

Paired sample t-tests or Wilcoxon Signed ranks tests were utilised to examine the differences in the amount of time spent in PA behaviours (sitting/lying, standing, in LIPA, MPA, VPA and MVPA) between baseline and GBA practice sessions for males and females separately. Paired sample t-tests and Wilcoxon Signed ranks tests were also utilised to compare the amount of total daily time spent in PA behaviours between T1 and T3 for males and females separately. Finally, differences in the means of each PA behaviour between males and females during baseline practice sessions, GBA practice sessions, and on total measured days at T1 and T3, were established using independent samples t-tests or Mann-Whitney U tests. To reduce the likelihood of Type I error, p-values were subjected to Benjamini–Hochberg adjustment. Cohen's d effect sizes (d) denoted a small (d=0.2), medium (d=0.5) and large (d=0.8) effect (Cohen 1988) and the alpha level required for significance for all tests was set at $p<0.05$.

6.2.6.2. Session Characteristics

The duration of each practice session was recorded, and time spent in each training form activity, playing form activity and "other" activity was coded and quantified. Previous research has generally used frequencies and percentage of total actions to describe coaching practices (Isabel et al. 2008, Partington et al. 2014, Potrac et al. 2007, Smith and Cushion 2006). However, as frequency data could vary in relation to the duration of a practice session (Ford et al. 2010), in this analysis, the duration of time spent in each practice activity type and "other" activity was calculated as a percentage of the total practice session duration (Hall et al. 2016, O'Connor et al. 2018). These values were calculated by dividing the duration of the activity by the total duration of the practice session and then multiplying this number by 100.

Paired sample t-tests or Wilcoxon Signed ranks tests were used to compare the amount of time spent in training form activity, playing form activity and "other" activity during baseline and GBA practice sessions for the U17 boys and U16 girls teams separately. Differences in the amount of time spent in training form activity, playing form activity and "other" activity between U17 boys and U16 girls teams during baseline and GBA practice sessions were established using independent sample t-tests or Mann-Whitney U tests. To reduce the likelihood of Type I error, p-values were subjected to Benjamini–Hochberg adjustment. Statistical analyses were performed using IBM SPSS 26.0 (SPSS, Inc; Chicago, IL). Cohen's d effect size measures were calculated as appropriate**.** The alpha level required for significance for all tests was set at $p<0.05$.

6.2.6.3. Player Perceptions

Descriptive statistics (frequencies and percentages) were used to analyse responses to Likert scale questions. A dichotomous variable was created for players' agreement with statements in relation to the practice sessions (1=Strongly Agree/Agree; 2=Disagree/Strongly Disagree). Chi squared analysis were run to identify differences in players' perceptions of the baseline and GBA practice sessions. Phi (φ) values of 0.1, 0.3 and 0.5 represent small, medium and large effect sizes, respectively (Cohen 1988). Chi square tests assume that 80% of cells have expected counts of 5 or more, thus where this assumption was violated, significance values for Fishers Exact Test were reported.

6.3. Results

6.3.1. Participant Characteristics

A total of 18 players from the U17 boys' team (mean age: 15.6±0.5 yrs.) and 20 players from the U16 girls team (mean age: 14.4±0.7 yrs.), who were present for two baseline and two GBA practice sessions and provided the minimum number of valid days of PA measurement at both timepoints, were included in the analysis.

6.3.2. Physical Activity Levels

6.3.2.1. Practice Session Physical Activity Levels

Figure 6.3 presents the distribution of time spent in sitting/lying, standing, LIPA, MPA, VPA and MVPA during baseline and GBA practice sessions. During the GBA practice sessions, participants spent significantly less time in sitting/lying (U17 boys: $t(27)=5.264$, $p=0.033$, $d=0.5$), standing (U17 boys: $t(27)=-5.264$, $p<0.001$, $d=1.5$; U16 girls: $t(35)=8.555$, $p<0.001$, $d=2.5$) and LIPA (U17 boys: $t(69)=11.857$, $p<0.001$, $d=2.8$) when compared to baseline practice sessions. Concurrently, participants were observed to spend significantly more time in MPA (U16 girls: $t(28)=-4.229$, $p<0.001$, $d=1.3$), VPA (U17 boys: $t(69)=-11.986$, $p<0.001$, $d=2.9$; U16 girls: $t(36)=-7.752$, $p<0.001$, $d=2.2$) and MVPA (U17 boys: $t(26)=-12.299$, $p<0.001$, $d=3.5$; U16 girls: $t(29)=-10.600$, $p<0.001$, $d=3.0$) during the GBA practice sessions.

In addition, significant differences were observed between genders during the baseline practice sessions, with male participants spending significantly less time standing ($t(48)=-3.993$, $p<0.001$, $d=1.1$), and significantly more time in LIPA ($t(48)=-6.814$, $p<0.001$, $d=1.9$) than their female counterparts. In contrast, during the GBA practice sessions, no significant gender differences were observed for time spent in each PA intensity ($p>0.05$).

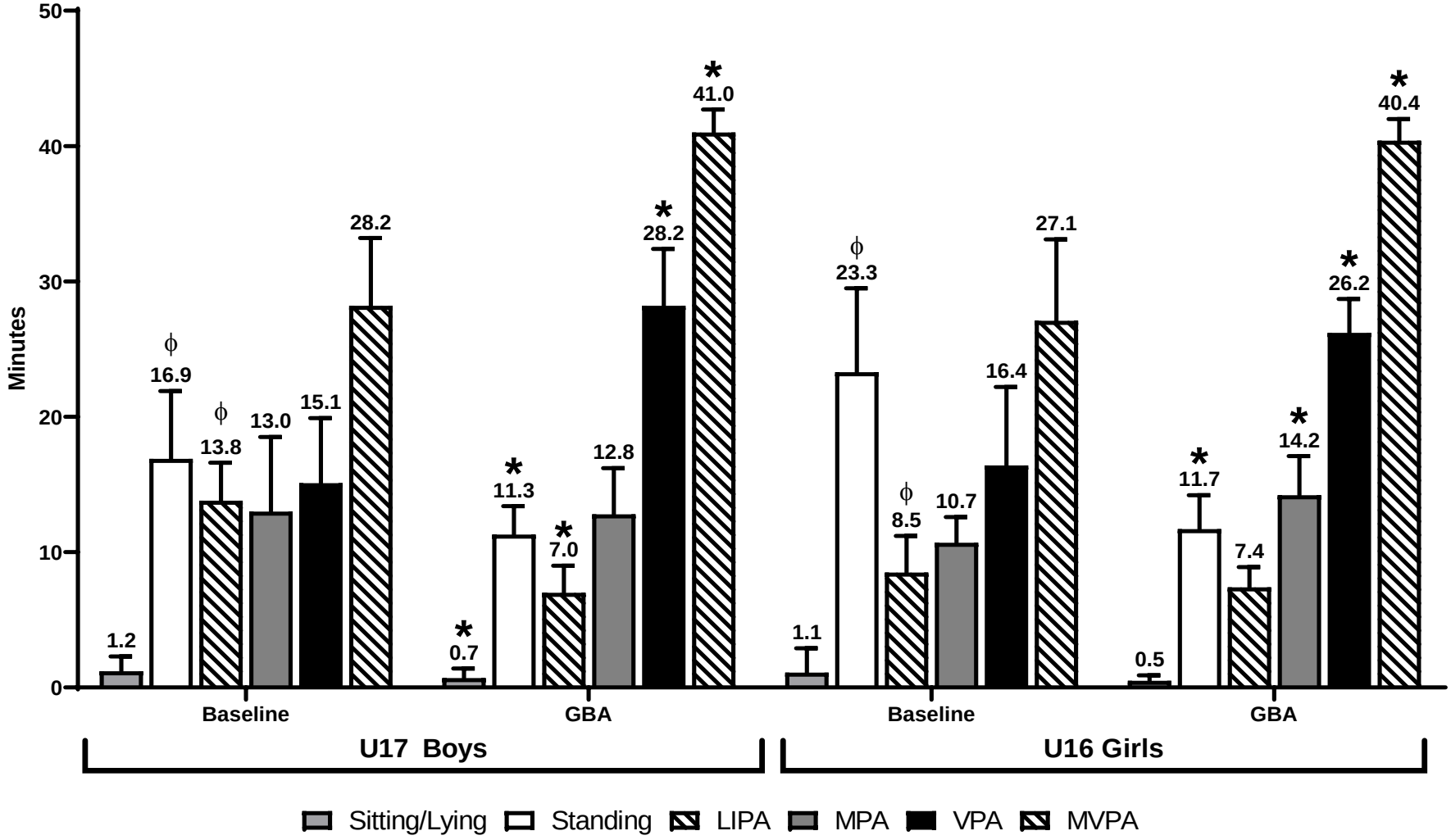


Figure 6.3 Physical activity intensity (minutes) during baseline and GBA practice sessions.

** Significant difference between baseline and GBA practice sessions ($p < 0.05$); Φ Significant difference between genders ($p < 0.05$)*

6.3.2.2. Daily Physical Activity Levels

Table 6.2 describes participants' daily waking time spent sitting/lying, standing, in LIPA, MPA, VPA and MVPA across a nine-day measurement period in both T1 and T3. Overall, between the timepoints, participants significantly increased time spent in MPA (Males: $t(105)=-2.416$, $p=0.017$, $d=0.47$; Females: $t(143)=-2.856$, $p=0.005$, $d=0.49$), VPA (Males: $t(90)=-3.174$, $p=0.006$, $d=061$; Females: $t(143)=-2.031$, $p=0.026$, $d=0.34$) and MVPA (Males: $t(95)=-3.201$, $p=0.003$, $d=0.62$; Females: $t(143)=-2.974$, $p=0.003$, $d=0.52$). Additionally, over time, female participants significantly increased total daily waking time (Females: $t(143)=-3.659$, $p<0.001$, $d=0.63$) and the amount of daily waking time spent standing (Females: $t(77)=-2.845$, $p=0.005$, $d=0.52$).

Statistically significant gender differences were observed at both T1 and T3, with females spending significantly more time in standing than their male counterparts (T1: $t(147)=-3.137$, $p=0.002$, $d=0.53$; T3: $t(101)=-4.179$, $p<0.001$, $d=0.82$). At T1, 22% of males and 20% of females met the current WHO PA guidelines. At T3, compliance with these PA guidelines increased, with 67% of males and 70% of females successfully meeting the guidelines.

Table 6.2 Mean daily physical activity intensity (minutes) for male and female participants at T1 and T3.

	U17 Boys		**U16 Girls**	
	T1	**T3**	**T1**	**T3**
Total Waking (mins)	719.8 (153.1)	766.4 (113.3)	743.6 (96.1)	**807.0 (103.9)***
Sitting/Lying (mins)	457.3 (104.9)	459.0 (132.8)	426.9 (119.3)	414.3 (119.2)
Standing (mins)	147.5 (78.5)	161.8 (77.7)	**188.9 (76.5)†**	**235.4 (100.5)*†**
LIPA (mins)	71.0 (45.9)	78.5 (44.1)	78.4 (51.3)	89.8 (37.9)
MPA (mins)	31.4 (20.6)	**41.5 (22.6)***	31.6 (20.6)	**42.6 (24.2)***
VPA (mins)	12.8 (16.0)	**25.7 (25.1)***	17.9 (19.1)	**25.0 (22.0)***
MVPA (mins)	44.2 (30.1)	**67.2 (43.1)***	49.5 (33.9)	**67.6 (36.3)***
Achieved PA Guidelines % (n)	22 (4)	20 (4)	67 (12)	70 (14)

*Values are Mean (SD) * Significant difference between T1 and T3 ($p < 0.05$); † Significant difference between genders ($p < 0.05$)*

6.3.3. Practice Session Characteristics

6.3.3.1. Practice Session Duration

Table 6.3 describes the mean duration of the baseline and GBA practice sessions across the participant groups. Practice session duration was not significantly different between baseline and GBA sessions for the U17 boys' team ($p=0.942$; $d=0.10$) and U16 girls team ($p=0.655$; $d=0.51$).

Table 6.3 Practice Session Duration

	U17 Boys	**U16 Girls**
Baseline Session Duration (min)	64.0 (3.7)	58.5 (2.1)
GBA Session Duration (min)	64.5 (6.0)	61.3 (7.4)

Values are Mean (SD)

6.3.3.2. Practice Activities

Table 6.4 presents the percentage of baseline and GBA practice session time spent in training form and playing form activity types. During baseline practice sessions, the U17 boys' team and U16 girls team were observed to spend most of practice session time in training form activities. In contrast, during the GBA practice sessions there was a significant decline in training form activities and an increase in playing form activities (U17 boys: $t(3)=20.820$, $p<0.001$; U16 girls: $t(2)=4.601$, $p=0.044$). Consequently, the U17 boys' team and the U16 girls team spent the majority of GBA practice session time in playing form activities. In addition, significant gender differences were observed during the baseline practice sessions, with the U17 boys' team spending significantly more time in training form activities ($t(2)=4.970$, $p=0.038$, $d=3.60$). In contrast, during the GBA practice sessions, no significant gender differences were observed for time spent in training form or playing form activities ($p>0.05$).

Table 6.4 Percentage of practice session duration spent in training form and playing form activity types.

	U17 Boys		U16 Girls	
	Training Form (%)	**Playing Form (%)**	**Training Form (%)**	**Playing Form (%)**
Baseline Session	75.0	25.0	53.2	46.8
GBA Session	11.6	88.4	10.3	89.7

Figure 6.4 presents a breakdown of the percentage of time spent in specific training form and playing form activities during baseline and GBA practice sessions. Overall, there were primary changes to two specific practice activities between the practice sessions. There was a large decline in the use of drills during GBA practice sessions for the U17 boys' team (Baseline: 19.8%; GBA: 0%) and U16 girls team (Baseline: 17.4%; GBA: 0%). Concurrently, there was a large increase in the use of conditioned games during GBA practice sessions for the U17 boys' team (Baseline: 25.0%; GBA: 70.3%) and U16 girls team (Baseline: 0%; GBA: 68.2%).

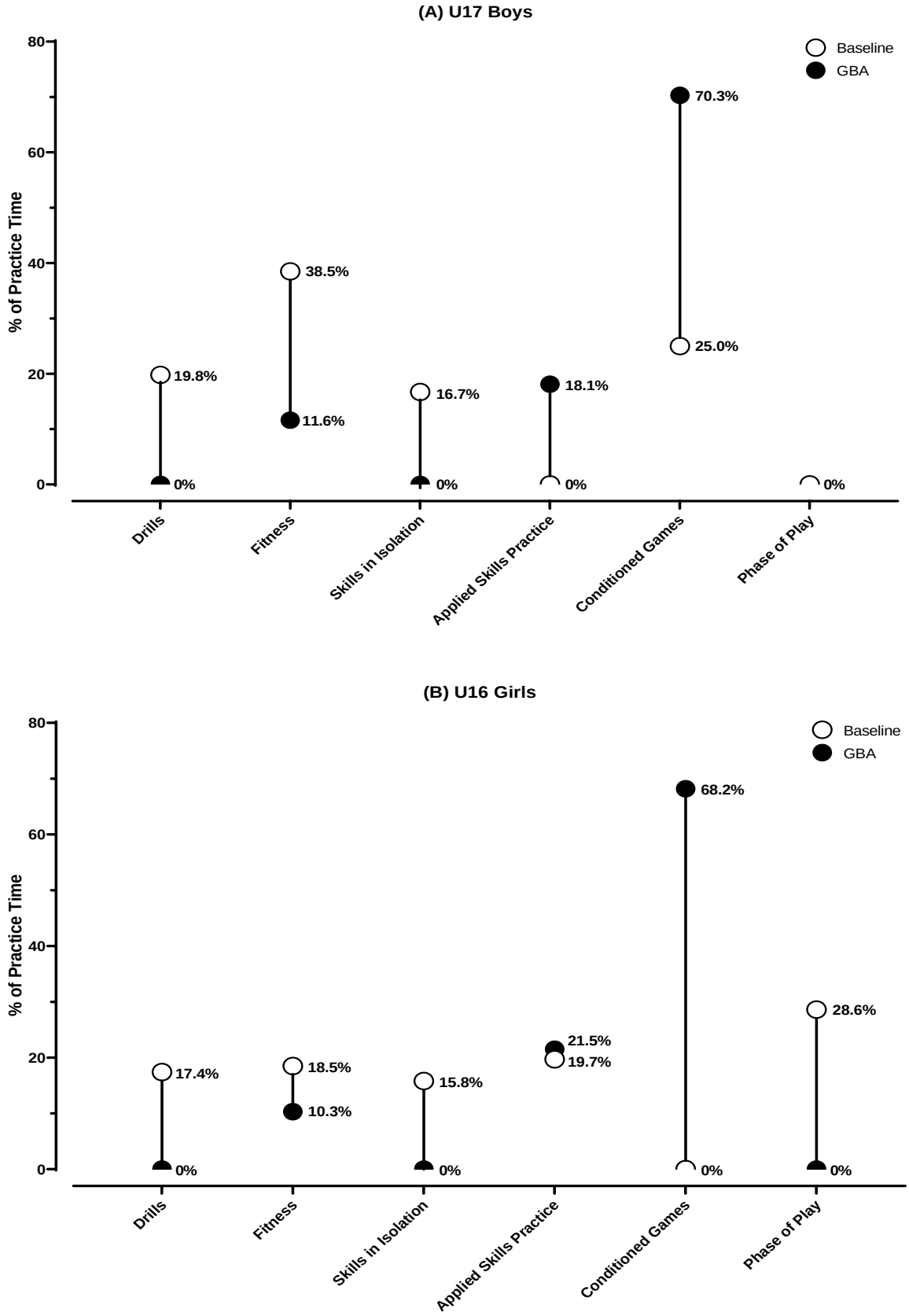
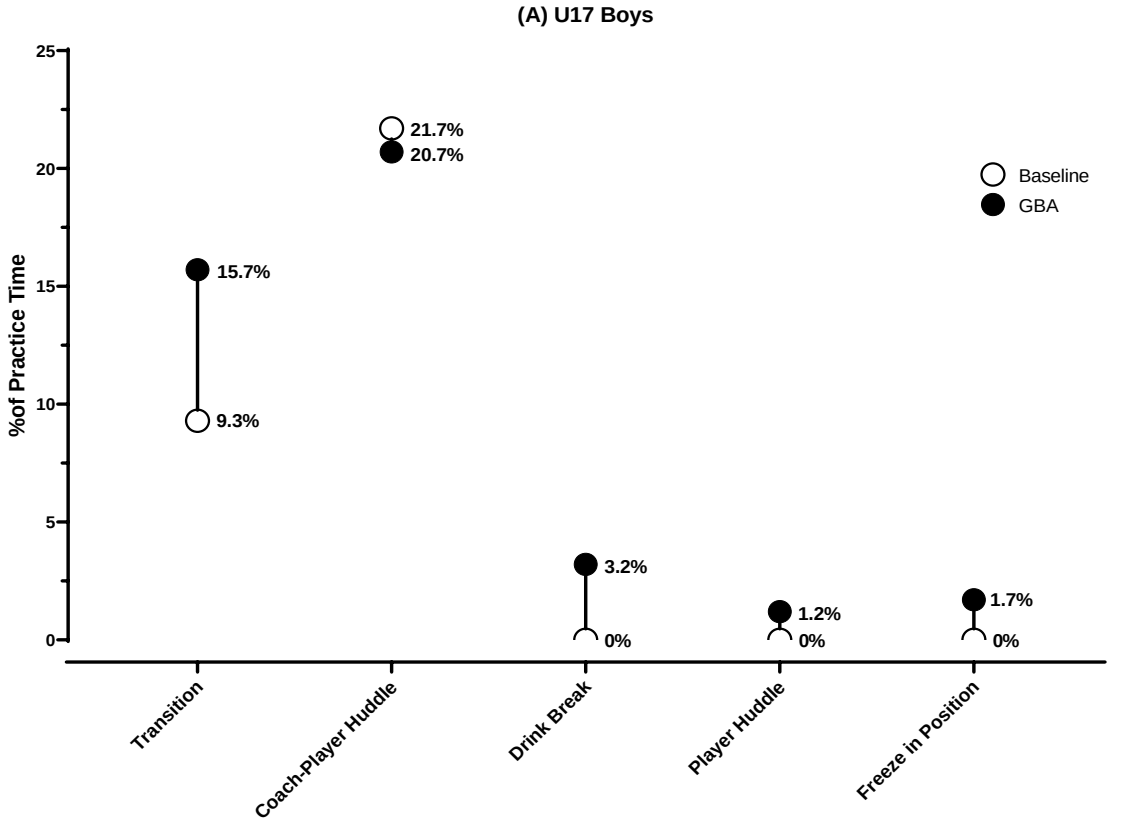


Figure 6.4 Breakdown of the specific activity types and the percentage time spent within each activity type during baseline and GBA practice sessions.

6.3.3.3. "Other" Activities

Compared to baseline practice sessions, the U17 boys' team (Baseline: 31.3%; GBA: 42.1%; t(3)=-2.262, p=0.109; d=2.79) and U16 girls team (Baseline: 31.6%; GBA: 43.4%; t(2)=-2.193, p=0.160; d=2.18) were observed to spend a larger percentage of time in "other" activities during the GBA practice sessions.

Figure 6.5 presents a breakdown of how players spent these "other" activity periods during practice sessions. Across all the participant groups, the time spent in coach-player huddles represented the largest "other" activity during both the baseline (U17 Boys: 21.7%; U16 Girls: 23.1%) and GBA (U17 Boys: 20.7%; U16 Girls: 19.9%) practice sessions. Across all groups, a larger percentage of time was spent in each of the remaining four "other" activities (i.e. transition, player huddle, drink break, freeze in position) during the GBA practice sessions.


(A) U17 Boys
%of Practice Time
25
20
15
10
5
0
21.7%
20.7%
15.7%
9.3%
3.2%
0%
1.2%
0%
1.7%
0%
Baseline
GBA
Transition
Coach-Player Huddle
Drink Break
Player Huddle
Freeze in Position

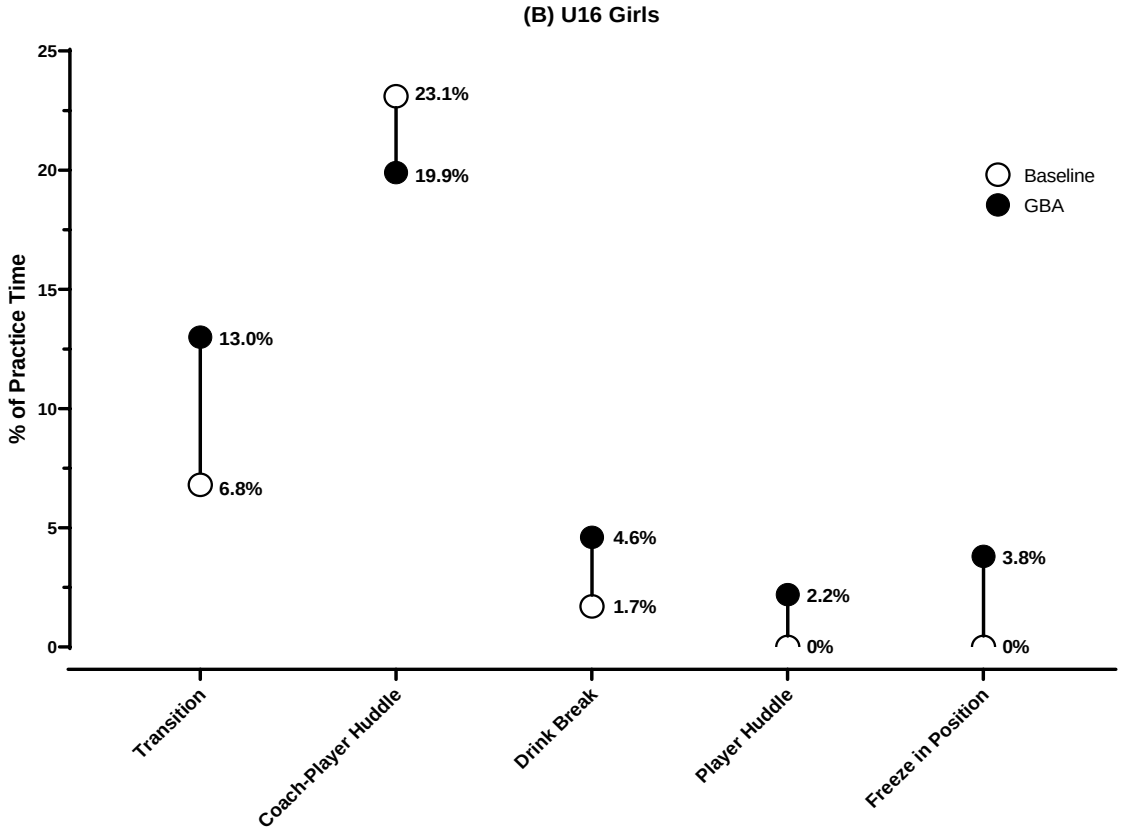

(B) U16 Girls
% of Practice Time
25
20
15
10
5
0
23.1%
19.9%
13.0%
6.8%
4.6%
1.7%
2.2%
0%
3.8%
0%
Baseline
GBA
Transition
Coach-Player Huddle
Drink Break
Player Huddle
Freeze in Position

Figure 6.5 Breakdown of percentage of time spent in "other" activities during practice sessions.

6.3.4. Player Perceptions

Table 6.5 displays the proportion of players who agree or disagree with statements related to their perceptions of the baseline and GBA practice sessions. Overall, despite demonstrating mostly positive opinions of both practice session types, significant differences were observed. Compared to the baseline sessions, a significantly higher proportion of players agreed that the GBA sessions were challenging (U17 Boys: $p=0.021$, $\phi=-0.2$; U16 Girls: $p=0.013$, $\phi=-0.3$) enjoyable (U17 Boys: $p<0.001$, $\phi=-0.5$; U16 Girls: $p<0.001$, $\phi=-0.5$), and of high intensity (U17 Boys: $p=0.023$, $\phi=-0.3$; U16 Girls: $p<0.001$, $\phi=-0.5$).

Additionally, players were more likely to agree that the GBA sessions had a clear plan/theme (U17 Boys: $p<0.001$, $\phi=-0.5$; U16 Girls: $p=0.003$, $\phi=-0.4$), and helped to develop their skills (U17 Boys: $p=0.008$, $\phi=-0.3$; U16 Girls: $p=0.018$, $\phi=-0.2$), decision making (U17 Boys: $p=0.023$, $\phi=-0.2$; U16 Girls: $p=0.007$, $\phi=-0.4$), game play (U17 Boys: $p=0.001$, $\phi=-0.4$; U16 Girls: $p=0.013$, $\phi=-0.3$), communication (U17 Boys: $p<0.001$, $\phi=-0.4$; U16 Girls: $p=0.013$, $\phi=-0.3$), and fitness (U17 Boys: $p=0.023$, $\phi=-0.2$; U16 Girls: $p=0.020$, $\phi=-0.3$). Lastly, a significantly larger number of players felt that the baseline sessions were boring when compared to the GBA sessions (U17 Boys: $p<0.001$, $\phi=-0.6$; U16 Girls: $p<0.001$, $\phi=-0.6$).

Table 6.5 Players' perceptions towards the baseline and GBA practice sessions.

Survey Statement			Agree (%)	Disagree (%)	p	χ 2 (ϕ)
The session was challenging	**U17 Boys**	**Baseline**	66.7	33.3	**p=0.021**	**5.3 (-0.2)**
		GBA	88.0	12.0		
	U16 Girls	**Baseline**	67.9	32.1	**p=0.013**	**6.2 (-0.3)**
		GBA	95.7	4.3		
The session was enjoyable	**U17 Boys**	**Baseline**	66.7	33.3	**p<0.001**	**19.1 (-0.5)**
		GBA	100.0	0.0		
	U16 Girls	**Baseline**	53.6	46.4	**p<0.001**	**14.3 (-0.5)**
		GBA	100.0	0.0		
The session was boring	**U17 Boys**	**Baseline**	63.3	36.7	**p<0.001**	**34.1 (-0.6)**
		GBA	4.0	96.0		
	U16 Girls	**Baseline**	50.0	50.0	**p<0.001**	**15.8 (-0.6)**
		GBA	0.0	100.0		
The session was of high intensity	**U17 Boys**	**Baseline**	76.7	23.3	**p=0.023**	**5.2 (-0.3)**
		GBA	94.0	6.0		
	U16 Girls	**Baseline**	53.6	46.4	**p<0.001**	**14.3 (-0.5)**
		GBA	100.0	0.0		
The session helped develop my skills	**U17 Boys**	**Baseline**	76.7	23.3	**p=0.008**	**7.0 (-0.3)**
		GBA	96.0	4.0		
	U16 Girls	**Baseline**	78.6	21.4	**p=0.018**	**5.6 (-0.2)**
		GBA	98.8	1.2		

The session helped develop my decision making	**U17 Boys**	**Baseline**	76.7	23.3	**p=0.023**	**5.2 (-0.2)**
		GBA	94.2	5.8		
	U16 Girls	**Baseline**	57.1	42.9	**p=0.007**	**7.4 (-0.4)**
		GBA	91.3	8.7		
The session helped develop my game play	**U17 Boys**	**Baseline**	73.3	26.7	**p=0.001**	**11.4 (-0.4)**
		GBA	98.0	2.0		
	U16 Girls	**Baseline**	67.9	32.1	**p=0.013**	**6.2 (-0.3)**
		GBA	95.7	4.3		
The session helped develop my communication with other players	**U17 Boys**	**Baseline**	63.3	36.7	**p<0.001**	**12.2 (-0.4)**
		GBA	94.0	6.0		
	U16 Girls	**Baseline**	60.7	39.3	**p=0.013**	**6.2 (-0.3)**
		GBA	91.3	8.7		
The session helped develop my fitness	**U17 Boys**	**Baseline**	70.0	30.0	**p=0.023**	**5.2 (-0.2)**
		GBA	90.0	10.0		
	U16 Girls	**Baseline**	57.1	42.9	**p=0.020**	**5.4 (-0.3)**
		GBA	87.0	13.0		
The session had a clear plan/theme throughout	**U17 Boys**	**Baseline**	60.0	40.0	**p<0.001**	**19.9 (-0.5)**
		GBA	98.0	2.0		
	U16 Girls	**Baseline**	46.4	53.6	**p=0.003**	**9.1 (-0.4)**
		GBA	87.2	12.8		

Values are percentages; χ 2 : chi square, φ: phi

6.4. Discussion

The aim of this research was to evaluate the effect of a GBA intervention on PA levels in youth Gaelic football players and to investigate the effects of the intervention on practice session characteristics and players' perceptions. The findings revealed that the intervention led to a significant increase in practice session PA levels and daily PA levels for both the U17 boys and U16 girls teams. With regards to session characteristics, the GBA intervention resulted in an increase in player exposure to playing form activity and "other" activity. The study also revealed that players responded more positively to the GBA practice sessions than the baseline practice sessions.

GBAs have not previously been considered in relation to increasing PA participation through sport (Harvey and Jarrett 2014). To bridge this research gap, this study took a novel approach to improve PA levels attained during youth Gaelic football practice sessions by implementing a GBA intervention. Subsequently, results of this research revealed that, when compared to baseline, or more traditional sessions, both the U17 boys (21% or 12.8min/hr) and U16 girls team (22% or 13.3min/hr) attained significantly greater amounts of MVPA during the GBA practice sessions. In addition, the GBA intervention demonstrated an ability to eliminate the gender disparity observed in the PA levels attained during baseline practice sessions, as males and females accumulated equivalent PA levels during GBA practice sessions. The improvement in PA levels observed in this study are consistent with some emerging quantitative evidence, where the use of GBAs helped players achieve increased PA levels in sessions (Miller et al. 2016, Nathan 2017, Sierra-Ríos et al. 2020). Miller and colleagues (2016) demonstrated that players in GBA-focused netball sessions had significantly higher levels of PA (i.e., steps per minute) than those that participated in traditional sessions. A second study recorded field hockey players involved in GBA practice sessions and found they had significantly higher heart rate measurements than those involved in traditional skills practice (Nathan, 2017). Most recently, Sierra-Ríos et al. (2020) determined that soccer players spent significantly more time in PA during TGfU practice sessions compared to traditional practice sessions.

A large body of research has demonstrated the importance of participation in OS to overall daily PA levels, as OS participating adolescents are significantly more physically active than their non-participating peers (Hebert et al. 2015, Kokko et al. 2018, Marques et al. 2016). Therefore, it appears logical that the increase in PA attained during GBA practice sessions may also have contributed to the significant increase in daily MVPA levels observed by players across the measurement timepoints (U17 boys: 23 min; U16 girls: 18 min, see table 6.2). Moreover, at T3, the percentage of male and female participants who achieved the PA guidelines increased to 67% and

70%, respectively. As outlined previously in study 1 of this thesis, the large proportion of Gaelic football time spent in low intensity PA behaviours presented an opportunity to increase time spent in MVPA. Thus, the findings of this study demonstrate the potential of GBAs to displace the time spent inactive, in turn enhancing the contribution of Gaelic football participation to overall daily PA levels. However, it should be noted that female participants were also observed to significantly increase total daily waking time at T3, providing them with more time to be physically active. Thus, this may also have contributed to the significant increase in time spent in MVPA by females at this timepoint.

The increase in PA levels during GBA practice sessions may be explained by players' increased exposure to playing form activity during these sessions (see Figure 6.4). During the baseline practice sessions coaches were observed to align with a traditional approach, as they spent a majority of practice session time in training form activities (U17 boys: TF: 75.0%; U16 girls: TF: 53.2%), which are deemed less relevant to game play and limit players opportunities to attain PA (Cohen et al. 2014, Harvey et al. 2013). In contrast, during the GBA practice sessions both the U17 boys and U16 girls teams significantly increased the percentage of practice session time spent in playing form activities by approximately 63% and 43%, respectively. These significant increases in playing form activity are in line with previous studies conducted in OS coaching settings, where there was a specific emphasis on increasing time spent in game-related tasks (Eather et al. 2019, Miller et al. 2016). Further, this study recorded changes in specific practice activities (i.e., drills, phase of play) across baseline and intervention phases, thus providing greater detail on the potential cause of any changes in PA levels that occurred (Lyle, 2018). Therefore, in the context of this study, the large increase in time spent in "conditioned games" during GBA practice sessions (see Figure 6.4), appears to be an important factor in explaining the improvements in players' PA levels during these sessions.

The results of this research also revealed that players spent large periods of time in "other" activities during both baseline and GBA practice sessions. Importantly, how this time is utilised within sessions can greatly impact player development (Harvey et al., 2013). Questioning and providing opportunities for dialogue are defining features within a GBA (Light, 2013), and have been proposed as a strategy for efficient utilisation of "other" activity periods within coaching sessions (Harvey et al., 2013; Light, 2013; Partington & Cushion, 2013). However, qualitative research has reported a perception amongst coaches that practice session constraints do not allow for questioning and dialogue to be frequently implemented, and that the intensity of sessions is compromised when these features are applied (Light & Evans, 2010). In this analysis, the results indicate that total percentage of practice session time spent in "other" activities, although non-

significant, was greater during the GBA practice sessions for both the U17 boys team (Baseline: 31.3%; GBA: 42.1%) and U16 girls team (Baseline: 31.6%; GBA: 43.4%). Interestingly, despite this increase in time spent in "other" activities, players perceived an increase in intensity of the GBA practice sessions, corroborated by the increase in quantitative PA data. These findings are consistent with the only previous GBA intervention study to measure periods of inactivity across baseline and intervention periods (Eather et al. 2019). Eather and colleagues' study with soccer coaches noted that there was no significant change in practice session time spent in practice activities, despite increasing their use of questioning by 34.5% (Eather et al. 2019). These findings demonstrate that the application of questioning and dialogue within GBA pedagogy does not negatively impact the intensity or PA levels attained during practice sessions, instead it may provide coaches with a strategy to maximise the impact of "other" activity periods.

Attaining an insight into what players determine to be useful and challenging holds important implications for coaches' practice (Harvey, 2009). Therefore, another important evaluation relating to GBA interventions involves assessing the players' perceptions in receiving this new coaching pedagogy. A dearth of evidence exists in coaching settings regarding the effects of GBA pedagogy on players' experiences. The limited research available has highlighted that players experience improvements in performance, enjoyment, greater team cohesion and motivation (Evans and Light 2007, Koekoek et al. 2014). In this analysis, while player's perceptions of both the baseline and GBA practice sessions were largely positive, significant differences were observed and the findings of this research are consistent with those observed in earlier studies. A significantly greater proportion of both the U17 boys and U16 girls players reported that the GBA practice sessions were enjoyable and challenging, while also reporting that the baseline practice sessions were boring. A larger percentage of players also reported to experience improvements in performance outcomes during the GBA practice sessions, including skill development, decision making, game play and communication. Finally, as alluded to earlier, significantly more players felt that the GBA practice sessions were of high intensity and helped develop their fitness. Overall, youth Gaelic football players demonstrated a significantly more positive view of the GBA practice sessions, providing further context and support for the utilisation of GBA pedagogy for improved player development. Furthermore, given that enjoyment is the most frequently cited predictor of dropout (Crane and Temple 2015, Gardner et al. 2017), GBA pedagogy may also support the continued participation in sport amongst adolescents and prevent the health and well-being detriments associated with drop-out (Vella et al. 2014a, Vella et al. 2014b).

6.5. Strength and Limitations

This research study had a number of strengths. Firstly, this is a novel study as, to the authors knowledge, it is the first to investigate the impact of a GBA intervention on youth Gaelic football players' PA levels. The results provide preliminary support for the application of a GBA to significantly improve the impact of Gaelic football participation on player's PA levels. Secondly, this is also the first study, to the best of the authors knowledge, to utilise specialist coaches to implement the GBA intervention practice sessions. The specialist coaches' extensive training and experience in the implementation of GBAs within Gaelic football settings ensured that the practice sessions satisfied the GBA validation benchmarks. Thus, this provides assurance that the improvement in players' outcomes (i.e. PA levels, perceptions) is attributable to the GBA intervention. Thirdly, this study coded and analysed the percentage of time spent in "other" activity independent of the practice activity type in which it occurred. Unlike previous research where "other" activity time was not separated from the recording of practice activity type (Miller et al., 2015), this approach provides a more detailed objective examination of time spent in training form and playing form activities and its impact on players' PA levels.

Despite the novelty of this study, there are limitations that should be considered. First, while the participants' PA levels were measured using a device-based measure, the impact of the GBA intervention on other youth Gaelic football player outcomes, such as skill development and decision making, was not assessed. Future research may address this gap through the employment of systematic observation instruments (e.g. Game Performance Assessment Instrument) to assess potential improvements in participants' game performance outcomes. Second, this was a pilot investigation, with a short intervention period and a small number of Gaelic football teams investigated. Therefore, these findings may not be generalisable across youth Gaelic football settings. Third, the improvements in player's perceptions during the GBA practice sessions should be viewed with caution, as it is possible that the introduction of the external specialist coaches may also have positively influenced this outcomes measure. Finally, as outlined previously, the participant coaches did not possess an explicit theme for their baseline practice sessions, but were observed to implement primarily attack focused sessions. Thus, the four GBA practice sessions designed and employed by the specialist coaches, linked to the theme of "Understanding Width", were chosen to mirror the attack focus of these baseline sessions. Nonetheless, it is possible that the inclusion of this theme and the associated playing form activities implemented may have promoted greater PA levels amongst the players than other themes that could have potentially been utilised (i.e. defence focused themes). Future interventions may address this limitation by

increasing the number of GBA intervention sessions and implementing different themes throughout, while also mirroring these themes or sessions in the "baseline" data collection.

6.6. Conclusion

The purpose of this study was to investigate the effects of a GBA intervention on player's PA levels, practice session characteristics and player perceptions. The current research supports the use of a GBA to positively impact session characteristics, as the intervention resulted in an increase in playing form practice activities. In relation to PA levels, all male and female players significantly increased both daily PA levels and PA levels attained during practice sessions, despite the emphasis in GBAs to apply structured periods of questioning and dialogue, and the resulting larger percentage of time spent in these "other" activities. Consequently, this study provides support for the efficacy of playing form activities, in particular conditioned games, in positively impacting player's PA levels during practice sessions. In addition, players reported a significantly more positive view of the GBA practice sessions in comparison to their standard practice sessions. In conclusion, this study provides support for the use of GBA pedagogy to significantly impact the youth Gaelic football players' PA levels.

Chapter 7. General Discussion, Limitations, Implications and Conclusion

7.1. Introduction

Organised sport (OS) participation is a key tool for the provision of physical activity (PA) in youth, yet it remains a poorly researched topic in this context. In particular, evidence is conflicting on the association between OS participation and meeting PA guidelines, while the level of PA attained during youth OS varies greatly depending on the sport type and context. Coaching pedagogies, in particular a game-based approach (GBA), should be considered in the context of PA promotion in youth OS. However, research investigating coaching practices in OS settings remains limited and studies which objectively investigate the impact of coaching approaches, including GBAs, on players' PA levels are lacking. The purpose of the research presented in this thesis was to understand and intervene on the contribution of Gaelic football to PA among youth players. The key findings of this thesis are summarised as follows:

1. Gaelic football participation supports the accumulation of significant amounts of MVPA, yet there remains potential to improve the contribution of Gaelic football to overall daily PA levels.
2. Youth Gaelic games coaches recognise the importance of players accumulating PA and the role of Gaelic football participation in PA promotion. Despite this, coaches are not employing coaching practices, specifically GBAs, which are likely to enhance player PA levels within their practice sessions, instead implementing their own folk pedagogies.
3. A GBA intervention significantly increased the PA levels attained during youth Gaelic football participation, while also improving players' perceptions of practice sessions and altering the practice session characteristics towards an authentic GBA approach.

These key findings will be discussed throughout this chapter. Additionally, important areas of future research for PA and coaching pedagogy will be outlined. The limitations of this thesis will be discussed, and finally, the conclusions pertaining to this body of work will be presented.

7.2. The positive impact of Gaelic football participation on players' physical activity levels.

In summarising the research conducted in youth OS settings, the literature review established that participation in OS has a primarily positive association with a range of health outcomes, including PA attainment (Bjørnarå et al. 2021). As such, participation in OS has been suggested as an effective approach for increasing PA throughout adolescence (Howie et al. 2020). Findings in this thesis confirm that youth Gaelic football is an effective setting for PA accumulation, as participants attain considerable levels of MVPA daily, while also being twice as likely to attain 60 minutes of MVPA on days that they participate in Gaelic football. These findings echo a growing body of literature which has highlighted the importance of OS participation to PA levels; that OS

participating youth attain significantly higher levels of PA and are more likely to meet the PA guidelines than their non-participating peers (Marques et al. 2016, Mooses and Kull 2019, Sprengeler et al. 2019). At the same time, the baseline assessment of PA in study 1 confirmed previous findings around gender and age-related PA (Corder et al. 2015, Harding et al. 2015, Marques et al. 2016, Silva et al. 2013), as males accumulated significantly more MVPA daily compared to females, while an age-related decline in MVPA was also observed.

The gender disparity in adolescent daily PA levels did not persist in the follow-up assessment of PA among Gaelic football participants, as female's daily MVPA levels and compliance with the PA guidelines increased across the seasonal timepoints. This novel finding may be explained in two ways; firstly, by the significant increase in MVPA attained by females on non-sports days across the season, resulting from increased discretionary time and the potential removal of school-related PA barriers (Corr et al. 2019). Secondly, the change in females' PA levels may also be a direct consequence of the significant increase in MVPA observed on sports days across the time points. Specifically, females were observed to significantly increase the amount of time spent in MVPA during Gaelic football participation over time, resulting in no gender differences in PA attained during OS participation. This may be linked to altered coaching approaches over time, considering that Gaelic games coaches reported to significantly increase their use of playing form activities as a season progressed (Chapter 5), which are more conducive to MVPA attainment than training form activities (Cohen et al. 2014). The potential for different coaching approaches, in particular a GBA, to positively impact the PA levels of female Gaelic football participants was reiterated in Chapter 6, as the GBA intervention eliminated the gender disparity observed in time spent in standing and LIPA during the baseline practice sessions. Further, this intervention resulted in female participants accumulating 8-15 minutes (13-25%) more time in MVPA during Gaelic football practice sessions when comparted to both timepoints in study 1. Ultimately, the disappearance of the gender gap in PA observed in this thesis is significant, as it is contrary to previous research which have consistently indicated that the amount of time spent in MVPA during OS participation varies considerably depending on gender (Schlechter et al. 2017).

While this research highlights the positive impact of Gaelic football participation to players' daily PA levels, participation alone did not ensure participants were sufficiently physically active. Cross-sectional and longitudinal findings, as well as baseline data from the intervention study, indicated that up to 78% of males and 80% of females did not meet PA guidelines, confirming previous research (Telford et al. 2016, Vella et al. 2016). Ridley et al., (2018) recognise that OS have multifaceted outcome goals and as PA attainment is not the sole objective, it is unrealistic to expect participants to achieve the PA guidelines in one session. Nonetheless, given that approximately

half of Gaelic football practice session time across both timepoints in Chapter 4 and at baseline measurement in Chapter 6 was spent in engaged in PA below a moderate intensity, there is scope for coaches to increase the duration of engagement in MVPA during Gaelic football participation. Indeed, coaches have been recognised as one of the primary factors influencing the intensity of PA attained during OS participation (Howie et al. 2020). Guagliano and colleagues (2015) also demonstrated that a coach education program successfully increased practice time spent in MVPA, while simultaneously reducing time spent inactive. Accordingly, there have been calls to investigate and improve the current quality of youth OS coaching and to determine efficient ways of optimising the dose of PA accumulated during youth OS (Leek et al., 2011; Vella et al., 2016).

7.3. Coaches' knowledge of physical activity and utilisation of Game-Based Approaches to support physical activity provision is limited.

Although coaches are considered central figures in the youth OS setting, uniquely positioned to deliver specific strategies and activities that support the development of players' PA levels (Howie et al. 2020, Sherwin et al. 2017), it remains unclear whether they are aware of their critical role in PA provision (Guagliano et al. 2014). As in the case of previous research (Guagliano et al. 2014), youth Gaelic games coaches place importance on the promotion and attainment of PA amongst their players, and were aware of their role in the provision of PA. Despite this, a low percentage of coaches were aware of or could accurately identify the current national PA guidelines for youth. Evidently, the development of formal coach education modules on PA guidelines and approaches to increase the PA attained during practice sessions may be useful methods to ensure Gaelic games makes a greater contribution to PA.

Youth Gaelic games coaches were also familiar with different coaching approaches, in particular, the GBA, which has been identified as a potentially effective approach to improve players' PA, in addition to other key player outcomes (Kinnerk et al. 2018). No research has examined the coaching approaches implemented at club level Gaelic games, despite over 90% of coaches indicating to actively coach at this level (Horgan, 2021). Ultimately, while Gaelic games coaches displayed an awareness and appreciation of GBAs, this was not transferred to their actual coaching practices. This was visible through the quantitative and qualitative assessment of their practice activity preferences, session sequencing and coaching strategies. Firstly, traditionally aligned coaches typically demonstrate a preference towards "coach-centred" strategies (Martens 2004, Partington and Cushion 2013, Romar et al. 2016), while coaches who position themselves in a facilitator role and encourage player involvement demonstrate the "player-centred" strategies advocated in GBA literature (Cushion, 2013). Overall, despite reporting to implement some GBA aligned strategies, such as the use of questioning to stimulate thinking and interaction, youth Gaelic

games coaches demonstrated a distinct reluctance to use group dialogue and discussion within their sessions, instead favouring direct instruction. These strategies reflect a traditional approach, whereby the coach holds the knowledge and players are passive receivers (Cassidy et al. 2015, Partington and Cushion 2013). These findings are consistent with the only other research to examine coaches' practices through the assessment of their coaching strategies (Light and Evans, 2013; Vinson et al., 2016).

Secondly, in line with the findings of previous studies in similar invasion team sports (Ford et al., 2010; Partington & Cushion, 2013), coaches estimated spending the majority of practice session time in training form activities. Further, despite being considered a distinguishing feature between traditional and GBA pedagogies (Cushion 2013), only two previous studies have explicitly documented coaches' sequencing of practice activities (Kinnerk et al., 2019; O'Connor et al., 2018). The findings among youth Gaelic games coaches supports this previous research, as coaches indicated sequencing training form activities early in their practice sessions prior to employing playing form activities. Overall, the predominate use of training from activities in a linear sequence strongly demonstrates a link to a traditional approach, whereby coaches believe that player's participation in games is insufficient in developing technical skills (Evans 2006). Indeed, research has highlighted that training form activities are effective at facilitating skill development in the early stages of learning (Rink 2014). However, the sequence reported by Gaelic games coaches and the belief outlined in the qualitative data that skills must be mastered before they can be applied in game-related activities, can create a separation between technique and tactical knowledge, leading to a disconnect between practice and game-play (Pill 2014). In contrast, GBA pedagogy permits the selective use of training from activities to improve technical skills, however, they should only be used when necessary and not as a starting point of the session (Metzler 2005, Metzler 2011).

In summary, engagement with youth Gaelic games coaches supports previous literature (Light & Evans, 2010) that suggests pedagogy research has relatively little explicit impact on sports coaches' practice. Given that coaching practice is predominantly developed by informal sources, such as observation and experience (Lyle, 2007), the limited knowledge of GBA pedagogy amongst Gaelic games coaches was expected. Interestingly, however, an epistemological gap was observed as coaches claimed to utilise one of the GBA models as the predominant approach within their coaching sessions. Consistent with other studies involving invasion team sports (Ford et al., 2010, Partington and Cushion, 2013), the overall findings presented here confirm that coaches are applying their own folk pedagogies, whereby they extract some elements of a GBA and insert these within a traditional coaching session (Cushion 2013). Ultimately, this prevalent use of folk pedagogies amongst coaches and the subsequent dilemmas in its application (Roberts 2011) are a

direct consequence of the omission of GBA pedagogy research and practice into Gaelic games formal coach education.

7.4. A Game-Based Approach increases the physical activity contribution of Gaelic football participation

The emergence of pedagogy in coaching research recognises that sports coaching is a complex process beyond the transfer of isolated skills to participating players (Cushion, 2010; Lyle, 2018; Lyle & Cushion, 2017). However, as highlighted previously, pedagogy has had little impact on youth Gaelic games coaching practices, resulting in many coaches adopting their own folk pedagogies and the subsequent implementation of activities and strategies that do not maximise PA attainment (Cohen et al. 2014, Miller et al. 2016). In general, uptake of GBAs by practitioners in coaching settings remains limited, primarily due to a dearth of research investigating the effect of interventions on outcomes critical to successful performance (Lyle, 2018). Given such findings, there have been calls for future research to investigate the impact and potential benefits of implementing a GBA on physical indices, including PA levels (Kinnerk et al., 2018).

This research provides support for the efficacy of GBAs in developing players' PA levels, as both participating male and female teams spent a larger percentage of time in MVPA during GBA practice sessions (67-68%) compared to both the baseline practice sessions (45-47%) and the earlier cross-sectional seasonal assessment of practice sessions (48-55%). As such, this research builds upon three relatively recent studies which reported that netball, field hockey and soccer players recorded significantly greater levels of PA during GBA sessions in comparison to traditional sessions (Miller et al. 2016, Nathan 2017, Sierra-Ríos et al. 2020). In addition, the GBA analysis revealed a significant increase in players' daily MVPA levels, as the proportion of male and female participants that achieved the PA guidelines during the intervention period increased by 45% and 50%, respectively. While a number of factors must be considered as also potentially effecting the PA levels attained during this data collection phase, such as seasonal variations and variable waking hours, the results suggest GBAs can significantly increase the contribution of Gaelic football participation to youth daily PA levels and the attainment of the PA guidelines.

The delivery of the GBA intervention by specialist coaches provides a novel demonstration of how an authentic GBA is implemented, while also providing a direct comparison to the practice sessions currently employed within youth Gaelic football settings. Specifically, during a GBA practice session, both male and female teams were observed to spend approximately 90% of practice session time in playing from activities (U17 boys: PF: 89%; U16 girls: PF: 90%). In contrast, a predominate use of training form activities was observed in both the baseline practice

sessions (U17 boys: TF: 75%; U16 girls: TF: 53%) and the self-reported practice sessions of Gaelic games coaches. Training form activities are deemed less relevant to game play and limit players' opportunities to attain PA (Cohen et al. 2014, Harvey et al. 2013). Thus, players' increased exposure to playing form activities, specifically "conditioned games", during GBA practice sessions may explain the increase in PA levels during these sessions. Interestingly, this study also determined that the percentage of practice session time spent in "other" activities was greater during the GBA practice sessions. Consistent with the only previous GBA intervention study to measure stationary or sedentary periods (Eather et al. 2019), this finding confirms the ability of a GBA to efficiently implement player-centred strategies (i.e. questioning) without negatively impacting PA levels attained during practice sessions (Harvey et al., 2013; Light, 2013).

Another important evaluation relating to the GBA intervention involves assessing the players' perceptions in receiving this new form of coaching. Attaining a better understanding of what players find beneficial and challenging holds significance not only for coaches and their practices (Harvey 2009), but also for players continued participation in OS and prevention of the health and well-being detriments associated with drop-out (Vella et al., 2014a, Vella et al., 2014b). Research has highlighted that drop-out from youth OS has emerged to become a global trend, with rates exceeding 30% in some countries (Crane and Temple 2015). This is consistent within Gaelic games, as the GAA reported a 19% drop-out rate for males between the ages of 12-16 years (Gaelic Athletic Association 2012). While these trends may in part reflect sampling, where adolescents are trying out or transferring between different OS (Coté et al. 2009), a large proportion of youth withdraw from OS as a result of limited enjoyment or negative experiences (Crane and Temple 2015, Sheridan et al. 2014). In order to counteract drop-out trends in OS, research has highlighted the crucial role that coaches play in providing players with social support and creating the conditions for continued participation, characterised by positive feedback and autonomy-supportive engagement styles (Lavallee et al. 2019). Considering that GBAs advocate the use of player-centred strategies which promote player autonomy and motivation, this approach has been identified as effective in preventing drop-out (Barquero-Ruiz et al. 2021). In this research, similar findings were observed as youth Gaelic football players demonstrated a significantly more positive view of the GBA practice sessions when compared to the baseline sessions. This included experiencing greater levels of enjoyment and fun, while also perceiving themselves to achieve greater improvements in a number of performance outcomes.

7.5. Limitations

Whilst some novel findings are presented within this thesis, it is important to acknowledge the limitations of the research. The limitations of each individual study have been identified and discussed in detail within each chapter. The aim of this section is to provide an overview of the overarching limitations of this thesis.

- Due to the use of convenience sampling, data collection for PA assessment was conducted in a small number of Gaelic football teams from the midlands and western regions of Ireland. As the sample is not representative of the population of Gaelic football participants in Ireland, the findings may not be generalisable to other populations in different geographic or socioeconomic settings. However, this study tried to address these issues through the recruitment of participants from Gaelic football clubs that were in both rural and urban areas and from different socio-economic settings.
- A primary focus of this thesis was to assess levels of PA engagement using a device-based measure among youth Gaelic football participants. Whilst the activPAL has been established as a valid measure for quantifying sedentary time and PA in youth (Dowd et al. 2012b, Ridgers et al. 2012b), it is not without limitations.
    - Due to its wear position the activPAL device is unable to monitor upper body activities (strength training, carrying loads etc.), water-based activity (swimming) and lower body activities which involve a cyclic motion (cycling, rowing). The inability of devices to examine such activities may result in the underestimation of PA, particularly in individuals that perform large amounts of the described activities. However, among adolescent PA studies, the contribution of these activities to daily PA is often reported to be small (Trost 2007). As mitigation, each participant was provided with a non-wear diary to record when he or she removed the monitor and to provide a reason why they removed it.
    - As the activPAL is unable to identify non-wear time, non-wear protocols which followed the methodologies employed for previous research using the activPAL (Dowd et al. 2012a) were employed. To identify non-wear time, a period of 60 minutes of consecutive zeros were identified and then subsequently removed from the corresponding monitoring day. As the activPAL has been reported to remain sensitive to subtle vibrations or random movements when removed, participants were asked to document their non-wear time in a non-wear diary which was then confirmed within the raw data file during analysis and removed accordingly.

- Participants were requested to wear the activPAL device for a total of nine consecutive days. While participants were clearly instructed to not alter their PA behaviour in response to wearing the device during these measurement periods, there is the possibility of reactivity, whereby participants intentionally alter their activity behaviours (Dössegger et al. 2014). Therefore, it is possible that the PA data presented in this thesis may not be reflective of the habitual activity of the participants. However, previous research has assessed participant reactivity to wearing accelerometers in youth populations and concluded that there is insufficient evidence of accelerometer reactivity amongst this cohort (Davis and Loprinzi 2016, Dössegger et al. 2014, Vanhelst et al. 2017).

The interpretability of the findings from the intervention research are limited by the relatively short intervention period and the absence of a true control group. The results of this chapter should be viewed as pilot work for larger studies, which encourages the further investigation of the impact of a GBA on PA levels.

7.6. Implications and Recommendations for Policy, Research and Practice

According to Greenhalgh et al. (2016), impact occurs when research generates beneficial changes beyond the academic domain, in addition to expanding the academic knowledge base. This PhD thesis has produced direct implications for Gaelic games stakeholders, including the NGBs (GAA, LGFA and Camogie Association), coaches, coach educators and players as well as policy makers and researchers. In particular, this research highlights a feasible pedagogical approach which coaches and coach education programmes may adopt to modify coach practices, and positively impact the PA levels of participating players.

7.6.1. Policy

- In 2016, the Irish government launched the National Physical Activity Plan for Ireland with a key aim of this plan to increase the proportion of children achieving at least 60 minutes of daily MVPA by 1% per annum and decrease the proportion of children who do not achieve the recommendations by 0.5% per annum (Healthy Ireland 2016). This plan identified OS participation as one of the eight areas for action to encourage greater PA engagement. The importance of OS participation was also acknowledged as one of the ISPAH's "8 investments that work for physical activity" (The International Society for Physical Activity and Health 2020). More recently, the Irish government launched the National Sport Policy and Sport Action Plan, which aims for at least 60% of the population to be actively participating in sport by 2027 (Department of Tourism 2021). This research has built upon previous studies

conducted in the youth OS domain, providing a critical examination of the value of youth OS settings as an opportunity for engagement in MVPA. The results of this study suggest that youth Gaelic football provides adolescents with an ideal opportunity to engage in substantial amounts of MVPA, providing further support for these national and international initiatives which promote OS as a successful means to increase PA engagement.

- The well documented health benefits of PA participation resulted in the creation of national and global PA guidelines. However, considering that clear communication strategies to accompany the publication of these PA guidelines is not common practice (Milton et al. 2020), it is unsurprising that a majority of Gaelic games coaches were unable to accurately identify the current national PA guidelines for youth. Nonetheless, coaches' displayed an awareness of the importance of PA and their role in providing PA for their players. These findings could provide support for the development of specific Government policies, in collaboration with the relevant NGBs, aimed at developing appropriate and effective communication of the PA guidelines to OS coaching populations, which in turn could have a positive impact on the PA levels of OS participants.
- In 2005, Sport Ireland developed a Women in Sport Programme, with the aim to "raise overall physical activity levels and support women's roles within funded bodies". This programme was successful in reducing the gender gap in OS participation from 15.7% to 4.5% (Sport Ireland 2017). More recently, Sport Ireland launched the Women in Sport Policy in 2019, which seeks to build on this work by increasing women's sustained involvement in sport in a number of capacities, such as coaches, volunteers, club members and participants (Sport Ireland 2019b). This policy, aligned with the National Sports Policy 2018-2027, outlined "active participation" as one of four key areas to emerge as future opportunities for women in sport. The findings of this research, which demonstrate the ability of Gaelic football participation to significantly increase female participants' MVPA levels and compliance with the PA guidelines, provides further support for this Sport Ireland policy and perhaps greater promotion of OS participation and improved coaching approaches amongst girls and women.

7.6.2. Research

- Given the paucity of research investigating the PA contribution of OS in youth, future research could build upon the findings in this thesis by investigating the PA levels attained during a wider range of OS, including both team sports and individual sports. Moreover, future research could incorporate additional device-based measurement tools, such as GPS, to examine other performance variables and further develop understanding of the various impacts of OS participation. Such investigations could provide support for other NGBs to investigate the

predominate coaching approaches implemented within their settings. Indeed, this future research may adopt the data collection methods used in this thesis as an effective means to obtain important information from their coaching populations. Furthermore, the findings of this data collection method could be utilised by the relevant NGBs to improve their coach education programmes, and introduce an alternative coaching pedagogy aimed at improving player development.

- Whilst the findings in this thesis underline the value of the youth OS setting as a context for PA promotion, it is only one setting in which adolescents may have the opportunity to be physically active. The findings of this research demonstrated seasonal changes in female participants' daily PA levels on both sports days and non-sports days. In light of these findings, future research should explore why the winter season is a less active period for OS participating female adolescents in comparison to their male counterparts and investigate approaches to reduce these PA barriers and further bridge the gender PA gap.
- As outlined previously (Section 2.5.4.), the NGBs recently announced the new Gaelic Games Player Pathway, to support the almost 500,000 playing members across both codes. However, despite this new joint initiative, the coach education programmes across the GAA, LGFA and Camogie Association remain independent. Indeed, as revealed in Study 2, differences in coach education level and years of coaching experience were observed between coaches of males and females. Considering the potential impact that Gaelic games coaches have on a variety of player outcomes, future research may examine whether coach education level or experience level has an impact on outcomes relevant to player performance.
- The results of this thesis provide support for the engagement in MVPA during GBA sessions. In addition, players reported to experience improvements in a number of performance outcomes during the GBA practice sessions, including skill development, decision making and communication. While it was beyond the scope of this research, future studies may seek to explicitly investigate some of these reported outcomes along with PA. For example, future research may investigate the claim by players that their decision-making skills improved by employing systematic observation instruments to assess potential improvements in participants' game performance.

7.6.3. Practice

- The NGBs of Gaelic games have recognised the potential benefits of a shift towards coaching through games and, as a result, developed their own game-based coaching model (Horgan & Daly, 2015). However, coaches primarily reported that their formal Gaelic games coach education did not adequately prepare them to apply a GBA within their sessions, while a

majority of coaches also failed to recognise any of the formal GBA models. Ultimately, the prevalent use of folk pedagogies amongst coaches and the subsequent dilemmas in its application (Roberts, 2011) are linked to the omission of GBA pedagogy research into formal coach education. To better prepare and support coaches to effectively and authentically implement GBAs in practice, Cushion (2013) proposes that coach education should incorporate mentoring and 'communities of practice'. Further, in the recent national Gaelic games coach survey, 95% of respondents were highly interested in future learning opportunities with sport specific coaching techniques, such as GBA. In addition, 80% of coaches prefer learning through other coaches, 60% through coaching courses and 32% through engagement with a mentor (Horgan, 2021). Given this information, NGBs could develop a community of practice and subsequent GBA Coach Education Model based around the specific preferences of Gaelic games coaches, and investigate its efficacy of positively impacting both player and coach development. A project as described may hold great value for coaching bodies in providing a framework and highlighting the viability of implementing and impacting mass change within their respective coaching populations.

- Coaches have cited practice session constraints, excessive time spent standing and a loss of intensity as reasons for not employing questioning or providing opportunities for dialogue and debate within their practice sessions (Light & Evans, 2010). The findings from this thesis help to challenge these claims, as the PA levels attained during the GBA practice sessions were significantly greater than the baseline sessions, despite also spending more time in "other" activities, where frequent structured periods of questioning were employed. Furthermore, players also reported to perceive the GBA sessions as being of greater intensity. These findings should alleviate concerns regarding the employment of questioning and dialogue as a strategy within sessions, while also providing coaches with a strategy to maximise the impact of "other" activity periods. NGBs can begin to share these findings with coaches to develop coaching practice.
- The typical coaching approaches reported in coaching research literature limit opportunities for players to engage in PA (Harvey et al., 2013; Partington & Cushion, 2013). In contrast, this PhD thesis supports previous work in demonstrating GBAs as a viable pedagogy to enhance players' PA levels (Miller et al., 2016). Specifically, the GBA intervention resulted in players spending over 20% more time in MPVA during the GBA practice sessions. However, coaches were observed to hold a traditional belief that players must develop sufficient levels of fitness early in the season, through the implementation of isolated conditioning activities, before introducing game-related activity. In combination with the existing body of research, which

revealed that GBAs improve several other outcomes, including decision-making, personal and social development, increased motivation and enjoyment (Kinnerk et al., 2018), the novel findings in this study provide a convincing case for coaches to adopt a GBA as a practical method to simultaneously develop PA and other outcomes necessary for successful performance.

- Given the popularity of OS and the benefits that may be derived from participation, it is perhaps surprising that drop-out rates are exceeding 30% annually in some countries (Crane & Temple, 2015). Moreover, a report conducted by the GAA highlighted a 19.38% drop-out rate of participants between the ages of 12-16-years (GAA, 2012). Enjoyment has been reported as the most frequently cited predictor of dropout from youth OS (Gardner et al., 2016). In this regard, significantly greater proportion of players reported that the GBA practice sessions were enjoyable when compared to their baseline/traditional sessions. These findings suggest that the promotion of a GBA as the predominate coaching approach within Gaelic games could support continued participation amongst adolescents and prevent the health and well-being detriments associated with drop-out (Vella et al., 2014a, Vella et al., 2014b).
- The differing PA levels attained during OS participation among males and females at various data collection points in this thesis suggests a potentially different coaching approach is being implemented for both groups. This could be linked to the contrasting qualifications and experience reported by coaches in the male and female game as outlined in the survey analysis of this thesis or perhaps the development stage of female players. The NGBs of Gaelic Games have established One Club Guidelines, to include a collective approach to coaching, Player Pathway for all players and are moving to jointly implement coach development (Gaelic Athletic Association 2021). Each of these actions point to ensuring an equal experience for males and females in Gaelic Games. Findings from this study suggest that this is warranted, even reinforcing a priority to implement and monitor equivalent coaching approaches among all players.

7.7. Conclusion

The findings presented in this PhD thesis contribute to the field of PA and coaching related literature. This research provided the first investigation into the PA contribution of Gaelic football participation, revealing that it is a setting for adolescents to accumulate MVPA and increases their chances of attaining the PA guidelines. This research also provided the first insight into the coaching approaches of youth Gaelic games coaches, highlighting that they are applying their own folk pedagogy within their practice sessions. Additionally, this research provided the first investigation into the effect of a GBA in a youth Gaelic football setting, resulting in significant

improvements in MVPA engagement during practice sessions as a result of the GBA intervention as well as improvements in overall daily PA. Collectively, the findings provided within this thesis have important implications and may be used to optimise youth Gaelic football participation as a context for PA attainment which will help to contribute towards more adolescents achieving the recommended levels of PA.

Bibliography

Abarca-Gómez, L., Abdeen, Z. A., Hamid, Z. A., Abu-Rmeileh, N. M., Acosta-Cazares, B., Acuin, C., Adams, R. J., Aekplakorn, W., Afsana, K. and Aguilar-Salinas, C. A. (2017) Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128·9 million children, adolescents, and adults. *Lancet, 390*(10113), pp. 2627-2642.

Adam Noah, J., Spierer, D., Gu, J. and Bronner, S. (2013) Comparison of steps and energy expenditure assessment in adults of Fitbit Tracker and Ultra to the Actical and indirect calorimetry. *Journal of Medical Engineering & Technology, 37*(7), pp. 456-462.

Ainslie, P. N., Reilly, T. and Westerterp, K. R. (2003) Estimating human energy expenditure. *Sports Medicine, 33*(9), pp. 683-698.

Ainsworth, B., Cahalin, L., Buman, M. and Ross, R. (2015) The current state of physical activity assessment tools. *Progress in Cardiovascular Diseases, 4*(57), pp. 387-395.

American College of Sports Medicine (1978) Position statement on the recommended quantity and quality of exercise for developing and maintaining fitness in healthy adults. *Medicine & Science in Sports & Exercise, 10*(3), pp. vii-vix.

American Heart Association (1972) Committee on Exercise. Exercise Testing and Training of Apparently Healthy Individuals. *A Handbook for Physician. New York*.

American Heart Association (1975) *Exercise testing and training of individuals with heart disease or at high risk for its development: A handbook for physicians,* American Heart Association.

An, H.-S., Kim, Y. and Lee, J.-M. (2017) Accuracy of inclinometer functions of the activPAL and ActiGraph GT3X+: A focus on physical activity. *Gait & Posture, 51*(1), pp. 174-180.

Arriba-Pérez, D., Caeiro-Rodríguez, M. and Santos-Gago, J. M. (2016) Collection and processing of data from wrist wearable devices in heterogeneous and multiple-user scenarios. *Sensors, 16*(9), pp. 1538.

Artino Jr, A. R., La Rochelle, J. S., Dezee, K. J. and Gehlbach, H. (2014) Developing questionnaires for educational research: AMEE Guide No. 87. *Medical teacher, 36*(6), pp. 463-474.

Atkin, A. J., Gorely, T., Clemes, S. A., Yates, T., Edwardson, C., Brage, S., Salmon, J., Marshall, S. J. and Biddle, S. J. (2012) Methods of measurement in epidemiology: sedentary behaviour. *International Journal of Epidemiology, 41*(5), pp. 1460-1471.

Atkinson, O. and Harvey, S. (2017) One youth soccer coach's maiden implementation of the Tactical Games Model. *ÁGORA Para La Educación Física Y El Deporte, 19*(2-3), pp. 135-157.

Aubert, S., Barnes, J. D., Abdeta, C., Abi Nader, P., Adeniyi, A. F., Aguilar-Farias, N., Tenesaca, D. S. A., Bhawra, J., Brazo-Sayavera, J. and Cardon, G. (2018) Global matrix 3.0 physical activity report card grades for children and youth: results and analysis from 49 countries. *Journal of Physical Activity and Health, 15*(s2), pp. S251-S273.

Aunger, J. and Wagnild, J. (2022) Objective and subjective measurement of sedentary behavior in human adults: a toolkit. *American Journal of Human Biology, 34*(1), pp. e23546.

Australian Sports Commission (1999) *Game Sense Cards*. Canberra: ACT: Australian Sports Commission.

Baquet, G., Stratton, G., Van Praagh, E. and Berthoin, S. (2007) Improving physical activity assessment in prepubertal children with high-frequency accelerometry monitoring: a methodological issue. *Preventive Medicine, 44*(2), pp. 143-147.

Barnett, L. M., Stodden, D., Cohen, K. E., Smith, J. J., Lubans, D. R., Lenoir, M., Iivonen, S., Miller, A. D., Laukkanen, A. and Dudley, D. (2016) Fundamental movement skills: An important focus. *Journal of Teaching in Physical Education, 35*(3), pp. 219-225.

Barquero-Ruiz, C., Morales-Belando, M. T. and Arias-Estero, J. L. (2021) A teaching games for understanding program to deal with reasons for dropout in under-11 football. *Research Quarterly for Exercise and Sport, 92*(4), pp. 618-629.

Bassett, D. R., John, D., Conger, S. A., Rider, B. C., Passmore, R. M. and Clark, J. M. (2014) Detection of lying down, sitting, standing, and stepping using two activPAL monitors. *Medicine & Science in Sports & Exercise, 46*(10), pp. 2025-2029.

Bassett, D. R., Rowlands, A. V. and Trost, S. G. (2012) Calibration and validation of wearable monitors. *Medicine & Science in Sports & Exercise, 44*(1 Suppl 1), pp. S32-38.

Bean, C. N., Fortier, M., Post, C. and Chima, K. (2014) Understanding how organized youth sport may be harming individual players within the family unit: A literature review. *International journal of environmental research and public health, 11*(10), pp. 10226-10268.

Beets, M. W., Patton, M. M. and Edwards, S. (2005) The accuracy of pedometer steps and time during walking in children. *Medicine & Science in Sports & Exercise, 37*(3), pp. 513-520.

Belton, S., O'Brien, W., Issartel, J., McGrane, B. and Powell, D. (2016) Where does the time go? Patterns of physical activity in adolescent youth. *Journal of Science and Medicine in Sport, 19*(11), pp. 921-925.

Beni, S., Fletcher, T. and Ní Chróinín, D. (2017) Meaningful experiences in physical education and youth sport: A review of the literature. *Quest, 69*(3), pp. 291-312.

Berlin, J. E., Storti, K. L. and Brach, J. S. (2006) Using activity monitors to measure physical activity in free-living conditions. *Physical Therapy, 86*(8), pp. 1137-1145.

Bjørnarå, H. B., Westergren, T., Sejersted, E., Torstveit, M. K., Hansen, B. H., Berntsen, S. and Bere, E. (2021) Does organized sports participation in childhood and adolescence positively influence health? A review of reviews. *Preventive medicine reports, 23*, pp. 101425.

Blair, R. and Capel, S. (2013) Who should teach physical education in curriculum and extra-curricular time. *Debates in physical education*, pp. 171-187.

Bland, V., Heatherington-Rauth, M., Howe, C., Going, S. and Bea, J. (2020) Association of objectively measured physical activity and bone health in children and adolescents: a systematic review and narrative synthesis. *Osteoporosis International, 31*(10), pp. 1865-1894.

Brage, S., Westgate, K., Franks, P. W., Stegle, O., Wright, A., Ekelund, U. and Wareham, N. J. (2015) Estimation of free-living energy expenditure by heart rate and movement sensing: a doubly-labelled water study. *PLoS One, 10*(9), pp. e0137206.

Brailey, G., Metcalf, B., Lear, R., Price, L., Cumming, S. and Stiles, V. (2022) A comparison of the associations between bone health and three different intensities of accelerometer-derived habitual physical activity in children and adolescents: a systematic review. *Osteoporosis International*, pp. 1-32.

Braun, V. and Clarke, V. (2012) Thematic analysis.

Breslin, G., Gossrau-Breen, D., McCay, N., Gilmore, G., MacDonald, L. and Hanna, D. (2012) Physical activity, gender, weight status, and wellbeing in 9-to 11-year-old children: a cross-sectional survey. *Journal of Physical Activity and Health, 9*(3), pp. 394-401.

Broderick, J., Ryan, J., O'Donnell, D. and Hussey, J. (2014) A guide to assessing physical activity using accelerometry in cancer patients. *Supportive Care in Cancer, 22*(4), pp. 1121-1130.

Brooks, G. A., Fahey, T. D. and White, T. P. (1996) *Exercise physiology: Human bioenergetics and its applications,* California, USA: Mayfield Publishing Company.

Brychta, R., Wohlers, E., Moon, J. and Chen, K. (2010) Energy expenditure: measurement of human metabolism. *IEEE Engineering in Medicine and Biology Magazine, 29*(1), pp. 42-47.

Buckley, J. P., Mellor, D. D., Morris, M. and Joseph, F. (2013) Standing-based office work shows encouraging signs of attenuating post-prandial glycaemic excursion. *Occupational and Environmental Medicine, 71*(2), pp. 109-11.

Bull, F. C., Al-Ansari, S. S., Biddle, S., Borodulin, K., Buman, M. P., Cardon, G., Carty, C., Chaput, J.-P., Chastin, S. and Chou, R. (2020) World Health Organization 2020 guidelines on

physical activity and sedentary behaviour. *British Journal of Sports Medicine, 54*(24), pp. 1451-1462.

Bunker, D. and Thorpe, R. (1982) A model for the teaching of games in secondary schools. *Bulletin of Physical Education, 18*(1), pp. 5-8.

Bunker, D. and Thorpe, R. (1983) Games teaching revisited. *Bulletin of physical education, 19*(1), pp. 5-8.

Bunker, D. and Thorpe, R. (1986) The curriculum model. *Rethinking games teaching*, pp. 7-10.

Butler, J. (2014) TGfU–Would you know it if you saw it? Benchmarks from the tacit knowledge of the founders. *European Physical Education Review, 20*(4), pp. 465-488.

Butte, N. F., Ekelund, U. and Westerterp, K. R. (2012) Assessing physical activity using wearable monitors: measures of physical activity. *Medicine & Science in Sports & Exercise, 44*(1S), pp. S5-S12.

Camacho-Miñano, M. J., LaVoi, N. M. and Barr-Anderson, D. J. (2011) Interventions to promote physical activity among young and adolescent girls: a systematic review. *Health education research, 26*(6), pp. 1025-1049.

Carson, V., Hunter, S., Kuzik, N., Gray, C. E., Poitras, V. J., Chaput, J.-P., Saunders, T. J., Katzmarzyk, P. T., Okely, A. D. and Connor Gorber, S. (2016) Systematic review of sedentary behaviour and health indicators in school-aged children and youth: an update. *Applied Physiology, Nutrition, and Metabolism, 41*(6), pp. S240-S265.

Carson, V. and Janssen, I. (2011) Volume, patterns, and types of sedentary behavior and cardio-metabolic health in children and adolescents: a cross-sectional study. *BMC Public Health, 11*(1), pp. 274.

Carson, V., Rinaldi, R., Torrance, B., Maximova, K., Ball, G., Majumdar, S., Plotnikoff, R., Veugelers, P., Boulé, N. and Wozny, P. (2014) Vigorous physical activity and longitudinal associations with cardiometabolic risk factors in youth. *International Journal of Obesity, 38*(1), pp. 16-21.

Carson, V., Tremblay, M. S., Chaput, J.-P., McGregor, D. and Chastin, S. (2019) Compositional analyses of the associations between sedentary time, different intensities of physical activity, and cardiometabolic biomarkers among children and youth from the United States. *PLoS One, 14*(7), pp. e0220009.

Caspersen, C. J., Powell, K. E. and Christenson, G. M. (1985) Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Reports, 100*(2), pp. 126.

Cassidy, T., Jones, R. L. and Potrac, P. (2015) *Understanding sports coaching: The pedagogical, social and cultural foundations of coaching practice,* London: Routledge.

Chan, A., Chan, D., Lee, H., Ng, C. C. and Yeo, A. H. L. (2022) Reporting adherence, validity and physical activity measures of wearable activity trackers in medical research: A systematic review. *International Journal of Medical Informatics, 160*, pp. 104696.

Chan, C. B. and Ryan, D. A. (2009) Assessing the effects of weather conditions on physical activity participation using objective measures. *International journal of environmental research and public health, 6*(10), pp. 2639-2654.

Chaput, J.-P., Saunders, T. J., Mathieu, M.-È., Henderson, M., Tremblay, M. S., O'loughlin, J. and Tremblay, A. (2013) Combined associations between moderate to vigorous physical activity and sedentary behaviour with cardiometabolic risk factors in children. *Applied Physiology, Nutrition, and Metabolism, 38*(5), pp. 477-483.

Chastin, S. F., Palarea-Albaladejo, J., Dontje, M. L. and Skelton, D. A. (2015) Combined effects of time spent in physical activity, sedentary behaviors and sleep on obesity and cardio-metabolic health markers: a novel compositional data analysis approach. *PLoS One, 10*(10), pp. e0139984.

Chen, K. and Bassett, J. D. (2005) The technology of accelerometry-based activity monitors: current and future. *Medicine & Science in Sports & Exercise, 37*(11), pp. S490-500.

Chinapaw, M. J., Mokkink, L. B., van Poppel, M. N., van Mechelen, W. and Terwee, C. B. (2010) Physical activity questionnaires for youth. *Sports Medicine, 40*(7), pp. 539-563.

Clark, H. J., Camiré, M., Wade, T. J. and Cairney, J. (2015) Sport participation and its association with social and psychological factors known to predict substance use and abuse among youth: A scoping review of the literature. *International Review of Sport and Exercise Psychology, 8*(1), pp. 224-250.

Cohen, A., McDonald, S., McIver, K., Pate, R. and Trost, S. (2014) Assessing physical activity during youth sport: the observational system for recording activity in children: youth sports. *Pediatric Exercise Science, 26*(2), pp. 203-209.

Cohen, J. (1988) *Statistical power analysis for the behavioral sciences,* 2nd ed.*,* New Jersey, USA: Lawrence Erlbaum Associates

Colley, R. C., Butler, G., Garriguet, D., Prince, S. A. and Roberts, K. C. (2019) Comparison of self-reported and accelerometer-measured physical activity among Canadian youth. *Health Reports, 30*(7), pp. 3-12.

Colley, R. C., Carson, V., Garriguet, D., Janssen, I., Roberts, K. C. and Tremblay, M. S. (2017) Physical activity of Canadian children and youth, 2007 to 2015. *Health Reports, 28*(10), pp. 8-16.

Conroy, D. E. and Coatsworth, J. D. (2006) Coach training as a strategy for promoting youth social development. *The Sport Psychologist, 20*(2), pp. 128-144.

Conway, J. M., Seale, J. L., Jacobs, D. R., Irwin, M. L. and Ainsworth, B. E. (2002) Comparison of energy expenditure estimates from doubly labeled water, a physical activity questionnaire, and physical activity records. *The American Journal of Clinical Nutrition, 75*(3), pp. 519-525.

Corder, K., Ekelund, U., Steele, R. M., Wareham, N. J. and Brage, S. (2008) Assessment of physical activity in youth. *Journal of Applied Physiology, 105*(3), pp. 977-987.

Corder, K., Sharp, S. J., Atkin, A. J., Griffin, S. J., Jones, A. P., Ekelund, U. and van Sluijs, E. M. (2015) Change in objectively measured physical activity during the transition to adolescence. *British Journal of Sports Medicine, 49*(11), pp. 730-736.

Corder, K., van Sluijs, E. M., Wright, A., Whincup, P., Wareham, N. J. and Ekelund, U. (2009) Is it possible to assess free-living physical activity and energy expenditure in young people by self-report? *The American Journal of Clinical Nutrition, 89*(3), pp. 862-870.

Corr, M., McSharry, J. and Murtagh, E. M. (2019) Adolescent girls' perceptions of physical activity: A systematic review of qualitative studies. *American Journal of Health Promotion, 33*(5), pp. 806-819.

Côté, J. and Gilbert, W. (2009) An integrative definition of coaching effectiveness and expertise. *International Journal of Sports Science & Coaching, 4*(3), pp. 307-323.

Coté, J., Horton, S., MacDonald, D. and Wilkes, S. (2009) The benefits of sampling sports during childhood. *Physical & Health Education Journal, 74*(4), pp. 6.

Crampsie, A. (2016) Playing identity politics: The Gaelic Athletic Association in modern Ireland. in Koch, N., (ed.) *Critical Geographies of Sport: Space, Power and Sport in Global Perspective*,London: Routledge. pp. 124-138.

Crane, J. and Temple, V. (2015) A systematic review of dropout from organized sport among children and youth. *European Physical Education Review, 21*(1), pp. 114-131.

Crouter, S. E., Albright, C. and BASSETT JR, D. R. (2004) Accuracy of polar S410 heart rate monitor to estimate energy cost of exercise. *Medicine & Science in Sports & Exercise, 36*(8), pp. 1433-1439.

Crouter, S. E., Clowers, K. G. and Bassett Jr, D. R. (2006) A novel method for using accelerometer data to predict energy expenditure. *Journal of Applied Physiology, 100*(4), pp. 1324-1331.

Cullen, B. D., Cregg, C. J., Kelly, D. T., Hughes, S. M., Daly, P. G. and Moyna, N. M. (2013) Fitness profiling of elite level adolescent Gaelic football players. *Journal of Strength and Conditioning Research, 27*(8), pp. 2096-2103.

Cullen, B. D., Roantree, M. T., McCarren, A. L., Kelly, D. T., O'Connor, P. L., Hughes, S. M., Daly, P. G. and Moyna, N. M. (2017) Physiological profile and activity pattern of minor Gaelic football players. *The Journal of Strength & Conditioning Research, 31*(7), pp. 1811-1820.

Cushion, C. (2010) Coach behaviour. in Lyle, J., (ed.) *Sports Coaching: Professionalisation and Practice*,Edinburgh, UK: Churchill Livingstone.

Cushion, C., Harvey, S., Muir, B. and Nelson, L. (2012) Developing the Coach Analysis and Intervention System (CAIS): Establishing validity and reliability of a computerised systematic observation instrument. *Journal of Sports Sciences, 30*(2), pp. 201-216.

Cushion, C. J. (2013) Applying game centered approaches in coaching: A critical analysis of the 'dilemmas of practice'impacting change. *Sports Coaching Review, 2*(1), pp. 61-76.

Davidson, L., McNeill, G., Haggarty, P., Smith, J. S. and Franklin, M. F. (1997) Free-living energy expenditure of adult men assessed by continuous heart-rate monitoring and doubly-labelled water. *British Journal of Nutrition, 78*(5), pp. 695-708.

Davis, B. and Sumara, D. (1997) Cognition, complexity, and teacher education. *Harvard educational review, 67*(1), pp. 105-126.

Davis, J. (1996) Direct determination of aerobic power. *Physiological Assessment of Human Fitness*, pp. 9-17.

Davis, R. E. and Loprinzi, P. D. (2016) Examination of accelerometer reactivity among a population sample of children, adolescents, and adults. *Journal of Physical Activity and Health, 13*(12), pp. 1325-1332.

de Almeida Mendes, M., da Silva, I. C., Ramires, V. V., Reichert, F. F., Martins, R. C. and Tomasi, E. (2018) Calibration of raw accelerometer data to measure physical activity: a systematic review. *Gait & Posture, 61*, pp. 98-110.

Deleplace, R. (1979) *Rugby de movement rugby total,* Paris: Editions Education Physique et Sports.

den Duyn, N. (1997) *Game sense workbook*. Canberra: Australian Sports Commission.

Department of Health and Children (2012) *Get Ireland Active: The National Guidelines on Physical Activity for Ireland.* Dublin: The Department of Health and Children and the Health Service Executive.

Department of Health and Children and The Health Service Executive (2009) *The National Guidelines on Physical Activity for Ireland.*

Department of Health and Social Care (2019) *UK Chief Medical Officers' Physical Activity Guidelines,.*

Department of Tourism, C., Arts, Gaeltacht, Sport and Media, (2021) *Sports Action Plan 2021-2023.*

Deverka, P. A., Lavallee, D. C., Desai, P. J., Esmail, L. C., Ramsey, S. D., Veenstra, D. L. and Tunis, S. R. (2012) Stakeholder participation in comparative effectiveness research: defining a framework for effective engagement. *Journal of Comparative Effectiveness Research, 1*(2), pp. 181-194.

Diaz, K. M., Krupka, D. J., Chang, M. J., Peacock, J., Ma, Y., Goldsmith, J., Schwartz, J. E. and Davidson, K. W. (2015) Fitbit®: An accurate and reliable device for wireless physical activity tracking. *International Journal of Cardiology, 185*(1), pp. 138-140.

Diehl, K., Thiel, A., Zipfel, S., Mayer, J., Litaker, D. G. and Schneider, S. (2012) How healthy is the behavior of young athletes? A systematic literature review and meta-analyses. *Journal of sports science & medicine, 11*(2), pp. 201.

Ding, D., Lawson, K. D., Kolbe-Alexander, T. L., Finkelstein, E. A., Katzmarzyk, P. T., van Mechelen, W. and Pratt, M. (2016) The economic burden of physical inactivity: a global analysis of major non-communicable diseases. *Lancet, 388*(10051), pp. 1311-1324.

Dössegger, A., Ruch, N., Jimmy, G., Braun-Fahrländer, C., Mäder, U., Hänggi, J., Hofmann, H., Puder, J. J., Kriemler, S. and Bringolf-Isler, B. (2014) Reactivity to accelerometer measurement of children and adolescents. *Medicine & Science in Sports & Exercise, 46*(6), pp. 1140.

Dowd, K., Harrington, D., Hannigan, A., Purtill, H., Kelly, S., Macken, A., Moyna, N., O'Gorman, C. and Donnelly, A. (2016) The development of activity profiles in adolescent females and their association with adiposity. *Pediatric Exercise Science, 28*(1), pp. 109-116.

Dowd, K. P., Harrington, D. M., Bourke, A. K., Nelson, J. and Donnelly, A. E. (2012a) The measurement of sedentary patterns and behaviors using the activPAL™ professional physical activity monitor. *Physiological Measurement, 33*(11), pp. 1887.

Dowd, K. P., Harrington, D. M. and Donnelly, A. E. (2012b) Criterion and concurrent validity of the activPAL™ professional physical activity monitor in adolescent females. *PLoS One, 7*(10), pp. e47633.

Dowd, K. P., Harrington, D. M., Hannigan, A. and Donnelly, A. E. (2014) Light-intensity physical activity is associated with adiposity in adolescent females. *Medicine & Science in Sports & Exercise, 46*(12), pp. 2295-300.

Dowd, K. P., Szeklicki, R., Minetto, M. A., Murphy, M. H., Polito, A., Ghigo, E., van der Ploeg, H., Ekelund, U., Maciaszek, J. and Stemplewski, R. (2018) A systematic literature review of reviews on techniques for physical activity measurement in adults: a DEDIPAC study. *International Journal of Behavioral Nutrition and Physical Activity, 15*(1), pp. 1-33.

Drewe, S. B. (2000) An examination of the relationship between coaching and teaching. *Quest, 52*(1), pp. 79-88.

Duignan, C. M., Slevin, P. J., Caulfield, B. M. and Blake, C. (2021) Exploring the use of mobile athlete self-report measures in elite Gaelic games: a qualitative approach. *The Journal of Strength & Conditioning Research, 35*(12), pp. 3491-3499.

Dumith, S. C., Gigante, D. P., Domingues, M. R. and Kohl III, H. W. (2011) Physical activity change during adolescence: a systematic review and a pooled analysis. *International Journal of Epidemiology, 40*(3), pp. 685-698.

Dyson, B. (2005) Integrating cooperative learning and tactical games models: Focusing on social interactions and decision making. *Teaching Games for Understanding: Theory, research, and practice*, pp. 149-168.

Eather, N., Bull, A., Young, M. D., Barnes, A. T., Pollock, E. R. and Morgan, P. J. (2018) Fundamental movement skills: Where do girls fall short? A novel investigation of object-control skill execution in primary-school aged girls. *Preventive medicine reports, 11*, pp. 191-195.

Eather, N., Jones, B., Miller, A. and Morgan, P. J. (2019) Evaluating the impact of a coach development intervention for improving coaching practices in junior football (soccer): The "MASTER" pilot study. *Journal of Sports Sciences, 38*(11-12), pp. 1441-1453.

Eather, N., Morgan, P. J. and Lubans, D. R. (2013) Improving the fitness and physical activity levels of primary school children: Results of the Fit-4-Fun group randomized controlled trial. *Preventive Medicine, 56*(1), pp. 12-19.

Edwardson, C. L., Winkler, E. A., Bodicoat, D. H., Yates, T., Davies, M. J., Dunstan, D. W. and Healy, G. N. (2017) Considerations when using the activPAL monitor in field-based research with adult populations. *Journal of Sport and Health Science, 6*(2), pp. 162-178.

Eiberg, S., Hasselstrom, H., Grønfeldt, V., Froberg, K., Svensson, J. and Andersen, L. B. (2005) Maximum oxygen uptake and objectively measured physical activity in Danish children 6–

7 years of age: the Copenhagen school child intervention study. *British Journal of Sports Medicine, 39*(10), pp. 725-730.

Eime, R. M., Young, J. A., Harvey, J. T., Charity, M. J. and Payne, W. R. (2013) A systematic review of the psychological and social benefits of participation in sport for children and adolescents: informing development of a conceptual model of health through sport. *International Journal of Behavioral Nutrition and Physical Activity, 10*(1), pp. 98.

Ekelund, U., Anderssen, S., Andersen, L. B., Riddoch, C. J., Sardinha, L. B., Luan, J. a., Froberg, K. and Brage, S. (2009) Prevalence and correlates of the metabolic syndrome in a population-based sample of European youth. *The American Journal of Clinical Nutrition, 89*(1), pp. 90-96.

Ekelund, U., Luan, J. a., Sherar, L. B., Esliger, D. W., Griew, P., Cooper, A. and Collaborators, I. C. s. A. D. (2012) Moderate to vigorous physical activity and sedentary time and cardiometabolic risk factors in children and adolescents. *JAMA, 307*(7), pp. 704-712.

Elliott, J. M. and McCullick, B. A. (2019) Exceptional adaptability in collegiate coaching. *Sports Coaching Review, 8*(3), pp. 199-223.

Emmonds, S., Sawczuk, T., Scantlebury, S., Till, K. and Jones, B. (2020) Seasonal changes in the physical performance of elite youth female soccer players. *The Journal of Strength & Conditioning Research, 34*(9), pp. 2636-2643.

Evans, J. R. (2006) Elite level rugby coaches interpretation and use of Games Sense. *Asian Journal of Exercise & Sports Science, 3*(1).

Evans, J. R. (2012) Elite Rugby Union Coaches; Interpretation and Use of Game Sense in New Zealand. *Asian Journal of Exercise & Sports Science, 9*(1).

Evans, J. R. and Light, R. L. (2007) Coach development through collaborative action research: A rugby coach's implemention of game sense pedagogy. *Asian Journal of Exercise & Sports Science, 5*(1), pp. 31-37.

Evenson, K. R., Goto, M. M. and Furberg, R. D. (2015) Systematic review of the validity and reliability of consumer-wearable activity trackers. *International Journal of Behavioral Nutrition and Physical Activity, 12*(1), pp. 159.

Farooq, A., Martin, A., Janssen, X., Wilson, M. G., Gibson, A. M., Hughes, A. and Reilly, J. J. (2020) Longitudinal changes in moderate-to-vigorous-intensity physical activity in children and adolescents: A systematic review and meta-analysis. *Obesity Reviews, 21*(1), pp. e12953.

Farrow, D., Pyne, D. and Gabbett, T. (2008) Skill and physiological demands of open and closed training drills in Australian football. *International Journal of Sports Science & Coaching, 3*(4), pp. 489-499.

Fenton, S. A., Duda, J. L. and Barrett, T. (2015) The Contribution of Youth Sport Football to Weekend Physical Activity for Males Aged 9 to 16 Years: Variability Related to Age and Playing Position. *Pediatric Exercise Science, 27*(2), pp. 208-218.

Ford, P. A., Perkins, G. and Swaine, I. (2013) Effects of a 15-week accumulated brisk walking programme on the body composition of primary school children. *Journal of Sports Sciences, 31*(2), pp. 114-122.

Ford, P. R., Yates, I. and Williams, A. M. (2010) An analysis of practice activities and instructional behaviours used by youth soccer coaches during practice: Exploring the link between science and application. *Journal of Sports Sciences, 28*(5), pp. 483-495.

Fraser-Thomas, J. and Côté, J. (2009) Understanding adolescents' positive and negative developmental experiences in sport. *The Sport Psychologist, 23*(1), pp. 3-23.

Freedson, P., Bowles, H. R., Troiano, R. and Haskell, W. (2012) Assessment of physical activity using wearable monitors: recommendations for monitor calibration and use in the field. *Medicine & Science in Sports & Exercise, 44*(1 Suppl 1), pp. S1.

Freedson, P., Pober, D. and Janz, K. F. (2005) Calibration of accelerometer output for children. *Medicine & Science in Sports & Exercise, 37*(11), pp. S523-S530.

Freedson, P. S., Melanson, E. and Sirard, J. (1998) Calibration of the computer science and applications, inc. accelerometer. *Medicine & Science in Sports & Exercise, 30*(5), pp. 777-781.

Friel, S., Nic Gabhainn, S. and Kelleher, C. (1999) *National health and lifestyles surveys: survey of lifestyle, attitudes and nutrition (SLAN) and the Irish Health Behaviour in in School-Aged Children Survey (HBSC).*

Fuezeki, E., Engeroff, T. and Banzer, W. (2017) Health benefits of light-intensity physical activity: a systematic review of accelerometer data of the National Health and Nutrition Examination Survey (NHANES). *Sports Medicine, 47*(9), pp. 1769-1793.

Gabbett, T., Jenkins, D. and Abernethy, B. (2009) Game-based training for improving skill and physical fitness in team sport athletes. *International Journal of Sports Science & Coaching, 4*(2), pp. 273-283.

Gaelic Athletic Association (2012) *Mobilising forces, modernising structures and moving with the times.* Dublin, Ireland: Gaelic Athletic Association.

Gaelic Athletic Association (2016) *About the GAA*, Available: https://www.gaa.ie/the-gaa/about-the-gaa/

Gaelic Athletic Association (2018) *Strategic Plan 2018-2021*. Dublin: Gaelic Athletic Association.

Gaelic Athletic Association (2021) *Gaelic Games Player Pathway*. Dublin.

García-González, L., Moreno, A., Gil, A., Moreno, M. P. and Villar, F. D. (2014) Effects of decision training on decision making and performance in young tennis players: An applied research. *Journal of applied sport psychology, 26*(4), pp. 426-440.

Garcia-Gonzalez, L., Moreno, M. P., Moreno, A., Gil, A. and Del Villar, F. (2013) Effectiveness of a video-feedback and questioning programme to develop cognitive expertise in sport. *PLoS One, 8*(12), pp. e82270.

García-Prieto, J. C., Martinez-Vizcaino, V., García-Hermoso, A., Sánchez-López, M., Arias-Palencia, N., Fonseca, J. F. O. and Mora-Rodriguez, R. (2017) Energy expenditure in playground games in primary school children measured by accelerometer and heart rate monitors. *International Journal of Sport Nutrition & Exercise Metabolism, 27*(5), pp. 467-474.

García López, L. M., Contreras Jordán, O. R., Penney, D. and Chandler, T. (2009) The role of transfer in games teaching: Implications for the development of the sports curriculum. *European Physical Education Review, 15*(1), pp. 47-63.

Gardner, L. A., Magee, C. A. and Vella, S. A. (2017) Enjoyment and behavioral intention predict organized youth sport participation and dropout. *Journal of Physical Activity and Health, 14*(11), pp. 861-865.

Garriga, A., Sempere-Rubio, N., Molina-Prados, M. J. and Faubel, R. (2021) Impact of seasonality on physical activity: A systematic review. *International journal of environmental research and public health, 19*(1), pp. 2.

Gavin, A., Keane, E., Callaghan, M., Molcho, M., Kelly, C. and Nic Gabhainn, S. (2015) *The Irish health behaviour in school-aged children (HBSC) study 2014*: Galway: Department of Health/NUIG.

Gavin, A., Költő, A., Kelly, C., Molcho, M. and Nic Gabhainn, S. (2021) *Trends in Health Behaviours, Health Outcomes and Contextual Factors between 1998-2018: findings from the Irish Health Behaviour in School-aged Children Study*. Dublin: Department of Health.

Gavin, K. W., Lane, A. and Dowd, K. P. (2020) The contribution of Gaelic football participation to youth physical activity levels. *Journal of sports science & medicine, 19*(4), pp. 652-661.

Gillinov, S., Etiwy, M., Wang, R., Blackburn, G., Phelan, D., Gillinov, A. M., Houghtaling, P., Javadikasgari, H. and Desai, M. Y. (2017) Variable accuracy of wearable heart rate monitors during aerobic exercise. *Medicine & Science in Sports & Exercise, 49*(8), pp. 1697-1703.

Given, L. M. (2008) *The Sage encyclopedia of qualitative research methods,* Sage publications.

Goodman, A., Paskins, J. and Mackett, R. (2012) Day length and weather effects on children's physical activity and participation in play, sports, and active travel. *Journal of Physical Activity and Health, 9*(8), pp. 1105-1116.

Goran, M. I. (1994) Application of the doubly labeled water technique for studying total energy expenditure in young children: a review. *Pediatric Exercise Science, 6*(1), pp. 11-30.

Gore, F. M., Bloem, P. J., Patton, G. C., Ferguson, J., Joseph, V., Coffey, C., Sawyer, S. M. and Mathers, C. D. (2011) Global burden of disease in young people aged 10–24 years: a systematic analysis. *The Lancet, 377*(9783), pp. 2093-2102.

Gralla, M. H., McDonald, S. M., Breneman, C., Beets, M. W. and Moore, J. B. (2019) Associations of objectively measured vigorous physical activity with body composition, cardiorespiratory fitness, and cardiometabolic health in youth: A review. *American Journal of Lifestyle Medicine, 13*(1), pp. 61-97.

Gray, S., Sproule, J. and Morgan, K. (2009) Teaching team invasion games and motivational climate. *European Physical Education Review, 15*(1), pp. 65-89.

Greenhalgh, T., Raftery, J., Hanney, S. and Glover, M. (2016) Research impact: a narrative review. *BMC medicine, 14*(1), pp. 1-16.

Gréhaigne, J.-F. and Godbout, P. (1995) Tactical knowledge in team sports from a constructivist and cognitivist perspective. *Quest, 47*(4), pp. 490-505.

Gréhaigne, J., Wallian, N. and Godbout, P. (2005) Tactical-decision learning model and students' practices. *Physical Education and Sport Pedagogy, 10*(3), pp. 255-269.

Griffin, L. L., Mitchell, S. A. and Oslin, J. L. (1997) *Teaching sport concepts and skills: A tactical games approach,* Champaign, IL: Human Kinetics.

Griffin, L. L. and Patton, K. (2005) Two Decades of Teaching Games for Understanding: Looking at the Past. *Teaching Games for Understanding: Theory, research, and practice*, pp. 1.

Growing Up in Ireland Study Team (2009) *Key findings: 9-year olds, The health of 9-year-olds, (No.4).* Dublin: ESRI/TCD/OMCYA.

Growing Up in Ireland Study Team (2012) *Key findings: 13-year olds, Physical activity and obesity among 13-year-olds (No.2).* Dublin: ESRI/TCD/DCYA.

Growing Up in Ireland Study Team (2016) *Key findings: Child Cohort at 17/18-years, Health, weight, physical activity and diet (No.2)*. Dublin: ESRI/TCD/DCYA.

Guagliano, J., Lonsdale, C., Kolt, G., Rosenkranz, R. and George, E. (2015) Increasing girls' physical activity during a short-term organized youth sport basketball program: A randomized controlled trial. *Journal of Science and Medicine in Sport, 18*(4), pp. 412-417.

Guagliano, J. M., Lonsdale, C., Rosenkranz, R. R., Kolt, G. S. and George, E. S. (2014) Do coaches perceive themselves as influential on physical activity for girls in organised youth sport? *PLoS One, 9*(9), pp. e105960.

Guagliano, J. M., Rosenkranz, R. R. and Kolt, G. S. (2013) Girls' physical activity levels during organized sports in Australia. *Medicine & Science in Sports & Exercise, 45*(1), pp. 116-122.

Guinhouya, B., Samouda, H. and De Beaufort, C. (2013) Level of physical activity among children and adolescents in Europe: a review of physical activity assessed objectively by accelerometry. *Public health, 127*(4), pp. 301-311.

Guthold, R., Stevens, G. A., Riley, L. M. and Bull, F. C. (2018) Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1· 9 million participants. *The lancet global health, 6*(10), pp. e1077-e1086.

Guthold, R., Stevens, G. A., Riley, L. M. and Bull, F. C. (2020) Global trends in insufficient physical activity among adolescents: a pooled analysis of 298 population-based surveys with 1· 6 million participants. *The Lancet Child & Adolescent Health, 4*(1), pp. 23-35.

Gutin, B., Owens, S., Okuyama, T., Riggs, S., Ferguson, M. and Litaker, M. (1999) Effect of physical training and its cessation on percent fat and bone density of children with obesity. *Obesity Research, 7*(2), pp. 208-214.

Hall, E. T., Gray, S. and Sproule, J. (2016) The microstructure of coaching practice: behaviours and activities of an elite rugby union head coach during preparation and competition. *Journal of Sports Sciences, 34*(10), pp. 896-905.

Hallal, P. C., Andersen, L. B., Bull, F. C., Guthold, R., Haskell, W., Ekelund, U. and Group, L. P. A. S. W. (2012a) Global physical activity levels: surveillance progress, pitfalls, and prospects. *The Lancet, 380*(9838), pp. 247-257.

Hallal, P. C., Dumith, S. C., Reichert, F. F., Menezes, A. M., Araújo, C. L., Wells, J. C., Ekelund, U. and Victora, C. G. (2011) Cross-sectional and longitudinal associations between physical activity and blood pressure in adolescence: birth cohort study. *Journal of Physical Activity and Health, 8*(4), pp. 468-474.

Hallal, P. C., Reichert, F. F., Ekelund, U., Dumith, S. C., Menezes, A. M., Victora, C. G. and Wells, J. (2012b) Bidirectional cross-sectional and prospective associations between physical

activity and body composition in adolescence: birth cohort study. *Journal of Sports Sciences, 30*(2), pp. 183-190.

Hallal, P. C., Victora, C. G., Azevedo, M. R. and Wells, J. C. (2006) Adolescent physical activity and health. *Sports Medicine, 36*(12), pp. 1019-1030.

Harding, S. K., Page, A. S., Falconer, C. and Cooper, A. R. (2015) Longitudinal changes in sedentary time and physical activity during adolescence. *International Journal of Behavioral Nutrition and Physical Activity, 12*(1), pp. 44.

Harrington, D., Dowd, K., Bourke, A. and Donnelly, A. (2010) Objectively measured sedentary levels of a cross-section of limerick adolescent females. *Fifth Physical Education, Physical Activity and Youth Sport*, pp. 19.

Harrison, F., Van Sluijs, E. M., Corder, K., Ekelund, U. and Jones, A. (2015) The changing relationship between rainfall and children's physical activity in spring and summer: a longitudinal study. *International Journal of Behavioral Nutrition and Physical Activity, 12*(1), pp. 1-9.

Harvey, S. (2009) A study of interscholastic soccer players perceptions of learning with Game Sense. *Asian Journal of Exercise & Sports Science, 6*(1), pp. 1-10.

Harvey, S., Cushion, C. J., Cope, E. and Muir, B. (2013) A season long investigation into coaching behaviours as a function of practice state: The case of three collegiate coaches. *Sports Coaching Review, 2*(1), pp. 13-32.

Harvey, S., Cushion, C. J. and Massa-Gonzalez, A. N. (2010a) Learning a new method: Teaching Games for Understanding in the coaches' eyes. *Physical Education and Sport Pedagogy, 15*(4), pp. 361-382.

Harvey, S., Cushion, C. J., Wegis, H. M. and Massa-Gonzalez, A. N. (2010b) Teaching games for understanding in American high-school soccer: A quantitative data analysis using the game performance assessment instrument. *Physical Education and Sport Pedagogy, 15*(1), pp. 29-54.

Harvey, S. and Jarrett, K. (2014) A review of the game-centred approaches to teaching and coaching literature since 2006. *Physical Education and Sport Pedagogy, 19*(3), pp. 278-300.

Harvey, S. and Light, R. L. (2015) Questioning for learning in game-based approaches to teaching and coaching. *Asia-Pacific Journal of Health, Sport and Physical Education, 6*(2), pp. 175-190.

Harvey, S., Pill, S. and Almond, L. (2018) Old wine in new bottles: a response to claims that teaching games for understanding was not developed as a theoretically based pedagogical framework. *Physical Education and Sport Pedagogy, 23*(2), pp. 166-180.

Hay, J., Maximova, K., Durksen, A., Carson, V., Rinaldi, R. L., Torrance, B., Ball, G. D., Majumdar, S. R., Plotnikoff, R. C. and Veugelers, P. (2012) Physical activity intensity and cardiometabolic risk in youth. *Archives of Pediatrics & Adolescent Medicine, 166*(11), pp. 1022-1029.

Hayes, G., Dowd, K., MacDonncha, C. and Donnely, A. (2021) Simultaneous validation of count-to-activity thresholds for five commonly used activity monitors in adolescent research: A step toward data harmonization. *Journal for the Measurement of Physical Behaviour, 4*(4), pp. 333-342.

Hayes, G., Dowd, K. P., MacDonncha, C. and Donnelly, A. E. (2019) Tracking of physical activity and sedentary behavior from adolescence to young adulthood: a systematic literature review. *Journal of Adolescent Health, 65*(4), pp. 446-454.

Healthy Ireland (2016) *Get Ireland Active! The National Physical Activity Plan for Ireland.*

Hebert, J. J., Møller, N. C., Andersen, L. B. and Wedderkopp, N. (2015) Organized sport participation is associated with higher levels of overall health-related physical activity in children (CHAMPS Study-DK). *PLoS One, 10*(8), pp. e0134621.

Henriksen, A., Mikalsen, M. H., Woldaregay, A. Z., Muzny, M., Hartvigsen, G., Hopstock, L. A. and Grimsgaard, S. (2018) Using fitness trackers and smartwatches to measure physical activity in research: analysis of consumer wrist-worn wearables. *Journal of Medical Internet Research, 20*(3), pp. e110.

Henson, J., Yates, T., Biddle, S. J., Edwardson, C. L., Khunti, K., Wilmot, E. G., Gray, L. J., Gorely, T., Nimmo, M. A. and Davies, M. J. (2013) Associations of objectively measured sedentary behaviour and physical activity with markers of cardiometabolic health. *Diabetologia, 56*(5), pp. 1012-1020.

Hidding, L. M., Chinapaw, M., van Poppel, M. N., Mokkink, L. B. and Altenburg, T. M. (2018) An updated systematic review of childhood physical activity questionnaires. *Sports Medicine, 48*(12), pp. 2797-2842.

Hill, R. and Davies, P. (2001) The validity of self-reported energy intake as determined using the doubly labelled water technique. *British Journal of Nutrition, 85*(4), pp. 415-430.

Hills, A. P., Andersen, L. B. and Byrne, N. M. (2011) Physical activity and obesity in children. *British journal of sports medicine, 45*(11), pp. 866-870.

Hills, A. P., Mokhtar, N. and Byrne, N. M. (2014) Assessment of physical activity and energy expenditure: an overview of objective measures. *Frontiers in Nutrition, 1*(5), pp. 1-16.

Hjorth, M. F., Chaput, J.-P., Damsgaard, C. T., Dalskov, S.-M., Andersen, R., Astrup, A., Michaelsen, K. F., Tetens, I., Ritz, C. and Sjödin, A. (2014) Low physical activity level and

short sleep duration are associated with an increased cardio-metabolic risk profile: a longitudinal study in 8-11 year old Danish children. *PLoS One, 9*(8), pp. e104677.

Hoffmann Jr, J. J., Reed, J. P., Leiting, K., Chiang, C.-Y. and Stone, M. H. (2014) Repeated sprints, high intensity interval training, small sided games: theory and application to field sports. *International Journal of Sports Physiology & Performance, 9*(2).

Holman, R. M., Carson, V. and Janssen, I. (2011) Does the fractionalization of daily physical activity (sporadic vs. bouts) impact cardiometabolic risk factors in children and youth? *PLoS One, 6*(10), pp. e25733.

Holt, N. L., Strean, W. B. and Bengoechea, E. G. (2002) Expanding the teaching games for understanding model: New avenues for future research and practice. *Journal of teaching in physical Education, 21*(2), pp. 162-176.

Hopper, T. (2011) Game-as-teacher: Modification by adaptation in learning through game-play. *Asia-Pacific Journal of Health, Sport and Physical Education, 2*(2), pp. 3-21.

Horgan, P. (2021) *Gaelic Games Coach Survey*. Dublin, Ireland: Gaelic Athletic Association.

Horgan, P. and Daly, P. (2015) The role of the coach developer in supporting and guiding coach learning: A commentary. *International Sport Coaching Journal, 2*(3), pp. 354-356.

Howie, E. K., Guagliano, J. M., Milton, K., Vella, S. A., Gomersall, S. R., Kolbe-Alexander, T. L., Richards, J. and Pate, R. R. (2020) Ten research priorities related to youth sport, physical activity, and health. *Journal of Physical Activity and Health, 17*(9), pp. 920-929.

Inchley, J. and Currie, D. (2013) *Growing up unequal: gender and socioeconomic differences in young people's health and well-being*. Health Behaviour in School-aged Children (HBSC) Study: International Report from the 2013/2014 Survey.

Irish Sports Council (2007) *Ballpark figures: Key research for Irish sports policy*: Dublin: Economic and Social Research Institute.

Irish Sports Council (2015) *The Irish Sports Monitor 2015 Annual Report*.

Isabel, M., António, S., Antonio, R., Felismina, P. and Michel, M. (2008) A systematic observation of youth amateur volleyball coaches behaviours. *International journal of applied sports sciences, 20*(2), pp. 37-58.

Janssen, I. (2014) Active play: an important physical activity strategy in the fight against childhood obesity. *Canadian journal of public health, 105*(1), pp. e22-e27.

Janssen, I. and LeBlanc, A. G. (2010) Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity, 7*(1), pp. 40.

Janssen, I., Wong, S. L., Colley, R. and Tremblay, M. S. (2013) The fractionalization of physical activity throughout the week is associated with the cardiometabolic health of children and youth. *BMC Public Health, 13*(1), pp. 1-8.

Janssen, X., Cliff, D. P., Reilly, J. J., Hinkley, T., Jones, R. A., Batterham, M., Ekelund, U., Brage, S. and Okely, A. D. (2014) Validation and calibration of the activPAL™ for estimating METs and physical activity in 4–6 year olds. *Journal of Science and Medicine in Sport, 17*(6), pp. 602-606.

Jarrett, K. and Harvey, S. (2016) Similar, but not the same: comparing the game based approaches of teaching games for understanding (TGfU) and Game Sense. *eJRIEPS. Ejournal de la recherche sur l'intervention en éducation physique et sport,* (38).

Jiménez-Pavón, D., Konstabel, K., Bergman, P., Ahrens, W., Pohlabeln, H., Hadjigeorgiou, C., Siani, A., Iacoviello, L., Molnár, D. and De Henauw, S. (2013) Physical activity and clustered cardiovascular disease risk factors in young children: a cross-sectional study (the IDEFICS study). *BMC medicine, 11*(1), pp. 1-11.

Johnson, W., Li, L., Kuh, D. and Hardy, R. (2015) How has the age-related process of overweight or obesity development changed over time? Co-ordinated analyses of individual participant data from five United Kingdom birth cohorts. *PLoS Medicine, 12*(5), pp. e1001828.

Jones, P. J., Catt, M., Davies, M. J., Edwardson, C. L., Mirkes, E. M., Khunti, K., Yates, T. and Rowlands, A. V. (2021) Feature selection for unsupervised machine learning of accelerometer data physical activity clusters–A systematic review. *Gait & Posture, 90*, pp. 120-128.

Jones, R. L. (2006) *The sports coach as educator: Re-conceptualising sports coaching,* London: Routledge.

Kalman, M., Inchley, J., Sigmundova, D., Iannotti, R. J., Tynjälä, J. A., Hamrik, Z., Haug, E. and Bucksch, J. (2015) Secular trends in moderate-to-vigorous physical activity in 32 countries from 2002 to 2010: a cross-national perspective. *European Journal of Public Health, 25*(2), pp. 37-40.

Kanters, M. A., McKenzie, T. L., Edwards, M. B., Bocarro, J., Mahar, M. T., Martel, K. and Hodge, C. (2015) Youth sport practice model gets more kids active with more time practicing skills. *Retos,* (28), pp. 173-177.

Karagiannis, K. and Pill, S. (2017) A case study exploring coaching practice and coaching perspectives at one soccer (Football) club. *Gymnasium, 18*(1).

Katzmarzyk, P. T., Friedenreich, C., Shiroma, E. J. and Lee, I.-M. (2022) Physical inactivity and non-communicable disease burden in low-income, middle-income and high-income countries. *British Journal of Sports Medicine, 56*(2), pp. 101-106.

Kelleher, C., Nic Gabhainn, S., Friel, S., Corrigan, H., Nolan, G., Sixsmith, J., Walsh, O. and Cooke, M. (2003) *The national health and lifestyles survey: Survey of lifestyles, attitudes and nutrition (Slan 2002) and the Irish health behaviour in school-aged children survey (HBSC)*: Health Promotion Unit Department of Health and Children Dublin.

Kelly, C., Gavin, A., Molcho, M. and Nic Gabhainn, S. (2012) *The Irish health behaviour in school-aged children (HBSC) study 2010*: NUI Galway: Health Promotion Research Centre.

Kenny, G. P., Notley, S. R. and Gagnon, D. (2017) Direct calorimetry: a brief historical review of its use in the study of human metabolism and thermoregulation. *European Journal of Applied Physiology, 117*(9), pp. 1765-1785.

Khan, K. M., Thompson, A. M., Blair, S. N., Sallis, J. F., Powell, K. E., Bull, F. C. and Bauman, A. E. (2012) Sport and exercise as contributors to the health of nations. *Lancet, 380*(9836), pp. 59-64.

Kidman, L. (2005) *Athlete-centred coaching: Developing inspired and inspiring people,* IPC Print Resources.

Kidman, L. and Hanrahan, S. J. (2010) *The coaching process: A practical guide to becoming an effective sports coach,* London: Routledge.

Kinnerk, P. (2020) *Coaching pedagogy in inter-county Gaelic football.* Unpublished PhD, University of Limerick, University of Limerick.

Kinnerk, P., Harvey, S., Kearney, P., MacDonncha, C. and Lyons, M. (2019) An investigation of the self-reported practice activities and session sequencing of inter-county Gaelic football coaches. *International Sport Coaching Journal, 6*(2), pp. 211-219.

Kinnerk, P., Harvey, S., MacDonncha, C. and Lyons, M. (2018) A review of the game-based approaches to coaching literature in competitive team sport settings. *Quest, 70*(4), pp. 401-418.

Kirk, D. (2010) Physical education and sport pedagogy. *Physical Education Matters, 5*(3), pp. 40.

Kirk, D., Brooker, R. and Braiuka, S. (2000) Teaching Games for Understanding: A Situated Perspective on Student Learning.

Kirk, D. and MacPhail, A. (2002) Teaching games for understanding and situated learning: Rethinking the Bunker-Thorpe model. *Journal of teaching in physical Education, 21*(2), pp. 177-192.

Klepac Pogrmilovic, B., Ramirez Varela, A., Pratt, M., Milton, K., Bauman, A., Biddle, S. J. and Pedisic, Z. (2020) National physical activity and sedentary behaviour policies in 76 countries: availability, comprehensiveness, implementation, and effectiveness. *International Journal of Behavioral Nutrition and Physical Activity, 17*(1), pp. 1-13.

Knowles, G., Pallan, M., Thomas, G. N., Ekelund, U., Cheng, K. K., Barrett, T. and Adab, P. (2013) Physical activity and blood pressure in primary school children: a longitudinal study. *Hypertension, 61*(1), pp. 70-75.

Koekoek, J., Kamp, J. V. d., Walinga, W. and Van Hilvoorde, I. (2014) Dutch elite youth soccer players perceptions of a TGfU-modified game practice. *ÁGORA Para La Educación Física Y El Deporte*.

Kohl, H. W., Craig, C. L., Lambert, E. V., Inoue, S., Alkandari, J. R., Leetongin, G., Kahlmeier, S. and Group, L. P. A. S. W. (2012) The pandemic of physical inactivity: global action for public health. *The Lancet, 380*(9838), pp. 294-305.

Kohl, H. W., Fulton, J. E. and Caspersen, C. J. (2000) Assessment of physical activity among children and adolescents: a review and synthesis. *Preventive Medicine, 31*(2), pp. S54-S76.

Kokko, S., Martin, L., Geidne, S., Van Hoye, A., Lane, A., Meganck, J., Scheerder, J., Seghers, J., Villberg, J. and Kudlacek, M. (2018) Does sports club participation contribute to physical activity among children and adolescents? A comparison across six European countries. *Scandinavian Journal of Public Health, 47*(8), pp. 851-858.

Komura, K., Nakae, S., Hirakawa, K., Ebine, N., Suzuki, K., Ozawa, H., Yamada, Y., Kimura, M. and Ishii, K. (2017) Total energy expenditure of 10-to 12-year-old Japanese children measured using the doubly labeled water method. *Nutrition & Metabolism, 14*(1), pp. 70.

Koorts, H., Timperio, A., Arundell, L., Parker, K., Abbott, G. and Salmon, J. (2019) Is sport enough? Contribution of sport to overall moderate-to vigorous-intensity physical activity among adolescents. *Journal of Science and Medicine in Sport, 22*(10), pp. 1119-1124.

Kozey-Keadle, S., Libertine, A., Lyden, K., Staudenmayer, J. and Freedson, P. S. (2011a) Validation of wearable monitors for assessing sedentary behavior. *Medicine & Science in Sports & Exercise, 43*(8), pp. 1561-1567.

Kozey-Keadle, S., Libertine, A., Staudenmayer, J. and Freedson, P. (2011b) The feasibility of reducing and measuring sedentary time among overweight, non-exercising office workers. *Journal of Obesity, 2012*.

Kracht, C. L., Champagne, C. M., Hsia, D. S., Martin, C. K., Newton Jr, R. L., Katzmarzyk, P. T. and Staiano, A. E. (2020) Association between meeting physical activity, sleep, and dietary

guidelines and cardiometabolic risk factors and adiposity in adolescents. *Journal of Adolescent Health, 66*(6), pp. 733-739.

Kriemler, S., Zahner, L., Schindler, C., Meyer, U., Hartmann, T., Hebestreit, H., Brunner-La Rocca, H. P., Van Mechelen, W. and Puder, J. J. (2010) Effect of school based physical activity programme (KISS) on fitness and adiposity in primary schoolchildren: cluster randomised controlled trial. *BMJ, 340*(1), pp. c785.

Kruk, J. (2009) Physical activity and health. *Asian Pacific Journal of Cancer Prevention, 10*(5), pp. 721-728.

Kwan, M., Bobko, S., Faulkner, G., Donnelly, P. and Cairney, J. (2014) Sport participation and alcohol and illicit drug use in adolescents and young adults: A systematic review of longitudinal studies. *Addictive behaviors, 39*(3), pp. 497-506.

Kwon, H. H. and Kim, M. (2010) Perceived leadership behavior of physical education teacher-coaches: When they teach vs. when they coach. *Journal of Teaching in Physical Education, 29*(2), pp. 131-145.

Ladies Gaelic Football Association (2011) *About Us*, Available: https://ladiesgaelic.ie/the-lgfa/about-us/.

Lakerveld, J., van der Ploeg, H. P., Kroeze, W., Ahrens, W., Allais, O., Andersen, L. F., Cardon, G., Capranica, L., Chastin, S. and Donnelly, A. (2014) Towards the integration and development of a cross-European research network and infrastructure: the DEterminants of DIet and Physical ACtivity (DEDIPAC) Knowledge Hub. *International Journal of Behavioral Nutrition and Physical Activity, 11*(1), pp. 1-10.

Lane, A., Murphy, N., Donohoe, A. and Regan, C. (2017) Health promotion orientation of GAA sports clubs in Ireland. *Sport in Society, 20*(2), pp. 235-243.

Lane, A., Murphy, N., Regan, C. and Callaghan, D. (2021) Health promoting sports club in practice: A controlled evaluation of the GAA Healthy Club Project. *International journal of environmental research and public health, 18*(9), pp. 4786.

Lascar, N., Brown, J., Pattison, H., Barnett, A. H., Bailey, C. J. and Bellary, S. (2018) Type 2 diabetes in adolescents and young adults. *The lancet Diabetes & endocrinology, 6*(1), pp. 69-80.

Launder, A. (2001) Play practice: the games based approach to teaching and coaching sports. *Human Kinetics, Champaign, IL*.

Launder, A. and Piltz, W. (2013) *Play practice: The games approach to teaching and coaching sports,* Champaign, IL: Human Kinetics.

Lavallee, D., Sheridan, D., Coffee, P. and Daly, P. (2019) A social support intervention to reduce intentions to drop-out from youth sport: The GAA super games centre. *Psychosocial Intervention, 28*(1), pp. 11-17.

Lee, I.-M. and Shiroma, E. J. (2014) Using accelerometers to measure physical activity in large-scale epidemiological studies: issues and challenges. *British Journal of Sports Medicine, 48*(3), pp. 197-201.

Lee, I.-M., Shiroma, E. J., Lobelo, F., Puska, P., Blair, S. N., Katzmarzyk, P. T. and Group, L. P. A. S. W. (2012) Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *The Lancet, 380*(9838), pp. 219-229.

Leek, D., Carlson, J. A., Cain, K. L., Henrichon, S., Rosenberg, D., Patrick, K. and Sallis, J. F. (2011) Physical activity during youth sports practices. *Archives of Pediatrics and Adolescent Medicine, 165*(4), pp. 294-299.

Leenders, N. Y., Sherman, W. M. and Nagaraja, H. N. (2006) Energy expenditure estimated by accelerometry and doubly labeled water: do they agree? *Medicine & Science in Sports & Exercise, 38*(12), pp. 2165-2172.

Levine, J. A. (2005) Measurement of energy expenditure. *Public Health Nutrition, 8*(7a), pp. 1123-1132.

Levine, J. A., Lanningham-Foster, L. M., McCrady, S. K., Krizan, A. C., Olson, L. R., Kane, P. H., Jensen, M. D. and Clark, M. M. (2005) Interindividual variation in posture allocation: possible role in human obesity. *Science, 307*(5709), pp. 584-586.

Light, R. (2002) Engaging the body in learning: promoting cognition in games through TGfU. *ACHPER Healthy Lifestyles Journal, 49*(2), pp. 23-26.

Light, R. (2004) Coaches' experiences of Game Sense: opportunities and challenges. *Physical Education & Sport Pedagogy, 9*(2), pp. 115-131.

Light, R. (2008) Complex learning theory—its epistemology and its assumptions about learning: implications for physical education. *Journal of Teaching in Physical Education, 27*(1), pp. 21-37.

Light, R. and Fawns, R. (2003) Knowing the game: Integrating speech and action in games teaching through TGfU. *Quest, 55*(2), pp. 161-176.

Light, R., Quay, J., Harvey, S. and Mooney, A. (2013) *Contemporary developments in games teaching,* Routledge.

Light, R. L. (2013) Positive pedagogy for physical education and sport: Game Sense as an example. in *Contemporary Developments in Games Teaching*: Routledge. pp. 41-54.

Light, R. L. and Evans, J. R. (2010) The impact of Game Sense pedagogy on Australian rugby coaches' practice: a question of pedagogy. *Physical Education and Sport Pedagogy, 15*(2), pp. 103-115.

Light, R. L. and Evans, J. R. (2013) Dispositions of elite-level Australian rugby coaches towards game sense: characteristics of their coaching habitus. *Sport, education and society, 18*(3), pp. 407-423.

Light, R. L. and Harvey, S. (2017) Positive pedagogy for sport coaching. *Sport, education and society, 22*(2), pp. 271-287.

Light, R. L., Harvey, S. and Mouchet, A. (2014) Improving 'at-action'decision-making in team sports through a holistic coaching approach. *Sport, education and society, 19*(3), pp. 258-275.

Logan, N., Reilly, J. J., Grant, S. and Paton, J. Y. (2000) Resting heart rate definition and its effect on apparent levels of physical activity in young children. *Medicine & Science in Sports & Exercise, 32*(1), pp. 162-166.

Lonsdale, C., Hodge, K. and Rose, E. A. (2006) Pixels vs. paper: Comparing online and traditional survey methods in sport psychology. *Journal of Sport and Exercise Psychology, 28*(1), pp. 100-108.

Lonsdale, C., Rosenkranz, R. R., Peralta, L. R., Bennie, A., Fahey, P. and Lubans, D. R. (2013) A systematic review and meta-analysis of interventions designed to increase moderate-to-vigorous physical activity in school physical education lessons. *Preventive Medicine, 56*(2), pp. 152-161.

Loprinzi, P. D. and Cardinal, B. J. (2011) Measuring children's physical activity and sedentary behaviors. *Journal of Exercise Science & Fitness, 9*(1), pp. 15-23.

Loprinzi, P. D. and Cardinal, B. J. (2013) Association between biologic outcomes and objectively measured physical activity accumulated in ≥ 10-minute bouts and < 10-minute bouts. *American Journal of Health Promotion, 27*(3), pp. 143-151.

Low, J., Williams, A. M., McRobert, A. P. and Ford, P. R. (2013) The microstructure of practice activities engaged in by elite and recreational youth cricket players. *Journal of Sports Sciences, 31*(11), pp. 1242-1250.

Lubans, D. R., Hesketh, K., Cliff, D., Barnett, L., Salmon, J., Dollman, J., Morgan, P. J., Hills, A. and Hardy, L. (2011a) A systematic review of the validity and reliability of sedentary behaviour measures used with children and adolescents. *Obesity Reviews, 12*(10), pp. 781-799.

Lubans, D. R., Morgan, P. J. and McCormack, A. (2011b) Adolescents and school sport: The relationship between beliefs, social support and physical self-perception. *Physical Education & Sport Pedagogy, 16*(3), pp. 237-250.

Lyden, K., Keadle, S. K., Staudenmayer, J. and Freedson, P. S. (2017) The activPALTM accurately classifies activity intensity categories in healthy adults. *Medicine & Science in Sports & Exercise, 49*(5), pp. 1022-1028.

Lyden, K., Petruski, N., Mix, S., Staudenmayer, J. and Freedson, P. (2014) Direct observation is a valid criterion for estimating physical activity and sedentary behavior. *Journal of Physical Activity and Health, 11*(4), pp. 860-863.

Lyle, J. (2007) A review of the research evidence for the impact of coach education. *International Journal of Coaching Science, 1*(1), pp. 19-36.

Lyle, J. (2018) The transferability of sport coaching research: A critical commentary. *Quest, 70*(4), pp. 419-437.

Lynch, B. A., Kaufman, T. K., Rajjo, T. I., Mohammed, K., Kumar, S., Murad, M. H., Gentile, N. E., Koepp, G. A., McCrady-Spitzer, S. K. and Levine, J. A. (2019) Accuracy of accelerometers for measuring physical activity and levels of sedentary behavior in children: A systematic review. *Journal of primary care & community health, 10*, pp. 2150132719874252.

Machado-Rodrigues, A. M., e Silva, M. J. C., Mota, J., Santos, R. M., Cumming, S. P. and Malina, R. M. (2012) Physical activity and energy expenditure in adolescent male sport participants and nonparticipants aged 13 to 16 years. *Journal of Physical Activity and Health, 9*(5), pp. 626-633.

Mahlo, F. (1969) *L'acte tactique en jeu,* Paris: Vigot Freres.

Malina, R. M. (2001) Physical activity and fitness: pathways from childhood to adulthood. *American Journal of Human Biology: The Official Journal of the Human Biology Association, 13*(2), pp. 162-172.

Malone, S., Solan, B. and Collins, K. (2017) The running performance profile of elite Gaelic football match-play. *Journal of Strength and Conditioning Research, 31*(1), pp. 30-36.

Mandigo, J., Butler, J. and Hopper, T. (2007a) What is Teaching Games for Understanding? A Canadian. *Physical & Health Education Journal, 73*, pp. 2.

Mandigo, J., Butler, J. and Hopper, T. (2007b) What is Teaching Games for Understanding? A Canadian perspective. *Physical & Health Education Journal, 73*(2).

Mannini, A., Intille, S. S., Rosenberger, M., Sabatini, A. M. and Haskell, W. (2013) Activity recognition using a single accelerometer placed at the wrist or ankle. *Medicine & Science in Sports & Exercise, 45*(11), pp. 2193.

Mansfield, L., Kay, T., Meads, C., Grigsby-Duffy, L., Lane, J., John, A., Daykin, N., Dolan, P., Testoni, S. and Julier, G. (2018) Sport and dance interventions for healthy young people (15–24 years) to promote subjective well-being: a systematic review. *BMJ Open, 8*(7), pp. e020959.

Marin-Puyalto, J., Mäestu, J., Gómez-Cabello, A., Lätt, E., Remmel, L., Purge, P., Vicente-Rodríguez, G. and Jürimäe, J. (2019) Frequency and duration of vigorous physical activity bouts are associated with adolescent boys' bone mineral status: A cross-sectional study. *Bone, 120*, pp. 141-147.

Marques, A., Ekelund, U. and Sardinha, L. B. (2016) Associations between organized sports participation and objectively measured physical activity, sedentary time and weight status in youth. *Journal of Science and Medicine in Sport, 19*(2), pp. 154-157.

Martens, R. (2004) Successful Coaching.(3rd edtn). *Human kinetics, Champaign, Illinois*.

Masse, L. C., Fuemmeler, B. F., Anderson, C. B., Matthews, C. E., Trost, S. G., Catellier, D. J. and Treuth, M. (2005) Accelerometer data reduction: a comparison of four reduction algorithms on select outcome variables. *Medicine & Science in Sports & Exercise, 37*(11), pp. S544-54.

Mattocks, C., Leary, S., Ness, A., Deere, K., Saunders, J., Tilling, K., Kirkby, J., Blair, S. N. and Riddoch, C. (2007) Calibration of an accelerometer during free-living activities in children. *Pediatric Obesity, 2*(4), pp. 218-226.

Mattocks, C., Tilling, K., Ness, A. and Riddoch, C. (2008) Improvements in the measurement of physical activity in childhood obesity research; lessons from large studies of accelerometers. *Clinical Medicine Pediatrics, 2*(1), pp. 27.

McMahon, E. M., Corcoran, P., O'Regan, G., Keeley, H., Cannon, M., Carli, V., Wasserman, C., Hadlaczky, G., Sarchiapone, M. and Apter, A. (2017) Physical activity in European adolescents and associations with anxiety, depression and well-being. *European child & adolescent psychiatry, 26*(1), pp. 111-122.

McNamara, E., Hudson, Z. and Taylor, S. J. (2010) Measuring activity levels of young people: the validity of pedometers. *British Medical Bulletin, 95*(1), pp. 121-137.

McVeigh, J. A., Winkler, E. A., Howie, E. K., Tremblay, M. S., Smith, A., Abbott, R. A., Eastwood, P. R., Healy, G. N. and Straker, L. M. (2016) Objectively measured patterns of sedentary time and physical activity in young adults of the Raine study cohort. *International Journal of Behavioral Nutrition and Physical Activity, 13*(1), pp. 1-12.

Meijer, G. A., Westerterp, K. R., Verhoeven, F. M., Koper, H. B. and ten Hoor, F. (1991) Methods to assess physical activity with special reference to motion sensors and accelerometers. *IEEE Transactions on Biomedical Engineering, 38*(3), pp. 221-229.

Metzler, M. (2005) *Instructional models for physical education* Arizona, USA: Hathaway, Publishers.

Metzler, M. W. (2011) *Instructional models for physical education,* Arizona, USA: Holcomb Hathaway.

Migueles, J. H., Cadenas-Sanchez, C., Ekelund, U., Delisle Nyström, C., Mora-Gonzalez, J., Löf, M., Labayen, I., Ruiz, J. R. and Ortega, F. B. (2017) Accelerometer data collection and processing criteria to assess physical activity and other outcomes: a systematic review and practical considerations. *Sports Medicine, 47*(9), pp. 1821-1845.

Miller, A. (2015) Games centered approaches in teaching children & adolescents: Systematic review of associated student outcomes. *Journal of Teaching in Physical Education, 34*(1), pp. 36-58.

Miller, A., Harvey, S., Morley, D., Nemes, R., Janes, M. and Eather, N. (2016) Exposing athletes to playing form activity: Outcomes of a randomised control trial among community netball teams using a game-centred approach. *Journal of Sports Sciences, 35*(18), pp. 1846-1857.

Milton, K., Bauman, A. E., Faulkner, G., Hastings, G., Bellew, W., Williamson, C. and Kelly, P. (2020) Maximising the impact of global and national physical activity guidelines: the critical role of communication strategies. *British Journal of Sports Medicine, 54*(24), pp. 1463-1467.

Milton, K., Cavill, N., Chalkley, A., Foster, C., Gomersall, S., Hagstromer, M., Kelly, P., Kolbe-Alexander, T., Mair, J. and McLaughlin, M. (2021) Eight investments that work for physical activity. *Journal of Physical Activity and Health, 18*(6), pp. 625-630.

Mitchell, S., Oslin, J. and Griffin, L. L. (2006) *Teaching sport concepts and skills: A tactical games approach,* 2nd ed.*,* Champaign, IL: Human Kinetics Publishers.

Mitchell, S. A., Oslin, J. L. and Griffin, L. L. (2013) *Teaching sport concepts and skills: A tactical games approach for ages 7 to 18,* Champaign, IL: Human Kinetics.

Montoye, A. H., Moore, R. W., Bowles, H. R., Korycinski, R. and Pfeiffer, K. A. (2018) Reporting accelerometer methods in physical activity intervention studies: a systematic review and recommendations for authors. *British Journal of Sports Medicine, 52*(23), pp. 1507-1516.

Montoye, H. (1996) *Measuring physical activity and energy expenditure. ,* Champaign, IL: Human Kinetics.

Mooses, K. and Kull, M. (2019) The participation in organised sport doubles the odds of meeting physical activity recommendations in 7–12-year-old children. *European Journal of Sport Science*, pp. 1-7.

Mooses, K., Oja, M., Reisberg, S., Vilo, J. and Kull, M. (2018) Validating Fitbit Zip for monitoring physical activity of children in school: a cross-sectional study. *BMC Public Health, 18*(1), pp. 1-7.

Morales-Belando, M. T. and Arias-Estero, J. L. (2017a) Effect of teaching races for understanding in youth sailing on performance, knowledge, and adherence. *Research Quarterly for Exercise and Sport, 88*(4), pp. 513-523.

Morales-Belando, M. T. and Arias-Estero, J. L. (2017b) Influence of teaching games for understanding on game performance, knowledge, and variables related to adherence in youth sailing. *Journal of teaching in physical Education, 36*(2), pp. 209-219.

Morales-Belando, M. T., Calderón, A. and Arias-Estero, J. L. (2018) Improvement in game performance and adherence after an aligned TGfU floorball unit in physical education. *Physical Education and Sport Pedagogy, 23*(6), pp. 657-671.

Morgan, K. and Sproule, J. (2012) Pedagogy for coaches. in Jones, R. and Kingston, K., (eds.) *An Introduction to Sports Coaching*: Routledge.

Moser, A. and Korstjens, I. (2018) Series: Practical guidance to qualitative research. Part 3: Sampling, data collection and analysis. *European Journal of General Practice, 24*(1), pp. 9-18.

Moy, B., Renshaw, I. and Davids, K. (2016) The impact of nonlinear pedagogy on physical education teacher education students' intrinsic motivation. *Physical Education and Sport Pedagogy, 21*(5), pp. 517-538.

Murakami, H., Kawakami, R., Nakae, S., Yamada, Y., Nakata, Y., Ohkawara, K., Sasai, H., Ishikawa-Takata, K., Tanaka, S. and Miyachi, M. (2019) Accuracy of 12 wearable devices for estimating physical activity energy expenditure using a metabolic chamber and the doubly labeled water method: validation study. *JMIR mHealth and uHealth, 7*(8), pp. e13938.

Murphy, J., Sweeney, M. R. and McGrane, B. (2020) Physical activity and sports participation in Irish adolescents and associations with anxiety, depression and mental wellbeing. Findings from the physical activity and wellbeing (paws) study. *Physical activity and health, 4*(1), pp. 107-119.

Nathan, S. (2015) Coaching school hockey in Malaysia: A exploratory analysis and effect of improvised TGfU pedagogical model on small sided game play. *Journal of Physical Education and Sport, 15*(4), pp. 712.

Nathan, S. (2017) The effect of Teaching Games of Understanding as a coaching instruction had on adjust, cover and heart rate among Malaysian and Indian junior hockey players. *Sports, 5*(2), pp. 44.

Ndahimana, D. and Kim, E.-K. (2017) Measurement methods for physical activity and energy expenditure: a review. *Clinical nutrition research, 6*(2), pp. 68-80.

Nelson, T. F., Steven, S., Stovitz, D., Thomas, F. M., Lavoi, N. M., Bauer, W. and Neumark-sztainer, D. (2011) Do youth sports prevent pediatric obesity? A systematic review and commentary. in *Current Sports Medicine Reports*: Citeseer.

Nguyen, T. H., Tang, H. K., Kelly, P., Van Der Ploeg, H. P. and Dibley, M. J. (2010) Association between physical activity and metabolic syndrome: a cross sectional survey in adolescents in Ho Chi Minh City, Vietnam. *BMC Public Health, 10*(1), pp. 1-9.

Nic Gabhainn, S., Kelly, C. and Molcho, M. (2007) *The Irish health behaviour in school-aged children (HBSC) study 2006*: Dublin: Department of Health and Children.

O'Connor, D., Larkin, P. and Williams, A. M. (2018) Observations of youth football training: How do coaches structure training sessions for player development? *Journal of Sports Sciences, 36*(1), pp. 39-47.

O'Connor, S., Leahy, R., Whyte, E. and Farrington, S. (2021) Male and female Gaelic games coaches' and referees' experiences, knowledge and views on sports-related concussion. *Physical therapy in sport, 49*, pp. 1-7.

Oh, M., Zhang, D., Whitaker, K. M., Letuchy, E. M., Janz, K. F. and Levy, S. M. (2021) Moderate-to-vigorous intensity physical activity trajectories during adolescence and young adulthood predict adiposity in young adulthood: The Iowa Bone Development Study. *Journal of Behavioral Medicine, 44*(2), pp. 231-240.

Osborn, W., Simm, P., Olds, T., Lycett, K., Mensah, F. K., Muller, J., Fraysse, F., Ismail, N., Vlok, J. and Burgner, D. (2018) Bone health, activity and sedentariness at age 11–12 years: cross-sectional Australian population-derived study. *Bone, 112*, pp. 153-160.

Owen, M. B., Curry, W. B., Kerner, C., Newson, L. and Fairclough, S. J. (2017) The effectiveness of school-based physical activity interventions for adolescent girls: A systematic review and meta-analysis. *Preventive Medicine, 105*, pp. 237-249.

Owen, N., Healy, G. N., Matthews, C. E. and Dunstan, D. W. (2010) Too much sitting: the population-health science of sedentary behavior. *Exercise and Sport Sciences Reviews, 38*(3), pp. 105.

Owens, S., Galloway, R. and Gutin, B. (2017) The case for vigorous physical activity in youth. *American Journal of Lifestyle Medicine, 11*(2), pp. 96-115.

Park, J., Kazuko, I.-T., Kim, E., Kim, J. and Yoon, J. (2014) Estimating free-living human energy expenditure: practical aspects of the doubly labeled water method and its applications. *Nutrition research and practice, 8*(3), pp. 241-248.

Partington, M. and Cushion, C. (2013) An investigation of the practice activities and coaching behaviors of professional top-level youth soccer coaches. *Scandinavian Journal of Medicine & Science in Sports, 23*(3), pp. 374-382.

Partington, M., Cushion, C. and Harvey, S. (2014) An investigation of the effect of athletes' age on the coaching behaviours of professional top-level youth soccer coaches. *Journal of sports sciences, 32*(5), pp. 403-414.

Pate, R. R., O'neill, J. R. and Lobelo, F. (2008) The evolving definition of" sedentary". *Exercise and Sport Sciences Reviews, 36*(4), pp. 173-178.

Pate, R. R. and O'Neill, J. R. (2011) Youth sports programs: contribution to physical activity. *Archives of Pediatrics & Adolescent Medicine, 165*(4), pp. 369-370.

Pate, R. R., Pratt, M., Blair, S. N., Haskell, W. L., Macera, C. A., Bouchard, C., Buchner, D., Ettinger, W., Heath, G. W. and King, A. C. (1995) Physical activity and public health: a recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *JAMA, 273*(5), pp. 402-407.

Patton, M. Q. (2002) Qualitative research and evaluation methods. Thousand Oaks. *Cal.: Sage Publications, 4*.

Pettee, K. K., Storti, K. L., Ainsworth, B. E. and Kriska, A. M. (2009) Measurement of physical activity and inactivity in epidemiologic studies. *Epidemiologic Methods in Physical Activity Studies*, pp. 15-33.

Physical Activity Guidelines Advisory Committee (2008) *Physical activity guidelines advisory committee report, 2008*. Washington, DC: US Department of Health and Human Services.

Physical Activity Guidelines Advisory Committee (2018) *Physical Activity Guidelines Advisory Committee Scientific Report*. Washington, DC: U.S. Department of Health and Human Services.

Piggott, D. (2012) Coaches' experiences of formal coach education: a critical sociological investigation. *Sport, education and society, 17*(4), pp. 535-554.

Pill, S. (2014) Informing game sense pedagogy with constraints led theory for coaching in Australian football. *Sports Coaching Review, 3*(1), pp. 46-62.

Pill, S. (2016) Implementing game sense coaching approach in Australian football through action-research. *ÁGORA Para La Educación Física Y El Deporte, 18*, pp. 1-19.

Pinder, R. A., Davids, K., Renshaw, I. and Araújo, D. (2011) Representative learning design and functionality of research and practice in sport. *Journal of Sport and Exercise Psychology, 33*(1), pp. 146-155.

Pizarro, A. P., Domínguez, A. M., Serrano, J. S., García-González, L. and del Villar Álvarez, F. (2017) The effects of a comprehensive teaching program on dribbling and passing decision-making and execution skills of young footballers. *Kinesiology, 49*(1), pp. 74-83.

Plasqui, G. and Westerterp, K. R. (2007) Physical activity assessment with accelerometers: an evaluation against doubly labeled water. *Obesity, 15*(10), pp. 2371-2379.

Poitras, V. J., Gray, C. E., Borghese, M. M., Carson, V., Chaput, J.-P., Janssen, I., Katzmarzyk, P. T., Pate, R. R., Connor Gorber, S. and Kho, M. E. (2016) Systematic review of the relationships between objectively measured physical activity and health indicators in school-aged children and youth. *Applied Physiology, Nutrition, and Metabolism, 41*(6), pp. S197-S239.

Polit, D. F. and Beck, C. T. (2017) *Nursing Research: Generating and Assessing Evidence for Nursing Practice.,* Tenth ed.*,* Philadelphia: Wolters Kluwer Health.

Potrac, P., Jones, R. and Cushion, C. (2007) Understanding power and the coach's role in professional English soccer: A preliminary investigation of coach behaviour. *Soccer & Society, 8*(1), pp. 33-49.

Powell, C., Carson, B. P., Dowd, K. P. and Donnelly, A. E. (2017) Simultaneous validation of five activity monitors for use in adult populations. *Scandinavian Journal of Medicine & Science in Sports, 27*(12), pp. 1881-1892.

Powell, K. E., Paluch, A. E. and Blair, S. N. (2011) Physical Activity for Health: What Kind? How Much? How Intense? On Top of What? *Annual Review of Public Health, 32*, pp. 349-365.

Práxedes, A., Del Villar Álvarez, F., Moreno, A., Gil-Arias, A. and Davids, K. (2019) Effects of a nonlinear pedagogy intervention programme on the emergent tactical behaviours of youth footballers. *Physical Education and Sport Pedagogy, 24*(4), pp. 332-343.

Práxedes, A., Moreno, A., Sevil, J., García-González, L. and Del Villar, F. (2016) A preliminary study of the effects of a comprehensive teaching program, based on questioning, to improve tactical actions in young footballers. *Perceptual and motor skills, 122*(3), pp. 742-756.

Preece, S. J., Goulermas, J. Y., Kenney, L. P., Howard, D., Meijer, K. and Crompton, R. (2009) Activity identification using body-mounted sensors—a review of classification techniques. *Physiological Measurement, 30*(4), pp. R1.

Pühse, U. (2005) *International comparison of physical education: concepts, problems, prospects,* Aachen: Meyer & Meyer Verlag.

Ragan, T. J. and Smith, P. L. (1999) *Instructional design,* New York: Macmillan Publishing Company.

Reid, P. and Harvey, S. (2014) We're delivering Game Sense… aren't we? *Sports Coaching Review, 3*(1), pp. 80-92.

Renshaw, I., Araújo, D., Button, C., Chow, J. Y., Davids, K. and Moy, B. (2016) Why the constraints-led approach is not teaching games for understanding: A clarification. *Physical Education and Sport Pedagogy, 21*(5), pp. 459-480.

Renshaw, I., Chow, J. Y., Davids, K. and Hammond, J. (2010) A constraints-led perspective to understanding skill acquisition and game play: a basis for integration of motor learning theory and physical education praxis? *Physical Education and Sport Pedagogy, 15*(2), pp. 117-137.

Rich, C., Griffiths, L. J. and Dezateux, C. (2012) Seasonal variation in accelerometer-determined sedentary behaviour and physical activity in children: a review. *International Journal of Behavioral Nutrition and Physical Activity, 9*(1), pp. 1-8.

Richard, J.-F. and Wallian, N. (2005) Emphasizing Student Engagement in the. *Teaching Games for Understanding: Theory, research, and practice*, pp. 19.

Riddoch, C. J., Mattocks, C., Deere, K., Saunders, J., Kirkby, J., Tilling, K., Leary, S. D., Blair, S. N. and Ness, A. R. (2007) Objective measurement of levels and patterns of physical activity. *Archives of Disease in Childhood, 92*(11), pp. 963-969.

Ridgers, N. D. and Fairclough, S. (2011) Assessing free-living physical activity using accelerometry: Practical issues for researchers and practitioners. *European Journal of Sport Science, 11*(3), pp. 205-213.

Ridgers, N. D., McNarry, M. A. and Mackintosh, K. A. (2016) Feasibility and effectiveness of using wearable activity trackers in youth: a systematic review. *JMIR mHealth and uHealth, 4*(4), pp. e129.

Ridgers, N. D., Salmon, J., Parrish, A.-M., Stanley, R. M. and Okely, A. D. (2012a) Physical activity during school recess: a systematic review. *American journal of Preventive Medicine, 43*(3), pp. 320-328.

Ridgers, N. D., Salmon, J., Ridley, K., O'Connell, E., Arundell, L. and Timperio, A. (2012b) Agreement between activPAL and ActiGraph for assessing children's sedentary time. *International Journal of Behavioral Nutrition and Physical Activity, 9*(1), pp. 1-8.

Ridley, K., Ridgers, N. D. and Salmon, J. (2016) Criterion validity of the activPALTM and ActiGraph for assessing children's sitting and standing time in a school classroom setting. *International Journal of Behavioral Nutrition and Physical Activity, 13*(1), pp. 1-5.

Ridley, K., Zabeen, S. and Lunnay, B. K. (2018) Children's physical activity levels during organised sports practices. *Journal of Science and Medicine in Sport, 21*(9), pp. 930-934.

Rikard, L. and Banville, D. (2006) High school student attitudes about physical education. *Sport, Education and Society, 11*(4), pp. 385-400.

Rink, J. (2014) *Teaching physical education for learning,* Boston, USA: McGraw-Hill Higher Education

Roberts, S. J. (2011) Teaching games for understanding: The difficulties and challenges experienced by participation cricket coaches. *Physical Education and Sport Pedagogy, 16*(1), pp. 33-48.

Roca, A. and Ford, P. R. (2020) Decision-making practice during coaching sessions in elite youth football across European countries. *Science and Medicine in Football, 4*(4), pp. 263-268.

Roe, M., Blake, C., Gissane, C. and Collins, K. (2016) Injury scheme claims in Gaelic games: a review of 2007–2014. *Journal of athletic training, 51*(4), pp. 303-308.

Romar, J.-E., Sarén, J. and Hastie, P. (2016) Athlete-Centred coaching using the Sport Education model in youth soccer. *Journal of Physical Education and Sport, 16*(2), pp. 380-391.

Rønne, M. S., Heidemann, M., Lylloff, L., Schou, A. J., Tarp, J., Laursen, J. O., Jørgensen, N. R., Husby, S., Wedderkopp, N. and Mølgaard, C. (2019) Bone mass development in childhood and its association with physical activity and Vitamin D levels. The CHAMPS-Study DK. *Calcified tissue international, 104*(1), pp. 1-13.

Rosenbaum, M., Leibel, R. and Hirsch, J. (1997) Obesity. *The New England Journal of Medicine, 337*, pp. 396-407.

Rosselli, M., Ermini, E., Tosi, B., Boddi, M., Stefani, L., Toncelli, L. and Modesti, P. A. (2020) Gender differences in barriers to physical activity among adolescents. *Nutrition, Metabolism and Cardiovascular Diseases, 30*(9), pp. 1582-1589.

Rowlands, A. V. (2007) Accelerometer assessment of physical activity in children: an update. *Pediatric Exercise Science, 19*(3), pp. 252-266.

Rowlands, A. V. (2018) Moving forward with accelerometer-assessed physical activity: two strategies to ensure meaningful, interpretable, and comparable measures. *Pediatric Exercise Science, 30*(4), pp. 450-456.

Rowlands, A. V. and Eston, R. G. (2007) The measurement and interpretation of children's physical activity. *Journal of Sports Science and Medicine, 6*(3), pp. 270.

Rubin, H. J. and Rubin, I. S. (2011) *Qualitative interviewing: The art of hearing data,* sage.

Ryan, T. and Clopton, A. (2009) Improving response rates in web surveys: A 2× 2 experiment. *Applied Research in Coaching and Athletics Annual, 24*, pp. 147-174.

Ryu, S., Loprinzi, P., Kim, H. and Kang, M. (2020) Sedentary Behavior and Obesity in Youth According to Meeting Physical Activity Guidelines: National Health and Nutrition Examination Survey 2003–2006. *Childhood Obesity, 16*(5), pp. 327-331.

Sacheck, J. M., Nelson, T., Ficker, L., Kafka, T., Kuder, J. and Economos, C. D. (2011) Physical activity during soccer and its contribution to physical activity recommendations in normal weight and overweight children. *Pediatric Exercise Science, 23*(2), pp. 281-292.

Säfvenbom, R., Haugen, T. and Bulie, M. (2015) Attitudes toward and motivation for PE. Who collects the benefits of the subject? *Physical Education and Sport Pedagogy, 20*(6), pp. 629-646.

Sallis, J. F., Bull, F., Guthold, R., Heath, G. W., Inoue, S., Kelly, P., Oyeyemi, A. L., Perez, L. G., Richards, J. and Hallal, P. C. (2016) Progress in physical activity over the Olympic quadrennium. *Lancet, 388*(10051), pp. 1325-1336.

Sallis, J. F. and Saelens, B. E. (2000) Assessment of physical activity by self-report: Status, limitations, and future directions. *Research Quarterly for Exercise and Sport, 71*(2), pp. 1.

Sasaki, J. E., da Silva, K. S., da Costa, B. G. G. and John, D. (2016) Measurement of physical activity using accelerometers. in *Computer-assisted and web-based innovations in psychology, special education, and health*: Elsevier. pp. 33-60.

Schiller, C., Winters, M., Hanson, H. M. and Ashe, M. C. (2013) A framework for stakeholder identification in concept mapping and health research: a novel process and its application to older adult mobility and the built environment. *BMC Public Health, 13*(1), pp. 428.

Schillewaert, N., Langerak, F. and Duharnel, T. (1998) Non-probability sampling for WWW surveys: a comparison of methods. *Market Research Society. Journal., 40*(4), pp. 1-13.

Schlechter, C., Rosenkranz, R., Milliken, G. and Dzewaltowski, D. (2017) Physical activity levels during youth sport practice: does coach training or experience have an influence? *Journal of Sports Sciences, 35*(1), pp. 22-28.

Seale, J. and Rumpler, W. (1997) Comparison of energy expenditure measurements by diet records, energy intake balance, doubly labeled water and room calorimetry. *European Journal of Clinical Nutrition, 51*(12), pp. 856.

Sedentary Behaviour Research Network (2012) Letter to the editor: standardized use of the terms "sedentary" and "sedentary behaviours". *Applied Physiology, Nutrition, and Metabolism, 37*(3), pp. 540-542.

Sellers, C., Dall, P., Grant, M. and Stansfield, B. (2016) Validity and reliability of the activPAL3 for measuring posture and stepping in adults and young people. *Gait & Posture, 43*, pp. 42-47.

Serra-Olivares, J., González-Víllora, S., García-López, L. M. and Araújo, D. (2015) Game-based approaches' pedagogical principles: exploring task constraints in youth soccer. *Journal of human kinetics, 46*(1), pp. 251-261.

Sheridan, D., Coffee, P. and Lavallee, D. (2014) A systematic review of social support in youth sport. *International Review of Sport and Exercise Psychology, 7*(1), pp. 198-228.

Sherwin, I., Campbell, M. J. and Macintyre, T. E. (2017) Talent development of high performance coaches in team sports in Ireland. *European Journal of Sport Science, 17*(3), pp. 271-278.

Shiely, F. and MacDonncha, C. (2009) Meeting the international adolescent physical activity guidelines: A comparison of objectively measured and self-reported physical activity levels. *Irish Medical Journal, 102*(1), pp. 15.

Shiroma, E. J., Schepps, M., Harezlak, J., Chen, K., Matthews, C., Koster, A., Caserotti, P., Glynn, N. and Harris, T. (2016) Daily physical activity patterns from hip-and wrist-worn accelerometers. *Physiological Measurement, 37*(10), pp. 1852.

Shovlin, A., Roe, M., Malone, S. and Collins, K. (2018) Positional anthropometric and performance profile of elite gaelic football players. *The Journal of Strength & Conditioning Research, 32*(8), pp. 2356-2362.

Sierra-Ríos, J. V., Clemente, F. M., Rey, E. and González-Víllora, S. (2020) Effects of 6 weeks direct instruction and teaching games for understanding programs on physical activity and tactical behaviour in U-12 soccer players. *International journal of environmental research and public health, 17*(14), pp. 5008.

Silva, G., Andersen, L. B., Aires, L., Mota, J., Oliveira, J. and Ribeiro, J. C. (2013) Associations between sports participation, levels of moderate to vigorous physical activity and cardiorespiratory fitness in childrenand adolescents. *Journal of Sports Sciences, 31*(12), pp. 1359-1367.

Silva, P., Sousa, M., Aires, L., Seabra, A., Ribeiro, J., Welk, G. and Mota, J. (2010) Physical activity patterns in Portuguese adolescents: The contribution of extracurricular sports. *European Physical Education Review, 16*(2), pp. 171-181.

Sirard, J. R. and Pate, R. R. (2001) Physical activity assessment in children and adolescents. *Sports Medicine, 31*(6), pp. 439-454.

Smith, J. D., Schroeder, C. and Smith, R. M. (2019) Pedometer accuracy and metabolic cost in elementary school children while walking, skipping, galloping, and sliding. *Physical Educator, 76*(1), pp. 1-23.

Smith, M. and Cushion, C. J. (2006) An investigation of the in-game behaviours of professional, top-level youth soccer coaches. *Journal of sports sciences, 24*(4), pp. 355-366.

Smith, M. P., Horsch, A., Standl, M., Heinrich, J. and Schulz, H. (2018) Uni-and triaxial accelerometric signals agree during daily routine, but show differences between sports. *Scientific Reports, 8*(1), pp. 1-8.

Smoll, F. and Smith, R. (2002) *Children and youth in sport: A biopsychosocial perspective,* Iowa, US: Hunt Publishing Company.

Song, P., Zhang, Y., Yu, J., Zha, M., Zhu, Y., Rahimi, K. and Rudan, I. (2019) Global prevalence of hypertension in children: a systematic review and meta-analysis. *JAMA pediatrics, 173*(12), pp. 1154-1163.

Sparkes, A. C. and Smith, B. (2013) *Qualitative research methods in sport, exercise and health: From process to product,* Routledge.

Sport Ireland (2017) *Irish Sports Monitor Annual Report 2017*. Ipsos MRBI.

Sport Ireland (2019a) *Irish Sports Monitor Annual Report 2019*: Ipsos MRBI.

Sport Ireland (2019b) *Women in Sport Policy*.

Sprengeler, O., Buck, C., Hebestreit, A., Wirsik, N. and Ahrens, W. (2019) Sports contribute to total moderate to vigorous physical activity in school children. *Medicine & Science in Sports & Exercise, 51*(8), pp. 1653-1661.

Sproule, J., Ollis, S., Gray, S., Thorburn, M., Allison, P. and Horton, P. (2011) Promoting perseverance and challenge in physical education: the missing ingredient for improved games teaching. *Sport, Education and Society, 16*(5), pp. 665-684.

Stabelini Neto, A., de Campos, W., Dos Santos, G. C. and Mazzardo Junior, O. (2014) Metabolic syndrome risk score and time expended in moderate to vigorous physical activity in adolescents. *BMC pediatrics, 14*(1), pp. 1-6.

Staiano, A. E., Broyles, S. T. and Katzmarzyk, P. T. (2015) School term vs. school holiday: associations with Children's physical activity, screen-time, diet and sleep. *International journal of environmental research and public health, 12*(8), pp. 8861-8870.

Stewart, T., Narayanan, A., Hedayatrad, L., Neville, J., Mackay, L. and Duncan, S. (2018) A dual-accelerometer system for classifying physical activity in children and adults. *Medicine & Science in Sports & Exercise, 50*(12), pp. 2595-2602.

Stolz, S. and Pill, S. (2014) Teaching games and sport for understanding: Exploring and reconsidering its relevance in physical education. *European Physical Education Review, 20*(1), pp. 36-71.

Stone, J. A., Rothwell, M., Shuttleworth, R. and Davids, K. (2021) Exploring sports coaches' experiences of using a contemporary pedagogical approach to coaching: An international perspective. *Qualitative Research in Sport, Exercise and Health, 13*(4), pp. 639-657.

Storey, B. and Butler, J. (2013) Complexity thinking in PE: game-centred approaches, games as complex adaptive systems, and ecological values. *Physical Education and Sport Pedagogy, 18*(2), pp. 133-149.

Stoszkowski, J. and Collins, D. (2016) Sources, topics and use of knowledge by coaches. *Journal of Sports Sciences, 34*(9), pp. 794-802.

Strain, T., Brage, S., Sharp, S. J., Richards, J., Tainio, M., Ding, D., Benichou, J. and Kelly, P. (2020) Use of the prevented fraction for the population to determine deaths averted by existing prevalence of physical activity: a descriptive study. *The lancet global health, 8*(7), pp. e920-e930.

Strath, S. J., Bassett, J. D., Thompson, D. L. and Swartz, A. M. (2002) Validity of the simultaneous heart rate-motion sensor technique for measuring energy expenditure. *Medicine & Science in Sports & Exercise, 34*(5), pp. 888-894.

Strath, S. J., Kaminsky, L. A., Ainsworth, B. E., Ekelund, U., Freedson, P. S., Gary, R. A., Richardson, C. R., Smith, D. T. and Swartz, A. M. (2013) Guide to the assessment of physical activity: clinical and research applications. *Circulation, 128*(20), pp. 2259-2279.

Sun, X., Adams, S. A., Li, C., Booth, J. N., Robertson, J. and Fawkner, S. (2021) Validity of the Fitbit Ace and Moki devices for assessing steps during different walking conditions in young adolescents. *Pediatric Exercise Science, 34*(1), pp. 1-5.

Sylvia, L. G., Bernstein, E. E., Hubbard, J. L., Keating, L. and Anderson, E. J. (2014) A practical guide to measuring physical activity. *Journal of the Academy of Nutrition and Dietetics, 114*(2), pp. 199.

Tammelin, R., Yang, X., Leskinen, E., Kankaanpaa, A., Hirvensalo, M., Tammelin, T. and Raitakari, O. (2014) Tracking of physical activity from early childhood through youth into adulthood. *Medicine & Science in Sports & Exercise, 46*(5), pp. 955-62.

Tan, C. W. K., Chow, J. Y. and Davids, K. (2012) 'How does TGfU work?': examining the relationship between learning design in TGfU and a nonlinear pedagogy. *Physical Education and Sport Pedagogy, 17*(4), pp. 331-348.

Taylor, W. (2014) Analysis of qualitative data. in *Research methods in sports coaching*: Routledge. pp. 181-191.

Telama, R. (2009) Tracking of physical activity from childhood to adulthood: a review. *Obesity Facts, 2*(3), pp. 187-195.

Telford, R. M., Telford, R. D., Cochrane, T., Cunningham, R. B., Olive, L. S. and Davey, R. (2016) The influence of sport club participation on physical activity, fitness and body fat during childhood and adolescence: the LOOK Longitudinal Study. *Journal of Science and Medicine in Sport, 19*(5), pp. 400-406.

The International Society for Physical Activity and Health (2020) *Eight investments that work for physical activity*.

Thivel, D., Tremblay, A., Genin, P. M., Panahi, S., Rivière, D. and Duclos, M. (2018) Physical activity, inactivity, and sedentary behaviors: definitions and implications in occupational health. *Frontiers in public health, 6*, pp. 288.

Thomas, G., Morgan, K. and Mesquita, I. (2013) Examining the implementation of a Teaching Games for Understanding approach in junior rugby using a reflective practice design. *Sports Coaching Review, 2*(1), pp. 49-60.

Thorpe, R., Bunker, D. and Almond, L. (1984) A change in focus for the teaching of games. in *Sport Pedagogy. Olympic Scientific Congress Proceedings*. pp. 163-169.

Tikkanen, O., Haakana, P., Pesola, A. J., Häkkinen, K., Rantalainen, T., Havu, M., Pullinen, T. and Finni, T. (2013) Muscle activity and inactivity periods during normal daily life. *PLoS One, 8*(1), pp. e52228.

Tomlin, D. L., Nell, T. L., Schaefer, K., Trill, D. and Naylor, P.-J. (2015) The contribution of soccer games and practices to achieving recommended physical activity in boys and girls. *J J Sport Medicine, 2*(2), pp. 13.

Tremblay, M. S., Aubert, S., Barnes, J. D., Saunders, T. J., Carson, V., Latimer-Cheung, A. E., Chastin, S. F., Altenburg, T. M. and Chinapaw, M. J. (2017) Sedentary Behavior Research Network (SBRN)–Terminology Consensus Project process and outcome. *International Journal of Behavioral Nutrition and Physical Activity, 14*(1), pp. 75.

Tremblay, M. S., Colley, R. C., Saunders, T. J., Healy, G. N. and Owen, N. (2010) Physiological and health implications of a sedentary lifestyle. *Applied Physiology, Nutrition, and Metabolism, 35*(6), pp. 725-740.

Tremblay, M. S., LeBlanc, A. G., Kho, M. E., Saunders, T. J., Larouche, R., Colley, R. C., Goldfield, G. and Gorber, S. C. (2011) Systematic review of sedentary behaviour and health indicators in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity, 8*(1), pp. 1-22.

Troiano, R., Berrigan, D., Dodd, K. W., Mâsse, L. C., Tilert, T. and Mcdowell, M. (2008) Physical activity in the United States measured by accelerometer. *Medicine & Science in Sports & Exercise, 40*(1), pp. 181-188.

Troiano, R. P., McClain, J. J., Brychta, R. J. and Chen, K. Y. (2014) Evolution of accelerometer methods for physical activity research. *British Journal of Sports Medicine, 48*(13), pp. 1019-1023.

Trost, S. G. (2001) Objective measurement of physical activity in youth: current issues, future directions. *Exercise and Sport Sciences Reviews, 29*(1), pp. 32-36.

Trost, S. G. (2007) State of the art reviews: measurement of physical activity in children and adolescents. *American Journal of Lifestyle Medicine, 1*(4), pp. 299-314.

Trost, S. G., Blair, S. N. and Khan, K. M. (2014) Physical inactivity remains the greatest public health problem of the 21st century: evidence, improved methods and solutions using the '7 investments that work' as a framework. *British Journal of Sports Medicine, 48*(3), pp. 169.

Trost, S. G., Loprinzi, P. D., Moore, R. and Pfeiffer, K. A. (2011) Comparison of accelerometer cut points for predicting activity intensity in youth. *Medicine & Science in Sports & Exercise, 43*(7), pp. 1360-1368.

Trost, S. G., McIver, K. L. and Pate, R. R. (2005) Conducting accelerometer-based activity assessments in field-based research. *Medicine & Science in Sports & Exercise, 37*(11 Suppl), pp. S531-43.

Trost, S. G., Pate, R. R., Freedson, P. S., Sallis, J. F. and Taylor, W. C. (2000) Using objective physical activity measures with youth: how many days of monitoring are needed? *Medicine & Science in Sports & Exercise, 32*(2), pp. 426.

Trost, S. G., Ward, D. S., Moorehead, S. M., Watson, P. D., Riner, W. and Burke, J. R. (1998) Validity of the computer science and applications (CSA) activity monitor in children. *Medicine & Science in Sports & Exercise, 30*(4), pp. 629-633.

Turner, A. (2005) Teaching and learning games at the secondary level. *Teaching games for understanding: Theory, research, and practice*, pp. 71-90.

Turner, A. P. and Martinek, T. J. (1999) An investigation into teaching games for understanding: Effects on skill, knowledge, and game play. *Research Quarterly for Exercise and Sport, 70*(3), pp. 286-296.

Turrisi, T. B., Bittel, K. M., West, A. B., Hojjatinia, S., Hojjatinia, S., Mama, S. K., Lagoa, C. M. and Conroy, D. E. (2021) Seasons, weather, and device-measured movement behaviors: A scoping review from 2006 to 2020. *International Journal of Behavioral Nutrition and Physical Activity, 18*(1), pp. 1-26.

Vaara, J. P., Vasankari, T., Koski, H. J. and Kyröläinen, H. (2019) Awareness and knowledge of physical activity recommendations in young adult men. *Frontiers in public health, 7*(310), pp. 1-9.

Van Acker, R., Carreiro da Costa, F., De Bourdeaudhuij, I., Cardon, G. and Haerens, L. (2010) Sex equity and physical activity levels in coeducational physical education: exploring the potential of modified game forms. *Physical Education and Sport Pedagogy, 15*(2), pp. 159-173.

Van Coevering, P., Harnack, L., Schmitz, K., Fulton, J., Galuska, D. and Gao, S. (2005) Feasibility of using accelerometers to measure physical activity in young adolescents. *Medicine & Science in Sports & Exercise, 37*(5), pp. 867-871.

van den Berg, C. and Kolen, A. M. (2015) Children in organized hockey: How much physical activity do they really get? *International Journal of Exercise Science, 8*(2), pp. 9.

Van Hecke, L., Loyen, A., Verloigne, M., Van der Ploeg, H. P., Lakerveld, J., Brug, J., De Bourdeaudhuij, I., Ekelund, U., Donnelly, A. and Hendriksen, I. (2016) Variation in population levels of physical activity in European children and adolescents according to cross-European studies: a systematic literature review within DEDIPAC. *International Journal of Behavioral Nutrition and Physical Activity, 13*(1), pp. 1-22.

van Sluijs, E. M., Ekelund, U., Crochemore-Silva, I., Guthold, R., Ha, A., Lubans, D., Oyeyemi, A. L., Ding, D. and Katzmarzyk, P. T. (2021) Physical activity behaviours in adolescence: current evidence and opportunities for intervention. *The Lancet, 398*(10298), pp. 429-442.

Vanhelst, J., Béghin, L., Drumez, E., Coopman, S. and Gottrand, F. (2017) Awareness of wearing an accelerometer does not affect physical activity in youth. *BMC medical research methodology, 17*(1), pp. 1-6.

Vella, S. A. (2019) Mental health and organized youth sport. *Kinesiology Review, 8*(3), pp. 229-236.

Vella, S. A., Cliff, D. P., Magee, C. A. and Okely, A. D. (2014a) Sports participation and parent-reported health-related quality of life in children: longitudinal associations. *The Journal of Pediatrics, 164*(6), pp. 1469-1474.

Vella, S. A., Cliff, D. P. and Okely, A. D. (2014b) Socio-ecological predictors of participation and dropout in organised sports during childhood. *International Journal of Behavioral Nutrition and Physical Activity, 11*(1), pp. 1-10.

Vella, S. A., Schranz, N. K., Davern, M., Hardy, L. L., Hills, A. P., Morgan, P. J., Plotnikoff, R. C. and Tomkinson, G. (2016) The contribution of organised sports to physical activity in Australia: Results and directions from the Active Healthy Kids Australia 2014 Report Card on physical activity for children and young people. *Journal of Science and Medicine in Sport, 19*(5), pp. 407-412.

Venetsanou, F., Kambas, A. and Giannakidou, D. (2015) Organized physical activity and health in preschool age: a review. *Central European journal of public health, 23*(3), pp. 200-207.

Verstraete, S. J., Cardon, G. M., De Clercq, D. L. and De Bourdeaudhuij, I. M. (2007) A comprehensive physical activity promotion programme at elementary school: the effects on physical activity, physical fitness and psychosocial correlates of physical activity. *Public Health Nutrition, 10*(5), pp. 477-484.

Verswijveren, S. J., Salmon, J., Daly, R. M., Arundell, L., Cerin, E., Dunstan, D. W., Hesketh, K. D., Della Gatta, P. A. and Ridgers, N. D. (2021) Reallocating sedentary time with total physical activity and physical activity bouts in children: Associations with cardiometabolic biomarkers. *Journal of Sports Sciences, 39*(3), pp. 332-340.

Vinson, D., Beeching, K., Morgan, M. and Jones, G. (2017) Collaborative evaluation of individual and team performance in training and match environments using the coach logic online platform. *International Sport Coaching Journal, 4*(1), pp. 47-62.

Vinson, D., Brady, A., Moreland, B. and Judge, N. (2016) Exploring coach behaviours, session contexts and key stakeholder perceptions of non-linear coaching approaches in youth sport. *International Journal of Sports Science & Coaching, 11*(1), pp. 54-68.

Wang, L. and Ha, A. S. (2012) Factors influencing pre-service teachers' perception of teaching games for understanding: A constructivist perspective. *Sport, education and society, 17*(2), pp. 261-280.

Ward, P. and Ayvazo, S. (2016) Pedagogical content knowledge: Conceptions and findings in physical education. *Journal of Teaching in Physical Education, 35*(3), pp. 194-207.

Ward, P., Clark, T., Zabriskie, R. and Morris, T. (2014) Paper/pencil versus online data collection: An exploratory study. *Journal of Leisure Research, 46*(1), pp. 84-105.

Warren, J. M., Ekelund, U., Besson, H., Mezzani, A., Geladas, N. and Vanhees, L. (2010) Assessment of physical activity–a review of methodologies with reference to epidemiological research: a report of the exercise physiology section of the European Association of Cardiovascular Prevention and Rehabilitation. *European Journal of Cardiovascular Prevention & Rehabilitation, 17*(2), pp. 127-139.

Watkins, C. and Mortimore, P. (1999) Pedagogy: What do we know. in *Understanding Pedagogy: and its Impact on Learning*,London: Sage.

Welk, G. J. (2005) Principles of design and analyses for the calibration of accelerometry-based activity monitors. *Medicine & Science in Sports & Exercise, 37*(11 Suppl), pp. S501-11.

Welk, G. J., Corbin, C. B. and Dale, D. (2000) Measurement issues in the assessment of physical activity in children. *Research Quarterly for Exercise and Sport, 71*(sup2), pp. 59-73.

Werner, P., Thorpe, R. and Bunker, D. (1996) Teaching Games for Understanding: Evolution of a model. *Journal of Physical Education, Recreation & Dance, 67*(1), pp. 28-33.

Westerterp, K. R. (2009) Assessment of physical activity: a critical appraisal. *European Journal of Applied Physiology, 105*(6), pp. 823-828.

Westerterp, K. R. (2017) Doubly labelled water assessment of energy expenditure: principle, practice, and promise. *European Journal of Applied Physiology, 117*(7), pp. 1277-1285.

White, D. K., Gabriel, K. P., Kim, Y., Lewis, C. E. and Sternfeld, B. (2015) Do short spurts of physical activity benefit cardiovascular health? The CARDIA Study. *Medicine & Science in Sports & Exercise, 47*(11), pp. 2353.

WHO/FIMS Committee on Physical Activity for Health (1995) Exercise for health. *Bulletin of the World Health Organization, 73*(2), pp. 135-136.

Wickel, E. E. and Eisenmann, J. C. (2007) Contribution of youth sport to total daily physical activity among 6-to 12-yr-old boys. *Medicine & Science in Sports & Exercise, 39*(9), pp. 1493-1500.

Williams, J., Greene, S., Doyle, E., Harris, E., Layte, R., McCoy, S., McCrory, C., Murray, A., Nixon, E. and O'Dowd, T. (2009) *Growing up in Ireland national longitudinal study of children. The lives of 9 year olds*. Dublin.

Wolff-Hughes, D. L., Fitzhugh, E. C., Bassett, D. R. and Churilla, J. R. (2015) Total activity counts and bouted minutes of moderate-to-vigorous physical activity: relationships with

cardiometabolic biomarkers using 2003–2006 NHANES. *Journal of Physical Activity and Health, 12*(5), pp. 694-700.

Woods, C., Moyna, N. and Quinlan, A. (2010) *The children's sport participation and physical activity study (CSPPA study)*. Research Report No 1. School of Health and Human Performance. Dublin, Ireland: Dublin City University and The Irish Sports Council.

Woods, C. B., Powell, C., Saunders, J. A., O'Brien, W., Murphy, M. H., Duff, C., Farmer, O., Johnston, A., Connolly, S. and Belton, S. (2018) *The Children's Sport Participation and Physical Activity Study 2018 (CSPPA 2018)*. Department of Physical Education and Sport Sciences, University of Limerick, Limerick, Ireland, Sport Ireland, and Healthy Ireland, Dublin, Ireland and Sport Northern Ireland, Belfast, Northern Ireland.

World Health Organisation (2011) *Physical Activity and Young People*. Geneva: Who Press.

World Health Organisation (2020) *Guidelines on physical activity and sedentary behaviour*. Geneva: World Health Organization.

World Health Organization (2010a) *Global recommendations on physical activity for health*: World Health Organization.

World Health Organization (2010b) Global recommendations on physical activity for health. Geneva: WHO. *ISBN, 1011132395*, pp. 60.

World Health Organization (2010c) *A practical guide to developing and implementing school policy on diet and physical activity*: World Health Organization.

World Health Organization (2018) *Global action plan on physical activity 2018-2030: more active people for a healthier world*: World Health Organization.

World Health Organization (2020) *WHO guidelines on physical activity and sedentary behaviour: at a glance*.

Zeng, H. Z., Hipscher, M. and Leung, R. W. (2011) Attitudes of high school students toward physical education and their sport activity preferences. *Journal of Social Sciences, 7*(4), pp. 529.

Zhang, S., Murray, P., Zillmer, R., Eston, R. G., Catt, M. and Rowlands, A. V. (2012a) *Activity classification using the GENEA: optimum sampling frequency and number of axes*. Unpublished, Lippincott Williams & Wilkins.

Zhang, S., Rowlands, A. V., Murray, P. and Hurst, T. L. (2012b) Physical activity classification using the GENEA wrist-worn accelerometer. *Medicine & Science in Sports & Exercise, 44*(4), pp. 742-748.

Appendices

Appendix A: Peer Reviewed Publications

Gavin, K.W., Lane, A. and Dowd, K.P., (2020). The contribution of Gaelic football participation to youth physical activity levels. *Journal of Sports Science & Medicine*, 19(4), 652–661, available: https://www.jssm.org/jssm-19-652.xml%3EFulltext.

©Journal of Sports Science and Medicine (2020) **19**, 652-661
http://www.jssm.org

Research article

The Contribution of Gaelic Football Participation to Youth Physical Activity Levels

Kevin W. Gavin ✉, Aoife Lane and Kieran P. Dowd
Department of Sport and Health Sciences, Athlone Institute of Technology, N37HD68, Ireland

Abstract

The primary aim of this study was to describe the contribution of Gaelic football participation to youth physical activity (PA) levels. Secondary aims were to objectively quantify the overall daily PA levels of participants across sex and age, to determine the PA levels achieved during Gaelic football practice sessions and games, and to compare PA levels on days with organized sporting activity (sports days) and days without organized sporting activity (non-sports days). One hundred and sixty adolescents (87 male, 73 female; mean age 14.5 ± 1.8 yrs.) wore an activPAL accelerometer to determine total sitting/lying time, standing time, light intensity physical activity (LIPA), moderate physical activity (MPA), vigorous physical activity (VPA) and moderate-to-vigorous physical activity (MVPA) during a seven day measurement period, including during Gaelic football participation. Participants achieved an average of 58.5 ± 23.6 minutes of MVPA daily. Males accumulated significantly more MVPA daily than females (Males=70.8±22.1 min; Females = 45.5 ± 16.5 min; $p < 0.001$; $\eta_p^2 = 0.401$) and time spent in MVPA daily significantly decreased with age ($p < 0.001$; $\eta_p^2 = 0.299$). Participants accumulated significantly more MVPA during games (36.0 ± 9.2 min/hr (60%)) than practice sessions (29.0 ± 8.3 min/hr (48%); $p < 0.001$; $d = 0.80$). On sports days, participants accumulated significantly more time in MVPA (Sports Days = 70.1 ± 36.0 min; Non-Sports Days = 54.2 ± 34.0; $p < 0.001$; $d = 0.45$) and were 2.16 times more likely to achieve 60 minutes of MVPA (OR = 2.16; 95% CI = 1.60–2.92) than on non-sports days. The results reveal that Gaelic football provides an opportunity for adolescents to accumulate PA, however, participants currently spent more than 50% of their practice time inactive or in low intensity activities. An opportunity remains to enhance the contribution of Gaelic football to overall daily PA levels, by replacing time spent inactive with time in MVPA.

Key words: Adolescent, MVPA, youth sports, accelerometer, guidelines.

Introduction

Regular participation in physical activity (PA) during childhood and adolescence has a positive impact on a range of health markers, including adiposity, blood lipid profiles, bone health and mental health (Poitras et al., 2016). PA in adolescence indirectly affects adult health status by increasing the probability of becoming more active in adulthood, which in turn is linked to more favourable health outcomes (Hallal et al., 2006). Recently, the World Health Organization (WHO) have published a new draft of PA guidelines, which recommend youth achieve at least an average of 60 minutes per day of moderate-to-vigorous physical activity (MVPA) across the week (World Health Organization, 2020). In contrast, the current Irish PA guidelines recommend youth should achieve a minimum of 60 minutes of MVPA every day (Department of Health and Children and The Health Service Executive, 2009). International research indicates that approximately 78% of males and 84% of females fail to attain this guideline of 60 minutes of MVPA daily (Sallis et al., 2016). Furthermore, the prevalence of achieving PA guidelines significantly decreases throughout adolescence, with the greatest decline observed in females (Corder et al., 2015; Harding et al., 2015). Such high levels of physical inactivity are a public health concern, given the important role PA plays in the prevention of overweight and obesity during childhood and adolescence (Hills et al., 2011). This is particularly relevant considering that the number of adolescents classified as obese globally has increased substantially from 11 million in 1975, to 125 million in 2016 (Abarca-Gómez et al., 2017).

Organized sports (OS) participation has been identified as a key tool for the provision of MVPA in youth (Ridley et al., 2018; Trost et al., 2014). Participation in OS is particularly popular among youth, with 40-59% of children and adolescents across Europe participating regularly (Tremblay et al., 2016). However, evidence is conflicting on the potential of OS participation to enhance the attainment of PA guidelines in youth. Research has demonstrated that adolescents who participate in OS are significantly more physically active (Hebert et al., 2015; Kokko et al., 2018; Marques et al., 2016), and more likely to meet the PA guidelines than their non-participating peers (Sprengeler et al., 2019). Additionally, OS participants accumulate more MVPA on sports days than on non-sports days (Mooses and Kull, 2019). However, evidence does suggest that OS makes a relatively small contribution to the daily PA levels of adolescents (Koorts et al., 2019), with 72-80% of OS participating youth failing to achieve the recommended amount of PA daily (Telford et al., 2016; Vella et al., 2016). Significant sex differences are also apparent among OS participating youth, with females consistently accumulating less time in MVPA daily and are less likely to meet the MVPA guidelines than their male counterparts (Marques et al., 2016; Telford et al., 2016). In addition, females are less likely to participate in OS and display greater dropout rates from OS than males (Howie et al., 2016).

Research investigating the PA contribution of OS in youth using device-based monitors is limited to a small range of sports, including soccer (Cohen et al., 2014a; Sacheck et al., 2011), netball (Guagliano et al., 2013), basketball (Wickel and Eisenmann, 2007), flag football

Received: 01 May 2020 / Accepted: 25 August 2020 / Published (online): 19 November 2020

Gavin, K.W., Lane, A. and Dowd, K.P., (2021). Seasonal changes in the physical activity levels of youth Gaelic football players. *Journal of Sports Sciences*, 39(17), 2023-2029. DOI: 10.1080/02640414.2021.1923204.

JOURNAL OF SPORTS SCIENCES
https://doi.org/10.1080/02640414.2021.1923204

Routledge
Taylor & Francis Group

PHYSICAL ACTIVITY, HEALTH AND EXERCISE

Check for updates

Seasonal changes in the physical activity levels of youth Gaelic football players

Kevin W. Gavin, Aoife Lane and Kieran P. Dowd

Department of Sport and Health Sciences, Athlone Institute of Technology, Athlone Ireland

ABSTRACT

This study quantified changes in physical activity (PA) levels attained by adolescents during Gaelic football (GF) participation across two time points in a season and determined if these changes affected their overall daily PA levels. A total of 130 adolescents (65 females;15.3 ± 1.5 years) wore an activPAL accelerometer to determine total moderate PA (MPA), vigorous PA (VPA) and moderate-to-vigorous PA (MVPA) during a seven-day measurement period, including during GF. The PA measurement was completed at "preseason" (T1) and "in-season" (T2) timepoints. Between T1 and T2, females significantly increased time spent in MVPA daily ($p < 0.001$, $d = 0.95$), on Gaelic football days (GFDs) ($p = 0.036$; $d = 0.30$), on non-Gaelic football days (NGFDs) ($p < 0.001$; $d = 0.43$), and during GF ($p < 0.001$, $d = 0.90$). Males did not record any significant changes in PA over time ($p > 0.05$). At T2, there were no significant differences in time spent in MVPA daily, on GFDs and NGFDs, and during GF between the genders ($p > 0.05$). The results suggest that the change in daily PA levels by females is a consequence of increased MVPA during GF and reduced PA barriers across the season.

ARTICLE HISTORY
Accepted 23 April 2021

KEYWORDS
Adolescents; moderate-to-vigorous physical activity; youth sports; accelerometry

Introduction

The importance of regular physical activity (PA) to the healthy development of children and adolescents is well established, with evidence highlighting links between PA and improved health markers (Janssen & LeBlanc, 2010; Poitras et al., 2016). Furthermore, PA behaviours adopted during adolescence are likely to be maintained into adulthood (Hayes et al., 2019; Tammelin et al., 2014), demonstrating the importance of promoting adequate PA participation during this early developmental stage (Camacho-Minano et al., 2011; Hallal et al., 2006). Latest guidelines for PA from the World Health Organization (WHO) recommend youth achieve at least an average of 60 minutes per day of moderate-to-vigorous physical activity (MVPA) across the week to attain these health benefits (World Health Organisation, 2020). Despite this, research has reported that up to 90% of Irish adolescents fail to meet the relevant guidelines for PA (Woods et al., 2018). Moreover, a gender disparity in PA participation has been widely reported, as females are consistently less physically active throughout youth (Sallis et al., 2016), and experience a steeper age-related decline in PA when compared to males (Farooq et al., 2020; Owen et al., 2017).

In response to the low levels of PA attained throughout adolescence, increased efforts have been placed on identifying effective settings to increase engagement in MVPA (Fenton et al., 2015). Participation in organised sport (OS) has been identified as one of the "eight investments that work" for increasing PA (The International Society for Physical Activity and Health (ISPAH), 2020), and is particularly relevant to youth given the existing cultural norms and infrastructure that encourages sports participation among this cohort (Howie et al., 2020). Indeed, research indicates that 58–80% of Irish youth participate in at least one OS per week (Woods et al., 2018). This could have positive implications for public health, as participation in youth OS is associated with increased daily PA levels (Hebert et al., 2015; Sprengeler et al., 2019), increased likelihood of attaining the PA guidelines (Kokko et al., 2018; Mooses & Kull, 2019), and psychological benefits (McMahon et al., 2017; Murphy et al., 2020).

Gaelic football is a field-based invasive team sport indigenous to Ireland, and has the highest OS participation rates among Irish youth, with 32% of 12–18 year olds participating regularly (Woods et al., 2018). Youth games are contested by two teams of 15 active players on a rectangular grass pitch, with the primary objective to outscore the opposing team across the 60-min period of competitive play (Beasley, 2015). Teams are awarded one point by putting the ball over the crossbar between two uprights, or three points by scoring a goal (Cullen et al., 2013). Similar to Australian Rules football and soccer, Gaelic football is a multidirectional sport, characterized by unpredictable bursts of high intensity anaerobic activity, interspersed with sustained light to moderate aerobic activity (Cullen et al., 2013; Malone et al., 2017). During these periods of high-intensity activity, players must perform key technical skills, including hand passing, kick passing, shooting, blocking, tackling, gaining possession and evading opponents (Cullen et al., 2017; Shovlin et al., 2018).

Despite the popularity of OS among this cohort, the specific role it plays in youth daily PA levels remains unclear. Participation alone does not ensure youth will achieve the PA guidelines (Ridley et al., 2018), with one study reporting that less than 20% of OS participating youth met the recommendations (Vella et al., 2016). Also, studies consistently demonstrate that irrespective of the sport type, sport context (practice or game), age or gender, youth OS participants spend the majority of their

CONTACT Kevin W. Gavin, Email k.gavin@research.ait.ie Research Hub, Athlone Institute of Technology, Co. Westmeath, N37HD68, Ireland.

Appendix B: Club Chairperson Information Sheet and Consent Form

Club Chairperson Information Sheet

Title of Project: The contribution of GAA participation to overall physical activity in Irish youth.
Name of Researcher: Kevin Gavin
Contact phone number: (087) 3133232
Email: k.gavin@research.ait.ie
Date:

Introduction:
We would like to invite your GAA Club to take part in a research study. Prior to making your decision, it is important that you understand why the research is being done and what it will involve for your Club and its members. The aim of this Information Sheet is to outline the purpose, risks and benefits of this research study. Take as much time as you need to read the information and if you have any questions please do not hesitate to ask. If you decide that your Club would like to take part in this research study, we ask you to sign the accompanying Consent Form. You should only sign the consent form when you feel that you understand what is being asked of your Club and its members, and you have had enough time to make your decision.

Purpose of this study:
The purpose of this research study is to look at the amount of physical activity that young people achieve during a GAA training session or match, and compare it to the rest of the day. In particular, we are looking at Irish boys and girls between the ages of 12 and 18 years of age. Your Club has been invited to take part in this study because of the strong participation levels of both males and females within these age groups in your club.

Does the Club have to take part?
The decision to take part in this research study is completely up to the GAA Club. If your Cub decides to take part in the study you are free to withdraw at any time and without giving any reason. Deciding to not take part or withdraw from the study at any time will not affect you (or the Club) in any way.

What will be required of the Club and its members during the study?
For this study we will require a list of registered Club members between the ages of 12 and 18 years. We will inform all of the members and their parents about the study at an information evening. If they would like to take part in the study, they will be asked to read an information sheet on the project, and to sign a Consent Form. We will require a total of 15 participants, split between male and female. The participants will be asked to be at the GAA Club at a specific date and time that suits all parties. On this day, we ask to have the use of a private room, where participants will

have their height, weight and waist circumference measured in the company of 2 researchers (1 male and 1 female).
They will then be shown how to correctly apply a small activity monitor (the activPAL) on their right leg. The activPAL is the device that records all the physical activity that occurs throughout the day. This device will be worn for a total of 7 days, before being returned to the researcher at the end of the research study.

What is the activPAL?
The activPAL is a small, discrete device (similar size to a small match box) that records all of the youth's physical activity throughout the day. It is applied to the right thigh using a sticky tape that allows it to be worn continuously throughout the day. The youth will be shown how to correctly apply and remove the activPAL. If the device feels uncomfortable or they would like to remove it at any time they are free to do so.

What are the possible risks of taking part in the Study?
There are no significant risks to the participants taking part in this research study. There may be some slight discomfort while taking off the sticky tape used to apply the activPAL to the skin.

Will the study be confidential?
All information, measurements and results taken during this research study will be kept strictly confidential and will not be shared with anyone else. The information collected during this research study will be stored in a way that protects the participant's identity. Results from this study will be reported as group data and will not identify the youth personally in any way.

Who do I Contact if I have any concerns or questions?
If you have concerns or questions throughout the study, feel free to contact the researcher at any time. The researchers name, contact number and email address are located at the top of this Information Sheet.

If you have any additional questions in relation to the research project, or would like more information about any aspect of the project, please feel free to contact the supervisory team:

Dr. Kieran Dowd,
Assistant lecturer,
Dept. Sport and Health,
Athlone Institute of Technology,
Athlone,
Co. Westmeath.

Dr. Aoife Lane,
Head of Department,
Dept. Sport and Health,
Athlone Institute of Technology,
Athlone,
Co. Westmeath.

If you have any concerns about this study and wish to contact someone independent and in confidence, you may contact the Chairperson of the AIT Research Ethics Committee, c/o Office of the Vice President for Research, Athlone Institute of Technology.
Email: ethics@ait.ie

Name of Researcher:
Date:

CLUB CONSENT FORM

Title of Project: The contribution of GAA participation to overall physical activity in Irish youth.

Please tick the box

1. I confirm that I have read the information sheet for the above study and have had the opportunity to ask questions. ☐
2. I am satisfied that I understand the information provided and have had enough time to consider the information. ☐
3. I understand that the club's participation is voluntary and is free to withdraw at any time, without giving any reason, without legal rights being affected. ☐
4. The club agrees to take part in the above study. ☐

_____	_____	_____
Name of Chairperson	Date	Signature

_____	_____	_____
Researcher	Date	Signature

1 for club; 1 for researcher; 1 to be kept with research notes

Appendix C: Parent and Participant Information Sheets and Consent Forms

Parent/Guardian Information Sheet

Title of Project: The contribution of GAA participation to overall physical activity in Irish youth.
Name of Researcher: Kevin Gavin
Contact phone number: (087) 3133232
Email: k.gavin@research.ait.ie
Date:

Introduction:
Your child is invited to take part in a research study being run by a postgraduate researcher from Athlone Institute of Technology as part of his Masters by research. Prior to making your decision, it is important that you understand why the research is being done and what it would involve for your child. The aim of this Information Sheet is to outline the purpose, risks and benefits of this research study. Take as much time as you need to read the information and if you have any questions please do not hesitate to ask. If you decide that you are happy for your child to take part in this research study, we ask you to sign the accompanying Consent Form. You should only sign the Consent Form when you feel that you understand what is being asked of your child, and when you have had enough time to make your decision.

Purpose of this study:
The purpose of this research study is to look at the amount of physical activity that children and adolescents achieve during a GAA training session or match, and compare it to the rest of the day. In particular, we are looking at Irish youth between the ages of 12 and 18 years. Your child has been randomly selected to take part in this study because they are currently playing either Gaelic Football or Hurling/Camogie and are aged between 12 and 18 years.

Does my child have to take part?
The decision to take part in this research study is completely up to you and your child. If you and your child decide to take part in the study, you are free to withdraw at any time without giving any reason. Deciding to not take part or withdraw your child from the study at any time will not affect you in any way.

What will my child have to do during the study?
For this study, your child will be asked to be at the GAA club at a specific date and time. On this day, your child will have their height, weight and waist circumference measured in a private area behind a privacy curtain. Both a male and female researcher will be present for all measures on these test days. If you prefer, you can accompany your child for these test. They will then be shown how to correctly apply a small activity monitor (the activPAL) on their right leg. The activPAL is

the device that records all the physical activity that occurs throughout the day. This device will be worn for a total of 7 days, before being returned to the researcher at the end of week.

What is the activPAL?
The activPAL is a small, discrete device (similar size to a small match box) that will record all the physical activity your child participates in throughout the day. It is applied to the right thigh using a sticky tape that allows it to be worn continuously, and only needs to be removed when swimming or in the bath. Your child will be shown how to correctly apply and remove the activPAL. If the device feels uncomfortable or they would like to remove it at any time, they are free to do so.

What are the possible risks of taking part in the study?
There are no significant risks to your child by taking part in this research study. There may be some slight discomfort while taking off the sticky tape used to apply the activPAL to the skin.

Will the study be confidential?
All information, measurements and results taken during this research study will be kept strictly confidential and will not be shared with anyone else. The information collected during this research study will be stored in a way that protects your child's identity. Results from this study will be reported as group data and will not identify your child personally in any way.

Who do I contact if I have any concerns or questions?
If you have concerns or questions throughout the study feel free to contact the researcher at any time. The researchers name, contact number and email address are located at the top of the Information Sheet.

If you have any additional questions in relation to the research project, or would like more information about any aspect of the project, please feel free to contact the supervisory team:

Dr. Kieran Dowd,
Assistant lecturer,
Dept. Sport and Health,
Athlone Institute of Technology,
Athlone,
Co. Westmeath.

Dr. Aoife Lane,
Head of Department,
Dept. Sport and Health,
Athlone Institute of Technology,
Athlone,
Co. Westmeath.

If you have any concerns about this study and wish to contact someone independent and in confidence, you may contact the Chairperson of the AIT Research Ethics Committee, c/o Office of the Vice President for Research, Athlone Institute of Technology.
Email: ethics@ait.ie

Participation Information Sheet

Title of Project: The contribution of GAA participation to overall physical activity in Irish youth.
Name of Researcher: Kevin Gavin
Contact phone number/email: (087) 3133232 / k.gavin@research.ait.ie
Date:

Introduction:
You have been invited to take part in a research study. Before you make up your mind about participating, it is important that you understand why the research is being done and what it would involve for you. The aim of this Information Sheet is to describe this research study. Take as much time as you need to read the information and if you have any questions please don't hesitate to ask us. If you decide that you would like to take part in this research study, we will ask you to sign a Consent Form. You should only sign the consent form when you feel that you understand what is being asked of you, and you have had enough time to make your decision.

Purpose of this Study:
The purpose of this study is to look at the amount of physical activity that you achieve during a GAA training session or match, and compare it to the rest of the day. In particular, we are looking at Irish youths between the ages of 12 and 18 years old. You have been asked to take part in this study because you are currently playing either Gaelic Football or Hurling/Camogie and between 12 and 18 years old.

Do I Have To Take Part?
The decision to take part in this study is completely up to you. If you decide to take part in the study, you are free to withdraw at any time and without giving any reason. Deciding to not take part or withdraw from the study at any time will not affect you in any way.

What Will I Have To Do During The Study?
For this study you will be asked to be at your GAA club at a specific date and time. On this day you will have your height, weight and waist circumference measured in a private area behind a privacy curtain. You will then be shown how to correctly apply a small activity monitor (the activPAL) on your right leg. The activPAL is the device that records all the physical activity that you do during the day. This device will be worn for a total of 7 days, before being returned to the researcher at the end of the research study.

What is the activPAL?
The activPAL is a small, match box sized monitor that records all your physical activity throughout the day. It is applied to your right thigh using a sticky tape that allows it to be worn continuously throughout the day, and only needs to be removed when swimming or in the bath. We will show

you how to correctly apply and remove the activPAL. If the device feels uncomfortable or you would like to remove it at any time you are free to do so.

What Are The Possible Risks of Taking Part in the Study?
There is no significant risks to you by taking part in this research study. There may be some slight discomfort while taking off the sticky tape used to apply the activPAL to the skin.

Will the Study be Confidential?
All information, measurements and results taken during this research study will be kept strictly confidential and will not be shared with anyone else. The information collected during this research study will be stored in a way that protects your identity. Results from this study will be reported as group data and will not identify you personally in any way.

Who Do I Contact if I have Any Concerns or Questions?
If you have concerns or questions throughout the study feel free to contact the researcher at any time. The researchers name, contact number and email address are located at the top of the Participation Information Sheet.

If you have any additional questions in relation to the research project, or would like more information about any aspect of the project, please feel free to contact the supervisory team:

Dr. Kieran Dowd,
Assistant lecturer,
Dept. Sport and Health,
Athlone Institute of Technology,
Athlone,
Co. Westmeath.

Dr. Aoife Lane,
Head of Department,
Dept. Sport and Health,
Athlone Institute of Technology,
Athlone,
Co. Westmeath.

If you have any concerns about this study and wish to contact someone independent and in confidence, you may contact the Chairperson of the AIT Research Ethics Committee, c/o Office of the Vice President for Research, Athlone Institute of Technology.
Email: ethics@ait.ie

Participant Identification Number:
Name of Researcher:
Date:

CONSENT FORM

Title of Project: The contribution of GAA participation to overall physical activity in Irish youth.

Please tick the box

1. I confirm that I have read the information sheet for the above study and have had the opportunity to ask questions. ☐
2. I am satisfied that I understand the information provided and have had enough time to consider the information. ☐
3. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, without my legal rights being affected. ☐
4. I agree to take part in the above study. ☐

_____	_____	_____
Name of Participant	Date	Signature
_____	_____	_____
Name of Parent/Guardian (if participant is under 18)	Date	Signature
_____	_____	_____
Researcher	Date	Signature

1 for participant; 1 for researcher; 1 to be kept with research notes

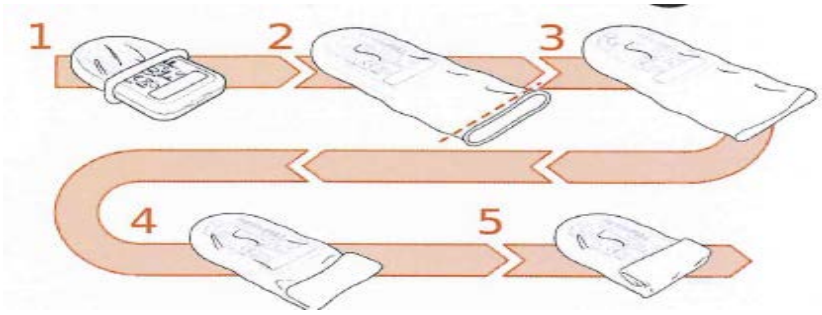
Appendix D: Participant activPAL Instructions and Non-Wear Diary

activPAL™ Physical Activity Monitor Instructions

STEP 1: Waterproofing the activPAL™

The activPAL™ must firstly be waterproofed by covering it in a plastic sleeve. Follow the diagram below to help.

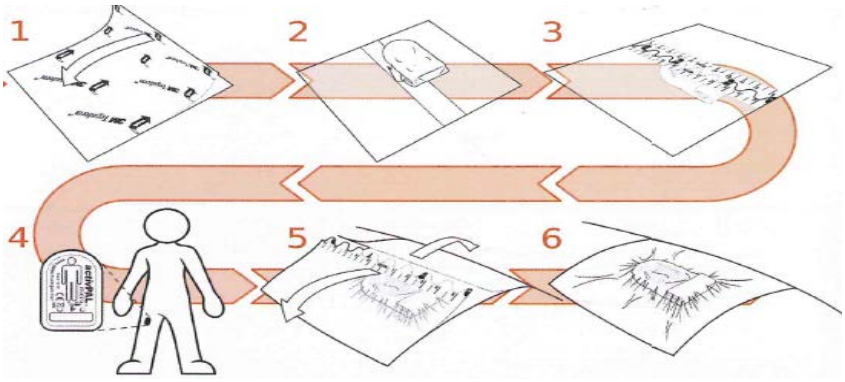
- Place the activPAL™ into the sleeve with the curved side first
- Roll the sleeve upwards, past the base of the device.
- The loose end of the sleeve should then be tied or folded tightly to ensure that no water gets into it.



STEP 2: Attaching the activPAL™ to your leg

The activPAL™ must be attached to your leg using the square piece of Tegaderm dressing.

- Firstly, place the dressing on a hard, flat surface with the white backing of the dressing that says "3M Tegaderm" facing upwards.
- Remove this white backing and you will be left with the sticky side of the dressing facing you.
- Place the activPAL face down in the middle of the sticky side of the Tegaderm dressing (Face down means that the side of the activPAL™ with the green light flashing should be face down on the sticky dressing).
- Place the dressing on the front of your right leg, halfway between your knee and your hip (The curved part of the activPAL should be facing up).
- Press the dressing onto your leg to ensure it is securely applied.
- Finally, remove the outer plastic of the dressing that has a list numbers on it and firmly press down on the final dressing a time.



Once the activPAL™ is applied we ask you to wear it all day and night for a total of 7 days, except when you are swimming, taking a bath or doing any other water-based activities. The activPAL™ can be worn in the shower. Please record on the attached activPAL diary the time and day that you took the activPAL™ off and put the activPAL™ on. If at any point the activPAL™ causes you discomfort you are free to take it off. The clear Tegaderm dressing may need to be replaced every 3 – 4 days if it begins to get loose. There are two additional bandages included in your bag, along with 2 additional sleeves for waterproofing the activPAL™, which should be enough for wearing the activPAL™ for a full week. However, if you run out and need more bandages or sleeves, please just call Kevin and he will deliver more to you. We will visit the GAA club next week to collect the activPAL™ and any remaining contents of the bag from you.

Frequently Asked Questions

Where should I apply the activPAL^{3M}?
It is most comfortable to wear the activPAL on the mid line of the right thigh, about half way down between the hip and the knee.

What if the activPAL^{3M} is not secure?
Ensure that you have the correct side of the bandage sticking to your leg. The sticky side of the bandage will not work well if your leg is wet, or if any lotions (moisturiser or fake tan for example) are on the leg. If the bandage comes loose, you may need to replace it.

When should I remove the activPAL^{3M}?
The activPAL can be worn comfortably all day and all night and should not impede normal activities. It can be kept on while taking a shower. However, it **MUST** be removed before taking a bath and swimming or before any other activities which may mean the activPAL could come into contact with water for a prolonged period.

How do I know the activPAL^{3M} is working?
The activPAL is a continuous recorder so will never stop recording. But you can be sure by checking the little light in the front panel. The light will flash green every six seconds. If it is not flashing green please ring Kevin immediately.

What if I lose the activPAL^{3M}?
Don't panic. If you lose or misplace the activPAL, please ring **Kevin** **IMMEDIATELY**. He will then try to retrace your steps with you, and will help you look for (and hopefully find) the activPAL. activPAL's are not cheap, so it is very important that you contact **Kevin** as soon as you have misplaced the device!

What if I'm in trouble or have a question?
At any stage, day or night, if you are having a problem with the device or have a question please give us a ring or text. No matter how small or silly you think the question is, it could turn out to be very important later on.

Kevin Gavin Mobile Number: (087) 3133232

"Once again, thank you for all your help and co-operation!"

activPAL™ Diary

NAME: _____
ID NUMBER: _____

Date	Day	Time Taken Off	Activity	Time Replaced
04/02/2018	*Wednesday*	*14:58*	*Swimming*	*15.38*

Appendix E: Coach Practice Session and Game Diary

COACH PRACTICE SESSION/GAME DIARY

DATE	START TIME	FINISH TIME	PRACTICE SESSION/GAME DETAILS
*EXAMPLE 01/11/2017	7pm	8pm	Practice Session • Warmup: Jogging and stretching – 10mins • Drill 1: Kickpassing – 15mins • Drill 2: Handpassing – 5mins • Drill 3: Tackling – 10mins • Drill 4: Shooting – 15mins • Cooldown: Jogging and stretching – 5mins

Appendix F: Survey

Coaching Approaches in Youth Gaelic Games

1. Introductory Page: Study Information

A research team from the Department of Sport and Health Sciences in Athlone Institute of Technology is inviting you to take part in a study on coaching approaches in youth Gaelic Games. Before you decide whether or not to take part, it is important that you understand what the research is for and what you will be asked to do. Please read the following information and thank you for taking the time to consider the invitation.

The purpose of this study is to explore coaching approaches in youth Gaelic Games (Gaelic Football/Hurling/Camogie) at club level. We are looking to hear from both current and former coaches of Gaelic Games teams between U12 and Minor grades at club level. Former coaches must have coached within the last 5 years.

Completion of this survey should take about 15 minutes. Questions range from ticking a box, to giving your views and opinions on coaching approaches in Gaelic Games. Please answer all questions, reflect as appropriate on each question and provide your honest answer. Results of this study will be used to inform and improve coaching development in Gaelic Games.

This study and survey has been approved by the Athlone Institute of Technology Research Ethics Committee. Your responses are anonymous, meaning that the researcher will not know who has completed each survey. Please note you are under no obligation to participate in this study and you are free to withdraw from the study at any time without reason.

If you have further questions regarding this research please feel free to contact me using the email address provided below. Your participation in this research is greatly appreciated.

Yours sincerely,

Kevin Gavin
PhD Student
AIT
k.gavin@research.ait.ie

Dr. Kieran Dowd
Faculty Member
AIT
kdowd@ait.ie

Dr. Aoife Lane
Faculty Member
AIT
alane@ait.ie

1

Coaching Approaches in Youth Gaelic Games

2. Participant Consent

Title: Coaching Approaches in Youth Gaelic Games.

By ticking the 'agree' box below you are adhering to the following points and may participate in this study.

• I have read and understood the participant information provided above.

• I understand what the project is about, and what the results will be used for.

• I am fully aware of all the procedures involving myself, and of any risks and benefits associated with the study.

• I know that my participation is voluntary and that I can withdraw from the study at any stage without giving reason.

• I am 18 years of age or older

• I am currently coaching or have coached a Boys or Girls club team in Gaelic Football or Hurling/Camogie between the U12 and Minor Grades in the last 5 years.

* 1. I agree with the above statements and consent to participate in the study

- ◯ Yes
- ◯ No

IMPORTANT:

Due to the current Covid-19 guidelines and restrictions on team sport and the effect that may have on how you coach your team, please consider a typical coaching season prior to the pandemic when answering the following questions.

Coaching Approaches in Youth Gaelic Games

3. Participant Characteristics

2. Please select the option that describes you?

- Current Coach
- Former Coach (within the last 2-5 years)

3

Coaching Approaches in Youth Gaelic Games

3. In what year did you last coach a youth Gaelic Games club team?

4. What is your gender?

- Female
- Male

5. What is your age?

- 18-24
- 25-34
- 35-44
- 45-54
- 55-64
- 65+

* 6. How many years experience do you have coaching Gaelic Games at all levels?

7. Please indicate ALL levels at which you have COACHED Gaelic Games by ticking the appropriate boxes below.

	Child (Age 7-11)	Youth (Age 12-17)	Adult (Age 18+)
Club	☐	☐	☐
County	☐	☐	☐
College/University	☐	☐	☐
Schools	☐	☐	☐

4

Coaching Approaches in Youth Gaelic Games

4. Coach Education

8. What levels of coaching education have you completed (or are currently completing)? Please select all that apply.

- [ ] No formal coach education
- [ ] Gaelic Games Coaching Workshops
- [ ] Foundation Award (GAA) / Fundamentals (LGFA) / Camán and Coach (Camogie)
- [ ] Award 1 (GAA) / Level 1 (LGFA or Camogie)
- [ ] Award 2 (GAA) / Level 2 (LGFA or Camogie)
- [ ] Coach Education Tutor Award
- [ ] Coach Education Tutor Trainer Award
- [ ] Diploma of Sport Coaching (or equivalent)
- [ ] Sports coaching related third level degree (e.g. Sports Science, Physical Education)
- [ ] Sports coaching related Masters (e.g. Masters in Sports Performance, Strength & Conditioning)
- [ ] Sports coaching related PhD
- [ ] Other education / accreditation (e.g. IRFU, CCC, NSCA, CSCS, UKSCA etc.)

If you have sports related Third level degree, Masters or PhD please specify in more detail below (i.e. course name)

5

Coaching Approaches in Youth Gaelic Games

5. Describing The Club Team You Are Coaching.

In this section we will be asking you about the club team you are coaching.

If you are coaching more than one team, please select the team you are coaching most regularly and answer your questions based on that coaching experience.

If you are a former coach, please select the team you most recently coached and answer your questions based on that coaching experience.

Note: Due to the current Covid-19 guidelines and restrictions on team sports, please consider a typical coaching season prior to the pandemic when answering the following questions.

9. What is the gender of the team you are coaching?

- Female
- Male

10. In what code are you coaching?

- Hurling/Camogie
- Gaelic Football

11. What is the age-group/grade of the team you are coaching?

- Under 11/12
- Under 13/14
- Under 15/16
- Under 17/18

12. In what county is your team situated?

* 13. How many years have you been coaching this team? (Please enter as a number i.e. 2)

6

14. How many members of your management team hold responsibilities for the design and coaching of pitch sessions?

- 1 (me only)
- 2
- 3
- 4
- 5
- 6 (or more)

* 15. On average, how many on-field training sessions do you have with this team each week? (Please enter as a number i.e. 2)

7

Coaching Approaches in Youth Gaelic Games

6. Describing your typical coaching approach to training.

In this section we will be asking you to describe your typical coaching approach to training

Please note, the following definitions will be used in this section to describe different stages of a Gaelic Games season.

EARLY SEASON: is used to describe the first period of the year when a team starts training and are playing league games. Players are still in school during this time period.

SUMMER SEASON: is used to describe the period of the year when a team are preparing for and playing championship matches. Players are finished in school during this time period.

STANDARD SEASON: is used to describe the entire length of a standard Gaelic Games season.

16. Does your coaching approach to training change/vary significantly from EARLY SEASON to SUMMER SEASON?

Note: If your coaching approach **does** change significantly from EARLY SEASON to SUMMER SEASON you will be asked to outline both stages below. If your coaching approach **does not** change significantly across a season you will be asked to just outline the STANDARD SEASON.

- ◯ Yes
- ◯ No

Department of Sport and Health Sciences

Coaching Approaches in Youth Gaelic Games

7. Describing your typical training sessions across a STANDARD SEASON.

Please note, the following definitions will be used in this section to describe content activity that a coach may use in their session:

Drills: Exercises practiced unopposed in lines that require the repetition of skills and prescribed directional movement.

Skills in Isolation: Similar to drills but don't occur in lines and are often completed with little or no movement allowing the player to solely concentrate on the skill being practiced.

Applied Skill Practice: Activities that involve some level of opposition and where technique is exposed to pressure and elements of decision making are required (1vs1/2vs2/4vs2).

Modified Games: Match-like activities with reduced numbers (6vs6/7vs7) where space/rule restrictions may be employed (e.g. conditioned games, small-sided games, possession games).

Full-Sided Games: Game played with the full complement of players present at a training session. Regulation rules with two goals.

Conditioning: Exercises completed **without** the ball that usually focuses on improving fitness, speed and agility etc (If you use modified games or full-sided games to improve fitness please select the appropriate option above).

17. In a typical pitch session, across a STANDARD SEASON, please estimate the duration of this session in MINUTES (Please enter as a number i.e. 60)

9

* 18. In a typical pitch session across a STANDARD SEASON, please estimate the amount of time in minutes, spent in each activity as this applies to your training.

(**Note:** This should add up to the duration of the session you have entered in Q15. You do not need to put a number in every box if it does not apply to your training)

Warm-up	
Cool Down	
Drills	
Conditioning	
Skills in Isolation	
Applied Skills Practice	
Modified Games	
Full-Sided Games	

19. In a typical pitch session across a STANDARD SEASON, please select the activities that you use and put them in the order in which they occur i.e. Warm-up is your 1st Activity, Drills is your 2nd Activity and so on.

(**Note**: you can tick the listed activities on multiple occasions i.e. an activity occurring a number of times throughout a session; only list the number of activities you use, you are not required to list 8)

	1st Activity	2nd Activity	3rd Activity	4th Activity	5th Activity	6th Activity	7th Activity	8th Activity
Modified Games	☐	☐	☐	☐	☐	☐	☐	☐
Drills	☐	☐	☐	☐	☐	☐	☐	☐
Full-Sided Game	☐	☐	☐	☐	☐	☐	☐	☐
Skills in Isolation	☐	☐	☐	☐	☐	☐	☐	☐
Applied Skills Practice	☐	☐	☐	☐	☐	☐	☐	☐
Warm-Up	☐	☐	☐	☐	☐	☐	☐	☐
Cool Down	☐	☐	☐	☐	☐	☐	☐	☐
Conditioning	☐	☐	☐	☐	☐	☐	☐	☐

10

Coaching Approaches in Youth Gaelic Games

8. Describing your typical training sessions in EARLY SEASON

Please note, the following definitions will be used in this section to describe content activity that a coach may use in their session:

Drills: Exercises practiced unopposed in lines that require the repetition of skills and prescribed directional movement.

Skills in Isolation: Similar to drills but don't occur in lines and are often completed with little or no movement allowing the player to solely concentrate on the skill being practiced.

Applied Skill Practice: Activities that involve some level of opposition and where technique is exposed to pressure and elements of decision making are required (1vs1/2vs2/4vs2).

Modified Games: Match-like activities with reduced numbers (6vs6/7vs7) where space/rule restrictions may be employed (e.g. conditioned games, small-sided games, possession games).

Full-Sided Games: Game played with the full complement of players present at a training session. Regulation rules with two goals.

Conditioning: Exercises completed **without** the ball that usually focuses on improving fitness, speed and agility etc (If you use modified games or full-sided games to improve fitness please select the appropriate option above).

20. In a typical pitch session during EARLY SEASON, please estimate the duration of this session in MINUTES. (Please enter as a number i.e. 60)

11

* 21. In a typical pitch session during EARLY SEASON, please estimate the amount of time in minutes, spent in each activity as this applies to your training.

(**Note:** This should add up to the duration of the session you have entered in Q19. You do not need to put a number in every box if it does not apply to your training)

Warm-up	
Cool Down	
Drills	
Conditioning	
Skills in Isolation	
Applied Skills Practice	
Modified Games	
Full-Sided Games	

22. In a typical pitch session during EARLY SEASON, please select the activities that you use and put them in the order in which they occur i.e. Warm-up is your 1st Activity, Drills is your 2nd Activity and so on.

(Note: you can tick the listed activities on multiple occasions i.e. an activity occurring a number of times throughout a session; only list the number of activities you use, you are not required to list 8)

	1st Activity	2nd Activity	3rd Activity	4th Activity	5th Activity	6th Activity	7th Activity	8th Activity
Modified Games	☐	☐	☐	☐	☐	☐	☐	☐
Drills	☐	☐	☐	☐	☐	☐	☐	☐
Full-Sided Games	☐	☐	☐	☐	☐	☐	☐	☐
Skills in Isolation	☐	☐	☐	☐	☐	☐	☐	☐
Applied Skills Practice	☐	☐	☐	☐	☐	☐	☐	☐
Warm-up	☐	☐	☐	☐	☐	☐	☐	☐
Cool down	☐	☐	☐	☐	☐	☐	☐	☐
Conditioning	☐	☐	☐	☐	☐	☐	☐	☐

Coaching Approaches in Youth Gaelic Games

9. Describing your typical training sessions across the SUMMER SEASON.

Please note, the following definitions will be used in this section to describe content activity that a coach may use in their session:

Drills: Exercises practiced unopposed in lines that require the repetition of skills and prescribed directional movement.

Skills in Isolation: Similar to drills but don't occur in lines and are often completed with little or no movement allowing the player to solely concentrate on the skill being practiced.

Applied Skill Practice: Activities that involve some level of opposition and where technique is exposed to pressure and elements of decision making are required (1vs1/2vs2/4vs2).

Modified Games: Match-like activities with reduced numbers (6vs6/7vs7) where space/rule restrictions may be employed (e.g. conditioned games, small-sided games, possession games).

Full-Sided Games: Game played with the full complement of players present at a training session. Regulation rules with two goals.

Conditioning: Exercises completed **without** the ball that usually focuses on improving fitness, speed and agility etc (If you use modified games or full-sided games to improve fitness please select the appropriate option above).

23. In a typical pitch session during SUMMER SEASON, please estimate the duration of this session in MINUTES (Please enter as a number i.e. 60)

* 24. In a typical pitch session during SUMMER SEASON, please estimate the amount of time in minutes, spent in each activity as this applies to your training.

(**Note:** This should add up to the duration of the session you have entered in Q23. You do not need to put a number in every box if it does not apply to your training)

Warm-up	
Cool Down	
Drills	
Conditioning	
Skills in Isolation	
Applied Skills Practice	
Modified Games	
Full-Sided Games	

25. In a typical pitch session during SUMMER SEASON, please select the activities that you use and put them in the order in which they occur i.e. Warm-up is your 1st Activity, Drills is your 2nd Activity and so on.

(**Note:** you can tick the listed activities on multiple occasions i.e. an activity occurring a number of times throughout a session; only list the number of activities you use, you are not required to list 8)

	1st Activity	2nd Activity	3rd Activity	4th Activity	5th Activity	6th Activity	7th Activity	8th Activity
Modified Games	☐	☐	☐	☐	☐	☐	☐	☐
Drills	☐	☐	☐	☐	☐	☐	☐	☐
Full-Sided Games	☐	☐	☐	☐	☐	☐	☐	☐
Skills in Isolation	☐	☐	☐	☐	☐	☐	☐	☐
Applied Skills Practice	☐	☐	☐	☐	☐	☐	☐	☐
Warm-up	☐	☐	☐	☐	☐	☐	☐	☐
Cool down	☐	☐	☐	☐	☐	☐	☐	☐
Conditioning	☐	☐	☐	☐	☐	☐	☐	☐

Coaching Approaches in Youth Gaelic Games

10. Describing your Coaching Approach

26. Based on your own coaching sessions and session planning, how often do you use / implement the following:

	Often	Sometimes	Rarely	Never
I encourage input and feedback from the players throughout the session.	○	○	○	○
I coach technical skills in isolation before coaching any tactical skills.	○	○	○	○
I use drills to coach specific tactics and strategies.	○	○	○	○
I use modified games or full-sided games to develop players game sense or decision making.	○	○	○	○
I develop a session plan prior to each training and stick to the plan I have laid out.	○	○	○	○
I involve other members of the management team in the development of the session plan.	○	○	○	○
I plan the questions I am going to ask the players prior to the training.	○	○	○	○
I use modified games as opposed to drills and conditioning for improving fitness.	○	○	○	○

15

	Often	Sometimes	Rarely	Never
I provide opportunities for players to discuss and debate their own strategies in upcoming sections of training.	○	○	○	○
I give players all the instructions, direction and tools they need to perform a task.	○	○	○	○
I use drills to allow players to practice their skills for "game conditions".	○	○	○	○
I ask players questions mid-session to develop their understanding and learning of concepts.	○	○	○	○
I ask players questions mid-session to stimulate thinking and interaction.	○	○	○	○
I ensure players are included in the decision-making process regarding team tactics and strategies.	○	○	○	○

16

Coaching Approaches in Youth Gaelic Games

11. Understanding of Game-Based Approach

In this section we will ask you what your understanding of the term "Game-Based Approach" is, and to what extent are you aware of theory regarding Game-Based Approaches.

27. Are you aware of the term Game-based approach in coaching?

- ◯ Yes
- ◯ No

28. Can you briefly state your understanding of the term Game-Based Approach?

29. Provide a rating of how confident you are using Game Based Approaches

- ◯ No Confidence
- ◯ Low Confidence
- ◯ Moderate Confidence
- ◯ High Confidence
- ◯ Complete Confidence

30. Where did you FIRST learn about Game Based Approach?

- ◯ Coaching Conference
- ◯ Another coach
- ◯ A player
- ◯ Reading literature
- ◯ Social media (i.e. twitter)
- ◯ Internet
- ◯ Coach education courses
- ◯ College
- ◯ Other (please specify)

31. The following are formal Game Based Approaches that have been developed, do you recognise any? (Select all that apply)

- ☐ Teaching Games for Understanding
- ☐ The Tactical Games Model
- ☐ Play Practice
- ☐ Game Sense
- ☐ The Games Concept Approach
- ☐ The Invasion Games Competence Model
- ☐ GAA Games-Based Wheel - MVA/Coach10 Model
- ☐ None of the above

32. Which of the following Game Based Approaches do you predominantly use in your coaching?

- ☐ Teaching Games for Understanding
- ☐ The Tactical Games Model
- ☐ Play Practice
- ☐ Game Sense
- ☐ The Games Concept Approach
- ☐ The Invasion Games Competence Model
- ☐ GAA Games-Based Wheel - MVA/Coach10 Model
- ☐ None of the above
- ☐ I don't use a Games-Based Approach

33. IF you selected a particular approach above, please briefly state why you predominantly use that particular approach?

18

34. What challenges (if any) exist in applying a Game-Based Approach in your coaching? (Select all that apply)

- [ ] Creating game-activity content
- [ ] Identifying themes for training sessions
- [ ] Unsure of when and how questioning should be implemented
- [ ] Adopting a facilitator role
- [ ] Pressure to win, therefore not being able to experiment with new coaching strategies
- [ ] Too little contact time with the group
- [ ] Opposition to Game-Based Approach from other members of management
- [ ] Subject knowledge on Game-Based Approaches
- [ ] No challenges exist
- [ ] Other (please specify)

35. To what extent has Gaelic Games coach education prepared you for applying a Game-Based Approach in your coaching?

- ○ Not Prepared
- ○ Somewhat Prepared
- ○ Adequately Prepared
- ○ Well Prepared
- ○ Very Well Prepared
- ○ N/A (I have not received Gaelic Games coach education)

19

Coaching Approaches in Youth Gaelic Games

12. Physical Activity Knowledge

In this section we will explore your knowledge of the current National Guidelines of Physical Activity in Ireland for Youth.

36. Have you seen, heard or read about the current national physical activity guidelines for youth?

- Yes
- No
- I Don't Know / Unsure

Department of Sport and Health Sciences

Coaching Approaches in Youth Gaelic Games

37. What is the recommended minimum amount of moderate-to-vigorous physical activity per week for youth based on the current national guidelines?

- 20 Minutes per Day, 5 Days a Week
- 20 Minutes per Day, 7 Days a Week
- 30 Minutes per Day, 5 Days a Week
- 30 Minutes per Day, 7 Days a Week
- 60 Minutes per Day, 5 Days a Week
- 60 Minutes per Day, 7 Days a Week
- I Don't Know / Unsure

Coaching Approaches in Youth Gaelic Games

38. Relating to coaching and physical activity, to what extent do you agree or disagree with the following statements:

	Strongly Agree	Agree	Unsure	Disagree	Strongly Disagree
It is a responsibility for Gaelic Games to promote physical activity among its youth members.	○	○	○	○	○
The Gaelic Games coach education addresses the promotion of physical activity.	○	○	○	○	○
I ensure players are always physically active throughout the session.	○	○	○	○	○
I limit the amount of time players spend standing during training sessions.	○	○	○	○	○
It is important players are physically active outside of sport.	○	○	○	○	○
I am responsible for influencing the physical activity behaviours of my players outside sport.	○	○	○	○	○
In terms of physical activity, I see myself as a role model for the players.	○	○	○	○	○
It is important that training sessions make a significant contribution to players' daily physical activity levels.	○	○	○	○	○

Appendix G: Email to Coaches and Coaching and Games Personnel

Dear Sir/Madam,

The Department of Sport and Health Sciences in Athlone Institute of Technology are recruiting volunteers to participate in upcoming interviews. The overall aim of the project is to explore the coaching approaches implemented at the youth Gaelic football level. To assist in the research, we want to explore the opinions, experiences and perceptions.

We are looking for you to partake in a 30-minute interview with the study's leading investigator. The interviews will be recorded in audio but please be assured that all information discussed will remain confidential and all content discussed will be coded with ID numbers to ensure anonymity.

We have attached an information sheet to this email which outlines the study and what would be required of you in detail. If you decide that you would be interested in participating in the research study, there is a consent form also attached. We thank you for your consideration.

Yours Sincerely,
Kevin Gavin

Department of Sport and Health,
Athlone Institute of Technology

Phone: 090-6468149
Email: k.gavin@research.ait.ie

Supervisor Contact Details:
Dr Kieran Dowd - kdowd@ait.ie
Dr Aoife Lane - alane@ait.ie

Appendix H: Coaches and Coaching & Games Personnel Information Sheet and Consent Form

Title of Project: To explore the current coaching approaches of youth Gaelic games coaches.
Name of Researcher: Kevin Gavin
Contact phone number/email: (087) 3133232 / k.gavin@research.ait.ie

Introduction
You have been invited to take part in a research study. Before you make up your mind about participating, it is important that you understand why the research is being done and what it would involve for you. The aim of this Information Sheet is to describe this research study. Take as much time as you need to read the information and if you have any questions please don't hesitate to ask us. If you decide that you would like to take part in this research study, we will ask you to sign a Consent Form. You should only sign the consent form when you feel that you understand what is being asked of you, and you have had enough time to make your decision.

Purpose of Study
The purpose of this study is to determine the current coaching approaches that are being used by youth Gaelic games coaches and examine your knowledge and perceptions of a games-based approach to coaching.

What is required of *you*?
You will be invited to attend a structured, audio recorded, interview lasting approximately 30 minutes. This interview will be undertaken at a time and location that is convenient to you. If there are restrictions still in place regarding the gathering of people in groups due to the Covid-19 pandemic, then the interview may be conducted over the phone or online. You will be asked to discuss and provide your opinion on a range of different coaching topics, such as your current coaching approaches to training, coach education training, coaching philosophy and previous coaching experience.

What are the benefits to you?
By taking part in this study, you will be offered an opportunity to express your opinions about coaching. You may get an insight into different coaching approaches that you may not have seen or considered previously. You will also have an insight into the design and implementation of research that will have a significant effect on the future coaching approaches in Gaelic football.

What are the risks to you?
There are minimal risks associated with participating in this study. You may have some slight discomfort or embarrassment with having to talk about yourself and your experiences. During the interview you will not be required to answer any questions with which you are uncomfortable with. Responses to the questions will be confidential to reduce this risk.

Testing Procedures
Interview - At the beginning of the interview, brief demographic information will be collected including age, gender, and years coaching Gaelic football. The interview discussion will begin with details on confidentiality and the voluntary nature of the discussion.

Confidentiality
The results and data collected from this study are regarded as confidential and will be used by the investigating team only. Audio recordings will be stored on an encrypted hard drive with access primarily granted to the primary investigator. Your data will be kept anonymous with the use of a personal ID number and the data will be destroyed 5 years after publication of this study.

Freedom of Withdrawal
Participation in this study is completely voluntary and therefore you have the right to withdraw from the study at any time, without prior notice or reason.

Who Do I Contact if I have Any Concerns or Questions?
If you have concerns or questions throughout the study, feel free to contact the researcher at any time. The names of the lead research, , his contact details and email address is located at the top of this Information Sheet.

If you have any additional questions in relation to the research project, or would like more information about any aspect of the project, please feel free to contact the supervisory team:

Dr. Kieran Dowd,
Assistant lecturer,
Dept. Sport and Health,
Athlone Institute of Technology,
Athlone,
Co. Westmeath.

Dr. Aoife Lane,
Head of Department,
Dept. Sport and Health,
Athlone Institute of Technology,
Athlone,
Co. Westmeath.

If you have any concerns about this study and wish to contact someone independent and in confidence, you may contact the Chairperson of the AIT Research Ethics Committee, c/o Office of the Vice President for Research, Athlone Institute of Technology.

Email: ethics@ait.ie

Participant Identification Number:
Name of Researcher:
Date:

CONSENT FORM

Title of Project: To explore the current coaching approaches of youth Gaelic games coaches.

Please tick the box

1. I confirm that I have read the information sheet for the above study and have had the opportunity to ask questions. ☐
2. I am satisfied that I understand the information provided and have had enough time to consider the information. ☐
3. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, without my legal rights being affected. ☐
4. I agree to take part in the above study. ☐

_____	_____	_____
Name of Participant	Date	Signature

_____	_____	_____
Researcher	Date	Signature

1 for participant; 1 for researcher; 1 to be kept with research notes

Appendix I: Coach Interview Topic Guide

Opening Questions:

1. Could start by giving a brief introduction of yourself, your coaching experience and why/how you got into coaching?

Topic 1: Coaching ethos

2. How do you get ready for a typical coaching session?
3. How would you describe a successful practice session?
    a. Main challenges? How to avoid/fix these challenges?
4. In your practice sessions how would you typically try to improve your players: (Use flipchart to discuss)
    a. Technical skills? (Give examples)
    b. Tactical skills? (Give examples)
    c. Fitness levels? (Give examples)
5. In your opinion, how would you describe a successful coach?
    a. Traits/characteristics
    b. Main goals/aims
6. Please rank the list of practice activities in order of how valuable they are to your coaching.

    (Flashcards: include examples of each activities)

    i. Conditioned Games/Small Sided Games
    ii. Drills
    iii. Conditioning
    iv. Full-Sided Games
    v. Skills in Isolation
    vi. Applied skills practice
    vii. Please explain why you ranked them in this way.

Topic 2: Games-Based Approach

7. What is your understanding of the term Game-Based Approach in coaching?
    a. Do you implement a GBA in your sessions?
8. What is your opinion of GBAs?
    a. Positives?
    b. Negatives?
    c. Challenges in applying a GBA in your sessions?

Topic 3: Physical Activity

9. Do you know what the current PA guidelines are for youth?
    a. Is attaining PA during your sessions important to your coaching?
    b. Do you think it should be a goal of coaches for their players to attain the PA guidelines during practice sessions?
10. Do you see yourself as a role model for you players with regards to being physically active?

Topic 4: Coach Education

11. To what extent has the GAA coach education prepared you for applying a Game-Based Approach in your coaching?
12. To what extent has the GAA coach education thought you about PA and its importance?
13. What type of upskilling have you completed previously?
    a. Workshops, online webinars etc?
14. How do you prefer to learn new coaching approaches/techniques?
    a. Handouts
    b. One to One
    c. Workshops

Summary

At end of interview, summarise what has been said and ask the participants if there is anything else they would like to add.

Appendix J: Coaching & Games Personnel Interview Topic Guide

Opening Questions:

1. What is your current role within the GAA/Club?
2. How long have you held this role?

Topic 1: Roles & Responsibilities

3. Can you describe your role and responsibilities within the GAA/Club structure?
    a. Roles within Province, County, Clubs, Schools, Academies, Coach education etc
4. Who do you report to/work alongside?
5. Who reports to you?
6. What are the GAA's/your clubs current coaching & games objectives and policies?
    a. Main aims/goals?

Topic 2: Coach & Games Development

7. Can you outline any previous coaching & games development projects that have been implemented within the GAA/Club?
    a. Details? How it was developed etc.
    b. What was it aims?
    c. Was it a Success/Failure?
    d. Why? Challenges.
8. Can you outline any current or future coaching & games development projects are/will be implemented within the GAA/Club?
    a. Details
    b. Has it been a Success/Failure?
9. Can you outline any barriers and/or facilitators you have observed to implementing coach education within the club setting?

Topic 3: GBA & Physical Activity

10. What is your understanding of the term Game-Based Approach in coaching?
    a. Is it a key goal/aim within the GAA/Club coaching & games development structure?
    b. MVA10/Turas
11. What is your opinion of GBAs?
    c. Positives?
    d. Negatives?
    e. Challenges in applying a GBA within a club coaching setting?
12. Do you know the current PA guidelines for youth?
13. Is PA a key goal/aim within the GAA/Club coaching & games development structure?
    a. Do you think it is the GAA's/Club's responsibility to provide PA?

Summary

At end of interview, summarise what has been said and ask the participants if there is anything else they would like to add.

Appendix K: Interview Instructions for Participants

Instructions for Interview Participants

[*First, I will explain that I am going to read out the welcome and instructions so that all interviews follow the same procedure*]

General Introduction – Hello and thank you for agreeing to participate in this interview. My name is Kevin Gavin, I am a PhD student at the Athlone Institute of Technology, and I am going to ask you some questions on topics relating to youth Gaelic football. I hope these questions will simulate discussion for you.

I am interested in your views and opinions, and please be assured that there are no wrong answers. Keep in mind that I am just as interested in negative comments as positive comments, and at times the negative comments are the most helpful. Your participation in this interview will provide use with very useful information and will be used to guide the development of a coach education programme for Gaelic football coaches.

Confidentiality – You are reminded that the interview will be recorded in audio. Recordings will solely be used in the analysis of responses. Access to the recordings will be limited to the research staff and will be stored on an encrypted hard drive. Public presentation of any piece of the recordings will not take place.

Voluntary nature of the discussion - Participation in the interview is entirely voluntary and you may stop participating at any time. If you feel uncomfortable discussing any aspect of the discussion, feel free to opt out of discussing that topic.

Do you have any questions before we start?

Appendix L: Club Chairperson Information Sheet and Consent Form

Title of Project: Evaluating the impact of games-based approach coaching on youth Gaelic football practice sessions.
Name of Researcher: Kevin Gavin
Contact phone number/email: (087) 3133232 / k.gavin@research.ait.ie

Introduction
We would like to invite your GAA Club to take part in a research study. Prior to making your decision, it is important that you understand why the research is being done and what it will involve for your club and its members. The aim of this information sheet is to outline the purpose, risks and benefits of this research study. Take as much time as you need to read the information and if you have any questions please do not hesitate to ask. If you decide that your club would like to take part in this research study, we ask you to sign the accompanying consent form. You should only sign the consent form when you feel that you understand what is being asked of your club and its members, and you have had enough time to make your decision.

Purpose of Study
A Games-Based Approach is a coaching method that involves the predominant use of games as opposed to drills for training players. It is also player-centred and involves the coach asking players questions and providing opportunities for discussion within the sessions. This study will investigate the effects of a Games-Based Approach in comparison to a traditional coaching approach on:

- Player's physical activity levels.
- Player's experiences of this coaching approach.
- Coaches' experiences of this coaching approach.

Does the Club have to take part?
The decision to take part in this research study is completely up to the club. If your club decides to take part in the study, you are free to withdraw at any time. Deciding to not take part or withdraw from the study at any time will not affect you (or the club) in any way.

What will be required of the Club during the study?
Should you wish to partake in this study, the following will be asked of the club:

- **Coaches:** We request permission to contact and distribute study information sheets to the relevant coaches of the club's boys and girls under 17 teams.
- **Players:** We request permission to contact and distribute study information sheets to the players and their parents/guardians of the under 17 teams. If they would like to take part in the study, they will be asked to sign a Player Consent Form and a Parent/Guardian Consent Form.
- **Video Recording:** We ask permission to video record the 6 training sessions taking place within your club.

What will be required of the Club Coaches during the study?
Should the coaches wish to partake in this study, the following will be asked of them:

- They will be asked to allow an external expert coach to carry out a total of 6 training sessions with their team over a period of 3 weeks.
- They will be asked to participate in a 5-minute voice recorded discussion at the end of each training session, where they can outline their experiences/thoughts of the previous session.

What will be required of the Club Players during the study?
Should the players wish to partake in this study, the following will be asked of them:

- **Physical Activity Measurement:** On weeks 1 & 3, 15-20 participants will be instructed to wear an activPAL 24 hours per day for a total of nine consecutive days. On week 2, participants will only be required to wear the activPAL during the training sessions.
- **Video Recording:** The players will be requested to consent to being video recorded during the training sessions. This is to allow for analysing the amount of time spent in games/drills.
- **Questionnaire:** At the end of each of the 6 training sessions, players will be requested to complete a short 5-minute questionnaire outlining their perceptions on the training sessions.

What is the activPAL?
The activPAL is a small, discrete device (similar size to a small match box) that records all of the youth's physical activity throughout the day. It is applied to the right thigh using a sticky covering that allows it to be worn continuously throughout the day. The youth will be shown how to correctly apply and remove the activPAL. If the device feels uncomfortable or they would like to remove it at any time they are free to do so.

What are the possible risks of taking part in the Study?
There are no significant risks to the participants taking part in this research study. There may be some slight discomfort while taking off the sticky covering used to apply the activPAL to the skin.

Will the study be confidential?
All information and data collected from this study will be kept strictly confidential and will not be shared with anyone else. Audio and video recordings will be stored on an encrypted hard drive with access granted to only the researcher and his supervisors. Your data will be kept anonymous with the use of a personal ID number and the data will be destroyed 5 years after the completion of this study.

Who do I contact if I have any concerns or questions?
If you have concerns or questions throughout the study, feel free to contact the researcher at any time. The researchers contact number and email address are located at the top of this information sheet. If you have any additional questions in relation to the research project, or would like more information about any aspect of the project, please feel free to contact the supervisory team:

Dr. Kieran Dowd,
Lecturer,
Dept. Sport and Health Sciences,
Athlone Institute of Technology,
Athlone,
Co. Westmeath.

Dr. Aoife Lane,
Head of Department,
Dept. Sport and Health Sciences,
Athlone Institute of Technology,
Athlone,
Co. Westmeath.

If you have any concerns about this study and wish to contact someone independent and in confidence, you may contact the Chairperson of the AIT Research Ethics Committee, c/o Office of the Vice President for Research, Athlone Institute of Technology. **Email:** ethics@ait.ie

Name of Researcher:
Date:

CLUB CHAIRPERSON CONSENT FORM

Title of Project: Evaluating the impact of games-based approach coaching on youth Gaelic football practice sessions.

Please tick the box

1. I confirm that I have read the information sheet for the above study and have had the opportunity to ask questions. ☐
2. I am satisfied that I understand the information provided and have had enough time to consider the information. ☐
3. I understand that the club's participation is voluntary and is free to withdraw at any time, without giving any reason, without legal rights being affected. ☐
4. The club agrees to take part in the above study. ☐
5. The club understands that each individual involved will provide consent and has the right to participate and withdraw from the study at any time. ☐

_____	_____	_____
Name of Chairperson	Date	Signature

_____	_____	_____
Researcher	Date	Signature

1 for club; 1 for researcher; 1 to be kept with research notes

Appendix M: Coach Information Sheet and Consent Form

Title of Project: Evaluating the impact of games-based approach coaching on youth Gaelic football practice sessions.
Name of Researcher: Kevin Gavin
Contact phone number/email: (087) 3133232 / k.gavin@research.ait.ie

Introduction
You are invited to take part in a research study. Before you make up your mind about participating, it is important that you understand why the research is being done and what it would involve for you. The aim of this information sheet is to describe this research study. Take as much time as you need to read the information and if you have any questions please don't hesitate to ask us. If you decide that you would like to take part in this research study, we will ask you to sign a consent form. You should only sign the consent form when you feel that you understand what is being asked of you, and you have had enough time to make your decision.

Purpose of Study
A Games-Based Approach (GBA) is a coaching method that involves the predominant use of games as opposed to drills for training players. It is also player-centred and involves the coach asking players questions and providing opportunities for discussion within the sessions. This study will investigate the effects of a Games-Based Approach in comparison to a traditional coaching approach on:

- Player's physical activity levels
- Player's experiences of this coaching approach.
- Your (the coaches) experiences of this coaching approach.

What is required of *you*?

Should you wish to partake in this study, the following will be asked of you:

- You will be asked to allow an external expert coach to carry out a total of 6 training sessions with your team over a period of 3 weeks. The first two training sessions will follow a "traditional approach", while the remaining 4 training sessions will be GBA sessions, delivered by the expert coach. The content and aim of each of these training sessions will be discussed and agreed upon between yourself and the expert coach to ensure you are content with the direction of these sessions. You will be invited to observe these training sessions and encouraged to ask any questions you may have about the approaches employed.
- You will be asked to participate in a 5-minute voice recorded discussion at the end of each training session, where you can outline their experiences/thoughts of the previous session.

What is required of your players?

Should the players wish to partake in this study, the following will be asked of them:

- **Training Sessions:** participants will be asked to participate in 6 training sessions over three weeks as per normal.
- **Physical Activity Measurement:** On weeks 1 & 3, participants will be instructed to wear an activPAL 24 hours per day for a total of nine consecutive days. On week 2, participants will only be required to wear the activPAL during the training sessions.
- **Video Recording:** The players will be requested to consent to being video recorded during the training sessions. This is to allow for analysing the amount of time spent in games/drills.
- **Questionnaire:** At the end of each of the 6 training sessions, players will be requested to complete a short 5-minute questionnaire outlining their perceptions on the training sessions.

What is the activPAL?

The activPAL is a small, discrete device (similar size to a small match box) that records all of the youth's physical activity throughout the day. It is applied to the right thigh using a sticky covering that allows it to be worn continuously throughout the day. The youth will be shown how to correctly apply and remove the activPAL. If the device feels uncomfortable or they would like to remove it at any time they are free to do so.

What are the possible risks of taking part in the Study?

There are no significant risks to the participants taking part in this research study. There may be some slight discomfort while taking off the sticky covering used to apply the activPAL to the skin.

Will the study be confidential?

All information and data collected from this study will be kept strictly confidential and will not be shared with anyone else. Audio and video recordings will be stored on an encrypted hard drive with access granted to only the researcher and his supervisors. Your data will be kept anonymous with the use of a personal ID number and the data will be destroyed 5 years after the completion of this study.

Who do I contact if I have any concerns or questions?

If you have concerns or questions throughout the study, feel free to contact the researcher at any time. The researchers contact number and email address are located at the top of this information sheet. If you have any additional questions in relation to the research project, or would like more information about any aspect of the project, please feel free to contact the supervisory team:

Dr. Kieran Dowd,
Lecturer,
Dept. Sport and Health Sciences,
Athlone Institute of Technology,
Athlone,
Co. Westmeath.

Dr. Aoife Lane,
Head of Department,
Dept. Sport and Health Sciences,
Athlone Institute of Technology,
Athlone,
Co. Westmeath.

If you have any concerns about this study and wish to contact someone independent and in confidence, you may contact the Chairperson of the AIT Research Ethics Committee, c/o Office of the Vice President for Research, Athlone Institute of Technology.
Email: ethics@ait.ie

Name of Researcher:
Date:

COACH CONSENT FORM

Title of Project: Evaluating the impact of games-based approach coaching on youth Gaelic football practice sessions.

Please tick the box

1. I confirm that I have read the information sheet for the above study and have had the opportunity to ask questions. ☐
2. I am satisfied that I understand the information provided and have had enough time to consider the information. ☐
3. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, without my legal rights being affected. ☐
4. I agree to take part in the above study. ☐

_____	_____	_____
Name of Participant	Date	Signature

_____	_____	_____
Researcher	Date	Signature

1 for participant; 1 for researcher; 1 to be kept with research notes

Appendix N: Player Information Sheet and Consent Form

Title of Project: Evaluating the impact of games-based approach coaching on youth Gaelic football practice sessions.
Name of Researcher: Kevin Gavin
Contact phone number/email: (087) 3133232 / k.gavin@research.ait.ie

Introduction
You are invited to take part in a research study. Before you make up your mind about participating, it is important that you understand why the research is being done and what it would involve for you. The aim of this information sheet is to describe this research study. Take as much time as you need to read the information and if you have any questions please don't hesitate to ask us. If you decide that you would like to take part in this research study, we will ask you to sign a consent form. You should only sign the consent form when you feel that you understand what is being asked of you, and you have had enough time to make your decision.

Purpose of Study
A Games-Based Approach (GBA) is a coaching method that involves the predominant use of games as opposed to drills for training players. It is also player-centred and involves the coach asking players questions and providing opportunities for discussion within the sessions. This study will investigate the effects of a Games-Based Approach in comparison to a traditional coaching approach on:

- Your physical activity levels.
- Your perceptions of the training sessions.

What is required of *you*?
Should you wish to partake in this study, the following will be asked of all players:

- **Training Sessions:** You will be asked to participate in 6 training sessions over three weeks as per normal.
- **Video Recording**: You will be asked to consent to being video recorded during each of the 6 training sessions.
- **Questionnaire:** At the end of each of the 6 training sessions, you will be requested to complete a short 5-minute questionnaire outlining your perceptions and experiences on the training sessions.

You may also be one of 15-20 players on the team randomly selected to complete the following:

- **Physical Activity Measurement:**
    - On weeks 1 & 3: You will be instructed to wear an activPAL 24 hours per day for a total of nine consecutive days.
    - On week 2: you will be required to wear the activPAL during the 2 training sessions only.
- **An infographic outlining the study timeline is presented at the bottom of this sheet.**

What is the activPAL?
The activPAL is a small, match box sized monitor that records all your physical activity throughout the day. It is applied to your right thigh using a sticky covering that allows it to be worn continuously throughout the day, and only needs to be removed when swimming or in the bath. We will show you how to correctly

apply and remove the activPAL. If the device feels uncomfortable or you would like to remove it at any time you are free to do so.

What are the benefits to you?

Research suggests that Games-Based Approaches in sports are an effective method for developing player's performance, skills, and physical activity levels. In addition, players have previously reported increases in enjoyment and motivation for playing due to this approach.

What are the possible risks of taking part in this study?

There are no significant risks to you by taking part in this research study. There may be some slight discomfort while taking off the sticky covering used to apply the activPAL to the skin.

Confidentiality

All information and data collected from this study will be kept strictly confidential and will not be shared with anyone else. Audio and video recordings will be stored on an encrypted hard drive with access granted to only the researcher and his supervisors. Your data will be kept anonymous with the use of a personal ID number and the data will be destroyed 5 years after the completion of this study.

Freedom of Withdrawal

Participation in this study is completely voluntary. You have the right to withdraw from the study at any time, without prior notice or reason.

Who Do I Contact if I have Any Concerns or Questions?

If you have concerns or questions, feel free to contact the researcher at any time. The researchers contact number and email address are located at the top of this information sheet.

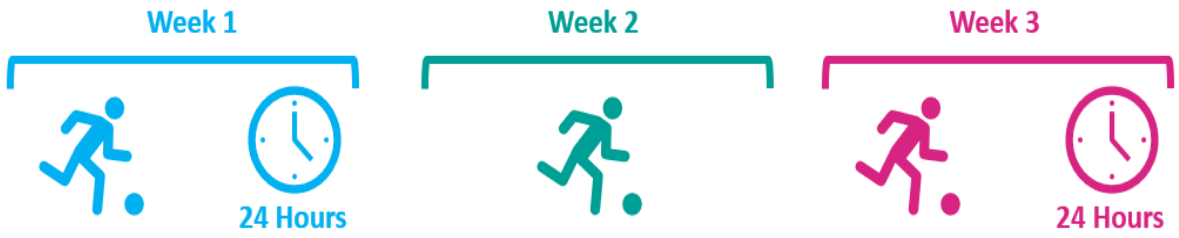
If you have any additional questions in relation to the research project, or would like more information about any aspect of the project, please feel free to contact the supervisory team:

Dr. Kieran Dowd,
Assistant lecturer,
Dept. Sport and Health,
Athlone Institute of Technology,
Athlone,
Co. Westmeath.

Dr. Aoife Lane,
Head of Department,
Dept. Sport and Health,
Athlone Institute of Technology,
Athlone,
Co. Westmeath.

If you have any concerns about this study and wish to contact someone independent and in confidence, you may contact the Chairperson of the AIT Research Ethics Committee, c/o Office of the Vice President for Research, Athlone Institute of Technology.
Email: ethics@ait.ie

Study Timeline



Training 1 & 2
- Traditional Approach Training Sessions
- Wear activPAL during Trainings
- Wear activPAL for the Full Week
- 5min Questionnaire

Training 3 & 4
- GBA Training Sessions
- Wear activPAL during Trainings ONLY
- 5min Questionnaire

Training 4 & 5
- GBA Training Sessions
- Wear activPAL during Trainings
- Wear activPAL for the Full Week
- 5min Questionnaire

Participant Identification Number:
Name of Researcher:
Date:

PLAYER CONSENT FORM

Title of Project: Evaluating the impact of games-based approach coaching on youth Gaelic football practice sessions.

Please tick the box

1. I confirm that I have read the information sheet for the above study and have had the opportunity to ask questions. ☐
2. I am satisfied that I understand the information provided and have had enough time to consider the information. ☐
3. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, without my legal rights being affected. ☐
4. I have not been advised by a medical professional to limit my participation in exercise. ☐
5. I do have any of the following medical conditions which could limit my participation in exercise: heart conditions, history of epilepsy or seizures, pregnancy or risk of pregnancy, uncontrolled asthma, diabetes, bone or joint problems. ☐
6. I agree to take part in the above study. ☐

_____	_____	_____
Name of Participant	Date	Signature
_____	_____	_____
Name of Parent/Guardian (if participant is under 18)	Date	Signature
_____	_____	_____
Researcher	Date	Signature

1 for participant; 1 for researcher; 1 to be kept with research notes

Appendix O: Parent Information Sheet and Consent Form

Title of Project: Evaluating the impact of games-based approach coaching on youth Gaelic football practice sessions.
Name of Researcher: Kevin Gavin
Contact phone number/email: (087) 3133232 / k.gavin@research.ait.ie

Introduction
Your child has invited to take part in a research study. Prior to making your decision, it is important that you understand why the research is being done and what it would involve for your child. The aim of this information sheet is to outline the purpose, risks, and benefits of this research study. Take as much time as you need to read the information and if you have any questions please do not hesitate to ask. If you decide that you are happy for your child to take part in this research study, we ask you to sign the accompanying consent form. You should only sign the consent form when you feel that you understand what is being asked of your child, and when you have had enough time to make your decision.

Purpose of Study
A Games-Based Approach (GBA) is a coaching method that involves the predominant use of games as opposed to drills for training players. It is also player-centred and involves the coach asking players questions and providing opportunities for discussion within the sessions This study will investigate the effects of a Games-Based Approach in comparison to a traditional coaching approach on:

- Your child's physical activity levels.
- Your child's perceptions of the training sessions.

What is required of your child?
Should your child wish to partake in this study, the following will be asked of them:

- **Training Sessions:** They will be asked to participate in 6 training sessions over three weeks as per normal.
- **Video Recording**: They will be asked to consent to being video recorded during each of the 6 training sessions.
- **Questionnaire:** At the end of each of the 6 training sessions, they will be requested to complete a short 5-minute questionnaire outlining their perceptions and experiences on the training sessions.

Your child may also be one of 15-20 players on the team randomly selected to complete the following:

- **Physical Activity Measurement:**
  - On weeks 1 & 3: They will be instructed to wear an activPAL 24 hours per day for a total of nine consecutive days.
  - On week 2: They will be required to wear the activPAL during the 2 training sessions only.
- **An infographic outlining the study timeline is presented at the bottom of this sheet.**

What is the activPAL?
The activPAL is a small, match box sized monitor that records all your child's physical activity throughout the day. It is applied to your right thigh using a sticky covering that allows it to be worn continuously throughout the day, and only needs to be removed when swimming or in the bath. We will show your child

how to correctly apply and remove the activPAL. If the device feels uncomfortable or your child would like to remove it at any time they are free to do so.

What are the benefits of taking part in this study?

Research suggests that Games-Based Approaches in sports are an effective method for developing player's performance, skills, and physical activity levels. In addition, players have previously reported increases in enjoyment and motivation for playing due to this approach.

What are the possible risks of taking part in this study?

There are no significant risks to your child by taking part in this research study. There may be some slight discomfort while taking off the sticky covering used to apply the activPAL to the skin.

Confidentiality

All information and data collected from this study will be kept strictly confidential and will not be shared with anyone else. Audio and video recordings will be stored on an encrypted hard drive with access granted to only the researcher and his supervisors. Your child's data will be kept anonymous with the use of a personal ID number and the data will be destroyed 5 years after the completion of this study.

Freedom of Withdrawal

Participation in this study is completely voluntary. You have the right to withdraw your child from the study at any time, without prior notice or reason.

Who Do I Contact if I have Any Concerns or Questions?

If you have concerns or questions, feel free to contact the researcher at any time. The researchers contact number and email address are located at the top of this information sheet.

If you have any additional questions in relation to the research project, or would like more information about any aspect of the project, please feel free to contact the supervisory team:

Dr. Kieran Dowd,
Assistant lecturer,
Dept. Sport and Health,
Athlone Institute of Technology,
Athlone,
Co. Westmeath.

Dr. Aoife Lane,
Head of Department,
Dept. Sport and Health,
Athlone Institute of Technology,
Athlone,
Co. Westmeath.

If you have any concerns about this study and wish to contact someone independent and in confidence, you may contact the Chairperson of the AIT Research Ethics Committee, c/o Office of the Vice President for Research, Athlone Institute of Technology.
Email: ethics@ait.ie

Study Timeline

Participant Identification Number:
Name of Researcher:
Date:

PARENT/GUARDIAN CONSENT FORM

Title of Project: Evaluating the impact of games-based approach coaching on youth Gaelic football practice sessions.

Please tick the box

1. I confirm that I have read the information sheet for the above study and have had the opportunity to ask questions. ☐
2. I am satisfied that I understand the information provided and have had enough time to consider the information. ☐
3. I understand that my child's participation is voluntary and that they are free to withdraw at any time, without giving any reason, without their legal rights being affected. ☐
4. My child has not been advised by a medical professional to limit their participation in exercise. ☐
5. My child does not have any of the following medical conditions which could limit their participation in exercise: a heart condition, history of epilepsy or seizures, pregnancy or risk of pregnancy, uncontrolled asthma, diabetes, bone or joint problem ☐
6. I agree to allow my child to take part in the above study. ☐

_____	_____	_____
Name of Participant	Date	Signature

_____	_____	_____
Researcher	Date	Signature

1 for participant; 1 for researcher; 1 to be kept with research notes

Appendix P: Player Post-Session Questionnaire

	Strongly Disagree	Disagree	Unsure	Agree	Strongly Agree
The session was challenging	○	○	○	○	○
The session was enjoyable	○	○	○	○	○
The session was boring	○	○	○	○	○
The session was of high intensity	○	○	○	○	○
The session helped develop my skills	○	○	○	○	○
The session helped develop my decision making	○	○	○	○	○
The session helped develop my game play	○	○	○	○	○
The session helped develop my thinking ability	○	○	○	○	○
The session helped develop my communication with other players and coaches	○	○	○	○	○
The session helped develop my fitness	○	○	○	○	○
The session had a clear plan/theme throughout	○	○	○	○	○
The use of games within the session was beneficial to my development.	○	○	○	○	○
The use of drills within the session was beneficial to my development.	○	○	○	○	○
The use of questioning and discussion was beneficial to my development.	○	○	○	○	○

Appendix Q: Turner and Martinek (1999) Validation Protocol Instrument

	Boys Session 1	Boys Session 2	Boys Session 3	Boys Session 4	Girls Session 1	Girls Session 2
(a) The players spent most of the lesson in games or game-related situations.	Yes	Yes	Yes	Yes	Yes	Yes
(b) The players spent the lesson learning specific skills taught by the coach before playing a game.	No	No	No	No	No	No
(c) The coach started the lesson with skill instruction.	No	No	No	No	No	No
(d) The coach intervened in game play or game-related practices to explain strategies to students.	Yes	Yes	Yes	Yes	Yes	Yes
(e) The coach based his/her teaching on observations of an initial game or game-related situation (3v1).	Yes	Yes	Yes	Yes	Yes	Yes
(f) The major emphasis of the lesson was skill teaching.	No	No	No	No	No	No
(g) The major emphasis of the lesson was tactical instruction in games or game-like practices.	Yes	Yes	Yes	Yes	Yes	Yes

Appendix R: Metzler (2005) Benchmark Instrument

	Boys Session 1	Boys Session 2	Boys Session 3	Boys Session 4	Girls Session 1	Girls Session 2
The coach uses a tactical problem as the organising centre for learning tasks/practice activities.	Yes	Yes	Yes	Yes	Yes	Yes
The coach begins each session with a game form to assess player knowledge and to provide context for remainder of session.	Yes	Yes	Yes	Yes	Yes	Yes
The coach identifies needed tactical and skill areas from game form.	Yes	Yes	Yes	Yes	Yes	Yes
The coach uses deductive questions to get players to solve tactical problem.	Yes	Yes	Yes	Yes	Yes	Yes
The coach uses clear communications for practice activities.	Yes	Yes	Yes	Yes	Yes	Yes
The coach uses high rates of guides and feedback during practice activities.	Yes	Yes	Yes	Yes	Yes	Yes
The coach provides a review that includes the tactical problems of the session.	Yes	Yes	Yes	Yes	Yes	Yes