

Physical Preparation in Adolescent Inter-County Ladies' Gaelic Football: Player Characteristics, Game Demands, and Coaching Practices

Teresa Molohan BA, BSc, MSc

Supervisors: Dr Stephen Behan, Dr David Nolan and Prof. Sarahjane Belton

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Declaration

I hereby certify that this material, which I now submit for assessment on the programme of study leading to the award of Doctor of Elite Performance (Sport) is entirely my own work, and that I have exercised reasonable care to ensure that the work is original and have conformed to the regulations on the use and declaration of Generative AI, and does not to the best of my knowledge breach any law of copyright, and has not been taken from the work of others save and to the extent that such work has been cited and acknowledged within the text of my work.

Signature of Candidate:

Teresa Molohan

Student Number: 21266196

Date: 26/08/26

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Google Gemini was used during the post-viva correction stage to assist with language editing, improve clarity, and proofread revised sections written in response to examiner feedback. Suggested revisions were critically reviewed, and I retained responsibility for all final decisions and thesis content. AI was not used in the design of the research, data collection, data analysis, generation of results, or preparation of the thesis submitted for examination.

Signature of Candidate:

Teresa Molohan

Student Number: 21266196

Date: 26/08/26

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b) Lead on writing of the study with collaboration from all authors

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List of Abbreviations

Abbreviation	Full Term
ACL	Anterior Cruciate Ligament
AFLW	Australian Football League Women's
ASCA	Australian Strength and Conditioning Association
ASR	Anaerobic Speed Reserve
CMJ	Countermovement Jump
COD	Change of Direction
CoP	Community of Practice
DJ	Drop Jump
DMSP	Developmental Model of Sports Participation
FB	Full Back
FF	Full Forward
FFM/FM	Fat-Free Mass/Fat Mass
FMS	Fundamental Movement Skills
FTEM	Foundations, Talent, Elite, Mastery
GAA	Gaelic Athletic Association
GNSS	Global Navigation Satellite System
GPA	Gaelic Players Association
GPS	Global Positioning System
GRF	Ground Reaction Force
HB	Half Back
HDOP	Horizontal Dilution of Precision
HF	Half Forward
HR	Heart Rate
HSR	High-Speed Running
ICGG	Introduction to Coaching Gaelic Games
IPP	Injury Prevention Programme
LGFA	Ladies Gaelic Football Association
LTAD	Long-Term Athletic Development

Abbreviation	Full Term
MAS	Maximal Aerobic Speed
MBT	Medicine Ball Throw
MF	Midfielder
MSS	Maximal Sprinting Speed
NGB	National Governing Body
NSCA	National Strength and Conditioning Association
PHV	Peak Height Velocity
PWV	Peak Weight Velocity
RAE	Relative Age Effect
RED-S	Relative Energy Deficiency in Sport
RM	Repetition Maximum
ROM	Range of Motion
RSA	Repeat Sprint Ability
RSI	Reactive Strength Index
SJ	Squat Jump
SSC	Stretch-Shortening Cycle
SSG	Small-Sided Games
SSS	Sport-Specific Skills
TD	Total Distance
UID	Unique Identifier
VHSR	Very High-Speed Running
VO_2	Volume of Oxygen
VT_2	Ventilatory Threshold 2
YPD	Youth Physical Development

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Abstract

Physical Preparation in Adolescent Inter-County Ladies Gaelic Football: Player Characteristics, Game Demands, and Coaching Practices

Teresa Molohan

Despite the rapid growth of Ladies Gaelic Football (LGF), research on the physical demands and coaching practices of adolescent inter-county players has been notably lacking. Using a multiphase, mixed-methods design, this thesis examined the physical preparation of adolescent inter-county LGF players by integrating objective evidence on player characteristics and match demands with an examination of the coaching environment in which athletic development is delivered.

The first research stream characterised the athletic profiles and match-play demands of U14–U18 inter-county players. Anthropometric and physical fitness assessments provided the first population-specific benchmarks for this cohort. Although significant anthropometric growth occurred across age groups, improvements in physical fitness were limited. Match-play analysis showed increasing demands across the pathway, with U18 players demonstrating higher work rates and high-intensity running outputs than U16 players. Both age groups also showed significant second-half declines in running performance, while the 'middle eight' positions experienced particularly high physiological loads. These findings indicate a potential mismatch between players' developing physical capacities and the increasing demands of competition, supporting the need for age- and position-specific conditioning.

The second research stream examined the coaching workforce responsible for implementing athletic development. Coaches recognised the importance of physical preparation but reported gaps in knowledge and coaching self-efficacy, alongside barriers including time and limited resources. The final study evaluated the GAA F3 Youth Athletic Development Level 1 Course using a pre- and post-intervention mixed-methods design. The course was associated with significant improvements in coaching self-efficacy and intended changes in coaching practice, while recognising that sustained behavioural change depends on wider contextual factors.

Overall, the thesis highlights a pathway that may rely too heavily on age-related physiological development rather than structured athletic preparation. By integrating player demands with coaching realities, it provides an evidence-informed basis for more structured long-term athletic development and coach education within the LGFA pathway.

Chapter 1: Introduction

1.1 Establishing Context

Female team sports have undergone a significant global transformation in recent years, marked by unprecedented growth in participation, professionalism, and visibility (Brassington et al., 2026). Ladies Gaelic Football (LGF) is the leading female team sport in Ireland and one of the fastest-growing in Europe (O'Connor et al., 2021a). Since its foundation in 1974, the sport has experienced exponential growth in participation, with over 1,000 registered clubs and membership now exceeding 200,000 (O'Connor et al., 2021a). Although primarily played in Ireland, it has a notable global presence, with clubs across Britain, Europe, and elsewhere (Ladies Gaelic Football Association [LGFA], n.d.-a). Gaelic football can be described as a hybrid of various invasion games, including basketball, rugby, soccer, and Australian Rules football (Cullen et al., 2013). Matches are played between two teams of fifteen players each on a rectangular pitch approximately 145 metres long and 90 metres wide. A point is scored when the ball is kicked or handpassed over the crossbar, while three points are awarded for a goal scored under the crossbar (Duggan et al., 2022b). The game is characterised as a high-intensity field sport involving intermittent, multi-directional sprints, jumping, evasion skills, and sport-specific skills such as kicking, catching, soloing, handpassing, tackling, and blocking (Brown & Waller, 2014).

The LGFA, together with the Camogie Association and the Gaelic Athletic Association (GAA), promote indigenous Gaelic sports such as Gaelic football, camogie, hurling, handball, and rounders. These organisations are among the largest voluntary and sporting bodies in Ireland (GAA, n.d.). Although ladies' football and camogie each have their own membership, governance, and traditions, the associations collaborate to promote Gaelic games and are considered part of the same ‘GAA family’ (Delaney & Fahey, 2005). Rooted in traditional parishes and counties, participation in Gaelic sports plays a vital role in the development of children and adolescents, with clubs serving as focal points in both urban and rural communities (Duggan et al., 2022). Children aged 8 to 12 take part in non-competitive games, known as Go Games, and then progress to organised competitive matches at each age level. Adolescents compete at various levels and may represent their club, school, county, or provincial teams, sometimes playing in both codes (Byrne et al., 2021). This multi-team and potentially multi-code participation, while common, places a significant cumulative load on the developing adolescent athlete and creates unique challenges for

coaches regarding training periodisation, load monitoring, adequate recovery, and the mitigation of injury and burnout risks; issues central to their long-term physical development (Duggan et al., 2022a). The highest level of youth participation in Gaelic games is county representation, where the top club players in each county are selected to represent their home county. Inter-county competitions are organised at the U14, U16, and U18 age groups at provincial and national levels, with eventual progression for some to the senior panel (LGFA, 2025).

The senior inter-county game has become more professional in its preparation, with players now training in high-performance environments comparable to international standards. Alongside increased participation and rising standards of play, the sport has benefited from greater media coverage and spectator engagement. Following the record-breaking attendance of 56,114 at the 2019 Ladies All-Ireland Football Final, the sport has shown significant resilience. The most recent 2025 LGFA Senior Final between Dublin and Meath attracted a crowd of 48,089, the highest attendance since the pre-pandemic peak. Broadcast engagement reflected this resurgence, with TG4 reporting a total reach of 490,000 viewers for the finals-day coverage. TG4's share of viewers was 27.3%, making it comfortably the most popular channel in Ireland during the game. Additionally, Sport TG4's social media platforms garnered over 3.4 million views during the week of the finals, underscoring the sport's established status as a significant cultural event in Ireland (TG4, 2025).

However, a significant disparity exists between the sport's growth and the scientific evidence base supporting it. While the male equivalent (Gaelic football) benefits from an expanding body of sports science literature on match demands (Boyle et al., 2021; Mangan et al., 2017), physiological profiling (O'Driscoll et al., 2024), injury epidemiology (Dekkers et al., 2022), nutrition (Beasley, 2015), and talent development (Kearney et al., 2025), the female game, particularly at the youth level, remains largely unquantified (Malone et al., 2023). Adolescence is a vital developmental phase characterised by complex, individualised processes of growth and maturation that can significantly influence physical performance, injury risk, and long-term athletic potential (Naughton et al., 2000). The onset of Peak Height Velocity (PHV) is associated with distinct anatomical and physiological changes that alter neuromuscular control, heighten injury susceptibility (notably anterior cruciate ligament risk), and often cause a temporary plateau in physical performance (Lloyd et al., 2016). Failing to consider maturational status in training and development frameworks can lead to flawed talent identification, excessive training loads, and a greater risk of burnout or injury (Lloyd et al., 2014).

In the amateur context of the LGFA, responsibility for managing this complex biological transition primarily rests with the volunteer coach. Although distinct from the Gaelic Athletic Association (GAA) in governance, the LGFA shares the same community-oriented ethos. The organisation is built on volunteerism. From local club administrators to inter-county managers, the workforce is driven by passion rather than remuneration (Horgan et al., 2021). While this volunteer model successfully promotes strong community involvement and inclusivity, an unavoidable consequence of this structure is that it creates systemic limits on high-performance support. Unlike privatised youth sport models common in North America or professional soccer academies in the UK, where paid professionals run athlete development programmes, the LGFA relies on parents and community members who are often 'time-poor' (Horgan et al., 2021) and may lack specialised knowledge of female physiology or strength and conditioning. This creates a fundamental tension. Adolescent female athletes enter a phase of heightened biological vulnerability just as the competitive demands of inter-county football intensify, yet they are supported by a volunteer infrastructure that lacks the resources to fill this gap. As a result, many high-potential players go through these developmental years without an evidence-informed roadmap, relying instead on data from similar team sports, anecdotal practices, or data from male cohorts (Emmonds et al., 2019).

1.2 Researcher Positionality

Throughout this programme of study, I have been deeply immersed in the landscape under investigation, so it is necessary to make my position explicit from the outset. My primary professional role is as a Games Promotion Officer (GPO) with Dublin GAA, which involves weekly coaching of approximately 600 children in local primary schools, delivering coach education workshops, and mentoring volunteer club coaches. I also volunteer as a coach at my own GAA club, Ballyboden St. Enda's, and have coached the Dublin Ladies' underage football teams from U14 to U18 for the past 13 years. In addition, I teach Youth Athletic Development part-time at Setanta College, a role that complements my GPO role. Unlike most Gaelic games coaches, who typically coach only one or two age groups, my GPO position allows me to work across the full spectrum of youth athletic development, from ages five to 18 and into adulthood. This offers an 'academy-to-retirement' perspective on the player pathway, enabling me to observe athletes' progression from fundamental movement skills at age five through to adult competition. Furthermore, teaching Youth Athletic Development at Setanta College requires me to continually reconcile academic theory with the practical realities of coaching on the pitch.

The motivation for this research stems from my involvement with the Dublin underage squads over the past 13 years. Across every squad I have worked with to date, I have held a dual role as both a football and a strength and conditioning (S&C) coach. As a youth S&C coach, my responsibility is to prepare players physically not only for the demands of the game at their current level but also for the transition from youth to adult football. The National Strength and Conditioning Association (NSCA) recommends that coaches implement strength and conditioning programmes that adequately prepare adolescent athletes for their respective sports (Lloyd et al., 2016). They also advise that the substantial physiological differences among the musculature of children, adolescents, and adults be considered when designing and implementing S&C for adolescent male and female players (Lloyd et al., 2016). However, despite evidence showing that such programmes reduce injury risk and enhance sport performance (Reynolds et al., 2012; Sommi et al., 2018), S&C coaches are utilised only with the minor (U18) group within the Dublin underage squads, and no structured athletic development occurs with these players until they reach that level. Many of our most talented inter-county players also train with multiple teams and across multiple sports. Without a well-designed programme to support them through maturation and concurrent participation, these athletes are exposed to a heightened risk of overuse injuries and underdevelopment (Bergeron et al., 2015). Establishing a solid foundation in strength and conditioning at the underage level can help them manage increasing training demands, prevent injuries, and realise their full potential as footballers.

Over the past decade, through my experience as a GPO, a coach developer, and an inter-county mentor, I have repeatedly observed a disconnect between the 'ideal' player pathway set out in policy documents and the lived experience of the adolescent player on the ground. In the absence of population-specific data, this often leads to a reductive 'copy and paste' approach from adult or male contexts, which may be developmentally inappropriate for the adolescent female athlete (Cowley et al., 2021; Emmonds et al., 2019; Lloyd & Oliver, 2012). Consequently, the primary motivation for this Professional Doctorate is to move beyond reliance on anecdotal observations towards evidence-informed practice, and, in doing so, equip the LGFA, its coaches, and its players with the tools necessary to optimise development and safeguard welfare.

Because I am situated within, rather than outside, the setting I have studied, a structured reflexive account of that position is warranted. Reflexivity is described here not as a single declarative statement but as the ongoing examination of how the researcher's background shapes the conduct and interpretation of the inquiry (Berger, 2015). Berger identifies three channels through which a researcher's position exerts influence: the access it affords, the nature of the

relationship formed with participants, and the interpretive lens brought to the data. On the insider-to-outsider continuum (Corbin-Dwyer & Buckle, 2009), I sit firmly towards the insider pole, and each of these three channels carries consequences that I have sought to manage through specific design decisions rather than dismiss. For example, while my insider role granted the unique access needed to gather player data in Studies 1 and 2, the scope was limited to a single county context, meaning the findings are most applicable to counties of similar size or playing population.

This research was conducted within a context in which I was already professionally involved. At the time of data collection, I was actively coaching within Gaelic games and had established relationships with the county and national LGFA Development Officers, coaches, and inter-county management teams. These relationships facilitated access to participants across the studies included in this thesis and were particularly important in securing engagement with the coach surveys presented in Studies 3 and 4.

The same relationships may also have influenced how participants engaged with the research. Coaches were aware of my background in the game, and some may have been more willing to participate as a result. Equally, some responses may have been influenced by perceptions of my own views and experiences. To reduce this possibility, surveys were distributed through gatekeepers and wider digital networks rather than through direct personal contact. All responses were anonymous.

My involvement as a coach was most relevant to Studies 1 and 2, in which data were collected from players in a county where I was working. The physical profiling procedures in Study 1 followed established testing protocols and were administered in line with standardised procedures. While this helped ensure consistency in data collection, the findings should be viewed within the context from which they were generated. The data represent a single county with high participation rates and were not intended to provide national normative values.

Study 4 required additional consideration. The study evaluated the GAA F3 Youth Athletic Development course, an area that directly overlaps with my own teaching and professional interests. Although I was not involved in designing the course, the programme is delivered nationally by a network of several tutors, of whom I was one, operating across all three Gaelic Games organisations. To mitigate potential bias, the survey was centrally distributed by the GAA to a broad nationwide remit of club F3, T1, and T2 coaches, significantly extending the scope of the evaluation beyond the LGFA alone. Accordingly, my role was strictly confined to the subsequent analysis of the

compiled dataset. Participation was entirely voluntary, and all responses were fully anonymised before I accessed them for analysis. Because no identifying or tracking information was collected, individual respondents' identities remained protected, ensuring that my role as a national tutor did not compromise the objectivity of the analysis.

My interest in this area of research developed through both coaching and academic work. Over time, I have formed views on the provision of physical preparation for adolescent players, and these experiences have inevitably informed my approach to the research questions addressed in this thesis. This was most relevant to the interpretation of the qualitative responses in Studies 3 and 4. To provide an additional perspective during the analysis, coding decisions were discussed with the supervisory team, and a sample of responses was independently reviewed by a second researcher. Emerging interpretations were also discussed with co-authors throughout the analysis. Reflexive considerations specific to individual studies are discussed in the relevant methodology chapters where they are most applicable.

1.3 Aims and Objectives

The overarching aim of this thesis is to establish the empirical foundation for an evidence-informed physical development framework in adolescent inter-county Ladies Gaelic Football. By linking player profiles, match demands, and coach education, this work bridges the gap between scientific theory and coaching practice in an amateur setting. Rather than treating player performance, match demands, and coach education as isolated variables, this thesis approaches the landscape as an interconnected ecosystem. By establishing baseline data where none currently exists, the ultimate goal is to provide a sustainable evidence base for best practice that directly aligns with the real-world capacities and constraints of the volunteer-led structure.

To achieve this aim, the research follows a concurrent, parallel, multi-study design. Each objective targets a specific knowledge gap identified in the literature and is addressed within a dedicated empirical chapter:

a) **Establishing the Athlete Profile (Chapter 3 / Study 1)**

   Objective 1: To establish the first population-specific anthropometric and physical fitness benchmarks (strength, speed, power, and endurance) for adolescent inter-county players across the competition age-grades (U14, U16, and U18). By introducing population-specific metrics, this study provides objective benchmarks to map how player development is established, monitored, and supported over time, and to inform injury risk screening.

b) **Quantifying the Running Game Demands (Chapter 4 / Study 2)**

Objective 2: To map the external match-play demands and positional running profiles of youth inter-county competition using Global Navigation Satellite Systems (GNSS) technology. This investigation defines the physical 'starting point' of youth competition relative to the senior standard, enabling coaches to move beyond intuition and design data-driven, developmentally appropriate strength and conditioning protocols.

c) **Examining Coaching Practices in Context (Chapter 5 / Study 3)**

Objective 3: To conduct a nationwide mixed-methods needs analysis exploring inter-county LGF coaches' current knowledge of physical preparation, actual pitch practices, and organisational challenges. This analysis identifies the specific coaching, experiential, and systemic barriers within the amateur sporting context that prevent the successful application of athletic development principles in practice.

d) **Evaluating Coach Knowledge and Coaching Self-Efficacy (Chapter 6 / Study 4)**

Objective 4: To conduct a pre- and post-experimental evaluation of the GAA F3 Youth Athletic Development Level 1 Course, measuring its capacity to enhance volunteer coaches' declarative knowledge and coaching self-efficacy. This final study critically assesses whether this targeted curriculum successfully alters coach efficacy to support sustainable, long-term implementation.

By transitioning from descriptive profiling (the athlete and the game) to applied intervention (the coach and their education), this thesis provides the empirical foundation necessary to optimise athletic development and safeguard player welfare within the amateur LGFA coaching environment.

1.4 Research Philosophy and Methodological Framework

Research is guided by a set of assumptions about the nature of reality, how knowledge is generated, and the most appropriate ways to investigate a particular phenomenon. Collectively, these assumptions are often referred to as a research paradigm (Guba & Lincoln, 1994; Scotland, 2012). A paradigm shapes decisions throughout the research process, from the questions asked to the methods used to answer them. For this reason, it is important to outline the philosophical position underpinning this thesis.

Two paradigms have been particularly influential in sport and exercise science. The first is post-positivism, which assumes that an external reality exists but acknowledges that it can never be measured perfectly (Guba & Lincoln, 1994). Research from this perspective typically focuses on objective measurement, hypothesis testing, and the identification of patterns that extend beyond individual cases. This approach has been widely adopted in sport science and is particularly evident in areas such as physiological testing, performance analysis, and athlete monitoring (Pisk, 2014).

In contrast, constructivist approaches focus on how individuals experience and make sense of the world around them (Creswell & Creswell, 2018; Guba & Lincoln, 1994). From this perspective, knowledge is developed through interaction and interpretation, with greater emphasis on context and lived experience. In talent development research, for example, an interpretivist approach enables researchers to explore how coaches and players understand concepts such as talent, development, and progression along a pathway. The strengths and limitations of both perspectives are relevant to the present research. The studies included in this thesis required the collection of objective data on player characteristics and match demands, while also seeking to understand the coaching environment in which player development occurs. Neither perspective, on its own, was sufficient to address these aims. Consequently, a pragmatic approach was adopted.

By anchoring this thesis in a pragmatic worldview, the research is not bound to a single philosophical position. Instead, pragmatism starts with the research problem itself and considers what evidence is required to address it (Morgan, 2007; Creswell & Plano Clark, 2018). Within a pragmatic epistemological framework, knowledge is understood as provisional and context-dependent, with its value determined by its credibility, relevance, and usefulness in addressing the problem under investigation (Biesta, 2010; Feilzer, 2010; Morgan, 2014). This was particularly relevant given the nature of the research questions examined throughout the thesis, which required both quantitative and qualitative forms of inquiry. The included studies sought to understand various aspects of talent development in female Gaelic games. Some questions required collecting and analysing objective data, such as physical profiling and performance characteristics, while others required exploring coaches' experiences, perceptions, and practices. A pragmatic position allowed these different forms of evidence to be considered alongside one another (Cherryholmes, 1992). It accepts that aspects of the talent development environment can be measured and compared, while also recognising that the experiences of players, coaches, and stakeholders shape how that environment operates in practice. As a result, the thesis draws on both quantitative and qualitative methods where they are most appropriate to the question being addressed. Different forms of evidence can therefore provide complementary forms of understanding. In this thesis,

quantitative evidence describes patterns in physical performance and match demands, while qualitative evidence provides insight into coaches' experiences, perceptions, and practices. The value of these forms of knowledge lies not in providing universal explanations, but in contributing credible and practically useful evidence to inform decision-making within the context in which it was generated. Within the pragmatic philosophical orientation adopted in this thesis, qualitative themes are understood as being generated through an iterative process of engagement with the data, rather than identified as objectively pre-existing features of the dataset. The analytical process involved iterative coding, comparison of coded material, grouping of conceptually related codes, and refinement into broader patterns of meaning. Consistent with pragmatic research, findings are interpreted with a focus on their relevance and usefulness within real-world settings (Giacobbi et al., 2005). The intention is not to produce universal explanations of talent development, nor to generate findings that are unique only to the specific participants involved. Instead, the aim is to generate evidence to inform understanding and practice in Ladies' Gaelic football and other comparable talent development environments.

The pragmatic position adopted in this thesis is reflected in the design of the four studies. Studies 1 and 2 focused on establishing physical and performance benchmarks for youth inter-county female Gaelic games. These studies required the collection of objective data using established measurement procedures, as the development of an evidence-informed player pathway depends on an understanding of the physical characteristics and match demands associated with participation at this level.

Studies 3 and 4 focused on the coaching environment responsible for implementing and applying this information in practice. While both studies were primarily quantitative, opportunities were provided for coaches to elaborate on their experiences and perspectives through open-ended responses. This allowed the research to move beyond describing coaching knowledge and behaviours and to explore some of the practical challenges coaches face in supporting player development.

Taken together, the four studies offer a broader understanding of athlete development than either strand of research could provide in isolation. Physical profiling and match analysis can identify what is required of players, but they offer little insight into whether coaches have the knowledge, confidence, or resources to act on that information. Equally, an exploration of coaching perspectives alone would not provide the objective evidence needed to inform pathway development. Bringing

these strands together provides a more complete understanding of the athlete development environment within female Gaelic games.

The studies were conducted as part of a multiphase mixed-methods programme of research. The quantitative and qualitative findings were synthesised during the interpretation stage, with results from the physical profiling and performance studies considered alongside evidence from the coaching workforce studies. Integration was achieved through narrative discussion presented in Chapter 7. Given that the studies involved different participant groups, the purpose of this integration was not to establish direct causal relationships but to examine how findings from one part of the research could help explain, support, or contextualise findings from another.

The choice of a pragmatic approach was therefore driven by the nature of the research problem rather than by allegiance to any single methodological tradition. Understanding athlete development within female Gaelic games required evidence on both player characteristics and the coaching environment in which those characteristics are developed. Addressing only one side of this equation would have provided an incomplete picture.

1.5 Ethical Considerations

Ethical approval for this research was granted by DCU Research Ethics Committee (Reference Number: DCUREC/2022/122). A copy of the formal ethical clearance letter is provided in Appendix A. Given the involvement of distinct populations, including minors (youth players in Studies 1 & 2) and adult volunteers (coaches in Studies 3 & 4), specific ethical protocols were tailored for each phase of the research. These included obtaining parental consent and child assent for all youth participants and ensuring anonymity and data protection (GDPR compliance) for all survey respondents. Detailed descriptions of the recruitment procedures, informed consent processes, and data management protocols specific to each study are provided in the relevant empirical chapters (Chapters 3–6) and in the appendices.

1.6 Thesis Structure

This thesis is organised into seven chapters:

Chapter 1 establishes the context, rationale, and philosophical framework for the research, highlighting the critical need for evidence-informed practice in the development of juvenile Ladies Gaelic Football.

Chapter 2 presents a critical review of the literature, beginning with an examination of Long-Term Athletic Development (LTAD) models and the implications of growth and maturation for adolescent female athletes. It then describes the physical demands and key qualities for performance in Ladies Gaelic football (LGF), and explores the methodologies used to assess these qualities. The technological approaches required to quantify match-play demands via time-motion analysis are then discussed. Finally, the chapter critically addresses the unique sporting environment and coaching context within the LGFA, exploring the challenges faced by volunteer coaches in a talent development environment.

Chapter 3 (Study 1): Presents a cross-sectional analysis of the anthropometric and physical performance characteristics of inter-county U14, U16, and U18 players. By introducing population-specific metrics across strength, speed, power, and endurance, this chapter provides objective benchmarks to systematically map and monitor player development over time.

Chapter 4 (Study 2): Investigates the match-play demands of U16 and U18 inter-county football using GPS technology, providing the first specific locomotor profiles for this population. By defining the physical requirements of youth competition relative to senior standards, this investigation enables coaches to move beyond anecdotal evidence and design data-driven, developmentally appropriate strength and conditioning programmes to meet the demands of the game.

Chapter 5 (Study 3): Presents a nationwide, mixed-methods needs analysis exploring the current knowledge, actual pitch practices, and organisational challenges of inter-county coaches. This comprehensive audit identifies the specific experiential, coaching, and systemic barriers within the amateur sporting context that actively prevent the successful application of athletic development principles on the field.

Chapter 6 (Study 4): Conducts a pre- and post-experimental evaluation of a targeted educational intervention: the GAA F3 Youth Athletic Development Level 1 Course. This study measures the programme's capacity to enhance volunteer coaches' declarative knowledge and coaching self-efficacy and assesses whether this targeted curriculum improves coaches' efficacy in supporting the sustainable, long-term implementation of physical preparation strategies.

Finally, ***Chapter 7*** synthesises the findings from both streams of inquiry. It considers the theoretical and practical implications of the research, acknowledges limitations, and provides evidence-informed recommendations for the LGFA, county boards, and future researchers.

Chapter 2: Literature Review

2.1 Introduction

Chapter 1 established the need for evidence-informed practice in ladies' Gaelic Football (LGF). While the broader GAA organisation has a stronger foundation of sports science research, LGF has historically lacked a comprehensive, female-specific evidence base (Malone et al., 2023). However, reflecting the sport's rapid growth and the increasing demand for high-performance data, research output has recently accelerated. Prior to 2021, only eight published papers explicitly featured Ladies' Gaelic Football in their titles. Since 2022, over 30 new LGF-specific publications have emerged. As this empirical landscape expands, there is a need to evaluate the existing data to establish pathways that optimise player development while reducing the risks of injury and burnout (Duggan et al., 2022b). Without this foundational knowledge, coaches, players, and organisations rely on anecdotal evidence rather than scientific data, which may not optimise performance or safeguard athlete well-being.

To contextualise the dual streams of inquiry in this thesis, this chapter will review the literature relevant to both the physical preparatio2.2.1n of adolescent female athletes and the coaching ecosystem that supports them. It begins by examining models of long-term athletic development, female growth and maturation, and the need for progressive athletic development programmes. The review then explores the physical demands of the game, the key qualities required for high performance, and the methodologies used to measure them. Finally, the socio-cultural landscape of LGF and the coach's role are discussed, highlighting the importance of coach education, declarative knowledge, and coaching self-efficacy. By synthesising these distinct yet interconnected areas, encompassing player anthropometric and fitness characteristics, game demands, inter-county athletic development practices, and coaches' coaching self-efficacy, this review will identify significant gaps in the current literature, thereby establishing the rationale for the present research.

2.2 Long-Term Athletic Development Models

Youth sport pathways can serve multiple goals, including promoting health and physical activity through increased participation and developing elite athletes within talent development sport systems (Till et al., 2021). In recent years, the need to adequately prepare youth for both high-level sport and a physically active life has sparked growing interest in long-term athletic development (LTAD) (Pichardo et al., 2018). Several LTAD models have been proposed, and although

each offers a unique perspective, their primary objective has been to prioritise long-term development over short-term success, enabling youth athletes to reach their full performance potential in adulthood (Balyi & Hamilton, 2004; Pichardo et al., 2018).

One of the earliest models in talent development was Gagné's (1993) Differentiated Model of Giftedness and Talent. Developed within education, it proposed that individuals possessed innate 'gifts' that could be developed into 'talent' through practice and learning (Gagné, 1993; Lloyd et al., 2015). Gagné advocated that practice time should increase with the level of talent sought and that individuals should be developed across multiple aptitudes (Gagné, 1993). This concept remained central to later talent development models (Pichardo et al., 2018). Arguably, the most influential models for youth athlete development are the Developmental Model of Sports Participation (DMSP) (Côté, 1999); the Long-Term Athletic Development (LTAD) model (Balyi & Hamilton, 2004); the Youth Physical Development (YPD) model (Lloyd & Oliver, 2012); and the FTEM framework (Gulbin et al., 2013), the latter of which underpins the Gaelic Games Player Pathway currently adopted by the Gaelic Games associations (GAA, LGFA, & Camogie Association, 2021). Each of these models offers a pathway for athlete development based on chronological age and/or maturation (Pichardo et al., 2018). Sitting beneath these broader frameworks, subsequent models of athletic development have been developed for individual components of fitness, such as strength, power, speed, agility, and aerobic endurance (Granacher et al., 2016; Lloyd et al., 2013; Meylan et al., 2014; Oliver et al., 2013).

2.2.1 Developmental Model of Sports Participation (DMSP)

The DMSP, grounded in both theoretical and empirical data, outlines the processes, pathways, and outcomes associated with sport development during childhood and adolescence (Côté & Vierimaa, 2014). According to this model (Figure 2.1), there are three potential pathways a child or adolescent might follow throughout their sporting career, based on chronological age: the sampling years (age 6–13), the specialising years (age 13–15), and the investment years (age 16+) (Côté et al., 2009). During the sampling years, children participate in a variety of enjoyable, engaging sporting activities that emphasise deliberate play. Sports diversification and the avoidance of specialisation are encouraged (Côté & Hancock, 2016). Sampling different sports develops a range of fundamental movement skills (FMS), enhancing a young person's overall athleticism (Duggan et al., 2022b). A key distinction within the DMSP is its emphasis on deliberate play in the early years, which contrasts with the deliberate practice that predominates in later stages. Deliberate play refers to youth-led activities designed for enjoyment and intrinsic motivation, with flexible rules (Côté,

1999). The DMSP argues that an early foundation of deliberate play is crucial for developing intrinsic motivation, which helps prevent burnout from an overemphasis on rigorous deliberate practice too early in an athlete's career (Côté, 1999).

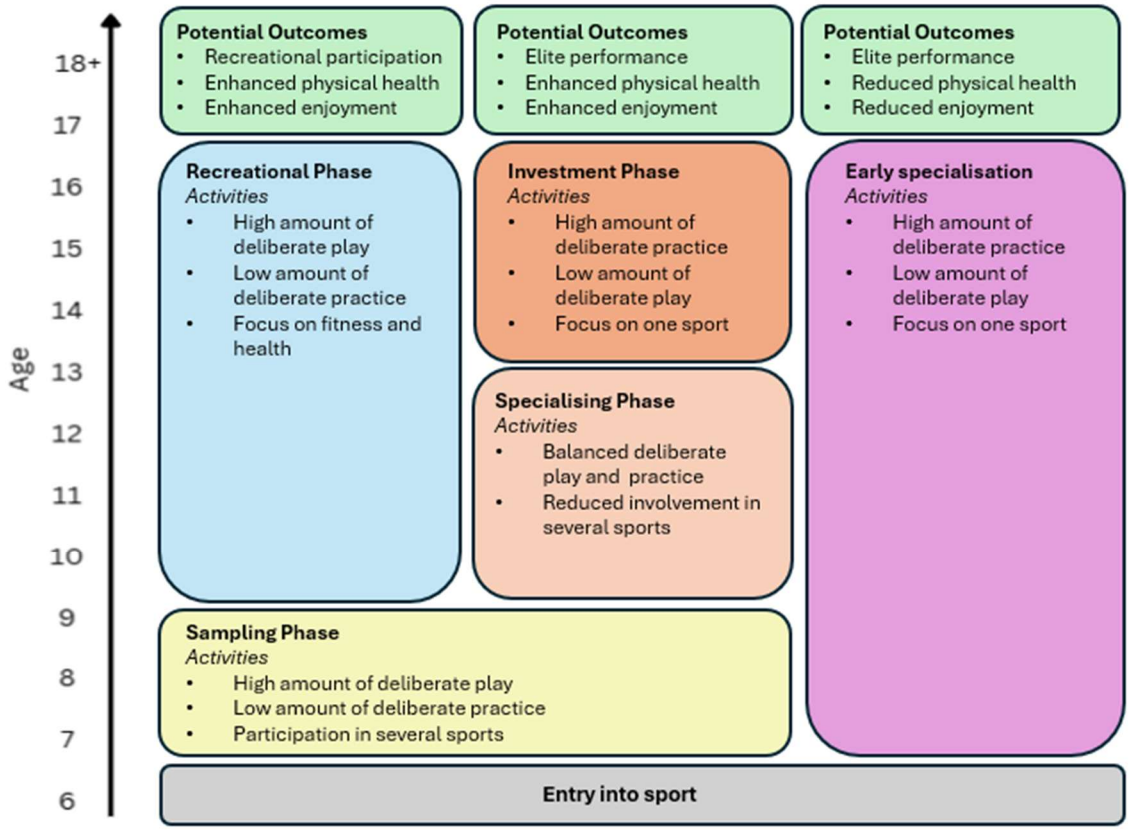


Figure 2.1

Developmental Model of Sports Participation (Côté & Vierimaa, 2014; Lloyd et al., 2015)

After this phase, young people may choose to enter the specialising years (age 13–15) or the recreational years (age 13+). In the specialising phase, involvement typically centres on one or two sports, with greater emphasis on purposeful, deliberate practice. Deliberate practice comprises training activities that enhance performance and improve skills and that are cognitively and/or physically demanding (Ericsson et al., 1993). Following the specialising phase, individuals may opt to enter the investment phase, focusing on achieving elite status in a single sport or activity. Alternatively, they may continue with recreational sport, remaining active for life (Pichardo et al., 2018).

Côté and Hancock (2016) proposed that youth sport involvement can lead to outcomes classified as the 3Ps: performance, participation, and personal development. The goals for the 3Ps include avoiding burnout and dropout, maximising involvement in various sporting activities, and fostering intrinsic motivation (Côté & Hancock, 2016). The authors argue that it is possible to achieve the goals of the 3Ps simultaneously when sports systems are organised according to participants' age and competitive level (Côté & Hancock, 2016). Despite this, governing bodies of various sports often organise their sports systems, prioritising one of the 3Ps at the expense of the others, such as favouring elite performance over widespread participation (Côté & Vierimaa, 2014). This imbalance is inherently problematic, as a premature hyper-focus on immediate performance can precipitate early specialisation, psychological burnout, and eventual dropout, thereby undermining an athlete's long-term potential (Brenner & Council on Sports Medicine and Fitness, 2016; Côté et al., 2009). This dynamic is particularly relevant to the underage inter-county LGF structure. While this system functions as the sport's primary pathway for developing future senior players, its competitive tournament structures heavily incentivise immediate performance and winning. Consequently, an exclusive focus on short-term performance at these developmental stages may compromise long-term participation and personal development, which are essential to sustaining a player's journey to the elite senior level.

> ***Note on Performance Terminology:*** *Within this thesis and the broader sports science literature, the descriptor 'elite' is used contextually to denote athletes competing at the highest available standard within their respective sporting structures. In professional athletic frameworks (such as the Australian Football League Women's [AFLW]), this refers to senior drafted or contracted professional athletes. In amateur sporting architectures (such as the LGFA or GAA), 'elite' specifically denotes senior inter-county players who represent the pinnacle of their competitive pathway.*

The foundational principles of the Developmental Model of Sports Participation (DMSP), particularly its emphasis on early sampling, have gained significant support from major international bodies. Position statements from both the National Strength and Conditioning Association and the International Olympic Committee endorse the sampling approach as a best practice for youth sport (Bergeron et al., 2015; Lloyd et al., 2016). This endorsement is primarily based on evidence suggesting that encouraging participation in a variety of sports during childhood can reduce the risks of psychological burnout and overuse injuries, which are often associated with the high training volumes of early, single-sport specialisation. Beyond its psychological and health benefits, the DMSP's stages of participation have also influenced the design of more physically focused

frameworks, such as the YPD model (Lloyd et al., 2015). These models have integrated DMSP's age-related stages to structure the progressive development of physical fitness components, such as strength and speed, thereby demonstrating their cross-disciplinary relevance.

Critique of the DMSP Model

A significant criticism of the DMSP is its primary reliance on chronological age, which fails to account for the substantial impact of biological maturity (Ford et al., 2011). The model's proposed age ranges for the sampling, specialising, and investment years do not account for the wide individual differences in maturational timing and tempo (Ford et al., 2011). For example, two 13-year-old athletes may be at very different stages of physical development due to puberty, yet the model would classify them in the same 'specialising years' category. For high-intensity, multidirectional sports such as LGF, where early and late maturers may have markedly different physical capacities, this oversight is especially problematic. Applying identical training loads to players at vastly different stages of their adolescent growth spurt increases injury risk, as those in peak growth phases tend to be less coordinated and more susceptible to non-contact injuries during explosive, multidirectional movements (Fort-Vanmeerhaeghe et al., 2016). This approach neglects other critical factors, such as an athlete's training history (including training age) and current level of movement competence, which are important considerations for designing appropriate and effective training (Pichardo et al., 2018).

Grouping youth athletes solely by chronological age also introduces two selection biases that confound talent identification. First, it fosters the Relative Age Effect (RAE), an administrative bias that systematically favours players born early in the selection calendar year (e.g., quarter 1) purely because of their chronological age advantage over peers born later in the same year (Cobley et al., 2009). Second, independent of birth date, it creates a maturational bias in which physically advanced early maturers are consistently mistaken for superior talent because of temporary, puberty-driven physical advantages, while more technically skilful late maturers are systematically overlooked (Cumming et al., 2017).

However, it must be acknowledged that the vast majority of literature examining both RAE and maturational bias has been conducted within male cohorts. While these systemic biases are present in female team sports, meta-analyses indicate that their magnitude is generally smaller, a variance historically attributed to shallower competition, lower overall participation rates, and less aggressive talent selection policies compared with male pathways (Smith et al., 2018). Nevertheless,

as LGF experiences exponential growth and increased competitive depth within its underage inter-county structures, assuming that female sports remain naturally insulated from these selection biases may be erroneous. Rather than simply mirroring male pathways, intensifying selection pressures are likely to expose the complex realities of female maturation, in which early physical development can simultaneously confer athletic advantages for some and increase the risk of dropout for others. As the DMSP relies entirely on rigid chronological brackets, it offers practitioners no structural mechanism to monitor or counter these shifting developmental dynamics. Recognising the inherent limitations of strictly chronological frameworks, contemporary models, most notably Balyi and Hamilton's (2004) Long-Term Athlete Development (LTAD) model, have emerged to offer developmental pathways structured around both chronological age and the physiological milestones of biological maturation.

2.2.2 Long-Term Athletic Development Model (LTAD)

In contrast to the predominantly psychological framework of the DMSP, Balyi and Hamilton's (2004) LTAD model (Figure 2.2) is more physiologically focused and has become widely adopted in youth sport (Duggan et al., 2022b; Ford et al., 2012). Its primary contribution has been to shift coaches' focus to the importance of biological maturation. It offers a structure that aligns specific fitness components with either chronological age or maturation. Balyi and Hamilton's model considers the developmental stages of children and adolescents, emphasising that scaled-down adult training programmes should not be applied to this group (Balyi & Hamilton, 2004). The authors stress the importance of adopting a long-term rather than a short-term approach to training and competition, arguing that an excessive early focus on competition can hinder athletic development later in their sporting careers (Balyi & Hamilton, 2004). The LTAD model is founded on the premise that children and adolescents experience potential 'windows of opportunity' during growth and maturation that should be exploited through appropriate training to optimise athletic potential (Balyi & Hamilton, 2004). These windows occur during natural periods of fitness development in growth and maturation and are believed to be times when youth are most receptive to training (Viru et al., 1999). The windows for developing speed, skill, and suppleness are based on chronological age, whereas biological age serves as a reference for windows related to strength and endurance (Balyi & Hamilton, 2004). Peak height velocity (PHV) and peak weight velocity (PWV) are recommended as reference points for maturation. Typically, the average age of PHV is 12 years for girls and 14 years for boys, with PWV occurring approximately 12 months later (Balyi & Hamilton, 2004).

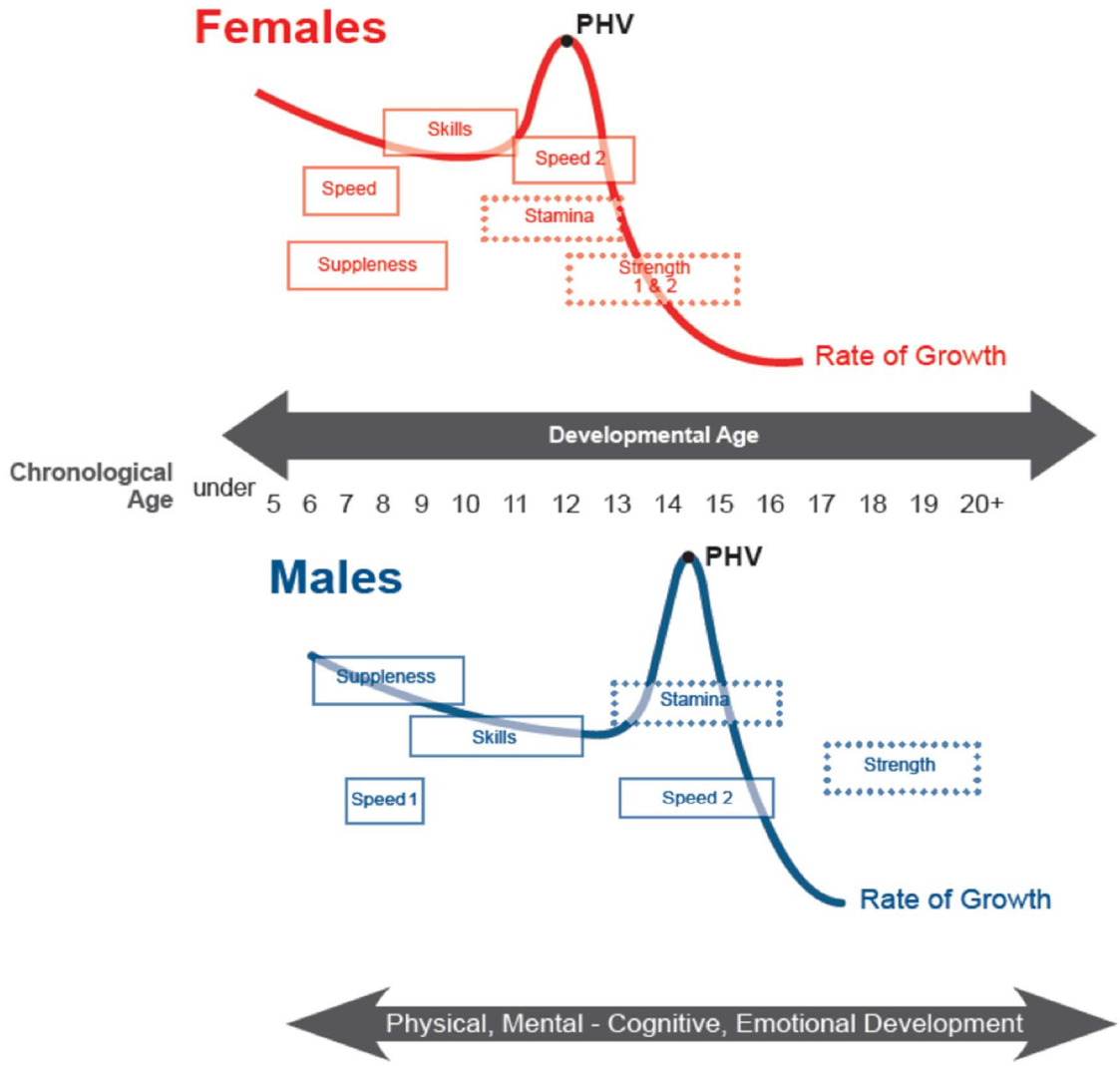


Figure 2.2

LTAD Model for Females and Males (Balyi & Hamilton, 2004)

Another feature of the LTAD model is the organisation of training progression into stages (Figure 2.3). During the FUNdamentals stage (ages 6–9 for males and 6–8 for females), children learn fundamental movement skills (FMS) in a fun, engaging environment. The primary focus is on developing players' physical capacities, and participation in as many sports as possible is encouraged (Balyi & Hamilton, 2004). The priority during the Learning-to-Train stage (ages 8–11 for females; 9–12 for males) is the further development of FMS and the acquisition of fundamental sports skills during a 'window of adaptation' for motor coordination. The Train-to-Train stage (ages 11–15 for females; 12–16 for males) is a crucial period for developing physical fitness, with aerobic fitness and strength as key priorities, alongside the consolidation of sport-specific skills (Balyi & Hamilton, 2004). The Training-to-Compete (ages 15–17 for females; 16–18 for males) and Training-to-Win

(ages 17+ for females; 18+ for males) stages aim to optimise and then maximise fitness and sport performance, while the final stage, Retirement and Retention, focuses on retaining ex-players in roles such as coaching, administration, or officiating (Balyi & Hamilton, 2004).

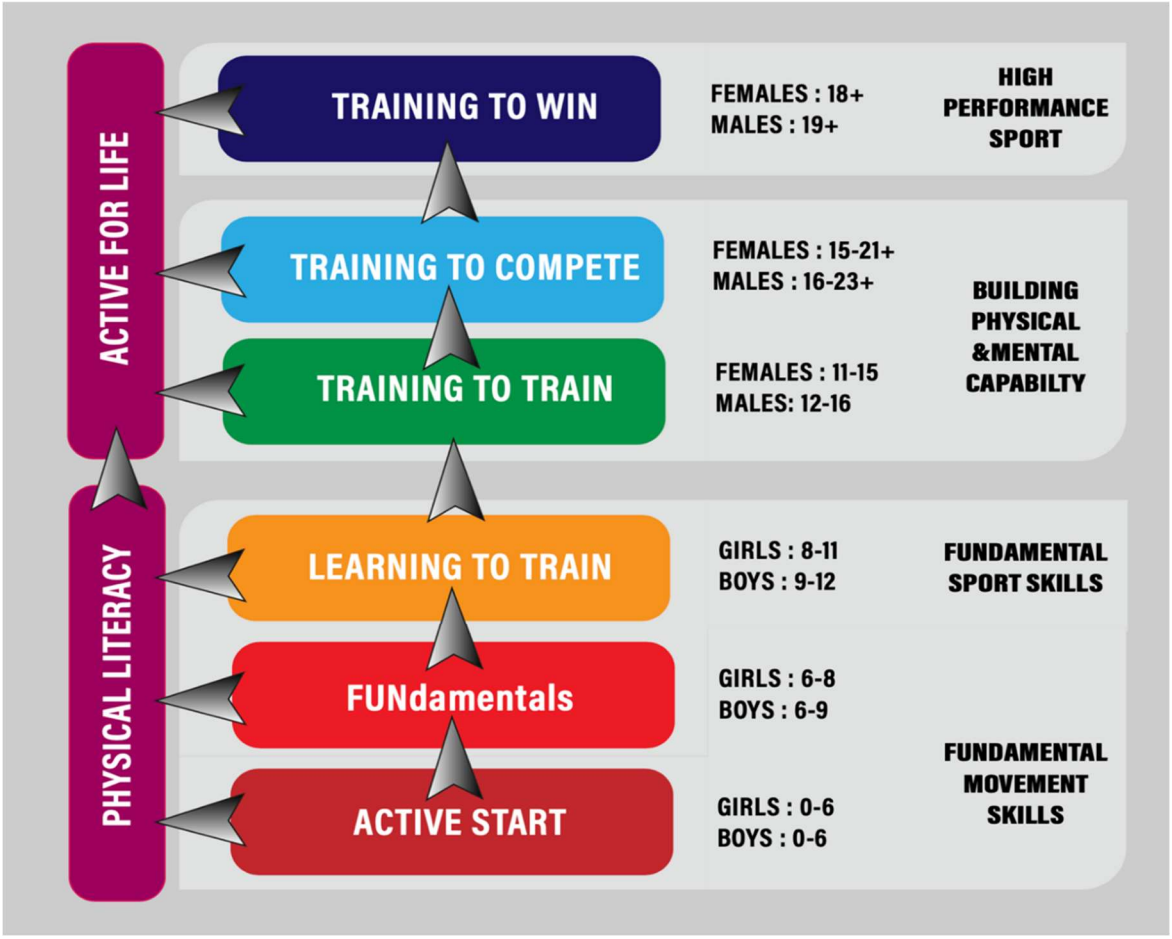


Figure 2.3

LTAD Stages (Balyi & Hamilton, 2004)

The LTAD model offers a methodical approach to training, and several of its stages have subsequently been incorporated into resistance training, plyometric, and weightlifting models (Granacher et al., 2016; Lloyd et al., 2011, 2012). The model has enhanced coaches' understanding of biological maturation in the development of young athletes and challenged the previous dogma of early athlete specialisation (Bailey et al., 2010). By using tools such as PHV, coaches can account for each athlete's individual maturation rate and apply the appropriate training protocols for each stage of the model (Bailey et al., 2010). The authors also emphasise the need to balance competition with training, allocating more time to training during the model's early stages. The recommended

training-to-competition ratios are 70:30 for the Learn-to-Train stage, 50:50 for the Train-to-Compete stage, and 25:75 for the Compete-to-Win stage (Balyi & Hamilton, 2004). The model improves on the flawed chronological age classification by recognising the varied growth and maturation rates among individuals (Bailey et al., 2010).

While the LTAD model has notably advanced thinking about youth athletic preparation, it is limited by its reliance on several unsupported premises that undermine its validity (Ford et al., 2011). These primarily concern the 10,000-hour rule, as well as the concepts of 'windows of opportunity' and 'critical periods' of development, all of which are discussed in further detail in the subsections that follow. Lloyd et al. (2015) further questioned the appropriateness of using the term 'athlete' within the LTAD model, as it implies a pathway solely for children and adolescents who display early sporting talent. Although developing sporting talent is important, most children and adolescents do not progress to elite sport and continue to participate at the grassroots level. Moreover, they may not participate in organised sports at all or fail to meet the daily physical activity guidelines recommended by organisations such as the World Health Organisation (Lloyd et al., 2015). Therefore, Long-Term Athletic Development should be viewed as a pathway for all children and adolescents, aimed at improving health, fitness, and performance (Lloyd et al., 2015).

Critique of the Long-Term Athletic Development Model

Despite its widespread adoption, the LTAD model has faced significant academic scrutiny in recent years. The primary criticisms revolve around the arbitrary nature of the 10,000-hour rule, a lack of empirical evidence supporting biological 'windows of opportunity,' limited prescriptive detail for coaches, and a failure to adequately individualise training. These four limitations will be discussed in the subsequent sections.

The 10,000-Hour Rule

The concept of prolonged practice as a prerequisite for the development of expertise originates from research on deliberate practice, most notably the work of Ericsson et al. (1993). Based on their research with expert musicians, Ericsson et al. (1993) reported that the most accomplished violinists had accumulated over 10,000 hours of deliberate practice by the age of 20, equivalent to approximately 25 hours per week on average, whereas amateur musicians had accumulated approximately 2,000 hours, equivalent to around 2 hours per week (Ericsson et al., 1993). Deliberate practice refers to activities that require cognitive or physical effort, do not provide immediate rewards, and are designed to improve performance (Ericsson et al., 1993). The concept

of deliberate practice in achieving expertise was later extended to include all areas of human endeavour, including sport (Baker & Young, 2014). Balyi and Hamilton (2004) incorporated this concept into the LTAD model, referring explicitly to the '10-year or 10,000-hour rule' and proposing that it takes approximately 8–12 years of training for a talented athlete to reach elite levels.

However, the requirement to amass 10,000 hours of practice to reach elite status has been questioned in research and may even hinder long-term development (Bailey et al., 2010; Ford et al., 2011) and contradicts the principles of personalised programme design (Lloyd et al., 2015). Attempting to accumulate 10,000 hours of training can increase the risk of overuse injuries or illness, especially during periods of rapid growth and poor coordination (Pichardo et al., 2018). Athletes who engage in high levels of specialisation and large training volumes face a greater risk of overuse injuries (Post et al., 2017), whereas late specialisation and lower levels of specific training during childhood are significant predictors of elite performance in adulthood (Moesch et al., 2011). Moreover, Baker and Young (2014) highlighted evidence that elite performance can be achieved following substantially less than 10,000 hours of practice, with some athletes reaching elite levels after approximately 4,000–6,000 hours.

Lack of Evidence for 'Windows of Opportunity'

Naturally occurring periods of accelerated adaptation across various physical qualities have been documented in the literature (Naughton et al., 2000; Viru et al., 1999). A preadolescent window has been identified for strength, power, speed, and endurance in both boys and girls. This has been attributed to age-related development of the central nervous system, with increased intra- and inter-muscular coordination contributing to improved motor control (Viru et al., 1999). An adolescent window was also identified, resulting from post-PHV anatomical, hormonal, metabolic, and biomechanical changes (Naughton et al., 2000). Balyi and Hamilton (2004) suggest that these 'critical' or 'sensitive' windows of opportunity should be exploited with appropriate training stimuli; otherwise, an athlete may not reach their full athletic potential. They base this on 'empirical observations and practical experience' from the former Eastern Bloc countries. However, empirical observations can be influenced by subjective bias and lack scientific rigour (Ford et al., 2011). It is also important to distinguish between 'critical' and 'sensitive' windows, as this affects training strategies (Bailey et al., 2010). A 'critical period' is a window during which a specific opportunity must be seized; failing to do so may prevent full athletic development. Conversely, the term 'sensitive period' refers to a window during which additional gains are more likely with consistent effort (Viru et al., 1999). Training outside a critical window may have little or no effect on the ability

in question, whereas training outside a sensitive period may yield reduced benefits (Van Hooren & De Ste Croix, 2020). This distinction is important because LTAD models often refer to sensitive periods, while some practitioners interpret these as critical periods (Van Hooren & De Ste Croix, 2020). Furthermore, the term ‘window’ implies that periods open and close, when in fact they may remain open throughout adulthood (Viru et al., 1999).

To date, evidence for these critical windows has largely relied on cross-sectional data and lower-quality intervention studies. The absence of robust longitudinal data means further research in this area is required (Ford et al., 2011). In the domain of physical literacy, which encompasses the development of fundamental movement and sports-specific skills, there is partial evidence supporting the LTAD model (Ford et al., 2011). Neurologically, peak periods of brain development generally occur at approximately 6–8 years and 10–12 years across both sexes (Ford et al., 2011), aligning with the LTAD's 'windows of opportunity' for fundamental and sports-specific tasks. While these neurological peaks are general, the specific windows are sex-dependent, typically ending earlier in females (approximately 11 years) due to the onset of peak height velocity (Balyi & Hamilton, 2004). Nevertheless, the indicators used in the literature to measure physical literacy make it difficult to draw definitive conclusions. For instance, a combination of plyometrics and resistance training produced a temporary improvement in FMS among boys; however, only strength outcomes were evaluated, not movement quality (Ingle et al., 2006). In another study involving 6–9-year-olds, improvements in physical literacy were observed following a year-long school-based intervention (Graf et al., 2005). However, these effects were not sustained in a six-year follow-up study (Barnett et al., 2009). These findings appear to contradict the LTAD concept of windows of opportunity, which posits that training specific physical literacy skills at particular developmental stages can enhance long-term skill development (Ford et al., 2011).

Similar developments have been observed in the literature concerning aerobic fitness. Early research produced inconsistent findings regarding the trainability of aerobic capacity in children, contributing to the development of the concept of maturational ‘windows of opportunity’ within LTAD models (Naughton et al., 2000; Ford et al., 2011). However, evidence of meaningful training responses was also reported before PHV, with Rowland (1985) reporting improvements in aerobic capacity of 10.1% and 8.8% in boys and girls, respectively. Subsequent evidence has challenged the interpretation that aerobic fitness is restricted to discrete periods of maturation. Harrison et al. (2015) concluded that aerobic fitness should be actively developed throughout an athlete’s development rather than aligned exclusively with specific periods of maturation. More recent reviews have similarly highlighted the importance of considering both maturation and training

stimulus when interpreting the development of aerobic fitness in youth athletes (Armstrong & Welsman, 2020). Furthermore, Pinho et al. (2024) provided further evidence of aerobic trainability throughout childhood and adolescence, reporting improvements in both cardiorespiratory fitness and maximal aerobic speed following structured exercise. Consequently, contemporary evidence does not support the interpretation that aerobic fitness can only be meaningfully developed during discrete maturational periods. Rather, aerobic fitness appears to remain trainable throughout childhood and adolescence, with training prescription adapted according to maturation, training history, and the characteristics of the exercise stimulus, including training frequency, programme duration, and training mode (Baquet et al., 2003).

A period of accelerated adaptation for speed is suggested to occur in both boys and girls between ages 5 and 9, with a second period reported around ages 12 and 14 (Viru et al., 1999). Post-PHV, the rate of speed development in females is significantly lower compared to males, and this has been attributed to anatomical and hormonal differences, while the development of the central nervous system and improved coordination are proposed to account for the initial period of accelerated adaptation (Ford et al., 2012; Viru et al., 1999). Several factors influence speed development in childhood, including neuromuscular development, biological and metabolic changes, and alterations in muscle length and cross-sectional area, making it challenging to identify the precise mechanisms responsible for the speed gains achieved throughout childhood (Viru et al., 1999). The LTAD model proposes two 'windows of opportunity' for developing speed: the first, from ages 6–8 years in girls and 7–9 years in boys, and a second, from 11–13 years in girls and 13–15 years in boys (Balyi & Hamilton, 2004). The role of maturation in the second speed window is attributed to hormone-mediated growth of fast-twitch fibres (Granacher et al., 2016; Viru et al., 1999). Studies in pre-adolescent football players found that the magnitude of speed gains in players who engaged in coordination training was similar to that of players who engaged in linear speed training, highlighting the role of coordination and neural control in speed development, while post-PHV gains have been attributed to both training and maturational effects (Venturelli et al., 2008). However, several studies have reported that adaptations can be lost following detraining (Botcazou et al., 2006; Fournier et al., 1982). Although the timing and magnitude of speed adaptations may vary with maturation, recent evidence indicates that speed-related qualities remain responsive to structured training throughout adolescence. An umbrella review of resistance-training meta-analyses reported small-to-medium improvements in linear sprint performance and moderate improvements in change-of-direction speed among children and adolescents (Lesinski et al., 2020). More recently, Luo et al. (2025) reported moderate-to-large improvements in linear sprint speed

and moderate improvements in change-of-direction speed following strength and plyometric training in female adolescent team-sport athletes. Thus, rather than being confined to discrete maturational windows, speed development appears to remain trainable when appropriate training stimuli are applied (Lesinski et al., 2020).

Muscular strength represents the maximum external force that a muscle or muscle group can exert in a single effort under specific, defined conditions (James et al., 2023). Strength is an essential component of most aspects of fitness, and positive associations have been found between strength and speed, agility, balance, power, endurance, and coordination (Faigenbaum et al., 2016; Granacher et al., 2016; Lloyd & Oliver, 2012). Force production depends on a complex interaction of muscular, mechanical, and neural factors, making the study of strength development in children challenging (Granacher et al., 2016). The LTAD model suggests that strength can always be trained but recommends the optimal 'window of trainability' for girls is immediately post-PHV, while for boys it is 12–18 months following PHV, with boys gaining much greater strength than girls post-PHV due to higher levels of circulating androgens (Balyi & Hamilton, 2004; Faigenbaum et al., 2009). This generalisation is particularly problematic for sports like LGF, where on-field performance requires a combination of strength, power, and neuromuscular control. By delaying the primary focus on strength until after PHV, the model may neglect crucial foundational neuromuscular development during the pre-PHV years, which is vital for reducing injury risk. This is a significant concern for adolescent female athletes who exhibit higher rates of non-contact anterior cruciate ligament injuries (Lloyd & Oliver, 2012; Radnor et al., 2020).

Studies show that strength can be trained during childhood and adolescence, with gains ranging from 5.3% to 87% (Faigenbaum et al., 1993, 1999). The large variation in gains is linked to factors such as training programme design, participants' age, initial strength levels, and the exercises used (Ford et al., 2011). More recent evidence provides considerably stronger support for the trainability of strength during youth. Lesinski et al. (2020) reported medium-to-large effects of resistance training on muscular strength and small-to-large effects on muscular power in healthy children and adolescents. Similarly, Pinho et al. (2024) found that supervised, structured exercise produced substantial improvements in muscular strength among children and adolescents, with strength-focused exercise yielding the largest effects. However, research on the optimal ‘window of trainability’ is limited, and no longitudinal strength-training studies have identified peak height velocity while controlling for growth and maturation. Therefore, further research is needed to determine whether an optimal window of opportunity truly exists (Ford et al., 2011). Overall, two key issues undermine the concept of ‘windows of opportunity’. First, it lacks robust empirical

evidence, and second, it offers no specific programming to apply the theory, rendering the idea practically non-actionable for coaches (Van Hooren & De Ste Croix, 2020).

Taken together, more recent evidence supports the broader trainability of physical fitness during childhood and adolescence, with improvements in muscular strength, cardiorespiratory fitness, muscular power, and maximal aerobic speed following supervised and structured exercise (Pinho et al., 2024). These findings support the view that meaningful training adaptations can be achieved throughout childhood and adolescence rather than being restricted to discrete maturational 'windows'. However, the magnitude and nature of these adaptations may be influenced by growth, maturation, training status, and the characteristics of the training stimulus (Lloyd et al., 2014; Tumkur Anil Kumar et al., 2021). Consequently, contemporary evidence challenges a rigid interpretation of LTAD models that assumes particular physical qualities have discrete periods of optimal trainability. Instead, physical qualities should be considered trainable throughout development, with training emphasis and prescription adapted to the individual's maturation, training history, and needs (Lloyd et al., 2014; Till et al., 2021; Tumkur Anil Kumar et al., 2021).

Lack of Prescriptive Detail.

While the LTAD model emphasises when to train for optimal gains, it provides no guidance on how to design and implement this training. It also lacks specific details on the type of training needed during these proposed sensitive periods to optimise training response (Van Hooren & De Ste Croix, 2020). For example, in speed development, sprint training, plyometrics, and resistance training all show positive effects on speed. However, plyometric training has been identified as the most effective method for improving speed in children, while a combination of plyometric, resistance, and sprint training proves more effective in adolescents (Van Hooren & De Ste Croix, 2020). Recent systematic review evidence further supports the effectiveness of strength and plyometric training in developing sprint and change-of-direction performance during adolescence. In female adolescent team-sport athletes, both strength and plyometric training have been shown to produce moderate-to-large improvements in linear sprint performance and moderate improvements in change-of-direction speed (Luo et al., 2025). Similarly, evidence from highly trained male youth soccer players indicates that strength, plyometric, and combined training can continue to improve strength, power, acceleration, and change-of-direction performance despite substantial prior training exposure (Oliver et al., 2024).

Long, slow aerobic intervals and fartlek training are recommended for endurance training. Nevertheless, this lower-intensity training may not be suitable for aerobic development in children, as research indicates that they need to exercise at above 80% of their maximum heart rate to achieve adaptations comparable to those of adolescents and adults (Baquet et al., 2003; Van Hooren & De Ste Croix, 2020). The frequency, intensity, and duration of training also influence the effectiveness of an intervention, as do programme variables such as load, sets, repetitions, and rest periods (Van Hooren & De Ste Croix, 2020). Although athlete development models often lack detailed information on training variables, such data is essential for practitioners seeking to optimise training adaptations during these hypothetical sensitive periods (Van Hooren & De Ste Croix, 2020). Furthermore, young athletes are reported to be more prone to injuries during the growth spurt, making individualised programmes that consider maturation and training load particularly important at these times (Gamble, 2008). This consideration may be overlooked in LTAD models that emphasise sensitive periods (Van Hooren & De Ste Croix, 2020).

Limitations in Individualisation.

Individual athlete differences and the influence of prior training experience are also not considered in the LTAD model. It is widely accepted that athletes with less experience and lower technical proficiency should undertake less advanced exercises than those who have participated in a structured, supervised programme for some time (Faigenbaum et al., 2009). This may limit the potential to exploit a sensitive period. For example, a 15-year-old female athlete with no resistance training experience will likely start with low-weight exercises and multiple repetitions before progressing to heavier loads, potentially missing the opportunity to capitalise on a proposed window for strength training (Van Hooren & De Ste Croix, 2020). Adaptations to training are generally greater in untrained individuals than in trained individuals, suggesting that higher training loads or intensities may be necessary for more experienced athletes to elicit an optimal response during a proposed sensitive period. Genetic factors also influence an individual's response to training (Van Hooren & De Ste Croix, 2020). Consequently, the most suitable training approach during this hypothetical sensitive period may vary among athletes depending on their prior training experience and genetic predisposition (Van Hooren & De Ste Croix, 2020).

In summary, while the LTAD model has been instrumental in enhancing coaches' understanding of biological maturation, its core principles, especially the 'windows of opportunity', rest on a foundation with limited empirical support. Although the model provides a coaching framework grounded in plausible principles, the evidence supporting its claims remains limited,

likely due to numerous factors influencing performance and the challenges of controlling these variables in paediatric research (Ford et al., 2011). The over-reliance on flawed data and the contradictions found across key physical qualities mean that its direct application by practitioners may be inappropriate. Therefore, although the LTAD model has increased coaches' and practitioners' awareness of the role of biological maturation in training young athletes, many assertions remain unsupported, and future recommendations to enhance physical performance from childhood to adulthood should be supported by empirical research (Ford et al., 2011). The significant gap between the model's plausible ideas and the lack of empirical support necessitated the development of a framework more firmly grounded in scientific evidence, leading directly to the proposal of the Youth Physical Development (YPD) model as a more robust alternative.

2.2.3 Youth Physical Development Model (YPD)

The YPD model, as outlined by Lloyd and Oliver (2012), offers an evidence-based approach to the development of physical performance in children and adolescents. The model draws on existing empirical research on the development of individual fitness components to create a comprehensive long-term strategy for physical development across childhood and adolescence. The YPD model emphasises long-term development of physical abilities for all youth and shifts away from the more 'athlete-centred' approach of earlier models (Lloyd et al., 2015). Unlike the LTAD model, which includes only five physical fitness components (strength, speed, skills, flexibility, and stamina), the YPD model incorporates nine components: FMS, SSS (sports-specific skills), strength, speed, power, agility, hypertrophy, mobility, and finally, endurance and metabolic conditioning (Figure 2.4; Lloyd & Oliver, 2012). This wider range is beneficial for a multifaceted sport such as LGF, which requires competence in all these physical attributes. A key principle of the YPD model is that research supports the trainability of each fitness component throughout childhood and adolescence (Pichardo et al., 2018). More recent evidence supports this principle, indicating that structured exercise can improve multiple fitness components across childhood and adolescence. Pinho et al. (2024) reported improvements in muscular strength, cardiorespiratory fitness, muscular power, and maximal aerobic speed following supervised, structured exercise among children and adolescents. Similarly, resistance-training evidence demonstrates improvements in strength, power, sprint, and change-of-direction performance beyond those attributable to growth and maturation alone (Lesinski et al., 2020). The model adopts an integrated horizontal and vertical approach, in which all fitness components are trainable at all stages; however, specific components are prioritised based on the individual's stage of maturation. For example, training for a 6-year-old girl will focus on developing FMS, whereas a 16-year-old player will include FMS maintenance exercises

in her dynamic warm-up (Lloyd & Oliver, 2012). FMS remains important throughout childhood and adolescence, but the emphasis on a particular fitness component varies with developmental stage (Lloyd & Oliver, 2012).

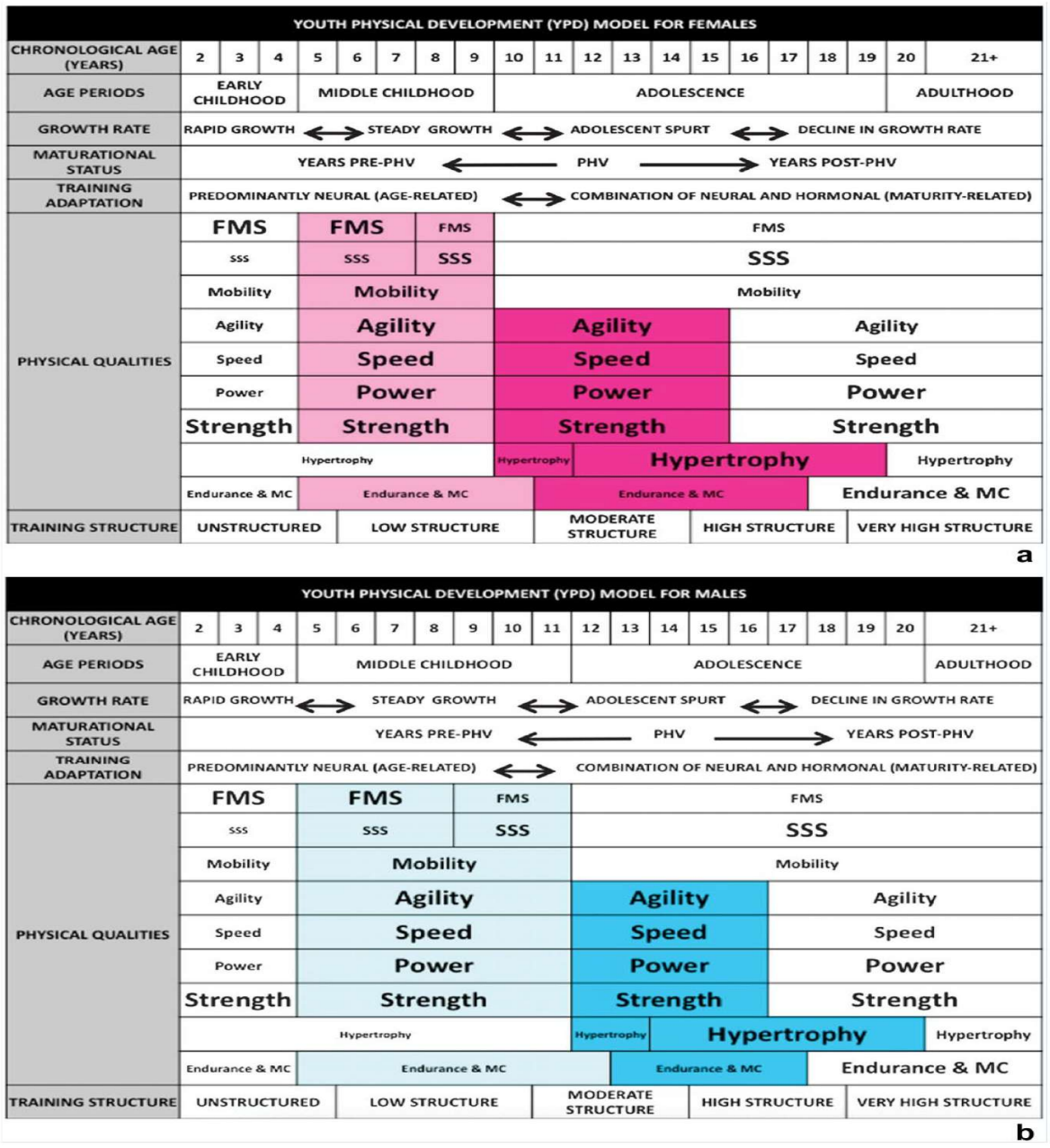


Figure 2.4

YPD Model for a Females and b Males (Lloyd & Oliver, 2012)

Note: Font size refers to importance; light coloured boxes refer to preadolescent periods of adaptation, dark coloured boxes refer to adolescent periods of adaptation; PHV = peak height velocity; FMS = fundamental movement skills; SSS = sport-specific skills; MC = metabolic conditioning.

The YPD model asserts that strength development should be a priority at all stages of development for both males and females, as strength is a fundamental component that underpins all other fitness components. This is supported by research showing close associations between muscular strength and speed, power, change-of-direction, endurance, and successful FMS development (Lloyd et al., 2012). Building strength is vital not only for improving performance but also for reducing the risk of sports injuries and enhancing markers of health and well-being, such as body fat levels and insulin sensitivity (Faigenbaum et al., 2009). The focus on muscular strength is particularly relevant to LGF, where sharp changes of direction, jumping, sprinting, and kicking all rely on a strong foundation of muscular strength (Duggan et al., 2023). Moreover, it is argued that strength training sessions should not be viewed as an addition to a young player's training plan but rather as a replacement for other activities, such as running or skills sessions (Lloyd & Oliver, 2012). Developing movement competency is also a core element of the YPD model, beginning with an early focus on improving FMS and gradually shifting to emphasising SSS. Movement skill competence is associated with increased participation in physical activity and improved health and well-being outcomes in both typical and overweight/obese youth (Lloyd et al., 2015). Thus, practitioners should regard the main principles of the YPD model as applicable to all youth, regardless of their involvement in organised sport or recreational physical activity (Lloyd et al., 2012).

Unlike the LTAD model, the YPD model considers the impact of prior training history, baseline fitness levels, maturation rates, and sex differences on training prescription. As children vary in the timing, tempo, and extent of maturation, it is essential that any athletic development model maintains flexibility and that training programmes can be tailored to the individual (Lloyd & Oliver, 2012; Lloyd et al., 2012). Regular monitoring of an athlete's height and weight can help estimate their growth rates and predict the onset of PHV. A child considered an early maturer may be able to progress to more advanced training techniques, whereas a late maturer might be introduced to such techniques at a later chronological age (Lloyd & Oliver, 2012). Training age (i.e., the number of years an athlete has been engaged in formalised training) is another key factor in developing training programmes. If an athlete has missed the earlier stages of the YPD model, even if approaching adulthood, the coach should start with FMS and muscular strength before advancing to more complex techniques. Conversely, an early-maturing young athlete who demonstrates excellent strength, speed, and power while maintaining the necessary technical competency should not be limited to basic training methods typical of her chronological age (Lloyd & Oliver, 2012; Lloyd et al., 2012).

Finally, practitioners must recognise the physiological and maturational differences between males and females and design programmes accordingly. During childhood, boys and girls follow similar growth and maturation trajectories, and the various fitness components develop at broadly similar rates. However, post-PHV, clear maturational differences are apparent across nearly all components of fitness, with males making greater gains in all components except flexibility (Lloyd & Oliver, 2012). Post-PHV, female athletes undergo several physiological changes that may negatively affect performance. These include increased joint laxity, increased knee valgus angle, poor neuromuscular control of the trunk, increased fat mass, and reliance on quad-dominant landing strategies, all of which have been associated with an increased risk of anterior cruciate ligament (ACL) injury (Hewett et al., 2005, 2006). Consequently, the YPD model recommends that female athletes engage in plyometrics, strength, core, and balance training to help mitigate the risk of this injury in their adult careers (Fort-Vanmeerhaeghe et al., 2016; Lloyd & Oliver, 2012). These training modalities directly address the neuromuscular deficits that contribute to ACL injuries during the sport's most common actions: landing from a high catch, decelerating into a tackle, or executing a rapid side-step. By prioritising this type of training throughout the peripubertal period, the YPD model offers a logical conceptual framework to help mitigate injury risk in LGF.

Limitations of the YPD Model

Despite providing a more comprehensive and individualised framework for youth physical development, the YPD model is not without limitations. Although the model is informed by empirical evidence concerning the trainability of individual fitness components, it remains a conceptual framework rather than a prospectively validated pathway for long-term athletic development (Lloyd & Oliver, 2012; Varghese et al., 2022). Limited empirical evidence directly evaluates the effectiveness of youth athlete-development models, including YPD, as complete developmental frameworks, and insufficient evidence exists to determine whether adherence to these models increases maximal athletic potential (Varghese et al., 2022). Consequently, the YPD model may be better regarded as a developmental framework than as an empirically validated pathway for maximising athletic performance. Furthermore, successful application of the model depends on the coach's knowledge and skills. While the model provides broad guidance on prioritising physical qualities across development, it does not provide detailed prescriptions for the frequency, volume, intensity, or progression of training required for individual athletes. Monitoring maturation, assessing technical competence, and designing programmes according to training age and individual development pose significant practical challenges, particularly in amateur or grassroots environments within LGF. Thus, an important limitation lies not only in the empirical

validation of the model itself, but also in the coach education and support systems required to translate its principles into practice. This gap forms a key component of the rationale for the present study.

2.2.4 Foundation, Talent, Elite, Mastery (FTEM) Framework

While the YPD model offers a best-practice framework for physical development and will serve as the primary theoretical basis for this thesis, it is also necessary to analyse the official player pathway adopted by the Gaelic Games community, the FTEM framework. Originating from a practitioner-led initiative at the Australian Institute of Sport, the FTEM framework was developed to unify previously fragmented athlete development pathways into a single, cohesive, whole-of-sport map (Gulbin et al., 2013). Unlike many age-based models, FTEM promotes an evidence-informed approach to optimise athlete development, recognising the non-linear and variable nature of progression (Weissensteiner, 2017). Drawing on the '3 worlds' framework by Bailey et al. (2010), this concept illustrates how engagement in sport can lead to three potential outcomes: an active lifestyle, sustained sports participation, or the achievement of sporting excellence. The main aim of FTEM is to deliver a favourable outcome for each pathway phase, with its 'catchphrase' being to 'provide the right support, at the right time, for the right athletes' (Weissensteiner, 2017). Although the FTEM framework is depicted as linear, it actually involves non-linear movements, with variable entry and exit points within the developmental pathway. Consequently, it is possible to 'leapfrog' multiple phases in either direction, such as reverting directly to T1 (Demonstration of High-Performance Potential) from E1 (Senior Elite Representation) during talent transfer to a different sport (Gulbin et al., 2013).

The FTEM framework is organised around four key macro-phases (see Figure 2.5), each comprising multiple stages that together illustrate an individual's entire sporting journey. The framework's foundational stages outline a sequential process for developing physical literacy. The journey begins with acquiring a broad range of fundamental movement skills, which are then refined through diverse practice and professional guidance (Weissensteiner, 2017). The process culminates at the sport-specific (F3) stage, where these well-established foundational skills are adapted to the constraints and rules of a given sport. Progression through these phases rests on the premise that mastering foundational movements is crucial to surpassing a 'proficiency barrier' and advancing to more complex, sport-specific skills.

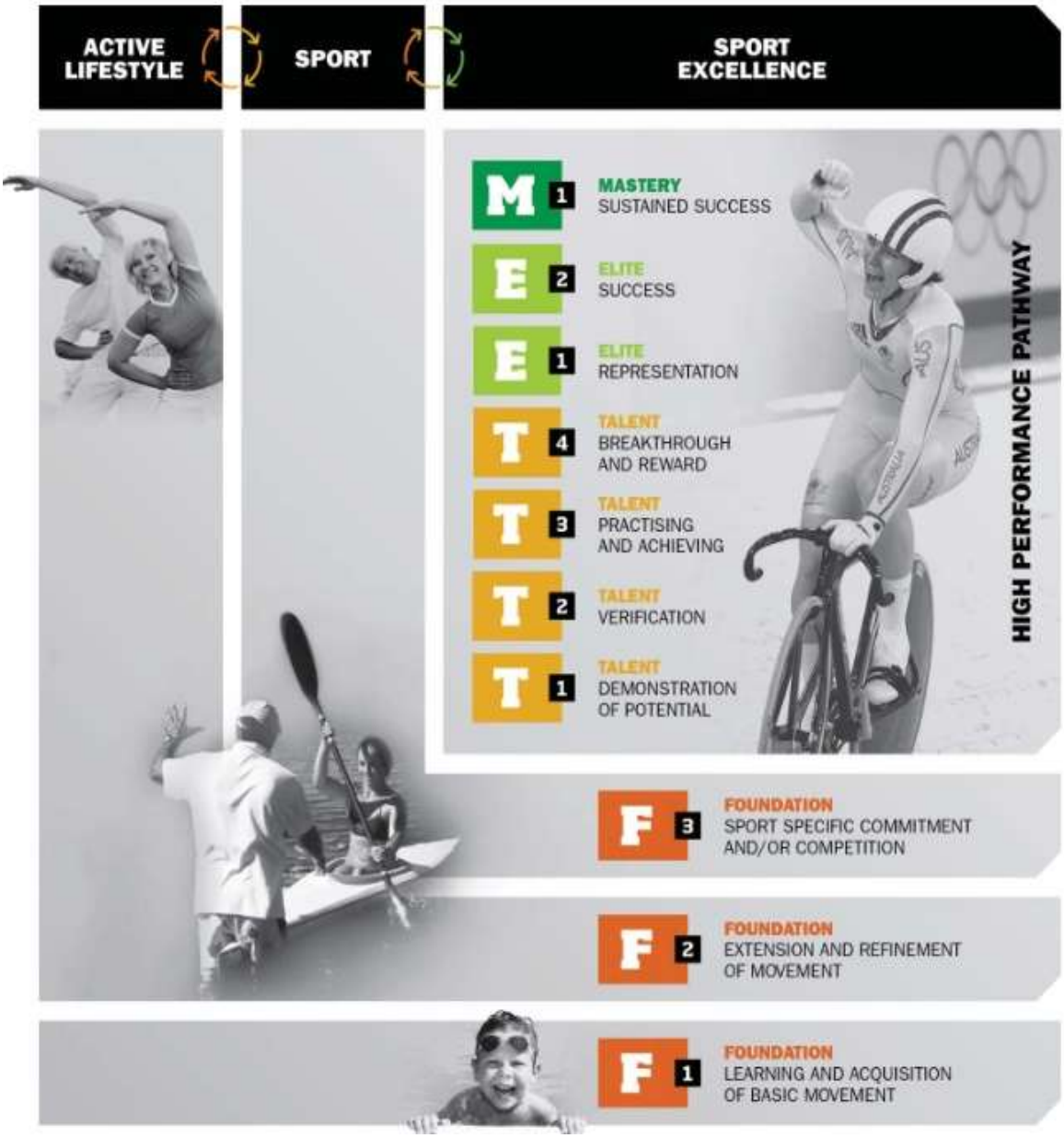


Figure 2.5

The FTEM Framework (Gulbin et al., 2013)

The talent (T) elements of the FTEM framework delineate the high-performance pathway, commencing with the identification of athletes in the top decile of their peer group (T1). This pathway progresses through subsequent stages (T2–T4), which are characterised by statistically significant improvements in performance (Gulbin et al., 2013). The primary purpose of this structured talent supply chain is to systematically enhance an individual's potential to achieve elite status while simultaneously minimising dropout. The identification and development of athletes

along this continuum relies on a combination of evidence-based metrics and the specialised knowledge of national sporting organisations (Weissensteiner, 2017).

The elite phase marks the culmination of the high-performance pathway, comprising athletes who have progressed from the talent stages to compete at the top-tier senior levels. This phase is characterised by the full integration and optimisation of physical, psychological, tactical, and technical abilities to succeed in major events such as world championships or national finals (Gulbin et al., 2013). Athletes at this level benefit from support from a comprehensive, multidisciplinary team committed to enhancing performance and sustaining consistent competitiveness in their sport (Weissensteiner, 2017). Following the elite phase, the mastery (M) phase holds dual significance. First, it refers to the few exceptional athletes who achieve sustained success and serial victories at the absolute pinnacle of their sport over multiple competitive cycles (Gulbin et al., 2013). Second, and more broadly, it underscores the importance of retaining these expert individuals as they transition from competitive careers into generative roles such as coaching, mentoring, officiating, or administration, thereby ensuring their accumulated expertise continues to benefit the sporting system for future generations (Weissensteiner, 2017).

Despite its widespread adoption and clear practical utility in high-performance pathways, the FTEM framework is subject to several theoretical and practical limitations. An evaluation of the model highlights critical shortcomings regarding its empirical basis, structural linearity, and sport-specific application.

Lack of Empirical Validation

A primary critique of the FTEM framework is the tension between its 'practitioner approach' and its lack of independent, empirical validation. The framework was presented as a practitioner-led solution rather than a scientifically validated theory, and substantial empirical evidence to validate its structure or its effectiveness in optimising athlete development is lacking (MacNamara & Collins, 2013). As with other models of athlete development, independent longitudinal research confirming that the FTEM structure genuinely optimises development or yields better outcomes than other systems is scarce (Cobley & Till, 2017). This leaves it open to the critique that it is a powerful organisational tool rather than a fully evidence-based developmental model (Till & Baker, 2020).

Linearity vs Non-Linear Development

While the framework is intended to be a flexible, multi-pathway model, its core structure remains fundamentally linear and hierarchical. A large body of research has characterised talent development as a dynamic, complex, and non-linear process (Abbott & Collins, 2004; Collins & MacNamara, 2012; Till & Baker, 2020). Athletes often experience setbacks, performance plateaus, and de-selection during the process (Collins & MacNamara, 2012). While the framework provides neat 'exit ramps' for recreational sport, it is less clear about athletes who drop back a level, overcome significant plateaus, or 're-enter' the high-performance pathway after a break. A sequential, stage-based model like FTEM struggles to adequately represent the nonlinear, often turbulent realities of an athletic career.

Talent Identification and Development

Despite the framework's well-intentioned 'Foundations' (F) stages that emphasise broad skill development, the very existence of a detailed, multi-stage 'Talent' (T) pathway can inadvertently promote the opposite (MacNamara & Collins, 2014). The structure can be misinterpreted by sporting organisations, coaches, and parents as a mandate to identify and stream talented athletes at a very young age to ensure they 'get on the pathway.' This can create pressure for early specialisation in a single sport, which has been linked to increased risks of burnout, overuse injuries, and dropout (Myer et al., 2015). Furthermore, the framework portrays talent identification as a simplistic process, whereas the complexity of talent identification (TI) is well documented (MacNamara & Collins, 2014). The number of athletes who enter the T2 phase (verification of potential) is based on the assessment of potential in the T1 phase and is generally constrained by available resources (Till & Baker, 2020). The selection of athletes in the T1 phase may therefore exclude late-maturing athletes (MacNamara & Collins, 2014). For example, within the Irish Gaelic Games context, the high status of underage representative squads, such as county development squads, can lead to a maturity-associated selection bias, favouring physically advanced early maturers over their potentially more talented, but later-maturing, peers. Consequently, the late-maturing but potentially more skilful LGF player may be overlooked or deselected, as the system is biased towards current performance rather than long-term potential. Furthermore, while the framework provides a detailed description of the stages of athlete development, it does not explain the mechanism of talent development itself and, as such, can be regarded as a useful organisational tool that maps out the what and where of a sporting journey but not the how and why of progression (MacNamara & Collins, 2014). This distinction is important for the volunteer LGF coach.

The FTEM framework may provide a map of where a player could potentially go (e.g., from T1 to T4). However, it provides no guidance to the volunteer coach on how to structure training to develop a player's physical qualities or on why a particular training modality is appropriate. This creates a significant gap between the framework's organisational structure and the practical requirements of player development.

Limited Integration of Psychosocial Factors

Finally, the FTEM framework is structurally focused on the physical and technical aspects of development and does not explicitly integrate psychosocial factors. While these can be inferred, core developmental drivers such as an athlete's motivation, social support systems, and identity outside sport are not central pillars of the framework. By omitting the essential roles of challenges, setbacks, and the cultivation of psychological characteristics, the framework describes the path but not the process of navigating it (Collins & MacNamara, 2012; MacNamara & Collins, 2014). A holistic developmental model should be built around this engine of development, focusing on nurturing the psycho-behavioural characteristics that enable an athlete to negotiate the pathway (MacNamara & Collins, 2014).

In summary, the FTEM framework is a landmark model that provides a practical, integrated language for sports development. However, its conceptual power is challenged by an underdeveloped empirical foundation. While the framework aims to be flexible, its linear structure and potential for misinterpretation in practice pose significant challenges, highlighting a gap between its commendable holistic vision and the complexities of real-world athlete development.

2.2.5 GAA Player Pathway - Adapting the FTEM Framework

The GAA, LGFA, and the Camogie Association have formally adopted the FTEM framework through the Gaelic Games Player Pathway (Figure 2.6). The pathway aims to provide a holistic, player-centred journey that supports both high performance and lifelong participation, reflecting the amateur and community ethos of Gaelic games (GAA, 2023). It has been adapted to the sport's specific needs and context and is built around six guiding principles that embody the associations' core values: 'Club is Core,' 'Player-Centred,' 'Quality Coaching Experiences,' 'Connection,' 'Inclusive,' and 'As Many as Possible, for as Long as Possible.' The inclusion of principles such as 'Connection' and 'Inclusive' reflects an effort by the Gaelic games organisations to counter a common criticism of player pathways, namely that, in practice, their talent-focused elements often overshadow their participation-focused aims, leading to a perception that they are geared primarily towards elite

outcomes. Structurally, the pathway comprises three main phases, Foundation, Talent, and Elite/High Performance, which are further divided into eight sub-phases (F1, F2, F3, T1, T2, T3, T4, and E1). Player development primarily occurs within clubs and communities during the Foundation phase. The most talented players may be further challenged outside the club environment in the Talent and/or the Elite/High-Performance spaces (GAA, 2023).



Figure 2.6

The Gaelic Games Player Pathway (GAA, 2023).

The Three Strands: Player, Environment, and Game

To simplify the complex, non-linear process of player development and accommodate diversity within the pathway, this model views development as an interaction among three strands at each stage: the player, their environment, and the game (GAA, 2023). The player remains the central focus of the pathway. The player refers to the individual and the qualities that must be nurtured over time to reach their potential, both on and off the pitch. The player strand emphasises the development of six key attributes: commitment, creativity, passion, resilience, respect, and responsibility. The environment strand includes coaches, teachers, and parents within clubs, schools, colleges, and county development squads who support players through guided challenge

and discovery, each with a specific role at certain stages. This strand also encompasses the games programme and the Gaelic games system. Finally, the game strand aims to enhance players' ability to meet the sport's specific demands. This improved competence is intended to transfer directly to performance in training and matches, which in turn can positively influence a player's intrinsic motivation and increase the likelihood of progression through the pathway. Building on the early elements of FMS in the F1 phase, players will, depending on the pathway phase, experience a different mix of capacity development. This mix includes physical, technical, tactical, and psychosocial components (GAA, 2023). This three-strand model can be interpreted as a direct attempt to address the limitations of FTEM regarding psychosocial factors. By explicitly including a 'player' strand (creativity, resilience) and an 'environment' strand (coaches, family), the GAA's framework seeks to develop the player holistically, an approach argued to be essential for long-term success (MacNamara & Collins, 2014).

2.2.6 Gaelic Games Sports Science Framework

The Gaelic Games Sports Science Framework is the GAA's comprehensive effort to operationalise the Player Pathway model. The document provides a blueprint for the support structures, personnel, and scientific principles at each stage, from the club-based Foundation (F1) to the elite (E1) level of the talent pathway (Lane et al., 2023). A key strength of the framework is its multidisciplinary and progressive approach. It outlines a systematic, escalating level of support across various domains, including Athletic Development, Nutrition, Sport Psychology, Physiotherapy, Skill Acquisition, and Performance Analysis. The provision of sports science support throughout the player pathway is considered through three key elements, focusing on recommended best practices for all participants in Gaelic Games: 'What' support is appropriate? 'Who' is responsible for delivering this support? and 'How' can the Gaelic Games system assist in its delivery? (Lane et al., 2023). The following subsections address the strengths and challenges of implementing this framework.

Strengths of the Framework.

From an athletic development perspective, at the F3/T1 stage, the focus is on improving movement competency, technique, speed, and strength. This is supported by F3 Level 1 Athletic Development coaches or individuals with a sports science-related qualification. As a player advances along the talent pathway, the framework introduces more structured elements, such as standardised fitness testing and screening, periodisation, and a higher level of coaching expertise.

At the T3/T4 stages, a high-performance environment is characterised by individualised programmes, GPS monitoring, and interdisciplinary teams. The inclusion of detailed 'Athletic Development Workload Principles' across all youth and talent stages is also a key positive, demonstrating a strong commitment to evidence-based practice and player welfare. The explicit mention of significant female health issues, including ACL injury risk and relative energy deficiency in sport (RED-S) at the T2 stage, also reflects a clear and progressive awareness of the specific needs of female athletes (Lane et al., 2023).

Challenges in Workload Management.

While the GAA Sports Science Framework is a comprehensive guide to best practice in Gaelic games, its practical application within an LGFA context is questionable. For instance, the outlined workload principles are the scientific gold standard (Lane et al., 2023). However, the document lacks a governance mechanism to ensure adherence to its provisions. For the T1–T4 LGFA player, who is also an F3 player for her club and a key player for her school, the framework offers no solution to the 'tug-of-war' between the teams. While these guidelines theoretically assign responsibility for workload management to the coaches, relying on informal cooperation without formal governance structures often fails. In practice, when coaches do not communicate, the burden of navigating these competing demands inevitably falls to the adolescent player and her parents. This systemic gap leaves the most committed and talented players, those the pathway is designed to support, most vulnerable to the risks of overload, burnout, and injury (DiFiori et al., 2014).

Challenges in Expertise and Resourcing.

For the talented adolescent LGFA player, the pathway offers a smooth progression, supported by the club (F3), into the county talent squad (T1). The framework assumes that the F3 club environment can deliver foundational athletic development. The player then advances to the T1 squad and is expected to engage in more advanced training. However, in practice, this does not always happen for many LGFA players. The crucial role of athletic development is often entrusted to volunteer coaches, making the framework's assumption of a step-up in expert-led support flawed. This is further complicated by the fact that many inter-county talent squads lack a dedicated, qualified S&C coach. The framework also recommends that qualified physiotherapists and/or athletic therapists be available for training and matches (Lane et al., 2023). Additionally, during the talent development phase, athletic development is advised to be overseen by a county-level

performance lead with accreditation at Gaelic Games Level 3 AD or its equivalent, a structure currently absent in most LGFA counties.

The primary aim of the Sports Science Framework is to provide expertise that enhances player health and performance while supporting coaches in their decision-making (Lane et al., 2023). However, within an LGFA context, significant gaps remain in coach capability, workload management, and the resources required to implement the framework effectively. This creates a noticeable gap between the model's aims and the actual experiences of talented adolescent LGFA players. Consequently, there is a critical need to quantify this discrepancy and develop practical, evidence-informed solutions that bridge the disconnect between the pathway's holistic vision and the real-world physical preparation of developing female Gaelic footballers. To do this, it is first necessary to understand the unique biological and physiological landscape of the individual at the centre of the process. The following section examines the growth and maturation characteristics of adolescent female athletes and the specific implications of these processes for physical performance and injury risk.

2.3 Growth, Maturation, and the Adolescent Female Athlete

The adolescent phase encompasses complex, non-linear biological changes that extend far beyond chronological age. For practitioners involved in athletic development, understanding how growth, maturation, and their sex-specific effects interact is crucial for designing safe and effective training programmes (Lloyd & Oliver, 2012). Ignoring these processes can lead to poorly managed training loads, increased injury risk, and an inability to optimise long-term athletic potential (Duggan et al., 2022).

During childhood, boys and girls show broadly similar patterns of growth and maturation, and many fitness components develop at similar rates, particularly before the adolescent growth spurt (Lloyd & Oliver, 2012). However, sex-based differences in physical performance are evident even in early childhood, with boys outperforming girls in running speed (3-4% faster), jumping distance (5-7% farther) (Atkinson et al., 2024), muscular strength (Handelsman, 2017), and object-control skills such as throwing and kicking (Behan et al., 2019; Chen et al., 2024). In contrast, girls typically display superior locomotor control (running, hopping, skipping), balance, and flexibility (Behan et al., 2019; Chen et al., 2024). These early differences are hypothesised to arise from a complex interplay of biological and environmental factors, including social learning through gender-specific role models and cultural activities (Chen et al., 2024).

In girls, the adolescent growth spurt typically begins around age 10, with peak height velocity (PHV) occurring at approximately 12 years (Lloyd & Oliver, 2012). Growth and maturation are marked by increases in height and weight, alongside maturation of the endocrine, cardiovascular, nervous, and muscular systems, leading to changes in performance (Quatman et al., 2006). However, during adolescence, distinct maturational differences between males and females become evident across almost all fitness components, with males making larger gains in all areas except flexibility (Ireland et al., 2004; Lloyd & Oliver, 2012). These performance variations are best explained by the greater increases in muscle size and strength observed in males than in females during adolescence, most likely due to higher increases in anabolic hormones (such as testosterone, growth hormone, and insulin-like growth factor 1) in males (Handelsman et al., 2018). Adolescent females are also more likely to show smaller increases in internal organ size and blood volume (Lloyd et al., 2018). Moreover, body composition changes significantly throughout childhood and adolescence in males, with increases in fat-free mass (FFM) and decreases in fat mass (FM) (Stratton & Oliver, 2019). By the end of the adolescent growth spurt, male FFM is 25–30% greater than female FFM, and their percentage of body fat is about half that of females (Stratton & Oliver, 2019). This largely explains the differences in athletic performance between males and females during adolescence and into adulthood, with males advantaged by relatively greater gains in muscle mass and smaller increases in FM.

Beyond these structural and morphological differences, menarche and the onset of the menstrual cycle are defining biological markers of female adolescent maturation. Hormonal fluctuations associated with the menstrual cycle, particularly variations in oestrogen and relaxin, have been identified as potential modulators of musculotendinous stiffness and joint laxity, further increasing the risk of ACL injury in female athletes (Balachandar et al., 2017; Hewett et al., 2006). The menstrual cycle can influence systemic physiology, affecting thermoregulation, substrate metabolism, and subjective markers of recovery and perceived exertion (Carmichael et al., 2021; McNulty et al., 2020). However, caution is warranted when interpreting these potential effects. Current systematic reviews indicate that much of the existing research in this domain is of low to moderate methodological quality, often yielding conflicting or trivial findings on the true impact of cycle phase on athletic performance (McNulty et al., 2020). Furthermore, individual physiological and psychological responses to these hormonal fluctuations vary greatly among athletes (Findlay et al., 2020). While further robust, high-quality research is necessary to formulate definitive, evidence-based guidelines, practitioners must nonetheless remain cognisant of these female-specific maturational markers to mitigate risks such as RED-S and ensure that workload management

strategies are responsive to the unique, individualised biopsychosocial needs of the developing athlete (Elliott-Sale et al., 2021).

2.3.1 Estimation of Biological Maturation

While athlete development models such as the YPD emphasise individualising training according to biological maturation rather than chronological age, accurately estimating maturational status remains a practical challenge. Biological maturation can be assessed using skeletal age, secondary sexual characteristics, longitudinal growth assessment, and anthropometric prediction methods (Malina et al., 2015; Towlson et al., 2021). Skeletal age is generally regarded as the criterion method for assessing biological maturity; however, radiographic assessment requires specialist expertise and clinical facilities and presents practical, financial, and ethical limitations for routine use in youth sport (Malina et al., 2015; Sullivan et al., 2023). Assessment of secondary sexual characteristics is similarly inappropriate for routine sporting environments because of its intrusive nature (Malina et al., 2015). Longitudinal assessment of stature provides a more direct means of identifying PHV but requires repeated measurements across the adolescent growth spurt and therefore cannot provide an immediate estimate of maturational timing. Consequently, non-invasive anthropometric methods have become widely used in youth sport research and practice (Malina et al., 2015). Two commonly applied approaches are the maturity-offset method (Mirwald et al., 2002) and percentage of predicted adult height (PAH) using the Khamis–Roche (KR) method (Khamis & Roche, 1994).

The Maturity-Offset Method

The Mirwald equation estimates the number of years an individual is from PHV using chronological age, standing height, sitting height, and body mass (Mirwald et al., 2002). It therefore provides an estimate of maturational timing rather than maturity status and has been widely used to account for maturational differences among athletes of the same chronological age (Malina et al., 2015; Towlson et al., 2021). Its principal advantage is practicality: it is non-invasive, inexpensive, and can be administered with basic anthropometric equipment, making it suitable for large cohorts and field-based settings (Cumming et al., 2017).

However, the method is subject to limitations in predictive accuracy. Maturity-offset equations have performed reasonably well for average-maturing boys near PHV but show greater error among early- and late-maturing individuals, with particularly important limitations reported in girls (Kozieł & Malina, 2018). Predictions also tend to compress the observed variation in age at

PHV, yielding predicted ages that are later than observed in early-maturing individuals and earlier than observed in late-maturing individuals (Kozieł & Malina, 2018). These limitations are particularly relevant to female youth sport, given that validation research has historically been heavily weighted towards male participants. Baker et al. (2025), for example, reported that 92% of participants across the reviewed studies were male. Consequently, maturity-offset estimates should be interpreted cautiously when used to classify individual athletes.

A further limitation arises when continuous maturity-offset estimates are converted into categories such as pre-, circa-, and post-PHV. Although categorisation may facilitate practical interpretation, it imposes thresholds on a continuous biological process and can increase the risk of misclassification around category boundaries (Baker et al., 2025; Towlson et al., 2021). Maturity offset is therefore best interpreted as an estimate of maturational timing, rather than a definitive measure of biological maturity.

Percentage of Predicted Adult Height

The KR method offers an alternative, non-invasive approach by estimating adult stature from chronological age, current stature, body mass, and mid-parental stature, allowing current height to be expressed as a percentage of predicted adult height (Khamis & Roche, 1994). Unlike maturity offset, which estimates distance from PHV, PAH provides an estimate of maturity status relative to predicted adult stature (Khamis & Roche, 1994). Its principal advantage is therefore the ability to estimate maturational status without radiographic assessment, making it feasible for youth sport.

However, the method also has limitations. Its estimate depends partly on accurate parental stature measurements and on predicting adult height, meaning that uncertainty in predicted final stature is incorporated into the resulting maturity-status estimate (Khamis & Roche, 1994; Towlson et al., 2021). Furthermore, although PAH% provides a continuous estimate of maturity status, it is often used to classify athletes into maturational groups using predefined thresholds. The choice of these thresholds can influence the resulting maturity-group classifications (Towlson et al., 2021). Thus, KR provides a useful alternative to maturity offset but, like other anthropometric approaches, should be regarded as an estimate of maturity status rather than a direct measure of biological maturity.

Overall, maturity-estimation methods offer a practical compromise between feasibility and precision. Direct methods, such as skeletal age, provide a more direct assessment of biological

maturation but are generally impractical in youth sport, whereas anthropometric approaches enable large-scale field-based assessment but introduce prediction error (Malina et al., 2015; Towlson et al., 2021). Their interpretation therefore requires consideration of the method used, its population-specific limitations, and the uncertainty associated with converting continuous estimates into categorical maturational groups.

2.3.2 Implications for Performance

The hormonal and biomechanical changes during maturation have profound and divergent implications for male and female athletic performance. Adolescent boys undergo an accelerated phase of neuromuscular development, with increases in power, strength, and coordination as they mature (Lloyd & Oliver, 2012; O'Brien-Smith et al., 2020). For example, adolescent males demonstrate steady increases in lower-body power measures, such as the vertical jump, whereas adolescent females do not exhibit comparable maturation-driven gains (Myer et al., 2011). These maturational divergences, compounded by historically disparate training environments, are evident in the physical profiles of elite field-sport athletes. A comparison of the fitness profiles of male and female elite and non-elite soccer players revealed significant age- and sex-specific differences in fitness traits. For instance, in tests of vertical jump, 15 m linear speed, and 15 m agility, senior male players outperformed senior female players by 33.9%, 13.6%, and 12.6%, respectively, while junior male players outperformed their female counterparts by 54.7%, 16.2%, and 24.7% in the same tests (Mujika et al., 2009). A notable difference was also observed in 20 m sprint times between senior international female and senior professional male rugby league players: 3.36 ± 0.18 s vs 3.09 ± 0.12 s (Dobbin et al., 2019; Jones et al., 2016). Similar significant differences between junior and senior athletes, as well as between males and females, in speed, vertical jump, and aerobic endurance have been documented in rugby union and rugby sevens (Bradley et al., 2020; Clarke et al., 2017).

Although maturation-related changes in strength, power, and speed are generally less pronounced in adolescent females than in males, this does not indicate an absence of trainability. In the absence of specific, structured neuromuscular training, female athletes frequently experience a performance plateau in traits such as strength and speed during mid-to-late adolescence (Quatman-Yates et al., 2013; Stratton & Oliver, 2019), with peak power often stagnating around 16 years of age (Papaiakovou et al., 2009). However, evidence indicates that adolescent females retain substantial capacity to adapt to structured training. Luo et al. (2025) reported moderate-to-large improvements in linear sprint performance and moderate improvements in vertical jump and change-of-direction speed following strength and plyometric training in female adolescent team-

sport athletes. Evidence shows that, with appropriate, structured neuromuscular training, adolescent females can continue to improve lower-body strength, power, speed, and endurance well into adulthood (Doyle et al., 2021; Emmonds et al., 2020; Radnor et al., 2018; Ramos et al., 2019, 2021).

2.3.3 Implications for Injury Risk

The risk of sports-related injury increases significantly at different stages of growth and development (Rumpf & Cronin, 2012). While muscle strains and ankle sprains are the most common injuries in youth field sports (Sanchez-Sanchez et al., 2025), rapid limb lengthening during peak height velocity (PHV) creates unique structural vulnerabilities. This accelerated bone growth often outpaces the lengthening of the surrounding muscle-tendon units, leading to transient reductions in motor skill performance, commonly known as 'adolescent awkwardness' (Read et al., 2019).

As adolescents mature, increased exposure to training and competition leads to greater repetitive loading, which can further increase the risk of injury (Read et al., 2019). The biological mismatch between bone and muscle-tendon growth rates frequently manifests as traction apophysitis at specialised growth plates that are subjected to repetitive loading during kicking, jumping, and running (Adirim & Cheng, 2003; DiFiori et al., 2014). The most common sites for apophysitis are the insertion of the patellar tendon on the tibial tubercle (Osgood-Schlatter disease) and the insertion of the Achilles tendon and plantar fascia on the calcaneus (Sever's disease) (Adirim & Cheng, 2003). While early-to-mid adolescence is dominated by these active growth-related conditions, athletes competing at the inter-county LGF level are typically post-PHV. Although the period of rapid skeletal growth has concluded, the sport's physical demands continue to rise. When athletes are subjected to the high training volumes and repetitive match-play loading inherent in inter-county environments, the injury profile shifts from growth-related conditions towards more general soft-tissue and joint structural injuries. Physiological changes such as increased joint laxity, increased knee valgus angle, poor trunk neuromuscular control, and reliance on quad-dominant landing strategies that emerge during puberty frequently remain ingrained if not actively corrected (Fort-Vanmeerhaeghe et al., 2016a, 2016b).

These specific maturational vulnerabilities have been explicitly linked to an increased risk of lower-limb injuries, particularly ACL injuries (Lloyd & Oliver, 2012). In LGF, the lower limb overwhelmingly dominates the injury profile. An analysis of insurance claims shows that knee injuries account for the highest proportion of cases (26.9%), followed by the ankle (13.1%) and

hamstring (9.3%) (O'Connor et al., 2023). Within this profile, ACL ruptures account for just 7.8% of total claims (approximately 1 in 12) but represent a disproportionately severe burden, accounting for 46.7% of total injury fund expenditure and 66% of all hospitalisation costs (O'Connor et al., 2023). These findings are aggregate data across both adult and juvenile LGFA memberships, with the juvenile category encompassing ages 4–18 years. These data limitations led the authors to recommend that future LGFA research focus exclusively on adolescent groups to prevent youth trends from being masked (O'Connor et al., 2023). Nevertheless, these overall trends underscore a serious financial and physical burden. Furthermore, the implications of an adolescent ACL injury extend far beyond immediate surgical intervention and sports absence, as the relative risk of early-onset post-traumatic osteoarthritis is increased, potentially leading to chronic functional limitations and a permanently diminished quality of life (Sanchez-Sanchez et al., 2025).

2.3.4 Implications for Adolescent Female Team Sports

Team sports such as soccer, rugby, basketball, and LGF are characterised by high-impact, multi-directional movements, including deceleration, cutting, and landing from jumps (Brown & Waller, 2014). These movements are precisely the mechanisms most often associated with non-contact ACL injuries (Hewett et al., 2006). While injuries in adult teams are typically evaluated through the lens of short-term team performance, the developmental consequences of severe injuries in youth players are far more pervasive. Being sidelined for an extended period (> 28 days) during the formative years fundamentally disrupts the tactical, technical, and physical adaptation windows (Le Gall et al., 2007). More critically, these prolonged athletic interruptions can permanently derail long-term athletic development, career prospects within the sport, and overall adolescent health outcomes (Maffulli et al., 2010). Mitigating these risks requires proactive, evidence-based injury prevention strategies embedded directly within the physical preparation framework for youth field-sport athletes. Effective programming should move beyond traditional, general fitness paradigms to actively safeguard athletes during this sensitive maturational phase (Hewett et al., 2006). Early athletic development interventions, incorporating age-appropriate resistance training, plyometric progression, and deceleration mechanics, are particularly critical during these early stages of organised sports participation to counteract the biomechanical deficits associated with maturation (Fort-Vanmeerhaeghe et al., 2016b). Consequently, the adolescent female team-sport athlete represents a unique population requiring a distinct, developmentally appropriate approach that prioritises movement quality over simply increasing training volume. Within this landscape, the strength and conditioning practitioner plays a crucial role, ensuring that

fundamental movement patterns are continuously relearned, refined, and reinforced to mitigate risk and support long-term athletic development (Read et al., 2019).

2.4 The Physical Demands and Key Qualities for LGF Performance

To prepare athletes effectively for elite competition, it is essential to understand the specific physiological requirements of their sport. This section explores the physical demands placed on LGF players and identifies the key athletic qualities required for high performance. It begins with an overview of the game, before detailing the specific locomotor demands and match-play characteristics essential for success at senior inter-county level. It then examines how these demands progress from youth to adult competition, culminating in an exploration of the core physical qualities, such as strength, speed, and endurance, that underpin optimal LGF performance.

2.4.1 Overview of the Game

Ladies Gaelic Football players follow a structured developmental pathway that introduces progressive physical and competitive demands. Children aged 8–12 participate in non-competitive matches, known as Go Games, before progressing to organised competitive structures at each subsequent age level. Adolescents compete at various levels and may represent their club, school, county, or provincial teams, often playing in both football and camogie codes (Byrne et al., 2021), as well as other sports. The highest level of youth participation is inter-county representation, where top club players are selected for U14, U16, and U18 squads, with eventual progression for some to the senior panel (LGFA, 2025). This multi-team and potential multi-code participation, while common, places a significant cumulative load on the developing adolescent athlete and creates unique challenges for coaches regarding training periodisation, load monitoring, adequate recovery, and the mitigation of injury and burnout risks, issues that are central to their long-term physical preparation (Duggan et al., 2022a).

While LGF shares many foundational similarities with male Gaelic football, historical rule differences have fundamentally shaped the physical and technical demands of the ladies' game. LGF matches are shorter in duration (60 minutes versus 70 minutes for senior men's inter-county fixtures). Players are permitted to pick the ball directly off the ground while standing, kickouts can be taken from the hand or the ground from the 21 m line, and two points are awarded for a 45 m free (Malone et al., 2023; Kelly et al., 2022). However, both codes have recently undergone the most significant structural revisions in their modern histories. Following the introduction of sweeping rule

changes to male Gaelic football in 2025 (GAA, 2024), the LGFA trialled 12 playing enhancements for the 2026 season to promote faster, more continuous play. Six of these modifications explicitly realigned the ladies' code with the new men's rules, including the introduction of a 40 m two-point scoring arc, a kick-out mark, and the ‘solo and go’ following a foul. Furthermore, the new rules mandate that at least three outfield players remain in the opposition half, the advancement of the ball by 50 m for delaying play, and the penalisation of team official dissent with a free kick from the 13 m line (LGFA, 2025c).

The remaining six enhancements are specific to the evolution of LGF and significantly alter traditional constraints (LGFA, 2025c). These include provisions for 'controlled contact’, allowing players to use their bodies to fairly contest possession, provided there is no excessive force. Tackling rules have also been modified to permit the dispossession of an opponent holding the ball against her body, provided the initial contact is on the ball. Defending players are now permitted to use one or both hands below shoulder height to legally delay an opponent's forward movement and prevent collisions. The strict persistent-fouling metric has been formalised, with three non-technical fouls automatically resulting in a yellow card and 10 minutes in the ‘sin-bin’. Finally, to promote attacking play, 45 m kicks must now be played forward, and the ‘square ball’ rule has been amended to permit an attacking player to legally enter the small rectangle after the final play of the ball during open play (LGFA, 2025c). While empirical research has yet to quantify the physiological or tactical impacts of these concurrent modifications, the evolution of the two sports suggests that applying legacy research from male Gaelic football to the female game may not capture its current nuances. This underscores a clear need for original, code-specific studies to accurately characterise the modern demands of LGF.

2.4.2 The Physical Demands of Senior Inter-County Ladies Gaelic Football

Establishing a performance benchmark for senior ladies' Gaelic football is an important first step in understanding the long-term physical development required for an adolescent player to transition successfully to the highest level of competition. However, research on the running demands of LGF remains limited. To date, only two studies have examined the game demands at senior inter-county level, and none have examined them at the club or youth levels. These studies have provided foundational data on physical outputs during competitive inter-county matches, helping to establish performance benchmarks. LGF is a high-intensity, intermittent field sport that places significant physical demands on players. While positional differences are significant, the mean distance covered across all outfield players during match play was 7,319 ± 1,021 m,

corresponding to a relative work rate of 116 ± 9 m·min−1 (Malone et al., 2023). Of this, 1,547 ± 432 m was high-speed running (≥ 4.4 m·s−1), and 630 ± 287 m was classified as very high-speed running (≥ 5.5 m·s−1). High-speed running accounted for 20.6 ± 5.4% of match-play (Malone et al., 2023). Players performed 42 ± 6 accelerations (≥ 3 m·s−2) and 53 ± 9 decelerations (≥ -3 m·s−2). The maximum velocity achieved was 7.17 ± 0.41 m·s−1, reflecting a relative maximum velocity of 86 ± 4% (Malone et al., 2023).

Positional Running Profiles

A key finding in both studies was the significant variation in running performance across playing positions. The middle three positional lines, comprising half-backs, midfielders, and half-forwards, consistently recorded the highest locomotor outputs compared with the full-back and full-forward lines. Table 2.1 provides a detailed breakdown of the running demands for each positional line. Half-backs, midfielders, and half-forwards recorded the highest total distances (TDs), covering substantially more distance than full-backs and full-forwards ($p < .05$, $\eta_p^2 = 0.201$) (Malone et al., 2024). A similar pattern was observed for high-speed running, with half-backs, midfielders, and half-forwards covering significantly greater distances than full-backs and full-forwards ($p < .05$, $\eta_p^2 = 0.175$) (Malone et al., 2024). This trend persisted in very high-speed running, where the middle three positional lines covered more ground than the inside lines ($p < .05$, $\eta_p^2 = 0.215$) (Malone et al., 2024). Full-backs and full-forwards showed a higher number of accelerations and decelerations than other positions ($p < .05$, $\eta_p^2 = 0.325$). There were no significant differences among positions in maximal velocity or the percentage of peak velocity during match play (Malone et al., 2024).

Table 2.1

The Running Profile of Senior Inter-County Ladies Gaelic Football with Respect to Position (Adapted from Malone et al., 2024)

	Full-Back	Half-Back	Midfield	Half-Forward	Full-Forward
Total Distance (m)	6,607 ± 878 [bd]	7,539 ± 854 [d]	7,937 ± 909 [abde]	7,711 ± 787	6,731 ± 679 [bd]
Relative Distance (m·min^{-1})	105 ± 14 [bd]	120 ± 13	126 ± 12 [abde]	122 ± 17	107 ± 19 [bd]
HSR (m)	1,280 ± 378 [bd]	1,750 ± 504	2,154 ± 453 [abde]	1,730 ± 554	1,380 ± 342 [bd]
Relative HSR (m·min^{-1})	20 ± 6 [bd]	28 ± 8	34 ± 7	27 ± 7	22 ± 5 [bd]
VHSR (m)	393 ± 111 [bde]	514 ± 184 [d]	932 ± 180 [abde]	744 ± 151	587 ± 197 [bd]
Peak Velocity (m·s^{-1})	7.04 ± 0.49	7.08 ± 0.51	7.45 ± 0.44	7.38 ± 0.41	7.20 ± 0.48
% Peak Velocity	86 ± 4	88 ± 4	89 ± 4	87 ± 2	88 ± 4
Accelerations (≥3 m·s^{-2})	44 ± 5 [c]	42 ± 5	35 ± 5	44 ± 7	50 ± 8 [c]
Decelerations (≤-3 m·s^{-2})	58 ± 5 [c]	51 ± 4 [c]	48 ± 3	56 ± 5 [c]	59 ± 6 [c]

Note. HSR = high-speed running; VHSR = very high-speed running. Data are presented as Mean ± SD. [a] Significantly different ($p < .05$) from Full-Backs. [b] Significantly different ($p < .05$) from Half-Backs. [c] Significantly different ($p < .05$) from Midfielders. [d] Significantly different ($p < .05$) from Half-Forwards. [e] Significantly different ($p < .05$) from Full-Forwards.

Specific positional profiles are common across most competitive team sports (Clarke et al., 2019; Datson et al., 2017; S. Malone et al., 2017c; McGuinness et al., 2019b; Young et al., 2021). As illustrated in Table 2.1, inter-county LGF exhibits a distinct positional profile in which the middle three lines (half-backs, midfielders, and half-forwards) accumulate greater total distance and higher-intensity running volumes than the inside full-back and full-forward lines (Malone et al., 2024). These middle three positional lines are often referred to as 'transitional' lines and frequently participate in gaining possession and linking attacking and defensive play. While the middle three lines require greater metabolic endurance than the inside lines, the full-back and full-forward lines had similar running profiles and showed more accelerations and decelerations, despite covering shorter total running distances (Malone et al., 2023). This highlights the unique mechanical load experienced by the inside lines. These positions often assume semi-restricted roles during both defensive and offensive phases of play. Full-backs and full-forwards need to position themselves close to the scoring area to contribute to attacking and defensive structures, particularly when

marking an opponent, as with full-backs (Malone et al., 2024). These roles involve short, explosive movements in congested spaces, including marking opponents, creating separation, and contesting possession, which require neuromuscular power and the ability to brake and re-accelerate efficiently (Harper & Kiely, 2018), which is a distinct demand from the metabolic endurance required for the middle three positions.

Tactical Influences on Running Demands

While LGF exhibits a clear positional running profile, evidence from the male game shows that these demands are not fixed and can vary significantly depending on performance levels, players' technical proficiency, and tactical strategies (McGahan et al., 2021). Because the LGF positional profile closely mirrors established findings in male Gaelic football (S. Malone et al., 2017c; McGahan et al., 2021), insights from the men's game provide valuable context. For example, in the male game, full-backs and midfielders in Division 3 had greater running demands than those in similar positions in Division 1. These players also demonstrated lower technical proficiency, completing fewer tackles in the middle third, which led to more involvements for the full-back line and, consequently, higher running demands (McGahan et al., 2021). Additionally, Division 1 teams executed more kick-passes than Division 3 teams, which could explain the lower high-speed running distance covered by Division 1 teams; since the ball travels farther in kick-passes than in hand-passes, the need for constant support running is reduced (McGahan et al., 2021; Timmons et al., 2025). The development of advanced tactical formations, such as counterattacking as a unit, utilising high and low blocks similar to soccer, employing zonal marking with a plus-one, or deploying a sweeper system where the centre half-back or half-forward assists the full-back line, can also influence the running requirements of these positional lines (Malone et al., 2023, 2024; Timmons et al., 2025).

Temporal Patterns

In addition to positional differences, significant temporal variations in LGF running performance have been observed. Both studies report a significant decline in running output as the game progresses (Malone et al., 2023, 2024). Half-by-half analysis shows that running intensity decreased notably in the second half, with the largest declines in the middle three positional lines. HSR was lower ($p < .05$) in the second half for half-backs (ES: 0.70; moderate), midfielders (ES: 1.02; moderate), and half-forwards (ES: 0.64; moderate) (Malone et al., 2023). VHSR followed similar patterns, with lower values in the second half for half-backs (ES: 0.83; moderate), midfielders (ES: 1.32; large), and half-forwards (ES: 0.69; moderate). Accelerations and decelerations also decreased

between halves for the middle three positional lines ($p < .05$; ES: 0.59–1.20; moderate) (Malone et al., 2023).

When analysing performance across quarters, a significant position-by-quarter interaction was observed ($F = 14.31$, $p < .001$, $\eta_p^2 = 0.137$) for all running performance variables, except peak velocity and percentage peak velocity (Malone et al., 2024). The first quarter was the most intense period of play. A consistent trend of reduced locomotor performance was evident in the second and fourth quarters for total distance (TD, $\eta_p^2 = 0.229$), high-speed running (HSR, $\eta_p^2 = 0.195$), very high-speed running (VSR, $\eta_p^2 = 0.117$), relative TD ($\eta_p^2 = 0.379$), and relative HSR ($\eta_p^2 = 0.209$) (Malone et al., 2024). The middle eight positions showed larger decreases in locomotor performance across the second and fourth quarters than the inside lines (Malone et al., 2024). When accelerations ($\eta_p^2 = 0.198$) and decelerations ($\eta_p^2 = 0.287$) were examined, a consistent decline in both was observed during the second and third quarters. Full-backs and full-forwards performed the most accelerations and decelerations across positional lines and experienced a greater reduction in these actions as the game progressed (Malone et al., 2024). A slight increase in intensity was seen at the start of the third quarter (after half-time), but it typically did not return to the levels seen in the first quarter (Malone et al., 2024).

Mechanisms of Performance Decline

The decline in LGF match-running performance observed across both halves and quarters of play can be attributed to several factors commonly identified in broader team-sport literature. The physical demands of competitive match play can lead to physiological fatigue, as studies indicate that players often have depleted glycogen levels after match play (Paul et al., 2015). However, it is challenging to identify fatigue through time-motion analysis, since field team sports are inherently submaximal, with players typically operating within their physical capacity (Waldron et al., 2014). Furthermore, because LGF is a skill-based sport that requires sustained concentration, perceptual skills, and continuous decision-making during a game, mental fatigue is likely to occur (McLoughlin et al., 2023). Mental fatigue is defined as a psychobiological state caused by prolonged periods of demanding cognitive activity, characterised by subjective feelings of tiredness and impaired attention and decision-making (Knicker et al., 2012). While a decline in match-running performance is often attributed to physical capacity, mental fatigue may interact with processes that limit physical performance. Mental fatigue increases perceived effort and reduces overall and low-intensity running during intermittent exercise (Smith et al., 2015). Additionally, it has been shown to impair soccer-specific performance aspects such as running, passing, and shooting (Smith et al., 2016).

Therefore, the temporal decline in LGF match-running performance is likely multifactorial, stemming from physical and mental fatigue, or both. The observation that the middle positional lines experience the greatest performance decrements highlights a key tactical challenge for coaches, namely that the players most responsible for the team's transitional play are also the most susceptible to fatigue. This indicates that a team's ability to maintain its tactical shape and high-intensity transitions depends directly on the specific fatigue resistance of its half-backs, midfielders, and half-forwards.

Reductions in match running performance have also been attributed to players consciously or subconsciously employing pacing strategies to sustain physical and technical performance in the later stages of the match (Paul et al., 2015). Pacing and fatigue are inherently linked during team sport performance. Unlike fatigue, which is an involuntary, unidirectional decline in performance, pacing is the strategic allocation of energy resources to ensure availability for critical match scenarios (Waldron et al., 2014). This self-regulation is not merely a reaction to tiredness but a proactive approach to ensure that limited energy reserves are available for game-defining moments, such as a breakaway scoring opportunity or a last-ditch defensive tackle. A key indicator of this strategy is the preservation of peak velocity despite a reduction in total work rate. This suggests that players are successfully reserving their maximum neuromuscular output for these critical periods (Waldron et al., 2014). In the context of senior inter-county LGF, total high-intensity running volume decreased significantly in the second half, but peak velocity did not (Malone et al., 2023, 2024). This maintenance of maximal sprint capability suggests that the observed drop in running volume may reflect intelligent pacing rather than total neuromuscular exhaustion. Maintaining peak velocity indicates that players still possess the capacity for a maximal sprint when the game demands it, likely influenced by factors such as the scoreline, opposition, and tactical instructions (Mangan et al., 2017, Paul et al., 2015).

Comparison with Other Female Team Sports

To contextualise these findings within the broader landscape of female team sports, relative intensity ($m \cdot min^{-1}$) is the most effective metric for comparing overall work rate, as it enables comparisons not only within the sport but also across other sports (Aughey, 2011). The average work rate in senior inter-county Ladies Gaelic Football (116 $m \cdot min^{-1}$) is similar to that observed in other elite sports. For example, international soccer has an intensity profile of 100–120 $m \cdot min^{-1}$, while international female field hockey players have average locomotor intensity profiles ranging from 70–124 $m \cdot min^{-1}$ during match play (Datson et al., 2017; McGuinness et al., 2019b). In women's

international rugby sevens, relative intensity has been reported to range from 94–116 m·min^{-1}, while the Australian Football League Women's (AFLW) is played at an intensity of 95–126 m·min^{-1} (Clarke et al., 2015; Clarke et al., 2019). However, comparisons beyond this normalised work rate, particularly regarding metrics such as high-speed running, must be interpreted with caution. Methodological differences, such as varying velocity thresholds used in the literature, along with fundamental differences in match duration, pitch dimensions, number of players, rules, substitutions, and tactical systems, can complicate direct comparisons. Therefore, while senior inter-county LGF exhibits a high overall work rate comparable to that of international and professional female field team sports, its unique locomotor profile is ultimately shaped by the specific demands of the game.

2.4.3 Progression of Match Demands from Youth to Senior Level

While these findings establish a foundational knowledge of the senior inter-county LGF game, understanding the progressive increase in demands from youth to adult competition is equally critical. The demands of team sport match-play increase with age and playing level across a variety of field-based sports (Casamichana et al., 2024; Clarke et al., 2017; Jennings et al., 2025; Ramos et al., 2019). In rugby sevens, small to moderate differences were found across junior, senior, and elite levels for sprint distance, relative distance, and maximum speed (Clarke et al., 2017). In soccer, as players advanced from U15, U16, and U17 age groups through to collegiate, professional, and international levels, the total match distance increased linearly from 6,936 ± 335 m to 10,144 ± 546 m, while the intensity of play rose from 87 ± 4 m·min^{-1} to 111 ± 6 m·min^{-1} (Vescovi et al., 2021). Younger players also spent proportionally more time walking and less time engaged in high-intensity running (> 16 km·h^{-1}; 545 ± 141 m vs 1,251 ± 276 m) than international players (Vescovi et al., 2021). The increased demands from youth to international levels were partly related to longer match durations (80 min vs 90 min), but more importantly, to higher match tempo (Vescovi et al., 2021). Similarly, when comparing the match-play activity demands of the developmental U18 pathway to the senior AFLW, the most notable differences were the greater relative distance and the very high-speed running requirements. Senior AFLW players cover an average of 117 m·min^{-1}, compared with 111 m·min^{-1} in the U18 national championship, while very high-speed running distances are reported to be two to three times higher (107–238 m) in the AFLW than those experienced in the U18 developmental competition (48–85 m; Jennings et al., 2025).

This age-related progression in physical demands has also been documented in male Gaelic football, where increases in running volume and match intensity are required as players transition

from adolescent age grades to senior inter-county levels. Studies examining male underage Gaelic football indicate that Under-15 and Under-18 players cover similar total distances in 60-minute matches (5,732 ± 1,047 m and 5,774 ± 737 m, respectively) (Cullen et al., 2013; Reilly et al., 2015). However, direct comparisons of high-speed running between the age groups are precluded by methodological differences. Specifically, while U15s accumulate 851 ± 297 m of high-speed running (Reilly et al., 2015), comparable accumulated volumes cannot be determined from the U18 data (Cullen et al., 2013). Nevertheless, a substantial physiological step-up is required to transition to the elite adult level, where longer match durations and elevated game tempos demand that senior inter-county players cover significantly greater total distances (8,889 ± 1,448 m) and high-speed running volumes (1,596 ± 594 m) (S. Malone et al., 2017c).

While these foundational youth profiles exist in male Gaelic football, and clear locomotor progressions are defined in soccer, rugby, and AFLW, the specific match-play demands of adolescent LGF and how they compare directly with the senior game remain unquantified. This lack of data prevents the creation of an evidence-informed developmental pathway, leaving practitioners to rely on anecdotal experience rather than empirical benchmarks when preparing adolescent LGF players for the specific demands of youth competition and their eventual transition to senior football.

2.4.4 Key Physical Qualities for LGF Performance

While match-play data, such as total distance and high-speed running volume, quantify the external running demands of competition, a deeper understanding of performance requires examining the underlying physical qualities that enable players to meet these demands. Key physical attributes, including strength, power, speed, endurance, and mobility, drive the specific, game-deciding actions in LGF. The following section will examine how these core physical qualities translate directly into on-field actions during match play.

Strength and Power

Muscular strength is fundamentally defined as the ability to apply force maximally in a single action under specific conditions. Consequently, it represents a multidimensional capacity rather than a singular isolated trait (James et al., 2023). Depending on the external load and the time available to express force, strength can be classified into five distinct, independent qualities: maximal isometric strength, explosive strength, heavy maximal dynamic strength, fast maximal dynamic strength, and reactive strength (James et al., 2023). Developing these specific strength

qualities is fundamental to a range of attributes that enhance an athlete's performance across general and sport-specific skills (Suchomel et al., 2016) and is closely linked to overall athletic development, including running speed, power, change-of-direction speed, jumping ability, endurance, and fundamental movement skill (FMS) proficiency (Lloyd & Oliver, 2012). Athletes with greater baseline strength also perform better on sport-specific tasks across disciplines such as rugby, baseball, handball, cycling, ice skating, and track-and-field throws (Suchomel et al., 2016).

Power is the expression of strength at high velocity and is critical for explosive actions (Hughes et al., 2024). These specific strength characteristics have been shown to distinguish elite from sub-elite playing standards in Ladies Gaelic Football (LGF). Elite players exhibit superior reactive, explosive, and maximal strength (peak force) compared with their sub-elite counterparts, with effect sizes ranging from moderate to large (Hughes et al., 2024). Specifically, elite players achieved higher peak force values than sub-elite players (2,114 ± 280 N vs 1,810 ± 357 N; E.S. = 0.91; Hughes et al., 2024). This physical superiority was also evident in explosive and reactive capabilities, with elite athletes demonstrating greater jump heights (0.274 ± 0.045 m vs 0.237 ± 0.043 m; ES = 0.85) and higher reactive strength index values (1.47 ± 0.28 vs 1.22 ± 0.27; ES = 0.91; Hughes et al., 2024). In LGF, these qualities are essential for many on-field actions. Both upper- and lower-body strength are needed to apply and absorb force when legally challenging an opponent for the ball, breaking through a tackle, or shielding possession. A strong and stable core is vital for efficient force transfer during these physical interactions (Shaikh et al., 2019). High-catching, a core skill in LGF, requires significant lower-body power. The explosive triple extension of the ankles, knees, and hips allows a player to maximise jump height and gain an aerial advantage (Lloyd & Oliver, 2012).

Muscular strength and power are consistently associated with improved kicking performance in female field sports (Ball et al., 2013; Inoue et al., 2014). Kicking for distance, whether by hand or from the ground, is a full-body power movement that involves a rapid transfer of force through the kinetic chain. The support (stance) leg plays a crucial role in initiating the kick by providing stability, absorbing landing forces, and transferring energy to the pelvis and torso. A straighter, stronger stance leg with greater braking force and reduced ground contact time is associated with higher foot velocities at ball contact and longer kicks (Ball et al., 2013). The core and pelvis act as transmission hubs, redistributing energy from the lower limb and rotating the trunk, which is essential for effective proximal-to-distal (core-to-limb) sequencing and maximum kicking force (Inoue et al., 2014). The kicking leg then completes the movement, amplifying the velocity generated upstream for explosive ball contact. Optimal mechanics rely on the entire lower-body kinetic chain working in coordination (Ball et al., 2013; Inoue et al., 2014).

Speed and Agility

The large pitch dimensions and the intermittent, chaotic nature of LGF place a premium on an athlete's ability to move quickly, both in a straight line and in response to opponents, teammates, and the ball. Sprinting ability is a fundamental aspect of performance in team sports, including GAA, football, rugby, hockey, and Australian rules football (Lockie et al., 2011). Acceleration, defined as the rate of change in velocity or the ability to rapidly increase running speed from a static or low-velocity state, is often argued to be more important in team sports than maximum velocity (Lockie et al., 2011). This is reflected in match data, with adult inter-county female LGF players performing an average of 42 ± 6 accelerations (≥ 3 $m \cdot s^{-2}$) and 53 ± 9 decelerations (≥ −3 $m \cdot s^{-2}$) per game (Malone et al., 2023). Similarly, in women's soccer, short sprints predominate, with 76% and 95% of all sprints between 0–5 m and 0–10 m, respectively (Datson et al., 2017). Acceleration is highly dependent on an athlete's relative strength and capacity to produce high horizontal forces (Comfort et al., 2014; O'Driscoll et al., 2024). High levels of acceleration are necessary for Gaelic footballers to win possession, evade an opponent, and transition quickly from defence to attack or vice versa (Bolger et al., 2025; Duggan et al., 2023). While acceleration is crucial for gaining an advantage, rapid deceleration is equally critical and arguably more physically demanding. High-intensity decelerations require large, eccentric muscle contractions to absorb braking forces, imposing a severe mechanical load on the lower limbs that contributes significantly to neuromuscular fatigue and muscle damage (Harper & Kiely, 2018).

Despite the high frequency and physiological toll of these short accelerative and decelerative bursts, the capacity to achieve a high absolute maximum velocity remains an equally important metric for team-sport athletes. The maximum velocity of senior LGFA players is reported as 7.17 ± 0.41 m·s−1, reflecting a relative maximal velocity of 86 ± 4% (Malone et al., 2023). Running at high maximum velocity enables players to outrun defenders, create scoring opportunities, break through defensive lines, facilitate effective positioning, and enable quick transitions between defence and attack and vice versa (Comfort et al., 2014; Haugen et al., 2014). Another goal of maximal-velocity sprinting is to achieve a high stride frequency in conjunction with an optimal stride length (Duggan et al., 2022a). It is recommended that female Gaelic team-sport athletes perform sufficient maximal-velocity sprinting (> 90% of their maximal velocity) during the season, as this may help reduce the risk of hamstring injury (S. Malone et al., 2017c). Therefore, improving acceleration and maximum-velocity mechanics may enhance performance and reduce the risk of posterior-chain injuries among female Gaelic team-sport athletes (Duggan et al., 2022a).

While linear speed, encompassing both acceleration and maximum velocity, is fundamental, the chaotic nature of match play means these qualities are rarely expressed in isolation. To successfully navigate the pitch and evade opponents, athletes must also be able to change direction rapidly. Agility has traditionally been defined as ‘a rapid whole-body movement with change of velocity or direction in response to a stimulus’ (Sheppard & Young, 2006). This model comprises two components: a change-of-direction (COD) speed component and a perceptual decision-making component (Sheppard & Young, 2006). Building on this, Jeffreys expanded the paradigm with the concept of 'gamespeed', a framework now embedded within GAA educational materials. Gamespeed defines agility more holistically as a context-specific action, in which an athlete maximises their performance by applying sport-specific movement at optimal velocity, precision, efficiency, and control, in anticipation of and in response to key perceptual stimuli and the skill requirements of the game (Jeffreys, 2010).

This contextual definition captures the chaotic nature of LGF, in which players rarely sprint for extended distances without accelerating, decelerating, or changing direction at various speeds (Duggan et al., 2022a). For example, an attacking player will react to a defender's movement and decide whether to pass to a teammate or engage the defender directly. A player who cannot manoeuvre effectively in a chaotic environment will struggle to apply their technical skills to the game's tactical demands (Jeffreys & Goodwin, 2016). Currently, there is a paucity of specific notational data quantifying these change-of-direction (COD) actions in LGF. However, research in men's Gaelic football shows that COD actions are incredibly common and may occur more frequently than in other field and court sports. Notational analysis found that players completed 380 ± 67 CODs per game, compared with 305 ± 50 in youth soccer and 242 ± 29 in netball (Talty et al., 2022). Overall, 34.5% of Gaelic football actions involved CODs, compared with 19.2% in soccer matches (Talty et al., 2022; Timmons et al., 2025). The most common CODs were shallow (≤90°; 74.9%). However, 80% of CODs exceeding 270° occurred during active play. The left/right split for CODs during active play was 47.1/49.9%, indicating no preference for completing actions on one side over the other. Given the identical pitch dimensions, similar rulesets, and tactical overlaps between the men's and women's games, it is highly probable that LGF follows a similarly demanding multi-directional pattern.

Biomechanically, executing the plant phase in a COD requires substantial ground reaction forces (GRFs) that exceed those needed for acceleration and maximum velocity (Spiteri et al., 2013). This supports the use of traditional strength training to enhance an athlete's ability to generate and tolerate significant GRFs. Stronger athletes decelerate more rapidly during the penultimate step

when approaching at higher speeds (Spiteri et al., 2013). However, to master the complex, dynamic 'gamespeed' patterns unique to field-based invasion sports, an individual athlete must also develop their perceptual and decision-making skills, including visual processing, pattern recognition, perceptual awareness, and timing (Young et al., 2022). This reactive component is fundamental to LGF. It underpins 1v1 duels, such as an attacking player performing a solo or 'dummy' to evade a tackle, or a defender responding to an attacker's cut or swerve to maintain a 'goalside' position. Agility is a key performance differentiator in several team sports (Paul et al., 2016). Therefore, developing both the reactive and non-reactive components of agility is essential and can significantly influence an athlete's ability to compete at the elite level in the sport.

Aerobic and Anaerobic Endurance

A player's physical ability to repeatedly perform high-intensity intermittent exercise during games is a key determinant of successful performance (Helgerud et al., 2001). For example, improving elite soccer players' aerobic capacity by 10.7% (from 58.1–64.3 mL·kg-1·min^{-1}) led to a 20% increase in total distance covered (from 8,619 to 10,335 m) and a 6.7% improvement in running economy. This enhanced aerobic base also directly affected high-intensity and tactical match actions, resulting in a 100% increase in sprints (from 6 to 12) and a 24% increase in ball involvements (from 47 to 58) per game (Helgerud et al., 2001). The nature of movement in invasion games requires the utilisation and development of all three energy systems (ATP-PC, glycolytic, and aerobic). The anaerobic system (ATP-PC and lactic system) provides the immediate energy for the most intense actions on the pitch, such as a full-paced sprint, a maximal jump, or a powerful tackle, while a player's ability to repeatedly perform these actions for the full 60-minute duration is dictated by the capacity of their aerobic system (Bishop et al., 2011; Gastin, 2001). A highly developed aerobic system is the foundation for performance and recovery in team sports (Stolen et al., 2005). It provides the energy for all lower-intensity activities, such as walking and jogging, and, critically, dictates the speed of recovery between high-intensity efforts (Tomlin & Wenger, 2001). A player with a superior aerobic base can replenish phosphocreatine (PCr) stores faster, clear metabolic by-products more efficiently, and therefore perform more high-intensity actions throughout a match (Spencer et al., 2005). Furthermore, a strong aerobic base is essential for maintaining technical skills and decision-making under fatigue (Duggan et al., 2020).

The practical manifestation of the interplay between the anaerobic and aerobic energy systems is repeat-sprint ability (RSA), which refers to the capacity to perform repeated high-intensity intermittent actions with minimal rest (Bishop et al., 2011). RSA is a key performance indicator in

team sports and illustrates how both energy systems work together (Bishop et al., 2011). This is directly applicable to LGF, where a player must repeatedly sprint to support attacks, contest or pass the ball, and then track back to defend. This skill relies heavily on a powerful anaerobic system to fuel the sprints and a resilient aerobic system to enable rapid recovery between efforts (Spencer et al., 2005). Heart rate (HR) measurement can serve as an indirect indicator of exercise intensity and is now common in team sports (Duggan et al., 2022). Although no HR data currently exist for LGF at senior level, similar team sports such as soccer and men's Gaelic football have consistently shown that match intensity is high, at approximately 85–90% of maximum heart rate (HR_{max}), near the anaerobic threshold (Boyle et al., 2022; Stolen et al., 2005).

Given the high metabolic demands of the match, a player's baseline aerobic capacity is a crucial determinant of playing level. As with other physical attributes, superior aerobic capacity, as measured by tests such as the Yo-Yo Intermittent Recovery Test Level 1 (Yo-Yo IR1), differentiates between playing levels in sports including soccer, AFLW, both rugby codes, rugby sevens and Gaelic games (Boyle et al., 2022; Brassington et al., 2026; Farley et al., 2022; Helgerud et al., 2001). For example, in AFLW, superior aerobic capacity, as measured by the Yo-Yo IR1, differentiates elite and sub-elite cohorts, with elite players typically achieving distances of 864 ± 391 m vs 517 ± 233 m for sub-elite players (Farley et al., 2022). In elite male Gaelic football, differences between starters and non-starters have also been noted, with starters covering significantly greater distances than non-starters (Boyle et al., 2022).

Mobility & Flexibility

While strength, speed, and endurance determine a player's capacity to perform and sustain high-intensity actions, mobility and flexibility govern the efficiency and safety of these movements. Mobility can be described as an athlete’s ability to move through a range of motion (ROM) in a stable and coordinated manner (Brooks & Cressey, 2013). Mobility is related to, but distinct from, flexibility, which refers to the capacity of a muscle and surrounding soft tissues to elongate (Skopal et al., 2024). Adequate flexibility is needed for optimal mobility; however, it must be balanced with strength and stability to effectively utilise the available ROM in a sporting context (Skopal et al., 2024). The literature on the isolated effects of specific stretching protocols on direct performance outcomes (e.g., sprint speed or jump height) is often conflicting and varies in quality (Behm et al., 2017; Skopal et al., 2024). While coaches regard mobility as important, its development may be limited by demanding training schedules and the need to focus on other components of fitness

(Skopal et al., 2024). However, for a dynamic, multi-directional sport like LGF, mobility is a vital quality, as it supports both efficient skill execution and injury prevention.

Two of the most common kicking styles in LGF are the instep and punt kicks. Kicking for distance requires considerable hip mobility and hamstring flexibility. Although there are currently no studies on the biomechanics of kicking styles in LGF, a 6-week programme combining static and dynamic stretching (e.g., leg swings) increased maximal punt-kicking distance by 4.2 m in Australian rules football (Donaldson, 2010). Similarly, in soccer, a higher dynamic ROM around the hip following a dynamic warm-up has been observed, resulting in increased angular velocity of lower-extremity joints during the forward and follow-through phases of instep kicking and an overall increase in instep-kicking velocity (Amiri-Khorasani et al., 2012). Good levels of hip and ankle mobility are also essential for skills such as high catching and low blocking, while handpass length is likely influenced by adequate thoracic spine and shoulder mobility. Furthermore, mobility training can help sustain the ROM needed for optimal sprint mechanics. Biomechanical analysis of sprinters shows that adequate hip range of motion, particularly hip flexion, is essential for maximising speed. This facilitates faster heel recovery, increases stride length, and reduces braking forces at heel contact (Bushnell & Hunter, 2007). The need to maintain these capacities is highlighted by research in rugby, which found that regular in-season training led to a 14.8% decline in flexibility and a corresponding 4.4% reduction in 30-meter sprint performance. However, implementing targeted mobility interventions, such as yoga, enabled athletes to maintain their range of motion and speed throughout the season, whereas the control group showed declines in both (Raj et al., 2021).

Mobility plays a key role in injury prevention, often explained by the concept of regional interdependence. This concept describes how movement impairments or dysfunction in one anatomical region can provoke compensatory, often harmful mechanics in a secondary joint (Heneghan et al., 2020). For the LGF athlete, limited hip mobility or restricted ankle dorsiflexion can force kinetic chain compensation during landing, cutting, or squatting tasks. As detailed in section 2.3.2, such compensation frequently results in dynamic knee valgus, which has been identified prospectively as a primary non-contact risk factor for severe lower-limb trauma (Hewett et al., 2005, 2006). Ensuring optimal joint kinematics throughout the kinetic chain is a cornerstone of developing and maintaining functional mobility in a holistic athletic development and injury-prevention programme.

Given that strength, speed, endurance, and mobility are deeply intertwined with successful LGF performance and injury mitigation, it is imperative that practitioners can accurately quantify

these traits. Consequently, establishing robust assessment protocols and utilising valid tracking technologies is essential for profiling players and monitoring match demands. The following section will outline the specific methodologies and technologies used to assess these key physical qualities and quantify match-play demands.

2.5 Assessing Key Physical Qualities in Female Athletes

Physical performance testing is a cornerstone of player development, providing the objective data needed to evaluate a player's physical capabilities (Datson et al., 2022). This data is essential for evidence-informed decision-making, enabling coaches and practitioners to identify individual needs, customise training programmes, and effectively monitor progress (Beato et al., 2023). The information from these assessments also informs broader strategic decisions on talent identification, player selection, and an athlete's readiness to train or compete (Duggan et al., 2023; Weakley et al., 2024). Several physical performance tests are available for team sports, including assessments of linear speed, lower-limb power (e.g., jump tests), and high-intensity intermittent endurance, which are considered important by coaches and practitioners due to their face and content validity (Datson et al., 2022). While laboratory-based 'gold-standard' assessments (e.g., force-plate analysis, 3D motion capture, or direct $VO_{2\ max}$ testing) provide the highest degree of precision, their implementation in team-sport settings is often impractical. Constraints such as high costs, requirements for technical expertise, time-intensive protocols, and the challenge of testing large squads simultaneously necessitate the use of field-based alternatives (Beato et al., 2023; Turner et al., 2011). Therefore, field tests are preferred due to their simplicity, time efficiency, and minimal equipment requirements (Turner et al., 2011). A summary of selected 'gold-standard' assessments and their validated field-based alternatives is presented in Table 2.2.

Table 2.2

Summary of Laboratory 'Gold Standard' Assessments and Their Validated Field-Based Counterparts

Physical Quality	Laboratory 'Gold Standard'	Validated Field-Assessment	Primary Output
Maximal Strength	1 Repetition Maximum (1RM)	Mid-Thigh Pull (Dynamometer)	Mass lifted (kg)
Lower-Body Power	Force Plate Analysis	Squat Jump (SJ) / Countermovement Jump (CMJ)	Jump Height (cm)
Reactive Strength	Force Plate Analysis	Drop Jump (DJ)	Reactive Strength Index (RSI)
Upper-Body Power	Isokinetic Dynamometry	Seated Medicine Ball Throw (MBT)	Throw Distance (m)
Linear Speed	3D Motion Capture / Timing Gates	5 m, 10 m, and 20 m Sprints	Time (s)
Change of Direction	3D Motion Capture	Pro-Agility Test / 505 Test	Time (s)
Aerobic Endurance	Direct $VO_{2\ Max}$ Testing	Yo-Yo Intermittent Recovery Test Level 1 (Yo-Yo IR1)	Distance Covered (m)
Mobility and Flexibility	3D Motion Capture / Universal Goniometry	Functional Movement Screen (FMS) / Sit and Reach	Score / Distance (cm)

Note. Information synthesised from Beato et al. (2023), Paul and Nassis (2015), and Turner et al. (2011).

For a field test to be considered a viable proxy for its lab-based counterpart, it must demonstrate strong scientific rigour: it must be valid (accurately measuring the intended attribute); reliable (consistently producing repeatable results, which is essential for tracking progress); and sensitive (able to detect small, meaningful adaptations resulting from training interventions) (Paul & Nassis, 2015). These criteria, along with practicality, are essential to ensuring that data from field assessments are robust enough to support evidence-informed decision-making. Validity and reliability are population- and method-specific (Castro-Piñero et al., 2010; Hopkins, 2000). Due to the biological noise introduced by growth and maturation, an assessment that is highly reliable in fully mature adult cohorts may show different variability in youth populations. Therefore, the psychometric properties (ICC and CV) discussed in the following sections reflect data derived specifically from adolescent female athletic cohorts unless otherwise stated. Where direct data for this demographic are unavailable, the next-closest population (e.g., adult females or pooled adolescent cohorts) is reported and acknowledged as a gap in the literature.

2.5.1 Assessing Strength and Power

Most sports, particularly those involving jumping, changing direction, or sprinting, require substantial force development and power output (Haff & Nimphius, 2012). Adequate power enables

athletes to overcome gravity, accelerate their bodies through space, and propel a ball across a court or playing field (Biggar et al., 2021). While maximal strength provides a foundation, direct assessment methods, such as 1RM testing, are often impractical and pose safety risks for novice and untrained athletes learning proper lifting techniques (Faigenbaum et al., 2009). As a result, practitioners and researchers rely on validated proxy tests to measure strength expression in terms of power and reactive strength (Beato et al., 2023). The squat jump (SJ) and countermovement jump (CMJ) are commonly used to evaluate lower-body strength and power. The SJ assesses concentric force development, whereas the CMJ measures the ability to produce force during slow stretch-shortening cycle movements (Van Hooren & Zolotarjova, 2017). While a force platform is required to analyse the kinetic strategy of the SSC (e.g., eccentric braking forces and rate of force development), jump height is the most common, valid, and reliable field-based outcome metric for quantifying this ability (McMahon et al., 2018). Jump height has also been correlated with sprint speed, agility, and sports skills (Suchomel et al., 2016).

However, reliance on gross performance outcomes may obscure changes in the underlying movement strategy. For example, youth athletes can achieve similar countermovement jump performance while employing different force-production strategies, meaning changes in how performance is produced may not be reflected in the overall outcome measure (Gillen et al., 2021; Mitchell et al., 2022). This is particularly relevant during adolescence, when changes in movement coordination and joint kinematics may occur alongside changes in physical performance (Wdowski et al., 2020). Consequently, although field-based outcome measures such as jump height and sprint time provide practical indicators of performance, they may not fully capture changes in how that performance is achieved. Where resources permit, assessment of movement and force-time characteristics can therefore provide additional insight into the mechanisms underlying changes in performance.

The CMJ demonstrates excellent test-retest reliability and sensitivity in adolescent female populations (ICC = .89–.97; CV < 4.8%) with inter-trial stability increasing as athletes progress from U16 to U18, reflecting stabilised locomotive mechanics (Chaabene et al., 2021; Pardos-Mainer et al., 2019; Thomas et al., 2017). Conversely, although the SJ is widely recognised as a valid measure of concentric power, specific reliability indices for adolescent females are scarce in the current literature. Consequently, practitioners often rely on data extrapolated from physically active adults or pooled male cohorts, which have reported high reliability (ICC = .74–.97) (Markovic et al., 2004).

The DJ measures the reactive strength index (RSI), the ratio of jump height to contact time during rebound jumps from a specified drop height. This metric reflects the lower body's ability to utilise the fast stretch-shortening cycle to rapidly generate high power outputs (Jarvis et al., 2021). The RSI is considered a reliable performance metric, particularly valuable for monitoring daily changes in an athlete's physical state. It serves as an effective tool for tracking neuromuscular fatigue and informing decisions about training load and an athlete's readiness to train or compete (Healy et al., 2018; Martinez, 2016). Moderate-to-strong reliability (ICC .57–.99; CV = 2.98–14%) and strong concurrent validity against gold-standard force platforms for RSI have been documented across diverse populations (Suchomel et al., 2016; Tenelsen et al., 2019).

The seated medicine ball throw (MBT) assesses upper-body power by measuring the maximum distance a person can throw a medicine ball from a seated, isolated position (Biggar et al., 2021). The MBT has been used to evaluate upper-body power across various populations and is a valid and reliable field test, with a reported ICC of .97–.99 (Beckham et al., 2019). The seated position of the MBT reduces the influence of the lower body and trunk, providing an isolated, standardised measure of upper-body and core muscles. This is preferred over local muscular endurance tests (e.g., push-ups), which are often compromised by changes in form (e.g., hip sagging) as fatigue sets in, thereby reducing their reliability (Kellner et al., 2021).

2.5.2 Assessing Speed and Agility

Sprinting and change-of-direction ability are key performance characteristics that enable team-sport athletes to reach the ball before their opponents, avoid tackles, create space, and secure turnovers (Young et al., 2015). Therefore, both linear and change-of-direction sprint tests are commonly used to assess performance (Duggan et al., 2022; Paul & Nassis, 2015). Linear sprinting involves sprinting in a straight line over varying distances, including phases of acceleration and maximum speed. A 5 m sprint is a typical measure of an athlete's initial acceleration, while the 20 m distance assesses an athlete's capacity to sprint over a common, game-related distance. Measurement consistency improves significantly as sprint distance increases. The 20 m sprint is highly reliable for female cohorts (ICC = .85–.91; CV = 1.1%–1.8%), whereas the initial 5 m acceleration phase shows moderately lower reproducibility (ICC = .61–.69; CV = 2.1%–4.4%) due to greater kinematic variability in overcoming static inertia from the starting stance (McMahon et al., 2017; Salter et al., 2025).

Change-of-direction sprinting involves planned whole-body direction changes, as well as rapid limb movements and direction changes (Altman et al., 2019). Several COD tests have been developed over the years, including the Illinois Agility Test, T-Test, 505, and Pro-Agility Test (Altman et al., 2019). Although some of these tests include the word ‘agility' in their names, they are not true agility tests because they assess pre-planned ‘closed-skill' actions, such as running a set pattern. In contrast, agility is an ‘open-skill’ that requires reacting to a game-specific stimulus (e.g., an opponent or the ball) before executing a change of direction or velocity (Altman et al., 2019). Although true agility, which involves this cognitive-perceptual component, is challenging to measure outside of game analysis, the physical ability to change direction (CODS) is a crucial foundation. Consequently, field tests such as Pro Agility are used as valid and reliable measures of the physical component of agility, with Stewart et al. (2014) reporting an ICC of .82 (95% CI [.67, .92]) and an absolute reliability CV of 1.81%.

2.5.3 Assessing Aerobic Endurance

Team-sport athletes require a well-developed aerobic system to recover during breaks in play and throughout maximal and submaximal activity (Duggan et al., 2020). High-intensity running is a key indicator of match performance. Consequently, assessing a player’s capacity to repeat such efforts and recover quickly is important (Bangsbo et al., 2008). Although a laboratory-based $VO_{2\,max}$ test is considered the ‘gold standard’ for measuring maximal aerobic capacity, it is impractical in team-sport settings (Bok & Foster, 2021). Therefore, several field tests have been developed to assess this capacity, including the multistage 20-metre shuttle run test, the 30-15 intermittent fitness test (30-15IFT), and the Yo-Yo Intermittent Recovery Test Level 1 (Yo-YoIRT1) (Bok & Foster, 2021).

The Yo-Yo IR1 evaluates an athlete's ability to repeatedly perform short, high-intensity running efforts (Veale et al., 2010). A key feature of this protocol is the inclusion of active recovery periods, which closely mimic the 'stop-start' nature typical of team sports (Bangsbo et al., 2008). The Yo-Yo IR1 has been validated as an effective measure of match-related fitness across numerous team sports, including soccer, AFL, basketball, rugby, and hockey (Markovic et al., 2004; Schmitz et al., 2018; Veale et al., 2010). Furthermore, studies have shown that the Yo-Yo IR1 can distinguish performance differences among players across a range of competitive levels and playing positions (Markovic et al., 2004; Schmitz et al., 2018). The Yo-Yo IR1's reproducibility has been well established in female team-sport athletes, with good test-retest reliability, as evidenced by ICC’s of .79–.97 and

coefficients of variation (CV) ranging from 10.1% to 11.6% (Póvoas et al., 2016). Consequently, it is an appropriate field-based tool to assess intermittent endurance capacity in LGF players.

2.5.4 Assessing Mobility and Flexibility

While mobility and flexibility are foundational to skill execution and injury mitigation, their objective quantification in large team-sport cohorts often poses logistical challenges. Common field assessments, such as the sit-and-reach test, which assesses hamstring and lower back flexibility, or the Thomas test, which measures hip flexor flexibility, can be time-consuming to administer in a squad setting and may lack the sensitivity to detect acute changes in performance (Howe & Waldron, 2019). When practitioners design time-efficient physical profiling batteries, they must prioritise assessments that yield the most impactful performance data. Consequently, assessments of strength, speed, power, and endurance are typically favoured, as these qualities show the strongest and most direct correlations with high-intensity match-play performance (Beato et al., 2023; Datson et al., 2022). Due to time constraints and the need for individualised clinical analysis, routine mobility and joint range-of-motion screening is frequently deferred to physiotherapists rather than being included in broad field-based physical performance batteries (McCall et al., 2014). A summary of the field-based tests and their reliability metrics is presented in Table 2.3.

Table 2.3

Reliability data for selected field-based tests in female adolescent athletes

Field-Based Assessment	***Physical Quality / Metric***	***Reliability (ICC)***	***Absolute Reliability (CV)***	***Source Reference(s)***
Countermovement Jump (CMJ)	Lower-body power (Slow SSC / Jump Height)	.89 –.97	< 4.8%	Chaabene et al. (2021); Pardos-Mainer et al. (2019); Thomas et al. (2017)
Squat Jump (SJ)	Concentric power (Jump Height)	.74 –.97	*Not specified for female adolescents*	Markovic et al. (2004)
Drop Jump (DJ)	Reactive strength (Fast SSC / RSI)	.57 –.99	2.98% – 14.0%	Suchomel et al. (2016); Tenelsen et al. (2019)
Seated Medicine Ball Throw (MBT)	Upper-body power (Throw Distance)	.97 –.99	*Not specified*	Beckham et al. (2019)
5 m Sprint	Initial acceleration (Time)	.61 –.69	2.1% – 4.4%	McMahon et al. (2017); Salter et al. (2025)
20 m Sprint	Game-related linear speed (Time)	.85 –.91	1.1% – 1.8%	McMahon et al. (2017); Salter et al. (2025)
Pro-Agility Test	Change of direction speed (Time)	.82 (95% CI [.67,.92])	1.81%	Stewart et al. (2014)
Yo-Yo Intermittent Recovery Test Level 1 (Yo-Yo IR1)	Intermittent aerobic endurance (Distance)	.79 –.97	10.1% – 11.6%	Póvoas et al. (2016)

2.6 Quantifying Match-Play Demands via Time-Motion Analysis

While field-based physical assessments (as outlined in Section 2.5) are crucial for profiling an athlete's isolated physical capacities, they cannot capture the dynamic, chaotic expression of these qualities in live competition. Gaelic football, for example, is characterised by intermittent, high-intensity activity that draws on a complex combination of aerobic and anaerobic energy systems (Brown & Waller, 2014). During a match, players are constantly engaged in multi-directional sprints, accelerations, decelerations, and changes of direction, interspersed with periods of low-intensity recovery (Cullen et al., 2013; S. Malone et al., 2017c).

To fully understand the external load placed on players during these chaotic passages of play, practitioners must bridge the gap between isolated fitness testing and live match-play. Consequently, continuous player tracking via time-motion analysis has become an indispensable

tool in modern sports science for objectively quantifying movement patterns (Cullen et al., 2013). Initially, player tracking was developed using video and notational analysis. However, this method was labour-intensive, making it challenging to track multiple players simultaneously and in real time (Dellaserra et al., 2014).

The development of Global Positioning System (GPS) technology has revolutionised this process, enabling the collection of quantitative data on the position, movement, speed, and acceleration of field sport athletes, information previously inaccessible through video time-motion analysis alone (Reilly et al., 2015). GPS technology is now widely used in team sports, including soccer (Datson et al., 2017; Morgans et al., 2022; Palucci Vieira et al., 2017), Australian Rules (Black et al., 2017; Jennings et al., 2025), Gaelic football (Boyle et al., 2021; S. Malone et al., 2017c), hurling (Keane et al., 2023; Young et al., 2018), camogie (O'Grady et al., 2022; Young et al., 2021), hockey (McGuinness et al., 2019a, 2019b), and both rugby codes (Clarke et al., 2017; Goodale et al., 2017; Kempton et al., 2013; Sheehan et al., 2022). The ability of GPS technology to track multiple athletes simultaneously is particularly advantageous in intermittent team sports, where running constitutes the primary physical activity, and changes of direction occur frequently (Hodun et al., 2016). The assessment of running demands includes total distance, maximal speed, relative distance, accelerations, decelerations, and distances covered in different speed zones, including walking, jogging, running, high-speed running, and sprinting (Scott et al., 2016; Young et al., 2018, 2021). This technology has made it possible to evaluate the physical demands of both practice and competition, providing coaches with vital information to develop training plans that effectively replicate those demands (Connors et al., 2022; Hodun et al., 2016; Malone et al., 2023; McGuinness et al., 2019a, 2019b). Moreover, it has enabled coaches to compare positional activity profiles (Boyle et al., 2021; Malone et al., 2023), analyse variations in running performance across different playing standards (Clarke et al., 2017; Keane et al., 2023; Young et al., 2018), detect match-related fatigue (Carling et al., 2016; Connors et al., 2022), consider contextual factors (Vescovi et al., 2019), and identify peak periods of match play (Connors et al., 2022; Kempton et al., 2013; Sheehan et al., 2022).

2.6.1 Principles of Global Navigation Satellite Systems (GNSS)

While GNSS refers to the global satellite network (including GLONASS, Galileo, and BeiDou), the term 'GPS' is widely used interchangeably in sports science (Grewal, 2011). GPS operates on the principle of trilateration (Ellens et al., 2024). Each satellite in the constellation, equipped with a highly accurate atomic clock, continuously transmits radio signals containing its position and the

exact time the signal was sent (Larsson, 2003). Player-worn GPS receivers collect these signals and determine their distance from each satellite by multiplying the signal's travel time by the speed of light (Schutz & Herron, 2000). Velocity is often determined not by changes in position but, more precisely, by the Doppler shift, which measures the change in the satellite signal's frequency caused by the receiver's movement (Scott et al., 2016). Velocity calculated from Doppler shift offers higher accuracy and lower error than that derived from positional differentiation (Ellens et al., 2024).

While GPS effectively tracks locomotion, its standard sampling rate (typically 10 Hz) cannot capture the forces associated with non-locomotive actions such as impacts, tackles, or jumps (J. Malone et al., 2017). To provide a complete picture of external load, player-tracking units incorporate microelectromechanical systems (MEMS) sensors, most notably triaxial accelerometers. Sampling at much higher frequencies (usually 100 Hz), these sensors record the incidence and magnitude of accelerations across three axes (vertical, horizontal, and lateral) and are sensitive to rapid changes in direction and velocity (J. Malone et al., 2017; Theodoropoulos et al., 2020). This raw data quantifies high-intensity movements with minimal displacement and is aggregated into metrics such as PlayerLoad™, a cumulative measure of all forces exerted on an athlete, including acceleration and deceleration, changes in direction, and impacts from collisions, tackles, and ground contact, such as foot strikes and falls (Finster-Rowan, 2024). Speed and impact characteristics can be further categorised into activity zones, known as speed bands and impact zones, respectively. Zone 1 represents the minimum level of effort or impact, while Zones 5 and 6, depending on the commercial brand, denote the maximum level. These details can be used to evaluate training or match conditions and to assess player performance or session intensity (Cummins et al., 2013).

2.6.2 Validity and Reliability of GPS Technology

The accuracy of GPS is affected by several factors (Witte & Wilson, 2004). These include the line of sight between the GPS receiver and the satellite, signal strength, and horizontal dilution of precision (HDOP) (Torres-Ronda et al., 2022). Environmental or structural obstructions, such as stadiums or tall buildings, can block the line of sight (J. Malone et al., 2017). Signal strength depends on the number of satellites connected to the receiver and their spatial arrangement in the sky (Torres-Ronda et al., 2022). GPS devices require at least four satellites for reliable connectivity; however, more satellites generally enhance signal quality (J. Malone et al., 2017). HDOP describes the geometric configuration of satellites relative to one another and the receiver, affecting the accuracy of triangulation for positioning (Witte & Wilson, 2004). An ideal HDOP of one, indicating

the highest triangulation accuracy, occurs when one satellite is positioned directly overhead and the others are evenly spaced along the horizon. In contrast, higher HDOP values reflect a clustering of satellites overhead, with a maximum value of 50 indicating an unreliable fix (Witte & Wilson, 2004). Although all GPS devices can record data on satellite count and HDOP, not all manufacturers permit users to access this information, which may limit the validity of study conclusions (J. Malone et al., 2017).

For practitioners, sampling frequency is the most critical determinant of data reliability. Early GPS iterations operating at 1–5 Hz demonstrated significant limitations, consistently underestimating metrics during high-speed running and rapid changes of direction (Hennessy & Jeffreys, 2018; Hoppe et al., 2018; Jennings et al., 2010). High error rates were also observed in inter-unit reliability at lower sampling rates, with significant practical implications when devices are worn by different athletes over time, although good intra-unit reliability was noted (Brosnan et al., 2022; J. Malone et al., 2017). Therefore, it has been recommended that coaches assign a specific device to each athlete for ongoing monitoring wherever possible (Jennings et al., 2010; J. Malone et al., 2017).

To overcome the inherent measurement limitations of low-frequency hardware, 10 Hz devices were developed and have since become the widely validated industry standard. These units are up to six times more reliable for measuring instantaneous velocity than older 5 Hz models (Varley et al., 2011). Good accuracy for total distance and high-speed running during moderate-distance shuttle runs (CVs of 1.9% and 4.7%, respectively) and strong inter-unit reliability for short sprints (CVs of 0.7%–1.7%) have been reported (Castellano et al., 2011). Despite these considerable improvements, 10 Hz devices still have limitations when measuring the most explosive actions. Accuracy decreases during very high-speed running (> 5.5 $m \cdot s^{-1}$) (Rampinini et al., 2015; Zabaloy et al., 2024), on tight change-of-direction courses, and during instances of extreme acceleration (> 4 $m \cdot s^{-2}$) (Scott et al., 2016; Zabaloy et al., 2024). While recent advancements have introduced 18 Hz multi-constellation devices (e.g., Catapult Vector Pro) to further reduce error rates during explosive movements, 10 Hz devices remain the most thoroughly validated and economically viable standard for amateur and sub-elite environments (Brosnan et al., 2022).

2.6.3 Establishing Velocity Thresholds

To capture the random and intermittent nature of football activity, distances covered at different velocities and accelerations are routinely categorised into specific zones (Park et al., 2019).

Quantifying the distance covered or time spent within these zones can provide insights into the physical demands of training or match play, inform population-specific practices such as training programme design, and help prepare players for the physical requirements of match play (Harkness-Armstrong et al., 2022a). Defining these zones also facilitates benchmarking performance across participants, competitive standards, and positional roles (Griffin et al., 2021; Harkness-Armstrong et al., 2022b; Vescovi et al., 2021).

While consensus on standardised thresholds facilitates comparison within and between sports, the use of arbitrary speed zones across sporting codes has been challenged, particularly when elite male thresholds are applied to female or youth cohorts (Park et al., 2019). Distance covered at high speed during matches is considered a key performance indicator, with sprinting representing the highest-intensity effort (Vescovi, 2012). Therefore, reliable measurement requires consistent use of speed thresholds that accurately reflect players' abilities. Sprint capacity varies widely across age groups among female players and also differs from that of males (Mujika et al., 2009; Vescovi et al., 2011). For example, applying a male sprint threshold (> 6.9 $m \cdot s^{-1}$) to female professional soccer players results in almost no recorded sprints, whereas a female-specific threshold (> 5.0 $m \cdot s^{-1}$) accurately captures high-intensity efforts comprising roughly 5.3% of their total match distance (Vescovi, 2012). Similarly, in international hockey matches, applying a sprint threshold of 5.2 $m \cdot s^{-1}$, based on research on male soccer players, yielded an average of 17 sprints for female athletes compared with 30 for males (Sweeting et al., 2017). Relying on inappropriate standardised thresholds can therefore create a 'ceiling effect' and fail to capture the true physiological demands placed on female or youth athletes (Harkness-Armstrong et al., 2022a, 2022b).

An alternative to relying on an absolute speed threshold is to use thresholds tailored to the individual, based on objective physiological measures such as the second ventilatory threshold (VT_2) or the maximum speed achieved during sprint testing (Clarke et al., 2015; Sweeting et al., 2017). VT_2 is derived from a maximal aerobic capacity test ($VO_{2\ max}$) and marks the transition between moderate- and high-intensity exercise (Abt & Lovell, 2009). Consequently, VT_2 provides an objective, individualised measure of the intensity above which a player is exerting at high intensity (Abt & Lovell, 2009). Using VT_2 speed (VT_{2speed}) to define high-intensity running also offers the advantage of individualisation and may be a better indicator of the physiologically demanding high-intensity efforts by players when analysing gameplay and training sessions via GPS (Clarke et al., 2015). While laboratory assessment of VT_2 provides the gold standard for identifying individual high-intensity running thresholds, its validity in team sports has been questioned due to its continuous nature,

which does not accurately reflect the intermittent, repeated accelerative patterns typical of team sports (Gualtieri et al., 2023). Additionally, practical application within a team environment is often limited by logistical, financial, and time constraints, as well as a lack of specialised technical expertise required to administer complex physiological tests (Abbott et al., 2018). A more feasible and ecologically valid alternative is the use of a maximal intermittent field test, such as the Yo-Yo Intermittent Recovery Test Level 1 (Yo-Yo IR1). Team sport coaches widely use the Yo-Yo IR1 to assess players' prolonged intermittent exercise capacity and subsequently estimate maximal aerobic speed (MAS) (Rago et al., 2020). MAS is strongly correlated with $VO_{2\ max}$ and, when combined with maximal sprinting speed (MSS), enables calculation of the anaerobic speed reserve (ASR), which captures the transition from high-speed running to sprinting (Abbott et al., 2018; Rago et al., 2020). This method maintains the principle of individualisation while offering a practical solution for coaches and sport scientists working with large groups of athletes.

Ultimately, whether practitioners opt for standardised or individualised thresholds depends on the primary objective. Standardised zones, when adjusted for age, sex, and competitive level, provide context and support long-term tracking, talent identification, and goal setting. The main purpose of this approach is to monitor external load and compare an athlete's performance against normative data based on peers, past performances, or the established demands of their competition level (Harkness-Armstrong et al., 2022a; J. Malone et al., 2017). Individualised thresholds quantify each athlete's internal load (Clarke et al., 2015). Since physical capacity varies greatly, what is considered moderate velocity for one athlete may represent a near-maximal effort for another. Overlooking this variability can lead to misinterpretation of the actual physiological effort during training or matches (Abt & Lovell, 2009). This is particularly crucial in youth populations, as maximal sprint speed and aerobic capacity can fluctuate by 3–12.5% within a single competitive season, necessitating regular re-testing (Emmonds et al., 2022; Parpa et al., 2024). Overall, the most effective approach may be to combine these methods to develop a comprehensive performance profile.

2.7 The Sporting Environment and Coaching Context in the LGFA

While Section 2.6 outlined the advanced technological methods available for monitoring match-play demands, the practical application of these tools and the implementation of athletic development programmes are heavily shaped by the environment in which athletes operate. To implement effective interventions, practitioners must understand the game's physical demands

while navigating specific infrastructural constraints, a lack of LGF-specific research, and a coaching landscape driven almost entirely by community volunteers.

2.7.1 The Gendered Gap in Infrastructure

Despite increased participation, visibility, and professionalism in women's sport worldwide, a gendered gap persists in infrastructure and general sports science provision for many female athletes compared with their male counterparts (Heyward et al., 2020). Female athletes, even at elite levels, often have less access to crucial performance support services, including medical care, performance analysis, and strength and conditioning (S&C) resources (Heyward et al., 2020). For example, a recent report from the Gaelic Players Association (GPA, 2023) highlighted disparities between male and female inter-county players in support, funding, and facilities. While male and female players undertake similar training loads, female players face a notable financial and infrastructural disadvantage (GPA, 2023). The report found that, while male inter-county players universally receive travel expenses and fully funded medical support, only 9.5% of female players received travel expenses, and 48% incurred personal costs to access a physiotherapist during the season (GPA, 2023). While acknowledging that some counties provide high-performance environments that enable female players to reach their potential, many operate within severe resource constraints, making it challenging to standardise minimum provisions across all squads. Consequently, significant disparities remain in the support available to players across different counties (GPA, 2023).

2.7.2 The Knowledge Gap and Reliance on Male Data

An additional obstacle to advancing athletic performance in LGF is the demographic imbalance in sports science research. Females have historically accounted for approximately 34%–39% of participants in the sports and exercise science literature (Costello et al., 2014; Cowley et al., 2021). However, a marked underrepresentation remains in sport-specific contexts. This knowledge gap is particularly evident in Gaelic games, where most research on game demands, physical characteristics, and coaching practices is disproportionately weighted towards male athletes. Consequently, male-derived data is often generalised to female players, despite the considerable biological and contextual differences between the sexes (Emmonds et al., 2019; Heyward et al., 2020). While certain foundational training principles can be adapted from a male context, the direct application of male-centric evidence to female populations may be erroneous (Emmonds et al., 2019). For example, using male speed thresholds or strength norms in LGF risks either

underestimating female abilities or prescribing inappropriate training loads. Therefore, research that specifically addresses the unique physiological and developmental needs of LGF athletes is required, as continued reliance on male data may diminish the effectiveness of training, injury prevention, and performance-enhancement strategies in the women's game (Emmonds et al., 2019; Heyward et al., 2020).

2.7.3 The Amateur Ethos and Volunteer Coaches

The volunteer-coach model forms the foundation of the Gaelic Games Associations (Horgan et al., 2021), reflecting the widespread reliance on volunteerism across community and youth sports globally (Wicker, 2017). The coaching workforce at all levels, from club to inter-county academies, is predominantly composed of parents and community volunteers. While this volunteer model underpins the association's growth and community engagement, it also poses specific challenges for high-performance player development. In their baseline report on coaching in Gaelic Games, Horgan et al. (2021) note that these coaches are often 'time-poor', balancing coaching responsibilities with full-time employment and family commitments. This aligns with the wider coaching science literature, which consistently identifies 'lack of time' and 'work/life balance challenges' as primary barriers to amateur coaches pursuing further education (Dixon & Bruening, 2005; Søvik et al., 2017; Wiersma & Sherman, 2005). The considerable time required to develop the expertise to plan and deliver evidence-informed physical preparation is often beyond what volunteer coaches can afford. Consequently, their primary focus is typically on technical and tactical preparation and the immediate requirements of match play, rather than long-term physical development (Till et al., 2021). This creates a core tension between the critical need for structured neuromuscular training in female athletes and the practicality of delivering it by volunteer coaches who may lack specific S&C qualifications or resources (Weldon et al., 2021).

2.7.4 Discrepancies in Coaching Practice

The resource and knowledge gaps highlighted above result in noticeable differences in how S&C practices are implemented on the ground for female athletes compared with their male counterparts. Research across various sports shows that coaches are much more likely to prioritise strength training for male athletes than for female athletes (Poiss et al., 2004; Reynolds et al., 2012; Sommi et al., 2018). In a sample of varsity high school programmes, 50% of coaches working with male athletes required engagement in strength training, compared with only 9% of coaches working with female athletes (Reynolds et al., 2012). At the academy level in soccer, female players were

found to have fewer weekly S&C sessions, to be less likely than male players to perform Olympic lifts, and to rely more heavily on subjective load prescriptions, which may lead to suboptimal performance gains (McQuilliam et al., 2022). This trend is mirrored in youth Gaelic Games, where female athletes engaged in significantly less muscle-strengthening activity than their male counterparts (2.7 days vs 3.5 days per week; $p < .05$; Lane et al., 2024). Most concerningly, 34.7% of girls engaged in no muscle-strengthening activity whatsoever, compared with 19.7% of boys (Lane et al., 2024). This lack of engagement exposes the female adolescent cohort to a heightened risk of injury and suboptimal development compared with their male peers.

2.7.5 The Implementation Challenge

Research on Gaelic games has shown that structured physical preparation, such as an entry-level warm-up routine, can significantly reduce injury risk among adolescent and young adult athletes (Schlingermann et al., 2018). However, despite these clear benefits, implementing consistent S&C practice remains challenging, particularly for coaches lacking the necessary knowledge or experience. This disconnect is evident across multiple team sports. For example, in soccer and volleyball, both coaches and players rate S&C as 'highly important', yet logistical limitations, such as financial constraints, inadequate facilities, and a lack of qualified personnel, often compel teams to rely on technical sports coaches to deliver athletic development programmes (Weldon et al., 2021, 2022). This pattern is particularly prevalent in ladies' Gaelic football, where many teams, even at the inter-county youth level, lack dedicated S&C coaches (see Chapter 5). Consequently, the task of designing and implementing athletic development programmes often falls to volunteers who may not possess the specialised knowledge needed to optimise player development. This disconnect between the 'ideal' training interventions described in the literature and the 'real-world' capacity of the volunteer coach highlights a critical need for accessible, context-specific solutions in the LGFA.

2.8 Coaching Efficacy and the Implementation Gap

Previous sections have outlined the external structural and logistical barriers to implementing athletic development, such as time constraints and heavy reliance on amateur volunteers. However, effectively supporting these coaches requires consideration not only of the coaching environment but also of the individual psychological factors that influence implementation. Within this thesis, knowledge refers to a coach's understanding of athletic development principles and their

application in practice. This includes declarative knowledge ('knowing what') and procedural knowledge ('knowing how'), which together provide the cognitive foundation for coaching decisions (Anderson, 1982; Nelson et al., 2006). Without this knowledge base, coaches are unlikely to implement or appropriately adapt athletic development principles in practice.

However, possessing knowledge alone does not guarantee that a coach believes they can successfully apply it in practice. Self-efficacy refers to a coach's belief in their capability to successfully apply that knowledge in practice (Bandura, 1997). Although the terms confidence, perceived competence, and self-efficacy are frequently used interchangeably within the coaching literature, they represent conceptually distinct constructs (Bandura, 1997; Feltz et al., 2009). Confidence is a broad, colloquial term often used to describe a coach's belief in their abilities, whereas perceived competence reflects an individual's overall judgement of their capability within a particular domain. For example, an inter-county coach may perceive themselves to be a highly competent football coach based on years of playing and coaching experience. However, that same coach may possess low self-efficacy for delivering a speed-development session or prescribing resistance training because they do not believe they can successfully teach sprint mechanics, prescribe appropriate training loads, or safely supervise resistance training, despite viewing themselves as a competent football coach overall. Consequently, self-efficacy is inherently task-specific, whereas perceived competence reflects a broader appraisal of capability within a coaching domain (Bandura, 1997; Chase et al., 2005; Feltz et al., 1999).

These internal psychological constructs are distinct from coaching practice, which refers to the observable behaviours and pedagogical actions implemented by coaches in applied settings. Developing coaches' knowledge of athletic development principles is an important component of coach education; however, knowledge acquisition alone is unlikely to produce sustained changes in coaching practice (Nelson et al., 2006; Cushion et al., 2010; Stoszkowski & Collins, 2016). The translation of declarative and procedural knowledge into coaching practice is non-linear and interactively mediated by self-efficacy beliefs, environmental constraints, and socialised sporting cultures (Bandura, 1997; Nelson et al., 2006; Sheeran & Webb, 2016). Given that this thesis examines coaches' beliefs about their capability to implement athletic development, Bandura's (1977, 1997) construct of self-efficacy, operationalised through Feltz et al.'s (1999) coaching efficacy framework, provides the most appropriate theoretical lens. Unlike broader models of coach learning, the coaching efficacy framework directly explains how coaches' beliefs about their instructional capabilities influence the implementation of coaching behaviours.

2.8.1. Self-Efficacy Theory

The successful translation of sports science theory into applied practice may be influenced by a coach's beliefs about their capability (Feltz et al., 1999; Santos et al., 2010). Bandura's (1977, 1997) Self-Efficacy Theory provides a robust psychological framework for this phenomenon. Bandura conceptualised self-efficacy not as a global trait of general confidence, but as a domain-specific belief in an individual's capacity to successfully execute the actions required to achieve a desired outcome (Bandura, 1977). Within this framework, Bandura (1997) identified four primary sources of information that individuals use to construct task-specific efficacy. The first and most potent determinant is enactive mastery experiences, in which successful task execution cultivates a strong belief in capability, whereas repeated failures undermine it. This is complemented by the second source, vicarious experiences, which involve observing peers or credible role models successfully execute a comparable task. The third source of information is verbal persuasion, whereby efficacy is augmented through realistic encouragement and constructive feedback from domain experts. Finally, an individual's physiological and affective states serve as the fourth critical mediating factor, as how a coach interprets their physical and emotional reactions in a specific context directly influences their task-specific self-efficacy (Bandura, 1977; Chase et al., 2005).

2.8.2 Coaching Efficacy

While Bandura's (1977, 1997) Self-Efficacy Theory provides the broader psychological framework underpinning beliefs about capability, Feltz et al.'s (1999) Coaching Efficacy Model applies these principles specifically to the coaching context. According to Feltz, coaching efficacy is defined as '*the extent to which coaches believe they have the capacity to affect the learning and performance of their athletes'* (Feltz et al., 1999, p. 5). In applied settings, this is often referred to colloquially as 'coach confidence', reflecting the internal belief that one can safely and effectively execute a specific coaching task. To capture this construct systematically, Feltz and colleagues developed a multidimensional model comprising four sub-domains: motivation, game strategy, character building, and technique efficacy. While all four domains interact to shape a coach's overall competence, the physical and biomechanical demands of athletic development place particular emphasis on technical efficacy, defined as coaches' beliefs in their ability to instruct, observe, diagnose, and correct athletes' performance. Consistent with Bandura's original concept, Feltz et al. (1999) proposed that these dimensions are strongly influenced by specific coaching preparation and prior experience. Building on this, Chase et al. (2005) demonstrated that a coach's past playing and coaching experiences are uniquely powerful determinants of their underlying efficacy beliefs. This

effect is particularly pronounced in the amateur sector. In a study of volunteer youth sport coaches, Feltz et al. (2009) found that while professional coaches may draw confidence from formal education or institutional support, volunteers rely almost exclusively on their past playing backgrounds to construct their technique efficacy.

The coaching efficacy framework highlights that these self-beliefs are highly context-dependent rather than universally transferable (Feltz et al., 1999). A volunteer coach may possess high technique efficacy for sport-specific tasks, such as analysing a kick-pass or instructing tactical play, by drawing on extensive playing and coaching experience (Chase et al., 2005; Feltz et al., 2009). However, athletic development requires specialised knowledge and skills, including resistance-training instruction, movement analysis, and injury-prevention strategies, which often fall outside the experiential and formal preparation of volunteer coaches (Feltz et al., 2009). Consequently, coaches may possess low task-specific self-efficacy for implementing athletic development despite perceiving themselves as competent football coaches more broadly. Feltz et al. (1999) proposed coaching behaviour as an outcome of coaching efficacy and provided preliminary empirical support for this relationship, with differences observed in several coaching behaviours between coaches with higher and lower coaching efficacy. However, coaching efficacy should not be considered a direct determinant of coaching practice, which is also influenced by environmental, organisational, and social factors. Within the context of athletic development, task-specific coaching self-efficacy may therefore represent one factor influencing implementation rather than a direct predictor of coaching behaviour.

2.8.3 The Implementation Gap in Athletic Development

One factor that may contribute to the implementation gap in athletic development is variation in coaches' task-specific self-efficacy. Coaches may possess knowledge of athletic development principles while remaining uncertain about their capability to apply this knowledge safely and effectively in practice. Evidence of this implementation gap has been reported within Gaelic games. Corrigan et al. (2023) found that LGF coaches perceived limitations in their ability to implement athletic development programmes safely and effectively. Similarly, Reilly and Kipps (2017) found that although 96% of male Gaelic football coaches acknowledged the efficacy of an injury prevention programme (IPP), only 8% reported implementing it. Findings from camogie also indicate challenges in the implementation of physical development, with only 23% of coaches perceiving themselves as sufficiently experienced and 43% believing they possessed the requisite skills to facilitate physical development safely (O'Connor et al., 2021b).These findings suggest that

recognising the value of athletic development does not necessarily translate into its consistent application in practice. While coaches' beliefs about their capability may influence implementation, coaching practice is also shaped by the broader social and cultural context in which it occurs. Jones (2006) argues that coaching takes place within complex, dynamic environments where established norms, traditions, and contextual constraints influence pedagogical decision-making. Consequently, implementation decisions are likely to reflect an interaction between coaches' self-efficacy beliefs and the social and organisational contexts in which coaching occurs, rather than either factor operating in isolation.

2.8.4 Bridging the Implementation Gap

To systematically address this implementation gap, educational interventions require intentional design that draws on Bandura's (1977) primary sources of efficacy while actively combating the historical pitfalls of coach education. Traditional formal coach education has been heavily criticised for inadvertently creating its own 'hidden curriculum' (Cushion et al., 2003; Cushion & Jones, 2014), which often privileges the passive, uncritical absorption of sports science theory over the chaotic and complex realities of practical coaching (Jones, 2006). Principally, coach education is often delivered in a decontextualised manner, failing to recognise learners' unique coaching environments whilst adopting a one-size-fits-all approach (Webb & Leeder, 2022). When this formal education is decoupled from the coach's applied context, it frequently fails to translate into behavioural change (Nelson et al., 2006). An over-reliance on passive, theory-based instruction (i.e., educational approaches centred on lectures, presentations, or online delivery of conceptual information, with limited opportunities for practical application) predominantly fosters an abstract understanding of principles, which is often insufficient to meaningfully alter coaching behaviour (Cushion et al., 2010). Research suggests that while coaches may acquire knowledge in these formal settings, they often lack the ability to critically justify and apply that information unless supported by social and interactive learning structures (Stoszkowski & Collins, 2016).

Consequently, blended pedagogical approaches that incorporate practical, face-to-face workshops offer a distinct empirical advantage in bridging this gap. Practical workshops provide coaches with opportunities to practise coaching skills, receive feedback, experience successful task execution, and refine technique in a supportive environment. These successful performance experiences constitute enactive mastery experiences, the strongest source of self-efficacy identified by Bandura (1997), and provide coaches with opportunities to apply theoretical knowledge through

practical coaching tasks and receive feedback on their performance (Bandura, 1997; Malete & Feltz, 2000)

2.9 Evaluation of Coach Education

2.9.1 The Kirkpatrick Model

Evaluation frameworks provide a structured means of assessing the effectiveness and outcomes of coach education interventions. One of the most prominent is Kirkpatrick's (1994) model. This model conceptualises training outcomes across four levels: reaction, learning, behaviour, and results (Kirkpatrick, 1994). Level 1 assesses participants' reactions to the training, including their perceptions of its relevance and usefulness; Level 2 evaluates learning-related outcomes, such as changes in knowledge, skills, attitudes, or self-efficacy; Level 3 examines whether learning is subsequently transferred into behaviour; and Level 4 considers broader outcomes or results associated with the intervention (Alliger & Janak, 1989).

The model offers a straightforward framework for distinguishing types of training outcomes and has therefore been widely adopted in education and professional development. This distinction is particularly useful in coach education, where positive reactions to an intervention provide limited evidence that learning or subsequent application has occurred (Alliger et al., 1997). Indeed, Alliger et al. (1997) found that utility-based reactions were more strongly associated with learning and transfer than affective reactions alone, underscoring the importance of distinguishing participants' perceptions of training from evidence of its educational effects.

2.9.2 Critique of the Kirkpatrick Model

However, the model has been criticised for implying a hierarchical and causal relationship among its four levels. Alliger and Janak (1989) identified three problematic assumptions underlying the model: that higher levels necessarily provide more valuable information than lower levels, that the levels are causally linked, and that outcomes at different levels are positively correlated. Consequently, positive reactions to training should not be taken as evidence that learning has occurred, and evidence of learning does not establish that it will subsequently be transferred into coaching behaviour.

This distinction is particularly important when evaluating coach education, as intended behavioural transfer should not be equated with observed behavioural change. Coaches may report

increased confidence and an intention to modify their coaching practices yet fail to implement those changes. The transfer of learning may also be influenced by contextual factors within the coaching environment. Bates (2004) argued that the Kirkpatrick model is limited in addressing both the summative question of whether training was effective and the formative question of how training might be improved. In particular, its emphasis on outcome levels provides limited explanation of the mechanisms and contextual conditions through which training outcomes occur. This is important when interpreting behavioural transfer, because the absence of observed behavioural change cannot necessarily be attributed to ineffective learning; it may instead reflect barriers within the environment in which coaches are expected to apply what they have learned. In sport, barriers such as limited time, workload, staffing, access to resources, and the applicability of available evidence can constrain the implementation of evidence-informed practice (Fullagar et al., 2019). Similarly, research in grassroots youth football has identified practical and contextual barriers to implementing coach education (Søvik et al., 2017). These issues are particularly pertinent to long-term athletic development, where practitioners have reported challenges related to governance and priorities, resources, education, staff communication, parents, and youth motivation (Till et al., 2022).

A further limitation concerns Level 4 outcomes. Broader outcomes, such as athlete performance or injury incidence, are influenced by numerous factors beyond coach education. Establishing a causal relationship between an educational intervention and these outcomes would therefore require longitudinal evaluation and appropriate control for potentially confounding influences. Consequently, improvements in learning or behavioural intentions should not be assumed to result in measurable Level 4 outcomes.

Alternative evaluation frameworks have sought to address some of these contextual limitations. For example, the RE-AIM framework evaluates interventions according to reach, effectiveness, adoption, implementation, and maintenance, thereby incorporating individual and organisational factors that influence implementation (Glasgow et al., 1999). RE-AIM therefore provides greater emphasis on implementation and contextual factors than the Kirkpatrick model, although the two frameworks serve different purposes. For evaluating coach education, Kirkpatrick's model remains useful for distinguishing participant reactions, learning-related outcomes, behavioural transfer, and longer-term outcomes, provided the relationships between these levels are not assumed to be causal.

Overall, the Kirkpatrick model provides a useful structure for distinguishing different levels of training outcomes, but its application requires caution. In particular, evidence of positive reactions or learning should not be assumed to demonstrate subsequent behavioural change, while behavioural transfer may depend on contextual factors beyond the training intervention itself (Alliger & Janak, 1989; Bates, 2004).

2.10 Conclusion, Gaps in the Research and Rationale for the Study

Despite the exponential growth in the popularity of LGF, empirical research has not kept pace with participation rates. The literature review highlights a complex landscape for the development of adolescent Ladies Gaelic Football players. While the GAA Player Pathway and Sports Science Framework aim to provide a comprehensive route for player development, several barriers hinder its effective implementation. The literature reveals a systemic mismatch in which the distinct physiological challenges faced by a maturing adolescent athlete, combined with the increasing physical demands of the sport at inter-county level, are set against the constraints of a resource-limited, volunteer-led environment. Consequently, practitioners and policymakers currently operate without population-specific data.

2.10.1 Identification of Research Gaps

Based on the preceding review, four fundamental research gaps are apparent across both player profiling and coach education.

a) Lack of Physical Profiling Data.

Currently, there is a paucity of research profiling the physical fitness characteristics of youth inter-county LGF players. Without essential descriptive data on anthropometry, strength, speed, power, and endurance, coaches lack the population-specific benchmarks needed for talent profiling, development monitoring, and injury risk assessment. Relying on data from senior cohorts or male populations is insufficient, given the unique maturation and injury profiles of the adolescent female athlete.

b) Game Demands at Youth Level are Unquantified.

While performance benchmarks for senior inter-county football have been established, the physical demands of the youth LGF game, particularly across the U14–U18 age grades, remain

unknown. Understanding the 'destination' (senior level) is insufficient without a clear understanding of the 'starting point' (adolescent level). This lack of data prevents the creation of an evidence-informed pathway to bridge the transition to adult competition, leaving preparation largely a matter of intuition rather than a data-driven strategy.

c) Lack of Insight into Current Coaching Practices and Efficacy.

A significant 'implementation gap' exists, with coaches acknowledging the importance of athletic development yet failing to deliver it. However, there is a lack of specific empirical data on LGF coaches' current knowledge and practices, as well as the efficacy of their techniques. It remains unclear how these coaches are currently training their players and whether their perceived lack of competence (as theorised in the coaching efficacy framework) is the primary driver of the implementation barriers observed in the amateur LGF environment.

d) Evaluation of Coach Education Efficacy.

Coach education is the primary means of addressing the aforementioned knowledge and efficacy gaps. However, there is a lack of empirical assessment regarding the effectiveness of specific athletic development curricula, such as the GAA F3 framework. The GAA F3 Youth Athletic Development Level 1 course serves as the primary, entry-level qualification for volunteer Gaelic games coaches attempting to upskill in physical preparation. Currently, it remains unclear whether formal courses effectively enhance both declarative knowledge and coaching self-efficacy, and whether these improvements translate into the amateur coaching environment.

2.10.2 Rationale for the Study

To effectively bridge the gap between sports science theory and applied practice, baseline descriptive data regarding the athlete, the competitive environment, and the coaching workforce must be established. Consequently, this thesis adopts a multi-study approach to systematically address the identified research gaps through four interconnected investigations.

First, it establishes the objective physiological demands of youth LGF by quantifying the anthropometric profiles, physical fitness characteristics, and match-play running demands of adolescent inter-county players. With these physical benchmarks defined, the research then pivots to the coaching workforce responsible for developing those qualities. By examining current coaching practices and subsequently evaluating the GAA's frontline F3 educational intervention, these four

interconnected studies provide the empirical foundation for designing and delivering robust, developmentally appropriate athletic development programmes for the LGF population.

Chapter 3: Anthropometric and Physical Fitness Profile of Adolescent Inter-County Ladies' Gaelic Football Players

The literature review identified several key gaps in understanding the physical preparation of adolescent inter-county Ladies Gaelic Football (LGF) players. Although long-term athletic development models offer broad principles for developing physical qualities during adolescence, population-specific evidence describing the characteristics of female Gaelic footballers across the youth pathway remains limited. In particular, there is insufficient evidence to determine whether physical development across the adolescent age grades is keeping pace with the demands placed on players as they progress towards senior inter-county football.

This issue is important because chronological age alone offers only a limited indication of physical development. Adolescence is characterised by substantial variation in growth, maturation, training history, and physical capacity, meaning that players of the same competition age may present with markedly different developmental profiles. Establishing appropriate benchmarks is therefore an important first step in understanding the physical characteristics of players within the current LGF pathway and in identifying areas where further development may be required.

Chapter 3 addresses this evidence gap through the thesis's first empirical study. U14, U16, and U18 inter-county players were assessed using a range of anthropometric and field-based physical performance measures, including body size, lower- and upper-body power, sprint performance, change-of-direction speed, and intermittent endurance. The study establishes population-specific data across consecutive competition age grades and examines whether physical performance shows meaningful progression along the adolescent pathway, providing the physiological foundation against which competitive match demands can subsequently be evaluated.

3.1 Introduction

Ladies' Gaelic football is one of the leading participation sports for females in Ireland (O'Connor et al., 2021a). Within the LGFA player pathway, adolescents compete at U14, U16, and U18 age grades at provincial and national levels, with the aim of developing players for senior representative competition (Ladies Gaelic Football Association [LGFA], n.d.). Progression through

these age grades occurs during a period of substantial physical development, while players must also develop the physical qualities required to meet the demands of the sport. Gaelic football is an intermittent, high-intensity field sport involving multidirectional sprinting, jumping, and evasion, alongside sport-specific skills such as kicking, catching, soloing, handpassing, tackling, and blocking (Brown & Waller, 2014; Cullen et al., 2013). Accordingly, high-intensity running, repeated-sprint ability, jumping, strength, speed, and agility are important physical attributes for performance (Wright & Lass, 2016).

Adolescence is characterised by substantial variation in growth and maturation, which can influence the development of physical performance across age grades. Typically, girls reach peak height velocity (PHV) at an earlier age than boys, and performance differences between males and females become increasingly apparent during adolescence (Malina et al., 2021; Wright & Lass, 2016). While male athletes generally continue to gain strength, speed, and power with increasing maturation, females tend to plateau during mid-to-late adolescence (O'Brien-Smith et al., 2020; Papaiakovou et al., 2009; Vescovi et al., 2011). These sex-specific developmental characteristics highlight the importance of establishing female-specific evidence when evaluating physical performance during adolescence.

Despite the growing popularity of female sport, females remain underrepresented in sports science and medicine research, and much of the available evidence has been derived from male athletes (Emmonds et al., 2019). Given the anatomical, physiological, and endocrinological differences between males and females, findings from male populations cannot necessarily be applied directly to female athletes (Cowley et al., 2021). This is particularly relevant in ladies' Gaelic football, where research on physical characteristics remains limited. Although some evidence exists for adult female Gaelic football players (Keane et al., 2010; Tucker & Reilly, 2005), and match-play demands have recently been described (Malone et al., 2023), evidence at the youth level remains scarce, with only one previous study examining the fitness profile of adolescent female players at club level (Byrne et al., 2021).

Physical performance testing enables coaches to assess key physical qualities and can inform player monitoring, development, talent identification, selection, and return-to-play decisions (Byrne et al., 2021; Datson et al., 2022; Gissis et al., 2006). Although no single physical, technical, tactical, or psychosocial characteristic can predict sporting success in isolation, validated field-based measures such as linear sprint speed and the YoYo Intermittent Recovery Test Level 1 (YoYoIR1) have been associated with performance in team sports (Vescovi et al., 2011). Research

across soccer, Australian rules football, Gaelic football, hurling, rugby league, and rugby union has demonstrated differences in jumping, sprinting, agility, and endurance performance according to playing level or selection status (Cullen et al., 2013; Emmonds et al., 2020; Farley et al., 2022; Gissis et al., 2006; Keane et al., 2021; Yao et al., 2021). Establishing population-specific physical performance data is therefore an important basis for monitoring development and informing appropriate training practices.

The primary aim of this study, therefore, was to determine the anthropometric and physical performance characteristics of inter-county female players in the under-14, under-16, and under-18 age grades. Understanding the physical differences between age groups will help identify characteristics associated with each developmental stage and provide a basis for evaluating training interventions and monitoring player development. Additionally, these data may aid the development of training programmes designed to support the transition to higher levels of competition. It was hypothesised that there would be significant differences in anthropometric characteristics between U14, U16, and U18 players, while there would be some significant differences in measurements of lower-body power, speed, and endurance between the groups.

3.2 Materials and Methods

3.2.1 Experimental Approach

A cross-sectional study design was used to compare the anthropometric and physical fitness characteristics of inter-county U14, U16, and U18 ladies' Gaelic football players. Prior to participating in this study, written parental consent and player assent were obtained. Participants were instructed to refrain from training for 24 h prior to testing to ensure maximal performance. Tests were completed in early pre-season in a single testing session for each group in an indoor hall and consisted of measurement of height and weight, 3 kg seated medicine ball throw (MBT), squat jump (SJ), countermovement jump (CMJ), drop jump (DJ), 0–5 m and 0–20 m sprint, pro-agility test, and YoYoIR1. All testing took place between 09:00 and 14:00, apart from one U14 group, who completed the testing between 19:00 and 21:00.

3.2.2 Participants

A total of 156 inter-county female players from the U14 (n = 33), U16 (n = 64), and U18 (n= 59) panels participated in this study. The U14 players were all born in the same calendar year, while

the U16 and U18 squads consisted of 15- and 16-year-old players and 17- and 18-year-old players, respectively. Participant recruitment was based on the entire available inter-county playing population within the participating county during the study period; therefore, no additional sampling was undertaken. The U14 players participate in two field-based sessions per week, while the U16 and U18 players participate in two field-based and one gym-based session per week. Each field-based training session lasts 90–120 min. Players partake in approximately 10–12 inter-county games per season, including challenge matches in preparation for competition. In addition, they continue to play with their clubs and may partake in other sports at club and school level. At the time of testing, each squad had just completed their trials process for selection and had trained collectively for 2–4 weeks.

3.2.3 Procedure

Following the anthropometric measurements, participants completed a standardised warm-up lasting approximately 12 minutes consisting of running, activation and mobilisation exercises, and finally some potentiation exercises, including jumping and sprinting. As this was the first time the participants had engaged in fitness profiling and to mitigate against a possible learning effect, the SJ, CMJ, straight-line sprinting over 20 m, and 180-degree change of direction efforts were included as part of the warm-up. For the MBT and DJ, demonstrations were provided. Adequate rest was provided prior to the commencement of testing. The order of testing is described in Figure 3.1 and was consistent across all testing sessions, from least to most fatiguing. Any player who was injured was excluded from the relevant tests.

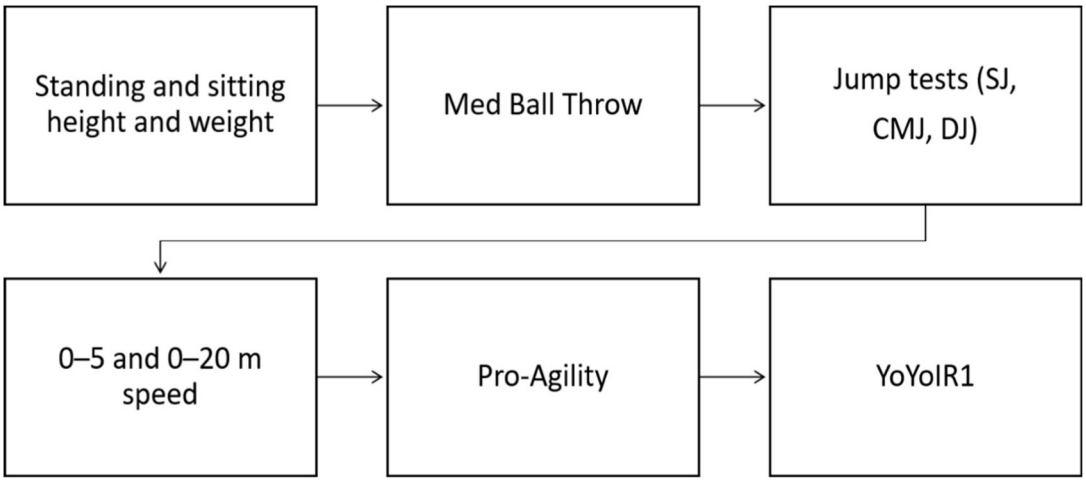


Figure 3.1

Test battery running order

3.2.4 Anthropometric Measurements

For the assessment of height and weight, participants were dressed in shorts and t-shirt with trainers removed. Standing and sitting height were measured to the nearest 0.1 cm using a portable stadiometer (Seca 213, Hamburg, Germany) with the head in the Frankfurt horizontal plane. Body mass was measured to the nearest 0.1 kg using an electronic weighing scale (Salter, SKU:9183 SV3R, Manchester, UK). Standing and sitting height, weight, and date of birth were used to estimate the occurrence of peak height velocity and maturity offset as described by Mirwald et al. (2002). The Mirwald equation has previously been reported to be a reliable (R^2 = .91, SEE = 0.50) and non-invasive, practical solution for the measurement of biological maturity (Emmonds et al., 2020; Mirwald et al., 2002).

3.2.4 Jump Tests (SJ, CMJ, and DJ)

Jump tests were conducted using a Chronojump A2 System jump mat (Boscosystems, Barcelona, Spain). This equipment has previously been reported to be both valid and reliable (ICC = 0.99) (Pueo et al., 2018). Participants performed all three jump types with hands fixed and placed on the hips. For the SJ, participants stepped onto the mat and self-selected their starting position. They were then required to hold this position for 3 s before jumping as high as possible without performing a countermovement action. If players were observed performing a countermovement action, or if there were large differences between the jump attempts, they were asked to repeat the jump. The CMJ was performed with the participants starting from an upright position. Participants made a downward countermovement to a self-selected depth and then jumped as high as possible. Finally, drop jumps were performed with participants starting from an upright position on a 30 cm box. Participants were then instructed to step directly off the box, land on both feet, and immediately perform a jump for maximal height and land back on the mat. Each jump was performed twice, with the highest jump height recorded as a measure of performance. Reactive Strength Index (RSI) was subsequently calculated by dividing the participants' DJ height by the contact time on the mat (Jarvis et al., 2021). The validity and reliability of these tests have previously been reported as high, with an ICC of .97 for the SJ and .98 for the CMJ (Markovic et al., 2004). Moderate to strong levels of reliability (ICC: .57–.99; CV: 2.98–14%) for the RSI have been shown across a range of populations (Jarvis et al., 2021).

3.2.5 Medicine Ball Throw

Upper-body power was assessed using a 3 kg seated medicine ball throw. Participants sat on the ground with their backs supported against a wall, with knees together and legs extended out in front. A measuring tape was used to mark distances on the floor to a distance of 5 m. Participants were given a 3 kg medicine ball and instructed to hold it with both hands close to the midline at chest height and then to throw it horizontally as far forward as possible. Distance was measured to the nearest 10 cm. Two attempts were allowed, with the furthest distance attained used for analysis. The MBT has been used to assess upper-body power in a variety of populations and has been shown to be a valid and reliable field test for upper-body power, with an ICC of 0.97–0.99 (Beckham et al., 2019).

3.2.6 Sprinting and Change of Direction

Sprinting speed was assessed over 5 m and 20 m using electronic timing gates (Dashr Timing Systems, Lincoln, NE, USA). Participants started in a two-point start 0.5 m behind the initial timing gate and were instructed to set off in their own time and run maximally past the 20 m timing gate. Each participant completed two trials, separated by a 2–3 min rest period to allow full recovery between attempts. Times were recorded to the nearest 0.01 s, with the fastest attempt used for statistical analysis. ICC values of 0.87 and 0.97 have been reported for 5 m and 20 m, respectively (Paul & Nassis, 2015).

Change of direction (COD) was examined using a modified version of the pro-agility test and timed using the electronic timing gates above (Dashr Timing Systems, Lincoln, NE, USA). Participants started in a neutral 2-point position on the centre line facing the tester. On 'Go', the participants sprinted 5 m to the right, turned off their right foot, then sprinted 10 m through the centre line to the left, turned off their left foot, and sprinted 5 m back to cross the centre line to finish the test. Participants were required to touch both endlines with their foot only. Each participant completed two trials, separated by a 2–3 min rest period to allow full recovery between attempts. ICC values for the pro-agility test range from 0.80 to 0.98 (Forster et al., 2022).

3.2.7 YoYo Intermittent Recovery Test Level 1

For the YoYoIR1, participants repeated 20 m shuttle runs at progressively increasing speeds from 10–19 $km \cdot h^{-1}$ dictated by an audio bleep from an app and played over a speaker.

Each shuttle run was followed by a 10 s recovery period during which participants walked around a marker placed 5 m behind the finishing line. The test was terminated when participants failed to achieve the shuttle run in time on 2 occasions or if they felt unable to complete another run at the determined speed. The final level achieved and the total running distance were recorded. Test reproducibility for the YoYoIR1 has been reported with CVs ranging from 4.9% to 8.1% (Schmitz et al., 2018).

3.2.8 Statistical Analysis

As participant recruitment comprised the entire available inter-county playing population within the participating county, an a priori sample size calculation was not undertaken. However, a sensitivity analysis was conducted using G*Power 3.1 (Faul et al., 2009) to establish the smallest effect the achieved sample was able to detect. Assuming a one-way ANOVA with three independent groups, an α level of .05, and statistical power of .80, the achieved sample of 156 participants was sufficient to detect effects of Cohen's f = 0.25 or larger, which is equivalent to a partial eta squared of approximately .06 and interpreted as a medium effect (Cohen, 1988). Within-session test–retest reliability was established for MBT, SJ, CMJ, DJ, sprint speed, and pro-agility by randomly selecting 3 of the participants in each testing session to repeat the tests. Test–retest reliability was evaluated using intraclass correlation coefficients (ICCs). Basic descriptive statistics (mean, SD, range, minimum, and maximum) were calculated for all measures. The level of significance was set at $p < .05$, and all data are reported as mean ± SD. The assumption of normality was confirmed using the Shapiro–Wilk test. A one-way analysis of variance (ANOVA) was used to investigate differences between the age groups. When the F test was significant ($p < .05$), Bonferroni post hoc comparisons were performed to identify the level of difference between the age groups. Non-normally distributed data were analysed using a Kruskal–Wallis test. The magnitude of potential age-group differences was determined using the partial eta squared (η_p^2) effect size (ES). Values of 0.01, 0.06, and 0.14 were interpreted as small, medium, and large, respectively (Cohen, 1988). Data were processed using SPSS software version 27 (SPSS 27 IBM Corp., Armonk, NY, USA).

3.3 Results

3.3.1 Anthropometric Data

Anthropometric data for the age groups are presented in Tables 3.1 and 3.2. The mean height for the U14 group was 162 ± 5 cm, while the mean height for the U16 group was 166 ±

6 cm and for the U18 group was 168 ± 5 cm. The mean weight for the U14, U16, and U18 groups was 57.7 ± 7.1 kg, 59.5 ± 6.8 kg, and 63 ± 8.2 kg, respectively. There were significant differences in height ($F(2, 153) = 11.1$, $p < .001$, $n_p^2 = .127$), weight ($F(2, 153) = 6.256$, $p = .002$, $n_p^2 = .076$), and age at PHV ($F(2, 153) = 120.627$, $p < .001$, $n_p^2 = .612$) between the three groups. Post hoc Bonferroni analysis identified differences in height between the U14 and U16 groups (3.61 ± 1.15 cm) and the U14 and U18 groups (5.51 ± 1.17 cm) but not between the U16 and U18 groups. Differences were also found in weight between the U14 and U18 groups (5.30 ± 1.61 kg) and between the U16 and U18 groups (3.47 ± 1.34 kg), but not between the U14 and U16 groups. Significant differences were also found between all three groups for estimated age at PHV. The estimated age of PHV for the U14, U16, and U18 groups was 12.2 ± 0.3, 12.6 ± 0.4, and 13.4 ± 0.4 years, respectively.

Table 3.1

Anthropometric data of U14, U16, and U18 LGF Players.

Group		Standing Height (cm)	Sitting Height (cm)	Weight (kg)	Age at PHV (Years)	Maturity Offset (Years)
U14 (n = 33)	Mean	162	83	57.7	12.2	1.5
	SD	5.5	2.7	7.1	0.3	0.3
	Range	24	11	28.5	1.3	1.6
	Minimum	153	76	43.3	11.6	0.7
	Maximum	177	87	71.8	12.9	2.3
U16 (*n* = 64)	Mean	166	85	59.5	12.6	2.5
	SD	5.5	3.4	6.8	0.4	0.6
	Range	29	15	36.9	1.9	2.2
	Minimum	152	77	41.8	11.8	1.3
	Maximum	181	92	78.7	13.7	3.5
U18 (*n* = 59)	Mean	168	86	63	13.4	3.6
	SD	5.1	3	8.2	0.4	0.5
	Range	26	15	42.5	2.2	2
	Minimum	155	81	49.5	12.2	2.6
	Maximum	181	96	92	14.4	4.6

Table 3.2

Comparison of mean differences in height, weight, and age at PHV

			Mean Difference	Std. Error	*p*	95% Confidence Interval	
						Lower Bound	Upper Bound
Standing Height	U14	U16	−3.608 *	1.153	.006	−6.40	−0.82
		U18	−5.512 *	1.170	<.001	−8.34	−2.68
	U16	U14	3.608 *	1.153	.006	0.82	6.40
		U18	−1.904	0.971	.156	−4.25	0.45
	U18	U14	5.512 *	1.170	<.001	2.68	8.34
		U16	1.904	0.971	.156	−0.45	4.25
Weight	U14	U16	−1.8304	1.5896	.754	−5.678	2.017
		U18	−5.3035 *	1.6124	.004	−9.206	−1.401
	U16	U14	1.8304	1.5896	.754	−2.017	5.678
		U18	−3.4731 *	1.3387	.031	−6.714	−0.233
	U18	U14	5.3035 *	1.6124	.004	1.401	9.206
		U16	3.4731 *	1.3387	.031	0.233	6.714
Age @ PHV	U14	U16	−0.4320 *	0.0824	<.001	−0.632	−0.232
		U18	−1.2137 *	0.0836	<.001	−1.416	−1.011
	U16	U14	0.4320 *	0.0824	<.001	0.232	0.632
		U18	−0.7818 *	0.0694	<.001	−0.950	−0.614
	U18	U14	1.2137 *	0.0836	<.001	1.011	1.416
		U16	0.7818 *	0.0694	<.001	0.614	0.950

Note: *The mean difference is significant at the .05 level.

Test–Retest Reliability

Within-session test–retest measurements for the SJ, CMJ, DJ, 0–5 m speed, 0–20 m speed, pro-agility, and MBT are presented in Table 3.3. The Pearson's correlation coefficient for the SJ, CMJ, DJ height, 0–5 m speed, 0–20 m speed, pro-agility, and MBT were .95, .94, .93, .96, .93, .92, and .91, respectively, indicating excellent reliability.

Table 3.3

Within-session reliability data.

	SJ (cm)	CMJ (cm)	DJ (cm)	Speed 5 m (s)	Speed 20 m (s)	Pro-Agility (s)	MBT (m)
Pearson Correlation	0.952 *	0.941 *	0.927 *	0.934 *	0.965 *	0.916 *	0.906 *
Sig. (2-tailed)	<.001	<.001	<.001	<.001	<.001	<.001	<.001
N	15	15	15	15	15	15	15

* Correlation is significant at the 0.01 level (2-tailed).

3.3.2 Physical Fitness Performance Data

Descriptive data and comparison of mean differences for the three groups are presented in Tables 3.4 and 3.5. There were no significant differences among the three groups for any of the physical fitness tests with the exception of the YoYoIR1 test, (Figure 3.2), where a significant difference was found between the U14 and U18 groups ($F(2, 147) = 3.645$, $p = .029$, $\eta_p^2 = 0.048$ (moderate).

Table 3.4

Physical fitness results for U14, U16, and U18 players.

		N	Mean	*SD*	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
MBT (m)	U14	33	3.4	0.3	0.1	3.3	3.5	2.8	4.0
	U16	63	3.5	0.3	0.0	3.4	3.6	3.0	4.3
	U18	58	3.6	0.4	0.0	3.5	3.7	2.8	4.4
YoYoIR1 Distance (m)	U14	32	750	306	54	640	860	240	1440
	U16	62	868	308	39	790	946	240	1680
	U18	54	944	348	47	849	1039	320	2200
Speed 5 m (s)	U14	32	1.19	0.10	0.02	1.15	1.22	1.02	1.39
	U16	62	1.16	0.08	0.01	1.14	1.18	1.00	1.36
	U18	57	1.16	0.10	0.01	1.14	1.19	0.94	1.45
Speed 20 m (s)	U14	32	3.52	0.18	0.03	3.45	3.59	3.19	3.83
	U16	62	3.53	0.15	0.02	3.50	3.57	3.17	4.08
	U18	57	3.58	0.25	0.03	3.51	3.65	3.11	4.48

		N	Mean	*SD*	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Pro-agility (s)	U14	32	5.71	0.29	0.05	5.61	5.81	5.20	6.62
	U16	62	5.73	0.35	0.04	5.64	5.82	5.08	6.82
	U18	55	5.59	0.31	0.04	5.51	5.68	4.94	6.30
SJ (cm)	U14	32	25.0	3.4	0.6	23.7	26.2	16.8	31.9
	U16	62	23.2	3.0	0.4	22.4	23.9	14.8	29.4
	U18	57	24.3	4.8	0.6	23.0	25.6	13.0	35.0
CMJ (cm)	U14	32	27.5	3.7	0.6	26.1	28.8	19.6	35.1
	U16	62	26.3	3.5	0.4	25.4	27.2	17.4	36.5
	U18	57	27.3	5.0	0.7	25.9	28.6	14.5	38.6
DJ Contact Time (s)	U14	32	0.222	0.027	0.005	0.212	0.232	0.170	0.285
	U16	62	0.225	0.034	0.004	0.216	0.234	0.157	0.359
	U18	56	0.219	0.026	0.004	0.212	0.226	0.151	0.265
DJ Height (cm)	U14	32	25.5	3.4	0.6	24.2	26.7	17.9	34.3
	U16	62	25.7	3.7	0.5	24.7	26.6	17.0	36.9
	U18	56	26.4	4.9	0.7	25.0	27.7	15.9	36.8
RSI	U14	32	1.2	0.2	0.0	1.1	1.2	0.8	1.9
	U16	62	1.2	0.2	0.0	1.1	1.2	0.7	2.0
	U18	56	1.2	0.3	0.0	1.1	1.3	0.7	1.9

Table 3.5

Mean physical fitness comparisons between U14, U16, and U18 players.

			Mean Difference	Std. Error	*p*	95% Confidence Interval	
						Lower Bound	Upper Bound
MBT	U14	U16	−0.0589	0.069	1.000	−0.226	0.109
		U18	−0.1516	0.070	0.098	−0.322	0.018
	U16	U14	0.0589	0.069	1.000	−0.109	0.226
		U18	−0.0927	0.059	0.348	−0.235	0.049
	U18	U14	0.1516	0.070	0.098	−0.018	0.322
		U16	0.0927	0.059	0.348	−0.049	0.235
YoYoIR1 Distance (m)	U14	U16	−117.742	70.296	0.288	−288.00	52.52
		U18	−194.444	72.047	0.023	−368.95	−19.94
	U16	U14	117.742	70.296	0.288	−52.52	288.00
		U18	−76.703	60.114	0.612	−222.30	68.90
	U18	U14	194.444	72.047	0.023	19.94	368.95
		U16	76.703	60.114	0.612	−68.90	222.3
Speed 5 m	U14	U16	0.02458	0.020	0.688	−0.0247	0.0739
		U18	0.02374	0.021	0.758	−0.0263	0.0738
	U16	U14	−0.02458	0.020	0.688	−0.0739	0.0247
		U18	−0.00084	0.017	1.000	−0.0424	0.0407
	U18	U14	−0.02374	0.021	0.758	−0.0738	0.0263
		U16	0.00084	0.017	1.000	−0.0407	0.0424
Speed 20 m	U14	U16	−0.01418	0.043	1.000	−0.1194	0.0911
		U18	−0.05908	0.044	0.547	−0.1659	0.0477
	U16	U14	0.01418	0.043	1.000	−0.0911	0.1194
		U18	−0.04490	0.037	0.667	−0.1336	0.0438
	U18	U14	0.05908	0.044	0.547	−0.0477	0.1659
		U16	0.0449	0.037	0.667	−0.0438	0.1336
Pro-Agility	U14	U16	−0.01822	0.071	1.000	−0.1897	0.1533
		U18	0.11823	0.072	0.313	−0.0569	0.2934
	U16	U14	0.01822	0.071	1.000	−0.1533	0.1897
		U18	0.13645	0.060	0.075	−0.0095	0.2824
	U18	U14	−0.11823	0.072	0.313	−0.2934	0.0569
		U16	−0.13645	0.060	0.075	−0.2824	0.0095

			Mean Difference	Std. Error	*p*	95% Confidence Interval	
						Lower Bound	Upper Bound
SJ	U14	U16	1.7900	0.842	0.105	−0.248	3.828
		U18	0.6594	0.854	1.000	−1.408	2.727
	U16	U14	−1.7900	0.842	0.105	−3.828	0.248
		U18	−1.1306	0.709	0.339	−2.848	0.587
	U18	U14	−0.6594	0.854	1.000	−2.727	1.408
		U16	1.1306	0.709	0.339	−0.587	2.848
CMJ	U14	U16	1.1337	0.906	0.638	−1.059	3.327
		U18	0.1948	0.919	1.000	−2.031	2.42
	U16	U14	−1.1337	0.906	0.638	−3.327	1.059
		U18	−0.9388	0.764	0.662	−2.788	0.91
	U18	U14	−0.1948	0.919	1.000	−2.420	2.031
		U16	0.9388	0.764	0.662	−0.910	2.788
DJ Contact Time	U14	U16	−0.002998	0.006	1.000	−0.01871	0.01271
		U18	0.003116	0.007	1.000	−0.01288	0.01911
	U16	U14	0.002998	0.006	1.000	−0.01271	0.01871
		U18	0.006114	0.005	0.803	−0.00719	0.01942
	U18	U14	−0.003116	0.007	1.000	−0.01911	0.01288
		U16	−0.006114	0.005	0.803	−0.01942	0.00719
DJ Height	U14	U16	−0.1985	0.910	1.000	−2.401	2.004
		U18	−0.8955	0.926	1.000	−3.138	1.347
	U16	U14	0.1985	0.910	1.000	−2.004	2.401
		U18	−0.6970	0.770	1.000	−2.563	1.169
	U18	U14	0.8955	0.926	1.000	−1.347	3.138
		U16	0.697	0.770	1.000	−1.169	2.563
RSI	U14	U16	−0.00187	0.056	1.000	−0.1381	0.1343
		U18	−0.06045	0.057	0.879	−0.1991	0.0782
	U16	U14	0.00187	0.056	1.000	−0.1343	0.1381
		U18	−0.05857	0.048	0.662	−0.1739	0.0568
	U18	U14	0.06045	0.057	0.879	−0.0782	0.1991
		U16	0.05857	0.048	0.662	−0.0568	0.1739

Note. MBT = Medicine Ball Throw; YoYoIR1 = YoYo Intermittent Recovery Test Level 1; SJ = Squat Jump; CMJ = Countermovement Jump; DJ = Drop Jump; RSI = Reactive Strength Index. * Significant difference ($p < .05$).

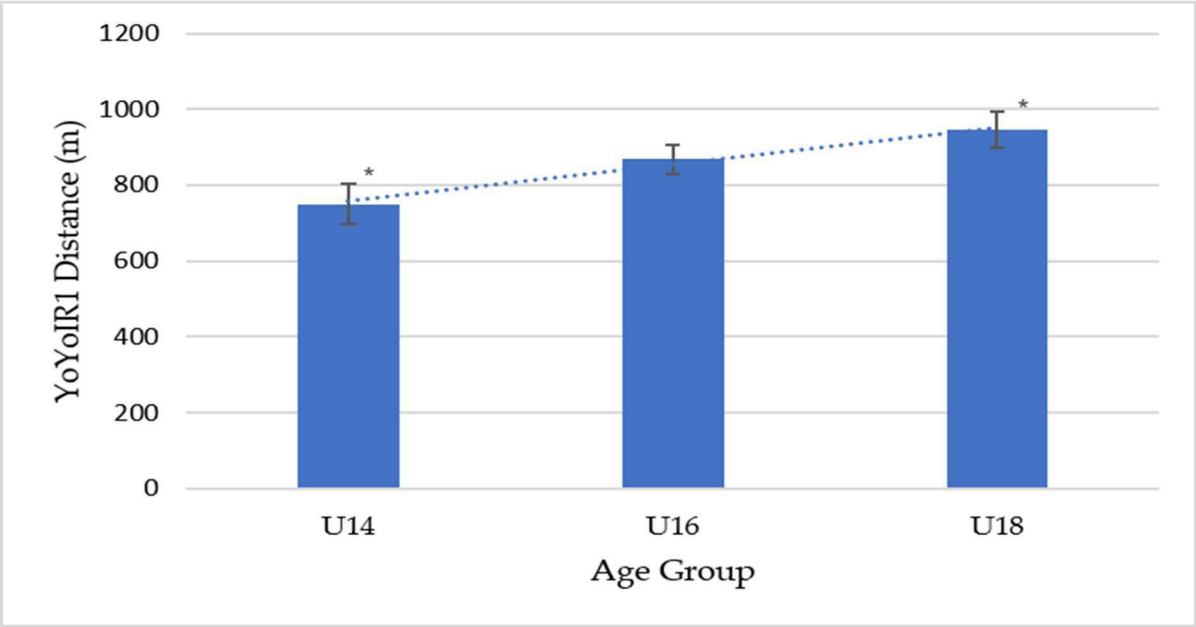


Figure 3.2

YoYoIR1 distance in inter-county ladies' Gaelic football across age groups (mean ± SE).

** Significant difference between U14s and U18s (p < .05)*

3.4 Discussion

The purpose of this study was to compare the anthropometric and physical performance characteristics of inter-county female Gaelic Football players from three different age groups. The findings highlighted differences between the age groups in the anthropometric measures of height and body mass, as well as in estimated age at PHV. In terms of the physical performance tests, the results of this study indicated that the U18 group performed better than the U14 group in terms of aerobic endurance, as measured by the YoYoIR1, but there were no significant differences between the three groups in measurements of upper-and lower-body strength and power, speed, and change of direction.

Growth and maturation have a significant influence on the development of female athletes and are characterised by an increase in height, weight, and body fat percentage and by a maturation of the endocrine, cardiovascular, nervous, and muscular systems, leading to changes in performance (Doyle et al., 2021; Ramos et al., 2019). In this study, the average age of onset of PHV as determined by the Mirwald equation for the U14 cohort was 12.2 ± 0.3

years, 12.6 ± 0.4 years for the U16 group, and 13.4 ± 0.4 years for the U18 group, indicating average-to-late maturation among female inter-county footballers, with the latest maturers dominating at U18 level. The Mirwald equation has previously been used in research on adolescent female soccer players to determine their stage of maturation and has been reported to be a reliable (R^2 = 0.91, SEE = 0.50) and non-invasive practical solution for the measurement of biological maturity (Emmonds et al., 2020; Mirwald et al., 2002). However, two longitudinal studies highlighted the limitations of the maturity offset prediction equations and predicted ages at PHV (Malina et al., 2014, 2016). A further study on the growth and maturation of female soccer players also found the same limitations in the maturity offset equation (Malina et al., 2021). In these studies, predicted ages at PHV were, on average, later than actual age at PHV from 10 to 18 years in girls. The difference between predicted and actual ages at PHV increased linearly with increasing chronological age (CA) at prediction in girls, although the increases from 11 to 14 years were not statistically significantly different (Malina et al., 2014). The authors concluded that predictions of age at PHV may be useful near the time of actual PHV among some average- and late-maturing girls within a narrow CA range but should not be used as a retrospective indicator of maturing timing in older girls as most are biologically mature and have stopped growing (Ramos et al., 2019). Therefore, while this study indicated that later-maturing girls dominated at U18 level compared to the other groups, the results should be taken with caution given the limitations of non-invasive prediction equations compared to more invasive measurements (Malina et al., 2021).

No significant differences were found between the three groups for the SJ and CMJ (U14 SJ 25.1 ± 3.4 cm, U16 SJ 23.2 ± 3.0 cm, U18 SJ 24.3 ± 4.8 cm; U14 CMJ 27.5 ± 3.7 cm, U16 CMJ 26.3 ± 3.5 cm, U18 CMJ 27.3 ± 5.0 cm). This is consistent with previous research by Vescovi et al. (2011), who showed improvements in CMJ performance until 15–16 years, after which there was a plateau until 21 years. Similarly, Ramos et al. (2021) found that U15 and U17 international soccer players did not display significant differences in the vertical jump, sprint, and specific endurance capacities between each other (Ramos et al., 2021). In contrast, Castagna and Castellini (2013) found large differences between female U17 and U19 international soccer players for SJ and CMJ (U17 SJ 28.2 ± 2.5; U19 SJ 29 ± 2.1; U19 CMJ 32.8 ± 2.9; U19 CMJ 34.3 ± 3.9). As biological maturation ceases at 17 years in females, improvements in physical performance tests in older age groups may be attributed to physiological adaptations elicited by increased total training load and an increase in match demands. These include greater stretch reflex, increased elastic energy potentiation, and enhanced neural potentiation, all of which would enhance CMJ performance (Doyle et al., 2021; Ramos et al., 2019).

There were no significant differences in this study in DJ height and consequently RSI between the U14, U16, and U18 groups, indicating that the force production capabilities of the three groups were similar (U14 DJ 25.5 ± 3.4 cm, U16 DJ 25.7 ± 3.7 cm, U18 DJ 26.4 ± 4.9 cm; U14 RSI 1.16 ± 0.2, U16 RSI 1.17 ± 0.2, U18 RSI 1.22 ± 0.3). Measures of strength are significantly and positively associated with RSI, indicating that stronger individuals achieve higher RSI scores (Markovic et al., 2004). There are very limited data available on normative scores for the RSI for adolescent female athletes. Emmonds et al. (2019) reported mean RSI scores of 1.17 + 0.14 in elite female club-level players. However, this was via a 40 cm drop jump, and as drop jump height affects performance, these results are not directly comparable.

The seated medicine ball throw assesses upper-body muscular power by measuring the maximal distance an individual can throw a medicine ball from an isolated, seated position (Biggar et al., 2021). Again, there were no significant differences between the three groups (U14 3.4 ± 0.3 m, U16 3.5 ± 0.3 m, U18 3.6 ± 0.4 m), indicating that upper-body strength and power gains did not occur due to maturation. There are currently no normative data for female athletes on the 3 kg MB throw. Biggar et al. (2021) assessed the seated med ball throw in a group of 12–15-year-old female physical education students, but a 2 kg med ball was used, so the results are not comparable.

No significant differences in sprinting speed were found over 0–5 m, 0–20 m, or in the pro-agility test (U14 0–5 m 1.19 ± 0.1 s, U16 1.16 ± 0.08 s, U18 1.16 ± 0.1 s; U14 0–20 m 3.52 ± 0.18 s, U16 3.53 ± 0.15 s, U18 3.58 ± 0.25 s; pro-agility U14 5.71 ± 0.29 s, U16 5.73 ±0.35 s, U18 5.59 ± 0.31 s). This is in agreement with Vescovi et al. (2011), who reported a plateau in sprinting performance over 18.2 m for female soccer players after 14 years of age. Similarly, Doyle et al. (2021) found no significant differences in sprinting speed over 20 m between U17 and U19 Irish international soccer players, while Ramos et al. (2021) found no significant differences between U15, U17, and U20 Brazilian international soccer players. Vescovi et al. (2011) found a modest improvement in female soccer players' performance on the pro-agility test up to 15–16 years, after which a plateau occurred.

The YoYoIR1 was the only test in which significant differences in performance were found, and this was between the U14 and U18 groups only. No significant differences were found between the U14 and U16 groups or between the U16 and U18 groups (U14: 750 ± 306 m, U16: 868 ± 308 m, U18: 944 ± 348 m). Emmonds et al. (2020) found that YoYoIR1 performance increases with age from early to mid-teens (U12 to U16). Similarly, Ramos et al. (2021) found increasing YoYoIR1 scores in U15 (710 ± 210 m), U17 (720 ± 230 m), and U20 (860 ± 240 m) Brazilian

international soccer players. They also found that senior players covered a far greater distance on the YoYoIR1 (1510 ± 320 m), indicating that improvements in aerobic capacity are attainable into adulthood.

3.4.1 Limitations and Future Research

This study has a number of limitations. All but three of the participants were tested for the first time, and while jumps, linear sprints, and change-of-direction sprints were included in the warm-up to ensure familiarisation, a potential learning effect may have influenced performance. As each panel had a large number of players, it was not possible to conduct testing within a narrow timeframe to account for possible circadian variation within the performance data. Several players also participate in multiple sports through school and clubs, and while each player was asked not to engage in physical activity in the 24 h prior to testing, compliance with this request could not be guaranteed. In addition, the data came from a single county with a large playing population, and it is possible that these findings are reflective of similar types of counties and not those with smaller playing populations who also compete at inter-county level. Although the sample size was sufficient to detect moderate between-group effects, it may have been underpowered to detect smaller differences. Therefore, non-significant findings should be interpreted with caution, as the absence of statistical significance does not necessarily imply the absence of meaningful differences. Future multi-county studies with larger samples would improve precision and increase sensitivity to detect smaller effects. There is therefore a need for data sharing between counties and within the LGFA in order to understand how ladies' Gaelic football develops along the talent development pathway. Research is also required to determine changes in the physical fitness profile throughout the inter-county season; to conduct longitudinal studies to measure the effectiveness of a long-term athletic development programme; and to assess the physical and physiological demands of the game at each age grade, between playing positions, and between club and inter-county players. Ascertaining the running demands at each age grade, level, and position will help inform training practice and allow coaches to design data-informed training drills and practices to adequately prepare players for the demands of the game (Duggan et al., 2023; Malone et al., 2023).

All three groups in this study were tested in early pre-season, just after selection to their respective panels, and, as such, these results represent baseline figures for strength, speed, power, and endurance. Although athletic development programmes have the potential to optimise performance and mitigate injury risks, none of the groups had engaged in a continuous structured programme of athletic development, while senior players engage in up to five sessions per week,

including two resistance-based sessions (Duggan et al., 2023). In the absence of specific neuromuscular training, females plateau in mid-to-late adolescence for factors such as strength and speed, while peak power in girls' plateaus around 16 years (Papaiakovou et al., 2009; Stratton & Oliver, 2019). However, progressive improvements in lower-body strength and power, speed, and endurance have been achieved into adulthood with appropriate training (Doyle et al., 2021; Emmonds et al., 2020; Ramos et al., 2019, 2021). A number of studies have highlighted differences in these qualities between senior and junior groups (Datson et al., 2022; Ramos et al., 2021; Vescovi et al., 2011) and between competitive standards (Doyle et al., 2021; Mujika et al., 2009; Ramos et al., 2019). Currently, there are no published data on these fitness characteristics for senior inter-county female Gaelic football players, but it is likely that substantial differences exist between underage players and senior players. Research to establish the fitness profile of senior players is also warranted. This will enable differences between underage and senior levels to be established and may provide a foundation for the establishment of training programmes to assist with competition level transitions (Malone et al., 2023).

3.5 Conclusion

In conclusion, the current study is the first to describe the anthropometric and physical fitness characteristics of inter-county ladies' Gaelic football players across age grades. This study demonstrated that U14, U16, and U18 inter-county ladies' Gaelic football players did not differ significantly in terms of upper- and lower-body strength and power, sprint speed, and change of direction speed, while moderate differences were found between the U14 and U18 groups for aerobic endurance only. The long-term athletic development of adolescent inter-county players should be a key priority for talent pathways. There is a need to strategically develop physical qualities such as strength, speed, and aerobic endurance to help reduce the risk of injury and to adequately prepare for the demands of ladies' Gaelic football at the current age grades and into senior level. This may be achieved by prescribing strength training sessions, using the warm-up as a tool to develop athleticism, speed, and agility, and using small-sided games to build the aerobic system in a game-specific way in addition to traditional conditioning approaches (Doyle et al., 2021; Duggan et al., 2023). The current study provides a first step in providing age-appropriate data to coaches working with inter-county teams across three age groups and may aid long-term player development pathways and individualise training programmes for these players

Chapter 4: The Running Performance Characteristics of U16 and U18 Inter-County Ladies' Gaelic Football Players: An Analysis Across Halves, Playing Positions, and Age Grades.

The previous chapter detailed the physical characteristics of adolescent inter-county players at each competition age grade. However, physical capacity alone does not determine competitive performance, and establishing that players differ, or do not differ, across age grades does not, in itself, indicate whether those capacities are sufficient to meet the running demands of competition. Understanding a player's underlying physical qualities, such as sprint velocity, aerobic capacity, and lower-body power, provides essential baseline context, but it reflects athletic potential rather than real-world application. These physical capacities acquire meaning only when considered in relation to the competitive demands they must meet.

Accordingly, Chapter 4 addresses this question by analysing match-play running performance among U16 and U18 inter-county LGF players. Using 10-Hz GPS technology, the study examines locomotor demands across halves of play, playing positions, and age grades. Particular attention is given to total and relative running demands, high-speed running, sprinting, and changes in performance between the first and second halves. These analyses provide evidence of the intensity and distribution of the physical demands encountered during youth inter-county competition.

The study also considers the implications of positional variation. Players do not experience the game in identical ways, and the demands placed on the middle-eight positions may differ substantially from those faced by the inside lines. Similarly, reductions in running performance across the match may indicate that players cannot sustain repeated high-intensity running efforts throughout competitive play.

Taken together, Chapters 3 and 4 address two complementary elements of the first research strand. Chapter 3 establishes players' physical capabilities, while Chapter 4 establishes the game's requirements. Considering these findings together allows the thesis to move beyond descriptive profiling and examine whether the physical development evident across the youth pathway appears sufficient to meet the demands of competition. It may also inform coaching practice by providing

reference data for talent identification, individual player monitoring, and guidance on developmental progression within the player pathway.

4.1 Introduction

Ladies' Gaelic football is an intermittent, high-intensity invasion game in which players perform multidirectional movements, with lower-intensity activities such as walking and jogging interspersed with high-intensity running, sprinting, acceleration, deceleration, and changes of direction (Cullen et al., 2017; Malone et al., 2023; Mooney et al., 2021). Inter-county competition represents the highest competitive standard, with selected players representing their county at U14, U16, and U18 levels, with potential progression to senior representative competition (Molohan et al., 2023). Teams comprise 15 players organised into six positional lines, with matches lasting 60 minutes. Positional differences in running demands have been identified in senior inter-county LGF (Malone et al., 2023) and U20 male Gaelic football (Mooney et al., 2021); however, whether match-play demands differ across adolescent LGF age grades and playing positions remains unclear.

Global Positioning Systems (GPS) technology is widely used to quantify the external running demands of intermittent team sports (Connors et al., 2022; J. Malone et al., 2017; S. Malone et al., 2017c; McGuinness et al., 2019a, 2019b). GPS-derived measures, including total and relative distance, maximal speed, accelerations, decelerations, and distances covered within different speed zones, enable the physical demands of match play to be quantified and provide coaches with data to inform the design of training programmes (Hodun et al., 2016; Scott et al., 2016; Young et al., 2018, 2021). This technology therefore provides an objective means of examining the locomotor demands experienced across different playing standards, positions, and periods of match play.

Research on the running requirements of Ladies' Gaelic football remains sparse (Duggan et al., 2021). To date, only two studies have reported the running demands of senior inter-county players (Malone et al., 2023, 2024). Independent of playing position, players covered an average distance of 7,319 ± 1,021 m at an intensity of 116 ± 9 $m \cdot min^{-1}$, with 1,547 ± 432 m completed as high-speed running (≥ 4.4 $m \cdot s^{-1}$) and a mean maximum velocity of 7.17 ± 0.41 $m \cdot s^{-1}$ (Malone et al., 2023). Positional analysis showed that the middle eight positions (half-backs, midfielders, and half-forwards) covered significantly greater distances than the full-back and full-forward lines (Malone et al., 2023). Furthermore, match-play analysis revealed that running demands peaked in the first quarter before declining in subsequent periods, with particularly notable reductions among the middle eight positions (Malone et al., 2024). Similar positional and temporal variations have been reported across other field-based invasion sports, including Gaelic football, hurling, soccer, Australian Rules football, camogie, and hockey (Black et al., 2019; Connors et al., 2022; McGuinness

et al., 2019a, 2019b; Mooney et al., 2021; O'Grady et al., 2022; Vescovi et al., 2021; Young et al., 2018).

Ensuring players are physically prepared to meet the demands of senior-level competition is a key component of player development (Morgans et al., 2022). Evidence from other female team sports indicates that match-play demands increase with age and playing level, including in women's rugby sevens (Clarke et al., 2017), soccer (Casamichana et al., 2024; Vescovi et al., 2021), and Australian Rules football (Jennings et al., 2025). In rugby sevens, small-to-moderate differences have been observed between junior, senior, and elite levels in sprint distance, relative distance, and maximum speed (Clarke et al., 2017). Similarly, in female soccer, total match distance increased from 6,936 ± 335 m at U15 level to 10,144 ± 546 m at international level, while relative running intensity increased from 87 ± 4 $m \cdot min^{-1}$ to 111 ± 6 $m \cdot min^{-1}$ (Vescovi et al., 2021). In Australian Rules football, AFLW players have also demonstrated greater relative and very high-speed running demands than elite-junior players (Jennings et al., 2025). Collectively, these findings suggest a progressive increase in match-play demands as female athletes advance through developmental pathways towards senior competition.

Although evidence from comparable female team sports provides useful context, differences in playing numbers, pitch dimensions, rules, technical skills, and tactical requirements limit their direct application to Ladies' Gaelic football. To date, no studies have examined the running requirements of U16 and U18 inter-county Ladies' Gaelic football. Establishing these demands will provide information regarding the physical requirements of competition at each age grade and may inform evidence-based decisions regarding training volume and intensity while supporting long-term player development (Palucci Vieira et al., 2019). Therefore, the current study aimed to examine the running performance demands of U16 and U18 inter-county match play across halves of play and between positions. It was hypothesised that running performance demands would decrease between halves at each age grade and that the middle eight positions (half-backs, midfielders, and half-forwards) would achieve greater total distance (TD), high-speed running (HSR), and sprint distance than the full-back and full-forward lines. It was also hypothesised that U18 players would exhibit greater performance demands for TD, HSR, and sprint distance than U16 players.

4.2 Methods

4.2.1 Experimental approach to the problem

The current study was designed to examine the match-play running performance of U16 and U18 inter-county ladies' Gaelic football players across halves of play using portable GPS technology. Both age grades were monitored in competitive championship play over a two-season

period (18th March 2023-11th July 2024; U16, n = 9 matches; U18, n = 12 matches). Challenge games were excluded from the analysis. Individual samples were collected from players who completed the full 60 minutes, resulting in 76 (U16) and 107 (U18) player profiles, respectively. Data were classified based on positional line and across halves of play, yielding the following number of samples per playing position: U16 full back (FB) *n* = 20, half back (HB) *n* = 2,0, midfield (MF) *n* = 11, half forward (HF) *n* = 14, full forward (FF) *n* = 11; U18 full back (FB) *n* = 31, half back (HB) *n* = 27, midfield (MF) *n* = 11, half forward (HF) *n* = 21, full forward (FF) *n* = 17. Data were collected 1–6 times per player throughout the investigation period. All matches were played at 14:00 on weekend afternoons, except for three in the latter stages of the championship, which took place at 19:30 on weekdays. Temperatures during match play ranged from 6 to 15 °C. All players completed two pitch and one gym session per week during the observation period and were requested to refrain from strenuous physical activity in the 24 hours prior to competitive matches.

4.2.2 Participants

One hundred and thirteen (*n* = 113) inter-county U16 (height 166 ± 5.5 cm, body mass 59.5 ± 6.8 kg) and U18 (height 168 ± 5.1 cm, body mass 63.0 ± 8.2 kg) players participated in the study. The U16 and U18 squads comprised 15- and 16-year-old players and 17- and 18-year-old players, respectively. The estimated age at peak height velocity (PHV) was 12.6 ± 0.4 years for U16 players and 13.4 years for U18 players. Ethical approval was granted by the Dublin City University Research Ethics Committee (DCUREC/2022/122), and written parental consent and player assent were obtained prior to sample collection.

4.2.3 Experimental procedure

Players were equipped with individual GPS units containing a triaxial accelerometer and a sampling rate of 10 Hz to monitor their running performance during match play (Catapult One Pod; Catapult Sports; Melbourne, Australia). A specially designed sports vest was worn beneath the player's jersey, with the GPS unit (84 mm × 42 mm × 21 mm) positioned between the scapulae in a protected pouch. Players used the same GPS device for all observations to mitigate inter-unit error (Keane et al., 2023). Activation and satellite lock were established by turning the units on 15 minutes prior to the pre-match warm-up (Connors et al., 2022; Young et al., 2021). The validity and reliability of 10 Hz devices utilising the PlayerTek technology found in the Catapult One have previously been established and reported as acceptable across a range of velocities and distances in intermittent team sports (Johnston et al., 2014; Mooney et al., 2021; Rampinini et al., 2015; Scott et al., 2016; Sheehan et al., 2022). Specifically, these units have demonstrated acceptable reliability for measuring total locomotive distances during shuttle-based movements, with coefficient of

variation (CV) ranges of 2.2–7.1% for 10 m shuttle distances and 1.0–3.1% for 20 m shuttle distances (Healey et al., 2021). Furthermore, the units demonstrated high inter-unit consistency during dynamic, sport-specific football activity (CV: 1.95–7.20%) (Healey et al., 2021). Previous research in an elite inter-county Gaelic football context, utilising identical 10-Hz units, also confirmed acceptable reliability for key high-speed metrics, with CV's of 5.8% for high-speed running distance (HSRD) and 11.7% for very high-speed running distance (VHSRD) (Mooney et al., 2021). GPS data were retrospectively downloaded after each competitive game using proprietary software (Catapult One Version 6.00.0000, Catapult Sports, Melbourne, Australia). The data file was trimmed to include only activity that occurred during each half of match play. Subsequently, the file was exported to a Microsoft Excel spreadsheet (Microsoft, Redmond, WA, USA). The Excel spreadsheet enabled categorisation of activity into total distance (TD) (m), high-speed running (HSR) (m; ≥ 4.4 $m \cdot s^{-1}$), sprint distance (m; ≥ 5.5 $m \cdot s^{-1}$), accelerations (n; ≥ 3 $m \cdot s^{-2}$), decelerations (n; ≤ -3 $m \cdot s^{-2}$), relative distance ($m \cdot min^{-1}$), and maximal speed ($m \cdot s^{-1}$). Zone 4 running was defined as speeds of 4.4-5.5 $m \cdot s^{-1}$, while zone 5 referred to sprint speeds of ≥ 5.5 $m \cdot s^{-1}$. HSR is defined as the total distance covered at ≥ 4.4 $m \cdot s^{-1}$ and thus includes sprint distance. An acceleration or deceleration was categorised once a player's speed changed by 3 $m \cdot s^{-2}$ (Keane et al., 2023). These specific speed thresholds were selected because they align with established age-grade and female invasion sports research, including ladies' Gaelic Football (Bradley et al., 2015; Connors et al., 2022; Malone et al., 2023, 2024; McGuinness et al., 2019a, 2019b; Ramos et al., 2019; Vescovi et al., 2021), thereby facilitating standardised, objective tracking and comparison of developmental progression between the U16 and U18 cohorts.

4.2.4 Statistical Analysis

All statistical analyses were performed using SPSS for Windows (Version 29, SPSS Inc., Chicago, IL, USA). Descriptive data are presented as mean ± standard deviation (SD). Initial whole-match comparisons between the U16 and U18 age grades were conducted using independent-samples t-tests, with 95% confidence intervals (CIs) reported for the mean differences. Subsequently, a mixed repeated-measures multivariate analysis of variance (MANOVA) was employed to examine the effects of team (U16 vs U18) and positional line (full-back, half-back, midfield, half-forward, and full-forward) on multiple dependent variables measured across two time points (1st half vs 2nd half). The dependent variables included: TD (m), HSR (m), Max Speed ($m \cdot s^{-1}$), Distance Per Minute ($m \cdot min^{-1}$), Distance in Speed Zone 4 (m), Distance in Speed Zone 5 (m), Accelerations (≥ 3 $m \cdot s^{-2}$), and Decelerations (≤ -3 $m \cdot s^{-2}$). Levene's test of equality was conducted for each dependent variable to assess between-subjects effects and the assumption of homogeneity of variance. Pillai's Trace was used as the multivariate test statistic. Bonferroni-corrected post hoc pairwise comparisons were conducted to identify specific group differences when a significant

interaction was observed. The significance level for all statistical tests was set at $p < .05$. Where significant effects were found, the magnitude of potential differences was determined using established effect size (ES) metrics. For the independent *t*-tests, ES was calculated using Cohen's *d*. Effect sizes were interpreted as trivial (< 0.20), small (0.20–0.49), moderate (0.50–0.79), and large (≥ 0.80) (Cohen, 1988). For the MANOVA, ES was determined using partial eta squared (η_p^2) with values of 0.01, 0.06, and 0.14 interpreted as small, moderate, and large, respectively (Cohen, 1988).

4.3 Results

Table 4.1 summarises the overall match-play running performance of U16 and U18 inter-county players. The mean distance covered by U16 players, irrespective of position, was 6,251 ± 1,394 m, corresponding to a relative intensity of 88 ± 20 m·min $^{-1}$. Players completed 826 ± 371 m of HSR, of which 206 ± 177 m was spent in speed zone 5 (≥ 5.5 m·s $^{-1}$). The number of accelerations and decelerations completed was 36 ± 11 and 44 ± 13, respectively, while the mean max speed attained during match play was 6.94 ± 0.36 m·s^{-1}. For the U18 group, the mean distance completed was 6,773 ± 1,221 m, corresponding to a relative intensity of 93 ± 16 m· min^{-1}. Players achieved a total of 1,071 ± 424 m of high-speed running, with 348 ± 195 m occurring in speed zone 5. The total number of accelerations and decelerations completed was 36 ± 12 and 48 ± 14, respectively. The average maximum speed attained was 6.94 ± 0.40 m·s^{-1}.

Table 4.1

Match-play running performance of U16 and U18 LGF

Performance Variable	**U16**	**U18**	***p***	**95% CI (Diff)**	**Cohen's *d***
Distance (m)	6,251 ± 1394	6,773 ± 1221	.008*	[-906, -139]	0.40
High Speed Running (m)	826 ± 371	1,071 ± 424	< .001*	[-364, -125]	0.61
Max Speed (m·s^{-1})	6.94 ± 0.36	6.94 ± 0.40	.893	[-0.38, 0.43]	0.02
Relative Distance (m·min^{-1})	88 ± 20	93 ± 16	.063	[-10, 0]	0.28
Distance Speed Zone 4 (m)	620 ± 242	723 ± 267	.008*	[-179, -27]	0.40
Distance Speed Zone 5 (m)	206 ± 177	348 ± 195	< .001*	[-197, -86]	0.76
Accelerations (*n*) (≥ 3 m·s^{-2})	36 ± 11	36 ± 12	.994	[-4, 4]	0.00
Decelerations (*n*) (≤ -3 m·s^{-2})	44 ± 13	48 ± 14	.075	[-8, 0]	0.27

*Note: Data are presented as mean ± SD. *Statistically significant difference between age grades (p < .05). Effect sizes (Cohen's d) are interpreted as trivial (< 0.20), small (0.20–0.49), moderate (0.50–0.79), and large (≥ 0.80).*

Multivariate analysis for within- and between-subjects factors indicated significant main effects for halves of play ($F(9, 165) = 13.974$, $p < .001$, $\eta_p^2 = 0.431$), team ($F(9, 165) = 7.855$, $p < .001$, $\eta_p^2 = 0.300$), and playing position ($F(36, 672) = 4.187$, $p < .001$, $\eta_p^2 = 0.183$) on the combined dependent variables. The interaction between team and playing position was not statistically significant for within- and between-subjects factors ($F(36, 672) = 0.724$, $p = .884$, $\eta_p^2 = 0.037$ and $F(36, 672) = 1.315$, $p = .106$, $\eta_p^2 = 0.067$). The 3-way interaction between halves of play, age-grade, and position was also not significant ($F(36,672) = 0.724$, $p = .884$, $\eta_p^2 = 0.037$).

Table 4.2 summarises the follow-up univariate tests. For halves of play, the greatest effect was seen for relative distance, which saw a large decrease in the second half of play ($p < .001$, $\eta_p^2 = 0.225$). Moderate, statistically significant reductions were also found for HSR ($p = .001$, $\eta_p^2 = 0.059$) and distance covered in Zone 4 ($p = .003$, $\eta_p^2 = 0.049$). No statistically significant differences between halves of play were observed for maximum speed, accelerations or decelerations.

Table 4.2

Effects of Half, Team, and Playing Position on Performance Measures

Performance Variable	***Source***	***F (df1, df2)***	***p***	η_p^2
Total Distance (m)	Half	5.89 (1, 165)	.016*	0.033
	Team	19.38 (1, 165)	<.001*	0.101
	Position	39.55 (4, 165)	<.001*	0.478
High Speed Running (m)	Half	10.79 (1, 165)	.001*	0.059
	Team	34.71 (1, 165)	<.001*	0.167
	Position	22.50 (4, 165)	<.001*	0.342
Max Speed ($m \cdot s^{-1}$)	Half	1.00 (1, 165)	0.318	0.006
	Team	0.29 (1, 165)	0.591	0.002
	Position	3.36 (4, 165)	.011*	0.072
Relative Distance ($m \cdot min^{-1}$)	Half	50.30 (1, 165)	<.001*	0.225
	Team	12.61 (1, 165)	<.001*	0.068
	Position	46.11 (4, 165)	<.001*	0.516
Distance Zone 4 (m)	Half	8.89 (1, 165)	.003*	0.049
	Team	20.31 (1, 165)	<.001*	0.105
	Position	29.50 (4, 165)	<.001*	0.405
Distance Zone 5 (m)	Half	4.34 (1, 165)	.039*	0.024
	Team	35.29 (1, 165)	<.001*	0.169
	Position	7.52 (4, 165)	<.001*	0.148
Accelerations (*n*) ($\geq 3\ m \cdot s^{-2}$)	Half	0.27 (1, 165)	0.601	0.002
	Team	0.00 (1, 165)	0.998	0.000
	Position	2.09 (4, 165)	0.085	0.046
Decelerations (*n*) ($\leq -3\ m \cdot s^{-2}$)	Half	0.96 (1, 165)	0.329	0.006
	Team	4.16 (1, 165)	.043*	0.023
	Position	7.87 (4, 165)	<.001*	0.154

*Statistically significant difference between halves of play, team or position ($p < .05$). Effect sizes (η_p^2) are interpreted as small (≥ 0.01), moderate (≥ 0.06), and large (≥ 0.14).

The comparison of age grades indicated that the U18 group exhibited superior running outputs compared to the U16 group across multiple variables. Significant differences were observed across age grades for high-speed running distance ($p < .001$, $\eta_p^2 = 0.167$) and the distances covered in speed zones 4 ($p < .001$, $\eta_p^2 = 0.105$) and 5 ($p < .001$, $\eta_p^2 = 0.169$). Statistically significant differences were observed between the age grades for TD ($p < .001$, $\eta_p^2 = 0.101$) and relative

distance ($p < .001$, $\eta_p^2 = 0.068$). No statistically significant differences were found between the age groups regarding maximum speed or acceleration. Playing position had the greatest significant influence on nearly all performance variables, consistently demonstrating large effect sizes. Large effects were found for TD ($p < .001$, $\eta_p^2 = 0.478$), HSR ($p < .001$, $\eta_p^2 = 0.342$), relative distance ($p < .001$, $\eta_p^2 = 0.516$), distance in speed zones 4 ($p < .001$, $\eta_p^2 = 0.405$), and 5 ($p < .001$, $\eta_p^2 = 0.148$), and decelerations ($p < .001$, $\eta_p^2 = 0.154$). No statistically significant differences in the number of accelerations were observed across playing positions.

Table 4.3 and Figure 4.1 present the post hoc Bonferroni comparisons. Running outputs were consistently higher for the middle eight positions (half-backs, midfielders, half-forwards) compared to the inside lines (full-backs and full-forwards). These positions also showed the greatest decline in second-half performance, particularly in high-intensity metrics such as relative distance and HSR. Higher physical outputs were observed in all positions as the age profile increased.

Table 4.3

Running Performance of U16 and U18 LGF by Playing Position and Halves of Play

Playing Position		**FB**	**HB**	**MF**	**HF**	**FF**
Total Distance (m)						
U16	1st Half	2,698 ± 461^{bcdx}	3,594 ± 494^{aex}	3,820 ± 542^{aex}	3,440 ± 613^{aex}	2,376 ± 853^{bcdx}
	2nd Half	2,578 ± 500^{bcdx†}	3,539 ± 476^{aex†}	3,473 ± 719^{aex†}	3,330 ± 510^{aex†}	2,341 ± 696^{bcdx†}
U18	1st Half	2,973 ± 488^{bcdy}	3,690 ± 382^{aey}	4,122 ± 269^{aey}	3,715 ± 592^{aey}	2,891 ± 480^{bcdy}
	2nd Half	2,979 ± 580^{bcdy†}	3,567 ± 431^{aey†}	3,822 ± 738^{aey†}	3,824 ± 577^{aey†}	2,907 ± 541^{bcdy†}
High Speed Running (m)						
U16	1st Half	346 ± 190^{bcdx}	533 ± 196^{aex}	565 ± 191^{aex}	459 ± 201^{aex}	258 ± 120^{bcdx}
	2nd Half	283 ± 145^{bcdx†}	486 ± 194^{aex†}	479 ± 155^{aex†}	424 ± 176^{aex†}	287 ± 153^{bcdx†}
U18	1st Half	380 ± 149^{bcdy}	639 ± 158^{aey}	847 ± 139^{aey}	621 ± 251^{aey}	415 ± 117^{bcdy}
	2nd Half	382 ± 197^{bcdy†}	591 ± 169^{aey†}	699 ± 205^{aey†}	652 ± 226^{aey†}	408 ± 124^{bcdy†}
Max Speed (m·s $^{-1}$)						
U16	1st Half	6.97 ± 0.40^{b}	7.05 ± 0.41^{a}	7.10 ± 0.41	6.94 ± 0.38	6.79 ± 0.44
	2nd Half	6.71 ± 0.54^{b}	7.12 ± 0.46^{a}	6.97 ± 0.29	6.91 ± 0.36	6.70 ± 0.58
U18	1st Half	6.84 ± 0.51^{b}	6.98 ± 0.47^{a}	7.13 ± 0.34	6.97 ± 0.50	6.94 ± 0.39
	2nd Half	6.76 ± 0.63^{b}	7.00 ± 0.38^{a}	7.11 ± 0.51	6.92 ± 0.47	7.01 ± 0.38

Playing Position		FB	HB	MF	HF	FF
Relative Distance (m·min^{-1})						
U16	1st Half	77 ± 12^{bcdx}	102 ± 14^{aex}	109 ± 16^{aex}	98 ± 18^{aex}	67 ± 23^{bcdx}
	2nd Half	71 ± 12^{bcdx†}	98 ± 14^{aex†}	96 ± 20^{aex†}	93 ± 13^{aex†}	64 ± 18^{bcdx†}
U18	1st Half	84 ± 14^{bcdy}	104 ± 12^{aey}	118 ± 9^{aey}	104 ± 16^{aey}	82 ± 13^{bcdy}
	2nd Half	78 ± 12^{bcdy†}	95 ± 11^{aey†}	101 ± 16^{aey†}	101 ± 12^{aey†}	78 ± 11^{bcdy†}
Distance Speed Zone 4 (m)						
U16	1st Half	245 ± 121^{bcdx}	411 ± 130^{aex}	408 ± 102^{aex}	354 ± 127^{aex}	198 ± 82^{bcdx}
	2nd Half	217 ± 94^{bcdx†}	369 ± 114^{aex†}	345 ± 103^{aex†}	324 ± 121^{aex†}	215 ± 109^{bcdx†}
U18	1st Half	273 ± 98^{bcdy}	445 ± 95^{aey}	563 ± 107^{aey}	395 ± 152^{aey}	274 ± 91^{bcdy}
	2nd Half	262 ± 116^{bcdy†}	393 ± 112^{aey†}	483 ± 145^{aey†}	434 ± 138^{aey†}	270 ± 73^{bcdy†}
Distance Speed Zone 5 (m)						
U16	1st Half	101 ± 87^{bcdx}	121 ± 98^{aex}	157 ± 113^{aex}	106 ± 101^{aex}	60 ± 58^{bcdx}
	2nd Half	66 ± 68^{bcdx†}	117 ± 111^{aex†}	134 ± 85^{aex†}	100 ± 105^{aex†}	72 ± 73^{bcdx†}
U18	1st Half	107 ± 70^{bcdy}	195 ± 84^{aey}	283 ± 93^{aey}	226 ± 134^{aey}	141 ± 52^{bcdy}
	2nd Half	120 ± 106^{bcdy†}	198 ± 89^{aey†}	217 ± 97^{aey†}	218 ± 122^{aey†}	138 ± 66^{bcdy†}
Accelerations (*n*) (≥ 3 m·s^{-2})						
U16	1st Half	19 ± 7	19 ± 6	21 ± 6	18 ± 6	15 ± 6
	2nd Half	17 ± 8	18 ± 4	19 ± 6	20 ± 5	14 ± 7
U18	1st Half	17 ± 8	21 ± 6	18 ± 7	17 ± 6	17 ± 6
	2nd Half	18 ± 8	20 ± 7	19 ± 10	19 ± 5	16 ± 5
Decelerations (*n*) (≤ -3 m·s^{-2})						
U16	1st Half	22 ± 7^{x}	26 ± 6^{ex}	23 ± 6^{ex}	22 ± 6^{x}	16 ± 8^{bcx}
	2nd Half	20 ± 7^{x}	25 ± 7^{ex}	22 ± 7^{ex}	23 ± 8^{x}	16 ± 9^{bcx}
U18	1st Half	23 ± 8^{y}	28 ± 7^{ey}	25 ± 4^{ey}	23 ± 7^{y}	20 ± 6^{bcy}
	2nd Half	24 ± 9^{y}	27 ± 7^{ey}	24 ± 10^{ey}	23 ± 8^{y}	19 ± 5^{bcy}

Note. FB = Full-back; HB = Half-back; MF = Midfield; HF = Half-forward; FF = Full-forward. Superscript letters indicate significant differences between groups. Data reported as mean ± SD. a: significantly different ($p < .05$) from FB; b: significantly different ($p < .05$) from HB; c: significantly different ($p < .05$) from MF; d: significantly different ($p < .05$) from HF; e: significantly different ($p < .05$) from FF; xy: significant difference ($p < .05$) between teams; †: significant difference ($p < .05$) between halves of play.

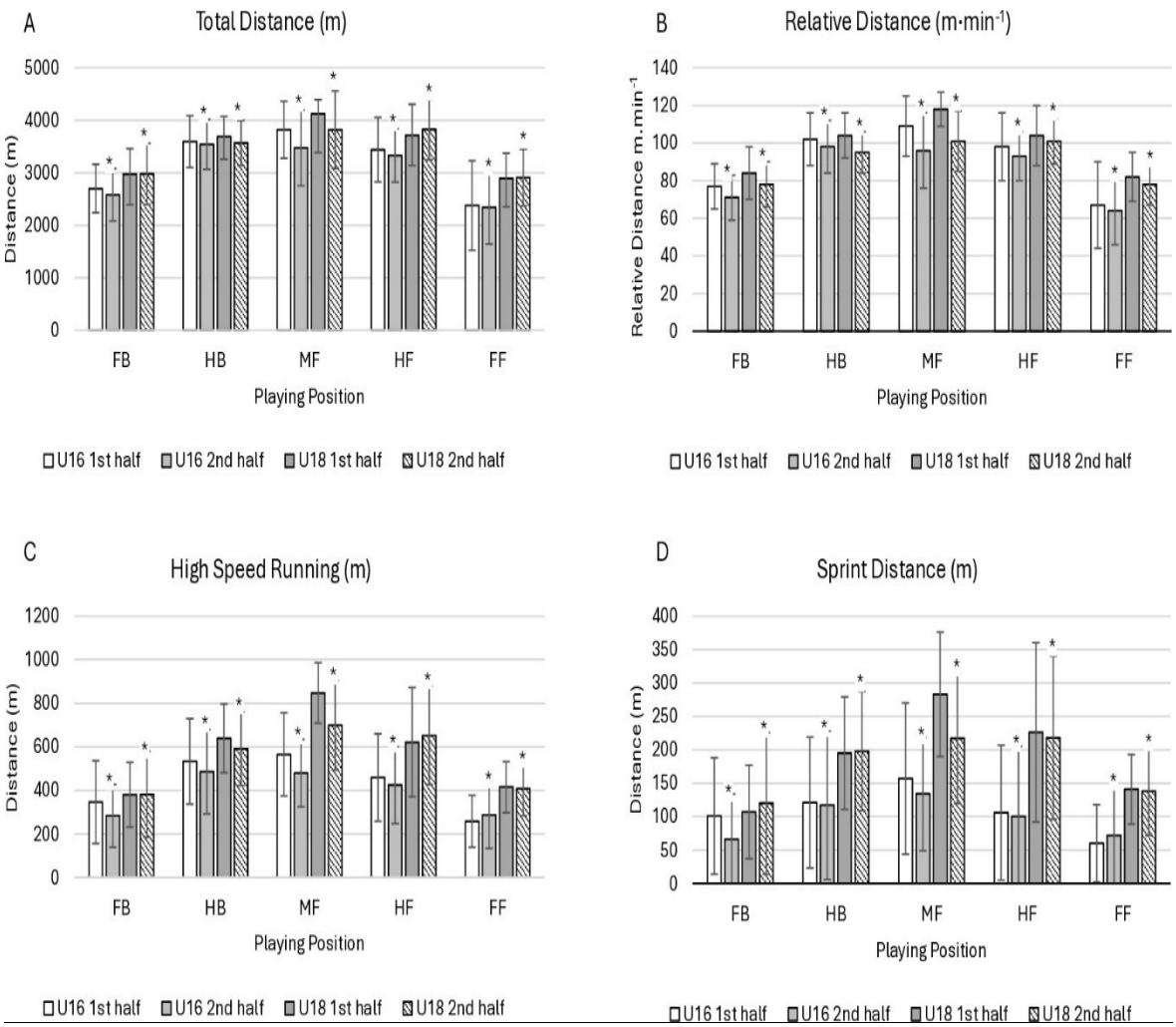


Figure 4.1

*The positional running performance profile of U16 and U18 LGFA players across halves of play for A) Total Distance (m), (B) Relative Distance (m·min^{-1}), (C) High Speed Running (m; ≥ 4.4 m·s^{-1}), and (D) Sprint Distance (m; ≥ 5.5 m·s^{-1}). Data are reported as mean ± SD. * Significant difference (p < .05) between halves of play.*

4.4 Discussion

This study is the first to detail the GPS-derived running demands of U16 and U18 inter-county Ladies' Gaelic football by playing position and halves of play. It was hypothesised that the running performance profile would differ between halves and playing position at each age grade and that U18 players would exhibit greater performance demands than U16 players. The main findings reveal a decline in running performance across halves of play, regardless of playing position and age grade. The middle eight positions exhibit the highest match-play demands and present a distinct positional running profile compared with the inside lines, while U18 players cover considerably greater total and high-speed running distances than U16 players.

Independent of playing position, U18 players demonstrated significantly greater total distance (p = .008), HSR (p < .001), and distance in speed zones 4 (p = .008) and 5 (p < .001) than U16 players, with small-to-moderate effect sizes. However, there were no statistically significant differences between age grades for overall relative distance (p = .063), maximum speed (p = .893), accelerations (p = .994), or decelerations (p = .075). The mean total distance covered by U16 players was 6,251 ± 1394 m while that of U18 players was 6,773 ± 1,221 m, corresponding to a relative distance of 88 ± 20 $m \cdot min^{-1}$ and 93 ± 16 $m \cdot min^{-1}$, respectively. For the U16 group, 13% of the total distance was spent in high-speed running and 3% in sprinting, rising to 16% and 5%, respectively, for the U18 group. The transition from U16 to U18, therefore, involves not only an increase in overall running volume (total distance) but also a greater accumulation of high-intensity efforts, as evidenced by the increased high-speed running and distance covered in speed zones 4 and 5. Consequently, coaches should progressively increase the emphasis on high-intensity conditioning to effectively prepare players for the demands of U18 and subsequently senior match-play (Ramos et al., 2019).

The frequency of both accelerations and decelerations was statistically similar across groups (p > .05), indicating that the fundamental requirement for initiating rapid speed changes and effective braking is comparable between U16 and U18 levels. However, given the high absolute frequency of these mechanically demanding actions, coaches should incorporate targeted deceleration training (Harper et al., 2019), alongside multi-directional agility drills that focus on controlled stops and directional changes at high speeds (McBurnie et al., 2022). These movement capacities can then be progressively applied within sport-specific contexts (McBurnie et al., 2022). Implementing these strategies, in conjunction with neuromuscular power development, prepares players for the highly intermittent nature of the sport, which requires frequent transitions between low-intensity movements and high-intensity, multi-directional efforts (Duggan et al., 2023).

No significant differences were found between the groups for maximal speed (U16: 6.94 ± 0.36; U18: 6.94 ± 0.40 $m \cdot s^{-1}$), consistent with previous research indicating a plateau in sprint performance after mid-adolescence (Doyle et al., 2021; Ramos et al., 2019; Vescovi et al., 2011). Investigations in soccer players found that no significant improvement in sprinting performance over 18.2 m occurred after age 14 (Vescovi et al., 2011). Similarly, no significant differences in 20 m sprinting speed have been found between U17 and U19 Irish international soccer players, or between U15, U17, and U20 Brazilian international soccer players (Doyle et al., 2021; Ramos et al., 2019). Analysis of U14, U16 and U18 inter-county Ladies' Gaelic footballers also found no significant difference in max speed over 20 m (Molohan et al., 2023).

However, evidence suggests this trend can be altered through targeted physical preparation. Research in younger female athletes (~13 years of age) demonstrates that targeted strength and plyometric training can significantly enhance sprinting performance (Talukdar et al., 2024). This trainability extends into late adolescence, where structured strength and plyometric interventions have been shown to significantly improve linear sprint speed in adolescent female team sport athletes, with strength training yielding particularly strong adaptations in those older than 15 years (Lin et al., 2025; Luo et al., 2025). Therefore, the plateau observed in the U16 and U18 cohorts may reflect a lack of consistent, targeted physical development, highlighting the need for progressive S&C programs to drive continued speed adaptations. Currently, neither the mean nor the range of sprint distances has been described in Ladies' Gaelic football. It may be that players do not achieve 'true' maximum sprinting speeds during match-play, as the sprint distances are insufficient due to the intermittent nature of the game. However, in elite inter-county Ladies' Gaelic football, peak speeds of 86 ± 4% were achieved across all positions, compared with peak speeds obtained during a 40 m linear sprint test in a pre-season testing battery (Malone et al., 2023; McGuinness et al., 2023).

A primary contribution of this research is the establishment of the first positional benchmarks across U16 and U18 age grades in LGF. To facilitate this objective tracking of developmental progress towards established senior standards (Bradley et al., 2015), standard absolute velocity thresholds were employed, consistent with recent research on female and youth cohorts (Malone et al., 2023, 2024; Ramos et al., 2019; Vescovi et al., 2021). However, when applying fixed, arbitrary criteria, consideration should be given to the inherent methodological limitations (Gualtieri et al., 2023; Park et al., 2019). While useful for standardised comparison, determining 'where to draw the lines' in female codes often lacks population-specific accuracy (Park et al., 2019), and small variations in threshold definitions can considerably alter reported match demands (Gualtieri et al., 2023). A fundamental limitation is that fixed thresholds solely quantify external playing load (GPS-derived distance) without accounting for individual physical capacities such as anaerobic fitness or maximum velocity (Park et al., 2019). Therefore, while these newly established LGF benchmarks provide collective profiles useful for broad benchmarking, they may obscure individual differences. The same absolute speed might represent a near-maximal effort for one player but only moderate intensity for another, reflecting vastly different internal workloads (physiological stress) among individual athletes within the same positional group (Gualtieri et al., 2023; Park et al., 2019).

Developmental differences have been identified in several other female team sports, such as soccer, (Vescovi et al., 2011), AFLW, (Jennings et al., 2025), and field hockey (Vescovi et al., 2016) as well as at the youth level in male Gaelic games (Cullen et al., 2017). Among youth soccer players,

notable differences in work rates were observed between U15, U16, and U17 players. The total, high-intensity (4.3 - 5.5 $m \cdot s^{-1}$), and sprinting (≥ 5.5 $m \cdot s^{-1}$) distances covered by U15 players were all lower than those recorded for U16 and U17 cohorts. These age-related differences remained even after adjusting for match duration, with relative distances of 86 $m \cdot min^{-1}$ reported for U15's compared to 93 and 95 $m \cdot min^{-1}$ for U16 and U17 players (Vescovi et al., 2021). Similarly, in international-level field hockey, relative intensity, HSR (4.4-5.5 $m \cdot s^{-1}$) and sprinting distances (≥ 5.5 $m \cdot s^{-1}$) increased between the U17 and U21 age grades (Vescovi et al., 2016). Collectively, these findings suggest a clear developmental progression in physical capacity across age groups as players mature. However, direct comparison between these studies and the current data remains challenging due to sport-specific rules, context, pitch sizes, playing numbers, differing research methodologies, and the lack of standardisation regarding GPS hardware models and velocity thresholds used across different sports (Bradley et al., 2015; J. Malone et al., 2017; Malone et al., 2024).

The consistent pattern of increasing demands across various team sports highlights the need to implement evidence-informed training structures specifically aligned with the increasing physical requirements of Ladies' Gaelic football as young athletes mature. Regular exposure to targeted, high-intensity conditioning stimuli is fundamental to facilitating the unique physiological and neuromuscular adaptations that underpin these increased physical capacities (Duggan et al., 2024). By quantifying these competitive requirements, coaches can establish a structured, periodised approach that combines isolated conditioning for targeted physical overload, such as sprint interval training (SIT) or repeated sprint ability, with game-like scenarios (e.g., SSGs) to prepare players for match situations (Duggan et al., 2024). Practitioners can adjust SSG constraints, such as using larger relative pitch sizes with fewer players or incorporating specific rules (e.g., requiring sprints after passing), to develop in-game decision-making alongside anaerobic power (Duggan et al., 2023; Malone et al., 2017a). Moreover, prioritising these repeated conditioning stimuli and ensuring specific overload within a technical and tactical context is essential for developing game-specific fitness and preparing players for the 'worst-case scenario' intensities encountered at each developmental stage (Duggan et al., 2024). Therefore, as players move from U14 to U16 and U18 levels, coaches should progressively increase the emphasis on these targeted, multifaceted conditioning strategies to support the ongoing adaptations in speed and high-intensity running required for senior performance.

The large effect sizes for TD ($p < .001$, $\eta_p^2 = 0.478$), HSR ($p < .001$, $\eta_p^2 = 0.342$), relative distance ($p < 0.001$, $\eta_p^2 = .516$), and distance in speed zone 4 ($p < .001$, $\eta_p^2 = 0.405$) and 5 ($p < 0.001$, $\eta_p^2 = 0.148$) underscore that playing position is the most influential factor dictating player workload in Ladies' Gaelic Football. Midfielders, half-backs, and half-forwards consistently demonstrated the

highest outputs, likely due to their pivotal tactical role linking offensive and defensive transitions (Malone et al., 2023). Conversely, the 'inside' full-back and full-forward lines covered significantly less total and high-speed running, reinforcing their more specialised roles involving explosive, short movements within tighter areas (Malone et al., 2023, 2024). This is consistent with observations in other adolescent female invasion sports (Black et al., 2019; McGuinness et al., 2019b; Vescovi et al., 2011; Young et al., 2021) and senior intercounty LGF (Malone et al., 2023, 2024). The consistency in positional demand patterns across U16, U18, and senior levels suggests that tactical roles and associated physical requirements are established early in a player's development.

Logistical constraints, such as limited contact time, are common in amateur and youth settings (Duggan et al., 2022). To maximise the limited contact time available, practitioners should prioritise structured SSGs as an efficient, integrated training modality that addresses physical, technical, and tactical requirements simultaneously (Mangan et al., 2022). This integrated approach aligns with contemporary tactical periodisation models for Gaelic football, which advocate for embedding conditioning elements directly within tactical practice (Mangan et al., 2022). For example, coaches can utilise larger SSGs with relative pitch sizes to optimise high-speed running, while incorporating smaller grids targeting high-intensity, explosive actions and anaerobic power (Mangan et al., 2019). This ensures players are prepared for both transitional running demands and high-intensity, localised engagement, regardless of their playing position. Furthermore, if second-half fatigue is identified as a limiting factor, coaches can efficiently implement SSG constraints (e.g., high-press rules) at the end of practice to ensure players develop the capacity to maintain technical and tactical proficiency under intense physical load (Vescovi et al., 2016).

While providing targeted preparation is necessary, coaches should also balance positional demands with principles of long-term player development. Youth players should be encouraged to experience different playing positions during training and games to develop a broad technical skill set and overall tactical awareness (Gaviria-Alzate et al., 2024). By avoiding early positional specialisation, players are forced to solve varied technical and tactical problems from different perspectives (e.g., viewing an overlap as both a defender and an attacker). This constant exploration and adaptation to varied constraints is essential for developing the deep 'gamesense' and adaptability required in adult competition (Gaviria-Alzate et al., 2024). Concurrently, early physical conditioning should focus on developing general athletic capacities before progressively shifting toward more position-specific qualities (Duggan et al., 2022). Developing this broad physical foundation is beneficial as positional roles are often interchangeable throughout the entire developmental pathway (U16, U18, and senior) (Timmons et al., 2025). Consequently, ensuring all players possess a robust physical capacity prepares them to meet the high running demands

observed in 'middle eight' positions, providing tactical flexibility for the coach at all age grades (Timmons et al., 2025).

4.4.1 Limitations

This study is not without its limitations. While data was collected over a two-year period, the number of competitive matches played by both teams, and thus the sample size, was relatively low (U16: n = 9; U18, n = 12). The study was conducted in a single county with a large playing population, and these results may be more generalisable to similar counties and not to those with smaller playing populations that also compete in the same championship. Training methods and philosophies, approaches to long-term player development, and competition can vary across counties and provinces, which may limit the representativeness of these results to the broader underage LGF landscape. Secondly, the specific match context, such as game importance, time of year, opposition quality, surface type, or match outcome (win/loss), which is known to significantly affect player work rates and tactical approaches, was not analysed (Black et al., 2019; Goodale et al., 2017; Vescovi et al., 2019). Thirdly, Horizontal Dilution of Precision (HDOP) data was not reported. HDOP is an indicator of GPS signal strength and positional accuracy. Therefore, the precision and potential variability in data accuracy across different matches and locations remain unknown, which could impact the reliability of the measured data (J. Malone et al., 2017). Fourthly, the data collection approach, where individual player samples were collected between 1 and 6 times per player, introduces potential variability. While providing a broad dataset, this uneven sampling might not fully capture the typical performance profile of individual players over a season and could potentially bias findings if players with more data points differ systematically from those with fewer. Finally, we acknowledge that while direct validation of the specific 'Catapult One' branding has not been reported, as detailed in our methodology, this concern is mitigated because the device utilises established PlayerTek 10-Hz technology, which is validated and highly reliable within inter-county Gaelic football contexts (Mooney et al., 2021; Rampinini et al., 2015).

4.5 Practical Applications

The findings of this investigation have important and direct implications for coaches and practitioners working with female youth athletes in Gaelic football. This foundational data addresses the current reliance on anecdotal evidence or generic data from other sports or male populations, providing coaches with female-specific benchmarks essential for appropriate and effective training (Molohan et al., 2023; Palucci Vieira et al., 2019). Coaches can utilise this information to design evidence-informed training programmes that progressively increase the volume and intensity of high-speed running, sprinting, and explosive actions to prepare U16 players

for the greater physical demands of the U18 age group, and U18 players for the requirements of senior competition. The identified distinct locomotor profiles across positional lines suggest that training should be tailored to these specific demands while maintaining a balanced approach to long-term athletic development. The high frequency of accelerations and decelerations highlights the sport's intermittent nature, indicating that coaches should incorporate targeted activities to develop explosive performance and reduce injury risk. By providing detailed positional and age-grade performance profiles, this research serves as a tool for talent identification, individual player monitoring, and the establishment of clear developmental progression within the player pathway.

4.6 Conclusion

This study offers the first comprehensive GPS-derived insights into the match-play running demands of U16 and U18 inter-county Ladies' Gaelic football, contributing important new knowledge to a significantly under-researched area. The findings highlight significant developmental and positional differences and show a decline in running performance across halves of play. Future research should extend these insights through longitudinal studies that monitor individual athlete development, assess the effectiveness of targeted training interventions to reduce second-half performance declines, examine the impact of contextual factors on match-play running performance, and explore the complex interactions among physical, technical, and tactical execution in inter-county Ladies' Gaelic football.

Chapter 5: Physical Preparation in a Talent Development Environment: Exploration of Ladies Gaelic Football Coaches' Knowledge, Practices, Perceptions and Challenges

Taken together, Chapters 3 and 4 complete the first research strand of this thesis and highlight a central challenge. While match-play demands escalate from U16 to U18 and are substantially greater at senior level, the physical qualities measured across the adolescent age grades show limited progression. However, player testing and match analysis cannot explain why this pattern occurs or whether the existing development environment provides sufficient opportunities for progressive physical preparation.

To equip players for these escalating demands, athletic development must be systematically planned, prescribed, and delivered. Within the inter-county LGF pathway, much of the responsibility for translating these requirements into day-to-day preparation rests with volunteer coaches who have limited access to dedicated strength and conditioning personnel. Coaches must therefore make decisions about physical preparation alongside technical, tactical, logistical, and organisational demands. Their knowledge, experience, confidence, available resources, and perceptions of the role of athletic development are consequently critical to the wider development environment.

Chapter 5 addresses this implementation question through a nationwide mixed-methods survey of inter-county LGF coaches. The chapter examines coaches' knowledge of physical preparation, reported training and testing practices, perceptions of the importance of athletic development, access to sports science support and technology, and the barriers and facilitators to implementation. Open-ended qualitative responses provide additional context on the practical challenges faced by coaches working within the inter-county pathway.

The purpose of this chapter is not simply to identify deficiencies in the coaching workforce. Rather, it is to establish the real-world context in which the physical development findings from Chapters 3 and 4 must be interpreted. Understanding what coaches currently know and do, alongside the operational constraints under which they work, is necessary to ensure that any subsequent recommendations for athletic development are feasible within the realities of the LGF environment.

5.1 Introduction

Optimal playing performance in Ladies' Gaelic football requires proficiency in game skills combined with physical attributes such as strength, speed, agility, high-intensity running, and repeated-sprint ability (Brown & Waller, 2014; Cullen et al., 2017; Farley et al., 2022; Mujika et al., 2009; Reilly & Collins, 2008; Wright & Lass, 2016). To support optimal performance and reduce injury risk, these physical qualities should be developed through structured strength and conditioning (S&C) training, complemented by field-based technical and tactical training (Duggan et al., 2022; Farley et al., 2022; Suchomel et al., 2016). Appropriate strength training, training-load management, and neuromuscular training programmes have also been recommended to reduce injury risk among developing athletes (Duggan et al., 2022; Schlingermann et al., 2018; Sommi et al., 2018; Weldon et al., 2022). Throughout this study, the terms 'physical preparation', 'strength and conditioning' (S&C), and 'athletic development' are used interchangeably to refer to the systematic training of these physical qualities.

Appropriate physical preparation is particularly important during adolescence. While the development of strength, speed, power, endurance, and coordination in males and females occurs at similar rates during childhood, a notable divergence emerges with the onset of adolescence (Lloyd & Oliver, 2012). While male athletes typically continue to improve their strength, speed, and power as they mature, female athletes may plateau in these qualities during mid-to-late adolescence (Molohan et al., 2023; O'Brien-Smith et al., 2020; Papaiakovou et al., 2009). However, targeted training practices and appropriate support during the developmental years, including the introduction of structured resistance training, access to S&C professionals, and individualised coaching programmes, may facilitate continued physical development (Lloyd & Oliver, 2012; Sommi et al., 2018; Zwolski et al., 2017). Access to appropriate physical preparation during these developmental years is therefore important to ensure that female athletes have the opportunity to develop the physical qualities required for their sport.

Despite increased participation, visibility, and professionalism in women's sport worldwide, a gendered gap persists in infrastructure and sports science provision for many female athletes compared with their male counterparts (Heyward et al., 2020). Female athletes, even those competing at elite levels, often have less access to performance support services, including medical care, performance analysis, and S&C support (Gaelic Players Association, 2023; Heyward et al., 2020). Differences have also been reported in the implementation of S&C practices, with some studies indicating that coaches are more likely to prioritise strength training for male than female athletes (Poiss et al., 2004; Reynolds et al., 2012; Sommi et al., 2018). Female athletes have also been reported to have limited exposure to sport-specific strength training prior to entering

collegiate sport (Roth & Knapp, 2017). Differences in S&C provision have been observed between male and female soccer academies, with female players completing fewer weekly in-season S&C sessions and being less likely to undertake Olympic lifting (McQuilliam et al., 2022). However, these differences are not consistent across all settings. Shurley et al. (2020) found no significant differences between male and female interscholastic athletes in whether they were required to strength train, the lifts used, or training intensity. These contrasting findings suggest that the provision of S&C for female athletes may be influenced by the specific sporting environment and the resources and expertise available within it.

Importantly, recognising the benefits of S&C does not necessarily translate into effective implementation. Similar challenges have been reported in other sports, including volleyball and soccer, where coaches and players rated S&C as 'important' to 'highly important', yet financial constraints, limited access to qualified S&C coaches, and inadequate training facilities restricted its implementation (Weldon et al., 2021, 2022). Where access to specialist S&C support is limited, responsibility for designing and implementing physical preparation programmes may therefore fall to sports coaches who may lack the specialised knowledge required to optimise player development and reduce injury risk (Weldon et al., 2021, 2022). Consequently, coaches' knowledge and understanding of S&C, together with the resources and support available to them, are important considerations when examining how physical preparation is implemented within a talent development environment.

While the importance of athletic development in Ladies' Gaelic football is acknowledged, a significant gap remains in the literature regarding the physical preparation practices employed within the adolescent inter-county game. Specifically, little is known about coaches' knowledge of physical preparation, their perceptions of athletic development, their coaching practices, or the challenges they face when implementing S&C in this environment. Therefore, this study aimed to explore inter-county coaches' current knowledge, practices, perceptions, and challenges regarding physical preparation within a talent development context. Establishing current practice and the factors that influence its implementation may identify areas where further education, resources, and support are required and inform the future development of S&C education and practice within Ladies' Gaelic football.

5.2 Methods

5.2.1 Study Design

This study employed an anonymous online survey to examine inter-county underage coaches' S&C practices and perspectives (see Appendix E for survey details). Ethical approval was

granted by the institutional research ethics committee (DCUREC/2022/122). The survey was created using Microsoft Forms (Microsoft Corporation, Redmond, Washington, USA) and adapted from the instrument developed by Ebben and Blackard (2001), which has been widely used to assess S&C practices in team sports (Ebben & Blackard, 2001; Ebben et al., 2004; Heyward et al., 2020; Jones et al., 2017; Simenz et al., 2005). To ensure content validity, the survey underwent an initial review and discussion within the research team. Modifications were made to the original survey to provide a more comprehensive overview of current practices. This included adding sections on recovery protocols, monitoring strategies, the use of sports science technologies, coaches' perspectives on the importance of athletic development, and barriers and facilitators to implementing S&C programmes at the inter-county level. Prior to distribution, the questionnaire was piloted with a small group of Gaelic games coaches (n=3), who met the inclusion criteria but were excluded from the final analysis. The pilot evaluated the questionnaire's clarity, relevance, time to completion, and overall usability to ensure it was appropriate for the target population. The mean completion time was approximately 10 minutes, which informed the time commitment communicated to participants at consent. No issues relating to question clarity, interpretation, ordering, or usability were identified by the coaches during the pilot. Following the pilot, minor editorial amendments were made to improve grammar and presentation; however, no substantive changes to the questionnaire were considered necessary prior to final distribution. The final questionnaire comprised seven sections: (a) informed consent, (b) demographic information, (c) education and qualifications, (d) current S&C practices, (e) recovery and monitoring practices, (f) coaches' perspectives on athletic development, and (g) barriers and facilitators. A total of 55 questions were included: 43 were fixed-response questions, and 12 were open-ended questions to allow for more detailed responses. Some questions allowed for the selection of multiple responses, which led to a variation in response count. The questionnaire was distributed via social media platforms (LinkedIn, Facebook, and X) and was also emailed to the Development Officers of each county for further dissemination to inter-county juvenile management teams.

5.2.2 Participants

From a potential target pool of 96 inter-county coaches (one representing each age grade in each of the 32 counties), 59 coaches (35 males and 24 females) participated in the survey (see Table 5.1). The LGFA is an amateur organisation, and Gaelic games coaches at both club and inter-county level are predominantly volunteers who dedicate their time and effort without financial compensation (Horgan et al., 2021). Participants provided consent after being fully briefed on the study's objectives, the confidentiality measures in place, and the anticipated time commitment. To be eligible for inclusion, coaches were required to be actively coaching or to have coached at inter-county level within the past year.

Table 5.1

Coaching Role by Gender

Role by Gender Frequency [n (%)]		
	Female	**Male**
Coach	13 (72%)	5 (28%)
Lead Coach	3 (43%)	4 (57%)
Manager	8 (24%)	26 (76%)
Total	24 (41%)	35 (59%)

5.2.3 Procedures

The questionnaire was circulated electronically from 5 March–24 May 2024. Follow-up correspondence via email and social media was sent at three and six weeks after initial circulation to encourage non-responders to complete the questionnaire. Responses were downloaded into a Microsoft Excel (Microsoft Corporation, Redmond, Washington, USA) spreadsheet for initial analysis.

5.2.4 Data analysis

Fixed-response questions were assessed using frequency analysis, and the mean and standard deviation were calculated where required. Pearson's Chi-square (χ^2) was used to establish whether there was an association between the age grade being coached and coaching experience, education, qualifications, and training practices. Where results were significant, Cramer's *V* was used as an effect size (strength of association) for the Pearson's Chi-square test and classified as follows: very weak ($V < 0.1$), weak ($0.1 \leq V < 0.3$), moderate ($0.3 \leq V < 0.5$), and strong association ($V \geq 0.5$) (Cohen, 1988). A one-way analysis of variance (ANOVA) was used to investigate differences between the age groups in current S&C practices. The assumption of normality was confirmed using the Shapiro–Wilk test. When the *F* test was significant ($p < .05$), Bonferroni post hoc comparisons were performed to identify the level of difference between the age groups. The magnitude of potential age group differences was determined using partial eta squared (η_p^2) effect size (ES). Values of 0.01, 0.06, and 0.14 were interpreted as small, medium, and large, respectively (Cohen, 1988). Statistical analysis was conducted using SPSS software, version 28 (IBM Corp., Armonk, NY, USA), and the significance level was set at $p \leq .05$.

A qualitative content analysis approach was used to assess open-ended questions, determining coaches' current knowledge and beliefs on the benefits of implementing an athletic

development programme at inter-county level. Content analysis is a flexible and systematic method for categorising and interpreting patterns within textual data (Hsieh & Shannon, 2005). Responses were read iteratively to ensure familiarity with the data and coded inductively, following the principles of conventional content analysis, which allows codes to be generated directly from the data rather than being predetermined (Elo & Kyngäs, 2008). An initial coding framework was developed based on recurring patterns and refined through constant comparison to enhance reliability and validity. Codes were then grouped into higher-order categories that represented overarching themes, aligning with established qualitative analytic strategies (Graneheim & Lundman, 2004). This method facilitated the exploration of both shared and divergent perceptions, enabling a nuanced understanding of participants' experiences as regards athletic development. All analyses were conducted collectively to ensure that themes reflected the depth and breadth of the dataset, maintaining fidelity to participants' original expressions.

5.3 Results

5.3.1 Demographics

In total, 59 LGFA coaches (n = 35 males [59%], n = 24 females [41%]; mean inter-county coaching experience of 2.7 ± 1.3 years) participated in the study, representing a response rate of 61%. There were no significant differences between age grades and years of inter-county coaching experience (χ^2 (8, N = 59) = 8.90, p = .351) or in the proportion of male versus female coaches across age grades (χ^2 (2, N = 59) = 1.38, p = .503). Significant differences were found when coaching roles were analysed by gender, with males holding 76% of manager roles (χ^2 (2, N = 59) = 11.15, p = .004, V = .435)

5.3.2 Education & Qualifications

The highest level of education in a sports-related field was a master's degree (n = 5), followed by a bachelor's degree (n = 7) and certificate/higher certificate (n = 3). A full list of the academic qualifications held by coaches in a sports-related field can be found in the supplementary material S2 (Appendix F). There were no significant differences between the age grades and qualifications in a sports-related field (χ^2 (2, N = 59) = 0.54, p = .764). Only two participants held professional S&C qualifications [National Strength & Conditioning Association (NSCA), n = 1, and Australian Strength & Conditioning Association (ASCA), n = 1], and these were coaching at U14 and U16 levels, respectively. Overall, 31% of coaches had the highest level of NGB qualification (LGFA Level 2/GAA Award 2). When overall NGB coaching qualifications were compared across age grades, no significant differences were found between the groups (χ^2 (6, N = 59) = 10.84, p = .093). A detailed breakdown of current coaching roles, gender, province, years of

inter-county coaching experience, education and qualifications across the three competition age grades is presented in Table 5.2.

Table 5.2

Frequency analysis of demographics, experience, education, and qualifications across age grades

	Frequency [n (%)]		
Age Grade	**U14**	**U16**	**U18**
Current Coaching Role			
Manager	12 (63%)	11 (55%)	11 (55%)
Lead Coach	2 (11%)	1 (5%)	4 (20%)
Coach	5 (26%)	8 (40%)	5 (25%)
Gender			
Female	6 (32%)	8 (40%)	10 (50%)
Male	13 (68%)	12 (60%)	10 (50%)
Province			
Connacht	4 (40%)	2 (20%)	4 (40%)
Leinster	6 (35%)	5 (29%)	6 (35%)
Munster	6 (38%)	6 (38%)	4 (25%)
Ulster	3 (19%)	7 (44%)	6 (38%)
Years of Experience Coaching at Inter-County Level			
1 year	6 (32%)	2 (10%)	4 (20%)
2-3 years	7 (37%)	8 (40%)	3 (15%)
3-5 years	2 (11%)	3 (15%)	5 (25%)
5-10 years	1 (5%)	5 (25%)	5 (25%)
>10 years	3 (16%)	2 (10%)	3 (15%)
Education & Qualifications			
Highest NGB qualification:			
ICGG/LGFA Fundamentals/GAA Foundation	7 (37%)	2 (10%)	4 (20%)
LGFA Level 1/GAA Award 1	10 (53%)	11 (55%)	6 (30%)
LGFA Level 2/GAA Award 2	2 (11%)	7 (35%)	9 (45%)
Diploma in GAA Coaching			1 (5%)
Sports-related Qualifications:			
Yes	5 (26%)	4 (20%)	6 (30%)
No	14 (74%)	16 (80%)	14 (70%)

Age Grade	Frequency [n (%)]		
	U14	U16	U18
Highest level of Education in a Sport-Related Field:			
Certificate/Higher Certificate	0 (0%)	0 (0%)	3 (50%)
BA/BSc	3 (60%)	3 (75%)	1 (17%)
MA/MSc	2 (40%)	1 (25%)	2 (33%)
PhD/DProf	0 (0%)	0 (0%)	0 (0%)
Professional S&C Qualifications	1 (5%)	1 (5%)	

5.3.3 Current Training and Testing Practices

Table 5.3 presents the current training practices employed by inter-county coaches at each age grade. The majority of teams engaged in two field-based sessions per week, with session durations ranging from 60 to 120 minutes. Gym-based sessions were implemented by 26% of U14's, increasing to 35% of U16's and 70% of U18's. Significant differences were found between the groups for the number of gym sessions completed per week ($F(2,58) = 7.544$, $p < .001$, ES = 0.212, large). Post hoc Bonferroni analysis identified differences between the U18 and both the U14 and U16 groups, but not between the U14 and U16 groups. At U14 and U16 levels, the manager or coach was primarily responsible for the team's physical development, while at U18 level the S&C coach was mainly responsible.

Table 5.3

Current Training and Performance Testing Practices by Age Grade

Age Grade	Frequency [n (%)]		
	U14	U16	U18
Training Practices			
No. of Field-Based Sessions per Week			
1	2 (11%)	1 (5%)	1 (5%)
2	13 (68%)	16 (80%)	16 (80%)
3	4 (21%)	3 (15%)	3 (15%)
Field Session Duration			
60 min	1 (5%)	2 (10%)	0 (0%)
75 min	9 (47%)	6 (30%)	4 (20%)
90 min	8 (42%)	11 (55%)	11 (55%)
120 min	1 (5%)	1 (5%)	5 (25%)
No. of Gym-Based Sessions per Week			
0	14 (74%)	13 (65%)	6 (30%)
1	5 (26%)	6 (30%)	8 (40%)
2	0 (0%)	1 (5%)	6 (30%)

Age Grade	**Frequency [n (%)]**		
Gym Session Duration			
Not done	10 (53%)	6 (30%)	6 (30%)
0-30 min	4 (21%)	7 (35%)	4 (20%)
30-45 min	2 (11%)	5 (25%)	1 (5%)
45-60 min	3 (16%)	2 (10%)	6 (30%)
>60 min	0 (0%)	0 (0%)	3 (15%)
Typical Resistance (Gym-Based) Session Weekly Schedule			
Not done	10 (53%)	6 (30%)	6 (30%)
Non-football training days	3 (16%)	3 (15%)	3 (15%)
Pre-football training	4 (21%)	6 (30%)	3 (15%)
Post-football training	0 (0%)	0 (0%)	0 (0%)
Stand-alone session	2 (11%)	5 (20%)	8 (40%)
Person Primarily Responsible for Developing Physical Qualities			
Manager	8 (42%)	6 (30%)	4 (20%)
Football Coach	4 (20%)	6 (30%)	1 (5%)
S&C Coach	6 (32%)	7 (35%)	13 (65%)
External	1 (5%)	0 (0%)	0 (0%)
Non-assigned/Unspecified	0 (0%)	1 (5%)	2 (10%)
Performance Testing Practices			
Aerobic/Anaerobic Capacity			
1 km run	2 (33%)	1 (8%)	1 (6%)
1.2 km run			2 (12%)
1.4 km run		1 (8%)	
Bronco	2 (33%)	5 (38%)	4 (24%)
YoYoIR1	2 (33%)	1 (8%)	3 (18%)
Bleep Test		3 (23%)	3 (18%)
Tempo Runs			2 (12%)
Shuttle Runs		1 (8%)	
1 km Ergometer bike			1 (6%)
Ski Pull			1 (6%)
Time Trial (distance not stated)		1 (8%)	
Speed			
5 & 20 m Sprint	1 (25%)		
40 m Sprint	1 (25%)		
100 m sprint			1 (33%)
Sprint (distance not stated)	2 (50%)		2 (66%)
Change of Direction			
Pro-Agility	1 (100%)	3 (43%)	
T Test		3 (43%)	
Agility (test not stated)		1 (14%)	1 (100%)
Lower Body Strength & Power			
Jump Tests	3 (100%)	1 (100%)	10 (77%)
1 RM Squat			1 (8%)
3 RM Squat			1 (8%)
Hamstring Strength (test not stated)			1 (8%)

Age Grade	Frequency [n (%)]		
Upper Body Strength & Power			
Med Ball Throw	1 (100%)		
Inverted Row		1 (33%)	1 (25%)
Push Ups		2 (67%)	1 (25%)
Hangtime			2 (50%)
Flexibility			
Flexibility (tests not stated)			1 (100%)
Core			
Plank/Core			3 (100%)
Sit-Ups		1 (100%)	
Other			
Balance Test (test not stated)	1 (100%)		
FMS	1 (100%)		

5.3.4 Recovery, Monitoring, Performance Testing & Use of Technology

Details of recovery, monitoring and wellness practices can be found in the supplementary material S3 (Appendix G), while details on coaches' use of performance testing and use of technology can be found in the supplementary material S4 (Appendix H).

5.3.5 Coaches' Perspectives

At U14 level, 89% of coaches believed aerobic and anaerobic capacity training was beneficial for football performance, while 11% were unsure of its benefits. At U16 level, 100% of coaches believed aerobic and anaerobic training benefited football performance, while 95% of U18 coaches believed it was beneficial to football performance. All coaches across each age group believed that both speed and agility training, and mobility and flexibility training were important for football performance. For strength and power training, 68% of U14 coaches, 90% of U16 coaches and 100% of U18 coaches believed it was beneficial for football performance. Twenty-one per cent and 10% of U14 and U16 coaches respectively, were unsure of its benefits, while 11% of U14 coaches did not believe it benefited football performance. Further details on the implementation and scheduling of the various fitness components in training can be found in the supplementary material S5 (Appendix I).

Coaches overwhelmingly believed that athletic development was 'extremely important' in injury prevention and injury rehab/return to play. At U14 level, 17 coaches considered it 'extremely important' for injury prevention, while 2 were neutral. At the U16 level, 18 coaches saw it as 'extremely important' and 2 were neutral, and at U18 level, all coaches classified athletic

development as ‘extremely important’ for injury prevention. Fifteen coaches believed that athletic development was ‘extremely important’ in injury rehab/return to play at U14 level, while 3 thought it was ‘somewhat important’ and one was ‘neutral’. At U16 level, 15 coaches regarded it as ‘extremely important’, 3 considered it ‘somewhat important’, and 1 was ‘neutral’, while at U18 level, 19 coaches believed athletic development was ‘extremely important’ and 1 stated it was ‘somewhat important’.

Coaches' responses to open questions regarding their beliefs on the benefits of the various fitness components are detailed in Table 5.4. Six main themes were generated regarding coaches’ beliefs about aerobic and anaerobic training: (i) better execution of skills, (ii) impact on decision-making, (iii) greater endurance/ability to cope with the game demands, (iv) injury reduction, (v) miscellaneous, (vi) unable to explain. For speed and agility, seven main themes were generated: (i) gaining primary possession, (ii) attacking skills, (iii) defensive skills, (iv) injury reduction, (v) replicating game demands, (vi) miscellaneous, (vii) unable to explain. Five main themes were generated regarding coaches' beliefs on the benefits of mobility and flexibility: (i) injury prevention, (ii) improved football skills, (iii) increased speed and agility, (iv) miscellaneous, (v) unable to explain, while six themes were generated for strength and power: (i) injury prevention, (ii) improved jumping, speed and agility, (iii) maintenance of possession/withstanding tackles, (iv) not needed, (v) miscellaneous, (vi) unable to explain.

Table 5.4

Coaches' perceptions of the benefits of various fitness components for football performance

		Frequency [n (%)]		
Theme	**Sample Response**	**U14**	**U16**	**U18**
Aerobic & Anaerobic Capacity				
Better execution of skills	*‘Fitness is so important in the modern game, key to performance of the skills under pressure'*	2 (11%)	2 (8%)	
Impacts Decision Making	*'It makes their decision making sharper in the latter stages of the game.'*	1 (5%)	2 (8%)	1 (5%)
Greater endurance/ability to cope with the game demands	*'Being able to sustain a full game and be able to implement bursts of speed essential for whole game ability'*	1 (5%)	8 (32%)	7 (32%)
Injury reduction	*‘Better recovery time and less injuries'* *‘It’s very important as it prevents injury'*		3 (12%)	2 (9%)
Miscellaneous	*‘It helps with bone strength and density increase of power and performance',* *‘I think conditioning both aerobic [and] anaerobic confers both a*	2 (11%)	3 (12%)	2 (9%)

		Frequency [n (%)]		
Theme	**Sample Response**	**U14**	**U16**	**U18**
	competitive advantage and psychological advantage to players'			
Unable to explain	*'Don't have the background to say'* *'Not sure'* *'Fits into an approach that covers everything'*	13 (68%)	7 (28%)	10 (45%)
Speed and Agility				
Gain primary possession	*'First to the ball is a huge advantage'* *'Speed allows players to get to the ball first'*	2 (10%)	1 (5%)	3 (12%)
Attacking skills (separation from opponent, evading tackles)	*'Faster players that can move in different directions are very hard to mark so yes very important in the game'* *'Yes the ability to move the ball at pace and be agile enough to evade tackles is key'*	2 (10%)		3 (12%)
Defensive skills (closing down opponent, tracking back)	*'Need to be able sprint for the ball or to catch your opponent'* *'Speed allows players to get to the ball first, to beat players, to get back on goal side'*	1 (5%)		1 (4%)
Injury reduction	*'Competitive advantage and both help in injury prevention if appropriately coached/rationed'*	2 (10%)	3 (14%)	3 (12%)
Replicates game demands	*'The demands of the game [are] require speed & agility so adding them into your training makes sense'* *'Football is more short bursts rather than long distance running so if players can work on speed and agility it will be more beneficial to them'*		5 (23%)	2 (8%)
Miscellaneous	*'Because Ladies football is non-contact speed is a vital component'* *'Promotes self-confidence'*	4 (19%)	7 (33%)	4 (15%)
Unable to explain	*'Always pushing girls to best of ability'* *'Modern game'* *'Part of the full picture'*	10 (48%)	6 (27%)	10 (38%)
Mobility and Flexibility				
Injury prevention	*'Supports injury prevention and allows players to handle the workload they are undertaking'*	7 (32%)	13 (50%)	11 (44%)
Improves football skills	*'Better flexibility enhances football skills and ability'*	2 (9%)	2 (8%)	1 (4%)
Increased speed & agility	*'It helps with speed and agility work because you're able to move more freely with more mobility'.*	3 (14%)	8 (31%)	2 (8%)

		Frequency [n (%)]		
Theme	**Sample Response**	**U14**	**U16**	**U18**
Miscellaneous	*'Not convinced there is strong evidence for this and certainly much less convincing evidence it improves performance or prevents injuries, but do work on it as part of activation in prefield sessions'.* *'Essential for injury prevention and maximum ability to gain and retain possession'*	2 (9%)	1 (4%)	5 (20%)
Unable to explain	*'This would benefit the players'* *'Critical component'* *'Enhanced mobility a pre-requisite for inter-county minor football'.*	7 (32%)	1 (4%)	6 (24%)
Strength and Power				
Injury Prevention	*'The stronger you are the better your tissue capacity to match the demands of the game and reduces risk of tissue overload and breakdown'.* *'Need to be strong on the ball when blocking and not get injured'*	4 (17%)	7 (26%)	3 (13%)
Improved jumping, speed & agility	*'They lead to increased speed and acceleration. They increase the power of the player and their ability to break defensive lines and to win the ball'*	5 (22%)	4 (15%)	3 (13%)
Maintain possession/withstand tackles	*'Vital for the players ability to take and give tackles and retain possession under pressure'*	3 (13%)	4 (15%)	3 (13%)
Not needed	*'Not at this age group'* *'Bigger benefits to older age groups'*	3 (13%)	2 (7%)	
Miscellaneous	*'With modern game you need to be stronger to compete, improves confidence and self-belief'*	1 (4%)	6 (22%)	6 (25%)
Unable to explain	*'While it is beneficial, not sure of the full impact/benefit'* *'Not sure'* *'Don't know'*	7 (30%)	4 (15%)	9 (38%)

Note. *Some coaches provided multiple responses, which were further subdivided into the themes generated.

5.3.6 Barriers and Facilitators

The barriers and facilitators to implementing a programme of athletic development at inter-county level are presented in Figures 5.1 and 5.2. At U14 and U16 levels, the greatest barriers were limited training time and resources. At U18 level, the greatest barriers identified were resources and the availability of qualified athletic development coaches. All three groups identified more resources, followed by coach education, availability of qualified athletic development coaches and more training time as facilitators of implementing a programme of athletic development. However,

when barriers were compared across age grades, no significant differences were found between the groups (χ^2 (6, *N* = 124) = 2.915, *p* = .819). Similarly, no significant differences were found between the age grades in respect of facilitators to athletic development (χ^2 (6, *N* = 126) = 0.909, *p* = .989).

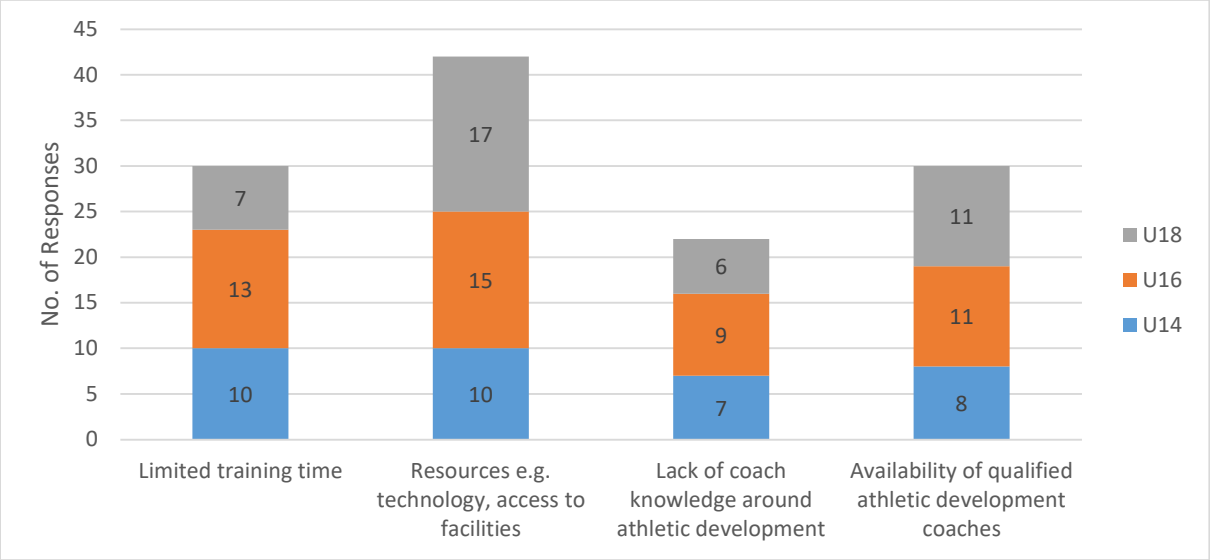


Figure 5.1

Barriers to implementing a programme of athletic development at inter-county level

Note. *Multiple responses by some coaches

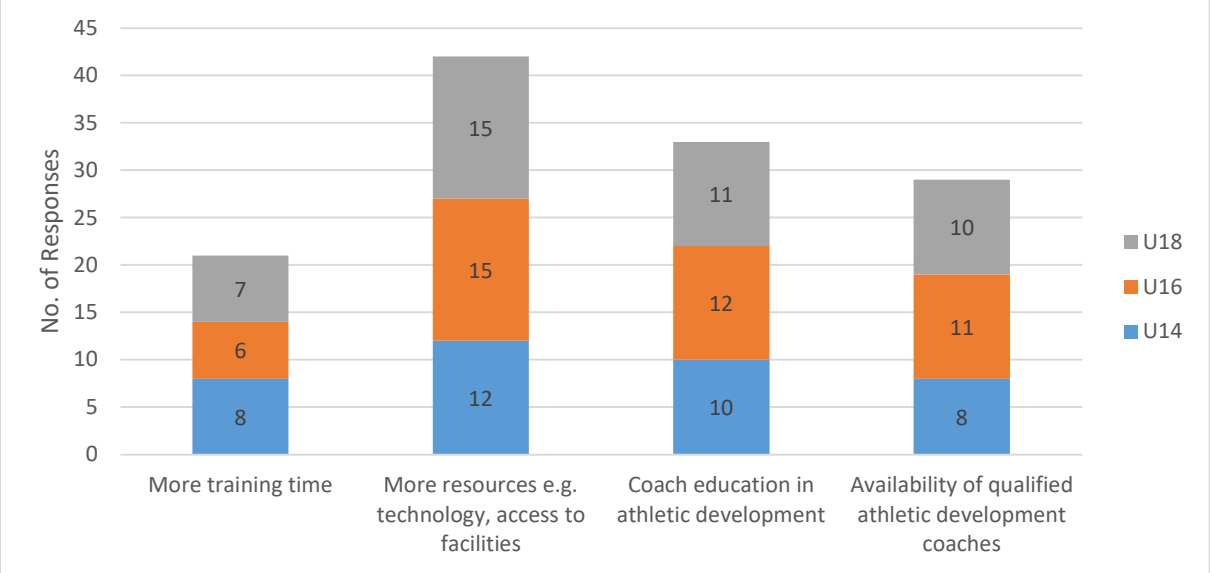


Figure 5.2

Facilitators in implementing a programme of athletic development at inter-county level

Note. *Multiple responses by some coaches.

5.4 Discussion

This study is the first to explore the current knowledge, practices, perceptions, and challenges of Ladies' Gaelic football coaches concerning physical preparation at inter-county level. Overall, coaches believed that including S&C practices to develop the various fitness components was beneficial for football performance and injury prevention. However, gaps in understanding and lack of expertise, combined with insufficient resources, lead to inconsistencies in coaching practice.

Coaches overwhelmingly believed (>89%) that the development of various fitness components positively benefited football performance, injury reduction and return to play, aligning with previous research in soccer, volleyball, and rugby (Heyward et al., 2020; Weldon et al., 2021, 2022). An awareness of the importance of strength training for youth athletes, particularly as they progress through age groups (U14 to U18), was also evident. Despite these positive perceptions, a disconnect exists between coaches' perceptions and their practice, with gym-based sessions notably underutilised, particularly among the younger (U14 and U16) age groups. Furthermore, there may have been some misunderstanding among coaches regarding the definition of a strength-development session. While 74% of U14 coaches and 65% of U16's stated that they did not engage in weekly gym sessions, only 53% and 30%, respectively, reported that gym sessions were not held when asked about gym session duration. These coaches may regard their training warm-up, which typically incorporates resistance-based exercises such as bodyweight squats, lunges, etc., as a strength-development session. While a well-structured warm-up can serve as a key tool in overall athletic development (Jeffreys, 2007), after a period of time, it is unlikely to provide sufficient overload to facilitate further strength gains. In the absence of specific neuromuscular training, female strength, speed, and power plateau in mid-to-late adolescence (Molohan et al., 2023; Papaiakovou et al., 2009; Stratton & Oliver, 2019). However, progressive improvements have been achieved into adulthood with appropriate training (Emmonds et al., 2020; Papaiakovou et al., 2009; Ramos et al., 2021; Stratton & Oliver, 2019). The World Health Organization (WHO), the National Strength and Conditioning Association (NSCA), and the International Olympic Committee (IOC) have all issued position statements supporting regular resistance training as an essential component of physical development (Bergeron et al., 2015; Lloyd et al., 2016; World Health Organization, 2020). Children aged 6 to 18 who engage in resistance exercise improve their muscular strength, power, running and kicking speeds, endurance, dynamic balance, flexibility, and overall motor function (Sommerfield et al., 2022; Sommi et al., 2018). Adolescence is characterised by changes in height and weight that can affect motor control and movement patterns. These changes may negatively impact performance and increase the likelihood of non-contact anterior cruciate ligament injuries (Lloyd & Oliver, 2012; Sommerfield et al., 2022). To mitigate these effects, it is recommended that resistance training be initiated for prepubescent females during primary school, in preparation for

the pubertal growth spurt and the subsequent decline in relative muscle strength (Sommi et al., 2018). Training programmes implemented during this development phase are the most effective in enhancing muscle mass, reducing the likelihood of injuries and enhancing performance (Sommi et al., 2018; Zwolski et al., 2017). Thus, it is recommended that coaches and practitioners emphasise the development of relative strength to improve performance and movement skills in adolescent girls (Sommerfield et al., 2017). Therefore, it is essential to educate coaches, particularly those who work with younger athletes, on the principles of effective strength training and its significance.

Tailored physical fitness testing for Gaelic football allows coaches to assess fitness levels, provide insights into long-term development, and create individualised training programmes for these athletes (Beato et al., 2022). Validated field-based tests, including the YoYoIR1 and linear sprint speed, are correlated with match performance outcomes (Farley et al., 2022). However, the use of inappropriate fitness tests can undermine these benefits and potentially lead to negative consequences (Faigenbaum et al., 2009). Several inconsistencies were evident when coaches were asked to list the specific tests used to measure the various components of fitness in this study. Eight U16 coaches reported measuring speed; however, no specific speed tests were identified. At U18 level, 12 coaches indicated that they measured speed, but only three specified sprint tests. Additionally, seven coaches reported measuring change of direction (COD), yet only one identified a specific COD test. Analysis of individual responses revealed that several coaches (n = 22) identified aerobic and anaerobic capacity tests, including the Bronco, YoYoIR1, time trials, and the beep test, as methods for measuring speed, while three were unable to list the tests used, suggesting a degree of confusion among LGFA coaches regarding the distinction between aerobic capacity (fitness) and speed. Furthermore, several performance tests lacked ecological validity for ladies' Gaelic football, including the ski pull, 1 km ergometer bike, 100 m sprint, and hangtime.

While field-based measures provide useful performance indicators, the direct assessment of maximal force capabilities often requires more specific protocols. Regarding absolute strength, the implementation of 1RM and 3RM testing by some coaches with novice athletes who are in the process of learning proper lifting techniques also poses safety risks (Faigenbaum et al., 2009). Attempting maximal lifts requires a high degree of technical proficiency to ensure safety and accuracy. Without this foundation, novice athletes are at an elevated risk of injury due to improper form, particularly when subjected to maximal loads (Faigenbaum et al., 2009). Therefore, there is a need for coach education in ecologically valid and standardised testing protocols to allow comparisons across age grades and counties. This might include easily administered field-based tests such as sprints over 0-5 m and 0-20 m, change of direction tests such as the 505 or pro-agility test, jump tests such as the countermovement jump or broad jump, upper body strength such as the medicine ball chest pass or pull-ups and tests of aerobic endurance such as the YoYoIR1

(Molohan et al., 2023). Regular fitness testing allows progress to be tracked over time and helps in adjusting training loads and intensities to ensure continuous improvement. Without proper coach education in ecologically valid and standardised testing protocols, comparisons across age grades and counties become unreliable, hindering the design of effective long-term development and training.

The qualitative responses in this study provided further insight into coaches' knowledge and beliefs regarding the significance of different fitness components for football performance, injury prevention, and return to play. Although coaches identified a lack of training time as a barrier to implementing a programme of athletic development, only three coaches had field-based training sessions of duration less than 75 minutes. Coaches may perceive that time spent on athletic development will reduce the time afforded to the technical and tactical aspects of the game. While this will naturally take precedence for football coaches, the use of integrated conditioning approaches, such as small-sided games (SSG), in conjunction with periodised planning, may be a viable alternative (Hammami et al., 2018; Ryan et al., 2022). The manipulation of variables, including pitch size, rules, and number of players, facilitates the development of specific physical qualities alongside the technical and tactical dimensions of the game in an efficient manner (Hammami et al., 2018). SSGs have also been demonstrated to have moderate to large effects on measures of agility, jump, sprint, and repeated sprint performance (Hammami et al., 2018). However, while SSGs offer concurrent training benefits, they may not provide sufficient overload to maximally develop force and strength qualities compared to isolated resistance training.

The issue of a lack of resources is common in female sports, with significant disparities in funding and support structures between male and female athletes. For example, 53% of adult female inter-county players currently lack full access to a gym, and 36% do not have full access to physiotherapy or S&C support (Gaelic Players Association, 2023). This phenomenon is particularly pronounced at the juvenile level, where volunteer football coaches assume primary responsibility for the design and implementation of athletic development programmes. A lack of female-specific scientific guidelines further exacerbates these logistical constraints. The S&C practices of male athletes have been extensively described in the literature across various sports, including swimming (Crowley et al., 2018), rugby (Jones et al., 2017), the NFL (Ebben & Blackard, 2001), hockey (Ebben et al., 2004) and basketball (Simenz et al., 2005). There are considerable variances in S&C approaches, indicating either a lack of consensus on the most effective methods or the existence of multiple valid strategies to achieve the desired outcome (Heyward et al., 2020). Despite these differences, this research offers valuable insights that may guide practitioners in designing effective physical preparation programmes (Heyward et al., 2020). However, a significant barrier to advancing female athletic performance is the comparative lack of research focused on female

athletes. Historically, sports science research has predominantly focused on male athletes, often with this data being generalised to females, despite the considerable biological and contextual differences between the sexes (Emmonds et al., 2019). Applying this androcentric evidence to female athletes may be erroneous (Emmonds et al., 2019). Therefore, research specifically addressing female athletes' unique physiological and developmental needs is required. The absence of such research may undermine the effectiveness of training, injury-prevention, and performance-enhancement strategies when implemented for female cohorts using male-oriented data (Emmonds et al., 2019; Heyward et al., 2020).

The current study indicates that the coach or manager is the primary individual responsible for developing physical fitness attributes in a substantial 60-62% of U14 and U16 teams, a figure that then sharply declines to 25% for U18 teams. However, the fact that only two participants in the study held professional S&C qualifications (NSCA and ASCA) highlights a discrepancy between coaches' educational backgrounds and the expertise necessary for effective S&C training. This situation, where a substantial number of volunteer amateur coaches without formal qualifications are tasked with the responsibility of athletes' physical development, raises concerns about the scope of their practice and their ability to provide appropriate guidance. Adding to these concerns is the notable finding that a high proportion of coaches across all age grades (32% overall) were unable to adequately explain the benefits of various fitness components to football performance, often providing limited or ambiguous responses revealing a lack of knowledge or depth of understanding (e.g. *'always pushing girls to best of ability'*; *'modern game'*; *'this would benefit the players'; 'critical component' and 'not sure*'). These responses indicate a clear and pressing need for targeted educational programmes aimed at enhancing the understanding and effective implementation of athletic development principles within Ladies' Gaelic football.

After resources, coach education emerged as the primary facilitator for the implementation of an athletic development programme, underscoring a distinct demand for knowledge and self-improvement among coaches. Investing in coach education can bridge the gap between current competencies and optimal performance benchmarks. By enhancing their understanding, coaches can better design and implement training programmes that maximise athlete development and minimise the risk of injury. Targeted educational initiatives can effectively address specific misconceptions and knowledge gaps, enabling all coaches, irrespective of their initial expertise, to contribute to their athletes' physical development. This provides the relevant governing bodies (LGFA & GAA) with a mandate to develop targeted, sport-specific athletic development education programmes that meet the unique needs of youth Gaelic football. The GAA family (LGFA, GAA & Camogie Association) has acknowledged the necessity for coach upskilling in youth athletic development and has recently established a basic certification aimed at this purpose. This blended

(online and in-person) programme encompasses seven key elements: planning, warm-up, force, speed and agility, endurance, growth and maturation, and health benefits, with practical guidance on integrating these practices into everyday training routines (Ryan et al., 2022). While the programme remains to be evaluated, it is anticipated that it will result in enhanced coaching practices, improved athletic performance, and ultimately higher standards in football when integrated with technical, tactical, and psycho-social development.

5.4.1 Limitations

This study has a number of limitations. While the response rate of 61% of the targeted coaches is reasonable, it is unknown how many coaches in total are coaching at inter-county level, and therefore, this sample may not be representative of all coaches working at this level. Responses regarding knowledge, practices, perceptions, and challenges in implementing an athletic development programme may be influenced by social desirability bias, whereby coaches may portray their understanding and practices more positively than they actually are. Factors such as interest in S&C, time availability, or perceived expertise could have influenced which coaches chose to participate. Coaches with more established S&C programmes may have been more likely to respond, thereby skewing the results towards a more positive view of current practices. If non-respondents have significantly different S&C practices, knowledge, or perceptions compared to respondents, the study's findings may not accurately represent the entire coaching population at talent development level. Although this purposive sample aimed to acquire as many replies as possible, the number of surveys needed for a valid analysis was not established prior to data collection. Furthermore, the findings may not be generalisable to club coaches or those working with older age cohorts.

5.4.2 Future Research

This study provides an overview of inter-county coaches' knowledge, perceptions, practices, and challenges regarding the implementation of an athletic development programme with their players. Building on these findings, future research employing more in-depth qualitative methods may be beneficial in identifying optimal ways to integrate athletic development into inter-county training practices. An in-depth examination of the reasons behind coaches' perceptions, their engagement in specific practices, and their planning methods is necessary to identify the barriers and facilitators affecting the practices of inter-county coaches. By understanding the underlying motivations and constraints faced by coaches, the most effective methods for integrating athletic development into existing training regimes can be identified. Informed strategies can then be developed from this information to enhance coach education and practice. Intervention studies will

help ascertain whether coach education programmes effectively translate into improved coaching practice. This holistic approach will not only address the immediate challenges faced by inter-county coaches but also contribute to the long-term improvement of athletic development programmes in inter-county training practices.

5.5 Conclusion

This is the first study to explore inter-county LGFA coaches' knowledge, practices, perceptions, and challenges of implementing a programme of athletic development in a talent development environment. Overall, coaches believed that the implementation of an athletic development programme was beneficial for both football performance and injury prevention, consistent with existing research. However, it was also evident that many coaches displayed a limited understanding of the importance of athletic development to their players' football performance, indicating a clear need for coach education to enhance knowledge and facilitate effective implementation of a sports-specific athletic development programme for LGFA players. Future coach education initiatives should explicitly link fundamental principles of strength, power, speed, agility, and endurance to the specific demands of Ladies' Gaelic Football. Practical guidance on how to structure and implement athletic development programmes within the constraints of their training environments and the LGFA season would also be useful. The impact of these enhanced coach education initiatives and their delivery methods on coaching practices, player athletic development, and injury rates in LGFA should then be evaluated. This will provide more actionable insights for the LGFA in developing impactful coach education programmes and contribute significantly to raising the standards of athletic development for female Gaelic footballers.

Chapter 6: The Impact of the GAA F3 Youth Athletic Development Level 1 Course on Coach Knowledge and Coaching Self-Efficacy: A Pre-Post Evaluation

Chapter 5 demonstrated that the physical preparation of adolescent inter-county LGF players is influenced not only by the demands of the game but also by the coaching environment's capacity to implement athletic development principles. Coaches recognised the importance of physical preparation, yet the findings also highlighted gaps in knowledge and understanding, as well as practical and organisational barriers that constrained implementation. These findings established the need to move beyond describing the implementation problem and to examine whether targeted coach education could address some of these constraints.

Coach education is one potential mechanism for supporting this process. However, the effectiveness of coach education depends not only on whether information is provided, but also on whether coaches develop the knowledge and task-specific self-efficacy required to apply it in their own coaching environments. This distinction is important within the pragmatic framework adopted in this thesis. Knowledge, self-efficacy, and coaching practice are related but distinct constructs, and changes in one should not automatically be interpreted as evidence of changes in another.

Chapter 6 therefore evaluates the GAA F3 Youth Athletic Development Level 1 course, a national, sport-specific intervention designed to support coaches in delivering adolescent athletic development. The course combines online learning with a practical face-to-face workshop covering warm-ups, force development, gamespeed, endurance, growth and maturation, planning, and health, participation, and retention. Its practical component is particularly relevant to the implementation gap identified in Chapter 5, as it provides coaches with opportunities to engage with movement techniques and applied coaching tasks.

This chapter uses a pre- and post-intervention mixed-methods design to examine the course's immediate impact. Quantitative measures assess coaches' immediate reactions to the course and changes in task-specific coaching self-efficacy across key areas of athletic development, while qualitative responses provide insight into coaches' experiences of the course and their intended changes to subsequent coaching practice. Consistent with the limitations of the design, intended changes in coaching practice are distinguished from observed changes in coaching behaviour.

This chapter marks the final empirical stage of the thesis. Whereas Chapters 3 and 4 establish the physical characteristics of adolescent inter-county LGF players and the running demands of competition, and Chapter 5 examines the coaching environment responsible for supporting their physical preparation, Chapter 6 evaluates a potential mechanism for strengthening coaches' capacity to deliver athletic development.

6.1 Introduction

As established in Chapter 5, coaches in the inter-county LGF pathway recognise the importance of athletic development for performance and injury prevention, yet gaps in knowledge and understanding, together with practical and organisational barriers, may constrain its implementation. This is particularly important during adolescence, when rapid growth and maturation occur alongside continued exposure to training and competition (Lane et al., 2023; O'Connor et al., 2023). Evidence-informed physical preparation, including resistance and neuromuscular training, can support the development of physical qualities and reduce injury risk in adolescent athletes (Lauersen et al., 2014; Suchomel et al., 2016). However, the provision of information or resources alone may not ensure their effective application in practice. Coach education may therefore provide a mechanism for coaches to develop the knowledge and task-specific self-efficacy required to apply athletic development principles within their own coaching environments (Lloyd et al., 2016; Till et al., 2022).

A potential barrier to translating sports science principles into coaching practice is coaches' perceived limitations in their knowledge and ability to deliver specific components of athletic development (Corrigan et al., 2023). Volunteer coaches may feel inadequately prepared to teach fundamental movement skills, manage adolescent growth and maturation, or identify and correct movement errors (Lloyd et al., 2016; Till et al., 2022). Research in Gaelic football and camogie has highlighted a similar divide between coaches' recognition of the importance of structured athletic development and injury prevention and their perceived knowledge, skills, and capability to implement these practices (O'Connor et al., 2021b; Reilly & Kipps, 2017). For example, although 96% of male Gaelic football coaches acknowledged the effectiveness of an injury prevention programme, only 8% reported implementing it. In camogie, only 23% of coaches perceived themselves as sufficiently experienced, and 43% believed they possessed the skills required to facilitate physical development safely (O'Connor et al., 2021b; Reilly & Kipps, 2017). These findings highlight the potential gap between recognising the value of athletic development and having the knowledge and task-specific self-efficacy required to implement it.

Coach education offers an opportunity to address this gap; however, traditional approaches have been criticised for relying heavily on the passive delivery of theoretical information, with limited attention to the practical contexts in which coaches operate (Cushion et al., 2010; Nelson et al., 2006; Stodter & Cushion, 2017). While coaches may acquire knowledge through formal education, the ability to apply it in practice may require opportunities for practical, interactive, and context-specific learning (Stoszkowski & Collins, 2016). This aligns with Self-Efficacy Theory, which holds that mastery experiences, observation of others, and constructive feedback can contribute to the development of task-specific self-efficacy (Bandura, 1977, 1997). Including practical learning opportunities within coach education may therefore support not only the development of knowledge but also coaches' beliefs in their capability to apply it in practice.

To address the need for greater integration of athletic development within Gaelic games, the GAA, LGFA, and Camogie Association Sports Science Working Group published an athletic development action statement advocating the integration of physical preparation into the coaching pathway (Ryan et al., 2022). Subsequently, the F3 Youth Athletic Development Level 1 course was developed to support coaches in delivering athletic development during adolescence. The curriculum includes warm-ups, force development, gamespeed, endurance, growth and maturation, planning, and health, participation, and retention. The course uses a blended learning model, combining online theoretical modules with a mandatory six-hour face-to-face practical workshop. During the practical component, coaches have opportunities to perform movement patterns, coach their peers, plan athletic development sessions, and receive feedback. This approach aligns with recommendations that coach education should extend beyond theoretical information and provide opportunities for coaches to apply knowledge in practical learning environments (Cushion et al., 2010; Nelson et al., 2006; Stodter & Cushion, 2017).

While the F3 Youth Athletic Development Level 1 course represents a national approach to supporting the delivery of adolescent athletic development within Gaelic games, its impact on coaches has not previously been evaluated. It remains unclear how coaches react to the course, whether participation improves their task-specific coaching self-efficacy, and how coaches intend to apply the course content within their subsequent coaching practice. Therefore, the primary aim of this study was to evaluate the immediate impact of the F3 Youth Athletic Development Level 1 course. Consistent with Level 1 (Reaction) of the Kirkpatrick evaluation framework, coaches' immediate reactions to the course were assessed through their evaluation of the course and their likelihood of recommending it to other coaches. Changes in task-specific coaching self-efficacy were examined pre- and post-course, while qualitative responses explored coaches' experiences and their intended changes to subsequent coaching practice. Intended changes in practice were considered separately from observed changes in coaching behaviour.

6.2 Methods

This study employed a quasi-experimental, mixed-methods pre- and post-intervention survey design. Ethical approval was granted by Dublin City University Research Ethics Committee (DCUREC/2022/122).

6.2.1 Participants

Participants were volunteer Gaelic games coaches recruited from 39 centrally and locally organised F3 courses delivered nationwide between 16th Mar 2025 and 28th Feb 2026. From this pool (*N* = 805), 358 coaches (*n* = 301 males, *n* = 54 females, *n* =3 prefer not to say) participated in the study. Participants provided informed consent after being fully briefed on the study's objectives, the confidentiality measures in place, and the voluntary nature of their participation, which did not affect their ability to complete the coaching qualification. To be eligible for inclusion, coaches were required to be registered for the F3 Athletic Development Course Level 1, complete the online and practical components of the course, and have previously attained a minimum of an Introduction to Coaching Gaelic Games (ICGG) qualification.

6.2.2 Survey Design

The evaluation of the F3 Athletic Development Course was guided by Kirkpatrick's (1994) four-level model of training evaluation. This framework systematically categorises training outcomes into four levels and has been successfully employed to evaluate governing body interventions across grassroots inclusion (Temple & Field, 2023), high-performance coaching pathways (Jowett et al., 2024), and pan-European youth sport initiatives (Adamakis & EduPASS Project Partners, 2024). Level 1 (Reaction), assesses participants' immediate satisfaction, engagement, and perceived relevance of the training; Level 2 (Learning) measures the acquisition of knowledge, skills, attitudes, and changes in task-specific coaching self-efficacy; Level 3 (Behaviour), evaluates whether learning is subsequently transferred into coaching practice; Level 4 (Results), quantifies the broader, long-term organisational or performance impacts resulting from the training (e.g., longitudinal injury reduction or increased team win rates). Given the immediate pre- and post-course scope of this study, it was not feasible to measure Level 3 (actual behavioural transfer) or Level 4 outcomes (longitudinal). Therefore, this study specifically focused on capturing evaluation data across Levels 1 and 2 of the Kirkpatrick model, while intended changes in practice were explored but did not constitute Level 3 behavioural evidence.

To ensure content validity, the survey was mapped directly to the F3 Athletic Development Course syllabus and grounded in established psychological frameworks. The assessment of coaching

self-efficacy was grounded in Feltz et al.'s (1999) Coaching Efficacy Model. Although the questionnaire used the term confidence, these items were interpreted as measures of task-specific coaching self-efficacy, consistent with Bandura's (1997) conceptualisation of efficacy beliefs. Using a 5-point Likert scale, the instrument asked coaches to self-report their overall confidence in delivering athletic development, as well as their specific confidence in each of the seven core modules (warm-up, force development, gamespeed, endurance, growth and maturation, health benefits, participation and retention, and planning). The evaluation of coaches' planned subsequent behaviours was informed by the Theory of Planned Behaviour (Ajzen, 1991). The Theory of Planned Behaviour proposes that behavioural intention is a proximal determinant of behaviour, although the translation of intention into action may be influenced by perceived behavioural control and contextual factors (Ajzen, 1991; Frank et al., 2015). As direct pitch-side observation of participants was beyond the scope of the present study, the post-course survey assessed coaches' anticipated behavioural transfer through their reported intentions to modify subsequent coaching practice. These self-reported intentions were therefore treated as indicators of anticipated, rather than observed, behavioural change. Coaching self-efficacy and behavioural intention were therefore treated as related but conceptually distinct outcomes within the present study.

Task-specific coaching self-efficacy was operationalised using a 7-item scale worded in terms of confidence. Internal consistency for this scale was assessed using Cronbach's alpha, demonstrating high reliability at both the pre-course ($\alpha = .92$) and post-course ($\alpha = .90$) time points. Consequently, a composite 'overall coaching self-efficacy' score was calculated for each participant by summing their responses across the 7 subcomponents.

The pre-course survey collected participant demographics, coaching background and qualifications, their expectations for the course, and baseline levels of coaching self-efficacy across the seven core modules and overall athletic development. The post-course survey reassessed coaching self-efficacy to enable paired-samples comparisons. Additionally, the post-course survey assessed overall course quality and satisfaction (Level 1). To explore intended changes in subsequent coaching practice, open-ended qualitative questions required coaches to articulate the specific skills they deemed most beneficial and explicitly outline the changes they intended to implement in their subsequent coaching practice. The complete survey instruments are available in the supplemental material (Appendix K, Appendix L).

6.2.3 Procedure

The survey was created using Microsoft Forms (Microsoft Corporation, Redmond, Washington, USA) and distributed electronically to the course participants. Prior to commencing the F3 Athletic Development Course, all coaches were provided with a participant information sheet

and gave informed consent. To maintain strict anonymity while enabling a paired-samples statistical analysis, participants were instructed to generate a self-assigned Unique Identifier (UID) upon opening the pre-course survey. Coaches completed this baseline survey prior to engaging with the course's online modules. The intervention concluded with an in-person practical coaching day. The practical day required coaches to work collaboratively in groups, designing and delivering peer-coaching micro-sessions across the core modules, culminating in a structured debrief provided by the coach developer. Following the conclusion of the practical day, participants were prompted to complete the post-course survey by entering their previously generated UID. These UIDs were subsequently utilised by the research team to match the pre- and post-intervention data sets prior to analysis, yielding a final sample of 150 successfully matched pre- and post-course pairs. Responses were downloaded into a Microsoft Excel (Microsoft Corporation, Redmond, Washington, USA) spreadsheet for initial analysis.

6.2.4 Data Analysis

Quantitative Analysis

Statistical analysis was conducted using SPSS for Windows (Version 29, SPSS Inc., Chicago, IL, USA). Descriptive statistics, including means and standard deviations, were calculated for participants' overall coaching self-efficacy and their task-specific coaching self-efficacy in each of the seven core modules (warm-up, force development, gamespeed, endurance, growth and maturation, planning, and health benefits, participation and retention) at pre- and post-intervention time points. The assumption of normality was assessed using the Shapiro-Wilk test. Although deviations from normality were observed, parametric paired-samples t-tests were retained as the primary analytical approach, given the large size of the final matched cohort (n = 150) and the applicability of the Central Limit Theorem. To ensure maximum rigour, a preliminary sensitivity analysis using Wilcoxon signed-rank tests was also conducted, which confirmed the same pattern of significance across all variables and supported the robustness of these parametric findings. To account for multiple comparisons across the eight paired t-tests, a Bonferroni correction was applied. Statistical significance was therefore set at $\alpha = 0.00625$ (0.05/8).

To assess whether the magnitude of change in coaching self-efficacy was influenced by demographic variables, a series of between-subjects analyses were conducted on the calculated difference scores. An independent-samples t-test compared total coaching self-efficacy change scores between male and female coaches. One-way analyses of variance (ANOVAs) were conducted to determine whether total coaching self-efficacy change scores differed by National Governing Body (NGB) qualification tier (Tier 1 [ICGG], Tier 2 [Award 1/Level 1], and Tier 3 [Award 2/Level 2]) or by prior coaching experience (≤3 years, 4–6 years, and ≥7 years). Furthermore, to assess whether

the pattern of change in coaching self-efficacy across the seven individual modules differed across these demographic groups, a series of one-way multivariate analyses of variance (MANOVAs) were conducted. Box's M test and Levene's test were used to evaluate the assumptions of equality of covariance matrices and homogeneity of variances, respectively. Effect sizes (Cohen's d) were used to determine the practical magnitude of any observed changes in coaching self-efficacy. Values of 0.2, 0.5, and 0.8 were interpreted as small, moderate, and large effects, respectively (Cohen, 1988).

Qualitative Analysis

To systematically categorise the open-ended survey responses, a conventional content analysis was employed (Hsieh & Shannon, 2005). Responses were read iteratively and inductively coded according to the concepts expressed by participants, without applying a predetermined coding framework. First, to establish the frequency of participants' baseline expectations, a content analysis of the pre-course open-ended question: 'What are your primary goals for taking this coaching course?' was conducted. Subsequently, to explore coaches' perceived learning from the course and their intended changes in subsequent coaching practice, qualitative data were extracted from two open-ended survey questions: 'What specific skills or knowledge gained from this course do you feel will be most beneficial in your coaching?' and 'What specific changes in your coaching practice do you foresee as a result of this course?'

Given the concise nature of the free-text survey responses, which predominantly consisted of brief phrases or single concepts, this approach is appropriate for large-scale survey data, where the objective is to systematically categorise explicit, surface-level meaning rather than to interpret deep, latent themes (Hsieh & Shannon, 2005). Qualitative data were imported into NVivo (Release 1.7.2, QSR International) to facilitate systematic data management, coding, and retrieval. To ensure intra-coder consistency, the dataset was systematically re-reviewed in NVivo after the initial coding phase to ensure consistency in the application of the codes (Schreier, 2012). To mitigate individual bias during this categorisation process, coding decisions were discussed iteratively with the supervisory team. Once the data were fully coded, NVivo's hierarchical structuring features were used to collapse similar codes into broader, higher-order categories. Finally, frequency counts of the applied codes were calculated, providing a quantitative summary of the prevalence of anticipated coaching changes and knowledge applications across the cohort (Graneheim & Lundman, 2004).

6.3 Results

From an initial pool of 805 eligible coaches, 358 participants completed the pre-course survey, representing a response rate of 44.7%. Following the conclusion of the coaching intervention, 179 participants responded to the post-course survey, yielding a retention rate of

50.0%. Of these 179 post-survey responses, 29 (16.2%) were excluded from the final analysis because respondents did not provide the required UID to match their pre- and post-course responses. Consequently, the final analytical sample consisted of 150 fully matched survey responses.

6.3.1 Participant Demographics

The final sample (*n* = 150) represented participants from 20 counties across all four provinces. As detailed in Table 6.1, the largest proportion of participants was from the province of Ulster (41.3%), reflecting a higher relative retention rate in this region compared to the initial eligible pool (24.1%). The cohort was predominantly male (80.0%), with female coaches comprising 18.7% of the sample. Participants demonstrated a wide range of coaching experience, with the majority (74.0%) having coached for four or more years, and 44% having seven or more years of experience. Regarding formal coach education, participants were stratified into three National Governing Body (NGB) qualification tiers based on their highest achieved certification. Over half of the participants (54.0%) held a Tier 2 qualification (Award 1/Level 1). Table 6.1 presents a breakdown of core participant demographics and qualifications. Additional data regarding specific coaching involvement, including primary coaching codes and age grades coached, is available in the supplementary material (Appendix M).

Table 6.1

Participant Demographics, Experience and Qualifications (n = 150)

Characteristic	**n**	**%**
Province (Counties)		
Munster (Cork, Kerry, Waterford)	34	22.6
Leinster (Carlow, Dublin, Kildare, Laois, Longford, Louth, Meath, Wexford)	53	35.3
Connacht (Galway)	1	0.7
Ulster (Antrim, Armagh, Cavan, Donegal, Down, Fermanagh, Monaghan, Tyrone)	62	41.3
Gender		
Male	120	80.0
Female	28	18.7
Prefer not to say / Other	2	1.3
Coaching Experience		
≤ 3 years	39	26
4-6 years	45	30
≥ 7 years	66	44
Highest Coaching Qualification		
Tier 1: Introduction to Coaching Gaelic Games (ICGG)	44	29.3
Tier 2: Award 1/Level1	81	54.0
Tier 3: Award 2/Level 2	25	16.7

6.3.2 Pre-Course Expectations

Responses of baseline expectations and learning goals were categorised into four dominant themes (Table 6.2). The most prominent baseline expectation, *Knowledge Acquisition & Validation*, highlighted a widespread desire among participants to deepen their theoretical understanding. This theoretical focus was closely matched by a need to *Develop Practical Coaching Skills,* with coaches specifically requesting on-pitch tools to blend AD into sport-specific practices. Beyond individual coaching skills, participants also viewed the course through a broader developmental lens. The *Player Welfare & Team Development* theme reflected a proactive focus on athlete health and progression, as well as player retention and engagement. Finally, the *Community & Club* Impact theme demonstrated an intent to cascade this newly acquired knowledge back into their broader club environments.

Table 6.2

Content Analysis of Pre-Course Expectations (n = 150)

Major Theme (n)	Subtheme (n)	Illustrative Quote
Knowledge Acquisition & Validation (124)	Increased S&C knowledge (46)	*'More detailed understanding of S&C development.'*
	General Knowledge Enhancement (30)	*'To extend my coaching knowledge'.*
	Greater understanding of youth AD (28)	*'I am Coaching Officer within our club & AD is a massive area where our coaches are trying to get their heads around. My hope was to develop my own understanding & improve our current structures around AD so coaches working with this age group are better prepared each season'.*
	Validation of current practices (11)	*'I want to know what I am doing when it comes to Athletic development is evidence based and the correct approach.'*
	Self-improvement (9)	*'Better myself for the sake of the girls'*
Develop Practical Coaching Skills (74)	Develop Coaching Skills (27)	*'Gaining a better understanding of techniques to use'*
	Improved planning (26)	*'[G]et better ideas of how to structure and plan'*
	Integration with sports-specific practices (12)	*'[I want to] be able to blend more strength and conditioning into training sessions while maintaining skill...'*
	Coaching Confidence (9)	*'To be more confident coaching athletic development with my group'*
Player Welfare & Team Development (68)	Implement Youth LTAD (34)	*'Build a strong base of youth athletic development to progress into Minor/Adult'*
	Player Engagement & Retention (13)	*'To be able to competently guide players under my responsibility through key physical development years in a safe and long term holistic way'*
	Fulfilling Potential (11)	*'[H]elp with the development of young athletes to get the best out of their own abilities'.*
	Injury Prevention (10)	*'Make kids injury resilient and maximise ability and fun'*

Major Theme (n)	Subtheme (n)	Illustrative Quote
Community & Club Impact (32**)**	Club Implementation (26)	*'[C]ontribute towards coaching athletic development within my club and school setting.'*
	Knowledge Sharing & Collaboration (6)	*'[H]elp develop the next generation of players within my club and county.'*

6.3.3 Intervention Evaluation Outcomes

To evaluate the impact of the F3 coaching intervention, outcomes were assessed using the Kirkpatrick Evaluation Model, with participant reaction and learning-related outcomes, including perceived knowledge gains and coaching self-efficacy, examined alongside coaches' intended changes in subsequent coaching practice.

Course Satisfaction

Participant reaction to the intervention was overwhelmingly positive. On a 5-point scale, overall quality was rated exceptionally high (M = 4.73, SD = 0.46), with 99.3% of participants rating the course a 4 or 5. Similarly, 95.9% rated their likelihood of recommending the course at 8 or higher out of 10. Qualitative feedback praised the knowledgeability of the coach developers, the blended learning design, and the collaborative learning environment, which provided opportunities for group work, feedback, and evaluation. Participants noted that the instructors *'broke [the science] down and made it easy to learn',* with several describing the delivery and presentation skills as '*excellent'* and *'very knowledgeable'.* Participants also appreciated the *'good combination of practical-theory-group work'* and the *'informative and interactive'* environment that encouraged *'good participation and involvement'.* A minor subset of coaches noted high cognitive load, suggesting the curriculum could be split over two days. Full descriptive statistics for course satisfaction and specific delivery metrics are available in the supplementary material (Appendix N, Appendix O).

Perceived Impact on Coach Knowledge and Skills

Content analysis of open-ended survey responses revealed the specific skills and knowledge that participants perceived as most beneficial for their future coaching practice (Table 6.3). Feedback was overwhelmingly weighted toward *Practical Application & Delivery* (159 references), with coaches highly valuing actionable AD drills, pedagogical skills, explicit session micro-planning techniques, and the ability to integrate these concepts into sport-specific sessions.

Table 6.3

Content Analysis of Impact on Coach Knowledge and Skills

Major Theme (n)	**Subtheme (n)**	**Illustrative Quote**
Foundational Athletic Development Theory (31)	Core Knowledge & Theoretical Principles (15)	*'An understanding of principles and linkages of the sectors covered'* *'My knowledge of the warm up has massively improved'.*
	Player Pathways & Holistic Development (10)	*'Opened my eyes to younger players' development.'* *'Learning about how different children are developing and how that can [a]ffect a session'.*
	General Curriculum Interest (6)	*'I think[s] the overall content was very good and even though I had some knowledge in areas going in this has brought it to the next level.'* *'All aspects. So relevant to what im [I'm] coaching now with u14 girls'.*
Practical Application & Delivery (159)	Athletic Development Drills & Activities (52)	*'New drills and how to progress and change them up'* *'Game speed drills and exercises'* *'Progressions and regressions of exercises which can be used to aid the development of force'*
	Coaching Skills & Delivery (22)	*'Specific coaching points and cues. The use of external cues'* *'Teaching points related to strength exercises.'*
	Session Integration (15)	*'A wider variety of getting strength and conditioning into a session.'* *'Game-based games being utilised for endurance work'*
	Athlete Monitoring & Injury Prevention (7)	*'Managing player load through planning the correct level of intensity'*
	Session Planning & Preparation (27)	*'Session planning and delivery based on the principles.'*
	- Macro-Planning & Periodisation (5)	*'Planning training sessions and build up to match days, with the right drills and recovery'.*

Major Theme (n)	Subtheme (n)	Illustrative Quote
	- Micro-Planning & Session Structure (31)	*'How to plan a session and know when the best time is to do certain drills.'*

Impact on Coaching Self-Efficacy

Total coaching self-efficacy scores significantly increased from a pre-course mean of 19.53 (*SD = 5.57*) to a post-course mean of 29.24 (*SD = 3.64*) (t(149) = 23.84, $p < .001$, $d = 1.95$). Participants' rating of their overall ability to coach AD increased from 3.07 (*SD = 0.91*) to 4.21 (*SD = 0.57*), t(149) = 16.55, p < .001, $d = 1.35$.

Analysis of the specific sub-components of AD indicated significant increases across all domains ($p < .001$) (Table 6. 4). The largest effect sizes were observed in Growth & Maturation ($d = 1.78$) and Force ($d = 1.70$), which also corresponded to the lowest initial pre-course mean scores.

Table 6.4

Paired Samples t-tests Comparing Pre- and Post-Course Coaching Self-Efficacy Scores (n = 150)

Self-Efficacy Domain	Pre-Course *M (SD)*	Post-Course *M (SD)*	*t*-value	*p*	95% Confidence Interval	Cohen's *d*
					Lower, Upper	
Total Coaching Self-Efficacy	19.53 (5.57)	29.24 (3.64)	-23.84	< .001	[-10.52, -8.91]	1.95
Overall AD Coaching Self-Efficacy	3.07 (0.91)	4.21 (0.57)	-16.55	< .001	[-1.28, -1.00]	1.35
Sub-Components						
Growth & Maturation	2.33 (0.95)	3.95 (0.73)	-21.74	< .001	[-1.77, -1.48]	1.78
Force	2.52 (1.01)	4.07 (0.65)	-20.83	< .001	[-1.69, -1.40]	1.70
Endurance	2.78 (0.99)	4.22 (0.64)	-19.57	< .001	[-1.59, -1.30]	1.60
Gamespeed	2.66 (0.98)	4.16 (0.67)	-18.99	< .001	[-1.66, -1.34]	1.55
Health Benefits, Retention & Participation	2.95 (0.94)	4.23 (0.66)	-17.31	< .001	[-1.43, -1.13]	1.41
Planning	2.95 (1.00)	4.19 (0.70)	-16.43	< .001	[-1.39, -1.09]	1.34
Warm-Up	3.34 (0.93)	4.39 (0.58)	-13.24	< .001	[-1.21, -0.90]	1.08

There were no statistically significant differences in the magnitude of change in coaching self-efficacy based on gender (t(146) = 0.02, p = .982), NGB qualification level (F(2, 147) = 1.04, p =

.355), or years of coaching experience (F(2, 145) = 0.76, p = .467). In all cases, the assumption of homogeneity of variances was satisfied, as assessed by Levene's test (p > .05). To assess the impact of these factors across the specific self-efficacy domains, a series of one-way Multivariate Analyses of Variance (MANOVAs) was conducted. Preliminary testing confirmed the equality of covariance matrices (Box's M p > .05). The MANOVAs revealed no statistically significant differences across the combined dependent variables for gender (Wilks' Λ = .929, F(7, 140) = 1.54, p = .159, η_p^2= .071), NGB qualification level (Wilks' Λ = .874, F(14, 282) = 1.41, p = .148, η_p^2= .065), or years of coaching experience (Wilks' Λ = .885, F(14, 278) = 1.25, p = .238, η_p^2 = .059).

Intended Changes in Coaching Practice

To explore coaches' intended changes in coaching practice, qualitative responses detailing envisioned adjustments to subsequent practice were analysed. Three major themes were generated as detailed in Table 6.5 below: *Practical Application & Delivery* (186 references), *Theory-Informed Practice* (19 references), and *Anticipated Barriers to Implementation* (10 references).

Table 6.5

Content Analysis of Intended Changes in Coaching Practice

Major Theme (n)	Subtheme (n)	Illustrative Quote
Practical Application & Delivery (186)	Coaching Skills & Delivery (42)	*'Focus on showing, spotting & fixing rather than just training.'*
		'Less static stretching and accept planned chaos rather than straight lines'
	Session Planning & Preparation (29)	*'More planning and introduction of Athletic Development as a whole'*
	-Macro-planning & Periodisation (10)	*'Planning for year round athletic development'*
	-Micro-planning & Session Structure (46)	*'Incorporating speed work to the start of a session and strength at the end'*
	Session Integration (31)	*'More confident in integration of these principles in a structured programme'*
		'More emphasis on warmups - never waste a warmup'
	Reflective Practice (15)	*'Better planning, try the session myself before delivering my own session'*
		'Change the old style to bring in new [and] exciting ways to trai[n]'
		'No more static stretching and warm up laps'.
	Athlete Monitoring & Injury Prevention (13)	*'More planning on session for overworked players'*

Major Theme (n)	Subtheme (n)	Illustrative Quote
		'Recovery'
Theory-Informed Practice (19)	Core Knowledge & Theoretical Principles (12)	*'Better planning and knowing the reason why I'm doing certain drills etc'*
		'A lot of the information around force was very new to me. [It's] [definitely] something [I] believe [I] have a better understanding of
	Player Pathways & Holistic Development (7)	*'Consider maturation levels'.*
		'Introducing this to U12 age group in a fun way to build good foundation'
Anticipated Barriers to Implementation (10)	Time & Coach Workload (5)	*'Getting time to get plans together due to work.'*
	Athlete Engagement & Club Support (5)	*'Getting minor boys buy in, but backing of other coaches in club help'*

The qualitative data indicate a robust intent among participants to transition from traditional, legacy-based coaching toward a more integrated AD model (*n* = 186 references). Coaches specifically planned to replace traditional *'laps and static stretching'* with integrated speed and strength units, moving from *'just training'* to a purposeful *'showing, spotting, and fixing'* methodology. These intended changes were frequently accompanied by references to increased theoretical understanding, with coaches describing how this knowledge would inform their subsequent session design and application across the player pathway. However, while self-reported intent and coaching self-efficacy increased following the course, coaches were realistic about anticipated barriers to sustained implementation, specifically time management and the necessity of club-wide organisational support.

6.4 Discussion

The primary aim of this study was to evaluate the impact of the F3 Athletic Development Level 1 course on volunteer Gaelic games coaches' coaching self-efficacy in delivering evidence-informed athletic development. Overall, the findings indicate positive outcomes at Levels 1 and 2 of the Kirkpatrick framework, alongside reported intentions to change subsequent coaching practice. The course elicited high levels of participant satisfaction, significant increases in coaches' self-efficacy, and catalysed an explicit intent to transition from traditional coaching approaches to structured, theory-based physical development.

The strongly positive reaction to the F3 course, with 99.3% of participants rating its overall quality as high, suggests that the curriculum successfully met the specific needs of the volunteer coaching population. In coach education, Level 1 evaluation metrics are often criticised for measuring subjective enjoyment rather than objective educational value. To address this limitation, Alliger et al. (1997) argued for separating general affective reactions (how much participants liked the course) from utility reactions (how useful they found the material). They demonstrated that merely enjoying a course has a near-zero correlation with subsequent behavioural change, whereas a participant's perception of practical relevance is a much stronger indicator of their intent to apply new knowledge. This perception of practical relevance is especially important in volunteer-driven sports organisations such as the GAA, LGFA, and Camogie Association. Unlike professional environments where adherence to new training methodologies may be mandated, volunteer coaches adopt new practices voluntarily. Consequently, their subjective evaluation of the training's applicability is critical to their engagement with the material (Nagel et al., 2019). If an educational intervention is not perceived as immediately valuable, coaches are highly likely to reject unfamiliar concepts and revert to deeply ingrained legacy coaching habits (Cushion et al., 2003; Piggott, 2012). Therefore, the high satisfaction scores reported in this study provide strong validation of the programme's usefulness and help cultivate the necessary buy-in for coaches to begin integrating athletic development into their training sessions.

This high degree of practical applicability stemmed primarily from the course's pedagogical design and delivery method. The blended learning model, which participants praised as a *'good combination of practical-theory-group work,'* effectively addressed a long-standing criticism of traditional coach education that it is often too theoretical and disconnected from the 'messy' reality of the pitch (Stodter & Cushion, 2017). The high satisfaction scores for these practical workshops also indicate that coaches highly value social learning environments where they can trial unfamiliar concepts in a safe, *'interactive'* and collaborative space. Furthermore, qualitative feedback highlighted the coach developer as a central pillar of this success, echoing Cushion et al. (2010), who argued that the educator's interpersonal skills are just as vital as the curriculum itself. Ultimately, while practical elements are already a standard feature of NGB coach education, these findings emphasise that their specific function in this context, in providing a supportive, peer-led space to demystify complex sports science principles, helped secure coaches' buy-in and their intent to translate theory into practice.

While practical relevance and supportive pedagogy secure this essential initial buy-in, course satisfaction metrics alone are limited in their ability to predict actual behavioural transfer. Sitzmann et al. (2008) argued that over-analysing participant reactions, whether affective or utility-based, does not meaningfully improve the prediction of training outcomes. Instead, their meta-

analysis demonstrated that a participant's post-training perceived competence is a superior predictor of whether new knowledge is successfully translated into practice. The quantitative data provide evidence of a substantial increase in coaching self-efficacy. Overall confidence scores increased significantly, yielding a large effect size (*d* = 1.95). Demographic factors such as gender, prior coaching experience, and existing NGB qualifications had no statistically significant influence on the magnitude of self-efficacy change, indicating that similar improvements occurred across these groups. Prior research has identified comparable challenges in youth sport, where coaches recognise the importance of physical development but report feeling inadequately prepared to deliver it (Lloyd et al., 2016; Molohan et al., 2026; O'Connor et al., 2021b). Although more experienced or highly qualified coaches might be expected to demonstrate smaller changes because of higher baseline scores, no such differences were observed in the present study. The universal efficacy found in this study suggests that the curriculum strikes an appropriate balance between accessibility and depth. It also highlights that even the highest-NGB-qualified and most experienced coaches have significant knowledge gaps in modern athletic development principles, reinforcing the need for continuous professional development (CPD) that goes beyond traditional technical-tactical skills.

The most notable shifts within this overall improvement occurred in the sub-components of Growth & Maturation (d = 1.78) and Force (d = 1.70). These domains recorded the lowest pre-course baseline scores, reflecting the historical reality that these 'sports-science-heavy' concepts are often intimidating for grassroots volunteers. Qualitative feedback corroborated these statistical gains, with participants explicitly noting that while *'information around force was very new'*, the intervention provided them with a *'better understanding'* of the mechanics. Similarly, coaches highlighted the practical value of learning *'how different children are developing and how that can [a]ffect a session'*. The course's ability to substantially improve coaching self-efficacy in these complex areas can be understood through the lens of Bandura's (1977) Social Cognitive Theory, particularly as applied to the sporting context by Feltz et al. (1999). According to Bandura (1977), enactive mastery, the experience of personal success in a specific task, is the most potent mediator of self-efficacy. Feltz et al. (1999) extended this construct to 'coaching efficacy', defining it as a coach's belief in their ability to affect their athletes' learning and performance. Importantly, Feltz and colleagues (1999) emphasised that coaching efficacy is not a generalised trait but is highly domain-specific, heavily reliant on prior preparation and enactive mastery experiences. While Growth & Maturation and Force saw the most dramatic gains, significant improvements in coaching self-efficacy were observed across all measured AD domains. By adopting a practical approach, the F3 workshops provided coaches with these mastery opportunities across the entire curriculum. Coaches were able to successfully practise new concepts in a safe, peer-supported setting. These

experiences are consistent with the types of mastery and feedback opportunities identified within Self-Efficacy Theory and may have contributed to the observed increases in coaching self-efficacy and coaches' subsequent intentions to apply the course content in practice.

The qualitative analysis of intended changes in coaching practice provides insight into how coaches anticipated applying the F3 course content within their subsequent coaching environments. The data revealed a strong intent to replace legacy coaching practices with integrated AD models. The coaches in this study explicitly planned to abandon antiquated routines, such as *'static stretching and warm up laps'*, which are now known to be suboptimal for performance and injury prevention (Behm et al., 2016). Instead, they intended to replace these practices with dynamic, *'planned chaos'* environments and integrated speed and strength units. The shift from *'just training'* to a purposeful *'showing, spotting, and fixing'* methodology is also noteworthy, as it indicates a change in the coach's self-perception. Coaches no longer saw themselves as mere facilitators of drills but as technical instructors capable of correcting movement patterns. This pedagogical shift is essential not only for optimising athletic performance but also for the high-fidelity implementation of injury prevention programmes like the GAA 15, the success of which relies on the coach's ability to provide accurate feedback on landing mechanics and postural control (O'Connor et al., 2021b).

Coach buy-in is a universally recognised barrier to behavioural change in sport. While presenting objective evidence is critical for challenging entrenched subjective coaching beliefs, this data must be actively interpreted and communicated in ways that align with a coach's specific, real-world context (Fullagar et al., 2019). The F3 course achieved this by combining accessible online theory with coach developers who successfully *'broke down'* the science on the pitch. This blended approach enabled volunteers to contextualise the science, relating the new evidence directly to the constraints and realities of their everyday coaching practice. Consequently, a recurring theme in the qualitative data was the link between *'knowing the why'* and the intent to change the *'how'*. Coaches reported that acquiring this foundational knowledge (e.g., speed mechanics and player maturation) equipped them with the cognitive foundation needed to internally validate changes to their training approach. Possessing this psychological anchor instils the *'confidence'* and *'validation'* required for volunteer coaches to discard comfortable, legacy practices and effectively deliver modern AD to their players, for example, by intending to *'blend more strength and conditioning into training sessions while maintaining skill'.*

Despite the high levels of intent and increased coaching self-efficacy fostered by the F3 course, this study also identified several anticipated barriers to implementation. As established by the 'intention-behaviour gap' (Sheeran & Webb, 2016), even the most motivated coaches will

struggle to implement new practices if systemic hurdles remain. The qualitative data from this study align with the broader literature on evidence-based practice, highlighting time, workload, and club buy-in as major hurdles, which can be categorised into individual, organisational, and stakeholder factors (Fullagar et al., 2019; Søvik et al., 2017).

At the individual level, time is universally cited as the most significant constraint. In the volunteer-led model of the GAA, LGFA and Camogie Associations, a coach is often an individual or parent with a full-time job who may coach multiple teams with limited access to pitches. This reality was reflected in the qualitative data, where the challenge of *'getting time to get plans together due to work'* was explicitly raised. Consequently, finding time to plan, integrate and embed these practices alongside traditional technical skills may be difficult for some coaches (Søvik et al., 2017). At the organisational level, a sports club's culture is often the strongest predictor of whether an educational intervention is sustained (Till et al., 2022). A critical barrier identified in grassroots sport is a lack of shared understanding (Søvik et al., 2017). This can occur when coaches on the same team have conflicting philosophies or different levels of exposure to new coach education. Tensions may arise between a coach who wishes to implement long-term athletic development strategies and a co-coach who remains results-oriented. This conflict frequently arises when only one coach from a team attends a workshop, leaving them to convince their fellow coach(es) to adopt the new training methods. Without a shared understanding, coaches may provide contradictory messages or feedback to players. The trained coach may feel isolated in their role, which often leads them to abandon new principles and revert to old habits (Søvik et al., 2017). Conversely, a unified coaching front acts as a powerful facilitator in overcoming player resistance. As one participant observed, while *'getting minor boys buy in'* can be difficult, having the *'backing of other coaches in club help[s]'*. Finally, resistance from external stakeholders, particularly parents, poses a substantial hurdle. Results-oriented parents can hinder the adoption of long-term athletic development philosophies, often pressuring coaches to prioritise immediate competitive success over developmental frameworks or injury-prevention protocols (Till et al., 2022). Therefore, the F3 intervention should not be seen as a one-off course but as part of a broader cultural shift. For modern AD to be truly integrated across the association, National Governing Bodies (NGBs) must move beyond individual coach education and begin targeting club officers and coaching committees to create a supportive, cohesive environment that sustains these new practices.

6.4.1 Limitations & Future Research

While this study provides the first empirical evaluation of a national-level AD intervention in Gaelic games, several limitations must be acknowledged. First, the data relies heavily on self-reported measures. Although the Theory of Planned Behaviour identifies intention as a predictor of

actual coaching practice (Ajzen, 1991), intention is not perfectly synonymous with behaviour. Therefore, reported intentions to change coaching practice should not be interpreted as evidence of subsequent behavioural change. Consequently, the well-documented intention-behaviour gap (Sheeran & Webb, 2016) suggests that while coaches may strongly intend to change their practice, the pressures of a competitive season may still prompt a regression to comfortable, legacy habits. Therefore, systematic field observations of live training sessions would provide a more objective measure of whether these enhanced coaching competencies translate into practice. Second, the survey response and retention rates (50%), while standard for voluntary longitudinal research (Baruch & Holtom, 2008), introduce potential selection bias. It is plausible that the coaches who completed the post-course evaluation were already highly engaged with the curriculum, which may inflate overall success metrics. Future research should also examine Kirkpatrick Level 3 through assessment of actual coaching behaviour before progressing to Level 4 outcomes relating to players. Longitudinal designs are required to determine whether the F3 intervention is associated with reduced injury incidence and improved physical performance metrics (e.g., jump height, sprint times) among youth players. Ultimately, the true systemic value of the F3 programme can only be realised by demonstrating that these changes in coaching practice occur and that these changes are subsequently associated with meaningful athlete outcomes.

6.5 Conclusion

The F3 Athletic Development Level 1 course marks an important step in coach education within Gaelic games. The findings demonstrate positive participant reactions to the course and significant increases in coaching self-efficacy across all measured domains of athletic development. Qualitative responses also indicated perceived gains in knowledge and practical understanding, alongside intentions to modify aspects of subsequent coaching practice**.** By successfully bridging the divide between sports science and grassroots volunteerism, the programme has shown that complex sports science concepts, such as force, speed mechanics and biological maturation, can be effectively communicated to a diverse coaching population. The intervention significantly increased coaching self-efficacy, yielding very large effect sizes in domains critical to player safety and long-term athletic development. However, the long-term success of the F3 programme depends not only on coach upskilling but also on integrating these practices into the broader Gaelic games training environment. While coaches may now possess the theoretical knowledge and practical tools to enact change, sustained implementation requires structural and cultural support from both clubs and national organisations. Ultimately, if backed by an environment that prioritises long-term development over immediate competitive results, the F3 framework offers a potentially effective mechanism for supporting youth athletic development across the three associations.

Chapter 7: Synthesis of Findings and Future Directions

The overarching aim of this thesis was to establish an evidence-informed foundation for the physical preparation of adolescent inter-county Ladies Gaelic football players. As highlighted in Chapters 1 and 2, while the sport has experienced exponential growth, the translation of sports science into applied practice has historically been constrained by a reliance on anecdotal evidence, an under-researched female demographic, and the logistical realities of an amateur, volunteer-led coaching ecosystem. To navigate this landscape, the research adopted a pragmatic, multiphase mixed-methods design, systematically investigating both the objective physical realities of the athlete (Stream 1) and the applied capacities of the coaching workforce (Stream 2). The primary contribution of this thesis is the integration of these complementary perspectives. The purpose of this final chapter is to synthesise these core findings, contextualise them within the broader literature, and identify key recommendations for future applied practice.

7.1 Summary of Key Findings

The findings of this thesis reveal a complex and frequently contradictory environment within the adolescent inter-county LGF talent pathway. Ultimately, a disconnect exists between the escalating physical demands placed on youth players and the systemic capacity of the volunteer workforce to safely prepare them for these increased demands. The following is a summary of the main findings highlighting this gap:

7.1.1 Physical Performance Plateaus

- While natural biological growth occurs across the U14, U16, and U18 cohorts, this is not matched by parallel improvements in physical performance metrics. Based on the cross-sectional data in this study, linear speed, change-of-direction speed, and explosive power do not significantly differ between these consecutive age groups. Although longitudinal tracking is required to make definitive statements about individual player development, these findings suggest players may be overly reliant on physical growth rather than structured athletic development to prepare for the increased demands of senior football.
- The only metric to show significant natural improvement across the pathway is intermittent endurance capacity. Although this study did not quantify specific training content and loads to directly correlate with changes in fitness, previous literature suggests that aerobic fitness can be adequately developed through the continuous tactical and small-sided games that

typically dominate traditional field-based training (Duggan et al., 2023, 2024; Malone et al., 2016). However, this type of training is unlikely to provide the specific mechanical overload necessary to facilitate gains in strength and power (Kraemer & Ratamess, 2004). Extensive existing literature highlights the importance of strength and power qualities, not only for optimising physical performance, but also for mitigating injury risk (Fort-Vanmeerhaeghe et al., 2016; Lloyd & Oliver, 2012; Suchomel et al., 2016).

7.1.2 Escalating Match Demands

- In contrast to the static physical profiles observed cross-sectionally, GPS data confirms that competitive match-play locomotor demands, including high-speed running and sprint distances, progressively increase across consecutive age grades. This divergence indicates a widening physiological deficit, where players are consistently exposed to higher game intensities without the requisite foundational strength and speed. Based on established literature regarding load tolerance and long-term athletic development (Gabbett, 2016; Pichardo et al., 2018), safely managing these escalating workloads requires structured physical preparation; without it, players may be left underprepared for the eventual transition to the senior game.
- Consistent with fitness testing, maximal speed did not differ significantly between U16 and U18 players. In team sports, expanding the anaerobic speed reserve (ASR) is a critical mechanism for tolerating increasing locomotor demands. For youth LGF players navigating the step-up in match intensity, a larger ASR reduces the physiological cost of sub-maximal, high-speed running. By lowering the relative percentage of maximal capacity required per sprint, this buffering effect enables players to perform repeated high-intensity actions while mitigating premature fatigue and subsequent performance decrements.

- Regardless of age or position, there is a consistent reduction in running performance (specifically relative distance and high-speed running) between the first and second halves of a match. Running demands are also heavily dictated by position, with the 'middle eight' players (half-backs, midfielders, and half-forwards) consistently recording the highest total and high-speed distances compared to the 'inside' lines. These lines also recorded the highest decrements in running performance across both halves of play.

7.1.3 Implementation Gap

- Surveys of inter-county coaches investigating physical preparation practices at inter-county level revealed a considerable gap between coach perceptions and actual training practices. While the vast majority of coaches believed that athletic development was beneficial for

football performance and injury prevention, gaps in understanding, lack of expertise, and insufficient resources contribute to inconsistencies in practice.

- Despite these positive perceptions, structured athletic development, particularly resistance training, was notably underutilised, particularly at the younger U14 and U16 levels. Although gym-based integration increased at U18, the data reveal a widespread coaching perception that structured resistance training is a secondary luxury to be deferred until athletes are older, rather than a foundational necessity for younger age brackets.

- A competency gap exists regarding physical testing; many coaches omit testing entirely, use inappropriate tests (such as aerobic protocols to measure maximal speed), or tests that lack ecological validity. Without valid and reliable profiling, long-term athletic progression cannot be accurately tracked, and talent identification remains highly subjective rather than data-driven.

7.1.4 Impact of Contextualised Coach Education

- The F3 Athletic Development Level 1 intervention helped to bridge the knowledge gap, significantly elevating coaches' self-efficacy by contextualising physical preparation within Gaelic games. The course resulted in a statistically significant and large increase in coaching self-efficacy which was universal across gender, prior experience, and existing qualification levels. Qualitative data corroborated these findings with coaches noting that the F3 course provided them with a better understanding of sports science principles and a clear intent to abandon legacy coaching practices, in favour of integrated models.

- Despite increased confidence following the intervention, the sustained translation of this knowledge onto the pitch remains hindered by systemic barriers, including time constraints, volunteer overload, and results-driven club cultures. This indicates that while coach education is a necessary catalyst, it is insufficient on its own. Sustainable change requires structural support and aligned competition frameworks from the governing bodies.

7.2 Consideration of Key Findings in the Context of the Literature

The primary role of a talent development pathway is to progressively prepare adolescent athletes for the more advanced physiological, psychological, tactical, and technical demands of adult competition (Barraclough et al., 2022). Clear differences in physical capacities have consistently been documented across a variety of field sports, both when comparing junior athletes to their senior counterparts and when evaluating athletes at different playing standards (Clarke et al., 2017; Jennings et al., 2025; Vescovi et al., 2021). Consequently, achieving an effective transition

from youth ranks to senior standards requires a systematic, non-linear progression in physical capacities to match the escalating intensity of the adult game (Clarke et al., 2017; Vescovi et al., 2021).

The overarching narrative of this thesis reveals a mismatch at the core of this developmental pathway. While the elite adult Ladies Gaelic Football (LGF) game has evolved into a highly intense, physically demanding field sport, the adolescent talent pathway is characterised by a distinct plateau in the development of physical capacity. Triangulating the objective player profiles (Stream 1) with the coaching practices and operational constraints of the volunteer workforce (Stream 2) highlights a system that relies on age-related physiological progression rather than structured athletic development. Although a statistical cause-and-effect relationship cannot be established between the players tested and the coaches surveyed, integrating this data provides an overview of the landscape, with the coaching data offering explanatory context for the observed physical plateaus. When viewed through the lens of established sports science literature, the lack of engagement in structured resistance training helps explain why youth players transition into adulthood without the physical robustness needed to withstand the demands of the adult game. The following sections synthesise these parallel streams, contextualising them within the sports science literature to outline how this thesis advances the field.

7.2.1 Chronic Neuromuscular Underloading

A major contribution of this thesis is the empirical evidence suggesting that inherent biological maturation alone may be insufficient to bridge the physiological gap between youth talent pathways and adult inter-county performance. While cross-sectional profiling (Study 1) revealed predictable anthropometric growth across the U14, U16, and U18 cohorts, this biological maturation was not matched by corresponding improvements in physical performance metrics. Scores for linear speed, change-of-direction speed, and upper- and lower-body explosive power remained largely consistent across the three age categories.

In Study 1, youth cohorts recorded mean countermovement jump (CMJ) heights that plateaued between 26 and 28 cm across age grades. Superficially, these scores appear to mirror the emerging literature on senior inter-county LGF players, who exhibit mean CMJ heights of 27.4 ± 4.5 cm (Hughes et al., 2024). However, drawing direct numerical equivalencies between these independent datasets requires caution, given differnces in testing instrumentation. Field-based flight-time protocols used in Study 1 are known to overestimate jump height relative to laboratory force plates (Eythorsdottir et al., 2024; Ruf et al., 2024). Therefore, accounting for this measurement bias indicates that the true neuromuscular power of these youth cohorts is likely lower than

reported, thereby masking a substantial performance gap between adolescent pathway players and their elite senior counterparts.

The long-term significance of this physical deficit is further underscored by broader neuromuscular profiling within the same adult cohort. Beyond absolute jump height, Hughes et al. (2024) demonstrated that maximal strength (isometric midthigh pull peak force), explosive power (propulsion peak power), and reactive strength are primary performance discriminators between elite and sub-elite adult standards. Elite inter-county players display significantly superior capabilities, characterised by large effect sizes, compared with their sub-elite club counterparts. Viewing these static physical profiles through this lens highlights the long-term consequences for players who do not overcome this late-adolescent plateau. By failing to achieve progressive gains in neuromuscular power and strength throughout adolescence, these players do not develop the specific traits required to reach elite standards. Consequently, without a move towards systematic, progressive resistance training across the age-grades, these pathway players will remain ill-prepared to bridge the physical gap between youth competition and elite senior inter-county performance.

This functional deficit is mirrored in linear sprint velocity. Adult inter-county players profile at 1.14 ± 0.06 s over 5 m and 3.34 ± 0.13 s over 20 m (McGuinness et al., 2026). In contrast, the youth acceleration and sprint times in Study 1 remained largely unchanged within a narrow band of 1.16 to 1.19 s, while 20-metre sprint times plateaued between 3.52 and 3.58 s across all three age categories. While a performance plateau is biologically typical for mid-adolescent females (Doyle et al., 2021; Papaiakovou et al., 2009; Vescovi et al., 2011), empirical evidence demonstrates that this trajectory can be actively altered through deliberate physical preparation. Targeted strength and plyometric interventions have been shown to significantly enhance sprinting mechanics and speed in female athletes as young as 13 years of age (Talukdar et al., 2024). This neuromuscular trainability persists well into late adolescence. Structured programming consistently drives linear speed improvements in female team-sport athletes, with resistance training yielding particularly pronounced adaptations in cohorts older than 15 years (Lin et al., 2025; Luo et al., 2025). Consequently, the distinct plateau observed across the age-grades in the current study reflects an absence of consistent, targeted physical stimulus rather than an insurmountable biological ceiling.

The findings from Stream 2 provide valuable contextual insight into this widespread developmental plateau, revealing a prevailing coaching culture that frequently omits or defers structured resistance training. Across the pathway, 74% of U14 and 65% of U16 coaches reported a complete absence of weekly gym-based conditioning. This non-implementation persists into late adolescence, with 30% of U18 coaches continuing to exclude gym sessions entirely.

Parallel to this structural neglect of force production, max-velocity development is similarly compromised by flawed field-based programming. True maximum-velocity enhancement requires athletes to sprint in a non-fatigued state, with full inter-set recovery (Buchheit & Laursen, 2013). Study 3's supplemental scheduling data (Appendix I), reveal that, although over 90% of coaches report implementing speed work, the majority (50–60%) integrate it between tactical elements, and 16% of U18 coaches execute it post-session. Sprinting under conditions of fatigue shifts the biological adaptation stimulus entirely away from neurological speed development towards further metabolic conditioning (Gabbett, 2016). When combined with the lack of progressive resistance training, this programming mismatch helps explain why linear sprint times over 5 and 20 m flatline, whereas intermittent endurance (Yo-Yo IR1) steadily improves as a direct physiological adaptation to the continuous, field-based tactical drills that dominate these coaching sessions. The intervention in Study 4 demonstrated that these pedagogical errors stem from a lack of technical coaching efficacy rather than an unwillingness to develop speed. Following the coach education intervention in Study 4, coaches demonstrated a significant increase in self-efficacy and a clearer conceptual understanding of the physiological rationale for sequencing alactic speed work prior to tactical fatigue. While permanent behavioural translation on the pitch remains subject to wider environmental constraints, this establishes that the late-adolescent physical plateaus observed in Stream 1 are not an inevitable biological ceiling. The literature and coaching data instead indicate that modifiable training practices may contribute to these trajectories.

7.2.2 Escalating Match Demands

A primary contribution of this thesis is the establishment of the first comprehensive baseline of GPS-quantified match demands for U16 and U18 inter-county cohorts. While the physical fitness profiles in Study 1 remained statistically stable across age groups, the GPS-quantified match-play data in Study 2 confirmed that competitive youth inter-county football imposes progressively higher locomotor demands. When these youth match-play metrics are compared with normative adult senior data, a clear trajectory of increasing physical intensity is evident. For instance, relative running distance increases from 88 ± 20 $m \cdot min^{-1}$ at U16 to 93 ± 16 $m \cdot min^{-1}$ at U18, ultimately reaching 116 ± 9 $m \cdot min^{-1}$ in adult senior inter-county competition (Malone et al., 2023). Similar step-ups are observed across the pathway for total high-speed running distance (U16: 826 ± 371 m; U18: 1071 ± 424 m; Senior: 1547 ± 432 m) and total sprint distance (U16: 206 ± 177 m; U18: 348 ± 195 m; Senior: 630 ± 287 m) (Malone et al., 2023, 2024). Furthermore, the distinct positional variations identified in Study 2 demonstrate that the 'middle eight' positions endure significantly greater workloads than the inside lines. Essentially, this shows that while youth match play does not reach the absolute physical intensities of the adult game, it mirrors the same tactical structure, in which positional role dictates the running demands (Malone et al., 2023; Timmons et

al., 2025). Similarly, the consistent decline in running performance in the second half of play, while multi-factorial in nature, mirrors findings from the adult game. Overall, the uniform fitness profiles from Study 1 strongly suggest that, without deliberate physical preparation targeting repeat-sprint ability, maximum velocity, and an expanded ASR, adolescent players may lack the requisite physical robustness to comfortably tolerate these escalating match workloads.

The Anaerobic Speed Reserve (ASR) represents the operational window between an athlete's maximal aerobic speed and their absolute maximal sprinting velocity (Sandford et al., 2021). In team sports, expanding this threshold is a critical mechanism for tolerating increasing locomotor demands. By raising the maximum velocity 'ceiling' through targeted training, the relative physiological cost of all sub-maximal, high-speed running is effectively reduced (Buchheit & Mendez-Villanueva, 2014). For youth LGF players navigating the step-up in match intensity, an expanded ASR minimises the absolute percentage of anaerobic capacity required for individual sprints. This buffering effect enables players to execute repeated high-intensity actions while mitigating premature fatigue and subsequent performance decrements (Sandford et al., 2021) and reducing susceptibility to soft-tissue and acute landing injuries (Gabbett, 2016). However, since the maximal velocity profiles of the youth cohorts in this thesis did not progress across age grades, players are entering an increasingly intense match-play environment without a corresponding expansion of this buffering threshold. Consequently, to meet the accelerating locomotor demands of the game from U16 to U18, youth players must execute repeated high-intensity efforts at an elevated percentage of their absolute physical capacity.

7.2.3 Inconsistent Assessment Practices

Analysis of the supplemental empirical data indicates that a substantial proportion of coaches do not conduct physical profiling of their athletes (Appendix H). Specifically, 47% of U14 and 45% of U16 coaches reported conducting no physical performance assessments. Reasons for this omission, such as a belief that players were 'too young' (30% at U14) or that testing was 'not needed' (20% at U14 and U16), directly contradict established long-term athletic development frameworks, which emphasise the need to monitor physical qualities during adolescence (Bergeron et al., 2015; Faigenbaum et al., 2009). Furthermore, the self-reported 'lack of expertise' (cited by 20% of U14 and 40% of U16 coaches) confirms a significant competency gap at this level.

While a subset of coaches used age-appropriate and ecologically valid assessments, the overarching trend points to a widespread omission of comprehensive testing, leaving most assessment batteries lacking genuine diagnostic value. This limitation is reinforced by pronounced underutilisation of objective sports science technology, with 84% of U14 and 75% of U16 coaches operating without any technological assistance to guide their athletic programming. In the absence

of valid and reliable instrumentation, coaches are unable to quantify changes in neuromuscular power or linear speed. The widespread omission of muscular strength and power profiling in the foundational stages appears to stem from coaches' pedagogical beliefs that align with the perception that resistance training is unnecessary for younger athletes. Consequently, profiling only becomes prominent at the U18 grade, where 50% of the cohort utilise vertical jump protocols. This delayed implementation reinforces the broader narrative that practitioners view structural physical preparation as a late-stage requirement rather than a continuous, pathway-long process.

However, the isolated use of maximal-load testing (e.g., 1RM or 3RM squats) by a minority of U18 coaches highlights a disregard for developmental readiness, failing to recognise that chronological age does not equate to training age (Lloyd et al., 2014). The survey data demonstrate a systemic lack of resistance-training history across the pathway, with 76% of U14s, 65% of U16s, and 35% of U18s reporting no prior gym-based conditioning. Given this demonstrably low training age, exposing technically novice, post-PHV athletes to maximal axial loading poses an acute, unnecessary musculoskeletal risk (Faigenbaum et al., 2009; Lloyd et al., 2014).

This underlying knowledge deficit is evident in the tracking of running performance, with qualitative descriptive data indicating a widespread tendency among practitioners to conflate metabolic conditioning ('being fit') with absolute running speed ('being fast'). Quantifying aerobic capacity is undeniably a crucial component of athletic profiling in Gaelic football, where a well-developed aerobic system is required to sustain high-intensity match running volumes and support rapid metabolic recovery (Duggan et al., 2023). However, using high-intensity intermittent endurance protocols, such as the 1.2 km shuttle run ('Bronco') or Yo-Yo tests, as a direct assessment of player speed reveals a fundamental misunderstanding of bioenergetics within this cohort. While these protocols are valid measures of aerobic fitness (Sella et al., 2021), they do not assess maximal alactic sprinting velocity, acceleration, or multi-directional speed. By using aerobic endurance protocols as proxy measures for speed, a substantial number of coaches fail to capture the high-force, anaerobic qualities that dictate game-defining actions and play a critical role in mitigating hamstring injuries (Edouard et al., 2023).

Ultimately, this inconsistency, in which evidence-based testing is isolated rather than universal, and in which a substantial proportion of practitioners either test the wrong energy systems or inappropriately administer maximal strength tests to novice athletes, reinforces the conclusion that testing practices are frequently misaligned with adolescent athletes and the game's physiological requirements. If test results cannot accurately and safely inform a targeted training intervention, the assessment ceases to be diagnostic and becomes merely observational. In doing

so, these profiling practices serve as descriptive records of a player's current fitness rather than prescriptive tools that can drive long-term athletic development.

7.2.4 The Volunteer Implementation Gap

The third major contribution of this thesis is its evaluation of the volunteer coaching workforce to determine why these developmental gaps persist and how they can be addressed systemically. The workforce responsible for steering inter-county talent pathways is almost entirely composed of community volunteers and parents. As documented in Horgan et al.'s (2021) baseline report on coaching in Gaelic games, these individuals are fundamentally 'time-poor' and must balance team logistics and pitch sessions with the demands of full-time external employment and family commitments.

This structural constraint aligns with global trends identified by Wicker (2017) in grassroots sports, where heavy reliance on volunteerism consistently creates operational bottlenecks. Furthermore, Weldon et al. (2021, 2022) observed across sports such as football and volleyball that, although clubs universally rate physical preparation as a high priority, persistent logistical barriers, including financial deficits, restricted facility access, and a lack of certified strength and conditioning personnel, routinely compel technical sports coaches to assume the supplementary role of athletic development personnel. This pattern is replicated within the LGFA inter-county pathway, where teams often lack access to dedicated, qualified sports science support. This leaves volunteer coaches in the position of having to adopt specialised, multidisciplinary roles for which they are fundamentally unprepared.

The baseline evaluation in Study 3 found that pathway coaches have near-universal conceptual buy-in, with over 89% recognising that physical preparation enhances performance and mitigates injury risk. Despite these positive perceptions, a profound 'intention-behaviour gap' prevents this buy-in from translating into regular pitch practice (Sheeran & Webb, 2016). While volunteer coaches value athletic development, they frequently report limited domain-specific 'technique efficacy' (Feltz et al., 1999) and may therefore feel ill-equipped to prescribe load, analyse movement mechanics, or manage musculoskeletal risks. This uncertainty often prompts coaches to retreat to traditional coaching habits, defaulting to familiar tactical drills or conditioning methods rather than delivering evidence-informed physical preparation (Jones, 2006).

Study 4 demonstrates that the structural gap in grassroots coach education can be effectively addressed through targeted, sport-specific design. By design, traditional NGB coach education pathways appropriately prioritise sport-specific technical and tactical development and are not structured to provide the deep, domain-specific training required to build physical-

preparation competencies. Therefore, volunteer coaches, frequently forced into the dual role of athletic development personnel (Weldon et al., 2021), often lack the 'technique efficacy' required to safely implement physical preparation (Webb & Leeder, 2022). Furthermore, while elite coaches derive their confidence from formal credentials, amateur volunteers rely almost entirely on their personal playing backgrounds to validate their coaching capabilities (Feltz et al., 1999).

To bridge this divide, the F3 Athletic Development Level 1 intervention drew on Bandura's (1977, 1997) social-cognitive architecture within a blended pedagogical model. By anchoring workshops on the training pitch, the F3 intervention directly facilitated enactive mastery experiences, enabling volunteer coaches to physically execute movements, practise diagnostic observation, and deliver real-time technical adjustments. When supplemented by vicarious experiences (observing expert tutors model appropriate coaching cues) and verbal persuasion (receiving immediate, constructive feedback from domain experts), these interventions can help to systematically build the technical efficacy required to deliver physical preparation safely.

The intervention triggered a large, statistically significant increase in overall coaching self-efficacy, observed across gender, prior experience, and baseline qualification levels. Notably, it drove substantial gains in confidence in complex sports science domains, specifically within the Growth and Maturation and Force modules, ensuring coaches are better equipped to adapt training protocols during the adolescent growth spurt. Post-intervention, participants reported a pedagogical shift in self-perception, moving from mere drill facilitators to active technical instructors. By fostering a deeper understanding of the underlying physiological mechanisms, coaches demonstrated a clear intent to abandon outdated legacy practices such as unstructured laps and static stretching, in favour of integrated speed and strength units and were empowered with the technical confidence to critically evaluate their scheduling choices.

However, while targeted education effectively improves individual coach self-efficacy and behavioural intent, translating this into sustained on-pitch practice remains acutely vulnerable to the 'intention-behaviour gap' (Sheeran & Webb, 2016), indicating that even highly motivated, newly upskilled coaches face significant implementation barriers. Post-intervention, acute time constraints, heavy volunteer workloads, and a lack of shared philosophical understanding among co-coaches consistently threatened sustained application of these new methodologies. Additionally, pressure from external stakeholders, such as parents and club officials prioritising immediate competitive success over long-term athletic development, can isolate upskilled practitioners. This isolation often compels them to abandon evidence-based practices and revert to familiar legacy habits. Therefore, while educational interventions such as the F3 course are highly effective at the individual level, reversing the physical plateaus identified in Stream 1 requires a

broader cultural shift. For athletic development to be authentically embedded across the talent pathway, governing bodies must move beyond isolated coach education and target broader organisational structures, fostering a cohesive, club- or county-wide environment that actively sustains and supports progressive physical preparation (Till et al., 2022; Wicker, 2017). To sustainably reverse the physical plateaus documented in Stream 1, NGBs must evolve beyond isolated coach education to a more coordinated, systemic alignment in which competition frameworks and club resource allocations are structurally designed to support athletic development, potentially underpinned by ongoing mentorship and communities of practice across the broader club infrastructure (Culver & Trudel, 2008). Taken together, the findings of this thesis and the wider evidence base indicate a need for earlier and more systematic development of the physical qualities underpinning performance, including strength, power, speed, and endurance, while recognising that the appropriate training stimulus should be individualised according to maturation, training age, and coaching context.

7.3 Practical Implications and Recommendations

Translating the integrated findings of this thesis into sustainable field practice requires moving beyond isolated coaching interventions. The findings indicate that physical underdevelopment, escalating match demands, inconsistent assessment, and limited coaching capacity are interconnected features of the current pathway. To better support the adolescent inter-county player, long-term progress should be facilitated by integrating collaborative practices across the macro (governing body), meso (county), and micro (pitch-level) layers of the Gaelic games network.

The strategic framework resulting from these macro, meso, and micro-level insights is summarised in Table 7.1, outlining the specific implementation directives required to modernise athletic development within adolescent inter-county Ladies Gaelic Football.

Table 7.1

Consolidated Strategic Framework for Athletic Development in Youth Inter-County LGF

Pathway Level	Key Stakeholder	Strategic Directive	Operational Action & Implementation
Macro (National)	LGFA National Executive & Committees	*Competition Restructuring*	Transition early youth grades (U14–U16) to tiered, league or tournament-based formats to guarantee a higher volume of competitive matches and dilute immediate knockout pressure.
		Talent Pathway Expansion	Remove restrictions on 'odd' age-grade development squads by reinstating formal U15 and U17 developmental panels to support a non-linear talent model.
Meso (County)	LGFA County Boards & Coaching Committees	*Coach Education Mandate*	Mandate and fund a minimum F3 Level 1 qualification for at least one coach per youth management team to embed technical efficacy and build coaching confidence.
		Silo Breakdown	Establish Communities of Practice linking U14, U16, and U18 coaches to support peer learning, align developmental objectives, and share solutions to common implementation challenges.
		Curriculum Standardisation	Implement a shared, progressive athletic development curriculum across all academy squads to ensure systematic physical progression independent of coaching turnover.
Micro (Pitch)		*Progressive Strength Foundation*	Embed low-tech, pitch-based resistance (bodyweight, partner-resisted, and safe landing/deceleration mechanics) before graduating players to formal gym loading.
		Pathway-Appropriate Profiling	Implement a standardised, field-based testing battery tailored to the needs of the players and the game, to facilitate tracking and measuring physical development over time.

7.3.1 Macro Layer Recommendations: Realigning Competition with Player Development

Key Recommendations:

- Restructure Inter-County competitions to prioritise development over performance
- Reinstatement of developmental panels at U15 and U17

Justification

The principal rationale for reforming the competition structure is that long-term development is shaped by the broader environment in which players are selected, trained, and evaluated. At the U14 age-grade, the LGFA has successfully introduced progressive, festival-based tournament structures, but this development-first ethos is discontinued at U16. Currently, the LGFA operates a rigid, knockout-based championship model in which players typically face a maximum of five to six competitive matches per year. While players also take part in several challenge matches early in the year, the low volume of competitive fixtures means every championship game carries substantial consequences. This pressurised environment inherently encourages volunteer coaches to prioritise immediate match outcomes. This is potentially incompatible with the longer time horizon required for progressive physical development. The current pathway therefore risks reinforcing the very performance-oriented culture that the broader LTAD literature cautions against, where immediate competitive success can take precedence over systematic development and athlete welfare.

This approach contrasts sharply with the structurally progressive pathways maintained by partner associations. For instance, the Camogie Association mitigates this pressure by providing tiered 'A' and 'B' competitive structures that guarantee players a schedule of 10 to 12 high-quality competitive matches each year. Because the early rounds of this format are less consequential, the structure maintains a clear developmental focus throughout the competition. From an athletic development perspective, this allows management teams to safely expose a wider pool of players to high-level game demands and build squad depth without the fear of immediate elimination. Similarly, the boys' GAA model offers a valuable template for prioritising long-term development. The GAA deliberately delays formal, high-stakes knockout competition until the U17 age grade. In the intervening years, the boys' model places firm emphasis on continuous talent development through regional tournaments, biobanded games, and developmental panels, effectively redirecting the focus toward a structured, multi-year curriculum rather than the pursuit of immediate trophies. These models provide potentially useful examples of how competition can maintain an appropriate level of challenge while reducing the emphasis on immediate results.

Reinstating U15 and U17 developmental squads would further support this principle. A healthy talent pathway is inherently non-linear; players mature at different rates and will naturally enter, exit, and re-enter the pathway throughout adolescence (Abbott et al., 2005). However, if players drop out of the county setup during these restricted 'odd' years, they miss out on crucial years of structured physical progression. Even if the foundational F3 coaching curriculum is widely implemented across clubs, standard club setups are generally not equipped to provide the advanced

overload stimulus that post-PHV players require to sustain their physiological adaptation (Kraemer & Ratamess, 2004). A more continuous pathway would therefore allow players to enter, exit, and re-enter the county system without losing access to structured development, while better accommodating differences in maturational timing and training history. The LGFA should therefore consider extending formal developmental opportunities across the odd age grades rather than allowing these gaps to interrupt the broader pathway.

7.3.2 Meso Layer Recommendations: Strengthening Inter-County Collaboration

Key Recommendations:

- Adopt a shared athletic development curriculum across inter-county squads
- Establish Communities of Practice
- Mandate and facilitate F3 qualification

Justification

While macro-level policy sets the broader boundaries of the pathway, these developmental principles are most often challenged at the inter-county level. Congested playing calendars, overlapping commitments between county and club, and a lack of a unified development philosophy persist across youth inter-county panels. To address these meso-level challenges and break down structural silos, county boards could greatly benefit from establishing collaborative frameworks.

Adopting a shared, progressive athletic development curriculum across all inter-county academy squads to standardise physical preparation ensures players transition seamlessly between age grades. This will also provide coaches with a clear structural roadmap and help reduce their planning burden. By anchoring the pathway in a long-term athletic development framework, counties can mitigate the disruption caused by the high annual turnover of volunteer coaches, ensuring that physical progression remains systematic rather than dependent on the arbitrary preferences of an incoming management team (Lloyd et al., 2015; Till et al., 2022). Furthermore, a unified curriculum ensures that the foundational movement mechanics and competencies established at U14 are logically and safely progressed into the specific force production and high-speed running exposures required at U18 and beyond, up to the senior level. This framework should define overarching physical qualities and goals while accounting for individual variation and training history, while affording coaches sufficient autonomy in how programming is implemented

County boards should also be encouraged to formalise Communities of Practice (CoPs) to bridge the protective 'team silos' that often form across academy age grades (Webb et al., 2016). These forums provide a mechanism for ongoing, peer-based learning and would enable U14, U16, and U18 inter-county coaches to share experiences, discuss problems arising from their own practice, align technical, tactical, and physical benchmarks, and develop shared understandings through participation in a common coaching environment (Wenger, 1998; Culver & Trudel, 2008). This is particularly relevant to the present findings because the F3 intervention increased coaches' self-efficacy and intentions to modify practice, but implementation remained vulnerable to differences in workload, coaching philosophy, and organisational support. Formal education alone may therefore be insufficient to sustain learning once coaches return to their normal environments. Sport coaching literature suggests that informal and social forms of learning can complement formal coach education and provide opportunities for coaches to reflect on, exchange, and apply knowledge within their own practice contexts (Stoszkowski & Collins, 2014, 2016). Within the LGF pathway, CoPs could bring U14, U16, and U18 coaches together to share experiences, align physical-development objectives, and discuss practical solutions to common implementation problems. They could also provide a mechanism for communication between county and club coaches, helping to address the coordination challenges associated with players participating across multiple sporting environments (Bjørndal & Ronglan, 2018). Rather than functioning as another formal educational requirement, the purpose would be to create an ongoing social-learning structure that supports the application and refinement of athletic-development practices over time.

Finally, as part of a broader support system, rather than a stand-alone solution, county boards should require that at least one coach on each inter-county youth management team holds a minimum F3 Level 1 Athletic Development qualification. Study 4 demonstrated substantial improvements in coaching self-efficacy and strong intentions to modify practice, but also identified time constraints, workload, and differences in coaching philosophy as barriers to implementation. Embedding this foundational competence across every squad should increase the likelihood that physical conditioning is evidence-informed, safely applied, and contextually relevant, thereby bridging the gap between national guidelines and pitch-level realities. By removing logistical barriers, specifically by organising and funding these practical courses locally, county boards can directly support volunteer practitioners, giving them significantly more confidence to implement a structured, integrated programme of athletic development.

7.3.3 Micro Layer Recommendations: Pitch-Level Practice

Key Recommendations:

- Integrate physical preparation implicitly within football-specific sessions
- Standardise safe, pathway-appropriate physical profiling on the pitch

Justification

At the micro-level, physical preparation must directly reflect the physiological realities of the game and the pedagogical constraints of a volunteer workforce. Recommendations at this level must account for the fact that LGF coaches are primarily technical and tactical practitioners working with limited time, facilities, and specialist support. Consequently, the most useful intervention is not necessarily to add a separate programme of extensive conditioning, but to embed appropriate physical stimuli within existing training structures.

Quantitative data from Streams 1 and 2 of this thesis showed a clear increase in match intensity from U16 to U18, yet youth players' physical capacities remained stagnant. Combined with the coaching data indicating limited and inconsistently sequenced physical preparation, this suggests that players may not be receiving sufficient progressive overload to match the increasing demands of competition. Because football coaches primarily serve as technical and tactical instructors, physiological adaptations to training occur mainly during football practice. Speed training warrants particular consideration because maximal-speed development requires high-quality efforts performed in a relatively fresh state and with sufficient recovery between repetitions (Buchheit & Laursen, 2013). Coaches should therefore protect short periods of high-quality acceleration and maximal-velocity exposure, ideally early within a session or within warm-up structures, before substantial fatigue develops. By embedding these brief sprint exposures in structured warm-ups and 'planned chaos' game-based environments, coaches can safely expose athletes to multi-directional movement and high-speed running.

Similarly, resistance training should be regarded as a developmental component of youth preparation rather than a late-adolescence addition. To address the critical deficit in muscular overload, practitioners can integrate low-tech, field-based resistance training. Incorporating bodyweight mechanics, partner or resistance-band exercises, and explicit instruction in safe landing and deceleration mechanics ensures players develop essential baseline strength and force-absorption capacity. The rationale is to establish movement competence and force-production capacity progressively, while avoiding unnecessary complexity or maximal loading in technically

inexperienced athletes. This approach is more consistent with the principle of individualised development than either delaying resistance training until U18 or prescribing identical gym-based programmes across age groups. This pitch-based approach can serve as a necessary developmental stepping stone, which can then be safely and systematically transitioned into formal gym settings for advanced strength development.

To support long-term player welfare, management teams across the pathway should utilise a standardised, field-based testing battery aligned with players' developmental needs and the specific demands of the game. A consistent battery of valid field-based assessments could provide coaches with information on linear speed, lower-limb power, and intermittent endurance while remaining feasible within volunteer-led environments. However, the findings of this thesis indicate that testing is only valuable when coaches understand what the test measures and how the result should influence training. Consequently, education should focus not simply on which tests to administer, but on how to interpret the results and translate them into an appropriate training response. Implementing a consistent profiling framework across all age grades will enable reliable measurement, benchmarking, and tracking of physical development over time, while remaining feasible within the practical constraints of the LGF environment.

7.4 Limitations & Future Research

While this thesis provides a comprehensive, multi-disciplinary analysis of the youth Gaelic games pathway, several methodological limitations must be acknowledged across the research streams. These are grouped into three main categories below:

7.4.1 Sample Generalisability and Selection Bias

The physical profiling and match-demand data (Studies 1 and 2) were collected from a single county with a large playing population. Consequently, these findings may not fully reflect the realities of counties with smaller playing numbers or different developmental philosophies. Furthermore, the coaching evaluations (Studies 3 and 4) are subject to selection bias. With response rates between 45% and 61%, it is plausible that the coaches who volunteered to participate were already highly engaged in athletic development, potentially inflating overall success metrics and skewing the data towards a more positive view of current S&C practices.

7.4.2 Data Collection and Contextual Variables

The collection of physiological and GPS data was constrained by the logistical realities of applied sports science. Study 1 relied on cross-sectional, one-off testing in early pre-season, so factors such

as circadian rhythms, prior 24-hour physical activity, and potential learning effects could not be strictly controlled. Furthermore, the reliance on cross-sectional data precludes making definitive conclusions about longitudinal, individual-player development. Similarly, the GPS analysis in Study 2 used a relatively small sample of matches and uneven player sampling. Contextual match factors, such as opposition quality, match outcome, or pitch surface, which are known to significantly influence locomotor outputs, were also not accounted for. Finally, because specific training loads, session content, and injury epidemiological data were not tracked longitudinally alongside fitness changes, all assertions regarding typical training adaptations or injury mitigation in this thesis are grounded in established sports science literature rather than direct empirical evidence from the current cohorts.

7.4.3 Reliance on Self-Reported Measures and the Intention-Behaviour Gap

The evaluation of coaching efficacy relied heavily on self-reported survey data, making it vulnerable to social desirability bias, in which coaches may overstate their competencies. Most importantly, although Study 4 demonstrated a significant increase in coaching confidence and intention, intention is not synonymous with behaviour. The absence of direct, live-field observations means the thesis cannot definitively confirm how effectively these newly acquired competencies withstand the 'chaotic realities' of the pitch. Furthermore, even if these practices are successfully implemented, the intervention's downstream impact on the athletes themselves remains unmeasured. Without longitudinal tracking, it is not yet possible to confirm whether this enhanced coaching efficacy directly translates into tangible player outcomes, such as improved physical performance parameters or reduced injury incidence rates.

7.5 Directions for Future Research

Building on the integrated findings and addressing this thesis's methodological limitations, future research should shift from cross-sectional profiling to sustained, longitudinal evaluation across both player biology and coaching pedagogy. In the physical domain, there is a critical need for longitudinal tracking of athletic development programmes to measure the real-world effectiveness of youth interventions over multi-year periods, paired with nationwide data-sharing to establish robust, multi-county normative profiles. Additionally, establishing the fitness and locomotor profiles of senior inter-county players is warranted to provide youth coaches with clear, data-driven targets for pathway transitions.

Furthermore, the introduction of new playing rules across Gaelic games requires ongoing re-evaluation of the demands of match play. Rule modifications, whether affecting physical contact,

transition speeds, or tactical restarts, inherently alter the sport's flow and intensity. Future research should utilise GPS and micro-sensor technology to quantify the effects of these playing rule changes on high-speed running volumes, acceleration/deceleration profiles, and overall player load. Establishing these updated physical benchmarks will be crucial to ensure that athletic development curricula remain contextually accurate and to safely prepare players for the evolving physiological demands of competition.

Within the coaching domain, future investigations should bridge the intention-behaviour gap by employing in-depth qualitative field observations to objectively assess how coaches deploy athletic development principles during live, contextualised training sessions. Ultimately, future studies evaluating NGB educational interventions should move beyond measuring coach satisfaction and confidence to empirically determining whether these educational frameworks directly translate into reduced injury incidence and improved physiological outcomes for the youth athletes they serve.

7.6 Conclusion

This thesis establishes a multidimensional framework linking the biological realities of the adolescent female athlete to the structural realities of the youth inter-county Gaelic games pathway. The findings reveal a critical disconnect in which young female players face escalating match demands, yet their physical development frequently stagnates during mid-to-late adolescence. This plateau is not an inevitable biological ceiling but is instead driven by a historical absence of structured athletic development. While targeted coach education significantly enhances instructional confidence, translating this into pitch practice remains highly vulnerable to broader systemic pressures, such as a lack of pathway coherence and results-driven tournament structures.

Addressing these physical plateaus and supporting player longevity requires a fundamental shift from individual coach responsibility to coordinated system alignment. Rectifying this reality requires governing bodies and county boards to collectively restructure the youth pathway to prioritise long-term talent development over immediate competitive outcomes. By embedding collaborative communities of practice across the network and equipping coaches with practical, adaptable tools for physical preparation, the system can effectively bridge the gap between educational intent and pitch-level reality. Ultimately, this approach cultivates a sustainable environment that protects youth players' well-being while maximising their potential to transition successfully into elite senior athletes.

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Appendices

Appendix A:

Ethical Approval

Ollscoil Chathair Bhaile Átha Cliath
Dublin City University

DCU

Dr Stephen Behan
School of Health and Human Performance

19th July 2022

REC Reference: **DCUREC/2022/122**

Proposal Title: **Effect of maturation on the fitness profile and game demands of inter-county Ladies Gaelic Football**

Applicant(s): **Dr Stephen Behan, Dr Sarahjane Belton, Teresa Molohan**

Dear Colleagues,

Thank you for your application to DCU Research Ethics Committee (REC). Further to expedited review, DCU REC is pleased to issue approval for this research proposal.

DCU REC's consideration of all ethics applications is dependent upon the information supplied by the researcher. This information is expected to be truthful and accurate. Researchers are responsible for ensuring that their research is carried out in accordance with the information provided in their ethics application.

Materials used to recruit participants should note that ethical approval for this project has been obtained from the Dublin City University Research Ethics Committee. Should substantial modifications to the research protocol be required at a later stage, a further amendment submission should be made to the REC.

Yours sincerely,

Dr. Melrona Kirrane

Dr. Melrona Kirrane
Chairperson
DCU Research Ethics Committee

DCU
Research & Innovation

Taighde & Nuálaíocht Tacaíocht
Ollscoil Chathair Bhaile Átha Cliath,
Baile Átha Cliath, Éire

Research & Innovation Support
Dublin City University,
Dublin 9, Ireland

T +353 1 700 8000
F +353 1 700 8002
E research@dcu.ie
www.dcu.ie

Appendix B

Chapters 3 & 4: Parents/Players Information Sheet

Dublin City University

Information Sheet-Plain Language Statement

Title of Study: 'The effect of maturation on the fitness profile and game demands of inter-county Ladies Gaelic football'

Investigators: Teresa Molohan, Dr. Stephen Behan & Dr. Sarahjane Belton,

University: School of Health & Human Performance, Dublin City University

Contact: teresa.molohan2@mail.dcu.ie

Ladies Gaelic Football is the largest participation sport for females in Ireland with over 200,000 registered members and a growing profile. As participation and viewership has risen, so too has the standard of play. Players are faster, fitter, stronger, more mobile, and more skilful than ever before and standards have been noticeably higher year on year. A young player progressing to a senior inter-county team now faces a huge increase in training load and intensity. Developing a good physical foundation at underage level can help them to cope with the increased training load, with injury prevention, and to achieve their full potential as footballers.

Despite the growing popularity of female sports, there is a lack of evidence-based research to assist coaches in team preparation. Data collected across all age groups and levels of competition is typically about male experiences. Due to the limited availability of data, it is common to make comparisons to the men's game in all sports. However, post-puberty there are significant differences in almost all aspects of physical performance when comparing males with females, with males making greater gains in most physical attributes. Given the known biological differences between males and females, it cannot be assumed that research on males can be directly applied to females. Assessing female player capabilities e.g., speed thresholds, strength norms etc., using male data will likely underestimate female players' performance given the greater physical stature and

physiological capacity of male players. Therefore, there is a need to start with descriptive research to understand the current level of performance within female sport and establish normative data. Greater knowledge of female game demands could reduce reliance on male data and better inform training and practice for these athletes.

Currently, there is a dearth of information related to the match-play demands of Ladies Gaelic football at senior level, with even less available for youth level. To help us design appropriate training programmes at this time, we must rely on other similar field games and/or male data. There is currently no published data on the fitness profile or game-demands of adolescent female players in inter-county Ladies Gaelic football. This leaves coaches to currently rely on personal experience and anecdotal reports when planning player preparation programmes. The role of a youth coach is to progress players appropriately through the player pathway and to prepare them for the demands of adult football. Given the increasing demands of Ladies Gaelic football at senior level, substantial emphasis should be placed towards developing physical attributes that contribute to improved performance.

What is the project about?

The research aims to

Determine the differences in physical performance characteristics (strength, speed, power, endurance etc) between U14, U16 and U18 inter-county LGFA players.

Establish the game demands at U14, U16 and U18 level across playing positions: no. of sprints, sprint distance, max speed, no. of accelerations & decelerations, distance/min, high metabolic load distance, total distance, HR max and HR average.

Design and implement a viable long-term athletic development pathway that is appropriate to the needs of the players and helps prepare them physically for the demands of senior inter-county or club football.

What will players have to do?

Players will be asked to participate in physical performance assessment sessions 2-3 times per season and wear GPS units and heart rate monitors during games.

What are the risks?

The risks are no greater than what would be expected from a normal exercise or training session. The wearing of GPS units and heart rate monitors does not increase the risk of injury in games.

Some fatigue and/or muscle soreness may occur as a result of the physical performance assessment sessions.

What are the benefits?

The information gathered will be made available to team managers/coaches to better inform training practices

Who else is taking part?

Players from the Dublin underage panels

What if I do not want to take part?

You may withdraw from the study at any time by approaching the investigator and informing them of your withdrawal. You do not have to give reasons for your withdrawal. Withdrawing consent means that no future data collection will take place but previously collected data will still be processed.

What happens to the information? Personal Data/GDPR Compliance:

The information will be stored safely, securely, and confidentially on a password protected computer in line with GDPR regulations. The principal investigator is the data controller. Personal data collected for this study will include name, date of birth, height, weight, fitness assessment results and game data results. This data will be used for the research purposes outlined in this document and will only be shared with named researchers working on the study. Information that can be used to identify individuals will not be released to anyone outside the study. Confidentiality will be ensured by assigning each participant an ID number which will allow identification by the investigators. All identifying data will be retained for 12 months following the completion of the study and then be destroyed by the principal investigator. Anonymous data will be retained in the case it is required for publication. Names will not be used in any of the research reports. Confidentiality of information provided can only be protected within the limitations of the law. It is possible for data to be subject to subpoena, freedom of information claim or mandated reporting by some profession. Individuals have the right to access their own information at any time by contacting Teresa Molohan at the email address above.

If you have any queries, you may contact the DCU Data Protection Officer, Mr Martin Ward (data.protection@dcu.ie; Ph: 7005118 / 7008257).

What happens at the end of the study?

At the end of the study the information will be used to present results, but the information will be completely anonymised.

What if I have more questions or do not understand something?

If you do not understand any aspect of this study, please contact me at teresa.molohan2@mail.dcu.ie and discuss any questions that you might have.

If participants have concerns about this study and wish to contact an independent person, please contact:

The Secretary, Dublin City University Research Ethics Committee, c/o Research and Innovation Support, Dublin City University, Dublin 9. Tel 01-7008000, e-mail rec@dcu.ie

Appendix C

Chapters 3 & 4: Informed Consent

Dublin City University Informed Consent Form

Title of Study: *The effect of maturation on the fitness profile and game demands of inter-county Ladies Gaelic football.*

Investigators: Teresa Molohan, Dr. Stephen Behan & Dr. Sarahjane Belton

University: School of Health & Human Performance, Dublin City University

Contact: teresa.molohan2@mail.dcu.ie

Purpose of the Research

Despite the growing popularity of female sports, there is a lack of evidence-based research to assist coaches in team preparation. To help us design appropriate training programmes at this time, we must rely on other similar field games and/or male data. There is currently no published data on the fitness profile or game-demands of adolescent female players in inter-county Ladies Gaelic football. This leaves coaches relying on personal experience and anecdotal reports when planning player preparation programmes. Greater knowledge of female game demands could reduce reliance on male data and better inform training and practice for these athletes.

The research aims to:

Determine the differences in physical performance characteristics (strength, speed, power, endurance, etc.) between U14, U16 and U18 inter-county LGFA players.

Establish the game demands at U14, U16 and U18 levels across playing positions: number of sprints, sprint distance, max speed, number of accelerations and decelerations, distance/min, high metabolic load distance, total distance, HR max and HR average.

Design and implement a viable long-term athletic development pathway that is appropriate to the needs of the players and helps prepare them physically for the demands of senior inter-county or club football.

Confirmation of particular requirements as highlighted in the Plain Language Statement

My daughter will be asked to participate in physical performance assessment sessions 2-3 times per year and wear GPS units and heart rate monitors during games.

Participant – please complete the following (Circle Yes or No for each question)

I have read the Plain Language Statement (or had it read to me)	Yes/No
I understand the information provided	Yes/No
I have had an opportunity to ask questions and discuss this study	Yes/No
I have received satisfactory answers to all my questions	Yes/No

Confirmation that involvement in the Research Study is voluntary

I understand that involvement within this research project is purely voluntary. Should I wish to withdraw my daughter from the study at any stage throughout, I am entitled to do so. No penalty will be imposed if she wishes to withdraw from the research study before all stages are completed.

Confirmation of arrangements to be made to protect the confidentiality of data, including that confidentiality of information provided is subject to legal limitations

I understand that confidentiality is an important issue during data collection. My daughter's identity or other personal information will not be revealed or published. She will be assigned an ID number under which all personal information will be stored in a secure file and saved in a password-protected laptop backed up to the DCU Google drive. The investigators alone will have access to her data. However, I understand that the confidentiality of information provided can only be protected within the limitations of the law. I am aware that data may be subject to a subpoena, a freedom of information request, or mandated reporting by a profession.

Confirmation of arrangements regarding retention/disposal of data

I understand that identifying data (e.g. name, date of birth) will be destroyed 12 months following the completion of this study. I am aware that the principal investigator will shred hard copies of identifying data in a secure bin and delete all electronic identifying data.

Signature

I have read and understood the information in this form. My questions and concerns have been answered by the researchers, and I have a copy of this consent form. Therefore, I give consent for my daughter to take part in this research project

Participants Signature: _____

Name in Block Capitals: _____

Witness: _____

Date: _____

Assent by Minor

I understand what is involved in this project. It has been explained to me by the research team and by my parents. I agree to take part.

Name of Minor in Block Letters: _____

Witness: _____

Signed: _____

Date: _____

Appendix D

Chapter 5: Coach Information Sheet

LGFA LTAD Questionnaire *Required

Participant Information

Study Title: Physical Preparation in a Talent Development Environment: Exploration of Ladies Gaelic Football Coaches Knowledge, Practices, Perceptions and Challenges

Introduction:

Over the past number of years, Ladies Gaelic Football has enjoyed increasing participation levels and a growing profile. Players are stronger, fitter, faster, more mobile, and more skilled than ever before, and standards continue to rise year on year. A young player progressing to a senior inter-county team now faces a large increase in training load and intensity compared to what they have experienced at under-age level.

However, the sporting landscape for LGFA players is substantially different from that of their male counterparts. Although inter-county players are on a 'talent development pathway', the facilitie, support structures, and financial resources available to them are quite different from the male equivalent. At under-age level, male players have access to qualified S&C staff at all age grades to facilitate their athletic development programme. Currently, female players do not enjoy most of these supports. Therefore, it falls to the football coach or manager to implement an appropriate athletic development programme to help prepare these players for both the demands of the game and the subsequent transition to adult football.

Further details are available here:

https://docs.google.com/document/d/1Y1FfbgRwFviXvAfSq3TuZp-c9f31R7R1tVeoCWbtBqk/edit?usp=sharing

What is this study about?

The study aims to investigate coaches' current knowledge and practices in implementing a programme of athletic development at U14, U16, and U18 inter-county levels. It also aims to explore coaches perceptions of the importance of athletic development and any challenges they may have in implementing such a programme.

Why have you been invited to take part?

You have been invited to take part as you are currently or recently coached or managed at inter-county level.

What will taking part involve?

Once you have read the information above, if you consent to take part, you will be asked to complete a short questionnaire, which will take 5–10 minutes to complete.

What are the risks?

There are no risks involved for coaches. Participation is completely voluntary.

What are the benefits?

The information gathered will be made available to managers and coaches to better inform training practices.

Who else is taking part?

Managers and coaches from the U14, U16 and U18 panels across the country

What happens to the information? Personal Data/GDPR Compliance

The information will be stored safely, securely, and confidentially on an encrypted DCU G-Drive, where dual password identification will be required to access the data file itself. The questionnaire is completely anonymous, and no names or personal data are required.

If you have any queries, you may contact the DCU Data Protection Officer, Mr Martin Ward (data.protection@dcu.ie; Ph: 7005118 / 7008257).

What happens at the end of the study?

At the end of the study, the information will be used to present results and may be used in a report or journal article developed as a result of the research, but the information will be completely anonymised.

What if I have more questions or do not understand something?

If you do not understand any aspect of this study, please contact me at teresa.molohan2@mail.dcu.ie and discuss any questions that you might have.

Appendix E

Chapter 5: LGFA Coaches Survey

Consent Form

I confirm that I have read and understood the statement above *

Yes ○

No ○

I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason *

Yes ○

No ○

I consent to take part in this survey *

Yes ○

No ○

Demographics

What is your current coaching role? *

Manager ○

Lead Coach ○

Coach ○

What age grade are you coaching? *

U14 ○

U16 ○

U18 ○

In what province do you coach? *

Munster ○

Leinster ○

Connacht ○

Ulster ○

Gender *

Male ○

Female ○

How many years of inter-county coaching experience do you have? *

1 year ○

2-3 years ○

3-5 years ○

5-10 years ○

>10 years ○

What level of NGB coach education do you have? Tick all that apply *

ICGG/ LGFA Fundamentals/GAA Foundation ☐

LGFA Level 1 ☐

LGFA Level 2 ☐

GAA Award 1 Youth/Adult ☐

GAA Award 2 Youth/Adult ☐

Other ☐

*Do you have any qualifications in a sports-related field e.g. Sports Science, Sports Management, S&C, Physio, Sports Psychology etc.? **

Yes ○

No ○

*If 'Yes', please describe **

*What is the highest level of education you have completed in a sport-related field above? **

Certificate/Higher Certificate ○

BA/BSc ○

MA/MSc ○

PhD/Prof Doc ○

*Do you have any professional strength and conditioning qualifications e.g. NSCA, ASCA, UKSCA, BASES etc **

Yes ○

No ○

*If 'Yes' to Q10 please describe **

Current Practices

How many field-based sessions do your team engage in per week? *

1 ○

2 ○

3 ○

4 ○

>4 ○

What is the typical duration of each session? *

60 min ○

75 min ○

90 min ○

120 min ○

How many gym-based sessions do your team engage in per week? *

0 ○

1 ○

2 ○

3 ○

Where do resistance/gym-based sessions fit into a typical weekly training schedule? *

Not done ○

Stand-alone session ○

Pre-football training ○

Post-football training ○

Non-football training days ○

What is the typical duration of each session? *

- 0-30 minutes
- 30-45 minutes
- 45-60 minutes
- > 60 minutes

Who is primarily responsible for developing physical qualities in your team? *

- Manager
- S&C coach
- Football coach
- Other

How many weeks in duration is the pre-season phase? *

- 0-2 weeks
- 3-4 weeks
- 5-6 weeks
- >6 weeks

Do you conduct physical performance testing of your players? *

- Yes
- No

If you selected 'No' to Q21, please describe why physical performance tests are not performed. *

How many times per year do you conduct testing? *

What aspects of physical performance are tested? Tick all that apply *

- [ ] Aerobic capacity (fitness)
- [ ] Change of Direction
- [ ] Mobility/Flexibility
- [ ] Power/Plyometrics
- [ ] Speed
- [ ] Strength
- [ ] Other

Describe the tests used to assess the physical aspects listed in Q24 e.g. Jump tests, 1 Rep Max, Pro-Agility test, Bronco test, YoYoIR1 etc *

Recovery & Monitoring

Do you implement recovery sessions into your training programme? *

- ○ Yes
- ○ No

Where do recovery sessions fit into a typical weekly training schedule? *

Pre-training ☐

Post- training ☐

Non-training days ☐

Do you monitor athlete wellness? *

Yes ○

No ○

What methods do you use? *

How often is athlete wellness monitored? *

Daily ○

Every session ○

Weekly ○

Do you monitor training and match loads? *

Yes ○

No ○

What methods do you use? (e.g. session RPE, GPS data etc) *

Select all sports science technologies used to assist with physical preparation decision-making *

- [ ] None
- [ ] GPS technology
- [ ] Heart rate monitoring systems
- [ ] Hydration status assessment tools
- [ ] Jump mats
- [ ] Timing gates
- [ ] Velocity-based training systems
- [ ] Other

Coaches' perspectives on the importance of athletic development

Do you believe that aerobic and anaerobic capacity training benefits football performance? *

- ○ Yes
- ○ No
- ○ Not sure

Please explain your answer *

Do you implement aerobic and anaerobic capacity training into your programme? (running without the ball) *

- ○ Yes
- ○ No

Where does aerobic and anaerobic training fit into a typical training schedule? *

Stand-alone session ☐

Pre-field session e.g. before football elements ☐

Integrated within field session e.g. short blocks between football elements ☐

Post-field session ☐

Do you believe that mobility/flexibility training benefits football performance? *

Yes ○

No ○

Not sure ○

Please explain your answer *

Do you implement mobility/flexibility training into your programme? *

Yes ○

No ○

Where does mobility/flexibility fit into a typical training schedule? *

Stand-alone session ☐

Pre-field session, e.g. as part of warm-up ☐

Integrated within field session e.g. short blocks between football elements ☐

Post-field session ☐

Do you believe that speed and agility training benefits football performance? *

Yes ○

No ○

Not sure ○

Please explain your answer *

Do you implement speed and agility training into your programme? *

Yes ○

No ○

Where does speed & agility fit into a typical training schedule? *

Stand-alone session ☐

Pre-field session, e.g. as part of warm-up ☐

Integrated within field session e.g. short blocks between football elements ☐

Post-field session ☐

Do you believe that strength and power/plyometric training benefits football performance? *

Yes ○

No ○

Not sure ○

Please explain your answer *

Do you implement strength & power/plyometric training into your programme? *

Yes ○

No ○

Where does strength & power/plyometrics fit into a typical training schedule? *

Stand-alone session ☐

Pre-field session ☐

Integrated within field session e.g. short blocks between football elements ☐

Post-field session ☐

How important is athletic development for reducing the likelihood of injuries? *

Extremely important ○

Somewhat important ○

Neutral ○

Slightly important ○

Not important ○

Please explain your answer *

How important is athletic development for injury rehab/return to play? *

- ○ Extremely important
- ○ Somewhat important
- ○ Neutral
- ○ Slightly important
- ○ Not important

Please explain your answer *

What are the biggest challenges you face when implementing athletic development at inter-county level ? *

- ☐ Limited training time
- ☐ Resources e.g. technology, access to facilities
- ☐ Lack of coach knowledge around athletic development
- ☐ Availability of qualified athletic development coaches
- ☐ Other

What would facilitate you implementing a programme of athletic development at inter-county level? *

- [ ] More training time
- [ ] More resources e.g. technology, access to facilities
- [ ] Coach education in athletic development
- [ ] Availability of qualified athletic development coaches
- [ ] Other

Appendix F

Chapter 5: Supplementary Material S2

Coaches' Sports-Related Academic Qualifications

Age Grade

U14

BSc Sport Science

Diploma in Sports Psychology

MSc Coaching Science in Sport;

BA - Sports Management and Coaching

Sports Science and S&C

PE Teacher

U16

Chartered Physiotherapist

MSc Sports Performance. BSc PE. IRFU S&C

Recreation and Leisure Management, Sports Massage

Physical Therapy

U18

Diploma in Sports Science.

MSc in Elite Sports Performance

S&C module completed

S&C module Connacht COE

Uefa

Youth S&C

Appendix G

Chapter 5: Supplementary Material S3

Recovery & Athlete Wellness Monitoring Practices (S3)

Frequency [n (%)]

Age Grade	**U14**	**U16**	**U18**
Recovery Sessions Implemented			
No	10 (47%)	7 (35%)	6 (30%)
Yes	9 (53%)	13 (65%)	14 (70%)
Typical Recovery Session Weekly Schedule			
Non-training days	2 (22%)	5 (38%)	8 (57%)
Pre-training	1 (11%)	2 (15%)	2 (14%)
Post-training	5 (56%)	4 (31%)	1 (7%)
Non-training days & pre-training	0 (0%)	1 (8%)	0 (0%)
Non-training days & post-training	1 (11%)	0 (0%)	2 (14%)
Pre-training & post-training	0 (0%)	1 (8%)	1 (7%)
Athlete Wellness Monitored			
No	8 (42%)	10 (50%)	7 (35%)
Yes	11 (58%)	10 (50%)	13 (65%)
Athlete Wellness Monitoring Frequency			
Daily	0 (0%)	0 (0%)	2 (15%)
Every session	5 (45%)	3 (30%)	5 (38%)
Weekly	6 (55%)	7 (70%)	6 (46%)
Methods Used			
Player Conversations	6 (40%)	6 (43%)	6 (38%)
Parent Conversations	4 (27%)	3 (21%)	1 (6%)
External Conversations e.g. FLO, Physio	1 (7%)	1 (7%)	1 (6%)
Schedule Check	1 (7%)	2 (14%)	0 (0%)
Direct Observation	2 (13%)	1 (7%)	3 (19%)
Wellness Questionnaires/Apps	1 (7%)	1 (7%)	5 (31%)
Training & Match Load Monitoring			
No	11 (58%)	8 (40%)	6 (30%)

Yes	8 (42%)	12 (60%)	14 (70%)
Methods Used			
Player Conversations	2 (22%)	5 (33%)	1 (7%)
Parent Conversations	1 (11%)	4 (27%)	0 (0%)
Checking Schedules	1 (11%)	1 (7%)	0 (0%)
GPS	0 (0%)	1 (7%)	3 (21%)
RPE	2 (22%)	2 (13%)	4 (29%)
Questionnaires	1 (11%)	0 (0%)	3 (21%)
Coach Session Data Collection	0 (0%)	1 (7%)	3 (21%)
Direct Observation	2 (22%)	1 (7%)	0 (0%)

* multiple methods used by some coaches

Appendix H

Chapter 5: Supplementary Material S4

Physical Performance Testing & Use of Technology

Frequency [n (%)] Age Grade	U14	U16	U18
Physical Performance Testing Conducted			
No	9 (47%)	9 (45%)	5 (25%)
Yes	10 (53%)	11 (55%)	15 (75%)
Reasons for not Performance Testing (n= 23)			
Too Young	3 (30%)	0 (0%)	0 (0%)
Not Needed	2 (20%)	2 (20%)	0 (0%)
Lack of Expertise	2 (20%)	4 (40%)	0 (0%)
Lack of County Board Support	0 (0%)	0 (0%)	3 (60%)
Lack of Time	1 (10%)	2 (20%)	1 (20%)
No interest from manager/lead coach	1 (10%)	0 (0%)	1 (20%)
Lack of resources	1 (10%)	2 (20%)	0 (0%)
*(>1 reason given by some coaches)			
Frequency of Testing			
1-2	4 (40%)	4 (36%)	6(40%)
2-3	3 (30%)	5 (45%)	5 (33%)
3-4	2 (20%)	2 (18%)	2 (13%)
>4	1 (10%)	0 (0%)	2 (13%)
Sports Science Technologies Used to Assist with Physical Preparation Decision Making			
None	16 (84%)	15 (75%)	9 (45%)
GPS Technology	1 (3%)	3 (13%)	6 (13%)
Heart rate monitoring systems	1 (3%)	0 (0%)	2 (4%)
Jump Mats	1 (3%)	1 (4%)	6 (13%)
Timing Gates	2 (6%)	2 (8%)	8 (17%)
Velocity Based Systems	0	0 (0%)	3 (6%)
Hydration Status Assessment Tools	0	0 (0%)	1 (2%)

* multiple methods used by some coaches

Appendix I

Chapter 5: Supplementary Material S5

Implementation & Scheduling of Fitness Components into Training

	Frequency [n (%)]		
Age Grade	**U14**	**U16**	**U18**
Implementation of aerobic and anaerobic training into training programme (running without the ball)			
Yes	16 (84%)	19 (95%)	19 (95%)
No	3 (16%)	1 (5%)	1 (5%)
Typical scheduling of aerobic and anaerobic training			
Pre-field session e.g. before football elements;	5 (26%)	9 (35%)	4 (16%)
Integrated within field session e.g. between football elements;	13 (68%)	15 (58%)	15 (60%)
Post-field session	1 (5%)	1 (4%)	4 (16%)
Stand Alone Session	0 (0%)	1 (4%)	2 (8%)
			*multiple responses by some coaches
Implementation of speed & agility training into training programme			
Yes	18 (95%)	18 (90%)	19 (95%)
No	1 (5%)	2 (10%)	1 (5%)
Typical scheduling of speed & agility training			
Pre-field session e.g. before football elements;	8 (38%)	11 (42%)	4 (16%)
Integrated within field session e.g. between football elements;	12 (57%)	13 (50%)	15 (60%)
Post-field session	0 (0%)	0 (0%)	4 (16%)
Stand Alone Session	1 (5%)	2 (8%)	2 (8%)
			*multiple responses by some coaches

Implementation of mobility & flexibility training into training programme			
Yes	15(79%)	16 (80%)	19 (95%)
No	4 (21%)	4 (20%)	1 (5%)
Typical scheduling of mobility & flexibility training			
Pre-field session e.g. before football elements;	8 (47%)	11 (39%)	12 (49%)
Integrated within field session e.g. between football elements;	8 (47%)	4 (14%)	9 (31%)
Post-field session	1 (6%)	3 (11%)	4 (14%)
Stand Alone Session	0 (0%)	6 (21%)	3 (10%)
Implementation of strength & power training into training programme			
Yes	9 (47%)	16 (80%)	17 (85%)
No	10 (53%)	4 (20%)	3 (15%)
Typical scheduling of strength & power training			
Pre-field session e.g. before football elements;	3 (33%)	8 (40%)	9 (41%)
Integrated within field session e.g.between football ele			
ments;	6 (67%)	8 (40%)	9 (41%)
Post-field session	0 (0%)	1 (5%)	1 (5%)
Stand Alone Session	0 (0%)	3 (15%)	3 (14%)

*multiple responses by some coaches

Appendix J

Chapter 6: Coaches Information Sheet

Coaches Information Sheet

Dublin City University

Information Sheet-Plain Language Statement

Title of Study: The Impact of the GAA F3 Youth Athletic Development Level 1 Course on Coach Knowledge and Perceived Competence: A Pre-Post Evaluation

Investigators: Teresa Molohan, Dr. Stephen Behan, Dr. David Nolan

University: School of Health & Human Performance, Dublin City University

Contact: teresa.molohan2@mail.dcu.ie

Introduction:

The development of young athletes within the GAA, LGFA and Camogie Association relies heavily on the guidance and expertise of their coaches. Coaches play a pivotal role in honing the sport-specific and athletic skills necessary for Gaelic games, but also in the overall well-being of their young players. Coaches are instrumental in determining the quality of the coaching provided, which in turn affects the outcomes for young athletes. Recognising this important influence, there is an increasing emphasis within youth sports on ensuring that coaches are equipped with the necessary skills and knowledge to create positive and developmental experiences that encourage long-term participation and development. To address this need, the three associations are actively working to upskill both current and new coaches by providing high-quality, accessible, and appropriate resources. The launch of the GAA F3 Youth Athletic Development Level 1 Course signifies a strategic initiative to meet the specific requirements of coaches working with adolescents within the Gaelic games framework.

The GAA F3 Youth Athletic Development Level 1 Course is specifically designed for coaches who are working with players in the F3/T1/T2 Youth phase, which encompasses athletes aged 13 to

17 years within the player pathway. This age group is a critical developmental stage characterised by significant variations in biological maturation. The course is intended for coaches looking to enhance their skills and knowledge and acquire the necessary competencies to provide high-quality, efficient, easy-to-access, and appropriate coaching. Therefore, the course is strategically targeted to equip coaches with specialised knowledge in athletic development that is directly relevant to the unique needs and challenges presented by adolescent GAA players.

To effectively evaluate the impact of the GAA F3 Youth Athletic Development Level 1 Course on coach learning and perceived competence, the utilisation of pre-post evaluation designs is of paramount importance. This approach involves administering surveys to participating coaches both before and after they complete the course to directly measure any changes in their knowledge, skills, and self-perceptions. Post-training assessments are valuable for gauging the overall effectiveness of the training programme and its practicality from the learners' perspectives. Prior to the training, pre-training assessments serve to identify the coaches' existing knowledge, skills, and abilities, providing a baseline against which post-course improvements can be measured.

What will coaches have to do?

You will be asked to complete a questionnaire before the start of the Level 1 course and another one after it is completed. These questionnaires will ask about your current knowledge and how confident you feel about different aspects of coaching young athletes in the area of Youth Athletic Development. You might also be asked to complete a short questionnaire a few months later.

What are the risks?

There are no risks involved to coaches. Participation is entirely voluntary.

What are the benefits?

By taking part, you will be helping the GAA to understand how well the Level 1 course is working and how it can be improved in the future. This could lead to better coaching resources and ultimately help young GAA players develop to their full potential.

Who else is taking part?

Other coaches who are taking the GAA F3 Youth Athletic Development Level 1 Course will also be invited to participate in this research.

What if I do not want to take part?

You may withdraw from the study at any time by approaching the investigator and informing them of your withdrawal. You do not have to give reasons for your withdrawal. Withdrawing consent means that no future data collection will take place, but previously collected data will still be processed.

What happens to the information? Personal Data/GDPR Compliance:

All participants will be asked to create their own unique identification (UID) number. This number will be generated by the participant by calculating the following;

● The second letter of the surname of a significant person (e.g., parent, significant other etc).

● The last three numbers of your mobile phone number

● The second letter of the significant person's first name

● The first number or letter of the first line of your home address

An example for a participant, who selected their mother, whose name is Mary Smith, phone number of 0864041651, and who lives in 16 Collins Avenue – they would generate their own UID of 'M651A1'

Each time a participant enters data or submits to testing, they will enter their UID. The research team will have no access to any personal data. If a participant wishes to review their own results from the study, they will have to contact a member of the research team for access to the anonymised dataset and view their own data corresponding to their UID.

All data will be collected using this UID and therefore, the research team will not be able to link any of the collected data to an individual.

All data will be stored on a secure, password-protected Google Drive.

Only the aforementioned supervisor and researchers will have access to this Google Drive.

Confidentiality of information provided can only be protected within the limitations of the law. It is possible for data to be subject to subpoena, a freedom of information claim, or mandated reporting by some profession. Individuals have the right to access their own information at any time by contacting Teresa Molohan at the email address above.

If you have any queries, you may contact the DCU Data Protection Officer, Mr Martin Ward (data.protection@dcu.ie; Ph: 7005118 / 7008257).

What happens at the end of the study?

At the end of the study, the information will be used to present results and may be used in a report or journal article developed as a result of the research, but the information will be completely anonymised.

What if I have more questions or do not understand something?

If you do not understand any aspect of this study, please contact me at teresa.molohan2@mail.dcu.ie and discuss any questions that you might have.

If participants have concerns about this study and wish to contact an independent person, please contact: The Secretary, Dublin City University Research Ethics Committee, c/o Research and Innovation Support, Dublin City University, Dublin 9. Tel 01-7008000, e-mail rec@dcu.ie

Appendix K

Chapter 6: Pre-Course Survey

Participant Information

* Required

Study Title: The Impact of the GAA F3 Youth Athletic Development Level 1 Course on Coach Knowledge and Perceived Competence: A Pre-Post Evaluation

Investigators: Teresa Molohan, Dr. Stephen Behan, Dr. David Nolan

School of Health & Human Performance, Dublin City University

Contact: teresa.molohan2@mail.dcu.ie

Introduction:

Thank you for participating in this evaluation of the GAA F3 Youth Athletic Development Level 1 Course. This evaluation aims to examine the course's impact on your learning and your perceived competence in coaching youth athletic development. As part of our efforts to improve coach education and support the development of Gaelic Games players, we would like to understand how this course advances your knowledge, confidence and skills in the area of youth athletic development. Your feedback is important for assessing the effectiveness of the current content and delivery, as well as identifying the course strengths and areas that might need improvement. This will ensure that the course meets the evolving needs of coaches working at the F3/T1/T2 level.

This evaluation involves the completion of two brief questionnaires:

A pre-course survey, which you are requested to complete now, will collect information regarding your existing knowledge, understanding, and confidence in the key topics addressed by the Level 1 course before beginning the program.

A post-course questionnaire, to be completed within 2 weeks of the conclusion of the course, will pose identical or similar questions. This will measure any changes in your knowledge, understanding, and confidence upon completing the programme. It will also provide an opportunity for you to give us your feedback on the course itself.

Further details are available here: https://docs.google.com/document/d/1_z1DAy-pDCmzVtjhyNM6bdt54DugDoyVc_rOeWH_Us4/edit?tab=t.0#heading=h.lww42z29x6rc

Consent to Participate

I have read the Participant Information Sheet (or had it read to me) and I understand the information provided. *

○ Yes

○ No

I have had an opportunity to ask questions and discuss the study, and I have received satisfactory answers to all my questions. *

○ Yes

○ No

I understand participation is voluntary and I may withdraw from the research study at any time during data collection, but once my responses have been submitted and anonymised, I will need to contact the principal investigator with my unique identification number to have my data removed *

○ Yes

○ No

I have read and understand the arrangements to be made to protect confidentiality of data, including that the confidentiality of information provided is subject to legal limitations. *

○ Yes

○ No

I understand the anonymous data will be retained for publication purposes. *

○ Yes

○ No

I understand that once all identifiable information has been removed, my responses may be shared with other researchers or made available in online data repositories. *

○ Yes

○ No

I consent to take part in this survey *

○ Yes

○ No

Unique Identification Number

You will be asked to create their own unique identification (UID) number. This number will be generated by calculating the following:

● The second letter of the surname of a significant person (e.g., parent, significant other etc).

● The last three numbers of your mobile phone number

● The second letter of the significant person's first name

● The first number or letter of the first line of your home address

For example, if you select your mother, whose name is Mary Smith, phone number of 0864041651, and who lives in 16 Collins Avenue – your UID is 'M651A1'. You will be asked to generate this UID on the pre- and post-evaluation survey. All data will be collected using this UID, and therefore, the research team will not be able to link any of the collected data to an individual.

Enter your UID below *

Demographics

Course Venue *

What county do you coach in? *

- Antrim
- Armagh
- Carlow
- Cavan
- Clare
- Cork
- Derry
- Donegal
- Dublin
- Down
- Fermanagh
- Galway
- Offaly
- Kerry
- Kildare
- Kilkenny
- Laois
- Leitrim
- Longford
- Louth
- Mayo
- Meath
- Monaghan
- Offaly
- Roscommon
- Sligo
- Tipperary
- Tyrone

- Waterford
- Westmeath
- Wexford
- Wicklow

Gender *

- Female
- Male
- Prefer not to say

Which code do you coach? Tick all that apply *

- Camogie
- Hurling
- Football
- Ladies Football

What age grade are you coaching? *

- F3 (Club 13-14 years)
- F3 (Club 15-16years)
- F3 (Club 17-19 years)
- T1 (Inter-County 13-14 years)
- T2 (Inter-County 15-16 years)
- T3 (Inter-County 17-19 years)

How many years of coaching experience do you have? *

- Less than 1 year
- 1-3 years
- 4-6 years
- 7-10 years
- More than 10 years

What level of NGB coach education do you have? Tick all that apply *

- ICGG/ LGFA Fundamentals/GAA Foundation
- GAA Award 1 Child
- GAA Award 2 Child
- GAA Award 1 Youth/Adult
- GAA Award 2 Youth/Adult

- ○ Camogie Level 1
- ○ Camogie Level 2
- ○ LGFA Level 1
- ○ LGFA Level 2

Do you have any professional strength and conditioning qualifications e.g. NSCA, ASCA, UKSCA, BASES etc * *

- ○ Yes
- ○ No

If 'Yes' to Q12 above, please describe. If 'no', state N/A *

Current Knowledge

Rate from 1 to 5 how confident you are currently in your knowledge of the following topics *

	1. Not at all confident	2. Somewhat confident	3. Moderately confident	4. Confident	5. Very confident
Warm Up	○	○	○	○	○
Force (Strength & Power Development)	○	○	○	○	○
Endurance	○	○	○	○	○
Gamespeed (Speed & Agility Development)	○	○	○	○	○
Understanding Growth & Maturation	○	○	○	○	○
Health Benefits, Retention & Participation	○	○	○	○	○
Planning	○	○	○	○	○

Please indicate how confident you are in your ability to coach athletic development. *

1	2	3	4	5

Not at all confident — Very confident

Course Expectations

Please select the option that best reflects your agreement with the following statements *

	1. Strongly Disagree	2. Disagree	3. Neutral	4. Agree	5. Strongly Agree
1. I have a clear understanding of the learning objectives of this course.	○	○	○	○	○
2. I believe the online content of this course will be relevant to my coaching/training needs.	○	○	○	○	○
3. I believe the practical content of this course will be relevant to my coaching/training needs.	○	○	○	○	○

What are your primary goals for taking this coaching course? *

What are your biggest challenges or areas where you seek improvement in your coaching practice? *

What specific topics are you most interested in exploring during the online modules? *

What specific skills or practical applications are you hoping to develop during the in-person session? *

Appendix L

Chapter 6: Post Course Survey

* Required

Participant Information

Study Title: The Impact of the GAA F3 Youth Athletic Development Level 1 Course on Coach Knowledge and Perceived Competence: A Pre-Post Evaluation

Investigators: Teresa Molohan, Dr. Stephen Behan, Dr. David Nolan

School of Health & Human Performance, Dublin City University

Contact: teresa.molohan2@mail.dcu.ie

Introduction:

Thank you for participating in this evaluation of the GAA F3 Youth Athletic Development Level 1 Course. This evaluation aims to examine the course's impact on your learning and your perceived competence in coaching youth athletic development. As part of our efforts to improve coach education and support the development of Gaelic Games players, we would like to understand how this course advances your knowledge, confidence and skills in the area of youth athletic development. Your feedback is important for assessing the effectiveness of the current content and delivery, as well as identifying the course strengths and areas that might need improvement. This will ensure that the course meets the evolving needs of coaches working at the F3/T1/T2 level.

This evaluation involves the completion of two brief questionnaires:

A pre-course survey, which you are requested to complete now, will collect information regarding your existing knowledge, understanding, and confidence in the key topics addressed by the Level 1 course before beginning the program.

A post-course questionnaire, to be completed within 2 weeks of the conclusion of the course, will pose identical or similar questions. This will measure any changes in your knowledge, understanding, and confidence upon completing the programme. It will also provide an opportunity for you to give us your feedback on the course itself.

Further details are available here: https://docs.google.com/document/d/1_z1DAy-pDCmzVtjhyNM6bdt54DugDoyVc_rOeWH_Us4/edit?tab=t.0#heading=h.lww42z29x6rc

Unique Identification Number

You will be asked to create their own unique identification (UID) number. This number will be generated by calculating the following:

- The second letter of the surname of a significant person (e.g., parent, significant other etc).
- The last three numbers of your mobile phone number
- The second letter of the significant person's first name
- The first number or letter of the first line of your home address

For example, if you select your mother, whose name is Mary Smith, phone number of 0864041651, and who lives in 16 Collins Avenue – your UID is 'M651A1'. You will be asked to generate this UID on the pre- and post-evaluation survey. All data will be collected using this UID, and therefore, the research team will not be able to link any of the collected data to an individual.

Enter your UID below *

Course Evaluation

Please rate your agreement with the statements below *

	1. Strongly Disagree	2. Disagree	3. Neutral	4. Agree	5. Strongly agree
The course satisfied my needs and expectations	○	○	○	○	○
The course fulfilled the objectives set out	○	○	○	○	○
The content was presented at a level that could readily be understood	○	○	○	○	○
There was opportunity for group work	○	○	○	○	○
There was opportunity for individual participation	○	○	○	○	○
The material presented had practical relevance	○	○	○	○	○
The practical session helped reinforce online learning	○	○	○	○	○
The teaching methods used helped me to learn effectively	○	○	○	○	○
The coach developers were knowledgeable of the subject (s)	○	○	○	○	○
There was opportunity for feedback and evaluation	○	○	○	○	○

How satisfied are you with the knowledge you gained from the course?

- ○ Very satisfied
- ○ Satisfied
- ○ Neither satisfied nor dissatisfied
- ○ Dissatisfied
- ○ Very dissatisfied

Rate from 1 to 5 how confident you are currently in your knowledge of the following topics

	1. Not at all confident	2. Somewhat confident	3. Moderately confident	4. Confident	5. Very confident
Warm Up	○	○	○	○	○
Force (Strength & Power Development)	○	○	○	○	○
Endurance	○	○	○	○	○
Gamespeed (Speed & Agility Development)	○	○	○	○	○
Understanding Growth & Maturation	○	○	○	○	○
Health Benefits, Retention & Particiaption	○	○	○	○	○
Planning	○	○	○	○	○

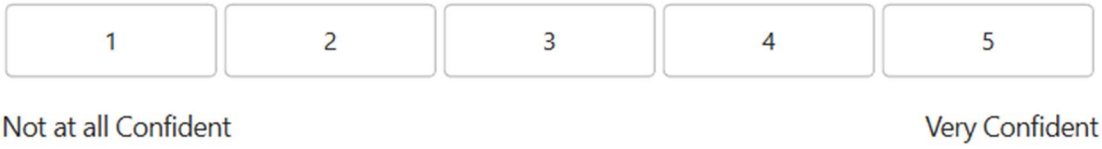
I feel better equipped to design effective training sessions incorporating athletic development



What specific skills or knowledge gained from this course do you feel will be most beneficial in your coaching? *

What specific changes in your coaching practice do you foresee as a result of this course? *

Please indicate how confident you are in your ability to coach athletic development following this course *



Do you have any other comments or suggestions for improving this course?

How likely are you to recommend this course to other coaches?



How would you rate the overall quality of the course? *

1	2	3	4	5

Poor Excellent

Appendix M

Chapter 6 Supplementary Material S1

Participant Demographics, Experience and Qualifications (*n* = 150)

Characteristic	***n***	***%***
Province (Counties)		
Munster (Cork, Kerry, Waterford)	34	22.6
Leinster (Carlow, Dublin, Kildare, Laois, Longford, Louth, Meath, Wexford)	53	35.3
Connacht (Galway)	1	0.7
Ulster (Antrim, Armagh, Cavan, Donegal, Down, Fermanagh, Monaghan, Tyrone)	62	41.3
Gender		
Male	120	80
Female	28	18.7
Prefer not to say / Other	2	1.3
Coaching Experience		
≤ 3 years	39	26
4-6 years	45	30
≥ 7 years	66	44
Highest Coaching Qualification		
Tier 1: Introduction to Coaching Gaelic Games (ICGG)	44	29.3
Tier 2: Award 1/Level1	81	54
Tier 3: Award 2/Level 2	25	16.7
Professional S&C Qualifications (ASCA, NSCA, UKSCA, BASES, etc)		
Yes	17	11.3
No	133	88.7
Primary Coaching Code(s)		
Single-Code Coaches	57	38
- Gaelic Football Only	51	34
- Hurling Only	3	2

Characteristic	*n*	*%*
- LGFA Only	0	0
- Camogie Only	3	2
Dual-Code Coaches	69	46
- Football & LGFA	43	28.7
- Football & Hurling	22	14.7
- Hurling & Camogie	4	2.7
Triple-Code Coaches	13	8.7
- Football, LGFA, & Camogie	8	5.3
- Football, Hurling, & LGFA	3	2
- Football, Hurling, & Camogie	2	1.3
All Codes		
- All Four Codes	11	7.3
Number of Age Grades Coached		
- One age grade	101	67.3
- Two age grades	35	23.3
- Three age grades	14	9.3
Age Grade Involvement*		
- 13-14 years	106	70.7
- 15-16 years	66	44
- 17-18 years	41	27.3

**Note: Age grade involvement will not sum to 100% as participants could select multiple responses.*

Appendix N

Chapter 6 Supplementary Material S2:

Course Satisfaction and Likelihood to Recommend (*n* = 150)

Course Evaluation Metric	n	%
Overall Quality Rating (1-5 Scale)		
5 (Highest Quality)	110	73.3
4	39	26.0
3	1	0.7
2	0	0.0
1 (Lowest Quality)	0	0.0
Likelihood to Recommend (1-10 Scale)		
10 (Extremely Likely)	95	63.3
9	23	15.3
8	26	17.3
7	5	3.3
1-6 (Neutral to Unlikely)	1	0.7

Appendix O

Chapter 6 Supplementary Material S3

Table S3 Descriptive Statistics for Specific Course Evaluation Criteria (*n* = 150)

Evaluation Criterion	Mean	SD	Positive Rating (%) *
Instructional Delivery & Support			
Coach Developers were knowledgeable	4.84	0.54	98.7
Opportunities for group work	4.79	0.57	98.7
Opportunities for feedback and evaluation	4.75	0.59	98.7
Teaching methods were adequate	4.67	0.63	98.0
Opportunities for individual participation	4.57	0.68	96.0
Course Design & Relevance			
Practical relevance of the course	4.70	0.62	98.0
Course was easily understood	4.69	0.68	94.7
Practical sessions reinforced online learning	4.68	0.64	97.3
Course fulfilled learning objectives	4.55	0.65	98.0
General course satisfaction	4.53	0.65	98.0
Relevance of practical content	4.43	0.54	98.0
Relevance of online content	4.29	0.59	93.3
Understanding of learning objectives	4.12	0.59	91.3

**Note: 'Positive Rating (%)' represents the combined percentage of participants who scored the item as a 4 or 5 on the 5-point Likert scale.*