PHYSICAL CHARACTERISTICS OF YOUTH FEMALE FOOTBALL TRAINING

T.G. Adams

A thesis submitted for the degree of Master of Science (by Dissertation) in Sport and Exercise Science

Department of Sport, Rehabilitation & Exercise Sciences

University of Essex

August 2025

Abstract

The aim of this thesis was to quantify the physical training characteristics of U10, U12, U14 and U16 youth female footballers, and compare within and between age groups and drill-types. Firstly, a systematic scoping review of the scientific literature involving youth female football players was conducted, to collate and summarise the aims, methodological approaches and findings of research across eight topics of sports science and medicine (biomechanics, fatigue and recovery, injury, match-play, nutrition, physical qualities, psychology and training load). Studies focused on physical qualities and injury topics, whilst training load was the least investigated, identifying it as a key area for future research. Therefore, the physical training characteristics of 116 youth female footballers representing two of The Football Association's (The FA) Emerging Talent Centres (ETCs) across U10, U12, U14 and U16 age groups were quantified over 80 training sessions using global positioning system (GPS) units.

External load generally increased across age-groups for overall sessions, drill-specific results determined that small-sided games (SSGs) resulted in greater physical outputs regarding total distance (TD) (moderate-very large ESs; 0.93 - 2.42), high-speed running (HSR) (moderate-large ESs; 1.17 - 1.67), maximum velocity (moderate-large ESs; 0.85 - 1.62) and decelerations (small-moderate ESs; 0.24 - 0.62) than possession and technical drills for all age-groups. Between age-group results revealed that older age-groups (U14 and U16) demonstrated greater external load across all drills in comparison to U10s and U12s (small-very large ESs; 0.33 - 2.82), except for U10s who performed more decelerations during possession and SSGs compared to U12s and U14s (small-moderate ESs; 0.54 - 0.69).

To conclude, this thesis presents novel information regarding the current physical training characteristics of youth female footballers which can serve as an evidence-base for practitioners working within ETCs to draw from. Furthermore, this thesis

discusses practical implications of the data and potential recommendations for stakeholders within female football in England, and the potential directions for future research within youth female football.

Acknowledgments

First, I would like to say thank you to my incredible supervisory team, Dr Alice Harkness-Armstrong, Dr Sally Waterworth, Tracy Lewis, Dr Naomi Datson, Dr Ruth Lowry and Dr Carla Harkness-Armstrong. Thank you, firstly for providing me with the opportunity to take on this amazing project but also for your support and guidance throughout this 2-year journey! Carla, thank you for being my bonus supervisor, providing the much-needed guidance on the biomechanics section of my review which I am hopeless at, and covering many miles to help me with data collection! Ruth, thank you for putting in the groundwork in helping to set up this project, without you this opportunity would not have been possible! To Naomi, Tracy and Sally, thank you all for your kindness and support every step of the way, and always pushing me to do better! Alice, thank you for always being encouraging and guiding me as I've grown as a researcher over the last 2 years. It's been a whirlwind, but I will always look back on this time fondly and will forever appreciate the many hours you spent accompanying me to London and Norwich for data collection!

I'd also like to give a special thank you to my football club, The FA Cup and Community Shield winners this year – Crystal Palace! Who gave me a morale boost when I needed it most. Now to time for the European tour!

To my girlfriend Hollie, thank you for being my emotional support throughout this 2-year journey, and for putting up with me when things got tough, I couldn't have got through this without you. To my Dad and brothers, Fred and Manny, I'll be forever thankful for your unwavering support, not just with this project, but in the many years leading up to it and onwards. Finally, to my Mum, you'll forever be my motivation, and I know you were cheering me on all the way like you used to do. This is for you.

Contents

Publications and Conference Presentations

Published Works

1. Adams T, Waterworth S, Lewis T, Datson N, Harkness-Armstrong C, Lowry R, Freeman P, Harkness-Armstrong A. The performance, health and development of youth women's footballers: A systematic scoping review. *Int J Sports Sci Coach*. 2025 Dec 12:17479541251411068.

2. Harkness-Armstrong, A., Adams, T., Lewis, T., Waterworth, S., Lowry, R., & Datson, N. Session and drill-specific physical characteristics of youth women's football training. Under review. *J Sports Sci.*

Conference Presentations

1. Adams, T., Waterworth, S., Lowry, R., Lewis, T., Datson, N., & Harkness-Armstrong, A. Physical characteristics of youth female football players during training. Poster session presented at: 14th World Congress of Performance Analysis of Sport; 2024 August 27-30; London, UK.

List of Figures

(SSG) and technical drills between U10, U12, U14 and U16 youth female footballers.

List of Tables

List of Frequently Used Abbreviations

CoD	Change of Direction
ETC	Emerging Talent Centre
ES	Effect Size
FIFA	Fédération Internationale de Football Association
GPS	Global positioning system
HSR	High-speed running
Hz	Hertz
IMU	Inertial Measurement Unit
kg	Kilograms
m	Meters
min	Minutes
$m \cdot s^{-1}$	Meters per second
$m \cdot min^{-1}$	Meters per minute
Pos	Possession
RAE	Relative Age Effect
RTC	Regional Talent Club
SE	Standard error
SPR	Sprinting
SSG	Small Sided Game
TD	Total distance
Tech	Technical
The FA	The Football Association
U	under

UEFA	Union of European Football Associations
VHSR	Very high-speed running
Vmax	Maximum velocity
WC	Women's Championship
WSL	Women's Super League
WSLA	Women's Super League Academy
yrs	Years

Chapter 1: General Introduction

1.1 The Female Football Talent Pathway Structure

The national governing body of football within England is The Football Association (The FA), who are responsible for setting and enforcing rules and regulations (e.g. anti-doping, policies, safeguarding standards, player registration), development and participation (e.g. running national programs, coach education), national teams and competitions (e.g. England men and women's as well as youth national teams, The FA Cup and Community Shield competitions) and inclusion and safeguarding (e.g. promoting equality and diversity in football, ensuring safeguarding compliance) (1,2). The FA is also responsible for The Women's Talent Pathway (Figure 1.1), which aims to create inclusive and accessible opportunities for 'every girl with talent and potential', with the ultimate goal of representing England's senior women's team, the Lionesses.

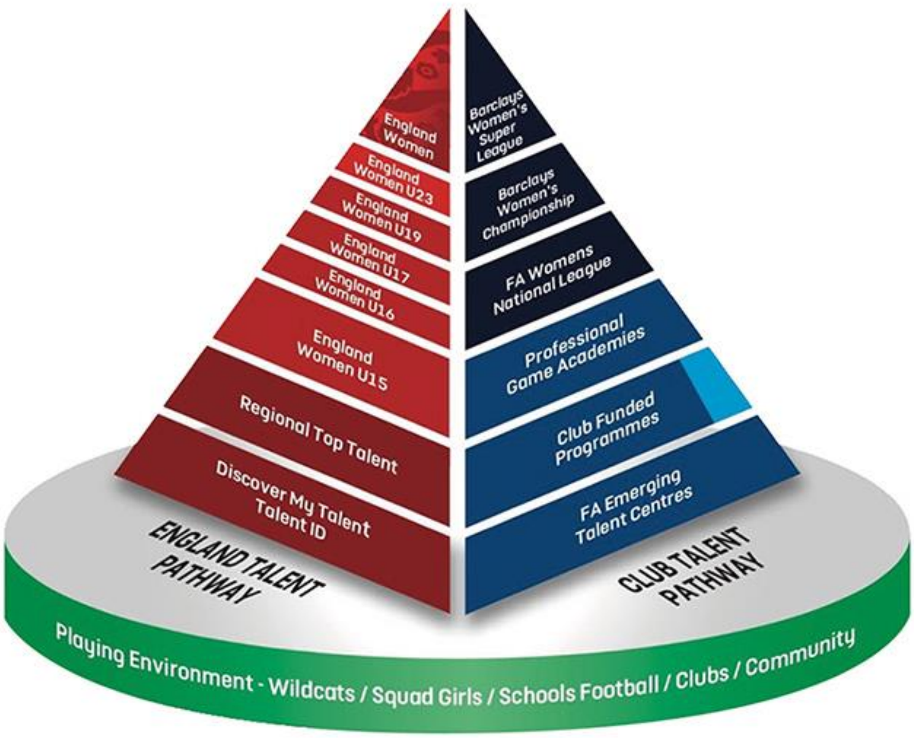

Figure 1.1 The Women's Talent Pathway Structure (3).

There are many ways in which youth female footballers can join the talent pathway, including via referral from a coach or teacher to the ‘Discover My Talent’ programme which aims to identify talented individuals for further involvement in the talent pathway (4). If successful, players will then proceed to join one of the 73 Emerging Talent Centres (ETCs) across England. Following a £5.25m investment from The Premier League, ETCs were established in 2022, replacing Regional Talent Clubs (RTCs) which previously were responsible for the delivery of youth female talent development (5,6). The goal of ETCs is to identify and develop future talent by providing local, high-quality training facilities. These settings offer more playing time, varied game formats, and the opportunity to play for grassroots clubs, schools, and representative teams alongside the ETC. (7). Players aged 8 to 16 years (yrs) are eligible to register for an ETC, to train within U10, U12, U14 and U16 age groups. ETCs operate for a minimum of 30-weeks per season, deliver a minimum of one session per-week and 1.5 hours of training per session, each session must include age-appropriate strength and conditioning or physical literacy. In addition to this, ETCs provide a minimum of one game every 6-weeks and exposure to a variety of formats, such as full-sided and small-sided football, and futsal. In terms of facilities, ETCs aim to provide players with access to a good quality all-weather playing surface (e.g. 3G pitch), dedicated goalkeeper training, suitable games programme facilities (e.g. futsal courts) and strength and conditioning equipment (e.g. resistance bands, foam rollers, TheraBands, Trigger balls etc.) (7). Further to this, ETCs provide high quality coaching, including; centre group coaches (level 2 UEFA C or above coaching qualification), a dedicated goalkeeper coach (FA level 2 goalkeeper or The FA National Goalkeeping Course or above coaching qualification) and a strength and conditioning coach (7).

A key exit route for players leaving ETCs, is progression into the next step of the Club Talent Pathway, and selection into a Pro Game Academy. Pro Game Academies consist of teams within the Women’s Super League (WSL) and Women’s Championship (WC), and offer professional standard coaching to players aged 14 to 20, with the goal of supporting players in reaching their potential within a high performing professional club environment and culture (8). Ultimately players within Pro Game Academies aim to progress into their respective senior teams, and to play professionally within one of these WSL or WC football clubs within the 1st and 2nd division professional leagues respectively.

Lastly, alongside the Club Talent Pathway is the England Talent Pathway, where eligible youth players with the highest potential aged 13 to 16 yrs, are invited to attend the Regional Top Talent Program which supports the transition of youth players from regional programmes into England youth teams. Players may enter the England Talent Pathway throughout, including at younger (e.g., U15, U16) or older (e.g., U19, U23) youth age groups, and therefore players aim to transition or progress into the later age groups and ultimately, into the senior national team (3).

1.2 Importance of Quantifying Training Characteristics

The role of training within football is multifaceted, covering physical, technical, tactical and psychological elements of performance, with not only the purpose of preparing for competition but also developing talent through skill acquisition. Within youth football, the intention of training changes depending on age group; early stages prioritise development over performance, focusing on developing fundamental movement skills and basic game understanding (9). As players progress, training aims to develop game-specific technical skills and tactical understanding, whilst environments are more reflective of game intensity as the focus of training shifts to preparing for competitive play. To achieve these objectives, a variety of training types may be utilised, such as field-based training (i.e., football-specific training), strength and conditioning (e.g. gym-based resistance training, plyometrics), rehabilitation (e.g. mobility work, neuromuscular control drills) and cognitive training (e.g. confidence building tasks, decision making drills) (10).

Field-based training is the primary context in which players competing at any stage or level will partake in, and is essential to acquiring and developing physical, technical and tactical skills in football. These sessions may be designed to include a variety of formats such as small-sided games (SSGs; e.g. 5v5), tactical drills, (e.g. full pitch positional scenarios, patterns of play), technical drills (e.g. isolated dribbling, passing and shooting) and possession-based drills (e.g. 5v2 keep-ball). Field-based training simulates match-play elements in isolation (e.g. technical, tactical and possession-based drills), under specific rules (e.g. SSGs) or directly (e.g. full-size pitch and team matches), to create representative training environments (i.e. reflective of perceptual-cognitive and movement demands) (11). Within the youth female talent pathway, training design primarily utilises field-based training in the deliverance of practices which are aligned to the long-term athlete development model (LTAD) (7). The LTAD is a framework which guides athlete’s progression through developmental stages, starting from early stages aiming to build fundamental skills and movements, to optimising competitive performance (9).

Training should consider the development of physical, technical, tactical, and psychosocial characteristics, and as such, training sessions often incorporate isolated, multiple or all elements depending on the context (e.g., age-stage of players, session aims) (12). Physical elements of training refer to the physiological demands placed on the body, which include speed, endurance, agility, power, strength and recovery (13,14) and can be quantified as external (i.e. the work performed by the player) or internal load (i.e. the psychophysiological response from the work performed). Technical skills refer to on the ball performance mechanics which include, dribbling, shooting and passing, but also more specific actions such as tackling, crossing, heading, set-pieces and throw-ins (15,16). Tactical skills refer to a player's ability to make decisions based on opponent behaviours, situational dependencies and strategic approaches, and to select the appropriate action during gameplay (17). Finally, psychosocial skills refer to both psychological (e.g. confidence, resilience, motivation and emotional control) and social (e.g. communication, teamwork and leadership) characteristics, which influence a player's performance, development and interactions within a team (18). Furthermore, The FA's Four Corner Model is a framework set up to support the holistic development of players by highlighting to coaches the importance of taking physical, technical, tactical and psychosocial characteristics into consideration when delivering training practices (19).

The complexities of match demands of football require training to involve a variety of different movements at varying speeds with frequent changes of direction (CoD), whilst covering technical (passing, dribbling shooting etc.), tactical (positioning, game understanding, decision making etc.) and psychosocial (team building and communication activities) elements of the sport (20). Therefore, research quantifying training characteristics can provide an important resource for stakeholders such as governing bodies (e.g. The FA, UEFA, CONCACAF etc.), coaches and applied practitioners (e.g. strength and conditioning) to draw from to inform their practices. For example, in 2021 UEFA launched the Fitness Competency Framework aiming to educate coaches across competitive levels on the physical demands of football, to utilise this knowledge and understanding to inform the design of training programmes to effectively develop physical competencies according to their respective context (i.e. age-stage and playing level) (21).

1.3 Quantifying Training Characteristics

Early studies quantifying internal training load utilised methods such as training impulse (TRIMP) via summated heart rate zones (training time x average heart rate = TRIMP score) (22,23). In terms of external training load, early methods involved time motion analysis, where movement and time spent performing movements were analysed via video footage (24). However, in the present day, this technique is not commonly used due to its time consuming and subjective nature (25). Technological advances have resulted in the quantification of external load becoming more accessible, via the introduction of Global Positioning System (GPS) units (26). GPS units can be used to reliably quantify various valid external load variables (27–29), such as total distance (TD), maximum velocity (Vmax), distance covered at different speeds (high-speed running (HSR), very high-speed running (VHSR), sprinting (SPR)) frequency of high-speed efforts as well as acceleration and deceleration efforts (30–32). In relation to football, variables such as TD, HSR and accelerations and decelerations are most commonly used to interpret and describe training load by practitioners (33) and the ease of using GPS to capture these metrics has made them most popular amongst researchers and practitioners (34).

The primary focus of research quantifying training characteristics in football has measured variables of internal and external load to understand training outcomes (35), injury (36) and fatigue (37,38). Studies within these areas have been utilised to inform periodisation, recovery strategies and training design (32,39,40). However, limitations do exist amongst methodological approaches: the intermittent nature of football results in TRIMP often underestimating training load (41), GPS units of low sampling frequency can underestimate high-speed movements and accelerations (42) and few studies explore the effects of drill type (43). Furthermore, research regarding training characteristics has predominantly focussed on elite male football, with relatively less studies involving female or youth populations (43).

1.4 Quantifying Training Characteristics in Female Football

Research has demonstrated the extent of the gap regarding research supporting both male and female footballers, which extends across research areas and topics (44). The under-representation of the female population in scientific literature across sports is well documented (45,46), and this is problematic as female athletes may not receive practices which are appropriate, as they may be derived from the much more developed and accessible male evidence bases (45). This is inappropriate due to the differences between populations (e.g., biological; fluctuations in hormone concentrations due to menstrual cycle (47), physiological; growth and maturation rates, muscle mass and force exertion (48)) in addition to the contextual differences between male and female football populations (e.g. access to facilities, sports science and medical provisions, training age and previous experience) (45). Due to these differences, findings derived from male football research are not reflective of the female football population. Therefore, it is important that future population-specific research be conducted, to develop an evidence base from which practitioners can draw from when informing applied practices.

There has been steady growth in literature regarding the training characteristics of women's football in recent years. Research has primarily focused on quantifying training load by monitoring external and internal load such as TD, accelerations, RPE and heart rate, and variations across a season or training microcycles (weekly training) (49–56). Studies reported differences between training load and match-play load, different training days, positional groups, starting status, playing standard, and season phase. There are limitations in methodological approaches as studies predominantly focus on elite populations, in addition to this, contextual factors such as drill types and variations are not considered when presenting external and internal load variables.

Recent publications investigating training demands within The FA's Women's Club Talent Pathway have quantified locomotor and technical training demands of senior environments, reporting the distribution of time spent across different drill types (57) and differences in external load across different training days (58), both between different standards of competition; WSL, WC and Women's Super League Academy (WSLA). WSL players were found to demonstrate greater external training load in comparison to WC and WSLA players, furthermore WSL players completed more technical and tactical training whilst WC and WSLA players were found to engage in for SSG and possession-based training. Findings from both studies provide important context into the differences in training load and training content, as well as provide an evidence base for practitioners to draw from to inform training practices within senior populations of the FA's Women's Club Talent Pathway.

However, the evidence base supporting youth populations remains even less saturated (59–65), meaning that practitioners are often forced to draw from findings on senior female populations. This is inappropriate due to physiological (e.g. growth and maturation rates, injury risk) (66), cognitive (e.g. emotional maturity, decision making, performance under pressure) (67), physical capacity (e.g. different responses to training intensity, risk of burnout) (68) and contextual (e.g. training and performance support provision, competition scheduling and pitch sizes) (45). Therefore, there is a need for female and youth female research, to provide population-specific findings regarding training characteristics.

1.5 Quantifying Training Characteristics in Youth Female Football

Currently, to the best of the authors knowledge, the literature regarding the training load of youth female footballers is limited to seven studies (59–65). Research has predominantly explored training load by quantifying external and internal load variables such as TD, HSR, wellness, RPE, recovery and motivation. Differences between playing standard, training period (e.g. seasonal variation, international and domestic playing periods) and playing status (starters and non-starters) were consistently explored. The effects of psychokinetic games and field obstacles on training outcomes were also monitored (60,65). Only elite level youth female footballers were included across studies, competing at either national or international level. Furthermore, no session-specific analysis was conducted across studies and the effects of drill variations were only considered in one study (60). At present, no research quantifying training characteristics has been conducted within England's youth female football talent pathway.

There is currently limited research exploring training characteristics in the England talent pathway. However, research regarding match-play has provided important findings on the external load of youth female footballers within the England youth talent pathway, exploring whole and peak physical characteristics (69), heart rate and activity profile (70,71) and motion characteristics (72,73). However, despite having the understanding of the whole and peak physical demands that match-play entails being important and useful for informing training prescription for players (74), the variations in drill length, content and objectives (e.g. skill acquisition, movement variety or injury prevention) mean that these findings cannot inform all facets of training practices. Therefore, research regarding training characteristics of youth female populations is required to be conducted, to inform practices which facilitate the application of training designs which create constraints and challenges that align with players developmental requirements. Furthermore, the investments into the infrastructure of the English youth female talent pathway indicates the importance of female academies in developing elite level players. Therefore, it is important to understand the current training practices occurring within the pathway, and whether they are facilitating adequate progression within and between stages.

From the perspective of the female football youth talent pathway in England, limited literature has been published which represents this population. Previous research conducted involving high-level youth female footballers in England, was done so within RTCs (69, 75–77), and as such, there is yet to be any research quantifying training or match-play characteristics of players within the newly established ETCs. ETCs introduced different training structures (1.5hrs per week across a 30-week season), multiple game formats (e.g. futsal, mixed games) and different curriculum and provision (e.g. physical, technical training and physical literacy support) (7). These contextual differences mean that research needs to be conducted which provide findings that are representative of the updated training environment. Furthermore, the limited literature that does include youth female players within the English youth talent pathway, predominantly involves U14 and U16 youth age groups (69, 78–80). Therefore, not only is research within this new set-up in the youth female talent pathway warranted due to the contextual changes in training environment and coaching practices, but also due to the inclusion of U10 and U12 age groups.

1.6 Aims and Objectives

1.6.1 Aims

To quantify the physical training characteristics of U10, U12, U14 and U16 youth female footballers, and compare within and between age groups and drill-types.

1.6.2 Objectives

1. To systematically review the scientific literature on the performance, health and development of youth female footballers, determine the methodological approaches adopted, summarise the findings of research areas, and identify gaps within the literature. (Chapter 2).
2. To quantify and compare session and drill-specific external load of U10, U12, U14 and U16 youth female football training (Chapter 3).
3. To synthesise the findings of both studies, provide recommendations to practitioners, discuss limitations of the current research and provide recommendations for future research (Chapter 4).

Chapter 2: The Performance, Health and Development of Youth Female Footballers: A Systematic Scoping Review

The information presented in this chapter has been updated and published:

Adams T, Waterworth S, Lewis T, Datson N, Harkness-Armstrong C, Lowry R, Freeman P, Harkness-Armstrong A. The performance, health and development of youth women's footballers: A systematic scoping review. *Int J Sports Sci Coach*. 2025 Dec 12:17479541251411068.

Abstract

In recent years, women and girls' football has seen substantial increase in support, participation and funding. Whilst research surrounding senior female players has become more substantial, for youth players, the evidence base is much more limited. As such, the current state of the literature investigating youth female football players is still relatively unknown. Therefore, the primary objective of this scoping review was to determine and summarise the current literature quantifying the performance, health and development of youth female football players. A systematic search of electronic databases was conducted on 23rd December 2023, and the PRISMA-ScR protocol was followed. Studies must have quantified at least one aspect of performance, health or development and involve youth female footballers. An initial 15,028 studies were identified, with 241 eligible to be included within the review. Of the eight research topics of sports science and medicine investigated, physical qualities were the most explored (n=98), followed by injury (n=41), biomechanics (n=32), psychology (n=28), match-play (n=17), nutrition (n=12), fatigue and recovery (n=9) and training load (n=4). The majority (69%) of studies were published from 2016 onwards, representing recent rapid growth in the youth female football literature. However, topics such as training load, fatigue and recovery and nutrition are still relatively unexplored areas. To conclude, this review has collated and summarised the current literature surrounding youth female footballers, identifying key areas for future research. Findings can be used to inform practices, supporting the performance health and development of players across multiple playing standards.

2.1 Introduction

Female football has seen significant global growth over recent years. The number of women and girls playing football globally has increased by nearly a quarter since 2019 (81), viewership has seen an average live audience increase of 106% in the Women's World Cup from 2015-2019 (82, 83). More recently, FIFA announced a historic milestone for female football, with an increase from 12 teams to 16 teams competing in the Olympic Football Tournament in Los Angeles in 2028 (84). On a continental scale, women and girls' strategies have been implemented, with CONCACAF introducing a dedicated women's football department in 2018 and, in 2019, setting out to grow participation and inspire women and girls as well as enhance the game commercially (85). Additionally, UEFA launched its "Unstoppable" 2024-2030 strategy, aiming to make football the most played team sport amongst women and girls in every country and the most sustainable and investable women's sport (86). At a national level, The English FA have released a new strategy, with short term aims to have 90% of schools delivering equal access opportunities for key stage 2 and 3 girls to play football and a long-term ambition to continue being world leaders on and off the pitch (87). Further, The FA have reported large increases (196%) in participation in women and girls football sessions (88), and funding into youth female playing environments, including the establishment of Emerging Talent Centres within the youth female talent pathway (5).

Literature focusing on women's football has been increasing with recent years, as highlighted by reviews on match-play (74), injury (89–91), nutrition (92) and physiological characteristics (93). However, due to these reviews investigating topics in isolation (e.g. match play (74), injury (90, 91, 89, 94, 95), nutrition (92), relative age-effects (96) and the menstrual cycle (97)), it is difficult to gain an overall perspective on the current state of the literature. Furthermore, our understanding of research investigating youth female football is even more limited, as reviews typically exclude youth players as part of their eligibility criteria (44, 90–92, 97). The focus of research on senior players is highlighted in a scoping review of research within female football by Okholm-Kryger et al.(44), where only 26% of the included 1,634 studies focussed on pre-senior football**.** The lack of (understanding of the) evidence investigating youth female football players is problematic, as may result in practices supporting the youth female population being derived from senior female populations. Generalisations from one population to another are ineffective due to both the contextual (e.g. quality of training facilities, access to expert staff etc. (45)), and population differences (e.g., physical capability (98), hormonal differences (99), biomechanical profiles (100)). Therefore, there is a need to gain an understanding of the evidence base in youth female football, to facilitate appropriate practical applications for this population.

Therefore, the aims of this scoping review are to: 1) systematically scope and review the scientific literature on the performance, health and development of youth female footballers, 2) determine the methodological approaches adopted, 3) summarise the findings of research areas, and 4) identify gaps within the literature. This will be the first review which has attempted to collate research on youth female footballers of all topics of sports science and medicine into one place, adopting a holistic approach in considering all aspects of performance, health and development to map out the state of the literature concerning youth female footballers. In turn, guide the focus of future research, further benefiting the performance, health and development of youth female footballers.

2.2 Methods

2.2.1 Design and Search Strategy

This scoping review was conducted in accordance with the extension for Scoping Reviews (PRISMA-ScR). (101) A systematic search of electronic databases (AIM, CINAHL, EMBASE, IndMed, LILACS, MEDLINE, PubMed, Scopus, SPORTDiscus, Web of Science) was conducted on 17th December 2023, with no date or language restrictions applied. The search strategy included the terms for the population (‘female’ OR ‘women’s’ OR ‘girls’ OR ‘youth’ OR ‘adolescent’) AND sport (‘football’ OR ‘soccer’ OR ‘futbol’) AND performance, health, or development (‘perform’ OR ‘competit*’ OR ‘match’ OR ‘game’ OR ‘training’ OR ‘demands’ OR ‘activity’ OR ‘tactical’ OR ‘technical’ OR ‘physiolog*’ OR ‘physical*’ OR ‘testing’ OR ‘qualities’ OR ‘power’ OR ‘speed’ OR ‘fitness’ OR ‘change of direction’ OR ‘agility’ OR ‘skill’ OR ‘health’ OR ‘menstrual’ OR ‘energy’ OR ‘nutrition’ OR ‘fuel*’ OR ‘diet*’ OR ‘composition’ OR ‘mental’ OR ‘psycholog* OR ‘well* OR ‘fatigue’ OR ‘recover* OR ‘load OR ‘lifestyle’ OR ‘injur*’ OR ‘rehabilit*’ OR ‘risk’ OR ‘incidence’ OR ‘exposure’ OR ‘development’ OR ‘athletic*’ OR ‘hormon*’ OR ‘maturation*’ OR ‘growth’ OR ‘anthropomet*). Additionally, the search strategy included AND NOT (‘futsal’ OR ‘American football’ OR ‘rugby’ OR ‘Australian rules football’ or ‘Gaelic football’). The search strategy was informed by recent reviews within sports science and medicine (44, 74, 90, 102, 103).

2.2.2 Study Selection

After removing duplicate studies, a two-stage screening process was used. Initial screening consisted of two researchers (TA, AHA) independently screening title, abstract, and keywords of studies against the eligibility criteria. Before moving to the next stage, both researchers met to discuss and resolve any disagreements. No third reviewer was required to facilitate this process. Full-text screening was then conducted independently by the same researchers, using the same eligibility criteria, again followed by the same process where both researchers discussed and resolved any disagreements. Selected studies following this two-stage screening process were included within this review.

Studies were included if they involved youth female football players, playing at any competitive standard (i.e., organised competitions; local, regional, national, or international). For the purposes of this review, youth was defined as players aged 19yrs or younger (as per the National Institute of Health's definition for adolescent) (104). Studies must have quantified at least one aspect of performance, health or development. Performance includes the technical, tactical, physiological and psychological characteristics of a player or team (105). Health relates to the physical, mental and social well-being of the player (106). Whilst development, refers to the chronological and biological development of the athlete (107). Only original research published in peer-reviewed journals were included, with conference proceedings/abstracts, book chapters, case-studies/reports, review articles, or student theses excluded. Studies which only included youth female football players in non-competitive environments (i.e., recreational, physical activity, school settings), senior female (i.e., >19yrs), males, or other football codes (i.e., American football, Australian rules, futsal, Gaelic football or rugby) or sports were excluded. Additionally, where studies only presented data which were not distinguishable or unique to youth female football players (i.e., youth female data grouped with male (108), non-competitive (109), senior female players (110)), these studies were also excluded. Lastly, studies which used youth female football players as participants, but did not investigate the performance, health and/or development of youth female football players were excluded (e.g., (111)).

2.2.3 Data Extraction

The lead researcher (TA) extracted all data, which was checked by another member of the research team who had expertise in the respective topic. Data relating to study characteristics (e.g., authors, year of publication, geographical location), participant characteristics (e.g., age, height, body mass, playing standard, age group), study aim(s), methodological approach (e.g., number of participants, data collection tools, outcome variables, comparison groups), and key findings were extracted. Where studies included irrelevant data (e.g., playing position data which grouped senior and youth players) (71), only the relevant data was extracted.

2.2.4 Data Synthesis

Due to the nature of a scoping review in mapping, identifying and summarising the evidence within a topic, no quantitative analysis was conducted (101). Data relating to study characteristics, methodological approach and key findings were presented as mean ± SD, unless otherwise stated.

2.3 Results

2.3.1 Search and Selection of Studies

A total of 15,028 studies were identified through the database search; after removing duplicates (n=5,765), conducting the initial screening and full-text screening, 241 studies were deemed eligible for inclusion in this review (Figure 2.1).

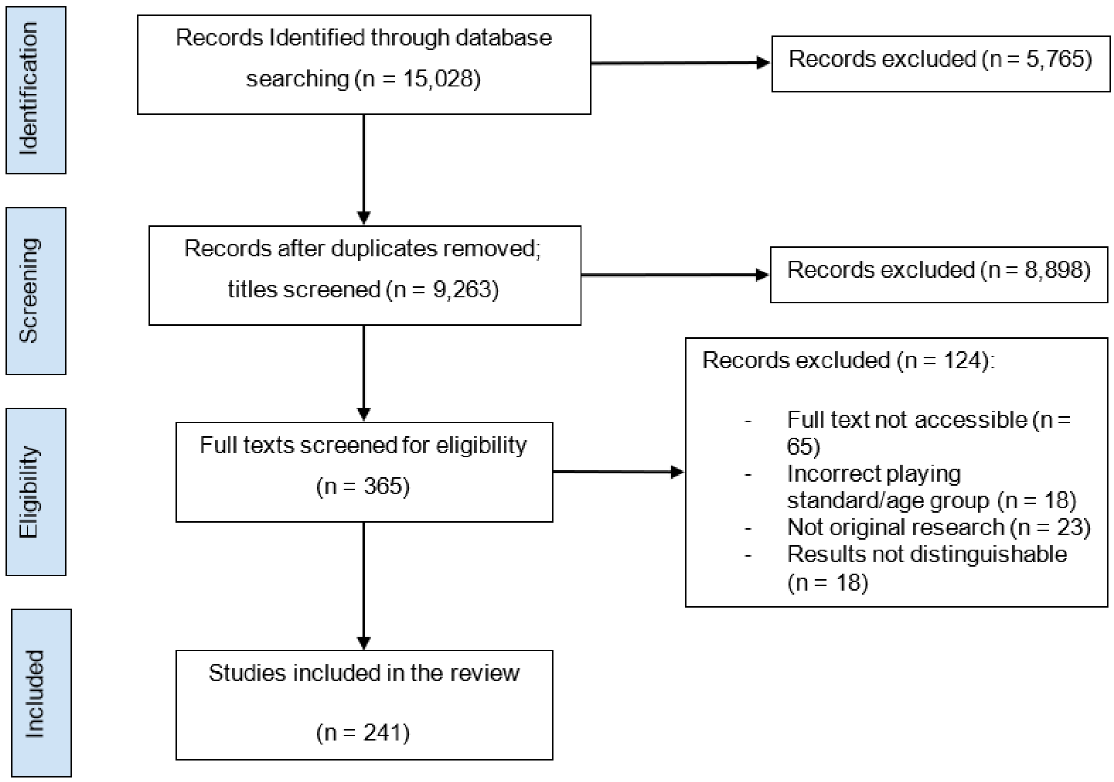

Figure 2.1. Flow of the study selection process to determine eligible studies.

2.3.2 Study Characteristics

2.3.2.1 Characteristics of Topics

Of the 241 studies included in this review, the performance, health and development of youth female footballers were covered within eight topics: biomechanics (n=32, 13%), fatigue and recovery (n=9, 4%), injury (n=41, 17%), match play (n=17, 7%), nutrition (n=12, 5%), physical qualities (n=98, 41%), psychology (n=28, 12%) and training load (n=4, 2%) (Figure 2.2).

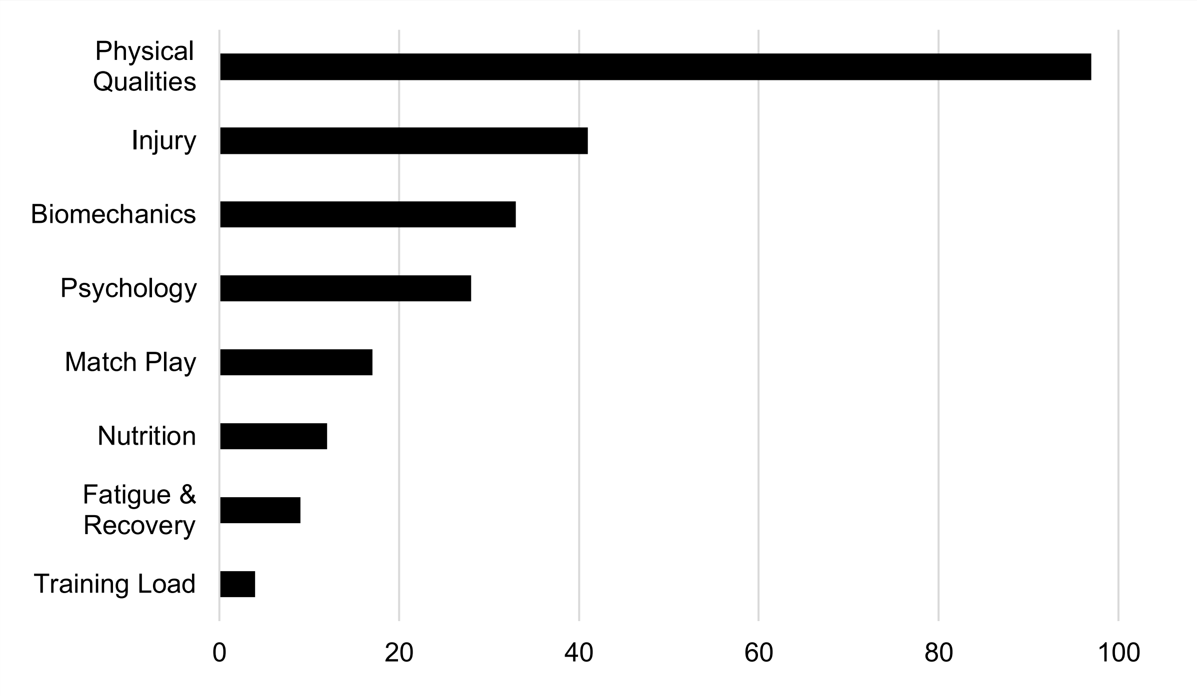

Figure 2.2. Number of studies within topics of studies investigating the health, performance and development of youth female footballers.

2.3.2.2 Publication Year

There has been a steady increase in the number of studies investigating the performance, health and development of youth female footballers since 2008 (Figure 2.3). Over 85% of studies have been published since 2009, with increases in the volume of publications coinciding with FIFA World Cup years (2011, 2015), similar to trends observed in a scoping review on research in female football (44). However, there has been a sharper increase in the volume of studies within recent years, with 60% (n=147) of studies published between 2018 and 2023.

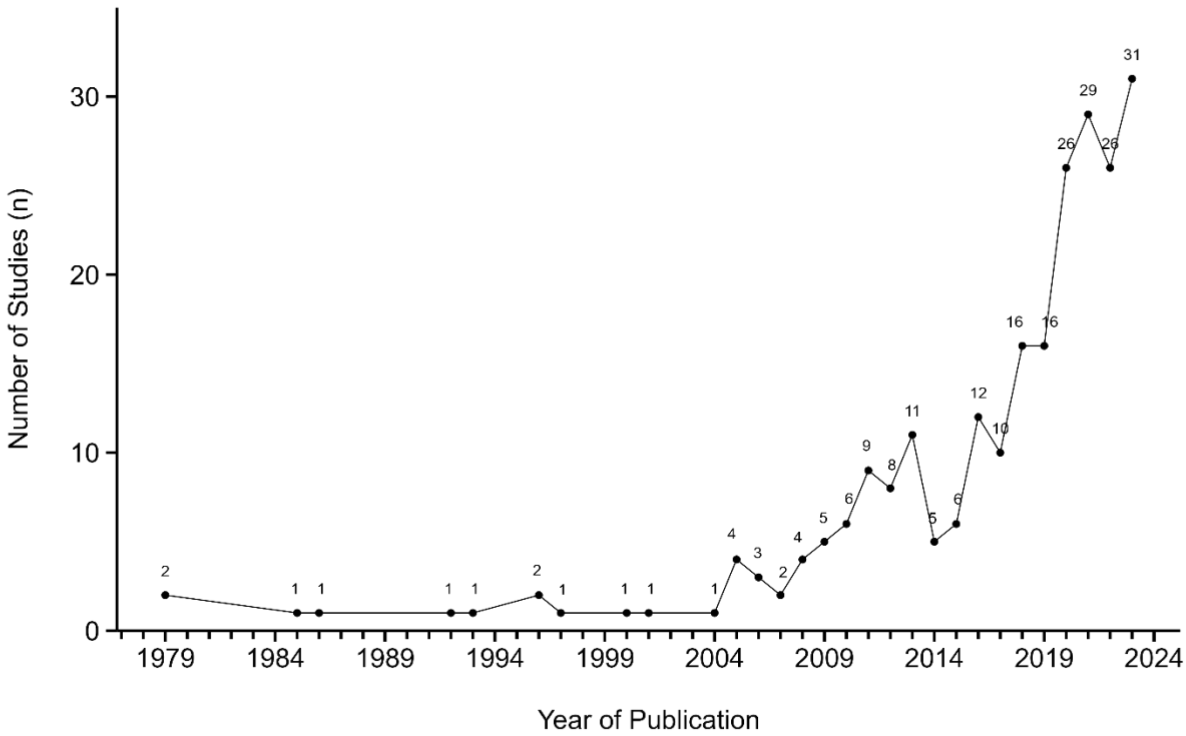

Figure 2.3. Number of studies published per year investigating the health, performance and development of youth female footballers.

Figure 2.4 depicts the extent to which topics have been explored regarding youth female football. The psychology and injury topics contain the publications on youth female football which date back the furthest in 1979 and 1985 respectively. A similar trend has been found in a scoping review on senior female football where sociology (1939), psychology (1975) and injury (1975) were the earliest studies published (44). Newly investigated topics in youth female football include fatigue and recovery and training load, with initial publications from 2015 and 2014 respectively. This may be due to increasing access to data collection equipment (e.g. GPS unit, video camera, force platform, heart rate monitor) required to undertake research in these areas.

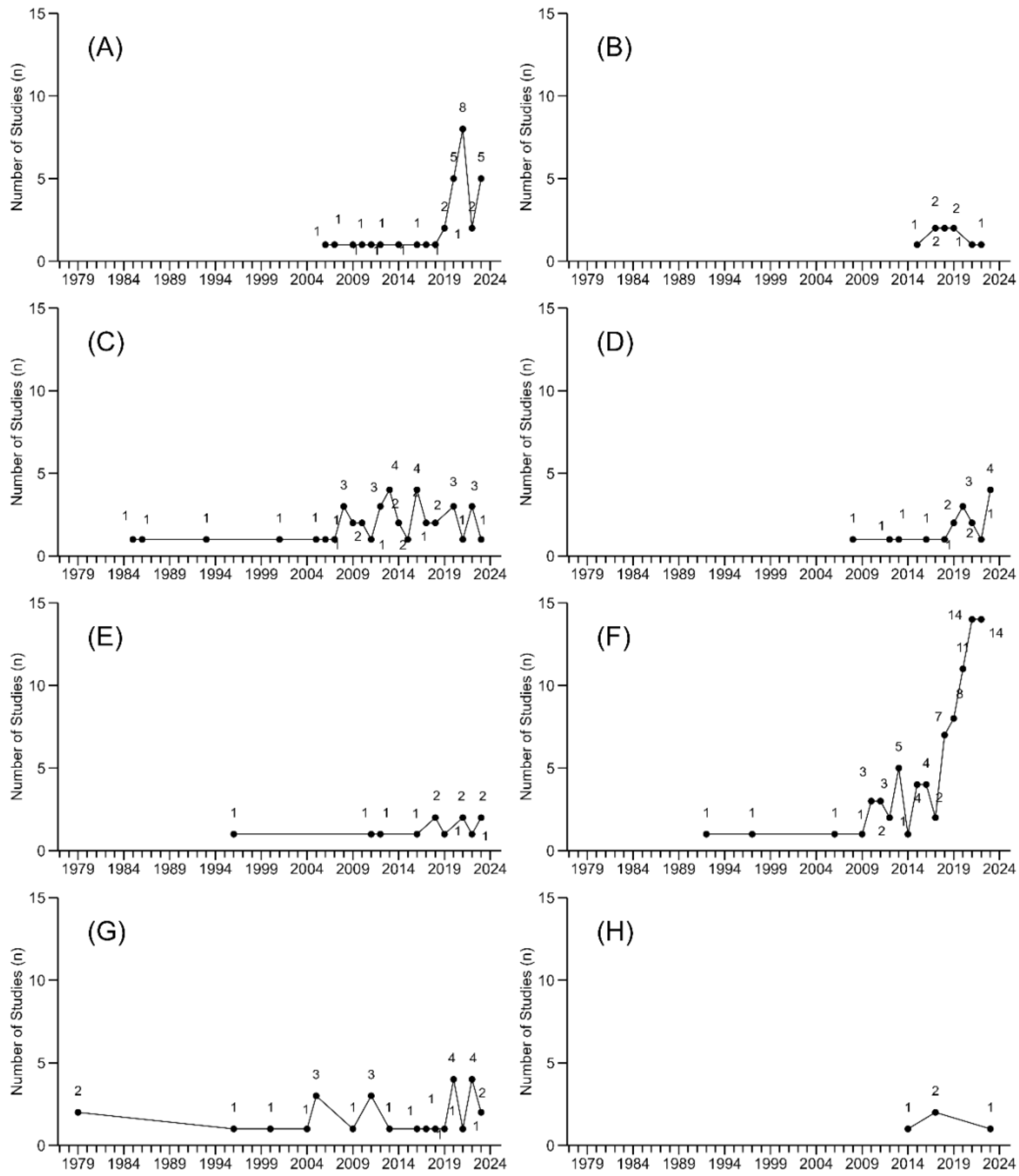

Figure 2.4. *Number of studies published per year investigating the health, performance and development of youth female footballers according to topic; A) biomechanics, B) fatigue and recovery, C) injury, D) match-play, E) nutrition, F) physical qualities, G) psychology, and H) training load.*

2.3.2.3 Geography of Studies

A total of thirty-one different countries were represented within this scoping review (Figure 2.5), the majority of studies came from: the USA (n=47; 20%), United Kingdom (n=27; 11%), Canada (n=26, 11%), Spain (n=22, 9%), Norway (n=16, 7%), Sweden (n=15, 6%), Germany (n=14, 6%), Denmark (n=9, 4%) and Australia (n=7, 3%). This may reflect the prominence of female football in these countries, which include the top female football leagues (i.e., NWSL in USA, WSL in England, Northern Super League in Canada, Liga F in Spain, Damallsvenskan in Sweden, Google Pixel Frauen Bundesliga in Germany, Kvindeliga in Denmark) (112). The United States exhibited considerable dominance in the areas of biomechanics and psychology, accounting for 55% (n=18) and 34% (n=10) of the studies in these respective fields. Additionally, it is worth noting that 77% (n=17) of publications concerning youth female football in Spain focused on the physical qualities topic, representing the highest proportion observed across all countries.

Figure 2.5. Geography of studies investigating the health, performance and development of youth female footballers.

Country representation by topic is presented in Figure 2.6 where biomechanics, injury and psychology were mostly represented by the USA, with publications making up 56%, 24% and 36% respectively. Publications from England made up 44% of fatigue and recovery topic studies as well as 24% of match-play studies. Publications from Canada made up 33% of studies within nutrition, and Spain was most represented amongst physical qualities studies (17%), although this is less pronounced due to the volume of studies within the topic. It is also worth noting that the physical qualities topic is represented by the most countries (n=27). Training load was the smallest topic (n=4), with three countries represented (n=3). Publications from African countries were the least represented across the literature on youth female football, appearing only in the injury and nutrition topics. This was closely followed by South American publications which only appear in three topics: match-play, physical qualities and fatigue and recovery. This is also the case with studies from Oceanic countries which only appear in biomechanics, match-play and physical qualities topics.

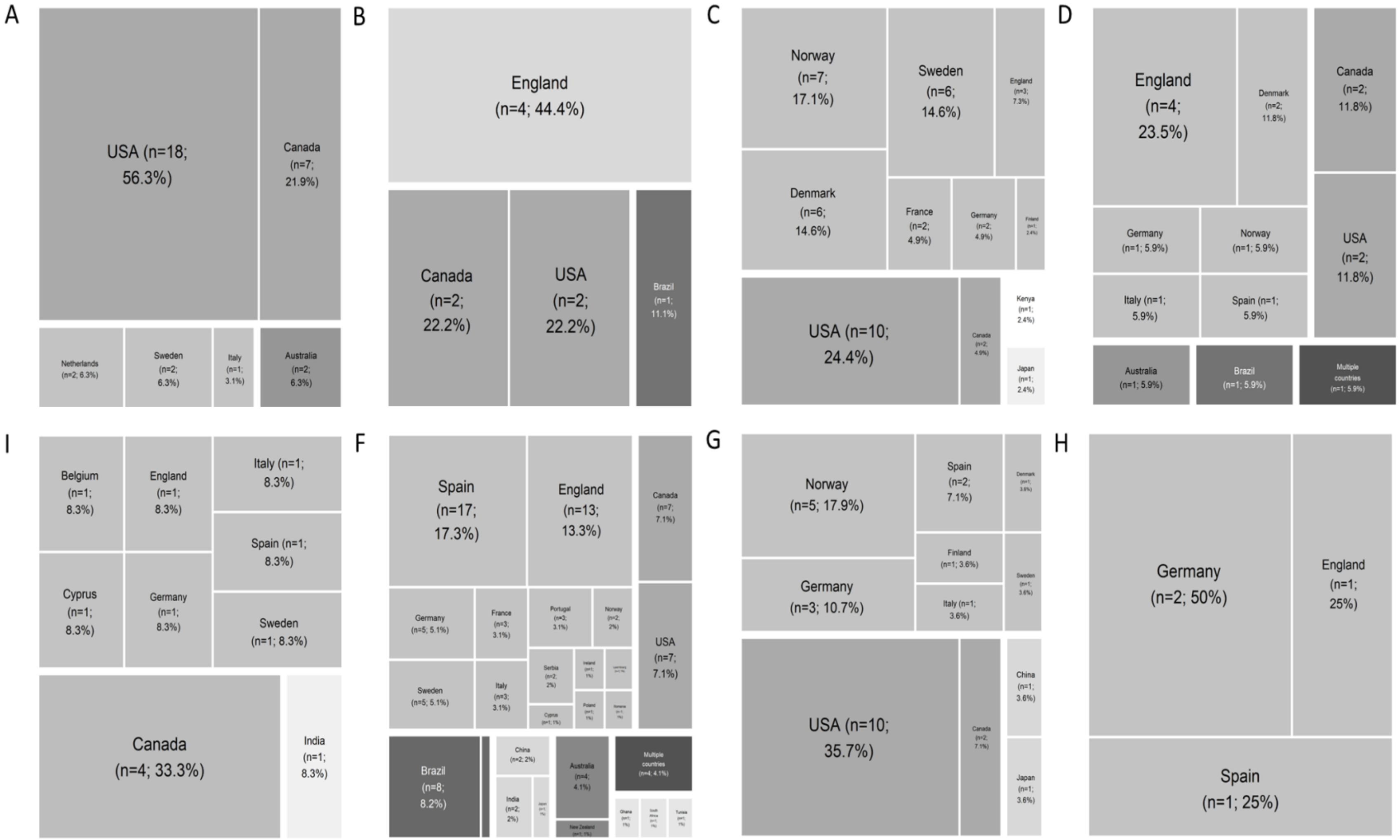

Figure 2.6. *Geography of studies investigating the health, performance and development of youth female footballers according to topic; A) biomechanics, B) fatigue and recovery, C) injury, D) match-play, E) nutrition, F) physical qualities, G) psychology, and H) training load*

2.3.3 Research Topics

2.3.3.1 Biomechanics

Thirty-two studies investigated biomechanics of youth female football (Appendix 1) assessing jumping, landing and/or cutting (n=17, 53%) (113–129), heading (n=13, 41%) (130–142), kicking (n=1, 3%) (143) and methodological aspects (n=1, 3%) (144). Players representing national (n=4, 12.5%) (125, 132, 137, 138, 144), regional (n=7, 22%) (116, 120, 122, 123, 126, 130, 131, 134) and local (n=13, 41%) (113–115, 119, 128, 129, 133, 135, 136, 139–142) playing standards were included in studies. In the remaining 25% of studies (n=8), playing standard was not stated (117, 118, 121, 124, 127, 143).

2.3.3.1.1 Jumping, Cutting and Landing

Local (n=6, 35%) (113–115, 119, 128, 129) and regional (n=4, 24%) (116, 120, 122, 123, 126) players were most commonly investigated across the sub-topic, with only one study (6%) involving national players (125). Six studies (35%) did not state playing standard (117, 118, 121, 124, 127). Common outcome variables included knee kinematics (n=12, 71%) (115, 116, 118–120, 122, 124–129) and kinetics (n=6, 35%) (115, 116, 122, 127–129), ground reaction force (n=3, 18%) (120, 121, 125), and jump performance (n=5, 29%) (117, 119–121, 124).

Most studies quantified jumping, cutting and/or landing biomechanics using force platforms (n=11, 65%) (115–117,120–123,125,127–129) and 3D motion analysis (n=10, 59%) (115–118,120,122,125,127–129), whereas three studies (17%) used 2D video analysis (119,124,126), and two (11%) used inertial measurement units (IMUs) (113,114). One study used a combination of a force plate and Swift speed mat to determine age-related changes in jump performance (121). Studies found sex-specific movement strategies in jumping, cutting and landing movements (122,123) as well as age-related changes in landing asymmetry (125), suggesting landing asymmetry reduces with increased age. Intervention studies typically found improvements in lower limb kinematics and kinetics following implementation of an injury-prevention training (115,124,128,129). Younger players showed greater improvements in knee valgus moment during a double leg jump task (129), however no other age-related effects following intervention have been reported. Additionally, improved knee kinematics and kinetics were found during an unanticipated side cutting and side-hopping task, after immediate verbal instruction (115). While multiple studies showing improvements in kinematics and kinetics following intervention is promising, all studies to date have been conducted in controlled laboratory environments. Therefore, it is unclear whether improvements can translate to training and match scenarios.

2.3.3.1.2 Heading

Players of local standard were most commonly investigated across this sub-topic (n=7, 54%), (133,135,136,139–141), followed by regional (n=3, 23%) (130,131,134) and national standards (n=2, 15%) (132,137,138). All papers quantified head impact kinematics using inertial measurement units, in the form of trackers (n=8, 62%) (130, 131, 134, 135, 137, 138, 141, 142) or mouthpieces (n=5, 38%) (132, 133, 136, 139, 140). Common outcome variables also included total number of headers or head impacts (n=8, 62%) (130–134,136–140), and neck muscle strength (n=3, 23%) (133,137,141) A single study assessed balance and neurocognitive function (141). Finally, variables were most commonly compared across ball-delivery method (n=6, 46%) (130,133,134,136,139) or age group (n=4, 31%) (130–132,140).

Better heading technique (i.e., impact location, technique score) was associated with improved heading kinematics (133,134). Head impact magnitudes differed depending on match scenario (e.g., goal kick, corner) (131,134,136,139,140), and ball characteristics (138). Older players experienced a higher frequency of head impacts (>15g) than younger players (U14 *vs.* U12) (131). Four studies assessed the effects of an intervention on heading kinematics (135,137,141,142). These studies predominantly (n=3) improved neck muscle strength, which subsequently led to improvements in heading kinematics (135,137,142). Therefore, with guidance and restrictions being introduced by national governing bodies (145) to reduce exposure to repeated head impacts, particularly for younger age groups, it is essential to ensure that appropriate training (e.g., heading technique, neck strength etc.) is implemented to optimally prepare players for purposeful heading.

2.3.3.2 Fatigue and Recovery

Nine studies investigated fatigue and recovery (146–153,77) (Appendix 2) assessing muscular function (n=5, 56%) (147–149,151,77), nervous system function (n=2, 22%) (146,150), physical qualities (n=1, 11%) (152) and well-being (n=1, 11%) (153). Participants in these studies competed in either national (n=5, 56%) (146–149,151) or regional (n=4, 44%) (134,152,153,77) competitions.

A variety of outcome variables were used to investigate fatigue and recovery. Variables assessing neuromuscular function (e.g., muscular delay (147), stiffness (148), hamstring to quadriceps ratio (149), strength and delayed onset of muscle soreness (DOMS) (151), knee flexion and valgus angle (77) were quantified using a variety of equipment (e.g., dynamometer (77,147,149), RPE (151,77), electromyography (EMG) (147), contact mat (148), force platform (77)). Variables assessing nervous system function (e.g. heart rate, heart rate delay, (146,150)) were quantified using a heart rate monitor (150) or electrocardiogram (ECG) electrodes (146).

Studies investigated differences between age groups (n=4, 44%) (147–149,151), exposure to heading tasks (n=2, 22%) (146,150), and training load (n=1, 11%) (153), however, predominantly explored fatigue and recovery across various time periods (n=7, 78%) (147–149). Seven of these studies (78%) investigated fatigue and recovery within an acute period, including; pre- vs post-match (151,152), pre- vs post-field-based soccer protocol (77,147–149), and stage of tournament (152). Whilst two studies (22%) investigated fatigue and recovery over a longitudinal period (over a 3-month period (153), over a competitive season (146).

Following a football-simulation protocol, older age groups had less electromechanical delay, (147) and greater leg stiffness (148) compared to younger age groups. Further, under fatigue, negative effects on hamstring-to-quadriceps ratio were observed for U15 players but beneficial effects for U17 players, particularly at joint angles near full extension where injury risk is higher (149). These age group differences may be due to differences in relative workload, as U15s were found to cover similar total distance in the football-simulation protocol to U17s but in less time (80 minutes for U15 players compared to 90 minutes for U17 players). Additionally, U17 players are generally more physically mature, having passed peak height velocity. Maturation is associated with increased neuromuscular control and stability, improved muscle coordination, and enhanced strength (149). Due to this and being better prepared for higher physical demands given an increased playing exposure, more mature players are less susceptible to fatigue. Furthermore, following competitive match-play, within a 168-

hour testing period U17 players were found to fully recover, while U13 and U15 players continued to exhibit elevated creatine kinase levels and delayed onset muscle soreness beyond this period (151). This indicates greater muscle damage and delayed recovery in younger players and suggests that younger age groups may be more susceptible to residual fatigue and potential injury risk if they don't have sufficient recovery time between matches. This may have important implications for fixture scheduling, load management, recovery strategies, and substitution strategies.

Future research could look to investigate how relative workload during training and matches affects fatigue-related injury risks and recovery across different age groups, as well as the effectiveness of conditioning programs tailored to specific maturation stages. Due to current research often not accounting for total relative workload completed prior to and during data collection, consideration should be given to how training and fixture schedules of different age groups effects their fatigue and recovery. Furthermore, quantifying this (e.g. GPS) would allow for a more comprehensive analysis. From a practitioner’s perspective, consideration needs to be given to the fact that, with more mature players being less susceptible to the effects of fatigue due to more advanced physical qualities, there needs to be a focus on developing the physical qualities of players from earlier age groups. Simultaneously, attention could be given to adjusting the volume of training or fixtures of younger age groups to support their decreased recovery abilities.

2.3.3.3 Injury

A total of forty-one studies investigated injuries within youth female football (Supplementary Material Table 3), predominantly exploring epidemiology (n=18, 46%)

(154–171) and risk factors (n=14, 34%) (172–185), with the remaining studies (n=9, 22%) exploring the efficacy of injury interventions (186–194). Studies most commonly involved regional players (n=20, 49%) (175, 159, 164, 167–169, 173, 176, 177, 181, 182, 184–187, 189, 191–194), followed by national (n=11, 29%) (155, 157, 160, 161, 163, 172, 174, 178, 180, 188, 190) and international players (n=4, 10%) (158, 165, 166, 171). Only one study (2%) recruited players who competed at a local level (156), and four studies (10%) did not state the playing standard of participants (154, 162, 170, 183).

2.3.3.3.1 Epidemiology

Of the eighteen studies which explored epidemiology in youth female footballers, there was a range of playing standards investigated (local: n=1, 5% (156); regional: n=5, 25% (159,164,167–169); national: n=5, 25% (155,157,160,161,163); international: n=4, 20% (158,165,166,171); not stated: n=3, 15% (154,162,170)). The most common outcome variables amongst studies included injury type and location (85%, n=16) (154,155,157,158,160–170), injury frequency (80%, n=13) (154, 155, 157, 175, 158–163, 165, 167, 171), match and training exposure or load (30%, n=6) (154, 155, 158, 160, 162, 163) and injury severity and duration (25%, n=5) (154,155,158,166,171). One study presented health belief construct questionnaire score (susceptibility, severity, barriers, benefits) (156). Practitioners, including coaches and medical professionals, collected data in 42% (n=8) of studies (155,158,161–163,165,167,171). Questionnaires or surveys were used in 35% (n=7) of studies (156,159,167–171) and self-report techniques such as via text message (157) and self-referral to a medical tent (154,166) were employed in 15% (n=3) of studies. One study used the International Classification of Diseases (ICD-10) alongside X-ray to diagnose injuries

(160). As previously noted, self-report or recall methods are limited by participants' recall accuracy.

Age group comparisons were common across this sub-topic (55%, n=11) (154–156,159–162,164,166,170,171). Differences between game type (training and matches) were compared in 25% (n=5) of studies (161,156,168,169,171) followed by injury status (injured and non-injured players) (20%, n=4) (165,164,167,168), playing standard (15%, n=3) (157, 164, 167), and time period (11%, n=2) (year, (158) and (season) (171)). Further comparison groups such as playing position (5%, n=1) (169), injury type (5%, n=1) (170), and injury surveillance type (e.g. parental internet based or certified athletic trainer) (5%, n=1) (167) featured just once across the sub-topic, and therefore, warrant further investigation.

Age group comparisons yielded findings typically consistent, with eight studies reporting that younger age groups experienced highest injury frequency, and thus greater injury risk (154,159–162,164,170,171). These findings align with existing literature on youth male players, suggesting that higher injury rates relate to skeletal maturity factors such as proximity to peak height velocity (195), skeletal age falling behind chronological age (196) or an immature skeleton (197). However, two studies observed injury incidence increased with age (155,166).

Studies which compared differences between game type (matches and training), presented inconsistent findings with two reporting that injury incidence was highest in training compared to matches (161,169), one observing more injuries in matches than training (171) and one reporting no difference (168). A limitation, and potential reason for the differences in findings could be due to playing facilities used by participants being maintained to varying standards, potentially influencing injury rates. Further, it should be noted that observation periods across studies varied with some taking place across a whole season (155,157) and others over shorter periods (e.g. tournaments) (154,162). Therefore, findings from studies observing over a shorter timespan cannot be generalised to longer footballing period formats, and vice-versa.

2.3.3.3.2 Risk Factors

Players within regional competitions were most frequently studied across this sub-topic (n=8, 62%) (173,175–177,181,182,184,185) followed by those from national competitions (n=4, 31%) (172,174,178,179). One study did not specify the playing standard (183).

Common outcome variables included injury frequency (n=6, 46%) (174,178–181,184), injury location (n=8, 62%) (172,175,177,179,181,182,184,185), injury severity (time loss due to injury) (n=6, 46%) (174,175,178,179,181,182), injury history (n=3, 23%) (172,173,176), training load (n=4, 31%) (174,176,182,183) and physical performance outcomes (e.g., knee strength, jump height (173,175), $\dot{V}O_2$ max (175,184)). Methods of determining injury characteristics (e.g. injury location, severity, history etc) and training load of players were varied including practitioner-reported injuries (n=4, 31%) (176,177,179,181), questionnaires (n=7, 54%) (172,174,177,180,182,183,185), and self-reported injuries (n=2, 15%) (178,184)). Questionnaires were also used to assess variables not directly related to injury such as well-being (Brief-COPE questionnaire) (183), technical-tactical attributes (180) and perceptions of early football specialisation (185). However, self-reporting techniques have limitations, particularly due to reliance on participants' accurate recall of injury detail which may affect accuracy of results.

Injury status was most commonly compared in this sub-topic, , investigated within 54% (n=7) of studies (172,174,176,177,182–184). Typically, injury status reflected current injuries, but three studies specifically examined previous injury as a risk factor for future injury (174,176,182). These three studies concluded that players with prior injury to the knee (174,176), groin, or ankle (182) had a significantly increased risk of a new injury occurring to the same region. One study reported an increased risk of injuries resulting in time-loss (174), although it lacked detailed information regarding type, severity, side and number of previous injuries. Future research should include detailed injury histories to better understand the risk of previous injury on injury re-occurrence. Due to low seasonal anterior cruciate ligament (ACL) and acute knee injury rates (3.5 events), there was low statistical power in risk factor modelling (Cox regression analyses) (176), therefore results from the ACL risk factor model in this study should be interpreted cautiously.

Other comparison groups included playing standard (173,180,185), playing surface (grass, artificial turf) (177,179,181), age group (179), type of sport (178), playing position (177) and player type (n=1, 5%) (indoor and outdoor players) (175). Notably, age group and playing position (common comparison groups in other topics) were less utilised across the sub-topic. Future research should explore these further to better understand how maturation and playing position affect risk of injury occurrence and characteristics. Of the three studies exploring playing surface, two found no significant differences in injury frequency between grass and artificial surfaces (179,181), while one other reported significantly higher training injuries on grass but no significant differences in matches (177). This is in contrast with previous research on senior players which suggests the opposite (198–200). This may potentially be due to grass pitches for youth players not being of (or maintained to) as high a standard as a senior pitch.

Two of the three studies exploring playing standard found that more skilled players had an increased risk of injury (180,185) while the other found no significant differences between elite and recreational players (173). The increased injury risk among higher skilled players aligns with previous research in youth male football (201), where greater exposure to contact events such as tackles and ariel duels is associated with higher injury rates. However, there was a small but potentially meaningful age difference (0.7 years) between the elite and recreational players, which could influence strength differences due to pubertal development (173). Additionally, factors such as greater training volume, intensity, and competitive demands in elite settings may also contribute to increased injury risk and should be considered when interpreting these findings. Future research should account for training experience and load to better isolate the effect of playing standard on injury risk.

2.3.3.3.3 Interventions

Nine studies investigated the effects of interventions on injury outcomes in youth female football (regional: n=7, 78% (187,186,189,191–194); national: n=2, 22% (188,190). Injury incidence was the most common outcome variable, included in 89% (n=8) of studies (187–194). Other outcome variables were more sporadically included across studies, for example training and match load: (n=3, 33%) (187,192,194), injury location (n=3, 33%) (190,191,194), injury type (n=3, 33%) (190,191,193), physical qualities (n=3, 33%) (186,188,192), compliance or adherence to intervention (n=3, 33%) (187,191,192), and injury severity (n=2, 22%) (190,191). The data collection of injury characteristics (frequency, type, severity, etc.) was predominantly conducted via practitioners such as coaches, therapists and other medical staff (n=5, 55%) (189–193), followed by questionnaires and surveys (n=3, 33%) of studies (188,189,194).

Interventions varied, including warm-up programs (n=3, 33%) (191–193), training programs (n=2, 22%) (186,187), injury prevention strategies (n=1, 11%) (189) and a change in ball (n=1, 11%) (194). One study excluded the intervention group and was therefore not used in analysis (188). The longest intervention was two competitive seasons (189), however, just over half of the studies had a season-long intervention (n=5, 55%) (187,190,191,193,194), with others lasting four months (n=2, 22%) (186,192). Of the two remaining studies, one excluded the intervention group (188), the other compared the effects of the intervention on trained and un-trained players (189). Four studies reported significant reductions in injury rates for players in intervention groups (186,190,193,194), while two studies found no significant differences in injury rate between the intervention and control groups (187,191); however, in one study, low compliance in one specific tertile of the intervention group partially explained the lack of effect (187), with the other tertile (with a high-compliance rate) demonstrating a significantly lower injury rate than the control group.

Comparison of injury intervention effects across comparative groups such as playing position, playing level, game type, fitness level and trained and untrained players were each examined in singular studies within youth female football. Future research should explore these variables more consistently, particularly by comparing variables such as injury frequency between these comparative groups, to better understand the effectiveness of injury interventions.

2.3.3.4 Match Play

Seventeen studies quantified the match-play characteristics of youth female football players (Appendix 4). Of those studies, 35% (n=6) investigated physical characteristics (71,70,69,78,72,73), 18% (n=3) quantified both physical and technical characteristics (202–204), 6% (n=1) quantified only technical characteristics (80), and the remaining 41% (n=7) examined heading incidence (205–211). Of the seventeen studies examining match play, 47% (n=8) involved participants competing in regional competitions (69,78,72,202,80,209,211). No study attempted to quantify the tactical characteristics of youth female football match-play, and therefore, future research is warranted in this area.

2.3.3.4.1 Physical Characteristics

Players in regional competitions were the most investigated playing standard in studies across this sub-topic, with only one study investigating the physical characteristics of international match-play (71). Studies examining external and internal load used a range of variables, such as, heart rate (70,204), total distance (71,70,69,78,72,73,202–204), distance covered in different speed zones (71,70,69,78,72,73,202–204), and number of accelerations (69,78,73). Studies predominantly used GPS devices, albeit of differing frequency (i.e.,1Hz (70), 5Hz (73,204), 10Hz (71,69,78,72,203)), to quantify distance- and speed-based variables, whilst one study used 2D video-based motion analysis (202). Consistent with research quantifying the match-play external load of senior female players (74), there were discrepancies in the speed thresholds and qualitative descriptors for speed zones between studies. Further inconsistencies in the methodological approach were observed for the inclusion criteria for observations (e.g., whole match

(71,78,72,73,204)) positional observations (69,203), >70mins (202)). Therefore, caution is advised when interpreting and comparing results of studies, and particularly the distances covered in speed zones.

Studies which involved multiple age groups (n=6) (71,69,78,72,73,203), quantified age group specific external load and consistently observed increasing external load with increasing age. However, when differing match durations between age groups were accounted for, age group differences were less pronounced. Therefore, future research should aim to include both absolute and relative data when investigating match-play external load across youth-age groups (69). Five studies investigated time-based differences (e.g. match-half/match-periods (70,78,73), segmental periods (72,202)), typically observing reductions in physical performance as the match progresses. Three studies quantified position-specific external load (71,69,78), and all observed differences between playing positions. Given that external load of youth female football appear to be position-specific, future research should aim to quantify physical match-play characteristics according to playing position and ensure appropriate differentiation of positional categorisation to truly capture position-specific characteristics (e.g. CD and WD (71,69,78) instead of DEF (73)). One study found different ball characteristics did not influence external load (202), whilst one study observed minimal differences in external load when manipulating the number of players (7v7 vs 8v8), and another reported external load were dependent upon the possession (i.e., in-possession, out-of-possession, ball-out-of-play) and match status (i.e., drawing, losing or winning) (79).

2.3.3.4.2 Technical Characteristics

The frequency of possession-based, offensive, and defensive technical actions during match-play were analysed in studies examining technical characteristics (79,80,202,204). All four studies used video recordings and notational analysis to collect technical data, likely consequential of the inaccessibility of more advanced data collection systems within youth environments (e.g., optical tracking systems).

Two studies found age group differences in technical characteristics (79,80), one of which also observed position-specific differences within and between age groups (80). For example, U14 central players performed more technical actions in-possession compared to wide players, whilst technical actions were more evenly distributed across playing positions at U16. The other study found technical actions differed depending upon match status (79). For example, U14 and U16 age groups technical data suggested a higher turnover of possession when losing compared to drawing or winning which may be consequential of differing tactical strategies or engaging in high-risk turnover situations (e.g. dribbles, crosses). The findings suggest that age group-specific coaching practices focussed on technical-tactical aspects of performance may be required (e.g. match strategies, training design, talent development). Additionally, future research should explore the influence of other contextual factors which have been shown to influence technical characteristics in other populations. For example, contextual factors such as match status and outcome (212), team and opposition formation (213), and environmental factors (214), have all been explored in senior female football. Lastly, one study found more technical actions were performed by U11 players during a 7v7 match compared to an 8v8 (204). Further research is warranted to understand how manipulating task constraints (e.g., pitch size, number of players, match duration) may influence technical characteristics and how this may vary between age groups, to assist with informing training design and talent development practices within youth female football environments.

2.3.3.4.3 Heading

All seven studies reported heading frequency during match-play (205–211), with four further quantifying heading characteristics (e.g., impact location (206,208,209), match situation (206,208,209)). All but one study (210) conducted post-match notational analysis, instead utilising a live notational analysis approach. The most common finding amongst studies which compared by age group was that heading frequency increased with age (206,208,210,211). Midfielders tended to perform more headers than defenders and attackers regardless of age group (207–209). One study also quantified heading frequency during training, and observed significantly more headers were performed during training compared to match-play (209). It is important that coaches are made aware of this, so that training can reflect the heading exposure of players in matches, resulting in players only receiving what is deemed to be the necessary level of exposure to improve heading technique. Lastly, none of the studies explored how heading incidence or characteristics may vary across a match, which may have implications for informing policy (e.g., heading rules and regulations), or practice (e.g., substitution strategies).

2.3.3.5 Nutrition

Twelve studies explored nutrition surrounding youth female footballers (Appendix 5) (215–226), including local players (n=1, 8% (224)), regional players (n=7, 58%, (215, 217, 218, 220–222, 225)), and national players (n=6, 50%; (215, 216, 218, 219, 223, 226)). Topics varied, with studies assessing energy intake and expenditure (215,217,223,225), hydration (219,221), bone health (218,222), food consumption (224,226) and nutritional status (220). Across studies, the most common outcome variables were body mass measurements (e.g., fat mass, fat free mass, muscle mass (kg, %) (215,218–226)). Macronutrient measurements were commonly presented in studies exploring energy intake, food consumption and nutritional status (215,217,220,222,224,226). Outcome variables were compared between age group (217,221), hydration status (216,219) and dietary condition (222,224) with a further three studies comparing differences between different game days and training sessions (216,221,223).

Four studies used self-reported food diaries (215,223) or dietary recall methods (222,225) along with physical and biochemical assessments, to investigate players' nutritional habits and their impact on health and performance. Results showed that a significant number of players did not meet energy requirements (215,217,223), carbohydrate (215,223) and protein requirements (215,220) or micronutrient requirements, specifically vitamin D, E, A and B12 as well as folate and calcium (215,220). These findings, however, should be interpreted with caution as self-reported dietary intake is often inaccurate. Indeed, after adjusting for known under-reporting, one study reported that prevalence of low energy availability dropped from 34% to 5% (223) Additionally, all studies have limited sample sizes, either having a small population or representing one age group (215,223). Despite the associations of energy availability with bone health, female soccer players were reported to have significantly higher bone mineral density compared to non-athletes (218) and short-term consumption of Greek yoghurt did not affect bone metabolism (222), but had a possible effect on the acute anti-inflammatory response during periods of intense training (224).

Two studies investigated hydration using urine specific gravity and found that a significant proportion of adolescent female soccer players were hypohydrated before and during training sessions. Chapelle et al. (216) found that between 44% and 78% of players were at least minimally hypohydrated during a tournament, with fluid intake insufficient to offset losses, even after an educational intervention. Similarly, Gibson et al. (221) reported that 45% of players arrived at training hypohydrated, and most consumed less than 250 mL of water during sessions, leading to mild dehydration despite moderate sweat losses. These studies were limited by small sample sizes, reliance on urine specific gravity for short-term hydration assessment, and self-reported fluid intake, which may lead to inaccuracies. Additionally, the studies were conducted over brief periods, limiting the understanding of long-term hydration behaviours, and did not account for varying environmental conditions that could impact hydration needs.

These studies highlight significant nutritional gaps among adolescent female soccer players, particularly in energy availability, carbohydrate intake, and micronutrient adequacy. Deficiencies in key nutrients such as iron and vitamin D were prevalent across studies, potentially impacting performance and recovery. Additionally, hydration status was suboptimal, with a high percentage of players starting training sessions in a hypohydrated state. The reliance on self-reported food diaries and dietary recall methods introduces potential biases, particularly under-reporting, which was addressed in some studies by adjusting intake estimates and underscoring the importance of accurate data collection. However, the small sample sizes and the short duration of some studies limit the ability to generalize the findings. Further research with larger cohorts and more objective tracking methods is needed to better assess the nutritional practices and their impact on performance and health among female soccer players.

2.3.3.6 Physical Qualities

Of the ninety-eight studies investigating the physical qualities of youth female footballers (Appendix 6), the majority quantified anthropometrics and physical characteristics (n=56, 57% (75, 76, 98, 108, 227–278)), followed by training interventions (n=17, 17% (279–295)), relative age effect (n=18, 18% (296–313), and evaluating validity and reliability (n=7, 7% (109, 314–319)). Physical qualities studies predominantly involved players competing in national competitions (n=36, 37% (76, 98, 229, 231, 233, 234, 237, 238, 242, 245, 246, 248, 249, 254, 266, 267, 274, 275, 279, 281, 282, 286, 287, 289, 291, 292, 294, 297, 299–301, 304, 312, 313, 317), and regional competitions (n=35, 34% (75, 108, 109, 227, 228, 230, 232, 235, 236, 241, 243, 244, 247, 250, 252, 253, 259, 261, 265, 271, 274, 275, 280, 284, 290, 292, 295, 296, 302, 303, 309, 311, 313, 314)), with only eight (8%) and seven studies (7%) involving international (240, 255, 264, 298, 300, 305, 306, 308) and local players (269,272,288,293,303,310,311), respectively. The playing standard of participants could not be determined for fifteen studies (15%) (239, 256, 268, 270, 273, 276–279, 283, 285, 315, 316, 318).

2.3.3.6.1 Anthropometrics and Physical Characteristics

Of the 56 studies in this sub-topic, the majority involved national (n=24, 43%) (76, 98, 229, 231, 233, 234, 237, 238, 242, 245, 246, 248, 249, 251, 254, 257, 258, 260, 262, 263, 266, 267, 274, 275) or regional (n=21, 38%) (228, 230, 232, 235, 236, 75, 241, 243, 244, 247, 250, 252, 253, 227, 108, 259, 261, 265, 271, 274, 275) standard players, whilst only three (5%) and two (4%) studies investigated international (240,255,264) and local players (269,272), respectively. A number of different outcome variables were used, including jump height or jump distance (n=29, 52%) (108,75,230–233,236,237,239–242,248,249,251,253,255,257,259,260,263,266–268,271,275,278,314), sprint time or distance (n=22, 39%) (75,230,232,233,236–242,254,257,258,260,263,266,267,271,275,277,278), force (n=10, 18%) (e.g. peak force, peak torque) (98, 75, 229, 76, 241, 242, 255, 259, 270, 274), bone health (n=8, 14%) (e.g. bone mineral density or content, bone length bone age) (243, 245, 246, 252, 253, 256, 227, 273), and blood and heart variables (n=6, 11%) (e.g. blood pressure, ventricular wall thickness) (228, 248, 261, 262, 264, 273). A variety of data collection techniques were deployed across the sub-topic with 34% (n=19) of studies using a stadiometer (for anthropometric measurements) (75, 229, 230, 236, 240, 76, 241, 248–250, 252–254, 256, 258, 260, 264, 272, 273), 20% (n=11) using timing gates (75,232,236–238,240,242,241,258,275,277), 18% (n=10) using a dynamometer (98,229,233,244,247,249,255,259,270,274) and 14% (n=8) using skinfold callipers (228,235,236,227,257,259,261,267). Studies measuring jump height and jump distance used optical measurement systems (e.g. photocells; n=12, 21%) (75,108,234,241,242,249,253,257,260,263,268,271), jump, contact or timing mats (n=6, 11%) (236,237,266,267,271,275) and force plates (n=3, 5%) (240,251,320).

The most common comparison group was age group with 50% (n=28) of studies comparing variables between at least two age groups (98,75,229,234,235,237–240,76,241,244,254–258,262–267,269,272,274–276). Of these, the U17 age category was the most common amongst studies (n=21), with U10 being the least, with only four studies included this age group (75,76,241,242). Two studies worth noting compared variables between seven (258) and eight (275) different age groups respectively. Findings of these studies have general consistency with youth male literature where jump height and jump distance has been demonstrated to increase across age groups (321–323). Further comparison groups include asymmetry (right and left, or dominant and non-dominant limb) (98, 108, 231, 232, 239, 244, 263, 265, 268, 270, 274) which was used in 20% (n=11) of studies, maturation stage (228,242,260,273) and playing level (230,236,267,269) were used in four different studies each. Five studies compared variables over a time period such as pre- and post-season and training period (241,246,261,277,276), all of these studies found significant changes in variables (increased performance) across their compared time period. Only two studies accounted for playing position (269,320), with significant differences in the explored variables only observed between outfield playing positions and goalkeepers.

A key limitation was that biological maturation of players over the period of data collection was often not considered. This was primarily due to studies using a cross-sectional design; therefore, it is important for future research to compare variables over time (e.g. pre- and post-season). Additionally, it is clear that more research on positional differences in anthropometric and physical characteristics is needed, as the only two studies which did take this approach had a low sample size (269,320) and so differences between outfield positions were difficult to determine. This may have implications for talent development and talent identification and recruitment practices.

2.3.3.6.2 Training Interventions

Of the seventeen studies investigating the efficacy of training interventions, participants were predominantly players competing in national competitions (n=9, 53%) (279,281,282,286,287,291,294,292,289), followed by regional competitions (n=5, 29%) (284,280,290,292,295), and local competitions (n=2, 12%) (288,293) (242, 245). Common outcome variables included, jump height and jump distance (n=12, 71%) (285,279–283,286–288,291,293,289), sprint time and sprint distance (n=11, 65%) (285,279,280,282–284,286,287,293,295,289), balance variables generated from the Y-Balance test (e.g. left and right posterolateral movement) (n=5, 29%) (281–283,286,291), power (W) (n=3, 18%) (285,279,290) and strength (n=1, 6%) (292). These variables were quantified using various equipment, the most common of which were timing gates (n=8, 47%) (279,282–284,286,289,293,295) and optoelectric cell systems (Optojump, Microgate, Bolzano, Italy) (n=6, 35%) (285, 280, 284, 286, 287, 316). Sport-specific items (i.e. footballs) were used in two studies (12%) (288,289) for kicking distance and kicking velocity to be quantified respectively.

Different intervention programs were used, including warm up and activation programs (n=4, 24%) (281, 283, 291, 294), injury prevention programs (n=2, 12%) (286, 293), transcranial direct current stimulations (n=1, 6%) (292) and sprint (n=5, 29%) (285, 284, 288, 290, 295), strength (n=4, 24%) (279, 282, 286, 290), jumping (n=1, 6%) (289) and football (n=1, 6%) (280) training programs. The intervention period for the majority of studies (n=11, 65%) lasted between 4-12 weeks (285, 279, 281, 283, 284, 286, 287, 290, 293, 295, 289), whilst three studies (18%) had a season-long intervention duration (280,282,291) and one (6%) was just 2-weeks (292). Most studies (n=12, 71%) compared an intervention group against a control group (280,281,283,284,286–288,290,291,293,294,289), others compared pre- vs post-intervention (n=5, 29%) (284,287,288,292,293) and others the effects of different types of training (n=3, 18%) (285,279,282). Twelve studies (71%) observed significant improvements in physical characteristics following an intervention (285,279–282,284,287–291). The other four either saw decrements or no significant changes in physical characteristics as a result of an intervention (283,288,293–295).

Studies which introduced an intervention alongside players current training made it difficult to determine the effects of the intervention in isolation (n=13, 76%) (280–289,291,293,294). Furthermore, studies which did not account for baseline fitness levels saw vast differences in individual player physical characteristics (n=3, 18%) (285,290,292). Therefore, future research should look to introduce interventions outside of players' usual playing seasons. This, alongside establishing baseline fitness levels of participants, may allow for more isolated differences to be established.

2.3.3.6.3 Relative Age Effects

Eighteen studies investigated relative age effect (RAE) of national (n=7, 39% (297,299–301,304,312,313)), international (n=5, 28% (298,300,305,306,308)), regional (n=7, 39% (296,302,303,309,311,313)) and local (n=3, 17% (303,310,311)) competitions, whilst playing standard could not be determined for one study (299). Studies predominantly conducted secondary analysis (n=16, 89%) using data from regional (n=2, (303,311)), national (n=10, (297,298,300–302,309,310,312,304)), continental (e.g., UEFA; n=1 (305)) or global governing bodies (i.e. FIFA; n=3 (306,307,324)). The remaining two studies conducted primary data analysis, utilising a questionnaire (no specific details provided), and anthropometric testing (296,299). The majority of studies (n=16, 89%) explored birth distribution using birth quartiles

(296–300,302,304–307,324,309–313) to investigate RAE, with half year birth distribution (n=6, 33%) (302–304,309–311), selection probability (n=2, 11%) (297,298) and predicted adult height (n=1, 6%) (296) used less frequently.

Age group was the most popular comparative group amongst studies (n=12, 66%) (296,298–300,304,309,312), followed by competitive level (e.g. regional, national, international etc.) (n=6, 33%) (297,299,300,309,311,313) and playing position (n=4, 22%) (298,307,309,324), two studies compared data between geographical location and it's relevant governing bodies (i.e. AFC, CONCAF, CONCACAF, CONMEBOL, OFC and UEFA) (307,324). Further Comparison Groups included: selection status (n=2, 11%) (296,303), maturity status (n=1, 6%) (299), year of competition (n=1, 6%) (306), success of team (n=1, 6%) (310) and chronological age (n=1, 6%) (311). RAE within different age groups (U12 to U19) were explored, with the most common being U17 (n=10, 56%) (298,301,302,305–307,309,312,313,324) and U19 (n=8, 44%) (298,300–302,305,309,310,313) players. However, no significant differences in RAE were determined between age groups in six studies (296,298,299,301,310,312). Eleven (61%) of the eighteen studies concluded there was a significant overrepresentation of players born in the first half of the year (birth quartiles Q1 and Q2) (298,302–307,309,311,313,324) compared to the second half (Q3, Q4). However, this was not consistent across age groups, as five studies (296,300,301,310,312) found no significant RAEs within the population (296,300,301,310,312). The lack of significance in findings could be due to these studies choosing to only assess the RAE in older age groups. Females tend to mature at a faster rate compared to males, and so age-related differences which can directly affect selection rate may be less pronounced in older age groups (325). Albeit, the two studies which assessed younger age groups (U12, (296,299); U13; (296), observed no RAE. However, these only investigated national players within two isolated countries (Canada, Spain). Future research should focus on investigating RAE across age groups, considering whether patterns exist in geographical location (e.g., regional, country, continental). Future insights into RAE can help practitioners to mitigating biases in selection processes, which often occur with youth male players (326), therefore developing a more equitable system for supporting the talent development of youth female players.

2.3.3.6.4 Testing

Testing studies (n=7) assessed the reliability and validity of fitness tests, equipment and data collection techniques. Five studies (71%) assessed performance tests (e.g., multi-stage fitness test (314), side-hop test (315), anaerobic sprint test (109) jumping, sprinting and agility tests (317,318)). One study assessed the validity of an inertial measurement system (Gyko, Microgate, Italy) and force plate (1000Hz, Kistler, Switzerland) to determine performance changes across a season (316). One study determined differential RPE scales were reliable for measurement of training and match load (319). Despite a variety of testing aims being presented, studies (n=3) used age group as the comparative group (315,317,318), whilst two studies presented the data collection technique used as the comparative group (314,316). Playing status (109) and training type (319) were stand-alone Comparison Groups among the other two studies. None of the seven studies (where it was applicable) used playing position as a comparative group, this was reported to be the result of having a limited sample size by four studies (314,109,316,77). Multiple studies only included one age group (314,109,316,77), which results in difficulty generalising findings to the wider youth female football population. Further limitations of studies included assumptions made on limb dominance (315), an inability to determine maximum effort from participants in fitness tests (318) and for the study assessing equipment validity, the inertial measurement device was not intended for stand-alone use and so findings may be inaccurate (316). Future research should aim to adopt a larger sample size and include competitive standard, age group, playing position as comparative groups in order to determine differences across the youth female football population.

2.3.3.7 Psychology

In total, twenty-eight studies investigated psychology surrounding youth female footballers (Supplementary Material Table 7) (327–354). Of these, 50% (n=14) recruited participants of a regional playing standard (329–331, 333, 335–337, 342, 344, 346, 350–352, 354)*,* 21% (n=6) were national standard (336, 327, 328, 338, 339, 349)*,* whilst local (n=3, 11%) (332, 343, 345) and international (n=3, 11%) (341, 340, 347) players were equally represented. Three studies (11%) did not state the playing standard of participants (334, 348, 353).

Studies that focused on psychological topics most frequently examined motivational climate (n=6, 21%) (342,344,343,341,340,347) and motor development and cognitive function (n=7, 25%) (335,336,327,328,339,334,348)*.* As a result, most outcome variables were psychometric scales representing anxiety (329,344,351,352,338), moral functioning (354,341,353), leadership (332,349), self-confidence (329,344), and self-talk (329,330)*.* These latent constructs were operationalised using several different questionnaires and scales such as; The Psychological Skills Inventory motivation subscale (334,355), Perceived Motivational Climate in Sport Questionnaire (356) (342,344,352,341,340,347), and the Task and Ego Orientation in Sport Questionnaire (329,330,354,353,357) to measure motivational constructs. The

Go/No-Go Task (327,328,358) was used to measure variables representing motor development (e.g., reaction time to determine impulsiveness). Outcome variables were most commonly compared across age group (n=5, 18%) (328,333,338,339,353), time period (e.g. pre- and post-game) (n=4, 14%) (327,331,333,345) and game or session stage (n=3, 11%) (335,350,351).

Studies exploring cognitive function and motor development assessed improvements in cognitive function over time (327), creating a valid soccer competence scale (334) and exploring motor performance as a predictor for footballing success in adulthood (339). Therefore, comparisons cannot be made as they deal with distinct topics. Contrastingly, studies exploring motivational climate are more comparable, with most establishing relationships between motivational climate and other characteristics and traits such as cognitive anxiety (344), peer acceptance (347), and sporting behaviour (340), determining that higher levels of intrinsic or self-determined motivation are positively related to biopsychosocial outcomes of football involvement. Multiple age groups were involved in five (28%) studies (333,328,338,339,353), however direct comparisons between them were only made in two. Beavan et al. concluded age had a negatively accelerated relationship with executive functions, and also determined that the likelihood to aggress increased across age groups (328).

None of the 28 studies used a control group of a non-athletic comparison group to establish psychological changes due to engaging in playing football or a football related training program or intervention. Therefore, future research could consider comparative designs to establish the differences or similarities between female footballers and their non-sporting or other sporting peers. To a similar end, a more consistent approach to examining age related differences would establish developmental changes in the psychological profile of the female footballer. Lastly, future research could explore performance-related psychological variables, such as visual exploratory activity (VEA) of players during training or matches (359) and explore whether VEA of youth female football players may differ according to age group, playing position or the influence of contextual factors (e.g., pitch location). This may have implications for talent identification and development practices, as well as informing training design and delivery.

2.3.3.8 Training Load

Only four studies quantified the training load of youth female footballers (Supplementary Material Table 8 (59–62)). These studies involved participants competing in national competitions (59,60), Rumpf et al. also included local and regional players (61), whilst Williams et al. only included regional players (62). The four studies had distinct aims for investigating training load within youth female football, including; describing seasonal variations in training, anthropometry, body composition and physical fitness (59), investigating training profiles and motivation across different age groups and competitive standards (61), determining the prevalence of non-functional overreaching and overtraining in elite youth players (62) and comparing the influence of obstacles in SSGs on tactical, physical and emotional responses of players (60). Consequently, methodological approaches for data collection and outcome variables varied across the four studies. Given the size of the current training load evidence base, and the range of aims, methodological techniques and findings, it is difficult to interpret and summarise this area of literature on youth female football. As such, the focus for future research is broad. Further research needs to develop our understanding of the training demands in different age groups and competitive standards within youth female football environments (319). Further, it is important to understand how representative these training environments are to competition or whether they are providing sufficient stimulus for physiological adaptations and athletic development, and therefore similar metrics should be investigated to those quantified for understanding the demands of match-play (69,72,71). Further, understanding whether training demands are appropriately preparing players for transitioning between youth age groups (e.g., given the age-related increases in match demands within youth female football (69,72)) or into senior female football environments (51,56–58). Lastly, investigating how training demands may differ according to drill type (as opposed to simply quantifying whole-session demands), could help coaches inform the design and delivery of activities within training sessions (e.g., age group specific benchmarks) (57).

2.3.4 Conclusion

This scoping review identified 241 studies investigating the performance, health and development of youth female footballers, categorising them into eight sports science and medicine topics: biomechanics, fatigue and recovery, injury, match-play, nutrition, physical qualities, psychology, and training load. Physical qualities were the most studied (n=98, 41%), though future research should address positional differences and age-specific RAE. Injury (n=41, 17%) was also a well-covered topic, yet gaps remain in understanding how factors like playing standard and fitness level affect injury risk. Biomechanics studies (n=32, 13%) focused on jumping, cutting, and landing in lab settings, highlighting the need for field-based research, to facilitate the translation of findings to real playing scenarios. Psychology studies (n=28, 12%) examined motivation and cognitive function but lacked non-athletic control groups, which may facilitate the assessment of psychological changes which occur from engaging in playing football. Match-play (n=17, 7%) covered a range of topics (e.g. heading and physical and technical characteristics), however future research in this area should consider the influence of task constraints and adopt more appropriate positional categories to ensure more specific differentiation between them. Nutrition (n=12, 5%) relied heavily on self-reporting (e.g. food diaries), suggesting a need for objective tracking of nutritional intake and larger sample sizes. Fatigue and recovery studies (n=9, 4%) lacked context on relative workload covered prior to and during data collection, as well as age-related physical differences. Training load (n=4, 2%) was the least developed topic, emphasising the need for further investigation to develop this evidence base and inform practice.

2.3.5 Implications for Next Chapter

The current chapter has highlighted research topics which are currently underdeveloped. Despite the recent increase in volume of studies regarding youth female footballers, training load was found to be the least explored, with only four studies, of which the aims and objectives are varied. Furthermore, the quantification of external load variables has not yet been adopted to understand training load. At present, practitioners working with youth female football players often draw findings from youth male literature to inform their practices. This is inappropriate due to the differences in physical capability and context in which they train. Therefore, Chapter 3 intends to contribute to this underdeveloped area of youth female literature by quantifying the external load of youth female footballers during training.

Chapter 3: Drill-Specific and Training Session Physical Characteristics of Youth Female Footballers

The data presented in this chapter has been submitted for peer-reviewed publication:

Harkness-Armstrong, A., Adams, T., Lewis, T., Waterworth, S., Lowry, R., & Datson, N. Session and drill-specific physical characteristics of youth women's football training. Under review. *J Sports Sci.*

3.1 Abstract

The aim of this study was to quantify the physical training characteristics of U10, U12, U14 and U16 youth female footballers and present whole session and drill-specific data to establish whether age group differences exist. Data was collected using 10 Hz GPS units over three four-week periods, where 885 player observations were made across 80 training sessions involving 116 total players from The FA's ETCs. Both whole session and drill-specific data was reported as absolute and relative; total distance (TD), high-speed running (HSR; >3.00 $m \cdot s^{-1}$), very high-speed running (VHSR; >4.83 $m \cdot s^{-1}$) and sprinting (SPR; >5.76 $m \cdot s^{-1}$) distances (m), and maximum velocity ($m \cdot s^{-1}$). The frequency of accelerations and decelerations (>1 $m \cdot s^{-2}$, >2 $m \cdot s^{-2,}$ >3 $m \cdot s^{-2}$) were recorded. Two linear mixed models were developed to quantify differences in physical variables during training sessions and drills. Across whole sessions, U16s covered more TD than U14s, both U14s and U16s covered greater absolute; HSR distance, VHSR distance and SPR distance compared to U10s and U12s. Drill specific differences within age groups revealed that all age groups covered greater TD and HSR distance during SSGs compared to possession and technical drills. Between age groups, U14s were found to cover more TD, HSR distance and VHSR distance during SSGs than U10s and U12s. During technical drills, U16s covered more TD than all other age groups. During possession drills, U12s covered more TD than U14s, however U14s covered greater VHSR distance than U10s and U12s. The findings from this research may be utilised by practitioners to inform current youth training practices. Future research should consider exploring the influence of playing position on training demands.

3.2 Introduction

The quantification of physical training characteristics has become increasingly important for optimising performance in football (360). Understanding how physical demands differ between different playing settings and activities can assist practitioners in developing effective training practices, periodisation plans and rehabilitation programmes (39,40). Previous research has quantified physical training characteristics of female football training for whole sessions (361) and drills (57). It is important to capture external load across both to facilitate whole session and drill-specific comparisons to understand the impact of contextual differences such as drill-type and task constraints. Most studies to date have predominantly focused on variables such as total distance (TD) and distance covered at different running velocities (e.g. high-speed running, very high-speed running, sprinting) (57, 58, 361). While some research has examined factors influencing external load (e.g. maturation stage or age group (242) and drill type (drill constraints)) (57), this has only been explored within senior populations.

The previous chapter outlined the current evidence base regarding youth female footballers. Of the eight research topics investigating sports science and medicine in youth female football, training load was the least populated, consisting of only four studies with distinctly different focus (i.e., seasonal changes in anthropometric and physical qualities (59), acute tactical, conditional and emotional responses to drill manipulations (60), age group and competitive standard motivation and training profiles (61), prevalence of non-functional overreaching and overtraining (62)). Furthermore, it should be noted that methodological approaches differed between studies, with only one utilising GPS as method of data collection (60). As a result, the inconsistency of the current studies regarding training load makes it more difficult to interpret the findings and draw evidence from for practitioners. Therefore, it is difficult for practices to be informed from the findings of these studies. As a result, practitioners working with youth female football populations often use evidence derived from other populations (e.g. senior female or youth male) to inform practices, which is inappropriate due to population differences (physiological, biomechanical etc.) (362,363), as well as contextual differences (e.g. training structure, provision and support etc.) (364). Consequently, it means that youth female footballers may not be receiving the appropriate support needed to assist their development both physically and technically. Therefore, research is warranted which quantifies the training characteristics of youth female footballers.

Due to the current lack of literature regarding training characteristics of youth female footballers, little is known of age group specific training characteristics. Understanding how training characteristics may differ between age groups can assist practitioners in informing the design and delivery of training, supporting player progression across age groups, and facilitating smoother transitions of youth players into senior football. More specifically, an understanding of how training characteristics differ across whole training sessions and between drills can further assist these applications and is important information for practitioners when designing age-appropriate training practices. Therefore, there is a need to establish a data set from which practitioners can draw from to gain insight into age group, session and drill specific differences in youth female footballers. Thus, the present study aimed to quantify and compare session and drill-specific external load of U10, U12, U14 and U16 youth female football training.

3.3 Methods

3.3.1 Participants

A total of 116 outfield youth female footballers from U10 (n = 15; height: 1.42 ± 0.11 m; body mass: 34.8 ± 11.8 kg), U12 (n = 40; height: 1.51 ± 0.12 m; body mass: 42.9 ± 17.0 kg), U14 (n = 39; height: 1.61 ± 0.10 m; body mass: 54.1 ± 20.6 kg) and U16 (n = 22; height: 1.68 ± 0.17 m; body mass: 60.3 ± 12.4 kg) age groups were recruited from two of The FA's ETCs. Age groups were based upon players' chronological age. Players in the ETCs received a minimum of one 1.5hr training session per week, and participated in a dedicated fixture programme which included a minimum of one competitive game every six-weeks (7). The study received ethics approval from The University of Essex Research Ethics Committee (reference ETH2324-0051) and all players (and parents/guardians) provided written informed assent (and consent for parents/guardians) before participation.

3.3.2 Procedures

An observational study design was conducted, in which data were collected from 80 training sessions (U10 n=12; U12 n=23; U14 n=24; U16 n=21) across three four-week periods during the 2023-24 season (January 2024 to May 2024). All training sessions were scheduled for a 90-minute duration (mean duration = 88.6 ± 7.2 mins) and were delivered on artificial turf. Both ETCs delivered multiple training sessions simultaneously on the same pitch and therefore had restricted pitch dimensions (ETC 1: four age groups with pitch dimensions not exceeding a quarter of the pitch, 37 x 27m; ETC 2: three age groups with pitch dimensions not exceeding half of the pitch, 55 x 37m). A total of 885 player observations were obtained (U10: n=148; mean per player = 9.3 ± 2.8; range = 1 - 12; U12: n=338; mean per player = 8.7 ± 2.5; range = 1 - 12; U14: n=314; mean per player = 8.5 ± 3.0; range = 1 - 12; U16: n=85; mean per player = 4.5 ± 3.7; range = 1 - 12).

Data were collected using 10Hz global positioning system units (GPS; Apex Pro, STATSports, Newry, Northern Ireland). These GPS units have previously been found to be valid and reliable in quantifying external load within team sports, demonstrating good-excellent inter-unit intraclass corelation coefficient (ICC) reliability for total distance (ICC = 0.999) and high-speed running distance (ICC = 0.974) as well as peak velocity (ICC = 0.98) (27,28). The GPS units were activated before being inserted into a pouch located on the upper back of purpose made vests. Data were downloaded post-training via Sonra software (v2.1.4, STATSports, Newry, Northern Ireland). The start and end of the training session and individual drills were identified, and raw GPS data files of player observations for the training session and each individual drill were exported for subsequent data analysis in RStudio (v4.4.1; RStudio Team, 2018).

The categorisation of individual drills was informed by previous research (57,365,366). Warm-up drills, possession drills (defined as having no goals/targets in which retention of possession rather than scoring is the primary objective), small-sided games (SSGs; defined as a match played realistic to regulations rules, with a reduced number of players and both teams scoring in the same way), technical drills (defined as individual or group drills isolating technical skills in a limited or no-pressure environment), and match simulations were observed across the training sessions. However, warm-up drills were excluded from the analysis due to the focus of research being on capturing drills that made up the main body of training sessions. Competitive match simulations were also excluded due to the low number of drill observations. A total of 2,373 drill observations were obtained (U10: n=351; mean per player = 23.4 ± 5.7; range = 10 -

30; U12: n=984; mean per player = 25.9 $\pm$ 6.9; range = 4 - 35; U14: n=854; mean per player = 23.7 $\pm$ 8.5; range = 1 - 38; U16: n=184; mean per player = 12.3 $\pm$ 8.2; range = 2 - 26).

Physical variables for individual player session and drill observations were quantified; total distance (TD), high-speed running (HSR; >3.00 $m \cdot s^{-1}$), very high-speed running (VHSR; >4.83 $m \cdot s^{-1}$) and sprinting (SPR; >5.76 $m \cdot s^{-1}$) distances (m), and maximum velocity ($m \cdot s^{-1}$). The velocity thresholds used in the current study have previously been established for application with youth female football players (78). Frequency of accelerations (n) and decelerations (n) in three different zones were also quantified. An acceleration (deceleration) was defined as an increase (decrease) in velocity that exceeds 1 $m \cdot s^{-2}$ (or 2 $m \cdot s^{-2}$ or 3 $m \cdot s^{-2}$) for a minimum duration of 0.5s. There is currently no standardised or recommended approach for the quantification of acceleration and decelerations within (youth) female football. Relative data were also presented to facilitate comparisons between observations with differing session and drill durations.

Prior to data analysis, a data filtering process identified and removed session and drill observations which consisted of greater than 3% of missing or erroneous data (78), which included raw data with; insufficient satellite connection (<8 satellites), low HDOP quality (≥2.0), or velocity data which exceeded the realistic capabilities of youth female football players (8.26$m \cdot s^{-1}$ (78)). Thus, a total of 7% of individual session observations (U10 = 9.5%; U12 = 8.3%; U14 = 3.8%; U16 = 7.1%), and 3.2% of drill observations (U10 = 2.3%; U12 = 2.8%; U14 = 3.6%; U16 = 4.4%) were excluded. This resulted in a total of 825 player session observations and 2,298 drill observations included for data analysis (Table 3.1).

Table 3.1. Total number of session and drill observations, and mean ± SD (and range) number of observations per player, according to age group, included in the dataset for analysis.

	Observations (n)	U10	U12	U14	U16	Total
Session	Total observations	134	310	302	79	825
	Observations per player	8.4 ± 3.0 (1 – 11)	7.9 ± 2.6 (1 – 11)	8.4 ± 3.0 (2 – 12)	4.4 ± 3.7 (1 – 12)	7.6 ± 3.3 (1 – 12)
Drill	Total observations	343	956	823	176	2298
	Observations per player	22.9 ± 6.1 (8 – 30)	25.2 ± 6.9 (4 – 35)	22.9 ± 8.4 (1 – 37)	11.7 ± 8.3 (1 – 26)	22.1 ± 8.6 (1 – 37)
Drill-Specific Observations						
Possession	Total observations	135	368	312	18	833
	Observations per player	9.0 ± 2.3 (4 – 12)	9.7 ± 3.34 (3 – 15)	9.2 ± 4.0 (4 – 17)	1.4 ± 0.9 (1 - 4)	8.3 ± 4.2 (1 – 17)
SSG	Total observations	122	230	271	97	720
	Observations per player	8.1 ± 2.6 (2 – 11)	6.2 ± 3.1 (2 – 12)	7.7 ± 2.7 (2 – 12)	6.9 ± 5.3 (1 – 15)	7.2 ± 3.4 (1 – 15)
Technical	Total observations	86	358	240	61	745
	Observations per player	5.7 ± 1.5 (2 - 7)	9.4 ± 3.4 (1 – 15)	6.7 ± 3.1 (1 – 11)	4.4 ± 2.7 (1 – 9)	7.4 ± 3.4 (1 – 15)

3.3.3 Statistical Analysis

Statistical analyses were conducted using RStudio (RStudio Team, 2018). Two linear mixed models (lme4 package) were developed to quantify differences in physical variables during training sessions and drills. For both linear mixed models, the assumptions of linearity and normality of distributions were checked visually. Homogeneity of variance was assessed using Levene's Test ($p \geq 0.05$). The first model quantified external load for training sessions, and included; a physical variable (e.g., TD, HSR) as a dependent variable, age group (U10, U12, U14 or U16) as a fixed effect, with club, player and session IDs as random effects. The second model quantified external load for drills, and included; a physical variable as dependent variable, age group and drill category (possession, SSG, technical) as fixed effects, and club, player, and drill IDs as random effects.

Estimated means (± SE) were derived from the respective model for each physical variable (emmeans package). Tukey's pairwise comparisons were conducted to determine differences between levels of fixed effects within respective models. Statistical significance was set at $p \leq 0.05$ for pairwise comparisons. Effect size (ES) was calculated (effsize package), and categorised as trivial (<0.2), small (0.2-0.59), moderate (0.6-1.19), large (1.2-1.99) or very large (≥2.0). If 90% confidence intervals included substantial (<0.2) positive and negative values, effects were considered unclear.

3.4 Results

3.4.1 Training Sessions

3.4.1.1 Training Sessions: Absolute Data

The absolute physical variables for each age group are presented in Table 3.2. The age group comparisons (statistical significance and ES) are presented in Figure 3.1.

Table 3.2. Estimated mean ± SE of absolute physical training characteristics of U10, U12, U14, and U16 youth female football players.

Variable (mean ± SE)	U10 (n=134)	U12 (n=310)	U14 (n=302)	U16 (n=79)
TD (m)	3639.9 ± 255.5	3594.1 ± 202.4	3429.9 ± 201.5	3849.6 ± 227.6
HSR Distance (m)	543.7 ± 97.5	478.7 ± 81.1	639.4 ± 81.04	692.9 ± 90.1
VHSR Distance (m)	37.7 ± 19.6	28.2 ± 18.1	78.0 ± 18.1	73.7 ± 18.9
SPR Distance (m)	10.7 ± 8.5	4.6 ± 7.8	23.3 ± 7.8	26.4 ± 8.2
Maximum Velocity ($m\cdot s^{-1}$)	5.56 ± 0.26	5.58 ± 0.24	6.20 ± 0.24	6.45 ± 0.26
Accelerations ≥1$m\cdot s^{-2}$ (n)	48.3 ± 3.2	42.3 ± 2.2	42.4 ± 2.2	46.4 ± 3.0
Decelerations ≥1$m\cdot s^{-2}$ (n)	55.1 ± 3.6	41.8 ± 2.4	42.9 ± 2.5	46.6 ± 3.4
Accelerations ≥2$m\cdot s^{-2}$ (n)	5.55 ± 0.59	5.15 ± 0.41	5.45 ± 0.41	6.54 ± 0.58
Decelerations ≥2$m\cdot s^{-2}$ (n)	0.70 ± 0.10	0.53 ± 0.07	0.59 ± 0.07	0.67 ± 0.11
Accelerations ≥3$m\cdot s^{-2}$ (n)	0.41 ± 0.06	0.36 ± 0.04	0.43 ± 0.04	0.46 ± 0.08
Decelerations ≥3$m\cdot s^{-2}$ (n)	0.70 ± 0.10	0.53 ± 0.07	0.59 ± 0.07	0.67 ± 0.11

U16s covered more TD (420m; moderate ES: 0.95 ± 0.49) compared to U14s, and HSR distance than U10s (149m; moderate ES: 1.01 ± 0.61) and U12s (214m; $p<0.05$; large ES: 1.46 ± 0.51). U14s also covered more HSR distance than U12s (160m; moderate ES: 1.09 ± 0.43). U16s covered greater VHSR distance than U10s (36m; $p<0.05$; large Es: 1.36 ± 0.48) and U12s (46m; $p<0.001$; large ES: 1.71 ± 0.40). U14s also covered more VHSR distance than U10s (40m; $p<0.01$; large ES: 1.52 ± 0.45) and U12s (50m; $p<0.001$; large ES: 1.88 ± 0.33). U14s and U16s covered greater SPR distance than U10s (U14: 12.62m; moderate ES: 1.14 ± 0.48; U16: 16m; $p<0.05$; large ES: 1.42 ± 0.51) and U12s (U14: 9m; $p<0.001$; large ES: 1.69 ± 0.36; U16: 22m; $p<0.001$; large ES: 1.97 ± 0.43).

U16s achieved a higher Vmax than all other age groups (U10: 0.89 $m \cdot s^{-1}$; $p<0.001$; very large ES: 2.16 ± 0.45; U12: 0.88 $m \cdot s^{-1}$; $p<0.001$; very large ES: 2.12 ± 0.37; U14: 0.25 $m \cdot s^{-1}$; moderate ES: 0.6 ± 0.37). U14s achieved a higher Vmax than both U10s (0.64 $m \cdot s^{-1}$; large ES: 1.56 ± 0.41) and U12s (0.63 $m \cdot s^{-1}$; large ES: 1.52 ± 0.31).

U10s performed more accelerations ($\geq 1 m \cdot s^{-2}$) than U12s (5.97; moderate ES: 0.62 ± 0.41) and U14s (5.92; moderate ES: 0.61 ± 0.41). U16s performed more accelerations ($\geq 2 m \cdot s^{-2}$) than all other age groups (U10: n = 1.00; small ES: 0.39 ± 0.30; U12: n = 1.39; small ES: 0.55 ± 0.26; U14: n = 1.10; small ES: 0.43 ± 0.26). There were no differences observed between age groups in the number of accelerations ($\geq 3 m \cdot s^{-2}$).U10s performed more decelerations ($\geq 1 m \cdot s^{-2}$) than all other age groups (U12: n = 13.26; $p<0.05$; large ES: 1.31 ± 0.43; U14: n = 12.17; $p<0.05$; large ES: 1.20 ± 0.43; U16: n = 8.51; moderate ES: 0.84 ± 0.48) players. U10s also performed more decelerations than U12s at $\geq 2 m \cdot s^{-2}$ (n = 0.17; small ES: 0.22 ± 0.16) and $\geq 3 m \cdot s^{-2}$ (n = 0.17; small ES: 0.22 ± 0.16).

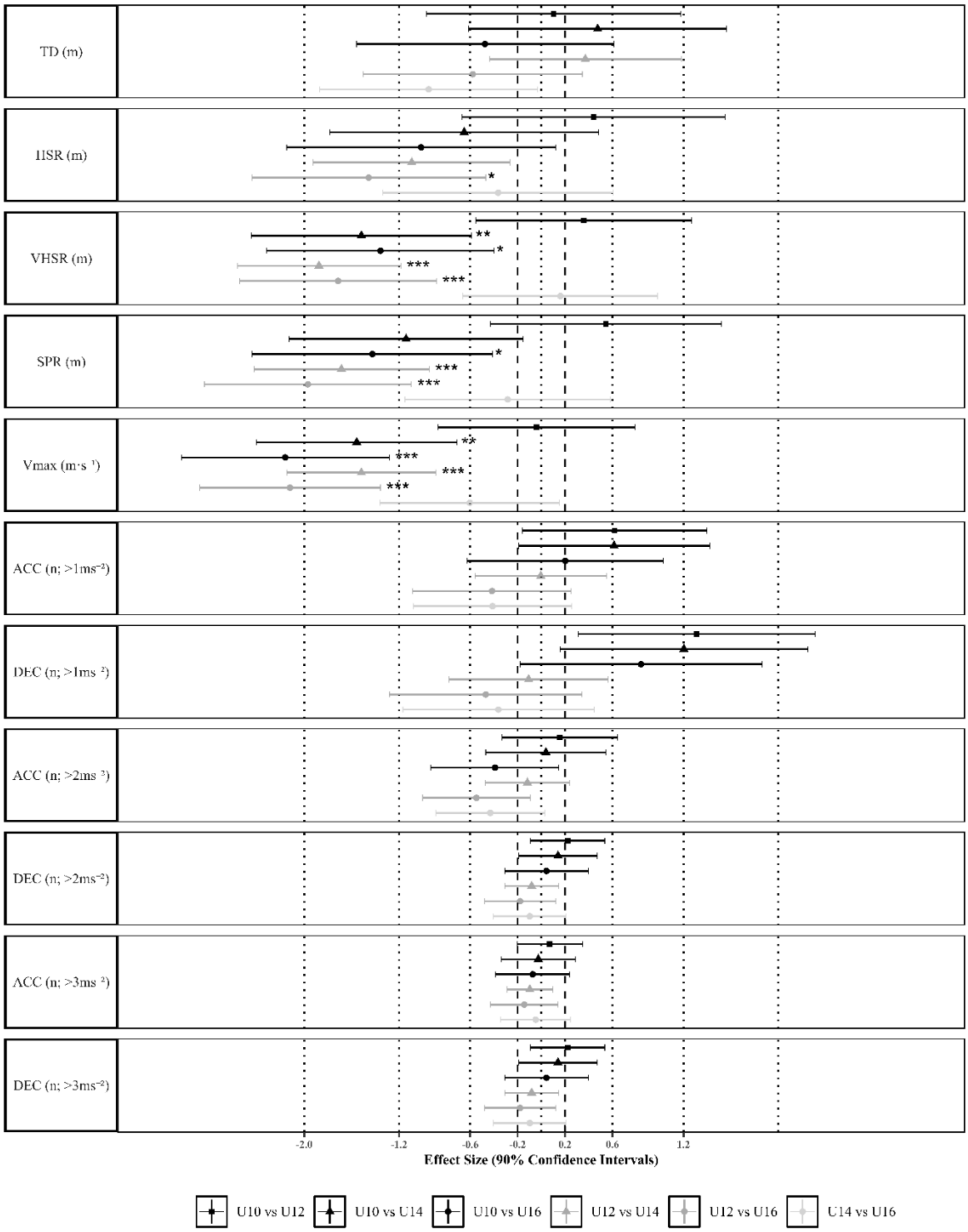

Figure 3.1. Effect size of differences in estimated mean and statistical significance of total distance (TD), high-speed running (HSR), very high-speed running (VHSR), and sprinting distances covered, and maximum velocity (Vmax), number of accelerations (ACC) and decelerations (DEC) performed during training sessions between U10, U12, U14 and U16 youth female footballers. **Statistically significant difference ($p < 0.05$*, $p < 0.01$**, $p < 0.001$***).*

3.4.1.2 Training Sessions: Relative Data

Table 3.3 presents the estimated mean for relative physical variables of all age groups across whole training sessions. The age group comparisons (statistical significance and ES) are presented in Figure 3.2.

Table 3.3. Estimated mean ± SE of relative physical training characteristics of U10, U12, U14, and U16 youth female football players.

Variable	U10 (n=134)	U12 (n=310)	U14 (n=302)	U16 (n=79)
TD ($m \cdot min^{-1}$)	39.79 ± 2.30	42.44 ± 1.62	41.32 ± 1.60	44.88 ± 2.02
HSR Distance ($m \cdot min^{-1}$)	5.86 ± 1.03	5.69 ± 0.78	7.77 ± 0.78	8.22 ± 0.91
VHSR Distance ($m \cdot min^{-1}$)	0.39 ± 0.21	0.33 ± 0.19	0.95 ± 0.19	0.88 ± 0.20
SPR Distance ($m \cdot min^{-1}$)	0.12 ± 0.09	0.05 ± 0.09	0.27 ± 0.09	0.31 ± 0.09
Accelerations ≥1$m \cdot s^{-2}$ ($n \cdot min^{-1}$)	0.52 ± 0.04	0.50 ± 0.03	0.51 ± 0.03	0.54 ± 0.04
Decelerations ≥1$m \cdot s^{-2}$ ($n \cdot min^{-1}$)	0.62 ± 0.04	0.49 ± 0.03	0.51 ± 0.03	0.54 ± 0.04
Accelerations ≥2$m \cdot s^{-2}$ ($n \cdot min^{-1}$)	0.06 ± 0.01	0.06 ± 0.01	0.07 ± 0.01	0.08 ± 0.01
Decelerations ≥2$m \cdot s^{-2}$ ($n \cdot min^{-1}$)	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00
Accelerations ≥3$m \cdot s^{-2}$ ($n \cdot min^{-1}$)	0.01 ± 0.00	0.00 ± 0.00	0.01 ± 0.00	0.01 ± 0.00
Decelerations ≥3$m \cdot s^{-2}$ ($n \cdot min^{-1}$)	0.01 ± 0.00	0.01 ± 0.01	0.01 ± 0.00	0.01 ± 0.00

U16s covered more TD than U10s (5.09 $m \cdot min^{-1}$; moderate ES: 0.98 ± 0.58) and U14s (3.6 $m \cdot min^{-1}$; moderate ES: 0.68 ± 0.49). U14s and U16s covered more HSR distance compared to U10s (U14: 1.91 $m \cdot min^{-1}$; moderate ES: 1.06 ± 0.58; U16: 2.36 $m \cdot min^{-1}$; large ES: 1.31 ± 0.62) and U12s (U14: 2.08 $m \cdot min^{-1}$; $p<0.05$; moderate ES: 1.15 ± 0.44; U16: 1.53 $m \cdot min^{-1}$; $p<0.05$; large ES: 1.40 ± 0.52). U14s and U16s covered more VHSR distance compared to U10 (U14: 0.56 $m \cdot min^{-1}$; $p<0.01$; large ES: 1.63 ± 0.44; U16: 0.49 $m \cdot min^{-1}$; $p<0.05$; large ES: 1.42 ± 0.48) and U12s (U14: 0.62 $m \cdot min^{-1}$; $p<0.001$; large ES: 1.81 ± 0.33; U16: 0.55 $m \cdot min^{-}1$; $p<0.001$; large ES: 1.60 ± 0.40). U14s and U16s covered greater SPR distance compared to U10s (U14: 0.15 $m \cdot min^{-1}$; moderate ES: 1.19 ± 0.46; U16: 0.19 $m \cdot min^{-1}$; $p<0.05$; large ES: 1.47 ± 0.50) and U12s (U14: 0.22 $m \cdot min^{-1}$; $p<0.001$; large ES: 1.69 ± 0.35; U16: 0.26 $m \cdot min^{-1}$; $p<0.001$; large ES: 1.97 ± 0.41).

U16s performed more accelerations (≥2$m \cdot s^{-2}$) than all other age groups (U10: 0.02 $n \cdot min^{-1}$; small ES: 0.56 ± 0.28; U12: 0.02 $n \cdot min^{-1}$; small ES: 0.55 ± 0.24; U14: 0.01 $n \cdot min^{-1}$; small ES: 0.38 ± 0.24). U10s performed more decelerations (≥1$m \cdot s^{-2}$) than all other age groups (U12: 0.12 $n \cdot min^{-1}$; $p<0.05$; moderate ES: 1.04 ± 0.38; U14: 0.11 $n \cdot min^{-1}$; moderate ES: 0.90 ± 0.39; U16: 0.07 $n \cdot min^{-1}$; moderate ES: 0.63 ± 0.44). No differences between age groups were observed in the number of accelerations (≥1$m \cdot s^{-2}$; ≥3$m \cdot s^{-2}$) or decelerations (≥2$m \cdot s^{-2}$; ≥3$m \cdot s^{-2}$) performed.

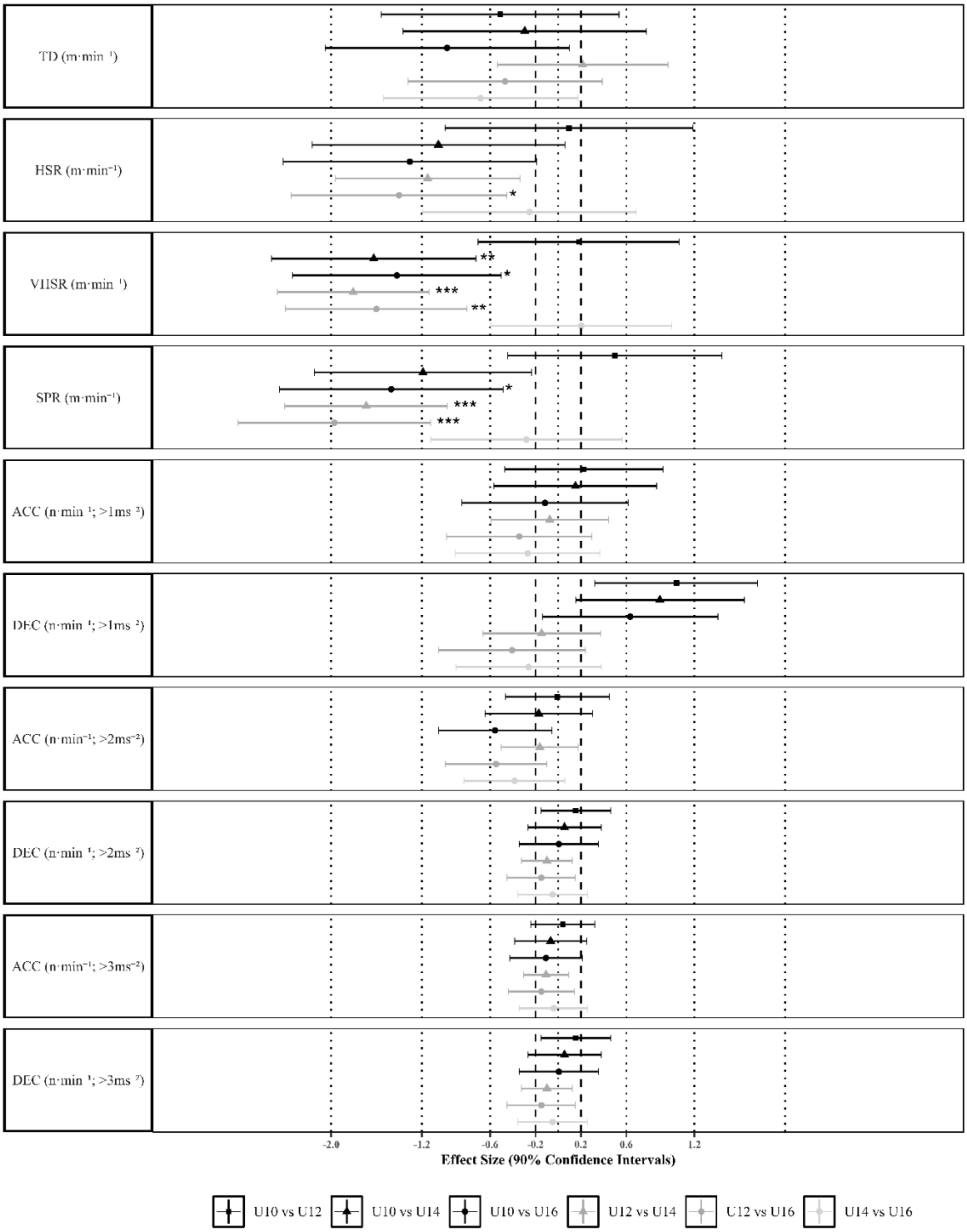

Figure 3.2. Effect size of differences in estimated mean and statistical significance of relative total distance (TD), high-speed running (HSR), very high-speed running (VHSR) and sprinting (SPR) distances covered, number of accelerations (ACC) and decelerations (DEC) performed during training sessions between U10, U12, U14 and U16 youth female footballers. **Statistically significant difference (p < 0.05*, p < 0.01**, p < 0.001***).*

3.4.2 Training Drills

The relative external load for each age group according to the training drill is presented in Table 3.4. The comparisons within age groups are presented in Figure 3.3A (U10s and U12s) and Figure 3.3B (U14s and U16s), and comparisons between age groups are presented in Figure 3.4.

Table 3.4. Estimated mean + SE of relative physical training characteristics across training drills for U10, U12, U14 and U16 age groups.

	U10			**U12**			**U14**			**U16**		
	POS	TEC	SSG	POS	TEC	SSG	POS	TEC	SSG	POS	TEC	SSG
TD ($m \cdot min^{-1}$)	47.2 ± 4.9	34.1 ± 5.6	52.4 ± 5.1	52.2 ± 2.7	40.8 ± 2.7	56.9 ± 3.3	45.1 ± 2.8	42.2 ± 3.1	64.3 ± 2.9	50.1 ± 5.6	52.1 ± 4.0	60.6 ± 3.4
HSR ($m \cdot min^{-1}$)	5.39 ± 2.06	1.74 ± 2.31	6.19 ± 2.12	6.42 ± 1.25	7.17 ± 1.25	7.50 ± 1.43	8.26 ± 1.25	8.09 ± 1.38	14.44 ± 1.28	8.36 ± 2.32	12.42 ± 1.73	12.76 ± 1.50
VHSR ($m \cdot min^{-1}$)	0.21 ± 0.25	0.14 ± 0.28	0.32 ± 0.26	0.29 ± 0.20	0.33 ± 0.20	0.26 ± 0.21	0.52 ± 0.20	0.79 ± 0.21	1.21 ± 0.20	0.43 ± 0.33	0.95 ± 0.22	0.80 ± 0.25
Vmax ($m \cdot s^{-1}$)	4.58 ± 0.23	3.87 ± 0.26	4.76 ± 0.23	4.75 ± 0.18	4.76 ± 0.18	4.89 ± 0.20	4.90 ± 0.18	4.88 ± 0.19	5.43 ± 0.19	4.88 ± 0.29	5.12 ± 0.22	5.58 ± 0.20
Acc ≥1$m \cdot s^{-2}$ ($n \cdot min^{-1}$)	0.70 ± 0.09	0.57 ± 0.10	0.70 ± 0.09	0.64 ± 0.07	0.54 ± 0.07	0.63 ± 0.07	0.66 ± 0.07	0.58 ± 0.07	0.70 ± 0.07	0.77 ± 0.12	0.67 ± 0.09	0.63 ± 0.08
Dec ≥1$m \cdot s^{-2}$ ($n \cdot min^{-1}$)	0.84 ± 0.09	0.62 ± 0.10	0.78 ± 0.09	0.65 ± 0.06	0.56 ± 0.06	0.62 ± 0.06	0.67 ± 0.06	0.56 ± 0.06	0.74 ± 0.06	0.79 ± 0.12	0.60 ± 0.08	0.71 ± 0.07

POS = Possession based drill; TECH = Technical drill; SSG = Small sided game.

3.4.2.1 Training Drills: Within Age groups

During possession drills, U10s covered more TD (13.10 $m \cdot min^{-1}$; large ES: 1.43 ± 0.61), HSR distance (3.65 $m \cdot min^{-1}$; moderate ES: 0.96 ± 0.59), achieved a higher Vmax (0.71 $m \cdot s^{-1}$; large ES: 1.30 ± 0.42), and performed more accelerations (≥1$m \cdot s^{-2}$; 0.13 $n \cdot min^{-1}$; small ES: 0.48 ± 0.29) and decelerations (≥1$m \cdot s^{-2}$; 0.22 $n \cdot min^{-1}$; moderate ES: 0.79 ± 0.30) compared to during technical drills. Further, U10s performed more decelerations (≥1$m \cdot s^{-2}$) during possession drills compared to SSGs (0.07 $n \cdot min^{-1}$; small ES: 0.24 ± 0.26). During SSGs, U10s covered more TD (18.30 $m \cdot min^{-1}$; very large ES: 2.00 ± 0.63) and HSR distance (4.45 $m \cdot min^{-1}$; moderate ES: 1.17 ± 0.60), achieved higher Vmax (0.88 $m \cdot s^{-1}$; $p<0.05$; large ES: 1.62 ± 0.43) and performed more accelerations (≥1$m \cdot s^{-2}$; 0.16 $n \cdot min^{-1}$; small ES: 0.49 ± 0.30) and decelerations (≥1$m \cdot s^{-2}$; 0.16 $n \cdot min^{-1}$; small ES: 0.55 ± 0.31) compared to during technical.

U12s covered greater TD (11.47 $m \cdot min^{-1}$; $p<0.05$; large ES: 1.25 ± 0.35) and performed more accelerations (≥1$m \cdot s^{-2}$; 0.09 $n \cdot min^{-1}$; small ES: 0.35 ± 0.17) and decelerations (≥1$m \cdot s^{-2}$; 0.09 $n \cdot min^{-1}$; small ES: 0.32 ± 0.17) during possession drills compared to technical drills. Similarly, U12s covered more TD (15.92 $m \cdot min^{-1}$; $p<0.01$; large ES: 1.74 ± 0.41), and performed more accelerations (≥1$m \cdot s^{-2}$; 0.09 $n \cdot min^{-1}$; small ES: 0.33 ± 0.20) and decelerations (≥1$m \cdot s^{-2}$; 0.07 $n \cdot min^{-1}$; small ES: 0.24 ± 0.20) during SSGs compared to technical drills. There were no differences observed in external load between possession drills and SSGs for U12 players.

During possession drills, U14s performed more accelerations (≥1$m \cdot s^{-2}$; 0.08 $n \cdot min^{-1}$; small ES: 0.28 ± 0.19) and decelerations (≥1$m \cdot s^{-2}$; 0.11 $n \cdot min^{-1}$; small ES: 0.38 ± 0.20) but less VHSR distance (0.27 $m \cdot min^{-1}$; small ES: -0.38 ± 0.25) compared to technical drills. U14s covered more TD (22.15 $m \cdot min^{-1}$; $p<0.001$; very large ES: 2.42 ± 0.41), HSR distance (6.34 m·min^{-1}; $p<0.01$; large ES: 1.67 ± 0.39) and VHSR distance (0.43 m·min^{-1}; moderate ES: 0.61 ± 0.25), achieved higher Vmax (0.55 m·s^{-1}; $p<0.05$; moderate ES: 1.01 ± 0.28), and performed a greater number of accelerations (≥1m·s^{-2}); (0.12 n·min^{-1}; small ES: 0.45 ± 0.20) and decelerations (≥1m·s^{-2}); (0.18 n·min^{-1}; moderate ES: 0.62 ± 0.20) during SSGs in comparison to technical drills. Furthermore, U14s covered greater TD (19.18 m·min^{-1}; $p<0.001$; very large ES: 2.10 ± 0.37), HSR (6.18 m·min^{-1}; $p<0.001$; large ES: 1.63 ± 0.35), and VHSR distances (0.69 m·min^{-1}; $p<0.01$; moderate ES: 1.00 ± 0.23), achieved a higher Vmax (0.53 m·s^{-1}; $p<0.01$; moderate ES: 0.98 ± 0.25) and number of decelerations performed (≥1m·s^{-2}; 0.07 n·min^{-1}; small ES: 0.24 ± 0.18) during SSGs in comparison to possession drills.

U16s covered more HSR distance (4.07 m·min^{-1}; moderate ES: 1.07 ± 0.68) and performed more decelerations (≥1m·s^{-2}; 0.19 n.min^{-1}; moderate ES: 0.67 ± 0.42) during technical drills compared to possession drills. U16s performed a greater Vmax during SSGs than in technical drills (0.46 m·s^{-1}; moderate ES: 0.85 ± 0.34). U16s also covered more TD (8.46 m·min^{-1}; moderate ES: 0.93 ± 0.49) and performed more decelerations (≥1m·s^{-2}; 0.10 n·min^{-1}; small ES: 0.36 ± 0.27).

drills. U16s covered greater TD (10.48 m·min^{-1}; moderate ES: 1.15 ± 0.65), HSR distance (4.40 m·min^{-1}; moderate ES: 1.16 ± 0.63) and VHSR distance (0.53 m·min^{-1}; moderate ES: 0.76 ± 0.45) during SSGs compared to possession drills. U16 players achieved greater Vmax (0.70 m·s^{-1}; large ES: 1.28 ± 0.48) during SSGs compared to possession drills, however, U16s performed more accelerations (≤1m·s^{-2}) (0.14 n.min^{-1}; small ES: 0.51 ± 0.39) during possession drills compared to SSGs.

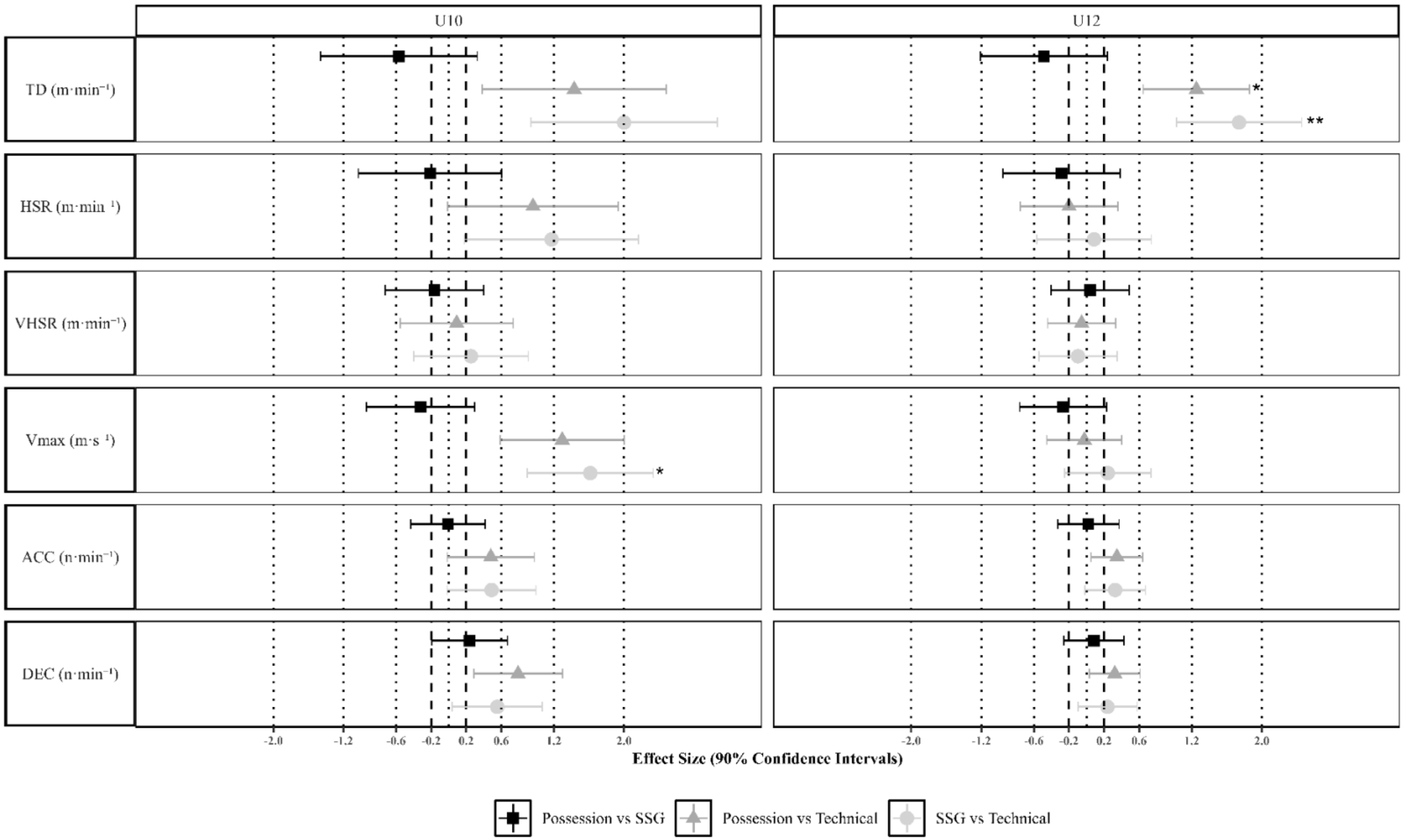

Figure 3.3A. Effect size of differences in estimated mean and statistical significance of relative total distance (TD), high-speed running (HSR), very high-speed running (VHSR) distances covered, and maximum velocity (Vmax), number of accelerations (ACC; >1m·s^{-1}) and decelerations (DEC; >1m·s^{-1}) between possession drills, small-sided games (SSG) and technical drills by U10 and U12 youth female footballers. **Statistically significant difference (p < 0.05*, p < 0.01**, p < 0.001***)*

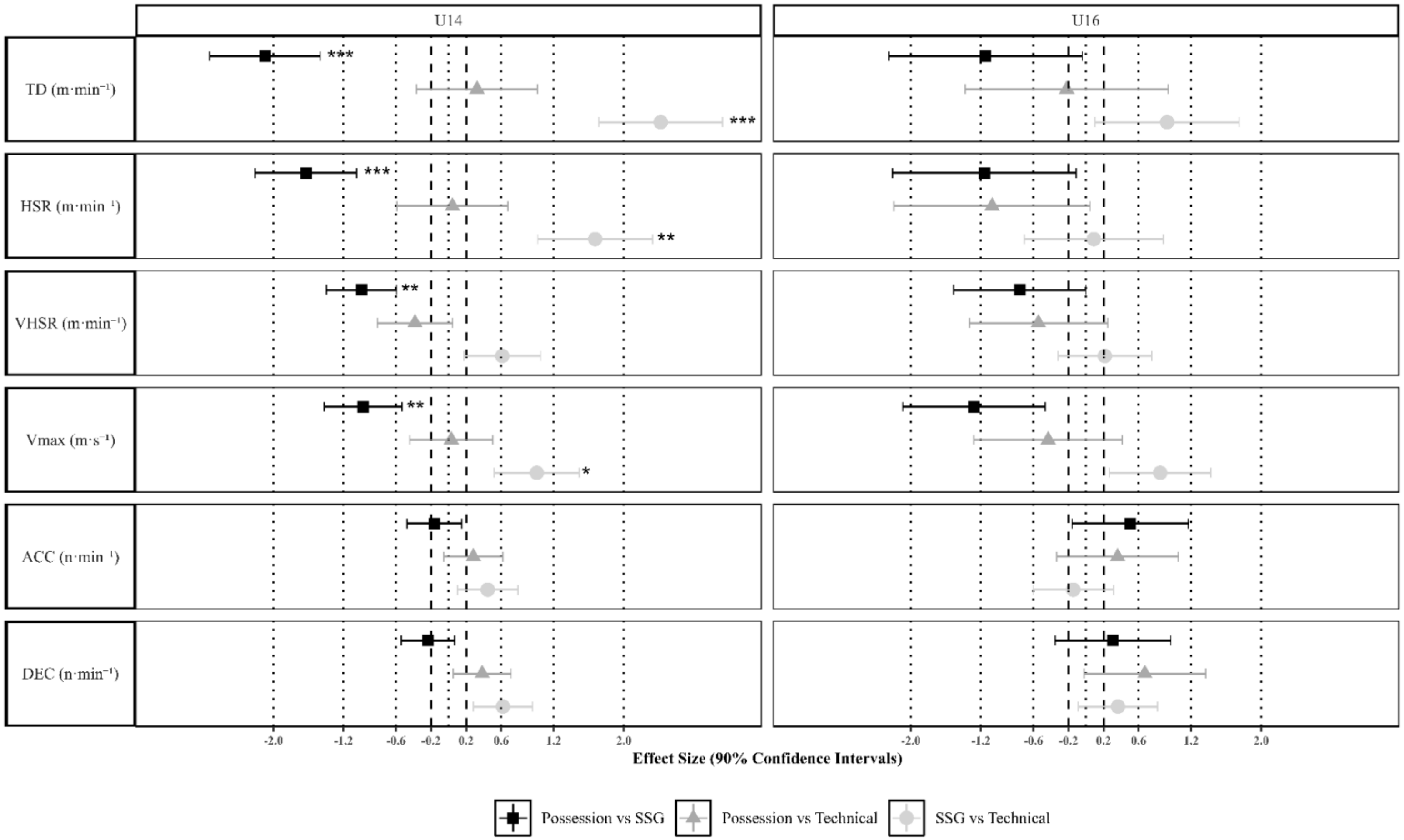

Figure 3.3B. Effect size of differences in estimated mean and statistical significance of relative total distance (TD), high-speed running (HSR), very high-speed running (VHSR) distances covered, and maximum velocity (Vmax), number of accelerations (ACC; >1m·s-1) and decelerations (DEC; >1m·s-1) performed between possession drills, small-sided games (SSG) and technical drills by U14 and U16 youth female footballers. *Statistically significant difference ($p < 0.05$*, $p < 0.01$**, $p < 0.001$***)

3.4.2.2 Training Drills: Between Age groups

During SSGs, U14s covered more TD than U10s (11.91 m·min^{-1}; large ES: 1.30 ± 0.63) and U12s (7.62 m·min^{-1}; moderate ES: 0.83 ± 0.48), and U16s covered more than U10s (8.16 m·min^{-1}; moderate ES: 0.89 ± 0.63). Both U14s and U16s covered more HSR distance than U10s (U14: 8.24 m·min^{-1}; $p<0.05$; very large ES: 2.17 ± 0.62; U16: 6.57 m·min^{-1}; large ES: 1.73 ± 0.64) and U12s (U14: 6.94 m·min^{-1}; $p<0.01$; large ES: 1.83 ± 0.47; U16: 5.26 m·min^{-1}; large ES: 1.39 ± 0.52). U14s covered greater VHSR distance compared to U10s (0.89 m·min^{-1}; $p<0.05$; large ES: 1.28 ± 0.35), U12s (0.95 m·min^{-1}; $p<0.001$; large ES: 1.36 ± 0.29) and U16s (0.26 m·min^{-1}; small ES: 0.37 ± 0.30), whilst U16s covered more than U10s (0.63 m·min^{-1}; moderate ES: 0.91 ± 0.37) and U12s (0.69 m·min^{-1}; moderate ES: 0.99 ± 0.32). Both U14s and U16s had higher Vmax than U10s (U14: 0.68 m·s^{-1}; large ES: 1.24 ± 0.39; U16: 0.82 m·s^{-1}; $p<0.05$; large ES: 1.51 ± 0.41) and U12s (U14: 0.54 m·s^{-1}; moderate ES: 0.99 ± 0.32; U16: 0.69 m·s^{-1}; $p<0.05$; large ES: 1.26 ± 0.35). U14s performed more accelerations than U12s (≥1m·s^{-2}; 0.07 n·min^{-1}; small ES: 0.27 ± 0.24). U10s and U14s performed more decelerations (≥1m·s^{-2}) than U12s (U10: 0.15 n·min^{-1}; small ES: 0.54 ± 0.35: U14: 0.11 n·min^{-1}; small ES: 0.40 ± 0.25).

In technical drills, U16s covered more TD than all other age groups (U10s: 11.32 m·min^{-1}; large ES: 1.97 ± 0.73; U12s: 18.00 m·min^{-1}; large ES: 1.24 ± 0.52; U14s: 9.93 m·min^{-1}; moderate ES: 1.09 ± 0.55). U10s covered the least HSR distance compared to all other age groups (U12s: 5.43 m·min^{-1}; large ES: 1.43 ± 0.66; U14s: 6.36 m·min^{-1}; large ES: 1.67 ± 0.70; U16s: 10.68 m·min^{-1}; $p<0.01$; very large ES: 2.82 ± 0.72), whilst U16s covered more than both U12s (5.25 m·min^{-1}; large ES: 1.38 ± 0.53) and U14s (4.33 m·min^{-1}; moderate ES: 1.14 ± 0.55). Both U14s and U16s covered more VHSR distance than U10s (U14: 0.65 m·min^{-1}; moderate ES: 0.93 ± 0.40; U16: 0.66

$m \cdot min^{-1}$; moderate ES: 0.95 ± 0.44) and U12s (U14 vs U12: 0.46 $m \cdot min^{-1}$; moderate ES: 0.65 ± 0.27; U16: 0.47 $m \cdot min^{-1}$; moderate ES: 0.68 ± 0.33). All age groups achieved a higher Vmax than U10s during technical drills (U12s: 0.89 $m \cdot s^{-1}$; $p<0.05$; large ES: 1.62 ± 0.43; U14s: 1.01 $m \cdot s^{-1}$; $p<0.01$; large ES: 1.85 ± 0.45; U16s: 1.24 $m \cdot s^{-1}$; $p<0.001$; very large ES: 2.27 ± 0.48), whilst U16s also outperformed U12s (0.36 $m \cdot s^{-1}$; moderate ES: 0.65 ± 0.36). U16s completed more accelerations (≥1$m \cdot s^{-2}$) compared to U12s (0.13 $n \cdot min^{-1}$; small ES: 0.49 ± 0.29) and U14s (0.09 $n \cdot min^{-1}$; small ES: 0.34 ± 0.30).

During possession drills, U12s covered more TD than U14s (7.11 $m \cdot min^{-1}$; moderate ES: 0.78 ± 0.42). There were no differences in HSR distance between age groups, however, U14s covered more VHSR distance than both U10s (0.31 $m \cdot min^{-1}$; small ES: 0.45 ± 0.33) and U12s (0.23 $m \cdot min^{-1}$; small ES: 0.33 ± 0.25). U14s achieved a higher Vmax compared to U10s (0.32 $m \cdot s^{-1}$; small ES: 0.58 ± 0.37). U10s completed more decelerations (≥1$m \cdot s^{-2}$) than both U12s (0.20 $n \cdot min^{-1}$; moderate ES: 0.69 ± 0.32) and U14s (0.17 $n \cdot min^{-1}$; moderate ES: 0.61 ± 0.32). U16s performed more accelerations (≥1$m \cdot s^{-2}$) than U12s (0.14 $n \cdot min^{-1}$; small ES: 0.52 ± 0.42).

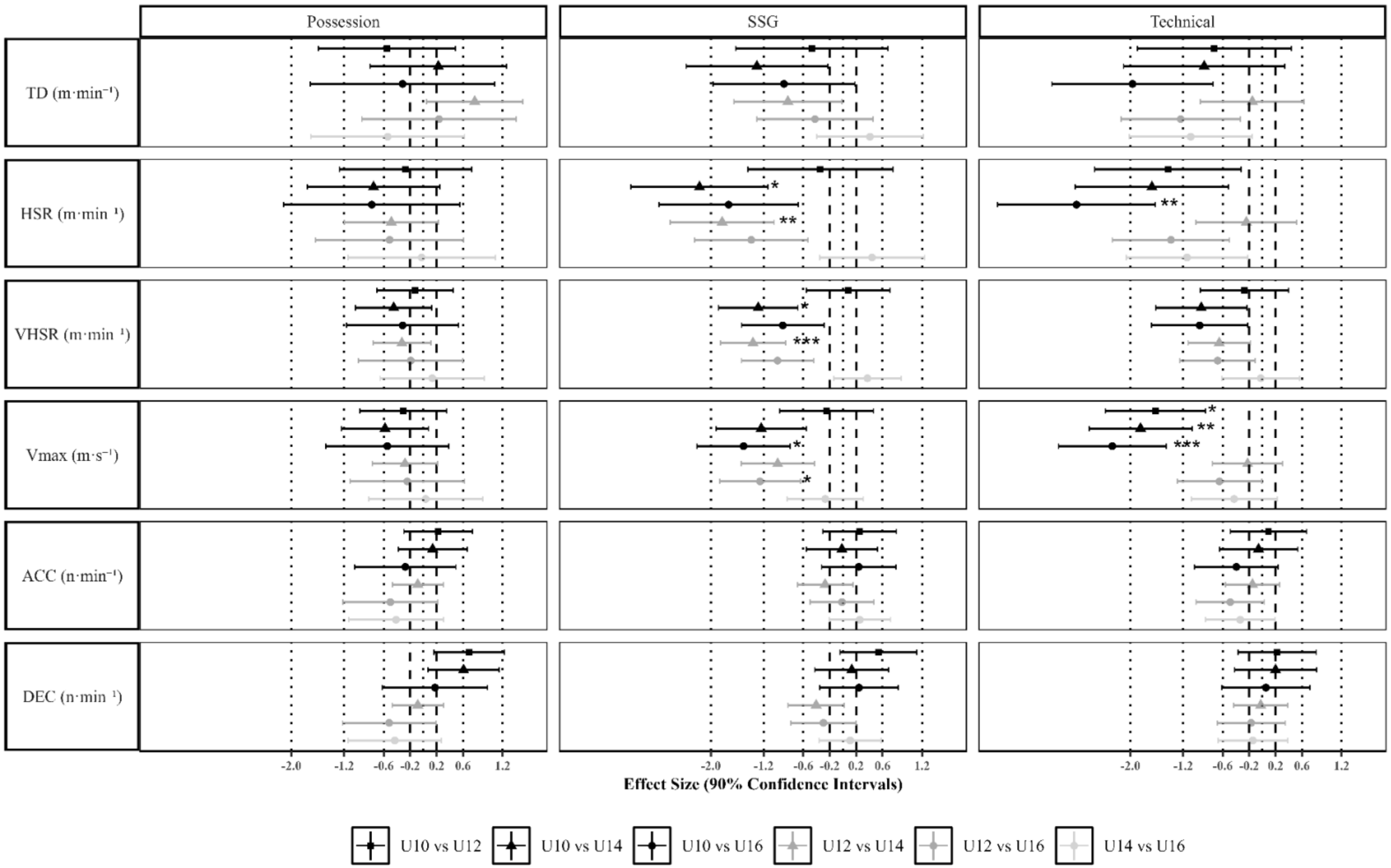

Figure 3.4. Effect size of differences in estimated mean and statistical significance of relative total distance (TD), high-speed running (HSR), very high-speed running (VHSR) distances covered, and maximum velocity (Vmax), number of accelerations (ACC; >1m·s^{-1}) and decelerations (DEC; >1m·s^{-1}) performed during possession drills, small-sided games (SSG) and technical drills between U10, U12, U14 and U16 youth female footballers. **Statistically significant difference ($p < 0.05$*, $p < 0.01$**, $p < 0.001$***)*

3.5 Discussion

The aim of this study was to quantify the external load of U10, U12, U14 and U16 youth female footballers during training, and compare the training session and drill-specific external load between and within age groups. This was the first known study to quantify the external load of youth female football players during training and consequently quantify drill-specific external load. There were differences in external load between age groups for overall sessions, with U16 players covering greater HSR, VHSR and SPR distances compared to U10 and U12 players. Additionally, there were drill-specific differences within and between age groups, suggesting that training demands are influenced by drill type and that physical capabilities differ between age groups. This study provides findings which contribute to the currently limited evidence base surrounding youth female training demands and can serve as a resource for practitioners to draw from to inform age-specific training practices.

The most commonly observed drills across training sessions were possession (n=833) and technical (n=745) drills, followed by SSGs (n=720). This is an important insight as it can inform practitioners on the current make-up of training sessions which may lead to applications such as adjusting practices to ensure consistency and progression for not just physical and technical ability, but also the tactical understanding of players across the talent pathway. Possession and technical drills, whilst important for developing key technical skills and tactical understanding, offer limited representativeness of match-play scenarios dependant of constraints. From a skill acquisition perspective, coaches are encouraged to deliver practices which encourage learning within match-play scenarios that deliver perception-action coupling (367) and opportunity to adapt through variable practice (368). Therefore, the use of SSGs within the makeup of training sessions within ETCs is important as they provide opportunity for representative decision making, tactical awareness and physical demands. From a talent development perspective, aligning drill content so that it is reflective of match demands and reflects progression, dependent upon age group and individual skill level, will facilitate the ability of players to transfer skills from training to match-play (369). In this respect, the current findings can inform training session design within ETCs, facilitating the delivery of varied, age-appropriate training practices, aiding the long-term development of youth female footballers.

Age group differences revealed that U16 players showed greater external load across HSR, VHSR and SPR during overall sessions compared to younger players (U10 and U12). Despite this, few differences were observed between U16 and U14 players across HSR $m{\cdot}min^{-1}$, VHSR $m{\cdot}min^{-1}$, SPR $m{\cdot}min^{-1}$, accelerations ($\geq 1m{\cdot}s^{-2}$, $\geq 3m{\cdot}s^{-2}$) and decelerations ($\geq 1m{\cdot}s^{-2}$, $\geq 2m{\cdot}s^{-2}$, $\geq 3m{\cdot}s^{-2}$). The same was observed between U10 and U12 players across TD $m{\cdot}min^{-1}$, HSR $m{\cdot}min^{-1}$, VHSR $m{\cdot}min^{-1}$, SPR $m{\cdot}min^{-1}$, accelerations ($\geq 1m{\cdot}s^{-2}$, $\geq 2m{\cdot}s^{-2}$, $\geq 3m{\cdot}s^{-2}$) and decelerations ($\geq 2m{\cdot}s^{-2}$, $\geq 3m{\cdot}s^{-2}$). These findings imply that there may be a lack of progression in external load between U10 and U12, and U14 and U16 age groups. There are some consistencies with these findings and those presented in a study exploring external load of youth female players by maturity status (years from PHV) (242). Which suggests steady increases in physical performance as maturity increases, however, it was also found progression is more pronounced in earlier maturation stages (U10 to U12) for 30m-sprint and change of direction. This is further exemplified by research on chronological age groups, which found the greatest differences in agility performance came between U12s and U14s (75).

When comparing the external load performed by U14 and U16 players during training to their age group equivalents during match-play (69), vast differences are seen. Greater relative TD (U14: 41.3 m·min^{-1} vs 92.4 m·min^{-1}; U16: 44.8 m·min^{-1} vs 92.6 m·min^{-1}), HSR (U14: 7.7 m·min^{-1} vs 19.8 m·min^{-1}; U16: 8.2 m·min^{-1} vs 20.5 m·min^{-1}), VHSR (U14: 0.95 m·min^{-1} vs 2.4 m·min^{-1}; U16: 0.88 m·min^{-1} vs 3.0 m·min^{-1}), SPR (U14: 0.27 m·min^{-1} vs 0.4 m·min^{-1}; U16: = 0.31 m·min^{-1} vs 0.6 m·min^{-1}) and maximum velocity (U14: 6.20 m·s^{-1} vs 6.67 m·s^{-1}; U16: 6.45 m·s^{-1} vs 6.90 m·s^{-1}) were performed during match-play compared to training (69). This may partially be due to comparisons against match play characteristics being made against whole session data, which includes both playing and non-playing activities, involving transition periods, drinks breaks and coaching interventions. In addition to this, match-play provides a competitive environment which may expose players to forms of external motivation (e.g. verbal encouragement from coaches or spectators), which has been shown to illicit greater physical performance (370) and is difficult to replicate during training. Furthermore, the size of the area in which the players performed may also have had an effect, with ETC players utilising a half or quarter pitch for training as opposed to a full size pitch (e.g., U14 = 37 x 27m - 55 x 37m vs 82 x 50m; U16 = 37 x 27m - 55 x 37m vs 91 x 55m) (371), and manipulating playing dimensions has previously been shown to influence external load (372,373). Consequently, players may not be exposed to training environments which are representative to match-play. There may be implications to players such as an increased risk of injury as a result of too little training load and intensity, as it has been identified that low amounts of high-speed distance is associated with non-contact and overuse injuries (374,375). Practices may need to be adjusted to increase the intensity and overall load of training to create an environment which is more representative to that of match-play, based on the interpretations of these findings. Further, future research may look to consider injury incidence of ETC players during match-play based on their weekly training load and intensity.

Findings identified that U10 players performed increased decelerations ($\geq 1 m \cdot s^{-2}$) during whole training sessions compared to all other age groups. In addition to this, drill observation results revealed that U10 players' training sessions consisted of more possession and SSGs and less technical drills than older age groups (possession = 138; SSG = 126; technical = 87). Further, it was found that for all four age groups, technical drills resulted in the least decelerations. Consequently, the less frequent use of technical drills in U10 training sessions may have influenced the increased number of decelerations being displayed by U10s. In addition to this, the small (quarter pitch) training area on which the U10s trained is another factor which has been found to increase deceleration load (376). There are injury risks associated with higher biomechanical loads in younger players, as it has been recognised that a high acceleration and deceleration load can lead to mechanical stresses on soft tissues (377). This often leads to anterior knee pain, particularly apophysitis type injuries where traction of tendon on bone can lead to pain and inflammation, especially during maturation in youth players (378). This is due to increased injury risk of the lower limbs being associated with rapid growth which is heightened during PHV (11.18 yrs (379)) (380).

Drill specific comparisons within age groups showed that youth players have a higher physical output during SSGs in comparison to possession and technical drills. There are contrasts seen when comparing this to elite senior female players, with differences in physical performance being much less pronounced between different drill types (57). This suggests that youth players may not approach all drills with the same intensity that senior players do, potentially due to senior players' increased physical capabilities (57). Additionally, differences in training area size must be taken into consideration when assessing comparisons in intensity, with senior players potentially having larger playing areas due to no pitch constraints issues (i.e., simultaneous session delivery) and thereby facilitating increased physical performance (372). Furthermore, the current research does not specify variations of drills consistent with the senior female research (e.g. intensive and extensive SSGs) (57). Understanding the differences in performance outputs between youth and senior players may be used by youth coaches to inform and adapt current practices, creating a training environment which is more representative to that of senior players, may assist youth players transitioning to senior football. Furthermore, coaches working with senior populations can utilise these findings to provide better support for youth players who are transitioning to senior football.

When looking at drill specific comparisons between age groups, older age groups consistently displayed greater external load across all three drill types when compared to younger age groups. However, there were some exceptions, with U12 players covering greater total distance than U14 players during possession drills, U14s covering greater VHSR distance compared to U16s during SSGs and U10 players performing more decelerations (≥1m·s^{-2}) than both U12 and U14 players across possession drills, and U12s during SSGs. This suggests that the physical capability of players progresses with age and therefore the intensity at which all three drill types are performed. This is consistent with research on equivalent age groups within youth male football which also found progression in external load during training as age group increased (381–383).

There are limitations of the current study which should be considered. Firstly, only two ETCs participated in this study, primarily due to the logistical considerations for facilitating data collection (e.g., location of/distance to ETC training venues, number of available GPS units, conflicting scheduling of training sessions). Consequentially, there was a limited number of potential players available to participate in the study. Further, only one of the participating ETC had an U10 age group, and fewer U16 players (n=22) were recruited in comparison to the other age groups (U12: n=40; U14: n=39) and consequently, a limited number of training and drill observations were obtained for these age groups. Future research should aim to adopt a multi-club sample, to increase the number of players within respective age groups, to ensure external load may be more representative of the wider population. Secondly, player positions were not accounted for in the analysis meaning position-specific differences were not explored. ETCs consist of whole squads, therefore multiple playing positions (DEF, MID, FWD) are included within the sample. However, the representation of playing positions within each age group was not obtained. Therefore, future research may look to report the positional breakdown of youth player samples and explore whether position specific differences exist in training characteristics. Thirdly, as data were recorded in-situ by one researcher, details relating to session design and activity structures (e.g., task constraints used across different drills; number of players, obstacles, scoring rules or touch limitations etc.) were not possible to capture reliably due to simultaneous age group sessions occurring. Adaptations, rules and limitations are known to affect the intensity of training drills (57,372,384). Therefore, it is important that future research exploring drill specific external load of youth female footballers monitors task constraints, adding context to different training drill types.

3.6 Conclusion

This study is the first to quantify the external load of youth female football players during training, comparing session and drill-specific external load between and within age groups. For overall sessions, progression in external load were observed across age groups. Within age groups, SSGs yielded greater external load in comparison to possession and technical based drills. Between age groups, greater external load was displayed by older age groups across all drill types when compared to younger age groups, with exceptions for U10 players performing more decelerations during possession and SSGs compared to U12 and U14 players. Practitioners may use findings from this research to inform current training practices, better preparing youth players for match-play, supporting the progression across the talent pathway and the transition into senior football. Future research should consider position-specific training demands, enabling comparisons to match-play performance with greater context. Further, future research is encouraged to explore the effects of task constraints on physical performance, providing greater context by facilitating deeper insights into the training characteristics of youth female footballers.

3.6.1 Contextualisation of findings

The key findings presented highlight general increases in external load across age groups for overall sessions, with SSG drills resulting in the highest physical outputs for all age groups. Older age groups (U14 and U16) performed greater TD, HSR and maximum velocity in comparison to younger age groups, though U10 players performed greater decelerations in comparison to all other age groups. However, results should be interpreted with caution. The large volume of results and overlapping effect sizes mean it is possible that some results may have occurred by chance. The following chapter will consider the practical relevance of the key findings presented within this thesis, as well as explore approaches for future research methods and design.

Chapter 4: General Discussion

This chapter will summarise and synthesise the findings presented within this thesis, discuss practical applications and suggest recommendations for different stakeholders (e.g. policy makers and practitioners) working within England’s youth female talent pathway will be made based on the current findings. Furthermore, this chapter will discuss limitations of the current thesis, and provide recommendations for future research exploring the training characteristics of youth female football players.

4.1 Summary

The aim of this thesis was to quantify the physical training characteristics of U10, U12, U14 and U16 youth female footballers, and compare within and between age groups and drill-types. Firstly, a systematic scoping review was conducted to determine the current state of the existing literature surrounding the performance, health and development of youth female football players (Objective 1; Chapter 2). Secondly, relative and absolute physical training characteristics for whole training sessions and drill types were quantified, and comparisons made within and between age groups (Objective 2; Chapter 3). Finally, the current chapter will synthesis the findings presented in the thesis, and present suggested practical applications and recommendations for future research (Objective 3; Chapter 4).

The aims of Chapter 2 were to: (1) systematically review the scientific literature on the performance, health and development of youth female footballers, (2) determine the methodological approaches adopted, (3) summarise the findings of research areas, and (4) identify gaps within the literature. This review was the first to map the existing sports science and medicine research regarding the youth female football population. A total of 241 studies were included in the review. Studies predominantly focused on physical qualities (41%), injury (17%) and biomechanics (13%) topics, whilst match-play (7%), nutrition (5%), fatigue and recovery (4%) and training load (2%) topics were the most underdeveloped across the literature. Only four studies investigated the training load of youth female football players, of which the aims and methodological approaches were inconsistent. As a result, it is difficult to interpret and draw findings from the current evidence base. Therefore, future research is warranted which explores the effects of age group, competitive standard and drill type on training demands in youth female football. In addition to identifying gaps in the current youth female football literature, this review has critically summarised the different methods adopted when conducting research across different topics and fields, presenting key strengths and limitations, which can guide the methodological approaches of future research. By providing a comprehensive overview of the current literature, this review can serve as a key resource as the area of literature develops.

To address a key gap in literature investigating training load highlighted in Chapter 2, the aim of Chapter 3 was to quantify and compare session and drill-specific external load of U10, U12, U14 and U16 youth female footballers during training. This study was the first to quantify session and drill physical training characteristics of youth female football players. In total, 116 players from two of The FA's ETCs participated in the study. Data collection took place over three four-week periods during the 2024 season, resulting in 825 session observations and 2,298 drill-specific observations. It was found that age group differences existed for whole sessions, with U16s and U14s presenting greater external load across HSR, VHSR and SPR distance compared to U10s and U12s. Drill-specific differences revealed that SSGs typically resulted in higher physical outputs in comparison to possession and technical drills.

4.2 Synthesis of Findings

Chapter 3 within the current thesis has added novel findings to the scientific literature regarding the training characteristics of youth female footballers, as the first study to quantify (and compare) training characteristics across multiple age groups and to quantify drill-specific characteristics. Further, it is also the first insight into the current training practices of ETCs within the youth female talent pathway. The current research has addressed prominent methodological limitations within training characteristics studies, and the wider youth female football literature. For example, the current study utilises a multi-club sample rather than recruiting from a singular club (59,60,63,65,71,72), a large number of (training) observations (64), and used velocity thresholds which were established for youth female football players (69–73).

The current findings reveal that, the absolute and relative external load of ETC players across U14 and U16 age groups are not reflective of match-play (69) (Table 4.1). Furthermore, players cover approximately half the absolute and relative TD, HSR, VHSR and SPR distances during training compared to match-play. Whilst not explicitly investigated during this research, there may several reasons for this discrepancy. For example; differing playing dimensions (i.e., pitch size and area per player (385)), the stop-start nature of training drills (e.g. water breaks, coach instructions etc.) may not replicate the intermittent nature of match-play (e.g., in-play vs ball-out-of-play time), and the presence or absence of motivational factors (e.g. match-status (386), spectator influence, fear of failure etc).

Table 4.1 External load of U14 and U16 youth female footballers during training and match-play.

Variable (mean ± SE)	Training (Chapter 3)		Match-play (69)	
	U14	U16	U14	U16
TD (m)	3429.9 ± 201.5	3849.6 ± 227.6	7148.0 ± 147.2	7678.7 ± 148.0
HSR Distance (m)	639.4 ± 81.0	692.8 ± 90.1	1530.4 ± 61.6	1695.5 ± 62.1
VHSR Distance (m)	78.0 ± 18.1	73.7 ± 18.9	187.6 ± 10.1	249.4 ± 10.3
SPR Distance (m)	23.3 ± 7.8	26.4 ± 8.2	28.8 ± 3.8	53.4 ± 3.9
Vmax ($m \cdot s^{-1}$)	6.20 ± 0.24	6.45 ± 0.26	6.67 ± 0.03	6.90 ± 0.03
TD ($m \cdot min^{-1}$)	41.3 ± 1.6	44.9 ± 2.0	92.4 ± 1.7	92.6 ± 1.7
HSR Distance ($m \cdot min^{-1}$)	7.77 ± 0.78	8.22 ± 0.91	19.8 ± 0.8	20.5 ± 0.8
VHSR Distance ($m \cdot min^{-1}$)	0.95 ± 0.19	0.88 ± 0.20	2.4 ± 0.1	3.0 ± 0.1
SPR Distance ($m \cdot min^{-1}$)	0.27 ± 0.09	0.31 ± 0.09	0.4 ± 0.1	0.6 ± 0.1

TD = Total Distance, HSR = High-Speed Running, VHSR = Very High-Speed Running, SPR = Sprint, Vmax = Maximum Velocity

Players within ETCs are performing a lower volume of TD during training in comparison to senior female footballers in later steps of the Club Talent Pathway, specifically, the Women's Super League (WSL), Women's Championship (WC) and Women's Super League Academy (WSLA) (Table 4.2) (57). Furthermore, when making comparisons between drill types, senior players covered greater TD during technical based drills as opposed to possession or variants of SSGs suggesting differing drill-specific demands during youth and senior female football environments in the Club Talent Pathway. The differences in training characteristics suggest that presently, the training demands imposed on U16 ETC players may not be adequately preparing them for the transition into the next steps of the Club Talent Pathway. Despite senior players covering greater relative TD than ETC players, this is not the case for HSR distance, with senior players covering much less across all drill types. However, it should be noted that there are methodological differences in the way external load was captured with the current study using 10Hz GPS units in comparison to foot-mounted inertial measurement units (IMUs). Foot IMUs are prone to underestimating top-end speed, and during SSGs, were found to measure higher distances below high speed running thresholds in comparison to 10Hz GPS units (387), and therefore should be considered when interpreting and comparing these findings. Furthermore, and importantly, players in ETCs may only have one training session per week, whilst players in the senior Club Talent Pathway environments have two to five sessions per week (58). Therefore, senior players will have a higher total training load across the week, in addition to higher loads within an individual session.

Table 4.2 Drill-specific external load (mean ± SE) of ETC U16s and WSL, WC and WSLA players during training.

	U16			WSL, WC & WSLA (57)			
Drill type	**Pos**	**Tech**	**SSG**	**Pos**	**Tech**	**SSGe**	**SSGi**
TD ($m \cdot min^{-1}$)	50.1 ± 5.6	52.1 ± 4.0	60.6 ± 3.4	57.3 ± 1.9	69.2 ± 2.4	67.4 ± 2.1	66.5 ± 2.1
HSR ($m \cdot min^{-1}$)	8.4 ± 2.3	12.4 ± 1.7	12.8 ± 1.5	0.6 ± 0.1	0.9 ± 0.1	0.8 ± 0.1	0.9 ± 0.1

WSL = Women's Super League, WC = Women's Championship, WSLA = Women's Super League Academy, SSG = small-sided games, SSGe = small-sided game extensive, SSGi = Small Sided Game intensive, TD = Total Distance, HSR = High-Speed Running.

4.3 Practical Applications

The findings from this thesis have provided practitioners working with youth female football players in England a novel insight into the training characteristics of ETCs. As a result, there are recommended practical applications for different stakeholders concerning the youth female football talent pathway in England.

4.3.1 Policy Makers

Three key recommendations are presented for policy makers (The FA), considering quality audits, training curricula, education and continuing professional development opportunities for coaches.

1. ***Review age-group specific pitch dimensions for ETC's with consideration of the number of players involved.***

A quality audit to review the number of players registered at ETCs and training facilities is recommended, to ensure high quality training standards are established and maintained across all ETCs. The ETC operating criteria (2024/25) currently states that ETCs should recruit a minimum of 60 players across the program, and whilst there are no stipulations on pitch dimensions for training sessions, these should be adjusted depending on the size of the cohort (7). In addition to this, the ETC criteria also states that “Centres must demonstrate that they are able to facilitate the number of participants it registers”, this includes having the appropriate coach to player ratio (U9: 1:6; U10/12: 1:8; U14/16: 1:10) as well as a “suitably sized” playing area (7). The current expectations within the ETC guidelines in this regard lack clarity, due to the ambiguity in terms such as “suitably sized”. The participating ETCs in the current thesis only utilised a quarter of a pitch per age group (37 x 27m; ETC 1) or a half pitch (55 x 37m; ETC 2), with similar dimensions across age groups regardless of the number of players per age group. The restricted dimensions are reflected in the training output characteristics (Chapter 3), with low distances being covered at HSR, VHSR and SPR. The FA’s guidelines on area per player state the following to calculate relative pitch area: “length x width = area size. Area size/number of players = relative pitch area” (388), with recommended guidelines for small, medium and large relative pitch area per player (Table 4.3). Reviewing the number of players registered to ETCs would provide estimates as to whether small, medium and large relative pitch areas per player are currently being or can be provided for each age group. Lastly, whilst limited match simulations were observed in this study, aligned with FA’s guidelines, research on appropriate playing area suggests the implementation of the following playing areas to replicate match demands; 100-200m^2/player for U12-U13 (389), 160-212m^2 for U15-U19 (390).

Table 4.3 Small, medium and large relative pitch area per player for U10-12, U13-U15 and U16-U18+

Age group	Small Relative pitch area (m^2/player)	Medium Relative pitch area (m^2/player)	Large Relative pitch area (m^2/player)
U10-U12	70-90	90-120	120-140+
U13-U15	80-100	100-130	130-160+
U16-U18+	90-110	120-150	150-180+

2. ***Establishing an age-specific, structured, progressive training curriculum to ensure physical outcomes are met for all players.***

Based on the observations and findings from the current thesis concerning age group differences in external load, an age-specific and progressive training curriculum is being recommended. This is to ensure that all players are provided with opportunities to engage in training that is specific to their age and level of the youth talent pathway (7). Age group differences revealed little progression in external load between U10 and U12, and U14 and U16 age groups. Therefore, consideration should be given as to whether there is scope for younger age groups (e.g. U10s and U12s) to train together (i.e. dual age banding), however it should be noted that ETCs are required to deliver a minimum of three groups (7). Where resources are limited, this would provide more available space for older groups, increasing playing dimensions to enable these age groups to achieve greater physical outcomes. Age group banding could be alternated based on the physical output goals of the session; for example, merging U14 and U16s when greater CoD outputs are desired will allow training sessions for U10 and U12 players to focus on covering greater distances. Furthermore, The ETC Operating criteria states “there is flexibility in what age groups centres choose to deliver and the potential combination of age groups”, implying that ETCs are permitted to using dual age banding for mixed or multiple age groups (7). Another option would be to introduce bio banding of age groups, introducing training groups based on biological maturity (e.g. percentage of predicted adult height) can reduce imbalances relating to size and maturity of players (391). Furthermore, age group specific data revealed that players across all age groups are covering little HSR distance as well as performing minimal accelerations, which may be due to training areas. There needs to be evidence of ETCs utilising the available (and potentially limited) training space effectively to provide variation in physical training outcomes that are appropriate and specific to each group. This will ensure that training programs are relevant to all aspects of the game, player age and capabilities as well as facilitate progression, to ensure that players are reaching the appropriate physical outcomes.

3. ***Design and deliver evidence-based education and continuing professional development opportunities for coaches and practitioners working within ETCs***

Currently, the experience level of staff working within ETCs varies dependent upon job role. For example, the minimum coaching qualification required by Player Development Leads (responsible for leading the training environment) is Level 3 (coaching or teaching qualification), Centre Group Coaches (responsible for supporting and developing all ETC players) require a Level 2 (UEFA C or above) coaching qualification, whilst Mentee Coaches (responsible for supporting the delivery of training sessions) require multiple level 1 or introduction qualifications (The FA's introduction to coaching football, FA DBS, Level 1 Safeguarding, FA Level 1 Introduction to First Aid) (7). Educational and professional development opportunities should be developed based on the training load data presented in this thesis, to educate coaches on current training loads, and potential ways to adapt training practices to create training environments to create age group specific training, progressive training, and ultimately support long-term athletic development within ETCs. These educational and development opportunities should be available to all coaches and practitioners operating within ETCs, and not solely restricted to Player Development Leads.

4.3.2 Coaches and practitioners working within and beyond the youth female talent pathway

There are several recommendations aimed at coaches and practitioners working within and beyond ETCs; considering the design of training sessions delivered to supplement progression between age groups, support the transition of players beyond ETCs into senior football, mitigate injury risk and holistically develop players.

1. ***To reflect upon challenges faced when implementing or trying to implement the training curriculum.***

A critical reflective process for ETC coaches and practitioners following the end of each season is being recommended. This will allow for discussions which consider the successes and challenges that were faced both individually and as a collective across the course of the season, as well as facilitate the evaluation of practices, facilities, coaching staff and registered player count. These reflective processes will enable individual ETCs the opportunity to conduct a specific needs analysis to assess opportunities and challenges which can be presented to The FA. In turn, this will allow The FA to consider ETC-wide challenges and opportunities to inform the development of action plans to mitigate potential issues, leading to better-quality training practices are more likely to be delivered. The FA currently offers mentoring support to coaches within The ETCs which provides guidance on rapport, observation, feedback and reflection (392), and such provision should ensure consideration of planning and review and not just delivery of coaching practice.

2. ***Coaches and practitioners should design and deliver training sessions in alignment with the progressive training curriculum.***

This recommendation aligns with the second recommendation for policy makers (*‘Establishing an age-specific, structured, progressive training curriculum to ensure physical outcomes are met for all players’*). There needs to be progression across age groups regarding physical training outputs, in addition to technical and tactical training outputs, given the importance of holistic player development aligned with The FA’s ‘Four Corner Model’ (19). As previously stated, the findings from the current thesis show that, in terms of physical training characteristics (e.g. TD, HSR, VHSR, SPR), the differences between U10s and U12s, and U14s and U16s is minimal. Therefore, practitioners working within ETCs need to tailor training activities so that they are more appropriately matched to the physical, technical and cognitive abilities of each age group. This could be achieved by designing and delivering sessions with greater variation, for example short, fun and engaging game-based training activities for younger age groups whilst they develop fundamental skills and slowly progressing into longer and larger training formats which demand more physicality, whilst refining technique and tactical awareness within representative activities (393). This will align with the ETCs goal of delivering training which is in line with Long Term Player Development principles of learning to train (8-11 yrs; fundamental football skills), training to train (10-14 yrs; building football specific and decision making skills) and training to compete (13-16+ yrs; optimising position specific, technical, tactical and decision making skills) (9). In turn, players will experience a progressive exposure to physical demands and skill acquisition principles as they mature and progress through the talent pathway.

3. Practitioners working beyond ETCs should utilise the current findings to support the transition of ETC players into senior football.

This recommendation is aimed for practitioners and staff working beyond ETCs (e.g. Pro Game Academies), who should utilise the current data to assist in bridging the gap in training demands between the ETC and next steps of the Club Talent Pathway to ensure smoother player transitions. Previously, the lack of evidence base surrounding the training characteristics of youth female footballers may have been limiting the knowledge, and therefore the ability practitioners' working within senior environments to adapt strategies for ETC players who are transitioning. The current thesis provides important insight into youth female training, which should be used to inform decisions to better support player progression and transition. Current senior player data demonstrates the increase in training volume between youth and senior environments reveals the extent of the step up, with WSLA and WC players training 3-4 days per week, and WSL players training 4-5 days per week (57). Therefore, not only are transitioning players required to perform greater physical outputs but also an increase in total volume, with two sessions to a minimum of three sessions per week.

4. To reduce the injury risk for all players by implementing training that is designed to elicit changes that enhance physical performance.

It is recommended that training environments are designed to induce physical adaptation of players across age-groups in order to facilitate progressive development. Match-play data from U14 and U16 age groups demonstrate a discrepancy in high-speed distances covered (69). The evidence presented in this thesis suggests that players across all age groups may not be sufficiently exposed to physical demands during training to develop physical capacities required for match-play demands. This may be due to the substantially smaller training pitch dimensions used within some ETCs, such as half (55m x 37m) and quarter pitches (37m x 27m), which limit the opportunity for players to reach higher velocities typically performed during match-play. Despite some ETCs being confined to smaller training areas, it is important that coaches look to adapt session design so that players can train in a manner that facilitates physiological adaptations. This would both enhance players physical performance and improve their capacity to tolerate match-play intensity. Coaches may achieve this by referring to recommendation 2 for policy makers, which suggests introducing ways to merge age groups, allowing for a greater area on the pitch to be utilised, resulting in an increased potential for players to reach higher training outputs (e.g. TD and HSR) (394). Furthermore, evidence suggests that implementing resistance-based training (e.g. weighted sled pushes/pulls) leads to improvements in sprinting mechanics (395), therefore eliciting the required physical changes needed for players to achieve the HSR outputs expected during match-play. Therefore, there should be greater consideration for the integration of structured strength and conditioning provision within ETCs to support physical development and injury risk reduction.

CoD types occurring either without the ball, offensively and at 90° turns have been found to occur most often during U16 youth female football match-play (114), giving valuable insight into what types of CoD load coaches should aim to replicate in training. Addressing these demands may help to reduce the risk of injury that often occurs when transitioning to an environment which is more physically demanding and requires greater intensity as well as different movement patterns (396). By effectively incorporating match-play elements into training environments, players will be less likely to experience abrupt changes, ensuring that they are well prepared for the demands of competitive play, reducing their risk of injury and leading to improved performance.

5. ***To implement a variety of training activities, and manipulate player outputs through appropriate constraints to holistically develop players***

Three training drill types were predominantly observed (technical, possession and SSGs), constituting the majority of 90-minute training sessions, strength and conditioning, position specific and tactical based drills were not observed. Whilst these three drills are important in developing player's fundamental skills and physicality, it is being recommended that a greater variety of training drills be implemented to develop players more holistically (10). Therefore, ETCs should consider the implementation of physical conditioning, tactical and position-specific activities, and full-sided games or match simulations across age groups where appropriate. As a result, in addition to player's physical capabilities, to consider alternative means for holistic development of tactical, technical, physical and psychosocial abilities. For applicable drills (e.g. SSGs, possession-based drills and other match play-like activities), coaches and practitioners may look to approach this by adjusting task constraints such as team size and rules (e.g. scoring rules, time-limits, limited touches and positional rules), which dictate the tactical approaches and intensity. This approach may facilitate the desired outcomes of coaches whilst enhancing the creativity and enjoyment of players (10). Manipulations and adaptations to drills may have particular intention, to facilitate wider holistic development (e.g., psychosocial characteristics) or isolated characteristics (e.g., physical HSR movements) which mimic match-play intensity. However, constraints must be tailored to different age groups appropriately. For example, reducing the complexity and focusing on the enjoyability of drills for U10s and U12s and designing more dynamic and challenging scenarios for U14s and U16s will encourage holistic development, whilst still aligning to the LTAD model (9).

4.4 Limitations

This thesis consists of a systematic scoping review of scientific literature quantifying the performance, health and development of youth female footballers, as well as quantified the physical training characteristics of youth female footballers, which serve as contributions to an area of literature which is currently very sparce. However, there are limitations which should be considered when interpreting the data presented in this thesis and translating the findings to inform applied practices. Firstly, despite efforts to recruit several ETCs, only two clubs agreed to take part in the study. The number of participating clubs was limited due to: GPS not being normal practice in ETCs (all data was collected by the lead researcher) the accessibility (e.g. location, time and cost for facilitating data collection) of some ETCs meant that data collection was not logistically feasible, training schedule clashes, and a limited number of GPS units (n=64). As a result, the current sample only represents approximately 3% of the total ETC population. Therefore, the findings from the current research may not be representative of the wider ETC population due to variations in staff, facilities, training practices and cohorts as differences across these variables may result in different physical training outcomes.

Secondly, whilst participant recruitment within participating ETCs was generally successful, this was predominantly within the U10, U12 and U14 age groups. Anecdotally, the younger age groups who showed more enthusiasm to join and engage with the research project. As a result, the U16 age group is underrepresented within the dataset, which limits the generalisability of the findings across other cohorts. Future research should consider a recruitment strategy that engages both players and coaches, to ensure the retainment of participants throughout the data collection period. This could be achieved by making clear the purpose of the data and the potential applications that may result from findings (e.g. changes to delivery of training practices).

Finally, data collection took place across a 12-week period from January to May 2024, which constitutes less than half of an ETC season (30-weeks). Therefore, data from the current research only captures the specific cohorts of those age groups for that part of the season. Previous research on seasonal variation in youth female footballers has suggested that changes in physical performance occur across the course of a season (241). Therefore, it is important that future research aims to capture the training characteristics of youth female footballers across a full 30-week season, to facilitate the comparison of within season changes to external load. At a minimum, data collection should take place during different seasonal periods, to capture any seasonal variations in training characteristics that may occur.

4.5 Future Research

Recommendations for future research have been presented throughout this thesis, for example recommendations focusing on methodological approaches for specific topics (Chapter 2), whereas suggestions for future research areas regarding training characteristics (Chapter 3). The following recommendations for future research aim to improve the current literature and practice on youth female football training characteristics.

As previously discussed, position-specific differences on physical training characteristics were not explored (Chapter 3). Position-specific differences have previously been observed in youth female match-play (69). Therefore, it is important to develop an understanding of whether training practices are appropriate in supplementing the development of players for their playing position, and thus important future research considers the influence of playing position on training characteristics. Additionally, future research should aim to explore the effects of task constraints (e.g. number of players, time limits, drill rules etc.) on the training characteristics of players, as well as how task constraints may differ between drill types. Previous research evaluating task constraints in youth male footballers has revealed that adaptations to training area size can manipulate the physical output of players (397). Therefore, understanding how task constraints may influence physical (and technical or tactical) outputs, can help to inform training practices and may assist practitioners in delivering training sessions which facilitate meaningful physical outputs.

The current thesis focused on quantifying external load, however, future research should aim to quantify technical and tactical characteristics of players in addition to this. A more holistic approach to understanding training characteristics is needed to gain an understanding into whether there are differences in technical (e.g. ball control, passing, shooting, dribbling) and tactical (e.g. game understanding, decision making) characteristics being presented across different age groups within ETCs. Further, to also establish whether similar age-related differences occur in technical and tactical characteristics between age groups, as well as understand more about how well training is reflecting match-play in these regards.

It is important that future research assesses the impact of external influencing factors such as diet, sleep and additional sport participation outside of the ETC environment on the training characteristics of youth female footballers. It should be acknowledged that there were initial plans for physical activity and nutritional data to be collected (via food diaries and GENEAactiv watches) and presented within the current thesis, to establish how these external factors may influence training characteristics. However, due to limited time, resources and not being a priority for inclusion within the current thesis, this was not pursued. (This was consequential of original research plans being written for a proposed PhD and then amended to an MSD research project). Exploring the effects of such external factors will provide greater context to the physical, technical and tactical performances of players during training. In turn, stakeholders such as governing bodies, practitioners and parents can gain an understanding of how these external factors influence a player's performance during training, as well as wider implications concerning nutrition, education and other lifestyle factors.

The current research does not explore the difference in training characteristics between clubs, and within and between sessions. As a result, the effects of the different training environments that ETCs provide have on training characteristics are yet to be explored. In addition to this, the differences in training characteristics within and between sessions are also absent from analysis. Therefore, there is scope for future research to isolate single-session data for analysis, to determine such variation within and between training sessions and drills.

Future research should aim to adopt a more expansive, multi-club approach to field a greater sample of the overall ETC population, capturing a wider range of training facilities and practices. In addition, this will facilitate between-club comparisons, presenting the opportunity to understand the variation that exists across ETCs. However, there are challenges to consider when looking to recruit multiple clubs, such as clashes in training schedule, location and travel time and available equipment and resources (e.g. GPS units, researchers carrying out data collection). The data collection period of the current research was conducted across 12 weeks of a 30-week season. Therefore, future research should aim to capture data across a greater period, ideally a whole ETC season. Additionally, this will allow for within-season variation in physical, technical and tactical characteristics to be explored. Understanding how these characteristics may fluctuate across the course of a season, may inform practitioners when designing training practices and periodisation strategies.

Whilst ETCs primarily deliver training sessions to players, they also aim to provide a minimum of one competitive game every 6-weeks. In addition to this, ETCs aim to expose players to various match-play formats (e.g., futsal, SSGs). Future research should quantify the physical (technical, and tactical) characteristics of the various match-play formats, to understand different representativeness of match-play and how they may influence training. In turn, this could provide information for policy makers and practitioners to use to reflect on whether the current format is facilitating players achieving the desired performance outcomes.

Finally, future research should look to quantify the training characteristics of players going through transitions between stages of the youth female talent pathway, such as the regional talent pathway and pro-game academies (e.g. new players within these stages). These represent later stages in both the England talent pathway and club talent pathway respectively, and both are steps that ETC players may advance to. Establishing the physical, technical and tactical training characteristics of payers within these set-ups will provide much needed evidence for practitioners not only working within, but also all other steps of the talent pathway. In turn, this can inform practitioners of the expected training load of players transitioning to the next stage, and adaptations can be made to support this.

4.6 Reflections

Conducting data collection for the current MSD thesis offered the valuable opportunity to make novel contributions to the existing underdeveloped evidence-base. Liaising with ETC coaches and staff as well as players and parents, provided insight into the logistical and relational considerations of conducting data collection within the youth football environment. Recording whole training sessions for multiple age groups simultaneously, whilst keeping track of different drill types, developed my skills in proactiveness and reinforced my appreciation for methodological consistency. Most importantly, immersing myself in the youth female football environment allowed me to observe training practices first-hand, and the current issues that coaches and staff experience. This combined with the findings of the current thesis, allowed for explicit recommendations to be made to stakeholders associated with ETCs and the youth female talent pathway, which could make positive change and benefit the development of the players representing them. Data collection did not come without its challenges; retaining the engagement of older age groups (e.g. U16s) in the project proved difficult. However, this does allow for the opportunity provide suggestions on how research can mitigate such problems in future. Furthermore, the Viva examination gave me an opportunity to reflect upon my findings and highlighted ways in which the interpretation of results could be enhanced by providing individual player variability and contextual influence, giving further direction to future research. These experiences have not only contributed to the robustness of this thesis but have also informed the approach to future research in youth female football environments.

4.7 Conclusions

The aim of this thesis was to (1) systematically review the scientific literature on the performance, health and development of youth female footballers and (2) quantify the physical training characteristics of youth female footballers. To summarise, a systematic scoping review collated all sports science and medicine literature investigating youth female football (Chapter 2), and provided a summary of aims, methodology and findings of each study. From this, the review has outlined gaps across the youth female football literature as well as identified key areas for future research within respective research topics. One of which included training load, with only four studies identified. To address this, Chapter 3 quantified session and drill-specific external load of youth female footballers during training, presenting relative and absolute data of U10s, U12s, U14s and U16s to determine whether age group differences exist. This study found differences across whole sessions and within and between drills, providing the first GPS quantified physical training characteristics of youth female footballers.

This thesis has presented novel research which serves as a resource for stakeholders working within the youth female talent pathway (e.g. policy makers, practitioners, talent identification) and for academics and researchers to utilise. The findings within the current thesis have facilitated the presentation of practical applications and recommendations as well as key considerations for future research regarding training characteristics of youth female footballers. To conclude, the findings from this thesis provides an insight into the physical training characteristics of youth female footballers and how this differs across age groups and drill types.

References

1. The FA - Written evidence (NPS0135) [Internet]. [cited 2025 July 17]. Available from: https://committees.parliament.uk/writtenevidence/22277/pdf/.

2. Association TF. What are The FA's duties? [Internet]. www.thefa.com. [cited 2025 July 17]. Available from: http://www.thefa.com/news/2017/feb/09/fa-response-to-governance-debate-090217.

3. Regional Top Talent | England Football [Internet]. [cited 2025 July 17]. Available from: https://www.englandfootball.com/england/youth/womens-talent-pathway/Regional-Top-Talent.

4. Future Lionesses Talent ID Events | England Football [Internet]. [cited 2025 July 17]. Available from: https://www.englandfootball.com/england/youth/womens-talent-pathway/discover-my-talent/Future-Lionesses-Talent-ID-Events.

5. ESFA. FA Emerging Talent Centres [Internet]. Engl. Sch. Footb. Assoc. 2022 [cited 2025 Feb 12]. Available from: https://schoolsfootball.org/playing-by-the-rules/fa-emerging-talent-centres/.

6. The Football Association. Discovering a "new generation" [Internet]. https://www.englandfootball.com. [cited 2025 May 11]. Available from: https://www.englandfootball.com/articles/2023/feb/09/new-emerging-talent-centres-launched-as-womens-girls-talent-pathway-revamped-20230902.

7. Operating Criteria - Girl's Emerging Talent Centres 2024/25 Season. The FA;

8. Pro Game Academies | England Football [Internet]. [cited 2025 July 17]. Available from: https://www.englandfootball.com/england/youth/womens-talent-pathway/Professional-Game-Academies.

9. Long Term Player Development Women's and Girl's Football. The FA;

10. The identificaiton of good practice principles to inform player development and coaching in European youth football [Internet]. [cited 2025 July 16]. Available from: https://uefaacademy.com/wp-content/uploads/sites/2/2019/06/2014_RGP_North-Julian_Youth-Development-in-Seven-Countries_Final-Report.pdf.

11. Pinder RA, Davids K, Renshaw I, Araújo D. Representative learning design and functionality of research and practice in sport. J Sport Exerc Psychol. 2011;33:146–155. doi: 10.1123/jsep.33.1.146. Cited: in: : PMID: 21451175.

12. Little T, Williams AG. Suitability of soccer training drills for endurance training. J Strength Cond Res. 2006;20:316–319. doi: 10.1519/R-17094.1. Cited: in: : PMID: 16686559.

13. Football and fitness: A scientific approach to performance. ResearchGate [Internet]. 2025 [cited 2025 July 31];

14. Sun M, Soh KG, Ma S, Wang X, Zhang J, Yaacob AB. Effects of speed, agility, and quickness (SAQ) training on soccer player performance-a systematic review and meta-analysis. PloS One. 2025;20:e0316846. doi: 10.1371/journal.pone.0316846. Cited: in: : PMID: 39983087.

15. Taylor JB, Mellalieu SD, James N, Shearer DA. The influence of match location, quality of opposition, and match status on technical performance in professional association football. J Sports Sci. 2008;26:885–895. doi: 10.1080/02640410701836887. Cited: in: : PMID: 18569554.

16. Rampinini E, Impellizzeri FM, Castagna C, Coutts AJ, Wisløff U. Technical performance during soccer matches of the Italian Serie A league: effect of fatigue and competitive level. J Sci Med Sport. 2009;12:227–233. doi: 10.1016/j.jsams.2007.10.002. Cited: in: : PMID: 18083631.

17. McPherson SL. The Development of Sport Expertise: Mapping the Tactical Domain. Quest. 1994;46:223–240. doi: 10.1080/00336297.1994.10484123.

18. Gledhill A, Harwood C, Forsdyke D. Psychosocial factors associated with talent development in football: A systematic review. Psychol Sport Exerc. 2017;31. doi: 10.1016/j.psychsport.2017.04.002.

19. Association TF. The FA's 4 Corner Model [Internet]. www.thefa.com. [cited 2025 July 14]. Available from: http://www.thefa.com/bootroom/resources/coaching/the-fas-4-corner-model.

20. Morgans R, Orme P, Anderson L, Drust B. Principles and practices of training for soccer. J Sport Health Sci. 2014;3:251–257. doi: 10.1016/j.jshs.2014.07.002.

21. UEFA.com. New fitness focus to complement the UEFA Coaching Convention [Internet]. UEFA.com. 2021 [cited 2025 Aug 20]. Available from: https://www.uefa.com/news-media/news/0270-13dc773e17a8-22adde735fb2-1000--new-fitness-focus-to-complement-the-uefa-coaching-convention/.

22. Halson SL. Monitoring Training Load to Understand Fatigue in Athletes. Sports Med. 2014;44:139–147. doi: 10.1007/s40279-014-0253-z.

23. Akubat I, Patel E, Barrett S, Abt G. Methods of monitoring the training and match load and their relationship to changes in fitness in professional youth soccer players. J Sports Sci. 2012;30:1473–1480. doi: 10.1080/02640414.2012.712711. Cited: in: : PMID: 22857397.

24. Withers RT. Match analysis of professional Australian soccer players. J Hum Mov Stud. 1982;8:159–176.

25. Bongers CCWG, Eijsvogels TMH. Time-motion analysis in the big data era: A promising method to assess the effects of heat stress on physical

performance. Temp Multidiscip Biomed J. 2018;5:197–198. doi: 10.1080/23328940.2018.1462656. Cited: in: : PMID: 30377637.

26. Pino Ortega J, Martínez-Santos R, Moreno M, Padilla C. Automatic analysis of football games using GPS on real time. J Sports Sci Med. 2007;6–11.

27. Beato M, Coratella G, Stiff A, Iacono AD. The Validity and Between-Unit Variability of GNSS Units (STATSports Apex 10 and 18 Hz) for Measuring Distance and Peak Speed in Team Sports. Front Physiol. 2018;9:1288. doi: 10.3389/fphys.2018.01288. Cited: in: : PMID: 30298015.

28. Beato M, de Keijzer KL. The inter-unit and inter-model reliability of GNSS STATSports Apex and Viper units in measuring peak speed over 5, 10, 15, 20 and 30 meters. Biol Sport. 2019;36:317–321. doi: 10.5114/biolsport.2019.88754. Cited: in: : PMID: 31938002.

29. Brosnan RJ, Watson G, Stuart W, Twentyman C, Kitic CM, Schmidt M. The Validity, Reliability, and Agreement of Global Positioning System Units-Can We Compare Research and Applied Data? J Strength Cond Res. 2022;36:3330–3338. doi: 10.1519/JSC.0000000000004139. Cited: in: : PMID: 34593728.

30. Malone JJ, Barrett S, Barnes C, Twist C, Drust B. To infinity and beyond: the use of GPS devices within the football codes. Sci Med Footb. 2020;4:82–84. doi: 10.1080/24733938.2019.1679871.

31. Hennessy L, Jeffreys I. The Current Use of GPS, Its Potential, and Limitations in Soccer. Strength Cond J. 2018;40:83–94. doi: 10.1519/SSC.0000000000000386.

32. Ravé G, Granacher U, Boullosa D, Hackney AC, Zouhal H. How to Use Global Positioning Systems (GPS) Data to Monitor Training Load in the “Real World” of Elite Soccer. Front Physiol [Internet]. 2020 [cited 2025 July 31];11. doi: 10.3389/fphys.2020.00944.

33. Akenhead R, Nassis GP. Training Load and Player Monitoring in High-Level Football: Current Practice and Perceptions. Int J Sports Physiol Perform. 2016;11:587–593. doi: 10.1123/ijspp.2015-0331.

34. Costa JA, Rago V, Brito P, Figueiredo P, Sousa A, Abade E, Brito J. Training in women soccer players: A systematic review on training load monitoring. Front Psychol. 2022;13:943857. doi: 10.3389/fpsyg.2022.943857. Cited: in: : PMID: 35967662.

35. Jaspers A, Brink MS, Probst SGM, Frencken WGP, Helsen WF. Relationships Between Training Load Indicators and Training Outcomes in Professional Soccer. Sports Med Auckl NZ. 2017;47:533–544. doi: 10.1007/s40279-016-0591-0. Cited: in: : PMID: 27459866.

36. Drew MK, Finch CF. The Relationship Between Training Load and Injury, Illness and Soreness: A Systematic and Literature Review. Sports Med Auckl NZ. 2016;46:861–883. doi: 10.1007/s40279-015-0459-8. Cited: in: : PMID: 26822969.

37. Silva JR, Rumpf MC, Hertzog M, Castagna C, Farooq A, Girard O, Hader K. Acute and Residual Soccer Match-Related Fatigue: A Systematic Review and Meta-analysis. Sports Med Auckl NZ. 2018;48:539–583. doi: 10.1007/s40279-017-0798-8. Cited: in: : PMID: 29098658.

38. Hader K, Rumpf MC, Hertzog M, Kilduff LP, Girard O, Silva JR. Monitoring the Athlete Match Response: Can External Load Variables Predict Post-match Acute and Residual Fatigue in Soccer? A Systematic Review with Meta-analysis. Sports Med - Open. 2019;5:48. doi: 10.1186/s40798-019-0219-7. Cited: in: : PMID: 31820260.

39. Scantlebury S, Till K, Beggs C, Dalton-Barron N, Weaving D, Sawczuk T, Jones B. Achieving a desired training intensity through the prescription of external training load variables in youth sport: More pieces to the puzzle required. J Sports Sci. 2020;38:1124–1131. doi: 10.1080/02640414.2020.1743047. Cited: in: : PMID: 32228154.

40. Oliveira R, Brito JP, Martins A, Mendes B, Marinho DA, Ferraz R, Marques MC. In-season internal and external training load quantification of an elite European soccer team. PloS One. 2019;14:e0209393. doi: 10.1371/journal.pone.0209393. Cited: in: : PMID: 31009464.

41. Gardner C, Navalta JW, Carrier B, Aguilar C, Perdomo Rodriguez J. Training Impulse and Its Impact on Load Management in Collegiate and Professional Soccer Players. Technologies. 2023;11:79. doi: 10.3390/technologies11030079.

42. Johnston RJ, Watsford ML, Kelly SJ, Pine MJ, Spurrs RW. Validity and interunit reliability of 10 Hz and 15 Hz GPS units for assessing athlete movement demands. J Strength Cond Res. 2014;28:1649–1655. doi: 10.1519/JSC.0000000000000323. Cited: in: : PMID: 24276300.

43. Teixeira JE, Forte P, Ferraz R, Leal M, Ribeiro J, Silva AJ, Barbosa TM, Monteiro AM. Monitoring Accumulated Training and Match Load in Football: A Systematic Review. Int J Environ Res Public Health. 2021;18:3906. doi: 10.3390/ijerph18083906. Cited: in: : PMID: 33917802.

44. Kryger K, Wang A, Mehta R, Impellizzeri F, Massey A, Mccall A. Research on women’s football: a scoping review. Sci Med Footb. 2021;1–10. doi: 10.1080/24733938.2020.1868560.

45. Emmonds S, Heyward O, Jones B. The Challenge of Applying and Undertaking Research in Female Sport. Sports Med - Open. 2019;5:51. doi: 10.1186/s40798-019-0224-x.

46. Zhu JW, Reed JL, Van Spall HGC. The underrepresentation of female athletes in sports research: considerations for cardiovascular health. Eur Heart J. 2022;43:1609–1611. doi: 10.1093/eurheartj/ehab846. Cited: in: : PMID: 34904147.

47. Carmichael MA, Perry K, Roberts AH, Klass V, Clarke AC. Menstrual cycle monitoring in applied sport settings: A scoping review. Int J Sports Sci Coach. 2025;17479541251333888. doi: 10.1177/17479541251333888.

48. Fort-Vanmeerhaeghe A, Benet A, Mirada S, Montalvo AM, Myer GD. Sex and Maturation Differences in Performance of Functional Jumping and Landing Deficits in Youth Athletes. J Sport Rehabil. 2019;28:606–613. doi: 10.1123/jsr.2017-0292. Cited: in: : PMID: 30222476.

49. Romero-Moraleda B, Nedergaard NJ, Morencos E, Casamichana D, Ramirez-Campillo R, Vanrenterghem J. External and internal loads during the competitive season in professional female soccer players according to their playing position: differences between training and competition. Res Sports Med Print. 2021;29:449–461. doi: 10.1080/15438627.2021.1895781. Cited: in: : PMID: 33663313.

50. Karlsson UB, Vagle M, Wiig H, Luteberget LS. Training Load Quantification in Women’s Elite Football: A Season-Long Prospective Cohort Study. Int J Sports Physiol Perform. 2023;18:603–614. doi: 10.1123/ijspp.2022-0272. Cited: in: : PMID: 37080539.

51. Doyle B, Browne D, Horan D. Quantification of internal and external training load during a training camp in senior international female footballers. Sci Med Footb. 2022;6:7–14. doi: 10.1080/24733938.2021.1886320. Cited: in: : PMID: 35236219.

52. Passos Ramos G, Datson N, Mahseredjian F, Lopes TR, Coimbra CC, Prado LS, Nakamura FY, Penna EM. Activity profile of training and matches in Brazilian Olympic female soccer team. Sci Med Footb. 2019;3:231–237. doi: 10.1080/24733938.2019.1615120.

53. Casamichana D, Barreira J, Castellano J, Barba Balda E, Erkizia B, Nakamura F. Comparative analysis of weekly and accumulated pre-season external load in a professional women’s soccer team and its reserve team. Sport Sci Health. 2025;21:787–795. doi: 10.1007/s11332-024-01315-4.

54. Mara JK, Thompson KG, Pumpa KL, Ball NB. Periodization and Physical Performance in Elite Female Soccer Players. 2015 [cited 2025 July 31]; doi: 10.1123/ijspp.2014-0345.

55. Savolainen EHJ, Ihalainen JK, Walker S. Female Soccer Players’ In-Season Weekly Training Load and Intensity: Comparison between National League’s Top and Bottom-Half Ranked Teams. J Hum Kinet. 2025;95:187–198. doi: 10.5114/jhk/189657. Cited: in: : PMID: 39944977.

56. Douchet T, Humbertclaude A, Cometti C, Paizis C, Babault N. Quantifying Accelerations and Decelerations in Elite Women Soccer Players during Regular In-Season Training as an Index of Training Load. Sports Basel Switz. 2021;9:109. doi: 10.3390/sports9080109. Cited: in: : PMID: 34437370.

57. Emmonds S, Dalton Barron N, Myhill N, Barrett S, King R, Weaving D. Locomotor and technical characteristics of female soccer players training:

exploration of differences between competition standards. Sci Med Footb. 2023;7:189–197. doi: 10.1080/24733938.2022.2089723. Cited: in: : PMID: 35703123.

58. Myhill N, Weaving D, Barrett S, King R, Emmonds S. A multi-club analysis of the locomotor training characteristics of elite female soccer players. Sci Med Footb. 2022;6:572–580. doi: 10.1080/24733938.2022.2114603. Cited: in: : PMID: 35980373.

59. Lesinski M, Prieske O, Helm N, Granacher U. Effects of Soccer Training on Anthropometry, Body Composition, and Physical Fitness during a Soccer Season in Female Elite Young Athletes: A Prospective Cohort Study. Front Physiol [Internet]. 2017 [cited 2025 Feb 17];8. doi: 10.3389/fphys.2017.01093.

60. Los Arcos A, Gonzalez Artetxe A, Bayer-Perez U, Folgado H. Consequences of field obstacles on tactical, conditional, and emotional dimensions in young female soccer players during small-sided games. Proc Inst Mech Eng Part P J Sports Eng Technol. 2023;239. doi: 10.1177/17543371231191845.

61. Rumpf M, Schneider A, Schneider C, Mayer M. Training Profiles and Motivation of Male and Female Youth Soccer Players. Int J Sports Sci Coach. 2014;9:207–216. doi: 10.1260/1747-9541.9.1.207.

62. Williams C, Winsley R, Rendeiro Pinho G, De Ste Croix M, Lloyd R, Oliver J. Prevalence of non-functional overreaching in elite male and female youth academy football players. Sci Med Footb. 2017;1:1–7. doi: 10.1080/24733938.2017.1336282.

63. Andersen TR, Kästner B, Arvig M, Larsen CH, Madsen EE. Monitoring load, wellness, and psychological variables in female and male youth national team football players during international and domestic playing periods. Front Sports Act Living. 2023;5:1197766. doi: 10.3389/fspor.2023.1197766. Cited: in: : PMID: 38162701.

64. González-García J, Romero-Moraleda B. The Impact of a Congested Competition Schedule on Load, Recovery, and Well-Being in Under-16 Female Soccer Players: A Comparison between Starters and Non-Starters during a Development Tournament. Appl Sci. 2024;14:8066. doi: 10.3390/app14178066.

65. Vargas J. (PDF) Original Article Enhancing ball passing creativity and effectiveness in youth women’s football: A single-case study. ResearchGate [Internet]. 2024 [cited 2025 Aug 25]; doi: 10.7752/jpes.2024.01022.

66. Sanchez-Sanchez J, Raya-González J, Martín V, Rodríguez Fernández A. Understanding Injuries in Young Female Soccer Players: A Narrative Review on Incidence, Mechanism, Location Risk Factors, and Preventive Strategies. Appl Sci. 2025;15:1612. doi: 10.3390/app15031612.

67. Selbekk SA, Lilleengen MS, Stålesen J, Ransom D, Sæther SA. Junior-to-senior transition in elite female football: identifying predominant sources of stress among junior players from both player and coach perspectives. Front

Psychol [Internet]. 2025 [cited 2025 Aug 25];16. doi: 10.3389/fpsyg.2025.1621559.

68. Randell RK, Clifford T, Drust B, Moss SL, Unnithan VB, De Ste Croix MBA, Datson N, Martin D, Mayho H, Carter JM, et al. Physiological Characteristics of Female Soccer Players and Health and Performance Considerations: A Narrative Review. Sports Med. 2021;51:1377–1399. doi: 10.1007/s40279-021-01458-1.

69. Harkness-Armstrong A, Till K, Datson N, Emmonds S. Whole and peak physical characteristics of elite youth female soccer match-play. J Sports Sci. 2021;39:1320–1329. doi: 10.1080/02640414.2020.1868669. Cited: in: : PMID: 33377422.

70. Barbero-Álvarez J, Gómez López M, Barbero-Alvarez V, Granda J, Castagna C. Heart rate and activity profile for young female soccer players. J Hum Sport Exerc. 2008;3. doi: 10.4100/jhse.2008.32.01.

71. Ramos GP, Nakamura FY, Penna EM, Wilke CF, Pereira LA, Loturco I, Capelli L, Mahseredjian F, Silami-Garcia E, Coimbra CC. Activity Profiles in U17, U20, and Senior Women’s Brazilian National Soccer Teams During International Competitions: Are There Meaningful Differences? J Strength Cond Res. 2019;33:3414–3422. doi: 10.1519/JSC.0000000000002170. Cited: in: : PMID: 28767483.

72. Mordillo E, Zago M. Motion characteristics of Under-15, Under-17 and Under-19 Italian youth women soccer matches. J Sports Med Phys Fitness. 2023;63:223–229. doi: 10.23736/S0022-4707.22.13923-X. Cited: in: : PMID: 35686863.

73. Vescovi JD. Motion characteristics of youth women soccer matches: female athletes in motion (FAiM) study. Int J Sports Med. 2014;35:110–117. doi: 10.1055/s-0033-1345134. Cited: in: : PMID: 23868688.

74. Harkness-Armstrong A, Till K, Datson N, Myhill N, Emmonds S. A systematic review of match-play characteristics in women’s soccer. PLOS ONE. 2022;17:e0268334. doi: 10.1371/journal.pone.0268334.

75. Emmonds S, Till K, Redgrave J, Murray E, Turner L, Robinson C, Jones B. Influence of age on the anthropometric and performance characteristics of high-level youth female soccer players. Int J Sports Sci Coach. 2018;13:779–786. doi: 10.1177/1747954118757437.

76. Emmonds S, Morris R, Murray E, Robinson C, Turner L, Jones B. The influence of age and maturity status on the maximum and explosive strength characteristics of elite youth female soccer players. Sci Med Footb. 2017;1:1–7. doi: 10.1080/24733938.2017.1363908.

77. Wright M, Chesterton P, Wijnbergen M, O’Rourke A, Macpherson T. The Effect of a Simulated Soccer Match on Anterior Cruciate Ligament Injury Risk Factors. Int J Sports Med. 2017;38:620–626. doi: 10.1055/s-0043-109238. Cited: in: : PMID: 28575923.

78. Harkness-Armstrong A, Till K, Datson N, Emmonds S. Determining age-specific velocity thresholds for elite youth female soccer players. Sci Med Footb. 2022;6:581–588. doi: 10.1080/24733938.2021.1991585. Cited: in: : PMID: 36540912.

79. Harkness-Armstrong A, Till K, Datson N, Emmonds S. Influence of match status and possession status on the physical and technical characteristics of elite youth female soccer match-play. J Sports Sci. 2023;41:1437–1449. doi: 10.1080/02640414.2023.2273653. Cited: in: : PMID: 37902235.

80. Harkness-Armstrong A, Till K, Datson N, Emmonds S. Technical characteristics of elite youth female soccer match-play: position and age group comparisons between under 14 and under 16 age groups. Int J Perform Anal Sport. 2020;20:942–959. doi: 10.1080/24748668.2020.1820173.

81. FIFA. Grow the participation [Internet]. FIFA. [cited 2025 Feb 12]. Available from: https://inside.fifa.com.

82. STATSCORE. Women's football is on the rise. What are its main drivers and challenges? [Internet]. statscore.com. [cited 2025 Feb 12]. Available from: https://www.statscore.com/market-research/womens-football-is-on-the-rise-what-are-its-main-drivers-and-challenges2/#:~:text=How%20women's%20football%20is%20growing,2019%20(source:%20FIFA.

83. The football landscape – The Vision 2020-2023 [Internet]. FIFA Publ. [cited 2025 Apr 10]. Available from: https://publications.fifa.com/en/vision-report-2021/the-football-landscape/.

84. FIFA celebrates historic step for women's football at LA28 Olympic Games [Internet]. [cited 2025 Apr 10]. Available from: https://inside.fifa.com/womens-football/media-releases/origin1904-p.cxm.fifa.com/fifa-celebrates-historic-step-for-womens-football-at-la28-olympic-games.

85. Concacaf Announces Strategic Plan to Develop Women's Football [Internet]. Concacaf. 2021 [cited 2025 Apr 10]. Available from: https://www.concacaf.com/en/article/concacaf-announces-strategic-plan-to-develop-women-s-football/.

86. Union of European Football Associations (UEFA). UEFA Women's Football Strategy 2024-2030: Unstoppable. [Internet]. 2024. Available from: https://editorial.uefa.com/resources/0292-1c3532529b72-3306578495fb-1000/unstoppable_uefa_women_s_football_strategy.pdf.

87. Association TF. 2024-28 women's and girls' strategy released [Internet]. www.thefa.com. [cited 2025 Apr 10]. Available from: http://www.thefa.com/news/2024/oct/31/womens-and-girls-2024-2028-strategy-reaching-higher-20243110.

88. The Football Association. Inspiring Positive Change - November 2022 [Internet]. www.thefa.com. [cited 2025 Feb 12]. Available from:

http://www.thefa.com/news/2022/nov/08/inspiring-positive-change-women-girls-football-strategy-update-20220811.

89. Robles-Palazón FJ, López-Valenciano A, De Ste Croix M, Oliver JL, García-Gómez A, Sainz de Baranda P, Ayala F. Epidemiology of injuries in male and female youth football players: A systematic review and meta-analysis. J Sport Health Sci. 2022;11:681–695. doi: 10.1016/j.jshs.2021.10.002. Cited: in: : PMID: 34700052.

90. Lopez-Valenciano A, Raya-González J, Garcia-Gomez J, Aparicio Sarmiento A, Sainz de Baranda P, De Ste Croix M, Ayala F. Response to Comment On: "Injury Profile in Women's Football: A Systematic Review and Meta-Analysis." Sports Med. 2021;51. doi: 10.1007/s40279-021-01532-8.

91. Mayhew L, Johnson MI, Francis P, Lutter C, Alali A, Jones G. Incidence of injury in adult elite women's football: a systematic review and meta-analysis. BMJ Open Sport Exerc Med. 2021;7:e001094. doi: 10.1136/bmjsem-2021-001094. Cited: in: : PMID: 34422291.

92. de Sousa MV, Lundsgaard A-M, Christensen PM, Christensen L, Randers MB, Mohr M, Nybo L, Kiens B, Fritzen AM. Nutritional optimization for female elite football players-topical review. Scand J Med Sci Sports. 2022;32 Suppl 1:81–104. doi: 10.1111/sms.14102. Cited: in: : PMID: 34865242.

93. Randell RK, Clifford T, Drust B, Moss SL, Unnithan VB, De Ste Croix MBA, Datson N, Martin D, Mayho H, Carter JM, et al. Physiological Characteristics of Female Soccer Players and Health and Performance Considerations: A Narrative Review. Sports Med Auckl Nz. 2021;51:1377–1399. doi: 10.1007/s40279-021-01458-1. Cited: in: : PMID: 33844195.

94. Petushek E, Sugimoto D, Stoolmiller M, Smith G, Myer G. Evidence-Based Best-Practice Guidelines for Preventing Anterior Cruciate Ligament Injuries in Young Female Athletes: A Systematic Review and Meta-analysis. Am J Sports Med. 2018;47:036354651878246. doi: 10.1177/0363546518782460.

95. Beech J, Jones B, Hughes T, Emmonds S. Injury Profile in Youth Female Athletes: A Systematic Review and Meta-Analysis. Sports Med. 2024;54:1207–1230. doi: 10.1007/s40279-023-01988-w.

96. Smith KL, Weir PL, Till K, Romann M, Cobley S. Relative Age Effects Across and Within Female Sport Contexts: A Systematic Review and Meta-Analysis. Sports Med. 2018;48:1451–1478. doi: 10.1007/s40279-018-0890-8.

97. Hamed D, Gonzalez-Muñoz A, Cuevas Cervera M, Pérez Montilla JJ, Aguilar Núñez D, Aguilar García M, Pruimboom L, Navarro Ledesma S. Effects of the menstrual cycle on the performance of female football players. A systematic review. Front Physiol. 2024;15. doi: 10.3389/fphys.2024.1359953.

98. Eustace SJ, Page RM, Greig M. Isokinetic strength differences between elite senior and youth female soccer players identifies training requirements. Phys Ther Sport Off J Assoc Chart Physiother Sports Med. 2019;39:45–51. doi: 10.1016/j.ptsp.2019.06.008. Cited: in: : PMID: 31254916.

99. Senefeld JW, Hunter SK. Hormonal Basis of Biological Sex Differences in Human Athletic Performance. Endocrinology. 2024;165:bqae036. doi: 10.1210/endocr/bqae036. Cited: in: : PMID: 38563597.

100. Gilani M. Gender Differences in Lower Body Biomechanics: Insights from High-Resolution Motion Capture for Computer Vision and Assistive Technologies [Internet]. ResearchGate. 2025 [cited 2025 Aug 25]. Available from: https://www.researchgate.net/publication/394455339_Gender_Differences_in_Lower_Body_Biomechanics_Insights_from_High-Resolution_Motion_Capture_for_Computer_Vision_and_Assistive_Technologies.

101. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, Moher D, Peters MDJ, Horsley T, Weeks L, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. Ann Intern Med. 2018;169:467–473. doi: 10.7326/M18-0850. Cited: in: : PMID: 30178033.

102. Dahl Pettersen S, Adolfsen F, Martinussen M. Psychological Factors and Performance in Women's Football: A Systematic Review. Scand J Med Sci Sports. 2021;32. doi: 10.1111/sms.14043.

103. Whitehead S, Weakley J, Cormack S, Alfano H, Kerss J, Mooney M, Jones B. The Applied Sports Science and Medicine of Netball: A Systematic Scoping Review. Sports Med. 2021;51:1715–1731. doi: 10.1007/s40279-021-01461-6.

104. Sacks D, Canadian Paediatric Society, Adolescent Health Committee. Age limits and adolescents. Paediatr Child Health. 2003;8:577. doi: 10.1093/pch/8.9.577.

105. Bangsbo J. Performance in sports--With specific emphasis on the effect of intensified training. Scand J Med Sci Sports. 2015;25 Suppl 4:88–99. doi: 10.1111/sms.12605. Cited: in: : PMID: 26589122.

106. Cueto M. The World Health Organization. In: Raviglione MCB, Tediosi F, Villa S, Casamitjana N, Plasència A, editors. Glob Health Essent [Internet]. Cham: Springer International Publishing; 2023 [cited 2025 Feb 12]. p. 421–424. Available from: https://doi.org/10.1007/978-3-031-33851-9_63.

107. The Editors of Encyclopaedia Britannica. Biological Development Summary | Britannica [Internet]. [cited 2025 Feb 12]. Available from: https://www.britannica.com/summary/biological-development.

108. Mollinedo-Gómez L, Osmani F, Lago-Fuentes C. Asimetrías en jugadores alevines de fútbol de una cantera de élite: diferencias entre sexos. Sport Sci J Sch Sport Phys Educ Psychomot. 2023;9:545–562. doi: 10.17979/sportis.2023.9.3.9632.

109. Jastrzebska A. Comparison of usefulness of two tests measuring anaerobic performance of untrained and soccer-training girls U12. Sci Rep. 2023;13. doi: 10.1038/s41598-023-46825-2.

110. Nayıroğlu S, Yılmaz AK, Silva AF, Silva R, Nobari H, Clemente FM. Effects of small-sided games and running-based high-intensity interval training on body composition and physical fitness in under-19 female soccer players. BMC Sports Sci Med Rehabil. 2022;14:119. doi: 10.1186/s13102-022-00516-z. Cited: in: : PMID: 35765044.

111. Faustino-da-Silva YV, Martinho DV, Coelho-E-Silva MJ, Valente-Dos-Santos J, Conde J, Oliveira TG, Ronque ERV, Agostinete RR, Fernandes RA, Sherar LB. Reproducibility and inter-observer agreement of Greulich-Pyle protocol to estimate skeletal age among female adolescent soccer players. BMC Pediatr. 2020;20:494. doi: 10.1186/s12887-020-02383-4. Cited: in: : PMID: 33106161.

112. CIES. Worldwide demographic analysis of women’s football - CIES Football Observatory [Internet]. Footb. Obs. - Mon. Rep. [cited 2025 Feb 12]. Available from: https://football-observatory.com/MonthlyReport96.

113. Alanen A-M, Barrons Z, Jordan MJ, Ferber R, Pasanen K. Between-day reliability of inertial measurement unit parameters during soccer-specific change of direction test. Int J Sports Sci Coach. 2023;19:1050–1057. doi: 10.1177/17479541231196733.

114. Alanen A-M, Benson LC, Jordan MJ, Ferber R, Pasanen K. Effects of Game-Specific Demands on Accelerations during Change of Direction Movements: Analysis of Youth Female Soccer. Biomechanics. 2023;3:250–257. doi: 10.3390/biomechanics3020021.

115. Celebrini R, Eng J, Miller W, Ekegren C, Johnston J, Macintyre D. The Effect of a Novel Movement Strategy in Decreasing ACL Risk Factors in Female Adolescent Soccer Players. J Strength Cond Res Natl Strength Cond Assoc. 2012;26. doi: 10.1519/JSC.0b013e3182472fef.

116. Celebrini RG, Eng JJ, Miller WC, Ekegren CL, Johnston JD, Depew TA, Macintyre DL. Effect of a novel movement strategy in decreasing ACL risk factors in female adolescent soccer players: a randomized controlled trial. Clin J Sport Med Off J Can Acad Sport Med. 2014;24:134–141. doi: 10.1097/JSM.0000000000000014. Cited: in: : PMID: 24184850.

117. DeLang MD, Hannon JP, Goto S, Bothwell JM, Garrison JC. Female Adolescent Soccer Players Utilize Different Neuromuscular Strategies Between Limbs During the Propulsion Phase of a Lateral Vertical Jump. Int J Sports Phys Ther. 2021;16:695–703. doi: 10.26603/001c.22134. Cited: in: : PMID: 34123522.

118. DiCesare CA, Kiefer AW, Bonnette S, Myer GD. High-Risk Lower-Extremity Biomechanics Evaluated in Simulated Soccer-Specific Virtual Environments. J Sport Rehabil. 2020;29:294–300. doi: 10.1123/jsr.2018-0237. Cited: in: : PMID: 30676190.

119. Grandstrand SL, Pfeiffer RP, Sabick MB, DeBeliso M, Shea KG. The effects of a commercially available warm-up program on landing mechanics in female

youth soccer players. J Strength Cond Res. 2006;20:331–335. doi: 10.1519/R-17585.1. Cited: in: : PMID: 16686560.

120. Grooten W, Karlefur O, Conradsson D. Effects of verbal knee alignment instructions on knee kinematics, kinetics and the performance of a single-leg jump in female adolescent soccer players. Eur J Physiother. 2020;22:1–9. doi: 10.1080/21679169.2019.1578823.

121. Jeras N, Bovend'Eerdt T, McCrum C. Biomechanical mechanisms of jumping performance in youth elite female soccer players. J Sports Sci. 2020;38:1335–1341. doi: 10.1080/02640414.2019.1674526.

122. Landry SC, McKean KA, Hubley-Kozey CL, Stanish WD, Deluzio KJ. Neuromuscular and lower limb biomechanical differences exist between male and female elite adolescent soccer players during an unanticipated side-cut maneuver. Am J Sports Med. 2007;35:1888–1900. doi: 10.1177/0363546507300823. Cited: in: : PMID: 17921416.

123. Landry S, McKean K, Hubley-Kozey C, Stanish W, Deluzio K. Gender differences exist in neuromuscular control patterns during the pre-contact and early stance phase of an unanticipated side-cut and cross-cut maneuver in 15-18 years old adolescent soccer players. J Electromyogr Kinesiol Off J Int Soc Electrophysiol Kinesiol. 2009;19:e370-9. doi: 10.1016/j.jelekin.2008.08.004.

124. Lindblom H, Waldén M, Carlfjord S, Hägglund M. Limited positive effects on jump-landing technique in girls but not in boys after 8 weeks of injury prevention exercise training in youth football. Knee Surg Sports Traumatol Arthrosc. 2020;28. doi: 10.1007/s00167-019-05721-x.

125. Lucarno S, Zago M, Rossi E, Muratore S, Baroncini G, Alberti G, Gualtieri D. Influence of age and sex on drop jump landing strategies in élite youth soccer players. Int J Sports Sci Coach. 2021;16:344–351. doi: 10.1177/1747954120952577.

126. O'Kane JW, Tencer A, Neradilek M, Polissar N, Sabado L, Schiff MA. Is Knee Separation During a Drop Jump Associated With Lower Extremity Injury in Adolescent Female Soccer Players? Am J Sports Med. 2016;44:318–323. doi: 10.1177/0363546515613076. Cited: in: : PMID: 26620296.

127. Ortiz A, Trudelle-Jackson E, McConnell K, Wylie S. Effectiveness of a 6-week Injury Prevention Program on Kinematics and Kinetic Variables in Adolescent Female Soccer Players: a Pilot Study. P R Health Sci J. 2010;29:40–48.

128. Thompson JA, Tran AA, Gatewood CT, Shultz R, Silder A, Delp SL, Dragoo JL. Biomechanical Effects of an Injury Prevention Program in Preadolescent Female Soccer Athletes. Am J Sports Med. 2017;45:294–301. doi: 10.1177/0363546516669326. Cited: in: : PMID: 27793803.

129. Thompson-Kolesar JA, Gatewood CT, Tran AA, Silder A, Shultz R, Delp SL, Dragoo JL. Age Influences Biomechanical Changes After Participation in an Anterior Cruciate Ligament Injury Prevention Program. Am J Sports Med.

2018;46:598–606. doi: 10.1177/0363546517744313. Cited: in: : PMID: 29281799.

130. Brooks JS, Allison W, Harriss A, Bian K, Mao H, Dickey JP. Purposeful Heading Performed by Female Youth Soccer Players Leads to Strain Development in Deep Brain Structures. Neurotrauma Rep. 2021;2:354–362. doi: 10.1089/neur.2021.0014. Cited: in: : PMID: 34901935.

131. Chrisman SPD, Ebel BE, Stein E, Lowry SJ, Rivara FP. Head Impact Exposure in Youth Soccer and Variation by Age and Sex. Clin J Sport Med Off J Can Acad Sport Med. 2019;29:3–10. doi: 10.1097/JSM.0000000000000497. Cited: in: : PMID: 29064865.

132. Filben TM, Pritchard NS, Miller LE, Miles CM, Urban JE, Stitzel JD. Header biomechanics in youth and collegiate female soccer. J Biomech. 2021;128:110782. doi: 10.1016/j.jbiomech.2021.110782. Cited: in: : PMID: 34656012.

133. Filben TM, Tomblin BT, Pritchard NS, Bullock GS, Hemmen JM, Neri KE, Krug V, Miles CM, Stitzel JD, Urban JE. Assessing the association between on-field heading technique and head impact kinematics in a cohort of female youth soccer players. Sci Med Footb. 2023;8:341–350. doi: 10.1080/24733938.2023.2264272. Cited: in: : PMID: 37753837.

134. Harriss A, Johnson AM, Walton DM, Dickey JP. Head impact magnitudes that occur from purposeful soccer heading depend on the game scenario and head impact location. Musculoskelet Sci Pract. 2019;40:53–57. doi: 10.1016/j.msksp.2019.01.009. Cited: in: : PMID: 30708266.

135. Le Flao E, Pichardo AW, Ganpatt S, Oranchuk DJ. An Accessible, 16-Week Neck Strength Training Program Improves Head Kinematics Following Chest Perturbation in Young Soccer Athletes. J Sport Rehabil. 2021;30:1158–1165. doi: 10.1123/jsr.2020-0537. Cited: in: : PMID: 34330102.

136. Miller LE, Pinkerton EK, Fabian KC, Wu LC, Espeland MA, Lamond LC, Miles CM, Camarillo DB, Stitzel JD, Urban JE. Characterizing head impact exposure in youth female soccer with a custom-instrumented mouthpiece. Res Sports Med Print. 2020;28:55–71. doi: 10.1080/15438627.2019.1590833. Cited: in: : PMID: 30880469.

137. Peek K, Andersen J, McKay MJ, Versteegh T, Gilchrist IA, Meyer T, Gardner A. The Effect of the FIFA 11 + with Added Neck Exercises on Maximal Isometric Neck Strength and Peak Head Impact Magnitude During Heading: A Pilot Study. Sports Med Auckl NZ. 2022;52:655–668. doi: 10.1007/s40279-021-01564-0. Cited: in: : PMID: 34590247.

138. Peek K, McKay M, Fu A, Meyer T, Oxenham V, Esopenko C, Caccese J, Andersen J. The effect of ball characteristics on head acceleration during purposeful heading in male and female youth football players. Sci Med Footb. 2021;5:195–203. doi: 10.1080/24733938.2021.1897657. Cited: in: : PMID: 35077287.

139. Pritchard S, Filben T, Haja S, Miller L, Espeland M, Stitzel J, Urban J. Head Impact Exposure in Youth Soccer: Comparing across Activity Types. Proc Inst Mech Eng Part P J Sports Eng Technol. 2023;175433712311586. doi: 10.1177/17543371231158669.

140. Tomblin BT, Pritchard NS, Filben TM, Miller LE, Miles CM, Urban JE, Stitzel JD. Characterization of On-Field Head Impact Exposure in Youth Soccer. J Appl Biomech. 2021;37:36–42. doi: 10.1123/jab.2020-0071. Cited: in: : PMID: 33152691.

141. Wahlquist VE, Kaminski TW. Analysis of Head Impact Biomechanics in Youth Female Soccer Players Following the Get aHEAD Safely in Soccer™ Heading Intervention. Sensors. 2021;21:3859. doi: 10.3390/s21113859. Cited: in: : PMID: 34204896.

142. Wahlquist VE, Glutting JJ, Kaminski TW. Examining the influence of the Get aHEAD Safely in Soccer™ program on head impact kinematics and neck strength in female youth soccer players. Res Sports Med Print. 2022;32:17–27. doi: 10.1080/15438627.2022.2079982. Cited: in: : PMID: 35611394.

143. Lyle MA, Sigward SM, Tsai L-C, Pollard CD, Powers CM. Influence of maturation on instep kick biomechanics in female soccer athletes. Med Sci Sports Exerc. 2011;43:1948–1954. doi: 10.1249/MSS.0b013e31821a4594. Cited: in: : PMID: 21448083.

144. Di Paolo S, Nijmeijer E, Bragonzoni L, Dingshoff E, Gokeler A, Benjaminse A. Comparing lab and field agility kinematics in young talented female football players: Implications for ACL injury prevention. Eur J Sport Sci. 2023;23:859–868. doi: 10.1080/17461391.2022.2064771. Cited: in: : PMID: 35400311.

145. The Football Association. Heading in Football [Internet]. https://www.englandfootball.com. [cited 2025 Feb 12]. Available from: https://www.englandfootball.com/participate/learn/brain-health/heading-in-football.

146. Bonn MM, Harriss AB, Thompson JWG, Dickey JP. Performing more than 20 purposeful gameplay headers in a soccer season may alter autonomic function in female youth soccer players. Res Sports Med Print. 2021;29:440–448. doi: 10.1080/15438627.2021.1888098. Cited: in: : PMID: 33596738.

147. De Ste Croix MBA, Priestley AM, Lloyd RS, Oliver JL. ACL injury risk in elite female youth soccer: Changes in neuromuscular control of the knee following soccer-specific fatigue. Scand J Med Sci Sports. 2015;25:e531-538. doi: 10.1111/sms.12355. Cited: in: : PMID: 25556396.

148. De Ste Croix MBA, Hughes JD, Lloyd RS, Oliver JL, Read PJ. Leg Stiffness in Female Soccer Players: Intersession Reliability and the Fatiguing Effects of Soccer-Specific Exercise. J Strength Cond Res. 2017;31:3052–3058. doi: 10.1519/JSC.0000000000001715. Cited: in: : PMID: 29065079.

149. De Ste Croix M, Priestley A, Lloyd R, Oliver J. Age-Related Differences in Functional Hamstring/Quadriceps Ratio Following Soccer Exercise in Female

Youth Players: An Injury Risk Factor. Pediatr Exerc Sci. 2018;30:376–382. doi: 10.1123/pes.2017-0034. Cited: in: : PMID: 29485920.

150. Harriss AB, Abbott K, Kimpinski K, Holmes JD, Johnson AM, Walton DM, Dickey JP. An Evaluation of Heart Rate Variability in Female Youth Soccer Players Following Soccer Heading: A Pilot Study. Sports. 2019;7:229. doi: 10.3390/sports7110229. Cited: in: : PMID: 31689916.

151. Hughes JD, Denton K, S Lloyd R, Oliver JL, De Ste Croix M. The Impact of Soccer Match Play on the Muscle Damage Response in Youth Female Athletes. Int J Sports Med. 2018;39:343–348. doi: 10.1055/s-0044-101147. Cited: in: : PMID: 29475207.

152. Spalding J. Changes in vertical jump height and sprint time during a congested match schedule in youth female soccer players. Sport J. 2022;24:1–15.

153. Watson A, Brickson S. Relationships Between Sport Specialization, Sleep, and Subjective Well-Being in Female Adolescent Athletes. Clin J Sport Med Off J Can Acad Sport Med. 2019;29:384–390. doi: 10.1097/JSM.0000000000000631.

154. Andreasen I, Faunø P, Lund B, Lemche P, Knudsen H. Soccer injuries among youth. Scand J Med Sci Sports. 1993;3:62–66. doi: 10.1111/j.1600-0838.1993.tb00363.x.

155. Beech J, Jones B, King R, Bennett P, Young S, Williams S, Stokes K, Emmonds S. The incidence and burden of injuries in elite English youth female soccer players. Sci Med Footb. 2022;6:605–615. doi: 10.1080/24733938.2022.2051730. Cited: in: : PMID: 35297310.

156. Butera C. Skin Cancer Risk Perception and Sunscreen Use in Adolescent Female Soccer Athletes. Dissertations [Internet]. 2014; doi: https://doi.org/10.22371/07.2014.018.

157. Clausen MB, Zebis MK, Møller M, Krustrup P, Hölmich P, Wedderkopp N, Andersen LL, Christensen KB, Thorborg K. High injury incidence in adolescent female soccer. Am J Sports Med. 2014;42:2487–2494. doi: 10.1177/0363546514541224. Cited: in: : PMID: 24989492.

158. Hägglund M, Waldén M, Ekstrand J. UEFA injury study--an injury audit of European Championships 2006 to 2008. Br J Sports Med. 2009;43:483–489. doi: 10.1136/bjsm.2008.056937. Cited: in: : PMID: 19246461.

159. Inoue Y, Tamura A, Misu S. Age of Adolescent Female Soccer Players at First Ankle Sprain and Menarche. Prog Rehabil Med. 2023;8:20230042. doi: 10.2490/prm.20230042. Cited: in: : PMID: 38034061.

160. Kolstrup LA, Koopmann KU, Nygaard UH, Nygaard RH, Agger P. Injuries during football tournaments in 45,000 children and adolescents. Eur J Sport Sci. 2016;16:1167–1175. doi: 10.1080/17461391.2016.1205145. Cited: in: : PMID: 27439027.

161. Le Gall F, Carling C, Reilly T. Injuries in young elite female soccer players: an 8-season prospective study. Am J Sports Med. 2008;36:276–284. doi: 10.1177/0363546507307866. Cited: in: : PMID: 17932408.

162. Lislevand M, Andersen TE, Junge A, Dvorak J, Steffen K. Injury surveillance during a 2-day national female youth football tournament in Kenya. Br J Sports Med. 2014;48:924–928. doi: 10.1136/bjsports-2013-092307. Cited: in: : PMID: 24273307.

163. Maehlum S, Dahl E, Daljord OA. Frequency of Injuries in a Youth Soccer Tournament. Phys Sportsmed. 1986;14:73–79. doi: 10.1080/00913847.1986.11709124. Cited: in: : PMID: 27441438.

164. O'Kane JW, Neradilek M, Polissar N, Sabado L, Tencer A, Schiff MA. Risk Factors for Lower Extremity Overuse Injuries in Female Youth Soccer Players. Orthop J Sports Med. 2017;5:2325967117733963. doi: 10.1177/2325967117733963. Cited: in: : PMID: 29114563.

165. Rosenbaum DA. Issues encountered by physicians during international travel with youth national soccer teams. Sports Health. 2011;3:230–234. doi: 10.1177/1941738111398612. Cited: in: : PMID: 23016012.

166. Schmidt-Olsen S, Bünemann LK, Lade V, Brassøe JO. Soccer injuries of youth. Br J Sports Med. 1985;19:161–164. doi: 10.1136/bjsm.19.3.161. Cited: in: : PMID: 4075068.

167. Schiff MA, Mack CD, Polissar NL, Levy MR, Dow SP, O'Kane JW. Soccer injuries in female youth players: comparison of injury surveillance by certified athletic trainers and internet. J Athl Train. 2010;45:238–242. doi: 10.4085/1062-6050-45.3.238. Cited: in: : PMID: 20446836.

168. Schneider A, Mayer M, Geißler U, Rumpf M, Schneider C. Injuries in Male and Female Adolescent Soccer Players. Sportverletz Sportschaden Organ Ges Orthopadisch-Traumatol Sportmed. 2013;27. doi: 10.1055/s-0032-1330764.

169. Schneider AS, Schneider C, Rumpf MC, Geißler U, Mayer M. Knieverletzungen bei männlichen und weiblichen adoleszenten Fußballspielern. Sport-Orthop - Sport-Traumatol - Sports Orthop Traumatol. 2013;29:40–44. doi: 10.1016/j.orthtr.2013.02.043.

170. Söderman K, Adolphson J, Lorentzon R, Alfredson H. Injuries in adolescent female players in European football: A prospective study over one outdoor soccer season. Scand J Med Sci Sports. 2001;11:299–304. doi: 10.1034/j.1600-0838.2001.110508.x.

171. Sprouse B, Alty J, Kemp S, Cowie C, Mehta R, Tang A, Morris J, Cooper S, Varley I. The Football Association Injury and Illness Surveillance Study: The Incidence, Burden and Severity of Injuries and Illness in Men's and Women's International Football. Sports Med. 2020;54:213–232. doi: 10.1007/s40279-020-01411-8.

172. Cheng AL, Merlo JA, Hunt D, Yemm T, Brophy RH, Prather H. Are Hip Physical Examination Findings Predictive of Future Lower-Body Injury Rates in Elite Adolescent Female Soccer Athletes at Minimum 5-Year Follow-Up? J Sport Rehabil. 2020;29:476–482. doi: 10.1123/jsr.2018-0350. Cited: in: : PMID: 31034343.

173. Chrisman SP, O'Kane JW, Polissar NL, Tencer AF, Mack CD, Levy MR, Schiff MA. Strength and jump biomechanics of elite and recreational female youth soccer players. J Athl Train. 2012;47:609–615. doi: 10.4085/1062-6050-47.6.01. Cited: in: : PMID: 23182007.

174. Clausen MB, Tang L, Zebis MK, Krustrup P, Hölmich P, Wedderkopp N, Andersen LL, Christensen KB, Møller M, Thorborg K. Self-reported previous knee injury and low knee function increase knee injury risk in adolescent female football. Scand J Med Sci Sports. 2016;26:919–926. doi: 10.1111/sms.12521. Cited: in: : PMID: 26179111.

175. Emery CA. Risk factors for injury in indoor compared with outdoor adolescent soccer. Am J Sports Med. 2006;34:1636–1642. doi: 10.1177/0363546506288018. Cited: in: : PMID: 16685083.

176. Hägglund M. Risk factors for acute knee injury in female youth football. Knee Surg Sports Traumatol Arthrosc Off J ESSKA. 2016;24:737–746. doi: 10.1007/s00167-015-3922-z. Cited: in: : PMID: 26704794.

177. O'Kane JW, Gray KE, Levy MR, Neradilek M, Tencer AF, Polissar NL, Schiff MA. Shoe and Field Surface Risk Factors for Acute Lower Extremity Injuries Among Female Youth Soccer Players. Clin J Sport Med Off J Can Acad Sport Med. 2016;26:245–250. doi: 10.1097/JSM.0000000000000236. Cited: in: : PMID: 26327288.

178. Sedeaud A, De Larochelambert Q, Moussa I, Brasse D, Berrou J-M, Duncombe S, Antero J, Orhant E, Carling C, Toussaint J-F. Does an Optimal Relationship Between Injury Risk and Workload Represented by the "Sweet Spot" Really Exist? An Example From Elite French Soccer Players and Pentathletes. Front Physiol [Internet]. 2020 [cited 2025 Feb 12];11. doi: 10.3389/fphys.2020.01034.

179. Soligard T, Bahr R, Andersen TE. Injury risk on artificial turf and grass in youth tournament football. Scand J Med Sci Sports. 2012;22:356–361. doi: 10.1111/j.1600-0838.2010.01174.x. Cited: in: : PMID: 20738822.

180. Soligard T, Grindem H, Bahr R, Andersen TE. Are skilled players at greater risk of injury in female youth football? Br J Sports Med. 2010;44:1118–1123. doi: 10.1136/bjsm.2010.075093. Cited: in: : PMID: 21047836.

181. Steffen K, Andersen TE, Bahr R. Risk of injury on artificial turf and natural grass in young female football players. Br J Sports Med. 2007;41 Suppl 1:i33-37. doi: 10.1136/bjsm.2007.036665. Cited: in: : PMID: 17550919.

182. Steffen K, Myklebust G, Andersen TE, Holme I, Bahr R. Self-reported injury history and lower limb function as risk factors for injuries in female youth

soccer. Am J Sports Med. 2008;36:700–708. doi: 10.1177/0363546507311598. Cited: in: : PMID: 18227233.

183. Tranaeus U, Ivarsson A, Johnson U, Weiss N, Samuelsson M, Skillgate E. The Role of the Results of Functional Tests and Psychological Factors on Prediction of Injuries in Adolescent Female Football Players. Int J Environ Res Public Health. 2022;19:143. doi: 10.3390/ijerph19010143. Cited: in: : PMID: 35010400.

184. Watson A, Brickson S, Brooks M, Dunn W. Preseason Aerobic Fitness Predicts In-Season Injury and Illness in Female Youth Athletes. Orthop J Sports Med. 2017;5:232596711772697. doi: 10.1177/2325967117726976.

185. Xiao M, Lemos JL, Hwang CE, Sherman SL, Safran MR, Abrams GD. High Specialization among Female Youth Soccer Players Is Associated with an Increased Likelihood of Serious Injury. Med Sci Sports Exerc. 2021;53:2086–2092. doi: 10.1249/MSS.0000000000002693. Cited: in: : PMID: 33927169.

186. De Ste Croix M, Hughes J, Ayala F, Taylor L, Datson N. Efficacy of Injury Prevention Training Is Greater for High-Risk vs Low-Risk Elite Female Youth Soccer Players. Am J Sports Med. 2018;46:3271–3280. doi: 10.1177/0363546518795677. Cited: in: : PMID: 30227000.

187. Hägglund M, Atroshi I, Wagner P, Waldén M. Superior compliance with a neuromuscular training programme is associated with fewer ACL injuries and fewer acute knee injuries in female adolescent football players: secondary analysis of an RCT. Br J Sports Med. 2013;47:974–979. doi: 10.1136/bjsports-2013-092644. Cited: in: : PMID: 23962878.

188. Leppänen M, Uotila A, Tokola K, Forsman-Lampinen H, Kujala UM, Parkkari J, Kannus P, Pasanen K, Vasankari T. Players with high physical fitness are at greater risk of injury in youth football. Scand J Med Sci Sports. 2022;32:1625–1638. doi: 10.1111/sms.14199. Cited: in: : PMID: 35621388.

189. Mandelbaum B, Silvers-Granelli H, Watanabe D, Knarr J, Thomas S, Griffin L, Garrett W. Effectiveness of a Neuromuscular and Proprioceptive Training Program in Preventing Anterior Cruciate Ligament Injuries in Female Athletes 2-Year Follow-up. Am J Sports Med. 2005;33:1003–1010. doi: 10.1177/0363546504272261.

190. Soligard T, Myklebust G, Steffen K, Holme I, Silvers-Granelli H, Bizzini M, Junge A, Dvorak J, Bahr R, Andersen T. Comprehensive warm-up programme to prevent injuries in young female footballers: Cluster randomised controlled trail. BMJ. 2008;337:a2469. doi: 10.1136/bmj.a2469.

191. Steffen K, Myklebust G, Olsen OE, Holme I, Bahr R. Preventing injuries in female youth football - A cluster-randomized controlled trial. Scand J Med Sci Sports. 2008;18:605–614. doi: 10.1111/j.1600-0838.2007.00703.x.

192. Steffen K, Meeuwisse WH, Romiti M, Kang J, McKay C, Bizzini M, Dvorak J, Finch C, Myklebust G, Emery CA. Evaluation of how different implementation strategies of an injury prevention programme (FIFA 11+) impact team

adherence and injury risk in Canadian female youth football players: a cluster-randomised trial. Br J Sports Med. 2013;47:480–487. doi: 10.1136/bjsports-2012-091887. Cited: in: : PMID: 23486935.

193. Waldén M, Atroshi I, Hedevik H, Wagner P, Hägglund M. Prevention of acute knee injuries in adolescent female football players: Cluster randomised controlled trial. BMJ. 2012;344:e3042. doi: 10.1136/bjsports-2012-e3042rep.

194. Zebis MK, Thorborg K, Andersen LL, Møller M, Christensen KB, Clausen MB, Hölmich P, Wedderkopp N, Andersen TB, Krustrup P. Effects of a lighter, smaller football on acute match injuries in adolescent female football: a pilot cluster-randomized controlled trial. J Sports Med Phys Fitness. 2018;58:644–650. doi: 10.23736/S0022-4707.17.07903-8. Cited: in: : PMID: 29719944.

195. van der Sluis A, Elferink-Gemser MT, Brink MS, Visscher C. Importance of peak height velocity timing in terms of injuries in talented soccer players. Int J Sports Med. 2015;36:327–332. doi: 10.1055/s-0034-1385879. Cited: in: : PMID: 25607518.

196. Malina RM. Maturity status and injury risk in youth soccer players. Clin J Sport Med Off J Can Acad Sport Med. 2010;20:132. doi: 10.1097/01.jsm.0000369404.77182.60. Cited: in: : PMID: 20215900.

197. Le Gall F, Carling C, Reilly T, Vandewalle H, Church J, Rochcongar P. Incidence of injuries in elite French youth soccer players: a 10-season study. Am J Sports Med. 2006;34:928–938. doi: 10.1177/0363546505283271. Cited: in: : PMID: 16436535.

198. Ekstrand J, Hägglund M, Fuller CW. Comparison of injuries sustained on artificial turf and grass by male and female elite football players. Scand J Med Sci Sports. 2011;21:824–832. doi: 10.1111/j.1600-0838.2010.01118.x. Cited: in: : PMID: 20456680.

199. Ekstrand J, Timpka T, Hägglund M. Risk of injury in elite football played on artificial turf versus natural grass: a prospective two-cohort study. Br J Sports Med. 2006;40:975–980. doi: 10.1136/bjsm.2006.027623. Cited: in: : PMID: 16990444.

200. Bjørneboe J, Bahr R, Andersen TE. Risk of injury on third-generation artificial turf in Norwegian professional football. Br J Sports Med. 2010;44:794–798. doi: 10.1136/bjsm.2010.073783. Cited: in: : PMID: 20820058.

201. Schwebel DC, Banaszek MM, McDaniel M. Brief report: Behavioral risk factors for youth soccer (football) injury. J Pediatr Psychol. 2007;32:411–416. doi: 10.1093/jpepsy/jsl034. Cited: in: : PMID: 17012737.

202. Andersen TB, Bendiksen M, Pedersen JM, Ørntoft C, Brito J, Jackman SR, Williams CA, Krustrup P. Kicking velocity and physical, technical, tactical match performance for U18 female football players--effect of a new ball. Hum Mov Sci. 2012;31:1624–1638. doi: 10.1016/j.humov.2012.07.003. Cited: in: : PMID: 23158018.

203. Harkness-Armstrong A, Till K, Datson N, Emmonds S. Influence of match status and possession status on the physical and technical characteristics of elite youth female soccer match-play. J Sports Sci. 2023;41:1437–1449. doi: 10.1080/02640414.2023.2273653. Cited: in: : PMID: 37902235.

204. Ørntoft C, Larsen MN, Andersen TB, Rasmussen LS, Póvoas SCA, Randers MB, Krustrup P. Technical Actions, Heart Rate, and Locomotor Activity in 7v7 and 8v8 Games for Female Youth Soccer Players. J Strength Cond Res. 2016;30:3298–3303. doi: 10.1519/JSC.0000000000001434. Cited: in: : PMID: 27050242.

205. Beaudouin F, Gioftsidou A, Larsen MN, Lemmink K, Drust B, Modena R, Espinola JR, Meiu M, Vouillamoz M, Meyer T. The UEFA Heading Study: Heading incidence in children's and youth' football (soccer) in eight European countries. Scand J Med Sci Sports. 2020;30:1506–1517. doi: 10.1111/sms.13694. Cited: in: : PMID: 32335945.

206. Harriss A, Johnson AM, Walton DM, Dickey JP. The number of purposeful headers female youth soccer players experience during games depends on player age but not player position. Sci Med Footb. 2019;3:109–114. doi: 10.1080/24733938.2018.1506591.

207. Harriss A, Walton DM, Dickey JP. Direct player observation is needed to accurately quantify heading frequency in youth soccer. Res Sports Med Print. 2018;26:191–198. doi: 10.1080/15438627.2018.1431534. Cited: in: : PMID: 29366355.

208. Peek K, Vella T, Meyer T, Beaudouin F, McKay M. The incidence and characteristics of purposeful heading in male and female youth football (soccer) within Australia. J Sci Med Sport. 2021;24:603–608. doi: 10.1016/j.jsams.2020.12.010. Cited: in: : PMID: 33414022.

209. Reeschke R, Haase FK, Dautzenberg L, Krutsch W, Reinsberger C. Training matters: Heading incidence and characteristics in children's and youth football (soccer) players. Scand J Med Sci Sports. 2023;33:1821–1830. doi: 10.1111/sms.14408. Cited: in: : PMID: 37259619.

210. Sandmo SB, Andersen TE, Koerte IK, Bahr R. Head impact exposure in youth football-Are current interventions hitting the target? Scand J Med Sci Sports. 2020;30:193–198. doi: 10.1111/sms.13562. Cited: in: : PMID: 31584703.

211. Wahlquist VE, Buckley TA, Caccese JB, Glutting JJ, Royer TD, Kaminski TW. Quantitative Analysis of Ball-Head Impact Exposure in Youth Soccer Players. J Sports Sci Med. 2023;22:591–596. doi: 10.52082/jssm.2023.591. Cited: in: : PMID: 37711709.

212. Maneiro R, Losada JL, Casal CA, Ardá A. The Influence of Match Status on Ball Possession in High Performance Women's Football. Front Psychol. 2020;11:487. doi: 10.3389/fpsyg.2020.00487. Cited: in: : PMID: 32265794.

213. Le Coz S, Iapteff L, Rioland M, Houde T, Carling C, Imbach F. A competing risk survival analysis of the impacts of team formation on goals in professional

football. Front Sports Act Living [Internet]. 2024 [cited 2025 Aug 25];6. doi: 10.3389/fspor.2024.1323930.

214. López-Fernández J, Gallardo L, Fernández-Luna Á, Villacañas V, García-Unanue J, Sánchez-Sánchez J. Pitch Size and Game Surface in Different Small-Sided Games. Global Indicators, Activity Profile, and Acceleration of Female Soccer Players. J Strength Cond Res. 2019;33:831–838. doi: 10.1519/JSC.0000000000002090. Cited: in: : PMID: 28658077.

215. Braun H, von Andrian-Werburg J, Schänzer W, Thevis M. Nutrition Status of Young Elite Female German Football Players. Pediatr Exerc Sci. 2018;30:157–167. doi: 10.1123/pes.2017-0072. Cited: in: : PMID: 28787242.

216. Chapelle L, Tassignon B, Aerenhouts D, Mullie P, Clarys P. The hydration status of young female elite soccer players during an official tournament. J Sports Med Phys Fitness. 2017;57:1186–1194. doi: 10.23736/S0022-4707.16.06527-0. Cited: in: : PMID: 27623755.

217. Cherian KS, Sainoji A, Nagalla B, Yagnambhatt VR. Energy Balance Coexists With Disproportionate Macronutrient Consumption Across Pretraining, During Training, and Posttraining Among Indian Junior Soccer Players. Pediatr Exerc Sci. 2018;30:506–515. doi: 10.1123/pes.2017-0276. Cited: in: : PMID: 30205762.

218. Düppe H, Gärdsell P, Johnell O, Ornstein E. Bone mineral density in female junior, senior and former football players. Osteoporos Int J Establ Result Coop Eur Found Osteoporos Natl Osteoporos Found USA. 1996;6:437–441. doi: 10.1007/BF01629575. Cited: in: : PMID: 9116388.

219. Francescato MP, Venuto I, Buoite Stella A, Stel G, Mallardi F, Cauci S. Sex differences in hydration status among adolescent elite soccer players. J Hum Sport Exerc. 2019;14. doi: 10.14198/jhse.2019.142.02.

220. Gibson JC, Stuart-Hill L, Martin S, Gaul C. Nutrition status of junior elite Canadian female soccer athletes. Int J Sport Nutr Exerc Metab. 2011;21:507–514. doi: 10.1123/ijsnem.21.6.507. Cited: in: : PMID: 22089309.

221. Gibson JC, Stuart-Hill LA, Pethick W, Gaul CA. Hydration status and fluid and sodium balance in elite Canadian junior women’s soccer players in a cool environment. Appl Physiol Nutr Metab Physiol Appl Nutr Metab. 2012;37:931–937. doi: 10.1139/h2012-073. Cited: in: : PMID: 22803782.

222. Klentrou P, McKee K, McKinlay BJ, Kurgan N, Roy BD, Falk B. Circulating Levels of Bone Markers after Short-Term Intense Training with Increased Dairy Consumption in Adolescent Female Athletes. Child Basel Switz. 2021;8:961. doi: 10.3390/children8110961. Cited: in: : PMID: 34828674.

223. McHaffie SJ, Langan-Evans C, Strauss JA, Areta JL, Rosimus C, Evans M, Waghorn R, Morton JP. Under-Fuelling for the Work Required? Assessment of Dietary Practices and Physical Loading of Adolescent Female Soccer Players during an Intensive International Training and Game Schedule. Nutrients. 2023;15:4508. doi: 10.3390/nu15214508. Cited: in: : PMID: 37960161.

224. McKinlay BJ, Wallace PJ, Olansky S, Woods S, Kurgan N, Roy BD, Josse AR, Falk B, Klentrou P. Intensified training in adolescent female athletes: a crossover study of Greek yogurt effects on indices of recovery. J Int Soc Sports Nutr. 2022;19:17–33. doi: 10.1080/15502783.2022.2044732. Cited: in: : PMID: 35599913.

225. Paludo AC, Gimunová M, Michaelides M, Kobus M, Parpa K. Description of the menstrual cycle status, energy availability, eating behavior and physical performance in a youth female soccer team. Sci Rep. 2023;13:11194. doi: 10.1038/s41598-023-37967-4. Cited: in: : PMID: 37433829.

226. Soto M, Sánchez-Díaz S, Castillo D, Lago A, Dominguez M, Rendo-Urteaga T, Raya-González J. Food intake, body composition and physical assessments in young male and female soccer players. Rev Espanola Nutr Humana Diet. 2021;

227. McCulloch RG, Bailey DA, Whalen RL, Houston CS, Faulkner RA, Craven BR. Bone Density and Bone Mineral Content of Adolescent Soccer Athletes and Competitive Swimmers. Pediatr Exerc Sci. 1992;4:319–330. doi: 10.1123/pes.4.4.319.

228. Nicolao A, Pedrinelli A, Zogaib P, Orbetelli R, Neto T. Influence of Sexual Maturation in Lactate Threshold in Female Soccer Players. Rev Bras Med Esporte. 2010;16:335–338. doi: 10.1590/S1517-86922010000500003.

229. Andrade MS, Junqueira MS, Andre Barbosa De Lira C, Vancini RL, Seffrin A, Nikolaidis PT, Rosemann T, Knechtle B. Age-related differences in torque in angle-specific and peak torque hamstring to quadriceps ratios in female soccer players from 11 to 18 years old: A Cross-sectional study. Res Sports Med Print. 2021;29:77–89. doi: 10.1080/15438627.2020.1742713. Cited: in: : PMID: 32200660.

230. Becerra-Patiño BA, Paucar Uribe JD, Ávila Martínez JD, Martínez-Benitez F, Martínez Benítez C. Analysis of physical variables as an indicator of performance in a sample of Colombian women’s soccer players: influence of being a starter and a non-starter. J Phys Educ Sport. 2023;23:1481–1487. doi: 10.7752/jpes.2023.06181.

231. Bishop C, Pereira LA, Reis VP, Read P, Turner AN, Loturco I. Comparing the magnitude and direction of asymmetry during the squat, countermovement and drop jump tests in elite youth female soccer players. J Sports Sci. 2020;38:1296–1303. doi: 10.1080/02640414.2019.1649525. Cited: in: : PMID: 31354103.

232. Bishop C, Read P, McCubbine J, Turner A. Vertical and Horizontal Asymmetries Are Related to Slower Sprinting and Jump Performance in Elite Youth Female Soccer Players. J Strength Cond Res. 2021;35:56–63. doi: 10.1519/JSC.0000000000002544. Cited: in: : PMID: 29489719.

233. Brännström A, Yu J-G, Jonsson P, Åkerfeldt T, Stridsberg M, Svensson M. Vitamin D in relation to bone health and muscle function in young female

soccer players. Eur J Sport Sci. 2017;17:249–256. doi: 10.1080/17461391.2016.1225823. Cited: in: : PMID: 27633075.

234. Castagna C. Vertical jump performance in Italian male and female national team soccer players. J Strength Cond Res. 2013;27:1156–1161. doi: 10.1519/JSC.0b013e3182610999. Cited: in: : PMID: 22692110.

235. Cherian KS, Shahkar F, Sainoji A, Balakrishna N, Yagnambhatt VR. Resting metabolic rate of Indian Junior Soccer players: Testing agreement between measured versus selected predictive equations. Am J Hum Biol Off J Hum Biol Counc. 2018;30. doi: 10.1002/ajhb.23066. Cited: in: : PMID: 28963803.

236. Datson N, Weston M, Drust B, Gregson W, Lolli L. High-intensity endurance capacity assessment as a tool for talent identification in elite youth female soccer. J Sports Sci. 2020;38:1313–1319. doi: 10.1080/02640414.2019.1656323. Cited: in: : PMID: 31451097.

237. Datson N, Weston M, Drust B, Atkinson G, Lolli L, Gregson W. Reference values for performance test outcomes relevant to English female soccer players. Sci Med Footb. 2022;6:589–596. doi: 10.1080/24733938.2022.2037156. Cited: in: : PMID: 35100523.

238. De Marco K, Lyons M, Joyce C, Conlon JA. The relationship between relative lower-body strength, sprint and change of direction ability in elite youth female soccer athletes. Int J Sports Sci Coach. 2024;19:805–811. doi: 10.1177/17479541231180329.

239. De Oliveira F, Corrêa Neto V, Barbosa R, Jesus I, Novaes J, Monteiro E. Power and Anaerobic Capacity in Female Soccer: A Comparison Between Different Age-Categories. Apunts Sports Med. 2023;58. doi: 10.1016/j.apunsm.2023.100421.

240. Doyle B, Browne D, Horan D. Differences in anthropometric and physical performance characteristics between U17, U19, and Senior Irish female international football players. Int J Sports Sci Coach. 2021;16:352–359. doi: 10.1177/1747954120968191.

241. Emmonds S, Sawczuk T, Scantlebury S, Till K, Jones B. Seasonal Changes in the Physical Performance of Elite Youth Female Soccer Players. J Strength Cond Res. 2020;34:2636–2643. doi: 10.1519/JSC.0000000000002943. Cited: in: : PMID: 30358700.

242. Emmonds S, Scantlebury S, Murray E, Turner L, Robsinon C, Jones B. Physical Characteristics of Elite Youth Female Soccer Players Characterized by Maturity Status. J Strength Cond Res. 2020;34:2321–2328. doi: 10.1519/JSC.0000000000002795. Cited: in: : PMID: 30199446.

243. Fagundes U, Vancini RL, Seffrin A, de Almeida AA, Nikolaidis PT, Rosemann T, Knechtle B, Andrade MS, de Lira CAB. Adolescent female handball players present greater bone mass content than soccer players: A cross-sectional study. Bone. 2022;154:116217. doi: 10.1016/j.bone.2021.116217. Cited: in: : PMID: 34583063.

244. Fältström A, Skillgate E, Tranaeus U, Weiss N, Källberg H, Lyberg V, Nomme M, Thome N, Omsland T, Petersen E, et al. Normative values and changes in range of motion, strength, and functional performance over 1 year in adolescent female football players: Data from 418 players in the Karolinska football Injury Cohort study. Phys Ther Sport. 2022;58. doi: 10.1016/j.ptsp.2022.10.003.

245. Ferry B, Duclos M, Burt L, Therre P, Le Gall F, Jaffré C, Courteix D. Bone geometry and strength adaptations to physical constraints inherent in different sports: comparison between elite female soccer players and swimmers. J Bone Miner Metab. 2011;29:342–351. doi: 10.1007/s00774-010-0226-8. Cited: in: : PMID: 20963459.

246. Ferry B, Lespessailles E, Rochcongar P, Duclos M, Courteix D. Bone health during late adolescence: effects of an 8-month training program on bone geometry in female athletes. Joint Bone Spine. 2013;80:57–63. doi: 10.1016/j.jbspin.2012.01.006. Cited: in: : PMID: 22405856.

247. Haag T, Schneider A, Beckmann C, Handel M, Schneider C, Mayer M. A test battery to investigate back pain in female soccer players. Sport Sci Health. 2016;12. doi: 10.1007/s11332-016-0296-7.

248. Gradidge PJ-L. A comparative study on the cardiac morphology and vertical jump height of adolescent black South African male and female amateur competitive footballers. Cardiovasc J Afr. 2018;29:32–35. doi: 10.5830/CVJA-2017-032. Cited: in: : PMID: 28817153.

249. Kobus M, Żądzińska E, Michaelides M, Parpa K. Primary Headaches and Physical Performance: A Professional Youth Female Soccer Team Study. Brain Sci. 2022;12:1702. doi: 10.3390/brainsci12121702. Cited: in: : PMID: 36552162.

250. Kottaras S, Stoikos J, McKinlay BJ, Ludwa IA, Josse AR, Falk B, Klentrou P. Bone Turnover Markers and Osteokines in Adolescent Female Athletes of High- and Low-Impact Sports Compared With Nonathletic Controls. Pediatr Exerc Sci. 2023;35:41–47. doi: 10.1123/pes.2022-0025. Cited: in: : PMID: 35894972.

251. Lilić A, Petkovic E, Stankovic M, Hadžović M. INFLUENCE OF BODY COMPOSITION PARAMETERS ON EXPLOSIVE POWER PERFORMANCE IN FEMALE ADOLESCENT FOOTBALL PLAYERS. Facta Univ Ser Phys Educ Sport. 2022;20:175–185. doi: 10.22190/FUPES220826016L.

252. Lozano-Berges G, Matute-Llorente Á, Gómez-Bruton A, González-Agüero A, Vicente-Rodríguez G, Casajús JA. Bone geometry in young male and female football players: a peripheral quantitative computed tomography (pQCT) study. Arch Osteoporos. 2018;13:57. doi: 10.1007/s11657-018-0472-2. Cited: in: : PMID: 29737414.

253. Lozano-Berges G, Matute-Llorente Á, Gómez-Bruton A, González-Agüero A, Vicente-Rodríguez G, Casajús JA. Do Serum 25-Hydroxyvitamin D

Concentrations Affect Body Composition, Physical Fitness, Bone Strength and Bone Biomarkers in Female Children and Adolescent Football Players? A One-Season Study. Int J Environ Res Public Health. 2022;19:15394. doi: 10.3390/ijerph192215394. Cited: in: : PMID: 36430113.

254. Mainer-Pardos E, Gonzalo-Skok O, Nobari H, Lozano D, Pérez-Gómez J. Age-related differences in linear sprint in adolescent female soccer players. BMC Sports Sci Med Rehabil. 2021;13:97. doi: 10.1186/s13102-021-00327-8. Cited: in: : PMID: 34420519.

255. Manson SA, Brughelli M, Harris NK. Physiological characteristics of international female soccer players. J Strength Cond Res. 2014;28:308–318. doi: 10.1519/JSC.0b013e31829b56b1. Cited: in: : PMID: 24476742.

256. Martinho DV, Coelho-E-Silva MJ, Gonçalves Santos J, Oliveira TG, Minderico CS, Seabra A, Valente-Dos-Santos J, Sherar LB, Malina RM. Body Size, Fatness and Skeletal Age in Female Youth Soccer Players. Int J Sports Med. 2023;44:711–719. doi: 10.1055/a-1686-4563. Cited: in: : PMID: 34734401.

257. Mujika I, Santisteban J, Impellizzeri F, Castagna C. Fitness determinants of success in men’s and women’s football. J Sports Sci. 2009;27:107–114. doi: 10.1080/02640410802428071.

258. Norikazu H. Age differences in change-of-direction performance and its subelements in female football players. Int J Sports Physiol Perform. 2015;10:440–445. doi: 10.1123/ijspp.2014-0214. Cited: in: : PMID: 25365733.

259. Nyland JA, Caborn DNM, Brosky JA, Kneller CL, Freidhoff G. Anthropometric, muscular fitness, and injury history comparisons by gender of youth soccer teams. Anthr Muscular Fit Inj Hist Comp Gend Youth Soccer Teams [Internet]. 1997 [cited 2025 Feb 12];

260. O’Brien-Smith J, Bennett K, Fransen J, Smith M. Same or different? A comparison of anthropometry, physical fitness and perceptual motor characteristics in male and female youth soccer players. Sci Med Footb. 2019;4:1–8. doi: 10.1080/24733938.2019.1650197.

261. Oyón P, Rubio FJ, Valero A. Young women soccer players. Anthropometric and physiological characteristics. Evolution in a Sports season. Arch Med Deporte. 2016;33:24–28.

262. Pambo P, Adu-Adadey M, Ankrah PT, Agbodzakey H, Scharhag J. Electrocardiographic and Echocardiographic Findings in Ghanaian Female Soccer Players. Clin J Sport Med Off J Can Acad Sport Med. 2021;31:e367–e372. doi: 10.1097/JSM.0000000000000851. Cited: in: : PMID: 32516237.

263. Mainer Pardos E, Bishop C, Gonzalo-Skok O, Nobari H, Perez-Gomez J, Lozano D. Associations between Inter-Limb Asymmetries in Jump and Change of Direction Speed Tests and Physical Performance in Adolescent Female Soccer Players. Int J Environ Res Public Health. 2021;18. doi: 10.3390/ijerph18073474.

264. Petrovic T, Zdravkovic M, Djelic M, Gavrilovic T, Mihailovic Z, Atanasijevic N, Stojkovic O. Influence of ACE and ACTN3 genes polymorphisms on cardiovascular adaptation in female football players. Genetika. 2022;54:1035–1047. doi: 10.2298/GENSR2203035P.

265. Philp F, Telford C, Reid D, McCluskey M. Normative performance values of modified Star Excursion Balance Test and Limb Symmetry in female adolescent footballers. Transl SPORTS Med. 2020;3:328–336. doi: 10.1002/tsm2.146.

266. Poehling RA, Tsai M-C, Manson SA, Koehle MS, Meylan CMP. Physical performance development in a female national team soccer program. J Sci Med Sport. 2021;24:597–602. doi: 10.1016/j.jsams.2020.12.009. Cited: in: : PMID: 33390301.

267. Ramos GP, Nakamura FY, Penna EM, Mendes TT, Mahseredjian F, Lima AM, Garcia ES, Prado LS, Coimbra CC. Comparison of Physical Fitness and Anthropometrical Profiles Among Brazilian Female Soccer National Teams From U15 to Senior Categories. J Strength Cond Res. 2021;35:2302–2308. doi: 10.1519/JSC.0000000000003140. Cited: in: : PMID: 31009426.

268. Raya-González J, Clemente FM, Castillo D. Analyzing the Magnitude of Interlimb Asymmetries in Young Female Soccer Players: A Preliminary Study. Int J Environ Res Public Health. 2021;18:475. doi: 10.3390/ijerph18020475. Cited: in: : PMID: 33435559.

269. Romero-Caballero A, Varela Olalla D, Loëns-Gutiérrez C. Fitness evaluation in young and amateur soccer players: Reference values for vertical jump and aerobic fitness in men and women. Sci Sports. 2021; doi: 10.1016/j.scispo.2020.04.004.

270. Rusu L, Dobre A, Chivaran A, Marin M. Relation between Muscle Force of Knee Extensors and Flexor Muscles and Sleep Quality of Women Soccer Players: A Pilot Study. Appl Sci. 2023;13:2289. doi: 10.3390/app13042289.

271. Sánchez García M, Rodriguez-Fernandez A, Villa-delBosque M, Bermejo Martin L, Sánchez J, Ramirez-Campillo R, Villa J. Effects of the menstrual phase on the performance and well-being of female young soccer players. Cult Cienc Deporte. 2022;

272. Swanson G, Haraldsdottir K, Anderson S, Watson A. The associations between acute and chronic sleep and aerobic capacity in adolescent female soccer players. Sport Sci Health. 2023;20. doi: 10.1007/s11332-023-01123-2.

273. V Martinho D, Valente-Dos-Santos J, Coelho-E-Silva MJ, Gutiérrez AO, Duarte JP, Lourenço-Farinha P, Luz LGO, Gonçalves-Santos J, Machado DRL, Leite N, et al. Scaling left ventricular mass in adolescent female soccer players. BMC Pediatr. 2020;20:157. doi: 10.1186/s12887-020-02043-7. Cited: in: : PMID: 32284059.

274. Vargas VZ, Motta C, Peres B, Vancini RL, Andre Barbosa De Lira C, Andrade MS. Knee isokinetic muscle strength and balance ratio in female soccer

players of different age groups: a cross-sectional study. Phys Sportsmed. 2020;48:105–109. doi: 10.1080/00913847.2019.1642808. Cited: in: : PMID: 31307251.

275. Vescovi JD, Rupf R, Brown TD, Marques MC. Physical performance characteristics of high-level female soccer players 12-21 years of age. Scand J Med Sci Sports. 2011;21:670–678. doi: 10.1111/j.1600-0838.2009.01081.x. Cited: in: : PMID: 21917018.

276. Wright M. Application and interpretation of the yo-yo intermittent recovery test to the long-term physical development of girls association football players. Sci Med Footb. 2019;3:1–10. doi: 10.1080/24733938.2019.1609071.

277. Wright MD. Changes in Sprint-Related Outcomes During a Period of Systematic Training in a Girls' Soccer Academy. J Strength Cond Res. 2019;33:793–800. doi: 10.1519/JSC.0000000000002055. Cited: in: : PMID: 28595239.

278. Zhang J, Lin J, Wei H, Liu H. Relationships between Functional Movement Quality and Sprint and Jump Performance in Female Youth Soccer Athletes of Team China. Child Basel Switz. 2022;9:1312. doi: 10.3390/children9091312. Cited: in: : PMID: 36138620.

279. González García J, Morencos E, Balsalobre-Fernández C, Rayo Á, Romero-Moraleda B. Effects of 7-Week Hip Thrust Versus Back Squat Resistance Training on Performance in Adolescent Female Soccer Players. Sports. 2019; doi: 10.3390/sports7040080.

280. Hammami MA, Ben Ayed K, Ali A, Zouita S, Marzougui H, Moran J, Clark CCT, Mekni R, Zouhal H. The effects of a soccer season on anthropometric characteristics, physical fitness, and soccer skills in North African elite female youth soccer players. Sci Sports. 2023;38:401–410. doi: 10.1016/j.scispo.2022.08.002.

281. Isla E, Romero-Moraleda B, Moya JM, Esparza-Ros F, Mallo J. Effects of a Neuromuscular Warm-Up Program in Youth Female Soccer Players. J Hum Kinet. 2021;79:29–40. doi: 10.2478/hukin-2021-0080. Cited: in: : PMID: 34400984.

282. Lesinski M, Prieske O, Chaabene H, Granacher U. Seasonal Effects of Strength Endurance vs. Power Training in Young Female Soccer Athletes. J Strength Cond Res. 2021;35:S90–S96. doi: 10.1519/JSC.0000000000003564. Cited: in: : PMID: 32149876.

283. Lindblom H, Waldén M, Hägglund M. No effect on performance tests from a neuromuscular warm-up programme in youth female football: a randomised controlled trial. Knee Surg Sports Traumatol Arthrosc Off J ESSKA. 2012;20:2116–2123. doi: 10.1007/s00167-011-1846-9. Cited: in: : PMID: 22203049.

284. Mathisen G, Svein AP. The effect of speed training on sprint and agility performance in female youth soccer players. J Phys Educ Sport. 2015;15:395–399. doi: 10.7752/jpes.2015.03059.

285. Fernandez Ortega JA, los Reyes YGD, Garavito Peña FR. Effects of strength training based on velocity versus traditional training on muscle mass, neuromuscular activation, and indicators of maximal power and strength in girls soccer players. Apunts Sports Med. 2020;55:53–61. doi: 10.1016/j.apunsm.2020.03.002.

286. Pardos-Mainer E, Casajús JA, Gonzalo-Skok O. Adolescent female soccer players' soccer-specific warm-up effects on performance and inter-limb asymmetries. Biol Sport. 2019;36:199–207. doi: 10.5114/biolsport.2019.85453. Cited: in: : PMID: 31624413.

287. Pardos-Mainer E, Casajús JA, Bishop C, Gonzalo-Skok O. Effects of Combined Strength and Power Training on Physical Performance and Interlimb Asymmetries in Adolescent Female Soccer Players. Int J Sports Physiol Perform. 2020;15:1147–1155. doi: 10.1123/ijspp.2019-0265. Cited: in: : PMID: 32820132.

288. Rubley MD, Haase AC, Holcomb WR, Girouard TJ, Tandy RD. The effect of plyometric training on power and kicking distance in female adolescent soccer players. J Strength Cond Res. 2011;25:129–134. doi: 10.1519/JSC.0b013e3181b94a3d. Cited: in: : PMID: 19966586.

289. Sanchez M, Sanchez-Sanchez J, Bermejo-Martín L, Del Bosque MV, Moran J, Romero-Moraleda B, Ramirez-Campillo R. Effects Of Jump Training On Youth Female Soccer Player's Physical Fitness. 2022 [cited 2025 Feb 19]; doi: 10.2174/1875399X-v15-e2208310.

290. Singha P. A study on the effects of 6 weeks of training on body composition, physical fitness and physiological variables of female football players. J Hum Sport Exerc. 2023;18:879–892. doi: 10.14198/jhse.2023.184.12.

291. Steffen K, Emery CA, Romiti M, Kang J, Bizzini M, Dvorak J, Finch CF, Meeuwisse WH. High adherence to a neuromuscular injury prevention programme (FIFA 11+) improves functional balance and reduces injury risk in Canadian youth female football players: a cluster randomised trial. Br J Sports Med. 2013;47:794–802. doi: 10.1136/bjsports-2012-091886. Cited: in: : PMID: 23559666.

292. Vargas VZ, Baptista AF, Pereira GOC, Pochini AC, Ejnisman B, Santos MB, João SMA, Hazime FA. Modulation of Isometric Quadriceps Strength in Soccer Players With Transcranial Direct Current Stimulation: A Crossover Study. J Strength Cond Res. 2018;32:1336–1341. doi: 10.1519/JSC.0000000000001985. Cited: in: : PMID: 28489629.

293. Vescovi JD, VanHeest JL. Effects of an anterior cruciate ligament injury prevention program on performance in adolescent female soccer players.

Scand J Med Sci Sports. 2010;20:394–402. doi: 10.1111/j.1600-0838.2009.00963.x. Cited: in: : PMID: 19558381.

294. Whittaker JL. Impact of the FIFA 11+ on the structure of select muscles in adolescent female soccer players. Phys Ther Sport Off J Assoc Chart Physiother Sports Med. 2015;16:228–235. doi: 10.1016/j.ptsp.2014.10.007. Cited: in: : PMID: 25869424.

295. Wright M, Hurst C, Taylor J. Contrasting effects of a mixed-methods high-intensity interval training intervention in girl football players. J Sports Sci. 2016;34:1–8. doi: 10.1080/02640414.2016.1139163.

296. Baxter-Jones ADG, Barbour-Tuck EN, Dale D, Sherar LB, Knight CJ, Cumming SP, Ferguson LJ, Kowalski KC, Humbert ML. The role of growth and maturation during adolescence on team-selection and short-term sports participation. Ann Hum Biol. 2020;47:316–323. doi: 10.1080/03014460.2019.1707870. Cited: in: : PMID: 31960720.

297. Bennett KJM, Novak AR, Fransen J, Duffield R. The prevalence of relative age effects and the influence of the talent pool size on Australian male and female youth football. J Sports Sci. 2023;41:172–180. doi: 10.1080/02640414.2023.2204582. Cited: in: : PMID: 37102421.

298. Brustio PR, Modena R, Boccia G, Vogliazzo M, Kelly AL. Youth-to-senior transition in women's and girls' football: Towards a better understanding of relative age effects and gender-specific considerations. PloS One. 2023;18:e0283781. doi: 10.1371/journal.pone.0283781. Cited: in: : PMID: 37141307.

299. Ginés HJ, Huertas F, García Calvo T, Ponce-Bordón JC, Figueiredo AJ, Ballester R. Age and Maturation Matter in Youth Elite Soccer, but Depending on Competitive Level and Gender. Int J Environ Res Public Health. 2023;20:2015. doi: 10.3390/ijerph20032015. Cited: in: : PMID: 36767382.

300. Götze M. Relative Age Effect in Elite German Soccer: Influence of Gender and Competition Level. Front Psychol. 2021;11:587023. doi: 10.3389/fpsyg.2020.587023. Cited: in: : PMID: 33542698.

301. Grossmann B. Relative Age Effect (RAE) in Football Talents – the Role of Youth Academies in Transition to Professional Status in Germany. Int J Perform Anal Sport. 2013;13:120–134. doi: 10.1080/24748668.2013.11868636.

302. Korgaokar AD, Farley RS, Fuller DK, Caputo JL. Relative Age Effect Among Elite Youth Female Soccer Players across the United States. Sport Mont. 2018;16:37–41.

303. Lagestad P, Steen I, Dalen T. Inevitable Relative Age Effects in Different Stages of the Selection Process among Male and Female Youth Soccer Players. Sports Basel Switz. 2018;6:29. doi: 10.3390/sports6020029. Cited: in: : PMID: 29910333.

304. Li Z, Mao L, Steingröver C, Wattie N, Baker J, Schorer J, Helsen WF. Relative age effects in Elite Chinese soccer players: Implications of the “one-child” policy. PloS One. 2020;15:e0228611. doi: 10.1371/journal.pone.0228611. Cited: in: : PMID: 32059000.

305. Matušica M. The influence of relative age on the selection of players for elite events in junior football. J Phys Educ Sport. 2023;23:790–799.

306. Pedersen AV, Aune TK, Dalen T, Lorås H. Variations in the relative age effect with age and sex, and over time-Elite-level data from international soccer world cups. PloS One. 2022;17:e0264813. doi: 10.1371/journal.pone.0264813. Cited: in: : PMID: 35482636.

307. Ribeiro E, Barreira J, Carraco D, Galatti L, Götze M, Cal Abad CC. The relative age effect in under-17, under-20, and adult elite female soccer players. Sci Med Footb. 2023;8:153–160. doi: 10.1080/24733938.2022.2164608. Cited: in: : PMID: 36592346.

308. Romann M. Influences of player nationality, playing position, and height on relative age effects at women’s under-17 FIFA World Cup. J Sports Sci. 2013;31:32–40. doi: 10.1080/02640414.2012.718442. Cited: in: : PMID: 22909307.

309. Sedano S, Vaeyens R, Redondo JC. The Relative Age Effect in Spanish Female Soccer Players. Influence of the Competitive Level and a Playing Position. J Hum Kinet. 2015;46:129–137. doi: 10.1515/hukin-2015-0041. Cited: in: : PMID: 26240656.

310. Simon C, Carson F, Faber IR, Hülsdünker T. Low prevalence of relative age effects in Luxembourg’s male and female youth football. PloS One. 2022;17:e0273019. doi: 10.1371/journal.pone.0273019. Cited: in: : PMID: 35998177.

311. Smith KL. An Examination of Relative Age and Athlete Dropout in Female Developmental Soccer. Sports Basel Switz. 2022;10:79. doi: 10.3390/sports10050079. Cited: in: : PMID: 35622488.

312. van den Honert R. Evidence of the relative age effect in football in Australia. J Sports Sci. 2012;30:1365–1374. doi: 10.1080/02640414.2012.707329. Cited: in: : PMID: 22876740.

313. Vincent J. Gender differences in the relative age effect among US olympic development program youth soccer players. J Sports Sci. 2006;24:405–413. doi: 10.1080/02640410500244655. Cited: in: : PMID: 16492604.

314. Castagna C, Impellizzeri FM, Manzi V, Ditroilo M. The assessment of maximal aerobic power with the multistage fitness test in young women soccer players. J Strength Cond Res. 2010;24:1488–1494. doi: 10.1519/JSC.0b013e3181d8e97a. Cited: in: : PMID: 20508449.

315. Fältström A, Hägglund M, Hedevik H, Lindblom H, Kvist J. The side hop test: Validity, reliability, and quality aspects in relation to sex, age and anterior

cruciate ligament reconstruction, in soccer players. Phys Ther Sport Off J Assoc Chart Physiother Sports Med. 2023;62:39–45. doi: 10.1016/j.ptsp.2023.05.008. Cited: in: : PMID: 37300972.

316. Lesinski M, Muehlbauer T, Granacher U. Concurrent validity of the Gyko inertial sensor system for the assessment of vertical jump height in female sub-elite youth soccer players. BMC Sports Sci Med Rehabil. 2016;8. doi: 10.1186/s13102-016-0061-x.

317. Pardos-Mainer E. Reliability and sensitivity of jumping, linear sprinting and change of direction ability tests in adolescent female football players. Sci Med Footb. 2019;3:183–190. doi: 10.1080/24733938.2018.1554257.

318. Sonesson S, Lindblom H, Hägglund M. Performance on sprint, agility and jump tests have moderate to strong correlations in youth football players but performance tests are weakly correlated to neuromuscular control tests. Knee Surg Sports Traumatol Arthrosc Off J ESSKA. 2021;29:1659–1669. doi: 10.1007/s00167-020-06302-z. Cited: in: : PMID: 33030610.

319. Wright MD, Songane F, Emmonds S, Chesterton P, Weston M, Mclaren SJ. Differential Ratings of Perceived Match and Training Exertion in Girls' Soccer. Int J Sports Physiol Perform. 2020;15:1315–1323. doi: 10.1123/ijspp.2019-0595. Cited: in: : PMID: 32947260.

320. Zhang J, Lin J, Wei H, Liu H. Relationships between Functional Movement Quality and Sprint and Jump Performance in Female Youth Soccer Athletes of Team China. Child Basel Switz. 2022;9:1312. doi: 10.3390/children9091312. Cited: in: : PMID: 36138620.

321. Currie W. Performance profiling of elite youth football players: the effects of age on performance [Internet] [MSc(R)]. University of Glasgow; 2018 [cited 2025 Feb 17]. Available from: https://eleanor.lib.gla.ac.uk/record=b3301820.

322. Williams CA, Oliver JL, Faulkner J. Seasonal monitoring of sprint and jump performance in a soccer youth academy. Int J Sports Physiol Perform. 2011;6:264–275. doi: 10.1123/ijspp.6.2.264. Cited: in: : PMID: 21725111.

323. Malina R, Eisenmann J, Cumming S, Ribeiro B, Aroso J. Maturity-associated variation in the growth and functional capacities of youth football (soccer) players 13-15 years. Eur J Appl Physiol. 2004;91:555–562. doi: 10.1007/s00421-003-0995-z.

324. Romann M, Rüeger E, Hintermann M, Kern R, Faude O. Origins of Relative Age Effects in Youth Football-A Nationwide Analysis. Front Sports Act Living. 2020;2:591072. doi: 10.3389/fspor.2020.591072. Cited: in: : PMID: 33345168.

325. Smoll FL, Smith RE. Children and youth in sport : a biopsychosocial perspective [Internet]. 2nd ed. Kendall/Hunt Pub. Co.; 1996 [cited 2025 Feb 17]. Available from: https://cir.nii.ac.jp/crid/1130282273185193984.

326. Pérez-González B, León-Quismondo J, Bonal J, Burillo P, Fernández-Luna Á. The New Generation of Professional Soccer Talent Is Born under the Bias of

the RAE: Relative Age Effect in International Male Youth Soccer Championships. Child Basel Switz. 2021;8:1117. doi: 10.3390/children8121117. Cited: in: : PMID: 34943315.

327. Ando S, Ogoh N, Saito S, Watanabe H, Ohsuga M, Hasegawa T, Ogoh S. Cognitive Function among Young Women's Football Players in the Summer Heat. Transl Sports Med. 2023;2023:5516439. doi: 10.1155/2023/5516439. Cited: in: : PMID: 38654921.

328. Beavan A, Spielmann J, Ehmann P, Mayer J. The Development of Executive Functions in High-Level Female Soccer Players. Percept Mot Skills. 2022;129:1036–1052. doi: 10.1177/00315125221096989. Cited: in: : PMID: 35521695.

329. Burton D, Gillham A, Glenn S. Motivational Styles: Examining the Impact of Personality on the Self-Talk Patterns of Adolescent Female Soccer Players. J Appl Sport Psychol - J APPL SPORT PSYCHOL. 2011;23:413–428. doi: 10.1080/10413200.2011.568469.

330. Burton D, Gillham A, Glenn S. The Forgotten Self-Talk Attribute: Examining Perceived Effectiveness Profiles and Patterns of Elite Female Junior Soccer Players. Int J Sports Sci Coach. 2013;8:357–372. doi: 10.1260/1747-9541.8.2.357.

331. Che X, Zhang Y, Lin J, Zhang K, Yao W, Lan J, Li J. Two-dimensional and three-dimensional multiple object tracking learning performance in adolescent female soccer players: The role of flow experience reflected by heart rate variability. Physiol Behav. 2023;258:114009. doi: 10.1016/j.physbeh.2022.114009. Cited: in: : PMID: 36326537.

332. Duguay AM, Loughead TM, Cook JM. Athlete leadership as a shared process: Using a social-network approach to examine athlete leadership in competitive female youth soccer teams. Sport Psychol. 2020;33:189–202. doi: 10.1123/tsp.2018-0019.

333. Fältström A, Skillgate E, Weiss N, Källberg H, Lyberg V, Waldén M, Hägglund M, Asker M, Tranaeus U. Lifestyle characteristics in adolescent female football players: data from the Karolinska football Injury Cohort. BMC Sports Sci Med Rehabil. 2022;14:212. doi: 10.1186/s13102-022-00603-1. Cited: in: : PMID: 36517880.

334. Forsman H, Gråstén A, Blomqvist M, Davids K, Liukkonen J, Konttinen N. Development and validation of the Perceived Game-Specific Soccer Competence Scale. J Sports Sci. 2016;34:1319–1327. doi: 10.1080/02640414.2015.1125518. Cited: in: : PMID: 26708611.

335. Harris M, Casey LB, Meindl JN, Powell D, Hunter WC, Delgado D. Using Behavioral Skills Training With Video Feedback to Prevent Risk of Injury in Youth Female Soccer Athletes. Behav Anal Pract. 2020;13:811–819. doi: 10.1007/s40617-020-00473-4. Cited: in: : PMID: 33269191.

336. Höner O, Raabe J, Murr D, Leyhr D. Prognostic relevance of motor tests in elite girls' soccer: a five-year prospective cohort study within the German talent promotion program. Sci Med Footb. 2019;3:1–10. doi: 10.1080/24733938.2019.1609069.

337. Kontos AP, Dolese A, Elbin RJ, Covassin T, Warren BL. Relationship of soccer heading to computerized neurocognitive performance and symptoms among female and male youth soccer players. Brain Inj. 2011;25:1234–1241. doi: 10.3109/02699052.2011.608209. Cited: in: : PMID: 21902552.

338. Kuettel A, Durand-Bush N, Larsen CH. Mental Health Profiles of Danish Youth Soccer Players: The Influence of Gender and Career Development. J Clin Sport Psychol. 2022;16:276–293. doi: 10.1123/jcsp.2021-0035.

339. Leyhr D, Raabe J, Schultz F, Kelava A, Höner O. The adolescent motor performance development of elite female soccer players: A study of prognostic relevance for future success in adulthood using multilevel modelling. J Sports Sci. 2020;38:1342–1351. doi: 10.1080/02640414.2019.1686940. Cited: in: : PMID: 31680634.

340. Miller B, Roberts G, Ommundsen Y. Effect of motivational climate on sportpersonship among competitive youth male and female football players. Scand J Med Sci Sports. 2004;14:193–202. doi: 10.1111/j.1600-0838.2003.00320.x.

341. Miller B, Roberts G, Ommundsen Y. Effect of perceived motivational climate on moral functioning, team moral atmosphere perceptions, and the legitimacy of intentionally injurious acts among competitive youth football players. Psychol Sport Exerc. 2005;6:461–477. doi: 10.1016/j.psychsport.2004.04.003.

342. Møllerløkken NE, Lorås H, Pedersen AV. A Comparison of Players' and Coaches' Perceptions of the Coach-Created Motivational Climate within Youth Soccer Teams. Front Psychol. 2017;8:109. doi: 10.3389/fpsyg.2017.00109. Cited: in: : PMID: 28203217.

343. Moore EW, Weiller-Abels K. Psychosocial Climates Differentially Predict 12- to 14-Year-Old Competitive Soccer Players' Goal Orientations. Women Sport Phys Act J. 2020;28:1–8. doi: 10.1123/wspaj.2019-0007.

344. Morales-Sánchez V, Caballero-Cerbán M, Postigo-Martín C, Morillo-Baro JP, Hernández-Mendo A, Reigal RE. Perceived Motivational Climate Determines Self-Confidence and Precompetitive Anxiety in Young Soccer Players: Analysis by Gender. Sustainability. 2022;14:15673. doi: 10.3390/su142315673.

345. Munroe-Chandler K, Hall C, Fishburne G, Shannon V. Using cognitive general imagery to improve soccer strategies. Eur J Sport Sci - EUR J SPORT SCI. 2005;5:41–49. doi: 10.1080/17461390500076592.

346. Olmedilla A, Cánovas M, Olmedilla-Caballero B, Ortega E. Characteristics relevant to sports performance: gender differences in youth soccer. Cuad Psicol Deporte. 2021;21:127–137. doi: 10.6018/cpd.417711.

347. Ommundsen Y, Roberts GC, Lemyre P-N, Miller BW. Peer relationships in adolescent competitive soccer: associations to perceived motivational climate, achievement goals and perfectionism. J Sports Sci. 2005;23:977–989. doi: 10.1080/02640410500127975. Cited: in: : PMID: 16195049.

348. Perroni F, Gallotta M, Pisano S, Reis V, Emerenziani GP, Guidetti L, Baldari C. Gender differences in anthropometric parameters and technical performance of youth soccer players. Sport Sci Health. 2018;14. doi: 10.1007/s11332-018-0456-z.

349. Price M, Weiss M. Peer Leadership in Sport: Relationships among Personal Characteristics, Leader Behaviors, and Team Outcomes. J Appl Sport Psychol - J APPL SPORT PSYCHOL. 2011;23:49–64. doi: 10.1080/10413200.2010.520300.

350. Scanlan TK. Factors Influencing the Competitive Performance Expectancies of Young Female Athletes. J Sport Exerc Psychol. 1979;1:212–220. doi: 10.1123/jsp.1.3.212.

351. Scanlan TK. Sources of Competitive Stress in Young Female Athletes. J Sport Exerc Psychol. 1979;1:151–159. doi: 10.1123/jsp.1.2.151.

352. Steffen K, Pensgaard AM, Bahr R. Self-reported psychological characteristics as risk factors for injuries in female youth football. Scand J Med Sci Sports. 2009;19:442–451. doi: 10.1111/j.1600-0838.2008.00797.x. Cited: in: : PMID: 18435692.

353. Stephens DE. Predictors of likelihood to aggress in youth soccer: An examination of coed and all-girls teams. J Sport Behav. 2000;23:311–325.

354. Stephens DE. Moral atmosphere and judgments about aggression in girls' soccer: Relationships among moral and motivational variables. J Sport Exerc Psychol. 1996;18:158–173.

355. Mahoney MJ, Gabriel TJ, Perkins TS. Psychological skills and exceptional athletic performance. Sport Psychol. 1987;1:181–199.

356. Duda JL, Walling MD, Chi L. The Perceived Motivational Climate in Sport Questionnaire: Construct and Predictive Validity. J Sport Exerc Psychol. 1996;15:172–183. doi: 10.1123/jsep.15.2.172.

357. Duda JL. Task and Ego Orientation in Sport Questionnaire [Internet]. 1989 [cited 2025 Feb 17]. Available from: https://doi.apa.org/doi/10.1037/t21903-000.

358. Gomez P, Ratcliff R, Perea M. A model of the go/no-go task. J Exp Psychol Gen. 2007;136:389–413. doi: 10.1037/0096-3445.136.3.389.

359. (PDF) Visual exploratory activity in elite women's soccer: an analysis of the UEFA Women's European Championship 2022. ResearchGate [Internet]. 2025 [cited 2025 Apr 14];

360. (PDF) Physical performance optimization in football. ResearchGate [Internet]. [cited 2025 Aug 25]. Available from: https://www.researchgate.net/publication/345007411_Physical_performance_optimization_in_football.

361. Romero-Moraleda B, Nedergaard NJ, Morencos E, Casamichana D, Ramirez-Campillo R, Vanrenterghem J. External and internal loads during the competitive season in professional female soccer players according to their playing position: differences between training and competition. Res Sports Med Print. 2021;29:449–461. doi: 10.1080/15438627.2021.1895781. Cited: in: : PMID: 33663313.

362. Ramachandran AK, Pedley JS, Moeskops S, Oliver JL, Myer GD, Lloyd RS. Changes in Lower Limb Biomechanics Across Various Stages of Maturation and Implications for ACL Injury Risk in Female Athletes: a Systematic Review. Sports Med Auckl NZ. 2024;54:1851–1876. doi: 10.1007/s40279-024-02022-3. Cited: in: : PMID: 38671176.

363. Butcher AJ, Ward S, Clissold T, Richards J, Hébert-Losier K. Maturation and biomechanical risk factors associated with anterior cruciate ligament injury: Is there a link? A systematic review. Phys Ther Sport Off J Assoc Chart Physiother Sports Med. 2024;68:31–50. doi: 10.1016/j.ptsp.2024.06.002. Cited: in: : PMID: 38908221.

364. Vescovi JD, Falenchuk O. Contextual factors on physical demands in professional women's soccer: Female Athletes in Motion study. Eur J Sport Sci. 2019;19:141–146. doi: 10.1080/17461391.2018.1491628. Cited: in: : PMID: 29961405.

365. Ford PR, Yates I, Williams AM. An analysis of practice activities and instructional behaviours used by youth soccer coaches during practice: exploring the link between science and application. J Sports Sci. 2010;28:483–495. doi: 10.1080/02640410903582750. Cited: in: : PMID: 20419591.

366. Cushion C, Ford PR, Williams AM. Coach behaviours and practice structures in youth soccer: implications for talent development. J Sports Sci. 2012;30:1631–1641. doi: 10.1080/02640414.2012.721930. Cited: in: : PMID: 23016800.

367. Chow JY, Davids K, Button C, Shuttleworth R, Renshaw I, Araújo D. The Role of Nonlinear Pedagogy in Physical Education. Rev Educ Res. 2007;77:251–278. doi: 10.3102/003465430305615.

368. Renshaw I, Davids K, Newcombe D, Roberts W. The Constraints-Led Approach: Principles for Sports Coaching and Practice Design. London: Routledge; 2019.

369. Chow JY, Davids K, Button C, Renshaw I. Nonlinear Pedagogy in Skill Acquisition: An Introduction. London: Routledge; 2015.

370. Hammami MA, Guerchi M, Selmi O, Sehli F, Ghouili H, Stângaciu OA, Marinău MA, Galeru O, Alexe DI. Effect of Verbal Encouragement on Physical Fitness,

Technical Skill and Physiological Response during Small-Sided Soccer Games. Sustainability. 2023;15:3624. doi: 10.3390/su15043624.

371. fa-recommended-pitch-sizes.pdf [Internet]. [cited 2025 Apr 5]. Available from: https://www.sportsequip.co.uk/pdfs/fa-recommended-pitch-sizes.pdf.

372. Castellano J, Puente A, Echeazarra I, Casamichana D. Influence of the Number of Players and the Relative Pitch Area per Player on Heart Rate and Physical Demands in Youth Soccer. J Strength Cond Res. 2015;29:1683. doi: 10.1519/JSC.0000000000000788.

373. Castillo D, Raya-González ,Javier, Manuel Clemente ,Filipe, and Yanci J. The influence of offside rule and pitch sizes on the youth soccer players' small-sided games external loads. Res Sports Med. 2020;28:324–338. doi: 10.1080/15438627.2020.1739687. Cited: in: : PMID: 32183556.

374. Verstappen S, van Rijn RM, Cost R, Stubbe JH. The Association Between Training Load and Injury Risk in Elite Youth Soccer Players: a Systematic Review and Best Evidence Synthesis. Sports Med - Open. 2021;7:6. doi: 10.1186/s40798-020-00296-1.

375. Bowen L, Gross AS, Gimpel M, Li F-X. Accumulated workloads and the acute:chronic workload ratio relate to injury risk in elite youth football players. Br J Sports Med. 2017;51:452–459. doi: 10.1136/bjsports-2015-095820. Cited: in: : PMID: 27450360.

376. Silva H, Nakamura FY, Beato M, Marcelino R. Acceleration and deceleration demands during training sessions in football: a systematic review. Sci Med Footb. 2023;7:198–213. doi: 10.1080/24733938.2022.2090600. Cited: in: : PMID: 35700979.

377. Vanrenterghem J, Nedergaard NJ, Robinson MA, Drust B. Training Load Monitoring in Team Sports: A Novel Framework Separating Physiological and Biomechanical Load-Adaptation Pathways. Sports Med. 2017;47:2135–2142. doi: 10.1007/s40279-017-0714-2.

378. Soprano JV. Musculoskeletal injuries in the pediatric and adolescent athlete. Curr Sports Med Rep. 2005;4:329–334. doi: 10.1007/s11932-005-0018-4.

379. Lima AB, Quinaud RT, Karasiak FC, Galvão LG, Gonçalves CE, Carvalho HM. Longitudinal Meta-Analysis of Peak Height Velocity in Young Female Athletes. Cureus. 2024;16:e59482. doi: 10.7759/cureus.59482. Cited: in: : PMID: 38826930.

380. Parry GN, Williams S, McKay CD, Johnson DJ, Bergeron MF, Cumming SP. Associations between growth, maturation and injury in youth athletes engaged in elite pathways: a scoping review. Br J Sports Med. 2024;58:1001–1010. doi: 10.1136/bjsports-2024-108233. Cited: in: : PMID: 39209526.

381. Connolly DR, Stolp S, Gualtieri A, Ferrari Bravo D, Sassi R, Rampinini E, Coutts AJ. How Do Young Soccer Players Train? A 5-Year Analysis of Weekly Training Load and its Variability Between Age Groups in an Elite Youth

Academy. J Strength Cond Res. 2024;38:e423–e429. doi: 10.1519/JSC.0000000000004813. Cited: in: : PMID: 39072663.

382. Wrigley R, Drust B, Stratton G, Scott M, Gregson W. Quantification of the typical weekly in-season training load in elite junior soccer players. J Sports Sci. 2012;30:1573–1580. doi: 10.1080/02640414.2012.709265. Cited: in: : PMID: 22852843.

383. Santos FJ, Figueiredo TP, Filho DMP, Verardi CEL, Macedo AG, Ferreira CC, Espada MC. Training Load in Different Age Category Soccer Players and Relationship to Different Pitch Size Small-Sided Games. Sensors. 2021;21:5220. doi: 10.3390/s21155220. Cited: in: : PMID: 34372457.

384. Ibáñez S, Pérez-Goye E, García J, Courel Ibáñez J. Effects of task constraints on training workload in elite women's soccer. Int J Sports Sci Coach. 2020;15:99–107. doi: 10.1177/1747954119891158.

385. Castellano J, Puente A, Echeazarra I, Usabiaga O, Casamichana D. Number of Players and Relative Pitch Area per Player: Comparing Their Influence on Heart Rate and Physical Demands in Under-12 and Under-13 Football Players. PLOS ONE. 2016;11:e0127505. doi: 10.1371/journal.pone.0127505.

386. Datson N, Dello Iacono A, Doncaster G, Page RM, McKeown A, Unnithan VB. Peak physical demands of elite women's soccer: Assessing playing position and post-goal locomotor patterns. Int J Sports Sci Coach. 2024;19:999–1010. doi: 10.1177/17479541231189240.

387. Sandmæl S, Dalen T. Comparison of GPS and IMU systems for total distance, velocity, acceleration and deceleration measurements during small-sided games in soccer. Cogent Soc Sci. 2023;9:2209365. doi: 10.1080/23311886.2023.2209365.

388. Cox A. Relative pitch area - Insight and analysis - England Football Learning - The England Football Community [Internet]. 2025 [cited 2025 July 13]. Available from: https://community.thefa.com/coaching/b/insights-analysis-blogs/posts/optimising-the-playing-area-for-effective-practice-design.

389. Castellano J, Puente A, Echeazarra I, Usabiaga O, Casamichana D. Number of Players and Relative Pitch Area per Player: Comparing Their Influence on Heart Rate and Physical Demands in Under-12 and Under-13 Football Players. PLOS ONE. 2016;11:e0127505. doi: 10.1371/journal.pone.0127505.

390. Riboli A, Olthof SBH, Esposito F, Coratella G. Training elite youth soccer players: area per player in small-sided games to replicate the match demands. Biol Sport. 2022;39:579–598. doi: 10.5114/biolsport.2022.106388. Cited: in: : PMID: 35959338.

391. Malina RM, Cumming SP, Rogol AD, Coelho-e-Silva MJ, Figueiredo AJ, Konarski JM, Kozieł SM. Bio-Banding in Youth Sports: Background, Concept, and Application. Sports Med. 2019;49:1671–1685. doi: 10.1007/s40279-019-01166-x.

392. Association TF. The FA Coach Mentor Programme | The Boot Room [Internet]. www.thefa.com. [cited 2025 July 14]. Available from: http://www.thefa.com/bootroom/about/ways-we-can-help/mentoring.

393. Serra-Olivares J, Clemente FM, González-Víllora S. Tactical expertise assessment in youth football using representative tasks. SpringerPlus. 2016;5:1301. doi: 10.1186/s40064-016-2955-1.

394. Nunes NA, Gonçalves B, Davids K, Esteves P, Travassos B. How manipulation of playing area dimensions in ball possession games constrains physical effort and technical actions in under-11, under-15 and under-23 soccer players. Res Sports Med Print. 2021;29:170–184. doi: 10.1080/15438627.2020.1770760. Cited: in: : PMID: 32452730.

395. Edwards T, Piggott B, Banyard HG, Haff GG, Joyce C. The Effect of a Heavy Resisted Sled-Pull Mesocycle on Sprint Performance in Junior Australian Football Players. J Strength Cond Res. 2023;37:388–393. doi: 10.1519/JSC.0000000000004269. Cited: in: : PMID: 35446285.

396. Gabbett TJ. The training-injury prevention paradox: should athletes be training smarter and harder? Br J Sports Med. 2016;50:273–280. doi: 10.1136/bjsports-2015-095788. Cited: in: : PMID: 26758673.

397. Santos F, Figueiredo T, Ferreira C, Espada M. Physiological and physical effects associated with task constraints, pitch size, and floater player participation in U-12 1 × 1 soccer small-sided games. Hum Mov. 2022;23:54–62. doi: 10.5114/hm.2022.108316.

398. Sánchez M, Sanchez-Sanchez J, Nakamura FY, Clemente FM, Romero-Moraleda B, Ramirez-Campillo R. Effects of Plyometric Jump Training in Female Soccer Player’s Physical Fitness: A Systematic Review with Meta-Analysis. Int J Environ Res Public Health. 2020;17:8911. doi: 10.3390/ijerph17238911. Cited: in: : PMID: 33266195.

Appendices

Appendix 1. Characteristics, aim, methods and key findings of biomechanics studies (n=32)

Study	Cohort/ sample size (*n*)	Participant characteristics (age, height, body mass)	Aim	Methods	Key findings
Jumping, landing and/or cutting (*n* = 17)					
Alanen et al., (2023) (113)	*Country* = Canada, *PS* = Local, *AG* = NS, *n* = 15 (*team/club: n* = 1)	15.3 ± 0.6 yrs 1.63 ± 0.06 m 56.7 ± 7.1 kg	To assess between-day reliability of change of direction biomechanics using IMUs.	*Data Collection:* Wireless dual-g triaxial IMU devices (Vicon Blue Trident, ± 16 g, 1125 Hz, ± 2000°/s, L4 level), Vicon iCaptureU application (Vicon Motion Systems Ltd., Oxford Metrics, UK). *Outcome Variables:* Peak resultant acceleration ($m{\cdot}s^{-2}$; left, right), peak angular velocity ($rad.s^{-1}$; left, right), time to 180° (s; left, right), total time (s; left, right). *Comparison Groups:* Test-day (1, 2).	Peak resultant acceleration and peak angular velocity showed unacceptable reliability regardless of turning side (left/right) and unacceptable limits of agreement. Turning and total time achieved acceptable to good reliability.
Alanen et al., (2023) (114)	*Country* = Canada, *PS* = Local, *AG* = U16-U17, *n* = 15 (*team/club: n* = 1)	16.9 ± 0.4 yrs 1.64 ± 0.06 m 59.7 ± 9.5 kg	To evaluate the importance of situational features during change of direction for peak vertical acceleration during final foot contact while turning, using IMUs during match-play (n = 1).	*Data Collection:* Triaxial IMU device (Shimmer 3 IMU ± 16 g, Shimmer Sensing, Dublin, Ireland, L4 level), video camera (4K camera, Sony, FDR-AX53, 120 fps, Sony Corporation, Toronto, ON, Canada). *Outcome Variables:* Peak vertical accelerations ($m{\cdot}s^{-2}$), ball possession (player/team), running speed (low, moderate, fast), body contact with other player during change of direction movement (yes, no), turning side (right, left), angle of change of direction movement (90° cut, 135° cut, 180° pivot turn), being challenged by an opposing player (yes, no). *Comparison Groups:* NS	The four most important features for an increase in peak vertical acceleration were running speed, change of direction angle, body contact with opposing player and being challenged by an opposing player.
Celebrini et al., (2012) (115)	*Country* = USA, *PS* = Local, *AG* = U15-U16, *n* = 10 (*team/club: n* = NS)	15.1 ± 1.3 yrs 1.64 ± 0.05 m 58.3 ± 11.4 kg	To determine whether peak knee flexion angles and peak knee abduction moments during planned and unanticipated side	*Data Collection:* Optotrak 3D motion analysis system (120 Hz, Optotrak 3020, NDI, Waterloo, Canada), force platform (600Hz, Bertec, Columbus, OH, USA).	Significant increase in peak knee flexion angle and decrease in peak knee abduction moment across all three tasks after immediate

			cuts, and a side hop task are improved after implementation of the Core-PAC training program.	*Outcome Variables:* Peak knee flexion angles (°), peak knee abduction moments (N.m.kg^{-1}), average speed of movements (m.s^{-1}). *Intervention: 4*-week Core-PAC on-field warm-up (20 minutes, 2 x per week), and at-home training (20 minutes, 2 x per week). *Comparison Groups:* Task type (side-cut, side-hop, unanticipated side-cut). Time period (baseline, immediate instruction, post-intervention).	instruction of the Core-PAC. General (insignificant) improvements after 4-week training program.
Celebrini et al., (2014) (116)	*Country* = USA, *PS* = Regional, *AG* = U15-U16, *n* = 20 (*team/club: n* = 2)	*Intervention (n=10):* 15.7 ± 0.5 yrs 1.65 ± 0.06 m 60.9 ± 5.7 kg *Control (n=9):* 15.1 ± 0.9 yrs 1.66 ± 0.06 m 63.1 ± 8.2 kg	To determine the effect of the Core-PAC warm-up on biomechanical risk factors for ACL injury during planned and unplanned side cuts, and a side hop task.	*Data Collection:* Optotrak 3D motion analysis system (120 Hz, Optotrak 3020, NDI, Waterloo, Canada), force platform (600Hz, Bertec, Columbus, Ohio). *Outcome Variables:* Peak knee flexion angles (°), peak knee abduction moments (N.m.kg^{-1}), average speed of movements (m.s^{-1}). *Intervention:* 6-week Core-PAC on-field warm-up (20 minutes, 4 x per week). *Comparison Groups:* Condition (intervention group, control). Task type (side-cut, side-hop, unanticipated side-cut). Time period (pre-intervention, post-intervention).	Participants in the intervention group demonstrated some improvements in biomechanical risk factors of ACL injuries during the side-hop and side-cut tasks following the 6-week training period.
DeLang et al., (2021) (117)	*Country* = USA, *PS* = NS, *AG* = NS, *n* = 17 (*team/club: n* = NS)	13.4 ± 1.7 yrs 1.61 ± 0.06 m 53.1 ± 8.2 kg	To examine energy generation contribution of the hip, knee, and ankle between dominant and non-dominant limbs during the vertical jump component of a lateral vertical jump.	*Data Collection:* Qualisys motion capture system (120Hz Oqus camera, Qualisys, Göteborg, Sweden), force plates (1200Hz, AMTI, Watertown, MA, USA), isokinetic dynamometer (Biodex Medical Systems). *Outcome Variables:* Vertical jump height (m), knee extension peak torque 60°/s (Nm.kg^{-1}), hip/knee/ankle energy generation contribution (%). *Comparison Groups:* Limb asymmetry (dominant, non-dominant).	Greater hip energy generation contribution and lesser knee energy generation contribution in the dominant limb compared to the non-dominant limb. No difference in ankle energy generation contribution.
DiCesare et al. (2020) (118)	*Country* = USA, *PS* = NS, *AG* = NS, *n* = 38 (*team/club: n* = NS)	16.0 ± 1.3yrs 165.0 ± 0.6 m 59.5 ± 9.9 kg	To examine biomechanical differences during a jump-landing task between a standard biomechanical assessment and a sport-specific VR-based assessment.	*Data Collection:* Optical motion capture system (240 Hz (standard) & 120 Hz (VR), Motion Analysis Corp, Santa Rosa, CA). *Outcome Variables:* Sagittal and frontal hip, knee and ankle angle (°). *Comparison Groups:* Test condition (standard, VR).	Sagittal plane range of motion was reduced during the sport-specific VR condition compared to the standard biomechanical assessment.
Grandstrand et al., (2006) (119)	*Country* = USA, *PS* = Local, *AG* = NS, *n* = 21 (*team/club: n* = NS)	*Intervention (n=12):* 10.2 yrs 1.48 m 38.8 kg	To examine lower extremity kinematics during a vertical drop jump, following implementation of the	*Data Collection:* Digital camcorder (30 fps, NS). *Outcome Variables:* Hip, knee and ankle separation (mm), VJ height (cm), poor landings (n, %), poor take-offs (n, %). *Intervention:* 8-week WIPP program (20 minutes, 2 x per week).	No difference in knee separation distances or maximum vertical jump height following the training program.

		Control (n=9): 9.8 yrs 1.44 m 36.4 kg	Warm-Up for Injury Prevention and Performance (WIPP) exercise program.	*Comparison Groups:* Condition (intervention, control). Jump stage (prelanding, landing, toe-off, maximum vertical). Time period (pre-intervention, post-intervention).	
Grooten et al., (2020) (120)	*Country* = Sweden, *PS* = NS, *AG* = NS, *n* = 28 (*team/club*: n=4)	*Intervention (n=14);* 12.9 ± 0.6 yrs 1.61 ± 0.05 m 49.5 ± 7.0 kg *Control (n=14):* 13.1 ± 0.3 yrs 1.60 ± 0.05 m 47.6 ± 7.2 kg	To investigate the acute effects of knee alignment instructions on knee kinematics and jump performance during a single-leg jump.	*Data Collection:* Eight-camera motion analysis system (100 Hz, Elite 2002, version 2.8.4380; BTS, Milan, Italy), Kistler force plates (100Hz, Kistler Group, Winterthur, Switzerland), 3D tracking system (Tracklab-BTS, Milan, Italy). *Outcome Variables:* Incorrect trials (n), contact time (s), jump time (s), max knee valgus (°), max knee flexion (°), max GRF (N), centre of pressure displacement (mm). *Intervention:* Experimental group received verbal instructions focussing on sustaining knee alignment in the frontal plane before each sub-set of jumps. *Comparison Groups:* Condition (experimental, control). Jump block (A 1-15, B 16-30, C 31-45).	Acute benefits of knee alignment instructions on knee kinematics, however the experimental group demonstrated worse jump performance than the control group.
Jeras et al., (2020) (121)	*Country* = Netherlands, *PS* = NS, *AG* = NS, *n* = 60 (*team/club: n* = NS)	9-11yrs (n=20): 10.6 ± 0.6 yrs 1.45 ± 0.05 m 35.5 ± 4.8 kg 12-14yrs (n=24): 13.1 ± 0.8 yrs 1.61 ± 0.07 m 49.6 ± 7.4 kg 15-19yrs (n=16): 16.8 ± 1.3 yrs 1.67 ± 0.08 m 62.6 ± 7.2 kg	To determine key biomechanical parameters during a countermovement, squat, and drop jump that explain age-related jump performance.	*Data Collection:* Force plate and cable transducer (600Hz, FT700 Power Cage, Ballistic Measurement System; Fitness Technology, Australia, 2015), Swift Speedmat (switch-based system; Swift Performance, Australia, 2017). *Outcome Variables:* Jump height (cm), peak force ($N.kg^{-1}$), peak power ($W.kg^{-1}$), maximal rate of force development ($N.s.kg^{-1}$), DJ contact time (s), DJ reactive strength index ($cm.s^{-1}$). *Comparison Groups:* Age group (9-11yrs, 12-14yrs, 15-19yrs). Jump type (CMJ, SJ, DJ).	Significant age-related effects on jump performance. Older age groups achieved greater jump heights across all jump types, due to greater power production during standing jumps and shorter ground contact times during reactive jumps.
Landry et al., (2007) (122)	*Country* = Canada, *PS* = Regional, *AG* = NS, *n* = 21 (*team/club: n* = NS)	16.7 ± 1.0 yrs 1.65 ± 0.07 m 60.8 ± 5.5 kg	To measure muscle strength, lower-limb kinematic and kinetic waveforms, and lower-limb muscle activation waveforms during the stance phase of an unanticipated side-cut manoeuvre.	*Data Collection:* EMG system (AMT-8 EMG, Bortec Inc), motion analysis system (100Hz, Northern Digital Inc, Waterloo, ON, Canada), force platform (1000Hz, Advanced Medical Technology Inc, Watertown, Mass), Cybex dynamometer (Lumex Inc, Ronkonkoma, NY). *Outcome Variables:* Maximum knee and ankle joint moment ($N.m^{-1}$), principal component magnitude (au), principal component score (au), ankle, knee and hip flexion/extension angle (°), hip internal/external rotation (°), muscle strength ($N.m^{-1}$).	Females had greater gastrocnemii, and rectus femoris muscle activation magnitudes and exhibited smaller hip flexion angle and moment magnitudes during the stance phase of the side-cut compared to males. Hip adduction, hip internal rotation, knee adduction, and ankle eversion moment differences were also

				Comparison Groups: Muscle site (lateral, medial).	captured by PCA during the first 10-20% of stance, when noncontact ACL injuries most often occur.
Landry et al., (2009) (123)	*Country* = Canada, *PS* = Regional, *AG* = U14-U18, *n* = 21 (*team/club: n* = NS)	16.7 ± 1.0 yrs 1.65 ± 0.07 m 60.8 ± 5.5 kg	To compare differences in muscle activation waveforms for the quadriceps, hamstrings and gastrocnemii during the pre-contact and early stance phase of an unanticipated side-cut and cross-cut manoeuvre.	*Data Collection:* EMG system (1000 Hz, AMT-8, Bortec, Inc. Calgary, AB, CA), force platform (1000Hz, Advanced Medical Technology Inc. Watertown, MA, USA), Cybex dynamometer (Lumex, Inc. Ronkonkoma, NY, USA). *Outcome Variables:* Muscle activation (%MVIC), principal component score (au). *Comparison Groups:* Cut type (side-cut, cross-cut). Phase (pre-contact phase, early stance phase), muscle site (lateral, medial).	Females performed unanticipated cutting manoeuvres with different neuromuscular control strategies than males; demonstrating greater muscle activation in the rectus femoris, medial and lateral gastrocnemii during the pre-contact and early stance phases and earlier muscle activation in the rectus femoris and medial and lateral hamstrings in the pre-contact phase.
Lindblom et al., (2020) (124)	*Country* = Sweden, *PS* = NS, *AG* = NS, *n* = 27 (*team/club: n* = 4)	14.0 ± 0.9 yrs	To evaluate jump-landing technique after 8 weeks of injury prevention training.	*Data Collection:* Camera (GoPro Hero5, GoPro, Inc., San Mateo, CA), dichotomised grading scale. *Outcome Variables:* Drop VJ subjective assessment (n, %; good control, reduced control, poor control), normalised knee separation distance (%), knee flexion angle (°). *Intervention:* 8-week warm-up program focussing on knee control (20 minutes, 2-3 x per week). *Comparison Groups:* Time period (baseline, follow-up).	Increase in knee flexion angle at initial contact during drop vertical jump and in tuck jump assessment total score after 8 weeks of injury prevention exercise programme training.
Lucarno et al., (2021) (125)	*Country* = Italy, *PS* = National, *AG* = U10, U11, U12, U13, U14, *n* = 57 (*team/club: n* = 1)	U10 (n=11): 1.35 ± 0.08 m 32.2 ± 8.9 kg U11 (n=12): 1.39 ± 0.05 m 33.5 ± 4.3 kg U12 (n=11): 1.47 ± 0.05 m 39.2 ± 6.1 kg U13 (n=12): 1.51 ± 0.08 m 50.1 ± 10.9 kg U14 (n=11):	To evaluate vertical drop-jump biomechanical strategies in professional academy players.	*Data Collection:* Force plates (BTS Bioengineering, Milano, Italy), 6-infrared camera optoelectronic motion capture system (100 Hz, Smart-D, BTS Bioengineering, Milano, Italy). *Outcome Variables:* Load symmetry (%), peak push-off force (body weight), peak knee flexion (°), knee adduction/abduction (°). *Comparison Groups:* Age group (U10, U11, U12, U13, U14). Limb asymmetry (dominant, non-dominant).	Age-related improvements in landing load asymmetry and normalised peak push-off force, but no difference in peak knee flexion angle or knee abduction/adduction angle across age groups.

		1.58 ± 0.07 m 53.9 ± 6.5 kg			
O'Kane et al. (2016) (126)	*Country* = USA, *PS* = Regional, *AG* = U13-U15, *n* = 351 (*team/club: n* = 33)	NS	To assess normalised knee separation during a drop-jump test and evaluate the association with risk of lower extremity injuries.	*Data Collection:* Video camera (NS), internet survey (NS). *Outcome Variables:* Normalised knee separation (percentile), knee injuries (n), lower extremity injuries (n). *Comparison Groups:* Jump phase (prelanding, landing, take-off). Menarcheal stage (premenarchal, postmenarchal).	Low normalised knee separation was associated with significantly increased risk of lower extremity and knee injuries, but only in postmenarchal players.
Ortiz et al., (2010) (127)	*Country* = USA, *PS* = NS, *AG* = U15, *n* = 30 (*team/club: n* = 2)	*Intervention (n=14):* 1.62 ± 0.04 m 55.3 ± 7.1 kg *Control (n=16):* 1.61 ± 0.07 m 52.5 ± 8.4 kg	To determine whether landing mechanics improved following a six-week injury prevention program.	*Data Collection:* Dynamometer (BEP-IIIa hand-held dynamometer, Human Performance Measurement, Inc., Arlington, TX), electronic inclinometer (BEP-VII electronic inclinometer, Human Performance Measurement, Inc., Arlington, TX), digital cameras (60 Hz, Visol Corp., Seoul, Korea), force plates (1000Hz, AMTI force plates, AMTI, Watertown, MA). *Outcome Variables:* Peak knee flexion, valgus and internal rotation angle (°) and moments ($Nm.kg^{-1}$). *Intervention:* 6-week sports injury prevention program – flexibility, functional strengthening and jumping and landing exercises (20-25 minutes, 2 x per week). *Comparison Groups:* Time period (pre-intervention, post-intervention). Condition (experimental, control).	There were no significant changes in joint range of motion or strength, with the exception of the quadriceps, following the short injury prevention program. There was also no change in peak knee joint angle or moment during the squat and drop jump tasks.
Thompson et al., (2017) (128)	*Country* = USA, *PS* = Local, *AG* = NS, *n* = 51 (*team/club: n* = 13)	*Intervention (n=28):* 11.8 ± 0.6 yrs 1.54 ± 0.08 m 41.6 ± 8.5 kg *Control (n=23):* 11.2 ± 0.6 yrs 1.49 ± 0.08 m 38.1 ± 6.0 kg	To investigate the biomechanical risk factors of ACL injury during cutting and jump-landing tasks, following a FIFA F-Marc 11+ injury prevention warm-up program.	*Data Collection:* 8-camera optical motion capture system (200Hz, Motion Analysis Corp), force plates (2000Hz, Bertec Corp). *Outcome Variables:* Peak hip adduction, knee flexion, knee valgus, and ankle eversion angle (°) and moments ($\%body weight.height^{-1}$). *Intervention:* 7–8-week injury prevention warm-up program (25 minutes, 2 x per week). Program consisted of running, stretching, strength, balance and jump-landing techniques. *Comparison Groups:* Condition (intervention, control). Time period (pre-test, post-test).	The injury prevention warm-up led to reduced peak knee valgus moment during the double-leg jump task and reduced peak ankle eversion moments in the cutting and double-leg jump tasks. However, there was no difference in peak knee valgus change scores between groups for the single-leg jump or cutting tasks.
Thompson et al., (2018) (129)	*Country* = USA, *PS* = Local, *AG* = NS, *n* = 94 (*team/club: n* = 27)	Preadolescent (n=51): *Intervention (n=28):* 11.8 ± 0.8 yrs 1.54 ± 0.08 m 41.6 ± 8.5kg	To quantify age-related differences in biomechanical and neuromuscular risk factors for ACL injury during cutting and jump-landing tasks before and after participation in the F-	*Data Collection:* 8-camera optimal motion capture system (200Hz, Motion Analysis Corp), force plates (2000Hz, Bertec Corp), surface EMG (2000 Hz, Trigno Wireless; Delsys Inc). *Outcome Variables:* Knee valgus angle (°) and moment ($\%bodyweight.height^{-1}$), muscle co-contraction ratio.	Age-related differences in knee valgus angle were found during all tasks, with younger groups displaying greater initial contact and peak knee valgus angles. Following the intervention, preadolescent athletes

		Control (n=23): 11.2 ± 0.6 yrs 1.49 ± 0.08 m 38.1 ± 6.0 kg Adolescent (n=43): *Intervention (n=22):* 15.9 ± 0.9 yrs 1.66 ± 0.04 m 58.2 ± 5.6 kg *Control (n=21):* 15.7 ± 1.1 yrs 1.66 ± 0.06 m 57.7 ± 7.7 kg	MARC 11+ injury prevention program.	*Intervention*: 7–8-week injury prevention warm-up program (25 minutes, 2 x per week). Program consisted of running, stretching, strength, balance and jump-landing techniques. *Comparison Groups:* Age group (preadolescent, adolescents). Condition (intervention, control).	showed greater improvements in initial contact knee valgus angle, and peak knee valgus moment compared to adolescents, in the double-leg jump task only.
Heading (*n* = 13)					
Brooks et al., (2021) (130)	*Country* = Canada, *PS* = Regional, *AG* = U13, U14, U15, *n* = 36 (*team/club: n* = 3)	13.4 ± 0.9 yrs 1.60 ± 0.10 m 50.6 ± 8.7 kg	To assess the relationship during purposeful headers between kinematic variables and maximum principal brain strain.	*Data Collection:* Wireless sensors (GForce Tracker; Artaflex Inc., Markham, Ontario, Canada). *Outcome Variables:* Total headers verified by video (n, %), average maximum principal strain (au), linear acceleration (*g*), angular velocity (rad.s^{-1}). *Comparison Groups:* Age group (U13 n=10, U14 n=16, U15 n=8). Position (DF, MDF, FWD). Game scenario (corner kick, deflection, punt, goal kick, pass in air, free kick, throw-in). Brain region (brainstem, corpus callosum, thalamus).	Rotational velocity of the head is a better predictor of brain strain than linear acceleration. Game scenario did not predict average peak maximum principal brain strain during purposeful headers.
Chrisman et al., (2019) (131)	*Country* = USA, *PS* = Regional, *AG* = U12, U14, *n* = 25 (*team/club: n* = NS)	NS	To measure age-related differences in head impact exposure during games.	*Data Collection:* Post-concussion Symptom Scale (NS), Paediatric Quality of Life Inventory (NS), Immediate Post-Concussion Assessment and Cognitive Test (NS), head impact monitor (1000Hz, xPatch, x2biosystems). *Outcome Variables:* Head impacts (15g or greater) (n), maximum peak linear acceleration of strongest head impact (g). *Comparison Groups:* Age group (U12 n=13, U14 n=11).	U14 players experienced significantly more head impacts than the U12 players. U12 players experienced 0 head impacts higher than 15g.
Filben et al., (2021) (132)	*Country* = USA, *PS* = NS, *AG* = U15, *n* = 6 (*team/club: n* = 1)	15.3 ± 0.1 yrs 1.67 ± 0.0 6m 61.08 ± 9.75 kg	To compare head kinematics and tissue-level brain strain of headers across youth and collegiate players.	*Data Collection:* Tri-axial accelerometer and gyroscope mouthpiece (4681Hz, 3shape, Copenhagen, DK). *Outcome Variables:* Total headers (n), peak linear acceleration (g), peak rotational velocity (rad.s^{-1}), peak rotational acceleration (rad.s^{2}), 95th percentile maximum principal strain (mm.mm^{-1}), cumulative strain damage measure curve (mm.mm^{-1}).	The number of headers in youth games was significantly lower than college games. Youth players also experienced lower head impact kinematics, and tissue-level brain responses compared to collegiate players.

				Comparison Groups: Age group (youth, collegiate). Session type (game, practice). Ball delivery method (kick, throw, header, other).	
Filben et al., (2023) (133)	*Country* = USA, *PS* = Local, *AG* = U14, U16, *n* = 14 (*team/club: n* = 1)	14.4 ± 0.9 yrs	To assess relationships between head impact kinematics and on-field heading technique.	*Data Collection:* Tri-axial accelerometer and gyroscope mouthpiece (4684Hz, 3shape, Copenhagen, DK), heading technique raters (Three National Collegiate Athletic Association Division I female soccer players). *Outcome Variables:* Peak linear acceleration (g), peak rotational acceleration (rad.s^{-2}), peak rotational velocity (rad.s^{-1}), hip ratio, technique score (%). *Comparison Groups:* Session type (game, practice). Ball delivery method (bounce off ground, header, long kick, overhand throw, self-serve, short kick, underhand throw).	Better heading technique was associated with lower peak rotational acceleration during games but not practice, nor with any other kinematic variable. Back extension and shoulder/hip alignment were considered important predictors of peak kinematics.
Harriss et al., (2019) (134)	*Country* = Canada, *PS* = Regional, *AG* = U13, U14, U15, *n* = 36 (*team/club: n* = 3)	13.4 ± 0.9 yrs 160.0 ± 0.10 m 50.6 ± 8.7 kg	To quantify linear and angular head kinematics during purposeful heading, and to determine whether head impact magnitude is influenced by game scenario and impact location.	*Data Collection:* G-force tracker (3000Hz, GFT2, Artaflex Inc., Markham, Ontario, Canada), video camera (Sony Vixia HD, EVS25, Endzone Video Systems, Sealy, Texas, United States). *Outcome Variables:* Game scenario frequency (%), linear acceleration (g), rotational velocity (°.s^{-1}), head impact location frequency (n). *Comparison Groups:* Game scenario (pass in air, throw in, deflection, punt, shot, goal kick, corner), head impact location (front, top, side, back).	Linear and angular head impact kinematic magnitudes depend on game scenario and head impact location. Headers performed with improper technique (top of head) resulted in the greatest rotational velocity and linear acceleration. The greatest linear acceleration occurred when heading from a shot, and the greatest angular velocity occurred following a corner.
Le Flao et al., (2021) (135)	*Country* = Canada, *PS* = Local, *AG* = U13, *n* = 11 (*team/club: n* = NS)	11.0 ± 1.3 yrs 1.55 ± 0.09 m 44.7 ± 10.3 kg	To examine head kinematics during controlled chest perturbations following a 16-week neck strength training program.	*Data Collection:* Triaxial inertial measurement unit (100Hz, IMU, MTws; Xsens Technologies, Enschede, The Netherlands), subjective neck strength assessment. *Outcome Variables:* Neck extension and flexion strength (kg), pitch (°), peak linear acceleration along the anterior–posterior axis (m·s^{-2}), peak resultant linear acceleration (m·s^{-2}). All measures reported as absolute and normalised to body mass values. *Intervention:* 16-week strength training program (2 x per week). *Comparison Groups:* Time period (pre-intervention, post-intervention).	The 16-week strength intervention significantly improved neck flexion and extension strength, pitch angle, and antero-posterior and resultant linear accelerations.
Miller et al., (2020) (136)	*Country* = USA, *PS* = Local, *AG* = U14, *n* = 7 (*team/club: n* = 1)	13.4 ± 0.6 yrs 1.58 ± 0.04 m 52.2 ± 6.5 kg	To collect real-world head impact data from female youth athletes.	*Data Collection:* Mouthpiece (1000 Hz, xPatch sensor, X2 Biosystems, Seattle, WA, USA) containing a tri-axial accelerometer (1000Hz, ADXL377, Analog Devices, Inc., Norwood, MA, USA) and tri-axial angular rate gyroscope	Significant variability in head impact magnitude among different heading events. Majority of head impacts occurred following a header

				(800Hz, L3G42000D, ST Microelectronics, Geneva, Switzerland). Video camera (NS). *Outcome Variables:* Sensor centre of gravity to head centre of gravity (cm), XYZ angle (°), number of impacts (n, %), linear acceleration (g), rotational velocity (rad.s^{-1}), rotational acceleration (rad.s^{2}). *Comparison Groups:* Impact source (ground, kick, head, throw, other). Ball delivery method (fall, dive, bounce, long kick, short kick, self-header, teammate header, overhand throw, underhand throw).	or thrown ball, however headers following a kicked ball resulted in significantly greater head kinematic values.
Peek et al., (2022) (137)	*Country* = Australia, *PS* = National, *AG* = U13, U14, U15, U17, *n* = 21 (*team/club: n* = 1)	*Intervention (n=14):* 15.0 ± 0.6 yrs 1.63 ± 0.02 m 54.9 ± 2.7 kg *Control (n=7):* 14.3 ± 1.9 yrs 1.59 ± 0.03 m 47.4 ± 2.8 kg	To explore the effects of the FIFA 11+ with added neck exercises on isometric neck flexor, extensor and side flexor strength, and head impact magnitude during purposeful heading.	*Data Collection:* IMU (800Hz, AX6, Axivity, Newcastle, UK), hand-held dynamometer (Gatherer Systems). *Outcome Variables:* Peak linear acceleration (g), peak angular velocity (°.s^{-1}), neck flexor, extensor and side-flexor strength (kg; left, right), composite neck strength (kg). *Intervention:* 5-week FIFA 11+ injury reduction program (3 x neck exercises, 3 x per week). *Comparison Groups*: Time period (pre-intervention, post-intervention). Condition (intervention, control).	Significant increases in neck strength, and moderate reductions in peak linear acceleration and peak angular velocity were demonstrated after the 5-week training program.
Peek et al., (2021) (138)	*Country* = Australia, *PS* = National, *AG* = NS, *n* = 26 (*team/club: n* = 1)	14.6 ± 1.7 yrs 1.63 ± 0.06 m 52.6 ± 9.1 kg	To examine the effects of different ball types and characteristics on linear head kinematics during purposeful heading.	*Data Collection:* IMU (800Hz, AX6, Axivity, Newcastle, UK). *Outcome Variables:* Linear head acceleration (g), angular velocity (rad.s^{-1}). *Comparison Groups:* Ball type (KickerBall, Adidas Starlancer, Heading-Pro, Deploy Envision).	Ball characteristics influence linear head kinematics. Peak linear accelerations could be reduced by up to 48% using a lighter size 5 ball, and by up to 33% using a lighter size 4 ball. Peak angular velocities could be reduced by up to 31% using a lighter size 5 ball, and up to 18% using a lighter size 4 ball. Reducing ball pressure was also associated with reductions in head acceleration.
Pritchard et al., (2023) (139)	*Country* = USA, *PS* = Local, *AG* = U14 (year 1), U15 (year 2), *n* = 8 (*team/club: n* = 1)	13.5 ± 0.1 yrs 1.67 ± 0.06 m 60.1 ± 9.3 kg	To compare head impact exposure across common training activities in soccer.	*Data Collection:* Mouthpiece with tri-axial accelerometer and gyroscope (NS), single time-synchronized camera (NS). *Outcome Variables:* Total exposure (hr), exposure per player-session (min), linear acceleration (g), rotational velocity (rad.s^{-1}), rotational acceleration (krad.s^{-2}), exposure (hr.player^{-1}), impact rate (pph), collision type (n).	Head impact exposure is influenced by the type of activity. Technical training activities were associated with the greatest mean impact rate, while team interaction and game play activities were associated

				Comparison Groups: Drill (technical training [passing, warm-up, dribbling, juggling, heading, ball control], team interaction [scrimmage, small-sided game, small-sided possession, finishing activities], game-play, position specific [goalkeeper, clearing], set pieces [corner kicks, free kicks, penalty kicks], other [conditioning, break]). Season (season 1, season 2). Session type (game, practice). Head impact type (ball to head, player collision, fall/dive).	with the lowest mean impact rates. In contrast, mean peak rotational kinematics were greatest in team interaction and game play activities but lowest during technical training activities. Peak linear acceleration was greatest during game play.
Tomblin et al., (2021) (140)	*Country* = USA, *PS* = Local, *AG* = U14, U16, *n* = 14 (*team/club: n* = 2)	NS	To characterise contact scenarios and associated peak head kinematics in competitive soccer.	*Data Collection:* Mouthpiece with gyroscope and accelerometer (NS), time-synchronised video (NS). *Outcome Variables:* Contact scenarios total (n), linear acceleration (g), rotational velocity (rad.s^{-1}), rotational acceleration (rad.s^{-2}). *Comparison Groups:* Age group: U14 n=4, U16 n=10). Contact scenario (body hit, body to body collision, dive, face hit, fall, head-to-head collision, head hit, standing header, jumping header). Session type (game, practice). Position (DF, MDF, FWD, GK).	Most contact scenarios were heading events, dives, and body collisions. Unintentional head impacts and head-to-head collisions accounted for <3% of all contact scenarios. Peak linear acceleration occurred in head-to-head collisions, peak rotational velocity during falls, and peak rotational acceleration during jumping headers.
Wahlquist et al., (2021) (141)	*Country* = USA, *PS* = Local, *AG* = U12, *n* = 12 (*team/club: n* = 1)	10.5 ± 0.5 yrs 1.49 ± 0.06 m 39.4 ± 7.2 kg	To examine the effects of an acute bout of heading on balance, neurocognitive functioning, and head impact biomechanics following the Get aHEAD Safely in Soccer™ program intervention.	*Data Collection:* Soccer machine (JUGS, Tualatin, OR, USA), head impact sensor (Triax SIM-G, Triax Technologies, Norwalk, CT, USA), Tekscan MobileMat (Tekscan, Boston, MA, USA), Balance Error Scoring System (BESS), SWAY Balance application (SWAY Medical, Tulsa, OK, USA), Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT). *Outcome Variables:* SWAY scores (%), BESS score, ImPACT score, peak linear acceleration (g), peak rotational acceleration (krad.s^{-2}), peak rotational velocity (rad.s^{-1}). Intervention: Get aHEAD Safety in Soccer program (2 x per week) throughout the season. *Comparison Groups: Time period* (baseline, pre-season, post-season).	Non-significant changes were observed in three of the SWAY balance stances at the end of the playing season, but no significant differences in computerised neurocognitive testing, balance error scoring system, self-reported symptoms, and head impact biomechanics following the program.
Wahlquist et al., (2022) (142)	*Country* = USA, *PS* = Local, *AG* = U12, *n* = 27 (*team/club: n* = 2)	*Intervention (n=14):* 10.6 ± 0.5 yrs 1.46 ± 0.05 m 37.3 ± 5.9 kg *Control (n=13):* 11.0 ± 0.4 yrs 1.52 ± 0.11 m 44.0 ± 13.0 kg	To examine head impact kinematics and neck and torso strength over the course of one soccer season, following the Get aHEAD Safely in Soccer™ program intervention.	*Data Collection:* Head impact sensor (Triax SIM-G, Triax Technologies, Norwalk, CT, USA), handheld dynamometer (microFET2, Hoggan Scientific, Salt Lake City, UT), *Outcome Variables:* Headers (n), neck girth (cm), neck flexion strength (N), neck extension strength (N), torso flexion strength (N), torso extension strength (N), peak linear acceleration (g), peak rotational acceleration (krad.s^{-2}), peak rotational velocity (rad.s^{-1}).	Generally, a low number of purposeful headers performed in games by U12 players was observed. Following the program, there were positive improvements in neck and torso strength, however there were no changes in head impact kinematics.

				Intervention: Get aHEAD Safely in Soccer program – consists of heading drills (15-20 purposeful headers) once a week and neck and core strengthening exercises twice a week. Intervention lasted one season (3.5 months). *Comparison Groups:* Condition (intervention, control). Time period (pre-season, post-season).	
Kicking (*n* = 1)					
Lyle et al., (2011) (143)	*Country* = USA, *PS* = NS, *AG* = NS, *n* = 20 (*team/club: n* = NS)	*Pre-pubertal (n=10):* 9.9 ± 0.3 yrs 1.42 ± 0.04 m 36.1 ± 5.1 kg *Post-pubertal (n=10):* 14.6 ± 0.5 yrs 1.63 ± 0.07 m 57.3 ± 6.7 kg	To compare age-related kicking biomechanics between pre- and post-pubertal female soccer players while performing an angled two-step approach kick.	*Data Collection:* Pubertal Maturation Observational Scale (NS), eight-camera motion analysis system (250Hz, Vicon, Oxford Metrics Ltd., Oxford, England, UK), force platform (1500Hz, Advanced Mechanical Technologies, Inc., Newton MA). *Outcome Variables:* Peak foot velocity ($m.s^{-1}$; swing limb), peak hip flexion (°; stance limb), peak hip extension (°; swing limb), peak knee flexion (°; swing limb, stance limb), peak hip extensor moment ($N.m.kg^{-1}.m^{-1}$; stance limb), peak hip flexor moment ($N.m.kg^{-1}.m^{-1}$; swing limb), peak knee extensor moment ($N.m.kg^{-1}.m^{-1}$; swing limb, stance limb). *Comparison Groups:* Pubertal stage (pre-pubertal, post-pubertal).	Age-related differences in stance limb kinematics, but similar swing limb kinematics indicate that prepubertal players kick with a mature kick pattern. Post pubertal players were able to achieve significantly greater peak foot velocities of swing limb through greater hip flexor moments.
Methodological (*n* = 1)					
Di Paolo et al., (2023) (144)	*Country* = Netherlands *PS* = National, *AG* = NS, *n* = 28 (*team/club: n* = NS)	14.9 ± 0.9yrs; 1.68 ± 0.05m; 56.2 ± 7.4kg	To compare lower-limb kinematics during agility movements performed in a laboratory environment versus a football field.	*Data Collection:* MVN IMU Lycra suit (240Hz, Xsens Technologies, Enschede, Netherlands). *Outcome Variables:* Frontal, transverse and sagittal ankle, knee, hip and pelvis angle (°). *Comparison Groups:* Condition (laboratory, field exercise, field game).	Kinematic differences between movements performed in the lab and on field. In the landing phase, average knee flexion was lowest for the LAB condition and highest for the field exercise and field game conditions. Average frontal ankle inversion-eversion was significantly higher in both field conditions.

NS = not specified. PS = playing standard. AG = age group. U = under. IMU = inertial measurement unit. ACL = anterior cruciate ligament. VR = virtual reality. fps = frames per second. CMJ = countermovement jump. SJ = squat jump. DJ = drop jump. EMG = electromyography. PCA = principal component analysis. VJ = vertical jump. DF = defender. MDF = midfielder. FWD = forward. GK = goalkeeper.

Appendix 2. Characteristics, aim, methods and key findings of fatigue and recovery studies (n=9).

Study	Cohort/ sample size (n)	Participant characteristics (age, height, body mass)	Aim	Methods	Key findings
Bonn et al. (2021) (146)	*Country* = Canada *PS* = Regional *AG* = NS, *n* = 22 (*team/club: n* = NS)	13.3 ± 0.9 yrs 1.63 ± 0.09 m 50.24 ± 9.90 kg	To investigate whether cumulative football heading experienced during gameplay in one season of football leads to changes in autonomic nervous system function, measured through heart rate variability, in female youth football players.	*Data Collection:* Video camera (Canon Vixia HD, Tokyo, Japan) and telescopic tower mount (EVS25, Endzone video camera system, Sealy, Texas), ECG electrodes (eVox, Evoke Neuroscience, New York, United States). *Outcome Variables:* Average purposeful headers (n), heart rate (beats.min^{-1}), standard deviation of normal-to-normal interbeat intervals (ms), total power (ms^2), high/low HR frequency (ms^2). *Comparison Groups:* Heading exposure level (low exposure n = 13, high exposure n = 9).	Number of purposeful football headers performed during an entire football season did not significantly impact autonomic nervous system function. There was, however, increased low frequency:high frequency power in the high-exposure group compared to the low-exposure group, with moderate practical importance.
De Ste Croix et al. (2015) (147)	*Country* = England *PS* = National *AG* = U13, U15, U17, *n* = 36 (*team/club: n* = NS)	U13: 12.1 ± 0.5 yrs 1.46 ± 0.06 m 40.8 ± 6.7 kg U15: 13.9 ± 0.6 yrs 1.59 ± 0.08 m 51.9 ± 8.8 kg U17: 15.8 ± 0.5 yrs 1.66 ± 0.06 m 61.9 ± 8.2 kg	To explore the effects of football-specific fatigue on electromechanical delay of the hamstrings during eccentric muscle actions in elite youth female football players.	*Data Collection:* Isokinetic dynamometer (1000Hz, Biodex System-3, Biodex Corp., Shirley, New York, USA), wireless 8-channel electromyography telemetry system (1000Hz, Delsys Myomonitor III, Delsys Inc., Boston, Massachusetts, USA), stadiometer (Holtain Harpenden, Crymych, UK), balance beam scales (Weylux, Birmingham, UK). *Outcome Variables:* Leg length (cm), offset from peak height velocity (yrs), electromechanical delay (ms). *Comparison Groups:* Age group (U13 n = 14, U15 n = 9, U17 n = 13). Electromechanical delay fatigue status (pre-fatigue, post-fatigue).	Football-specific fatigue significantly increased electromechanical delay, indicating compromised neuromuscular control required to stabilize the joint. These effects were significantly greater in the youngest (U13) age group compared with the older (U15 and U17) age groups. Electromechanical delay was consistently longer following the fatigue task regardless of age, muscle, or movement velocity.
De Ste Croix et al. (2017) (148)	*Country* = England *PS* = National *AG* = U13, U15, U17, *n* = 36 (*team/club: n* = NS)	U13: 12.1 ± 0.5 yrs 1.46 ± 0.06 m 40.8 ± 6.7 kg U15: 13.9 ± 0.6 yrs 1.59 ± 0.08 m 51.9 ± 8.8 kg U17:	To investigate the intersession reliability, and the influence of football-specific fatigue on measures of leg stiffness in female youth football players.	*Data Collection:* Mobile contact mat (2.5Hz, Smartjump; Fusion Sport, Brisbane, Australia), quartz metronome (SQ-44; Seiko, United Kingdom). *Outcome Variables:* Leg length (cm), offset from peak height velocity (yrs), absolute leg stiffness (kN.m^{-1}), relative leg stiffness, distance covered (km) during aerobic field test (SAFT$_{90}$). *Comparison Groups:* Age group (U13 n = 14, U15 n = 9, U17 n = 13). Fatigue status (Pre fatigue, post fatigue).	Fatigue resulted in age-dependent effects on leg stiffness. The youngest age group (U13) showed a possible decrease in relative leg stiffness, suggesting a negative neuromuscular response to fatigue. Results in the U15 age group were unclear, whereas the oldest players (U17) showed a very

		15.8 ± 0.5 yrs 1.66 ± 0.06 m 61.9 ± 8.2 kg			likely increase in relative leg stiffness following a football-specific fatigue protocol. Football-specific fatigue appears to induce an inhibitory response in younger, prepubertal players, potentially increasing their risk of injury.
De Ste Croix et al. (2018) (149)	*Country* = England *PS* = National *AG* = U13, U15, U17, *n* = 36 (*team/club: n* = NS)	U13: 12.1 ± 0.5 yrs 1.46 ± 0.06 m 40.8 ± 6.7 kg U15: 13.9 ± 0.6 yrs 1.59 ± 0.08 m 51.9 ± 8.8 kg U17: 15.8 ± 0.5 yrs 1.66 ± 0.06 m 61.9 ± 8.2 kg	To explore the age-related effects of football specific fatigue on hamstrings to quadriceps ratio in female youth football players.	*Data Collection:* Isokinetic dynamometer (Biodex, Corp., Shirley, NY). *Outcome Variables:* Hamstring to quadricep ratio measured with 60°.s^{-1}/120°.s^{-1}/180°.s^{-1} velocities at 0-10°, 10-20° and 20-30° angles. *Comparison Groups:* Age group (U13 n = 14, U15 n = 9, U17 n = 13). Fatigue status (Pre fatigue, post fatigue).	Effects of football-specific fatigue on hamstring to quadriceps ratio are age dependent. Effects were unclear in the U13 age group, likely detrimental in the U15 age group, and very likely beneficial in the U17 age group, particularly in joint angles near full extension.
Harriss et al. (2019) (150)	*Country* = Canada *PS* = Regional *AG* = NS, *n* = 15 (*team/club: n* = 1)	12.5 ± 0.5 yrs 1.60 ± 0.10 m 49.1 ± 5.5 kg	To investigate the feasibility of the study design (participant recruitment, adherence, retention, and adverse events) and the effect sizes associated with changes in heart rate variability indices between a football heading condition and control footer condition.	*Data Collection:* Heart rate monitors (Firstbeat Technologies Ltd., Jyväskylä, Finland), head impact sensor (GFT2, Artaflex Inc., Markham, ON, Canada), mechanical football ball pitching machine (Pro Trainer Football, Alameda, CA, USA). *Outcome Variables:* Heart rate (beats.min^{-1}), standard deviation of normal-to-normal interbeat intervals (ms), root mean square of successive normal-to-normal interval differences (ms), proportion of consecutive normal-to-normal intervals that differed by more than 50 ms (%), total power (ms^2), absolute high/low frequency (ms^2), normalised HF/LF (nu), HF/LF ratio. *Comparison Groups:* Heading condition (pre-header, post-header, control (footer).	Heart rate variability was found to be a feasible and meaningful outcome measure for assessing heading thresholds in youth football players. For all time domain measures, effect sizes between header and footer conditions were small, except for standard deviation of normal-to-normal interbeat intervals, which increased following both conditions and showed a moderate effect size.
Hughes et al. (2018) (151)	*Country* = England *PS* = National *AG* = U13, U15, U17, *n* = 33 (*team/club: n* = NS)	U13: 12.2 ± 0.6 yrs 1.52 ± 0.09 m 40.7 ± 7.8 kg U15: 13.8 ± 0.6 yrs 1.61 ± 0.04 m 51.8 ± 7.4 kg	To examine the effect of competitive match play on creatine kinase activity and delayed-onset muscle soreness in elite youth players.	*Data Collection:* Stadiometer (Holtain Limited, Crymych, UK), Questionnaire (3-day physical activity questionnaire), spectrophotometer (Reflotron systems, F. Hoffman-La Roche Ltd, Basel, Switzerland), RPE scale, visual analogue scale. *Outcome Variables:* Mean creatine kinase (IU.L^{-1}), visual analogue scale score (cm), exposure to weekly physical activity (mins), RPE scale score (n).	Match play significantly increased creatine kinase levels and delayed-onset muscle soreness, indicating muscle damage. Recovery rates varied by age, with only U17 players recovering to baseline creatine kinase levels within 168 hours. Younger players may

		U17: 15.8 ± 0.4 yrs 1.67 ± 0.03 m 58.6 ± 4.7 kg		*Comparison Groups:* Age group (U13 n = 11, U15 n = 10, U17 n = 12). Time period (Baseline, pre-match, 80 hours post-match, 128 hours post-match, 168 hours post-match).	therefore be at greater risk of injury due to incomplete recovery before subsequent matches.
Spalding et al. (2022) (152)	*Country* = USA *PS* = Regional *AG* = U16, *n* = 20 (*team/club: n* = 1)	14.7 ± 0.2 yrs 1.16 ± 0.01 m 58.1 ± 1.9 kg	To examine changes in jump height and sprint time during a competitive female youth football tournament, and to explore the relationship between jump height and accumulated match load.	*Data Collection:* Force platform (1000Hz, Single 2-axis force platform, PS-2142; PASCO, Roseville, CA), optical timing gates (Brower, IR Emit, Draper, Utah, USA), RPE scale. *Outcome Variables:* Minutes played (n), RPE scale score (n), CMJ height (cm), 20m sprint time (s). *Comparison Groups:* Tournament period (Pre, match 1, match 2, match 3, post tournament).	Jump height significantly decreased and sprint time significantly increased from pre- to post-tournament. No significant relationship was observed between relative changes in jump height and accumulated match load.
Watson et al. (2019) (153)	*Country* = USA *PS* = Regional *AG* = U14, U15, U16, U17, U18, *n* = 54 (*team/club: n* = NS)	15.2 ± 1.5 yrs	To prospectively evaluate the independent relationships between sport specialisation, sleep, and subjective well-being in female youth football players, while controlling for training load and age.	*Data Collection:* Cycle ergometer (Racemate, Seattle, WA), metabolic cart (Cosmed, Chicago, IL), well-being questionnaire (NS). *Outcome Variables:* Average daily training load (AU), well-being factor (fatigue, soreness, mood, stress, sleep quality) score (n), sleep duration (hrs), time to exhaustion (mins), VO2 MAX (ml.kg.min^{-1}). *Comparison Groups:* Training load group (specialised n = 21, non-specialised n = 33). Time period (across 3-months). Age group (U14 n = 11, U15 n = 11, U16 n = 10, U17 n = 9, U18 n = 13).	Specialised players reported significantly worse fatigue, soreness, mood and sleep quality compared to non-specialised players. There were no significant differences in daily training load during the season between specialised and non-specialised players.
Wright et al., (2017) (77)	*Country* = England, *PS* = Regional, *AG* = NS, *n* = 17 (*team/club: n* = NS)	13.1 ± 1.4yrs 1.58 ± 0.08m 50.3 ± 13.4kg	To measure changes in kinematic markers of neuromuscular control and force characteristics associated with ACL injury over a 90-minute simulated soccer match, using a countermovement, and single-leg drop jump.	*Data collection:* Force platform (Kistler 9281 CA Kistler Instrument Corporation, New York, USA), 6-camera motion capture system (100Hz, Vicon MX13 & Vicon Nexus 1.7, Vicon Motion Systems UK), CentiMax scale (CR100). *Outcome variables:* RPE (au), knee flexion and valgus angle (°), mean force (Nm.kg^{-1}), flight time to contact time ratio (s). *Comparison Groups:* Time period (baseline, post 15 min, post 30 min, post 45 min, post half-time, post 60 min, post 75 min, post 90 min).	Subjective measures indicated progressive increases in exertion and decreases in readiness; however, no significant changes were observed in markers of neuromuscular control or jump performance.

NS = not specified. PS = playing standard. AG = age group. AU = Arbitrary Units. ECG = Electrocardiogram. HF = High Frequency. LF = Low Frequency. RPE = Rate of Perceived Exertion. ACL = Anterior Cruciate Ligament.

Appendix 3. Characteristics, aim, methods, and key findings of injury studies (n=41)

Study	Cohort/ sample size (n)	Participant characteristics: age, height, body mass	Aim	Methods	Key findings
Epidemiology (n=18)					
Andreasen et al. (1993) (154)	*Country* = Denmark. *PS* = NS. *AG* = 10.5-12.5, 12.5-14.5, 14.5-16.5, 16.5-17.5, 17.5-19.5yrs, *n* = 3321 (*team/club: n* = NS)	NS	To prospectively investigate youth football tournaments to determine injury rate and type and to clarify injury mechanisms in football tournaments.	*Data Collection*: Self-referral to medical tent. *Outcome Variables*: Playing time (h), injury rate (injuries.1000h^{-1}), injury severity (mild, severe), injury location (head and face, trunk, upper extremities, lower extremities), injury type (contusion, strain/sprain, fracture, other), injury duration (days) (severe injuries only). *Comparison Groups:* Age group (10.5-12.5, 12.5-14.5, 14.5-16.5, 16.5-17.5, 17.5-19.5).	10% of players reported to the medical tent with an injury. Serious injury rate was 4.4 injuries per 1000 hours of play. Most injuries sustained were contusions or sprains and strains and occurred in the lower extremities. Highest injury rates were observed between the ages of 14.5 and 16.5 years and could correspond with puberty associated changes. More injuries were sustained in the second half of matches and in the final rounds of the tournament.
Beech et al. (2022) (155)	*Country* = England *PS* = National *AG* = U10, U12, U14, U16, *n* = 375 (*team/club: n* = 6)	NS	To describe the incidence, severity and burden of injury in 8- to 16-year-old elite youth female football players within English academies.	*Data Collection:* Qualified academy therapist. *Outcome Variables:* Match and training exposure (h), injury total (n), injury onset (acute, gradual), injury burden (days lost.1000h^{-1}), injury severity time bins (days), injury incidence (injuries.1000h^{-1}), injury location (head and neck, upper limbs, trunk, lower limbs), injury type (muscle strain, sprain/ligament injury, haematoma/contusion/bruise, fracture, tendinosis, apophysitis, concussion). *Comparison Groups:* Age group (U10 n = 62, U12 n = 104, U14 n = 104, U16 n = 105).	Injury incidence and burden was highest for the U16 age group as well as in matches compared to training. However, a large portion of preventable injuries, soft-tissue, and non-contact in nature, were sustained in training.
Butera et al. (2015) (156)	*Country* = USA *PS* = Local *AG* = U14, U15, U16, U17, U18, *n* = 77 (*team/club: n* = 1)	15.7 ± 1.4 yrs	To explore perceptions of the risk of skin cancer and sunscreen use among 13- to 18-year-old adolescent female club football athletes and to examine the relationship of risk perception to sunscreen use.	*Data Collection:* Questionnaire (Shelestak and Lindow (2011), "Perceptions & Practices Regarding Skin Cancer Prevention"). *Outcome Variables:* Health belief construct (susceptibility, severity, barriers, benefits) (mean score, n). Covariates for sunscreen use (agreement level) (%).	Athletes who applied sunscreen before games were 2.4 times more likely to also apply sunscreen before practices. Significant positive correlations were found between sunscreen use and perceived susceptibility and benefit subscale scores as well

				Comparison Groups: Game-type (training, matches). Age group (U14 n = 18, U15 n = 13, U16 n = 21, U17 n = 20, U18 n = 5).	as with parent and teammate encouragement to apply sunscreen.
Clausen et al. (2014) (157)	*Country* = Denmark *PS* = National *AG* = U18, *n* = 438 (*team/club:* n = 32)	NS	To investigate the injury incidence in adolescent female football using self-reports via mobile telephone text messaging. To explore the association between soccer exposure, playing level, and injury risk.	*Data Collection:* Self-report via text message. *Outcome Variables:* Injuries (n), injury incidence (injuries.1000h^{-1}), exposure (h), injury location (knee, ankle, lower leg, groin, thigh front/back, hip, foot, Achilles, spine). *Comparison Groups:* Playing level (low, medium, high).	The incidence of injuries was 15.3 the incidence of time-loss injuries was 9.7, and the incidence of severe injuries was 1.1 per 1000 hours of football exposure. Playing level was not associated with the risk of time-loss injuries. The injury incidence in adolescent female football is high, and this includes many severe injuries. Players with low football participation (≤1 h.wk^{-1}) have a significantly higher injury risk compared with players participating more frequently.
Hägglund et al. (2009) (158)	*Country* = Sweden *PS* = International *AG* = U19, *n* = 144 *(team/club: n* = 8)	2006 17.9 ± 0.8 2007 18.0 ± 0.9 2008 18.3 ± 0.8	To study the incidence and nature of injuries at European Championships, to compare training and match injury characteristics and to study differences in injury incidence between tournaments.	*Data Collection:* Team physician. *Outcome Variables:* Exposure training/matches (h), injury rate (injuries.1000h^{-1}), injury severity (slight, minimal, mild, moderate, severe) (n). Injury type (fracture, bone stress, dislocation/subluxation, ligament sprain, meniscus/cartilage, muscle strain/rapture, tendon strain/tendinopathy, haematoma/contusion, laceration, concussion) (n). Injury location (head/neck, upper extremity, low back/pelvis/trunk, hip/groin, thigh, knee, lower leg, ankle, foot) (n). *Comparison Groups:* Year (2006, 2007, 2008).	The lowest match injury incidence was seen in the women’s Under-19 tournaments (20.5). Training injuries constituted 20% of all injuries and caused 26% of all match unavailability. A greater proportion of match injuries were due to trauma and occurred from player contact compared to training injuries. A higher frequency of re- injury was found among training injuries than match injuries.
Inoue et al. (2023) (159)	*Country* = Japan *PS* = Regional *AG* = NS *n* = 131 (*team/club: n* = 3)	NS	To investigate the occurrence of ankle sprains in adolescent female football players by examining the relationship between the age of players at the first sprain and the age at menarche.	*Data Collection:* Questionnaire (NS). *Outcome Variables:* Injury frequency (n), time between menarche and first ankle sprain (y). *Comparison Groups:* Age (12yr, 13yr, 14yr, 15yr, 16yr).	Ankle sprains most commonly occurred for the first time at U12, followed by the age groups U13, U10, and U11 years. About 25% of participants experienced their first ankle sprain at the age of menarche, 20% at 1 year after menarche, and 16% a year before menarche. The incidence of the first ankle sprain was high in the second and fifth years after starting to play football. Adolescent female football players were

					not injured early in their careers.
Kolstrup et al. (2016) (160)	*Country* = Denmark *PS* = National *AG* = 11-15, 16-19, *n* = NS (*team/club: n* = NS)	NS	To investigate the injury types and locations in children and adolescent football players and the differences between genders and age groups.	*Data Collection:* Classification of Diseases (ICD-10), X-Ray (NS). *Outcome Variables:* Matches (n), playing hours (n), sports injuries (n), injury rate (injuries.1000h^{-1}). Injury location (head, neck, thorax, shoulder and upper arm, abdomen, low back and pelvis, elbow and forearm, wrist and hand, hip and thigh, knee and lower leg, ankle and foot) (n). Injury type (contusion, superficial, open wound, fracture, sprain and strain) (n). *Comparison Groups:* Age group (11-15, 16-19).	The most common injury location was lower extremities (66.7%), and the most common injury type was contusion (24.4%). Girls had a relative risk of injury of 1.5, and they had a higher proportion of injuries to knee and lower leg. In conclusion, the youngest girls had a higher incidence of almost all injury categories than any other group. In general, the incidence of injury decreased with age.
Le Gall et al. (2008) (161)	*Country* = France *PS* = National *AG* = U15, U16, U17, U18, U19, *n* = 110 (*team/club: n* = NS)	NS	To investigate the incidence of football related injuries in young elite female French players.	*Data Collection:* Physician. *Outcome Variables:* Injury incidence (injuries.1000^{-1}), severity (days 1-7, 7-30, >30), injury location (ankle, thigh, knee, groin, back, foot, lower leg, hand, pelvis, shoulder, arm, trunk, hip, head, neck). Injury type (sprain, strain, contusion, tendinopathy, back injury, meniscal, fracture, osteochondrosis, chondral, dislocation). *Comparison Groups:* Age group (U15, U16, U17, U18, U19). Game type (training, matches).	The risk of injury and incidence was significantly greater in the U15 group compared with the U19 group. Traumatic injuries amounted to 536 (86.4%) and 83 (13.4%) were overuse injuries. There were 51.9% minor injuries, 35.7% moderate injuries, and 12.4% major injuries. Most injuries were located at the lower extremities (83.4%), with the majority affecting the ankle (n = 157). The most commonly diagnosed injury was ankle sprain (16.8%).
Lislevand et al. (2014) (162)	*Country* = Kenya *PS* = NS *AG* = U13, U16, 16+, *n* = 938 (*team/club: n* = 69)	NS	To analyse the incidence, characteristics and circumstances of injuries during a female youth amateur football tournament in Kenya.	*Data Collection:* Injury recorders. *Outcome Variables:* Exposure (h), injury frequency (n). Injury severity (no time loss, slight, minimal, mild, moderate, severe) (n). Injury incidence (injuries.1000^{-1}). Injury location (head/neck, upper limb, trunk, hip/groin, thigh, knee, lower leg, ankle, foot/toe) (n). Injury type (contusion, sprain, laceration/skin lesion, strain, overuse injury) (n). *Comparison Groups:* Age group (U13 n = 433, U16 n = 213, 16+ n = 292).	Players in the U13 age group had significantly increased risk of injury compared to the 16+ age group. Time loss injuries were rare. The injuries most commonly affected the lower limb (n=100; 82%); contusions to the ankle (n=15; 12%) and foot/toe (n=15; 12%) were the most common specific injury types. Most acute injuries (89 of 113, 79%) were caused by player contact.

Maehlum et al. (1986) (163)	*Country* = Norway *PS* = National *AG* = U14, 14-16, 17-18, *n* = NS *(team/club: n* = 332)	NS	To investigate injury rates in rates in a youth football tournament.	*Data Collection:* Physicians. *Outcome Variables:* Matches (n), player hours (n), injury incidence (injuries.1000h^{-1}). Injury type – sprain, contusion, luxation, laceration, fracture, other (n). Injury location – head/neck, trunk, upper extremity, lower extremity (n). *Comparison Groups:* Age group (U14, 14-16, 17-18).	Injury rate was 17.6 per 1000 player-hours for girls. Of total injuries, 45.5% were contusions, 25.5% were sprains, 13.8% were lacerations, 6.2% were fractures and 9% were 'other' injuries.
O'Kane et al. (2017) (164)	*Country* = USA *PS* = Regional *AG* = NS *n* = 351 *(team/club: n* = 33)	NS	To identify the number and rate of overuse injuries in female football players (ages 12-15 years), describe the anatomic location and type of injury, and evaluate contributing risk factors.	*Data Collection:* Injury surveillance system – Parental survey and player telephone interview. *Outcome Variables:* Injury location (hip, groin, thigh, knee, lower leg, foot, ankle) (n). Laterality – Right, Left, Both). Injury type (tendinitis, patellofemoral pain syndrome, Osgood-Schlatter disease, periostitis, muscle strain, stress fracture) (n). Risk factor (joint hypermobility, muscle strength – hamstring/quadriceps strength 180° per 1 SD, hip flexor/extensor/abduction/adduction/external rotation per 1 SD, NKS during drop-jump test). *Comparison Groups:* Overuse injury status (players with overuse injury n = 83, no overuse injury n = 70). Age group (12-15 yrs). Race (White, Black, Asian/Pacific Islander, Multiracial, Hispanic). Playing level (select, premier).	Players in the U13 age group presented significantly higher lower extremity injury cases than other age groups. Knee injuries accounted for 47% of overuse injuries. Increased valgus was associated with a 3.2-fold increased risk for knee injury. A 1-SD increase in hamstring strength was associated with a 35% decreased risk for overuse knee injuries, and a 1-SD increase in quadriceps strength was associated with a 30% decreased risk. A 1-SD increase in hip flexor strength was associated with a 28% decreased risk for overuse knee injuries, and a 1-SD increase in external rotation strength was associated with a 35% decreased risk. Lower extremity overuse injuries in female youth football players affected primarily the knee. Lower knee separation distance, decreased lower extremity strength, and playing on more than one football team increased injury risk.
Rosenbaum et al. (2011) (165)	*Country* = USA *PS* = International *AG* = U17, *n* = 1064 *(team/club: n* = NS)	NS	To determine the types of injuries and medical problems, as well as general team health and performance issues, encountered by physicians traveling internationally with youth national football teams.	*Data Collection:* Physicians. *Outcome Variables:* Injury location (head/neck, rib/upper back, abdomen, low back/pelvis, shoulder/clavicle, forearm, head/fingers, hip/groin, thigh, knee, lower leg/ankle, foot/toe) (n). Medications used (NSAID, acetaminophen, muscle relaxer, narcotic analgesic, prednisone, oral antibiotic, antihistamine, decongestant, antiviral, anticough,	Mean severity for all player cases was 5.19 days missed. Nearly 69% of injuries involved the lower extremities: strains, sprains, and contusions accounted for 74.1% of injuries. Gastrointestinal, dermatologic, and

				albuterol MDI, antacid, antiemetic, antidiarrheal, topical steroid, topical antifungal, hypnotic, antimigraine, topical anaesthetic) (n). Injury type (concussion, other bone injury, sprain, meniscus/cartilage, muscle strain, tendonitis/bursitis, hematoma/contusion, epistaxis, effusion, post-surgical pain, URI, bronchitis, asthma, pharyngitis, reflux, nausea/vomiting, abdominal pain, diarrhoea, menstrual cramps, insomnia, skin infection, eczema, insect bite, urticaria, otitis externa/media, apthous stomatitis, oralhsv, dental infection) (n). *Comparison Groups:* Injury status (injured, non-injured). Player type (staff, player).	otolaryngologic complaints accounted for 77.8% of noninjuries. Medications were administered in 71% of cases, with analgesics, cough and cold remedies, antibiotics, and gastrointestinal agents accounting for the majority. The leading team health and performance concerns were nutrition/ hydration, conditioning, prevention, and doping control.
Schmidt-Olsen et al. (1985) (166)	*Country* = Denmark *PS* = International *AG = 9-11,* 12-13, 14-16, 17-19, *n* = 1325 *(team/club: n* = NS)	NS	To estimate the incidence, type, severity and site of soccer injuries by direct registration of all injuries at the playing field and to form an impression of the need of medical services at international tournaments.	*Data Collection:* Self-referral to medical tent. *Outcome Variables:* Injury severity (slight, moderate, severe) (n), injury incidence (injuries.1000^{-1}). Injury location (head and face, shoulder, arm, trunk, back, hand and fingers, groin and hip, thigh, knee, lower limb, ankle, foot and toes) (n). Injury type (fracture, dislocation, sprain, rupture, contusion, cerebral concussion, facet syndrome, blisters, skin abrasions and cuts, muscle strain) (n). *Comparison Groups:* Age group 9-13 n = 361, 14-16 n = 732, 17-19 n = 232).	Girls presented 44 injuries per 1,000 playing hours and injury incidence frequency increased with age. 81% of all injuries were localised to the lower extremity especially the ankle and foot. Contusion was the most frequent diagnosis amounting to a third of all injuries. Blisters and excoriations amounted to nearly a fifth, 4% of the injuries were fractures, especially in the upper extremity; overuse injuries were seen only in 5.2% of the cases.
Schiff et al. (2010) (167)	*Country* = USA *PS* = Regional *AG* = U12 – U14, *n* = 88 (*team/club: n* = 4)	NS	To determine whether certified athletic trainers and parental, internet-based surveys provided comparable data for identifying football injuries.	*Data Collection:* Internet-based survey, athletic trainer. *Outcome Variables:* Total injuries (n), acute injuries (n), game injuries (n), practice injuries (n), overuse injuries (n), injury incidence (injuries.1000h^{-1}), injury location (hip, knee, ankle, lower leg) (n). *Comparison Groups:* Injury status (players with acute injuries n = 22, players with overuse injuries n = 17, uninjured players n = 49). Playing level (elite, recreational). Injury surveillance type (parent internet based, certified athletic trainer, both).	For athletic trainers only, internet-based surveys only, and both systems combined, we found acute injury rates of 3.0 per 1000 AEHs, 3.9 per 1000 AEHs, and 4.7 per 1000 AEHs and overuse injury rates of 1.0 per 1000 AEHs, 2.9 per 1000 AEHs, and 2.9 per 1000 AEHs, respectively. Players sustained 27 acute injuries (44% ankle, 11% knee, 11% hip) reported by at least 1 of the 2 systems, with 63% reported by athletic trainers and 85% by Internet-based survey. Players sustained 17 overuse injuries (35% knee, 29% lower leg) reported by

					either system, with 35% reported by athletic trainers and 100% by Internet-based survey.
Schneider et al. (2013) (168)	*Country* = Germany *PS* = Regional *AG* = U12 – U14, *n* = 269 (*team/club: n* = NS)	14.4 ± 1.7 yrs 1.64 ± 0.07 m 52.6 ± 9.1 kg	To analyse the injuries in female youth football players in Germany.	*Data Collection:* Internet-based survey. *Outcome Variables:* Total injuries (n), contact injuries (n), non-contact injuries (n). Injury location (upper extremities, lower extremities, spine, neck, head, arm, knee, hips, thigh, foot/toes, shoulder, ankle) (n). Injury type (strain, sprain, laceration, contusion, fracture, muscle injury, cerebral haemorrhage, concussion) (n), injury mechanism (intrinsic, extrinsic) (n). *Comparison Groups:* Game type (training, matches).	The total number of injuries was 2373. The lower extremities were affected in 70% of all reported cases. Strains were the most common injuries in the lower and upper extremities (35%). 52.1% of the injuries in girls were reported as contact injuries. There was no significant difference seen between amounts of injuries were observed in training versus games.
Schneider et al. (2013) (169)	*Country* = Germany *PS* = Regional *AG* = U15 – U19, *n* = 269 (*team/club: n* = 60)	*Injured:* 14.5 ± 1.63 yrs *Non-injured:* 14.3 ± 1.69 yrs	To analyse knee injuries female youth football players.	*Data Collection:* Questionnaire (NS). *Outcome Variables:* Injury type (joint and ligament injuries, muscle and tendon injuries, fractures, contusions, skin injuries) (n). *Comparison Groups:* Injury status (injured n = 83, non-injured n = 186). Playing position (forward, midfield, defence, goalkeeper). Game type (training, matches).	A total of 83 knee injuries in female players occurred. The most common injury types were injuries of joint & ligament (32.4%). Strikers (40.2%) showed the highest rates. The confounders, level, age and weekly training load showed no influence whereby increasing training experience significantly increased the injury rate.
Söderman et al. (2001) (170)	*Country* = Sweden *PS* = NS *AG* = U15, U16, U17, U19, *n* = 153 (*team/club: n* = 10)	15.9 ± 1.2 yrs	To investigate prospectively the incidence, type, location and severity of football related injuries among adolescent females during one entire outdoor season.	*Data Collection:* Questionnaire (NS). *Outcome Variables:* Injury location (upper extremity, back, groin, thigh, knee, calf, ankle, foot) (n). Injury type (fracture, metacarpus, sprain, strain, contusion, dislocation, hematoma) (n). Incidence rate (injuries.1000h^{-1}), injury frequency (n). *Comparison Groups:* Injury type (traumatic, overuse). Age group (14-14.9, 15-15.9, 16-16.9, 17-19.2).	Adolescent female football players in the present study had a lower injury incidence rate compared to those reported in studies on adult female football players. The injuries were most often of moderate severity and the most frequent injury was ankle sprain, often appearing as a re-injury.
Sprouse et al. (2020) (171)	*Country* = England *PS* = International *AG* = U15, U16, U17, U18, U19, *n* = 5852 (*team/club: n* = 9)	NS	To determine the incidence and characteristics of injury and illness in female senior and youth international football.	*Data Collection:* Team medical support staff *Outcome Variables:* Injury incidence (injuries.1000h^{-1}), injury burden (dabsent.1000h^{-1}), injury severity (minor, moderate, severe, major), cause (contact, non-contact).	In women's international football, 503 injuries were recorded (senior: 177; youth: 326) during 80,766 hours of exposure and match injury incidence (27.6 ± 11.3

				Comparison Groups: Season (12/13, 13/14, 14/15, 15/16, 16/17, 17/18, 18/19, 19/20). Age group (senior, youth). Game type (training, matches).	injuries.1000h^{-1}) and burden (506.7 ± 350.2 days absent.1000h^{-1}) were significantly greater than training injury incidence (5.1 ± 1.8 injuries.1000h^{-1}) and burden (87.6 ± 32.8 days absent.1000h^{-1}).
Risk Factors (n=14)					
Cheng et al. (2020) (172)	*Country* = USA *PS* = National *AG* =NS, *n* = 88 (*team/club: n* = 1)	Not injured: 14.3 ± 1.9 yrs Injured: 14.8 ± 1.8 yrs	To describe the injury profile in elite adolescent female football athletes and to assess whether findings on a baseline physical examination consistent with a cam deformity are associated with future lower-body injury rate in elite adolescent female football athletes.	*Data Collection:* Goniometer (NS), follow-up injury survey (NS). *Outcome Variables:* BMI (kg.m^2), initial soccer playing age (y), athlete position (forward, midfield, defence, goalkeeper) (n), prior injury at baseline (n), hip passive ROM flexion/internal rotation/external rotation (°). Injury location (lumbopelvic, low back, pelvis, hip, thigh, knee, shin, ankle, foot, mechanism, recovery) (n). *Comparison Groups:* Injury status (not injured (n = 46), injured (n = 42). Asymmetry (right and left leg).	The low back was the most common injury region (16/88, 18.2%). Almost half of all injured athletes (20/42, 47.6%) sustained overuse injuries, and 16/42 (38.1%) had an incomplete recovery. Higher body mass index and reaching menarche were associated with sustaining an injury. Lower-body injuries were significantly common in elite adolescent female football athletes, with over one third of injured athletes reporting permanent negative impact of the injury on their playing ability. Baseline hip physical examinations were not associated with future injury rate.
Chrisman et al. (2012) (173)	*Country* = USA *PS* = Regional *AG* = NS n = 92 (*team/club: n* = 8)	Elite: 12.5 ± 0.5 yrs 1.57 ± 0.05 m 49.9 ± 5.3 kg Recreational: 13.2 ± 0.5 yrs 1.61 ± 0.04 m 50.6 ± 4.7 kg	To examine injury risk factors of strength and jump biomechanics by football level in female youth athletes and to determine whether research recommendations based on elite youth athletes could be generalized to recreational players.	*Data Collection:* Dynamometer (model Pro 3; Biodex Medical Systems, Inc, Shirley, NY), Handheld dynamometer (model microFET2; Hoggan Health Industries, Inc, Draper, UT), Sportsmetrics standardised video-analysis technique (SPortsmetrics, Inc, Cincinnati, OH), Canon digital camcorder (modelZR850; Canon USA), *Outcome Variables:* Mean time played (y), BMI (kg.m^2), previous injuries (n), hip strength (N), knee strength (Nm), Knee Valgus estimate (°), vertical jump (cm). *Comparison Groups:* Playing standard (elite n = 50), recreational n = 42).	Elite players were similar to recreational players in all measures of hip and knee strength, vertical jump height, and normalised knee separation. Female elite youth players and recreational players had similar lower extremity strength and jump biomechanics. No difference in previous injuries between elite and recreational players.
Clausen et al. (2016) (174)	*Country* = Denmark *PS* = National *AG* = U18,	Self-reported previous knee injury: 1.68 ± 0.06 m 58.5 ± 7.5 kg	To investigate self-reported previous knee injury and low KOOS as risk factors for future knee injuries in adolescent female football.	*Data Collection:* KOOS Questionnaire, Text message. *Outcome Variables:* Total exposure (h), number of injuries (n), time loss injuries (n). KOOS subscale score (AU).	Self-reported previous knee injury significantly increased the risk of a time-loss knee injury. Risk of time-loss knee injury was also significantly

	n = 326 (primary analysis), 253 (secondary analysis) *(team/club: n =* 31/30)	No self-reported previous knee injury: 1.67 ± 0.05 m 57.7 ± 7.1 kg		*Comparison Groups:* Previous injury status (self-reported previous knee injury n = 98, no self-reported previous knee injury n = 228).	increased in players with low KOOS subscale scores (< 80 points) in Activities of Daily Living, Sport/Recreational and Quality of Life. Self-reported previous knee injury and low scores in three KOOS subscales significantly increase the risk of future time-loss knee injury in adolescent female football.
Emery et al. (2006) (175)	*Country* = Canada *PS* = Regional *AG* = U14, U16, U18, *n* = 164 (*team/club: n* = 21)	14.7 ± 0.5 yrs 1.56 ± 0.1 m 57.9 ± 2.9 kg	To investigate injuries in youth indoor football players. In addition, these injury rates will be compared across the same study population with data collected from the previous outdoor season.	*Data Collection:* Certified athletic therapist. *Outcome Variables:* BMI (kg.m^2), VJ (cm), predicted VO_2 Max (mL.kg.min^{-1}), Eyes Closed Dynamic (s), injury rate (injuries.1000h^{-1}), injury location (ankle, knee, groin, head, lower leg, foot, upper leg, shoulder). *Comparison Groups:* Age group (U14 n = 57, U16 n = 61, U18 n = 46). Player type (indoor players, outdoor players).	There was no significant difference between injury rates by age group in indoor football compared with outdoor football The risk of injury in the most elite division of play was greater in outdoor compared with indoor football. The most commonly injured body part in both indoor and outdoor football was the ankle, followed by the groin in indoor and the knee in outdoor football
Hägglund et al. (2016) (176)	*Country* = Sweden *PS* = Regional *AG* = U14 – U18 *n* = 4556 (*team/club: n* = 230)	14.1 ± 1.2 yrs 1.63 ± 0.07 m 53.3 ± 8.6 kg	To prospectively evaluate risk factors for acute time-loss knee injury, in particular ACL injury, in female youth football players.	*Data Collection:* Study selected physiotherapists and physicians. *Outcome Variables:* Players injured (%), BMI (kg/m^2), training sessions/matches per week (n), Menarche (yes/no), previous acute knee injury (yes/no), match exposure (ratio), current knee complaints (yes/no). *Comparison Groups:* Injury type (acute knee injuries n = 96, ACL injuries n = 21). Injury status (previous acute knee injury, no previous acute knee injury).	Female youth football players with a familial disposition of ACL injury had an increased risk of ACL injury and acute knee injury. Older players and those with knee complaints at pre-season were significantly more at risk of acute knee injury.
O'Kane et al. (2016) (177)	*Country* = USA *PS* = Regional *AG* = U13 – U15, *n* = 351 (*team/club: n* = 33/4)	NS	To evaluate extrinsic risk factors including field surface and footwear and describe the characteristics of acute lower extremity injuries in a sample of 11–15-year-old elite female youth football players.	*Data Collection:* Physician, Internet based survey. *Outcome Variables:* Injury location (foot, ankle, lower leg, knee, thigh, hip, groin) (n), sprain/strain number (%), contusion number (%), fracture number (%), injury duration (days). *Comparison Groups:* Injury status (lower extremity injury cases, uninjured). Game type (practice, game). Playing surface (dry, wet, artificial turf, grass). Shoe type (cleats, turf shoes). Position (forward, defender, midfielder, goalie).	One hundred seventy-three acute lower extremity injuries occurred involving primarily the ankle (39.3%), knee (24.9%), and thigh (11.0%). Over half (52.9%) recovered within 1 week, whereas 30.2% lasted beyond 2 weeks. During practices, those injured were significantly more likely to play on grass than artificial turf and more likely to wear cleats on

					grass than other shoe and surface combinations. During games, injured players were significantly more likely to play defender compared with forward. It is concluded that at this level, training on artificial turf is safer than on grass.
Sedeaud et al. (2020) (178)	*Country* = France *PS* = National *AG* = U16 – U18, *n* = 24 *(team/club: n* = NS)	17.1 ± 0.8 yrs	To examine the relationships between the occurrence and severity of injuries using three workload ratios (acute chronic workload ratio, exponentially weighted moving averages, robust exponential decreasing index) in elite female football players and female pentathletes.	*Data Collection:* Self-reports (cross-checked by medical staff). *Outcome Variables:* Number of injuries (n), severity of injuries (n), Acute Chronic Workload ratio, Exponentially Weighted Moving Averages, Robust Exponential Decreasing Index (AU). *Comparison Groups:* Sport (football n = 24, pentathlon n = 12).	A total of sixty-six injuries (2.75 per athlete) were reported in the soccer players and twelve in pentathletes (1 per athlete). The cumulative severity of all injuries was 788 days lost in football and19 in pentathlon: respectively, 11.9 days lost per injury in football player and 3.0 per pentathlete. The mean values across the three methods in football showed a higher number of injuries detected in the [0; 0.8] workload ratio zone: 22.3 ± 6.4. They were 17.3 ± 3.5 in the sweet spot ([0.8–1.3] zone) and 17.6 ± 5.5 in the [1.5; +8] zone. In comparison to the 1.5; +8 zone, football players reported a higher number of days lost to injuries in the presumed sweet spot and in the [0–0.8] zone: 204.7 ± 28.7 and 275.0 ± 120.7 days, respectively.
Soligard et al. (2012) (179)	*Country* = Norway *PS* = National AG = NS *n* = 19,147 (*team/club: n* = NS)	NS	To investigate the risk of acute injuries among youth male and female footballers playing on third-generation artificial turf compared with grass.	*Data Collection:* Team coaches and referee. Injury form. *Outcome Variables:* Injury type (contusion, sprain, strain, fracture, dislocation, abrasion/laceration) (n), injury location (lower body, foot, ankle, lower leg, knee, thigh, hip, groin, upper body, back/spine, stomach/chest, arm/hand/fingers, shoulder, neck, head) (n), injury severity (1-3, 4-7, 8-28, >28 days). Injuries (n), injury incidence (injuries.1000h^{-1}). *Comparison Groups:* Exposure group (n = 18,376), Injuries group (n = 771). Age Group13y, 14y, 15-16y, 17-19y). Playing surface (artificial, grass).	The overall incidence of injuries was 39.2 (SD: 0.8) per 1000 match hours; 34.2 (SD: 2.4) on artificial turf and 39.7 (SD: 0.8) on grass. For females the incidence was 42.7 (SD:5.3) and 41.9 (SD: 1.6 injuries per 1000 match hours on artificial turf and grass respectively. After adjusting for the potential confounders age and gender, there was no difference in the overall risk of injury or in the

					risk of time loss injury between artificial turf and grass. However, there was no difference in the risk of ankle injuries between the two surfaces, the risk of ankle injuries was almost half on turf compared to grass., A higher risk of back and spine, shoulder and clavicle injuries were reported on artificial turf compared with grass.
Soligard et al. (2010) (180)	*Country* = Norway *PS* = Regional *AG* = NS, *n*= 1034 (*team/club: n* = 56)	NS	To investigate whether there are any associations between football specific skills and risk of injury in young female players.	*Data Collection:* Questionnaire to assess technical, tactical and physiological attributes. Standard questionnaire for injury data completed by physical therapist via phone. *Outcome Variables:* Technical/tactical/physiological attributes (n, %), total injuries (n), lower extremity injuries (n), acute injuries (n), overuse injuries (n), contact injuries (n), non-contact injuries (n), injury incidence (injuries.1000h^{-1}). *Comparison Groups:* Playing standard (low skill, high skill).	Across the different skill attributes, the injury incidence in the high-skilled players varied from 4.4 to 4.9 injuries per 1000 player hours, compared to 2.8 to 4.0 injuries per 1000 player hours in the low-skilled players. Players skilled at ball receiving were at greater risk of injury. Players highly skilled in passing, shooting, heading, tackling and decision making in defence had a significantly higher risk of injury Physically strong players were at significantly greater risk of sustaining any injury to their lower extremity both acute and contact injuries compared to their physically weaker teammates.
Steffen et al. (2007) (181)	*Country* = Norway *PS* = Regional *AG* = U17, *n* = 2020 (*team/club: n* = 109)	NS	To investigate injury risk on artificial turf compared with natural grass among young female football players.	*Data Collection:* Physical therapists, coaches. *Outcome Variables:* Playing exposure (h), total injuries (n), injury incidence (injuries.1000h^{-1}), injury type (contusion, sprain, strain, other), injury location (ankle, upper body, lower body, groin, thigh, knee, other), contact v non-contact, time loss (1-7, 8-21, >21 days). *Comparison Groups:* Playing surface (artificial, grass, gravel, indoor)	421 (21%) players sustained at least one injury with a total of 526 injuries overall leading to an injury incidence of 3.7.1000^{-1} playing hours. The incidence of acute injuries on artificial turf and grass did not differ significantly with respect to match injuries or training injuries. In matches, the incidence of serious injuries was significantly higher on artificial turf. Ankle sprain was the most common type of injury (34% of all acute

					injuries), and there was a trend towards more ankle sprains on artificial turf than on grass.
Steffen et al. (2008) (182)	*Country* = Norway *PS* = Regional *AG* = U17, *n* = 1430 (*team/club: n* = 113)	15.4 ± 0.8 yrs 1.66 ± 0.6 m 56 ± 7.0 kg	To examine whether injury history and lower limb function assessed by a self-administered questionnaire represent risk factors for new injury.	*Data Collection:* Risk Factor Questionnaire (NS). *Outcome Variables:* BMI ($kg.cm^2$), years in organised soccer (n), training per week (h), time-loss injuries (d), players with new injuries (%), injury location (ankle, knee, thigh, groin, hip, lower leg, foot including toe (n). *Comparison Groups:* Injury status (previously injured n = 1003, not previously injured n = 422).	A history of a previous injury to the ankle, knee, thigh or groin significantly increased the risk of new injuries to the same region. Reporting reduced function for the ankle or knee was also a significant risk factor. However, the sensitivity of the questionnaire was low when reporting previous injuries and lower limb function for predicting new injuries.
Tranaeus et al. (2022) (183)	*Country* = Sweden *PS* = NS *AG* =NS *n* = 419 (*team/club: n* = NS)	13.9 ± 1.1 yrs	To investigate if the combination of demographic, psychosocial and physiological factors can predict a traumatic injury in adolescent female football players.	*Data Collection:* Questionnaire (four-point Likert scale, Brief COPE, OSTRC-O). *Outcome Variables:* Mean score (stress, active coping, instrumental support, planning, acceptance, emotional support, positive reframing, humour, religion) (n), one-leg long box jump test (cm), square hop test (cm), training/match hours per week (n). *Comparison Groups:* Injury status (no injury n = 158, injury n = 261).	A total of 62% of the players reported at least one traumatic injury during the 52 weeks. The coping strategy “positive reframing” had the strongest association with the risk of traumatic injuries. The combination of more frequent use of the coping strategy, positive reframing, and high levels of physical performance capacity may prevent a traumatic injury in adolescent female footballers.
Watson et al. (2017) (184)	*Country* = USA *PS* = Regional *AG* = 13-18 or NS, *n* = 54 (*team/club: n* = NS)	15.1 ± 1.5 yrs	To determine whether preseason aerobic fitness predicts in-season injury and illness risk in female adolescent football players.	*Data Collection:* Cycle ergometer (Velotron; Racermate). Injuries self-reported. *Outcome Variables:* Total injuries (n), injury incidence ($injuries.1000h^{-1}$), weekly injuries (n), weekly illnesses (n). Injury location (ankle, knee, head, upper leg, back, foot) (n). Injury type (sprain, muscle strain, concussion, contusion) (n). BMI ($kg.m^2$), soccer experience (y), VO_2Max ($L.min^{-1}$)/($mL.kg.min^{-1}$), T_{max} (min), VO_{2VT} ($L.min^{-1}$)/($mL.kg.min^{-1}$), T_{VT} (min). *Comparison Groups:* Injury status (uninjured n = 31, injured n = 23). Illness status (no illness n = 31, illness n = 23).	Individuals who reported an illness had significantly lower VO2max than those who did not. With the Poisson regression models, VO2max was a significant predictor of both injury and illness, while no significant relationships were identified between injury or illness and age, years of experience, T_{max}, or BMI.
Xiao et al. (2021) (185)	*Country* = USA *PS* = Regional AG = U17, *n* = 767 (*team/club: n* = NS)	14.7 ± 1.6 yrs	To assess the associations between serious injury (≥3-month time loss) and level of specialisation among high-level female football players and to compare the	*Data Collection:* Questionnaire (NS). *Outcome Variables:* Injury location (knee, lower leg/ankle, hip/thigh, foot, head, upper extremities) (%). Perceptions surrounding early soccer specialisation questionnaire	Serious injuries affected 23.6% of youth and 51.4% of college/professional athletes. Anterior cruciate ligament tears were significantly more prevalent in

			specialisation and college commitment ages of female youth football players to Division I college and professional football athletes.	(strongly disagree, somewhat disagree, neutral, somewhat agree, strongly agree) (AU). *Comparison Groups:* Playing standard (low specialisation, moderate specialisation, high specialisation). Playing status (quit, currently playing).	college/professional players compared with youth athletes. Highly specialised youth athletes (66.5%) were significantly more likely to have sustained a serious injury from soccer compared with athletes with low specialisation but not moderate specialisation. A significantly higher proportion of youth athletes specialised at a young age (≤10 yrs) compared with college/professional players. High specialisation in female youth soccer players is associated with an increased likelihood of sustaining a serious injury.
Interventions (n=9)					
De Ste Croix. (2018) (186)	*Country* = England *PS* = Regional *AG* = U12, U14, U16, *n* = 125 *(team/club: n* = 5)	*Intervention* 13.1 ± 1.7 yrs 1.55 ± 0.09 m 49.5 ± 10.0 kg *Control* 12.8 ± 1.6 yrs 1.54 ± 0.09 m 51.4 ± 9.6 kg	To examine the efficacy of a robustness training programme on injury risk factors in elite female youth players and if high risk athletes respond to this training. .	*Data Collection*: Mobile contact mat (2.5hz, Smartjump; Fusion Sport) and handheld unit (iPAQ; Hewlett Packard), 2D motion analysis (Quintic cameras, Quintic Consultancy Ltd, Unit 8, Coleshill, Birmingham). *Outcome Variables*: Knee flexion ROM (º), knee valgus motion (º), pKAM (AU), leg stiffness (N.m^{-1}). *Intervention*: 16-week intervention, 3 x week (1 coach-led: 20 min sport-specific warm up including dynamic warm-up dynamic flexibility, plyometric and landing technique, speed and agility); 2 player-led: robustness training including body weight, strength, stabilisation and balance exercises). *Comparison Groups:* Intervention (n = 71; high risk (pKAM > 0.8) n = 33, low risk (pKAM <0.55) n = 33, excluded (pKAM 0.55-0.80) n = 5, control (n = 54).	Knee valgus, leg stiffness, and pKAM were all significantly improved with a multicomponent robustness program. The benefit was greater in players at high-risk based on pKAM probability.
Hägglund et al. (2013) (187)	*Country* = Sweden *PS* = Regional *AG* = NS *n* = 4556 (*team/club: n* = 184/121 (intervention), 157/109 (control)	NS	To evaluate team and player compliance with a neuromuscular training programme in adolescent female football and to study the association between compliance and acute knee injury rates.	*Data Collection:* Computer-based player attendance form (NS). *Outcome Variables:* Compliance rate (low, intermediate, high), mean number of neuromuscular training program sessions per week/season (n), matches/training sessions during season (n). Team compliance (%), player compliance (%), player training attendance (%), injury incidence (injuries.1000h^{-1}), number of injuries (n).	Players in the high-compliance tertile had an 88% reduction in the ACL ligament injury rate, whereas the rate in the control group players was not significantly different from those in the low-compliance tertile. Significant deterioration

				Intervention: Neuromuscular training programme (15-minute warm up program, 2x per week) over the course of one season. *Comparison Groups:* Intervention (n = 2471), control (n = 2085).	in team and player compliance occurred over the season.
Leppänen et al. (2022) (188)	*Country* = Finland *PS* = National *AG* = NS *n* = 88 (*team/club: n* = 20)	NS	To investigate physical fitness and football-specific skills and their association with injury risk in 9–14-years-old football players.	*Data Collection:* SMS, Questionnaire (Oslo Sports Trauma Research Centre Overuse Injury Questionnaire). *Outcome Variables:* 5-jump (m), 30m sprint (s), figure of eight (s), CMJ (cm), Yo-Yo IR1 (s), passing (s), dribbling (s), fitness score (n), football-specific skills score (n), total injuries (n), acute injuries (n), overuse injuries (n). *Intervention:* Intervention group excluded from study. *Comparison Groups:* Age group (9-10yr n = 20, 11yr n = 22, 12yr n = 26, 13yr n = 20), Fitness level (most fit, reference, least fit).	High level of physical fitness was associated with increased rate of all injuries. The level of football-specific skills had no influence on the overall injury rate. Burden of overuse injuries, but not acute injuries was significantly higher in most fit players compared with the players in the reference group.
Mandelbaum et al. (2005) (189)	*Country* = USA *PS* = Regional *AG* =NS *n* = 2946 (1st year), n = 2757 (2nd year) *(team/club: n* = 52 (1st year), n = 45 (2nd year)	NS	To determine whether a neuromuscular and proprioceptive performance program was effective in decreasing the incidence of anterior cruciate ligament injury within a select population of competitive female youth football players.	*Data Collection:* Knee injury questionnaire (NS), MRI scan (NS), arthroscopic procedure (NS), injury reports (coach). *Outcome Variables:* Total exposures (n), injury incidence (injuries.1000h^{-1}). *Intervention:* Prevent Injury and Enhance Performance Program – 3 basic warm-up activities, 5 stretching techniques, 3 strengthening exercises, 5 plyometric activities, 3 football specific agility drills. Completed over 2 seasons. *Comparison Groups:* Year (year 1 n = 2946, year 2 n = 2757). Trained (n = 1885), untrained (n = 3818).	During the 2000 season, there was an 88% decrease in anterior cruciate ligament injury in the enrolled subjects compared to the control group. In year 2, during the 2001 season, there was a 74% reduction in anterior cruciate ligament tears in the intervention group compared to the age- and skill-matched controls. Using a neuromuscular training program may have a direct benefit in decreasing the number of anterior cruciate ligament injuries in female football players.
Soligard et al. (2009) (190)	*Country* = Norway *PS* = National *AG = NS* *n* = 1892 (*team/club: n* = 93)	NS	To examine the effect of a comprehensive warm- up programme designed to reduce the risk of injuries in female youth football.	*Data Collection:* Coaches, physical therapist, medical student. *Outcome Variables:* Exposure to football (h), total injuries (n), injury location (lower extremities, knee, ankle, leg, anterior/posterior thigh, hip/groin) (n). Injury type (sprains, strains, contusions, fractures, contact, non-contact) (n), injury severity (minimal, mild, moderate, severe) (n).	264 players had relevant injuries: 121 players in the intervention group and 143 in the control group. In the intervention group there was a significantly lower risk of injuries overall (0.68, 0.48 to 0.98), overuse injuries (0.47, 0.26 to 0.85), and severe injuries (0.55, 0.36 to 0.83). A

				Intervention: Warm-up programme to improve strength awareness, and neuromuscular control – 20 minute, 3-part warm-up. *Comparison Groups:* Intervention group (n = 1055), control group (n = 837)	structured warm-up programme can reduce the risk of injuries in young female football players.
Steffen et al. (2008) (191)	*Country* = Norway *PS* = Regional *AG* = U17, *n* = 2020 (*team/club: n* = 109)	15.4 ± 0.8 yrs	To examine the effect of the "11," used as a warm-up exercise program to prevent injuries among young female football players.	*Data Collection:* Balance mats (40 x 50cm, 7cm thick, Alusuisse Airex, Swtizerland), Physical therapists. *Outcome Variables:* Compliance (compliant, non-compliant (%)), injuries (n), injury incidence (injuries.1000h^{-1}). Injury location (upper body, lower body, groin, thigh, knee, ankle) (n), injury type (contusion, sprain, strain), contact, non-contact, time loss (1-7, 8-21, >21 (d)). *Intervention:* 10 exercises focusing on core stability, balance, dynamic stabilisation, and eccentric hamstring strength. 5 mins of jogging before completing the 20 min exercise program. Carried out for the duration of the season. *Comparison Groups:* Control group (n = 947), Intervention (n = 1073). Game type (match, training).	A total of 396 players (20%) sustained at least one injury. Of these players 57(3%) and 15 (1%) sustained two and three injuries respectively totalling 483 injuries. No difference was observed in the overall injury rate between the intervention (3.6 injuries.1000h^{-1}) and control group nor in the incidence for any type of injury. During the first 4 months of the season, the training program was used during 60% of the football training sessions, but only 14 out of 58 intervention teams completed more than 20 prevention training sessions.
Steffen et al. (2013) (192)	*Country* = Canada *PS* = Regional *AG* = U16 – U18, *n* = 385 (*team/club: n* = 29)	NS	The objective of this cluster-randomised study was to evaluate different delivery methods of an effective injury prevention programme (FIFA 11+) on adherence and injury risk among female youth football teams.	*Data Collection:* Team trainer, coach or manager, balance pads (Airex, Switzerland). *Outcome Variables:* Single-leg balance (s), star excursion balance test (cm), single-leg triple hop (cm), jump over-a-bar (n), practice/match exposure (h), adherence to FIFA 11+ (n, %), team sessions per week (n), team exercises per session (n), injury incidence (injuries.1000h^{-1}). *Intervention:* FIFA 11+ - 20 min warm-up programme with neuro- muscular training consisting of 15 exercises developed to prevent lower extremity injuries in football players. Carried out over the four-month season. *Comparison Groups:* Control group (n = 135), Regular intervention group (n = 121), comprehensive intervention group (n = 129). Playing level (tier 1/2/3) (n). Playing position (forward, midfield, defence, goalkeeper) (n).	Following a coach workshop, coach-led delivery of the FIFA 11+ was equally successful with or without the additional field involvement of a physiotherapist. There was no reduction in injury risk if the physiotherapist was involved in delivery of the FIFA 11+ or not. Proper education of coaches during an extensive preseason workshop was significantly more effective in terms of team adherence than an unsupervised delivery of the 11+ programme to the team.
Walden et al. (2012) (193)	*Country* = Sweden *PS* = Regional *AG* = U14 – U18, *n* = 4564	*Intervention group:* 14.0 ± 1.2 yrs 1.64 ± 0.7 m 53.3 ± 8.6 kg	To evaluate the effectiveness of a neuromuscular warm-up programme in reducing the rate of acute knee injury,	*Data Collection:* Physiotherapists and physicians. *Outcome Variables:* Mean training sessions/matches per week/season (n), type of tear (total, partial), menarche (n), previous acute knee injury (n), previous ACL injury (n),	Seven players (0.28%) in the intervention group, and 14 (0.67%) in the control group had an anterior cruciate ligament injury. By Cox

	(team/club: n = 230)	*Control group:* 14.1 ± 1.2 yrs 1.64 ± 0.6 m 53.3 ± 8.4 kg	particularly anterior cruciate ligament injury	current knee complaints (n), familiar disposition of ACL injury (n), injury incidence (injuries.1000h^{-1}). *Intervention:* 15-minute neuromuscular warm-up programme (targeting core stability, balance, and proper knee alignment) carried out twice a week throughout the season. *Comparison Groups:* Intervention (n = 2479), Control (n = 2085).	regression analysis according to intention to treat, a 64% reduction in the rate of anterior cruciate ligament injury was seen in the intervention group. A neuromuscular warm-up programme significantly reduced the rate of anterior cruciate ligament injury in adolescent female football players. However, the absolute rate difference did not reach statistical significance.
Zebis et al. (2018) (194)	*Country* = Denmark *PS* = Regional *AG* =U18, *n* = 332 (*team/club: n* = 25)	NS	To investigate if the introduction of a lighter, smaller football with female adolescent players has any effect on injury patterns	*Data Collection:* Text message, phone call. *Outcome Variables:* Total injuries (n), exposure (h), injury incidence (injuries.1000h^{-1}). Injury location (knee, ankle, posterior/anterior thigh, lower leg, hip, low back, foot, neck, head, hand) (n). *Intervention:* Played with a lighter football (circumference 64cm; mass 0.360kg; pressure 0.8 bar) for a full season. *Comparison Groups:* Intervention group (n = 147), Control group (n = 185).	46 acute time loss injuries were registered (5 severe injuries). The incidence rate was 15.2 injuries per 1000 hours of match-play for the intervention group and 18.6 in the control group. The greater injury incidence rate in the control group was not significant.

NS = not specified. PS = playing standard. AG = age group. AU = Arbitrary Units. SD = Standard Deviation. AEHs = Athlete Exposure Hours. BMI = Body Mass Index. ROM = Range of Motion. KOOS = Knee injury and Osteoarthritis Outcome score. ACL = Anterior Cruciate Ligament. pKAM = High Knee Abduction Moment. SMS = Short Messaging Service. Yo-Yo IR1 = Yo-Yo Intermittent Recovery test Level 1. CMJ = Countermovement Jump. MRI = Magnetic Resonance Imaging.

Appendix 4. Characteristics, aim, methods, and key findings of match-play studies (n=17)

Study	**Cohort/sample size (n)**	**Participant characteristics (age, height, body mass)**	**Aim**	**Methods**	**Key findings**
Physical characteristics (n=6)					
Barbero-Álvarez et al. (2008) (70)	*Country* = Spain *PS* = NS *AG* = NS *n* = 12 *(team/club: n* = 1)	12.1 ± 0.9 yrs 1.55 ± 0.06 m 48.4 ± 9.2 kg	Quantify the cardiovascular demand and activity profile during friendly match-play.	*Data Collection*: 1Hz GPS, and HR monitor (SPI Elite, GPSports Systems, Australia). *Outcome Variables*: Mean and maximum HR (b·min^{-1}), TD (m; m·min^{-1}), TD (m; %) in speed zones (stopped: 0 - 0.4, walking: 0.05 - 3, LSR: 3.1 - 8, MSR: 8.1 – 13, HSR: 13.1 – 18, SPR: >18 km·h^{-1}), maximum speed (km·h^{-1}), work:rest ratio. *Comparison Groups*: Match-half. *Observations*: Matches (n = 1; 2 x 25-min halves, 7-a-side). Individual observations (n = NS). Inclusion criteria (NS).	Players spent 40% of match duration above 90% maximum HR. Only 6.2% of TD covered at high intensity running or above, with a 91% variability observed in SPR distance. Players covered less TD in the second half.
Harkness-Armstrong et al. (2021) (69)	*Country* = England *PS* = Regional *AG* = U14, U16 *n* = 201 (*team/club:* U14 n = 6, U16 n = 6)	U14: 12.9 ± 0.7 yrs 1.59 ± 0.06 m 48.5 ± 8.9 kg U16: 15.0 ± 0.6 yrs 1.62 ± 0.06m 56.1 ± 6.4 kg	Quantify and compare age group and position-specific whole and peak physical characteristics of competitive match-play for U14 and U16s.	*Data Collection*: 10Hz GPS (Optimeye S5, Catapult Sports, Australia). *Outcome Variables*: TD (m; m·min^{-1}), TD (m; m·min^{-1}) in speed zones (HSR: 12.5 – 19.0, VHSR: 19.1 – 22.5, SPR: >22.5 km·h^{-1}), maximum speed (m·s^{-1}). *Comparison Groups*: Age group (U14 n=93, U16 n=108), playing position (CD, WD, CM, WM, FWD). *Observations*: Matches (U14 n = 26, 2 x 35mins, 11-a-side; U16 n = 24, 2 x 40mins, 11-a-side). Individual observations (U14 n = 277, U16 n = 204). Inclusion criteria (positional observations).	U16s covered greater TD (m) and distance at all speeds (m); VHSR and SPR (m·min^{-1}); peak TD and HSR (m·min^{-1}) across several peak-durations, and VHSR (m·min^{-1}) across all peak-durations compared to U14s. Position-specific differences between and within age groups. In both age groups, CD covered least TD (m; m·min^{-1}) and HSR (m; m·min^{-1}), whilst CM covered the most TD (m; m·min^{-1}), but least VHSR and SPR (m; m·min^{-1}).
Harkness-Armstrong et al. (2022) (78)	*Country* = England *PS* = Regional *AG* = U14, U16 *n* = 201 (*team/club:* U14 n = 6, U16 n = 6)	U14: 12.9 ± 0.7 yrs 1.59 ± 0.06 m 48.5 ± 8.9 kg U16: 15.0 ± 0.6 yrs	Determine speed thresholds for U14 and U16 youth female soccer players.	*Data Collection*: 10Hz GPS (Optimeye S5, Catapult Sports, Australia). *Outcome Variables*: LSR (m), HSR (m), VHSR (m) and SPR (m). *Comparison Groups*: Match-half, age group (U14 n=89, U16 n=98). Playing position (CD, WD, CM, WM, FWD).	Youth speed thresholds were established for HSR (≥3.00 m·s^{-1}), VHSR (≥4.83 m·s^{-1}), and SPR (≥5.76 m·s^{-1}). Match-half did not influence speed thresholds, but age group and playing position did.

		1.62 ± 0.06m 56.1 ± 6.4 kg		*Observations*: Matches (U14 n = 26, 2 x 35mins, 11-a-side; U16 n = 24, 2 x 40mins, 11-a-side). Individual half-match observations (U14 n = 369, U16 n = 330). Inclusion criteria (whole half-match).	Adopting senior thresholds resulted in less HSR, VHSR, and SPR compared to youth thresholds.
Mordillo et al. (2023) (72)	*Country* = Italy *PS* = National *AG* = U15, U17, U19 *n* = 58 (team/club: n = 1)	NS	Describe the activity profiles of U15, U17 and U19 players during competitive match-play.	*Data Collection*: 10Hz GPS (BT-Q1000eX, Qstarz International Co. Ltd, Taiwan) *Outcome Variables*: TD (m; m·min^{-1}), TD (m·min^{-1}) in speed zones (walking: 0 – 6, LSR: 6 – 11; MSR: 6 – 11; HSR: 14.1 – 18; VHSR: 18 – 22; SPR: >22 km·h^{-1}), metabolic power (walking: 0 – 5; low: 5 – 10; intermediate: 10 – 18; high: 18 – 31.5; very-high: 31.5 – 49.5; max: >49.5 W). *Comparison Groups*: Age group (U15 n=18, U17 n=20, U19 n=22). Match periods (U15: 1st, 2nd, 3rd; U17 & U19: 1st, 2nd). *Observations*: Matches (U15 n = 12, 3 x 20mins, 9-a-side; U17 n = 12, 2 x 40mins, 11-a-side; U19 n = 16, 11-a-side, 2 x 45mins). Individual observations (U15 n = 35, U17 n = 35, U19 n = 50). Inclusion criteria (whole match).	TD, VHSR and SPR (m) increased across age groups, but when relative to match-play duration there was an only an increase between U15 and U17 (m·min^{-1}). HSR (m·min^{-1}) also increased with age. U19 players had the most between-period reductions in performance.
Ramos et al. (2019) (71)	*Country* = Brazil *PS* = International *AG* = U17 *n* = 14 (*team/club:* n = 1)	15.6 ± 0.5 yrs 1.65 ± 0.06m 58.0 ± 4.3 kg	Compare distances covered by U17, U20, and senior Brazilian national teams during competitive international tournament match-play.	*Data Collection*: 10Hz GPS (MinimaxX S5, Catapult Sports, Australia). *Outcome Variables*: TD (m), TD (m) covered in speed zones (HSR: 15.6 – 20; SPR: >20 km·h^{-1}), accelerations (n; >1m·s^{-2}), decelerations (>1m·s^{-2}), PlayerLoad (AU). *Comparison Groups*: Playing position (CD, WD, MID, FWD). *Observations*: Matches (n=7, 2 x 45mins, 11-a-side). Individual observations (n = 43; CD n = 7, WD n = 10, MID n = 17, FWD n = 9). Inclusion criteria (whole match).	U17s had the lowest values in all outcome variables. Within the U17 age group, WDs covered the most TD, HSR and SPR (m), and performed the most accelerations and decelerations.
Vescovi et al. (2014) (73)	*Country* = USA *PS* = National *AG* = U15, U16, U17 *n* = 89 (*team/club:* n = NS)	NS	Determine age group and position-specific locomotor characteristics of competitive youth female match-play.	*Data Collection*: 5Hz GPS (SPI Pro, GPSports, Australia). *Outcome Variables*: TD (m; m·min^{-1}), TD (m) covered in speed zones (standing and walking: 0 - 6, jogging: 6.1 – 8, LSR: 8.1 – 12, MSR 12.1 – 15.5, HSR: 15.6 – 20; SPR: >20 km·h^{-1}), sprints (n), distance per sprint (m), maximum speed (km·h^{-1}). *Comparison Groups*: Age group (U15 n = 11, U16 n = 63, U17 n = 15). Playing position (DEF, MID, FWD). Match-half. *Observations*: Matches (n = NS; 11-aside; U15 2 x 40mins, U16 2 x 40mins, U17 2 x 45mins). Individual observations (U15 n = 11; U16 n = 63, U17 n = 15). Inclusion criteria (whole match).	U15s performed less TD, MSR, HSR, SPR and sprints (n) compared to U17s and U19s. The only difference between U17s and U19s was a decrease in walking (m) and increase in LSR. Differences between playing positions (not age group specific) were observed. MID covered more TD, LSR, MSR than DEF, but less SPR, performed less sprints and achieved a lower maximal velocity than FWD.

					No age group differences in changes between first and second half for distance-related variables.
Physical & technical characteristics (n=3)					
Andersen et al. (2012) (202)	*Country* = Denmark *PS* = Regional *AG* = U18 *n* = 150 (*team/club:* n = 10)	NS	Quantify heart rate, activity profiles, fatigue development and technical-tactical performance during simulated matches.	*Data Collection:* HR monitor (Polar Team2, Polar Electro Oy, Finland), video camera (DM-MV 600, Canon, Japan), time-motion analysis, computerised notational analysis (SportsCode Elite v5.1.9, Sportstec Int, Australia). *Outcome Variables*: Physical: mean and maximum HR (b·min^{-1}), HR zones (%; <70, 70-80, 80-90, 90-95, >95% HR_{max}), TD (km), TD (km; %) in speed zones (standing: 0 - 6, walking: 6 - 8, jogging: 8 – 12, LSR: 8 – 15, MSR: 15 – 18, HSR: 18 – 25; SPR: >25, sideways running >10, backwards running >10 km·h^{-1}), number (n) and duration (s) of efforts, RPE (AU). Technical: long high/low passes attempted (n) and completed (%), long/short passes attempted (n) and completed (%), total passes attempted (n) and completed (%), ball receipts (n) and successful receipts (%), 1v1s (n), headers (n), challenges (n), deep passes (n), crosses attempted (n) and completed (%), free-kicks (n), corners (n), shots (n), goals (n). *Comparison Groups*: Match period (0-20, 20-40, 40+, 40-60, 60-80, 80+ mins), football (new-ball (circumference = 64 cm, mass = 0.360 kg, pressure = 0.8 bar), standard-ball (circumference = 69 cm, mass = 0.445 kg, pressure = 0.9 bar)). *Observations*: Matches (11-aside; 2 x 40mins; new-ball n=5, standard ball n=5). Individual observations (HR & GPS n=25, RPE n=33, technical n=NS). Inclusion criteria (>70mins in both new-ball and standard-ball matches).	No difference in HR variables, RPE, number of efforts, TD, or HSR between new- and standard-ball matches. The only difference in technical actions was more challenges during new-ball matches. There were reductions in TD and HSR within from the first 20mins to the last 20mins, and within match halves.
Harkness-Armstrong et al. (2023) (79)	*Country* = England *PS* = Regional *AG* = U14, U16 *n* = 199 (*team/club:* U14 n = 5, U16 n = 6)	U14: 12.9 ± 0.7 yrs 1.59 ± 0.06 m 48.5 ± 8.9 kg U16: 15.0 ± 0.6 yrs 1.62 ± 0.06m 56.1 ± 6.4 kg	Quantify and compare the physical and technical characteristics of U14 and U16 competitive match-play according to match and possession status.	*Data Collection*: 10Hz GPS (Optimeye S5, Catapult Sports, Australia), video camera (Panasonic HC-V750, Panasonic, Japan), computerised notational analysis (Pro Plus, Nacsport, Spain). *Outcome* Variables: Physical: TD (m·min^{-1}), TD (m·min^{-1}) in speed zones (HSR: >12.5, VHSR: >19.0, SPR: >22.5 km·h^{-1}). Technical: Percentage of match-play (%), number of possessions (n·min^{-1}), duration of possessions (s), touches per possession (n·min^{-1}), passes per possession (n·min^{-1}), successful pass (%), first touch pass (n·min^{-1}), successful first touch pass (%), dribble (n·min^{-1}), successful dribble (%). *Comparison Groups*: Age group (U14 n = 81, U16 n = 108), match status (drawing, losing, winning), possession status (in-possession, out-of-possession, ball-out-of-play).	Physical variables according to possession status, differed between age groups and was dependent on match status. Both age groups covered more distance when the ball was in-play compared to out of play regardless of match status. Physical and technical variables differed according to match status. Regardless of match status, U14s had a more

				Observations: Matches (U14 n=24, 2 x 35mins, 11-a-side; U16 n = 21, 2 x 40mins, 11-a-side). Individual observations (U14 n = 210, U16 n = 177). Inclusion criteria (positional observations).	offensive playing style when in-possession compared to U16s.
Ørntoft et al. (2016) (204)	*Country* = Denmark *PS* = NS *AG* = U11 *n* = 24 (*team/club:* n = 4)	NS	Quantify technical and physical performance during 7v7 and 8v8 match simulations.	*Data Collection:* 1Hz HR monitor (Polar Team2, Polar Electro Oy, Finland), 5Hz GPS (SPI Pro, GPSports, Australia), digital video camera (Canon HF20E; Canon, Tokyo, Japan), computerised notational analysis (Amisco, Denmark). *Outcome Variables*: Physical: mean and maximum HR ($b{\cdot}min^{-1}$), HR zones (%; <60, 60-70, 70-80, 80-90, 90-100 HR_{max}), TD (m), TD in speed zones (m; 0-0.2, 0.2-4, 4-8, 8-12, 12-16, 16-20, >20 $km{\cdot}h^{-1}$), efforts in speed zones (n), maximum speed ($km{\cdot}h^{-1}$). Technical: number of technical actions (n). *Comparison Groups*: Match format (7v7, 8v8). *Observations*: Matches (1x 20mins; 7v7 n = 2, 8v8 n = 2). Individual observations (technical and HR n = 24; GPS n = 14). Inclusion criteria (whole match in both match formats).	No difference was observed in any HR variables between 7v7 and 8v8. No difference in TD, TD in speed zones below 16 $km{\cdot}h^{-1}$, and peak speed between 7v7 and 8v8 formats. TD in speed zones and efforts above 16 $km{\cdot}h^{-1}$ was significantly higher in 8v8 matches. More technical actions were performed in 7v7 than in 8v8, but no difference in the success rate of technical actions.
Technical characteristics (n=1)					
Harkness-Armstrong et al. (2020) (80)	*Country* = England *PS* = Regional *AG* = U14, U16 *n* = 199 (*team/club:* U14 n = 5, U16 n = 6)	U14: 12.9 ± 0.7 yrs 1.59 ± 0.06 m 48.5 ± 8.9 kg U16: 15.0 ± 0.6 yrs 1.62 ± 0.06m 56.1 ± 6.4 kg	Quantify and compare the age group and position-specific technical characteristics of U14 and U16 competitive match-play.	*Data Collection:* Video camera (Panasonic HC-V750, Panasonic, Japan), computerised notational analysis (Pro Plus, Nacsport, Spain). *Outcome Variables*: Total match time (%), number of possessions (n), duration of possessions (s), touches per possession (n), passes per possession (n), total possession (s), average possession (s), offensive touches (n), passes (n), successful passes (%) first touch passes (n), successful first touch passes (%), dribbles (n), successful dribbles (%), crosses (n), shots (n), defensive touches (n), aerial challenges (n), blocks (n), clearances (n), interceptions (n), tackles (n), fouls (n). *Comparison Groups*: Age group (U14 n = 81, U16 n = 108), playing position (CD, WD, CM, WM, FWD). *Observations*: Matches (U14 n = 24, 2 x 35mins, 11-a-side; U16 n = 21, 2 x 40mins, 11-a-side). Individual observations (U14 n = 239, U16 n = 210). Inclusion criteria (positional observations).	Both age groups had similar team possession-based characteristics similar, passes were the most frequently performed offensive action, whilst interceptions and tackles were the most frequent defensive actions. Offensive and defensive variables were position-dependent in both age groups. U16 players had similar distribution of technical actions in possession, whilst U14 central players (CD, CM) performed more actions in possession than wide players (WD, WM).
Heading (n=7)					
Beaudouin et al. (2020) (205)	*Countries* = Denmark, England, Germany, Greece, Italy, Romania, Spain, Netherlands	NS	Analyse heading incidence during training and competitive match-play.	*Data Collection*: Video camera (NS), notational analysis (NS), standardised injury registration form. *Outcome Variables*: Match and training exposure (h), headers (n; IR), headers per match (n)/training session (n), headers per player (n), head injuries (n), players with number of headers (%).	An average of 17.7 ± 9.5 headers per match compared to 34.1 ± 126.9 headers during training sessions. Total headers during matches varied between countries.

	PS = NS *AG* = U16 *n* = NS (*team/club:*: n = 74)			*Comparison Groups*: Country (Denmark, England, Germany, Greece, Italy, Romania, Spain, Netherlands). *Observations*: Matches (n = 74); training (n = 53). Individual observations (n = NS). Inclusion criteria (NS).	
Harriss et al. (2019) (206)	*Country* = Canada *PS* = Regional *AG* = U13, U14 U15. *n* = NS (team/club: U13 n = 3, U14 n = 3, U15 n = 3)	NS	Quantify and compare purposeful heading from during competitive youth soccer match-play according to age group, playing position, and impact location.	*Data Collection*: Video camera (Sony Vixia HD), computerised notational analysis (EVS25, Endzone Video Systems, Sealy, Texas, United States). *Outcome Variables*: Total headers (n; IR). *Comparison Groups*: Age group (U13, U14, U15), playing position (MID, DEF, FWD), impact location (front, top, side, back, face), game scenario (corner, drop kick, free-kick, throw-in, long range kick, goal-kick, deflection). *Observations*: Matches (n = 20 per age group; U13 & U14: 75-min, U15: 90min). Individual observations (n = NS). Inclusion criteria (NS).	The number of purposeful headers increased with age, with age group differences observed in impact location for headers. Playing position and game scenario had no effect on the number of purposeful headers.
Harriss et al. (2018) (207)	*Country* = Canada *PS* = Regional *AG* = U14 *n* = 12 (team/club: n = 1)	13.3 ± 0.5 yrs 1.60 ± 0.09 m 50.9 ± 7.2 kg	Determine the agreement between players' recall a competitive season's heading frequency and video-based observation.	*Data Collection*: Video camera (Canon Vixia HD, Tokyo, Japan), heading questionnaire, computerised notational analysis (EVS25, Endzone Video Systems, Sealy, Texas, United States). *Outcome Variables*: Total headers (recall number of headers, actual number of headers) (n), headers per match ($n.min^{-1}$). *Comparison Groups*: None. *Observations*: Matches (n = 20). Individual observations (n = NS). Inclusion criteria (n = NS).	Players self-reported double the number of headers in a season compared to video observation, with a strong relationship between recalled and observed number of headers.
Peek et al. (2021) (208)	*Country* = Australia *PS* = National *AG* = U13, U14, U15, U16, U17. *n* = NS (*team/club:* n = 55)	NS	Determine incidence and characteristics of unintentional head impacts and purposeful headers during competitive match-play.	*Data Collection*: Video camera (NS), notational analysis. *Outcome Variables*: Match exposure (h), unintentional head impacts (ball/not ball) (n), head impacts requiring medical attention (n), purposeful headers (n), headers per match (n), number of headers (IR), header characteristics: duel (%), pitch location (defensive third, middle third, attacking third), match situation (free-play, throw-in, corner-kick, free-kick), flight of ball (<10, 11-25, >26m), impact location (back, face, forehead, side, top). *Comparison Groups*: Age group (U13, U14, U15, U16, U17), playing position (DEF, MID, FWD), pitch location (defensive third, middle third, attacking third). *Observations:* Matches (n = 10 per age group; U13 & U14: 2 x 30mins, U15, U16 & U17: 2 x 35mins). Individual observations (n = NS). Inclusion criteria (NS).	Purposeful headers accounted for 99% of head impacts. The number of purposeful headers increased with age. MID performed more headers than DEF or FWD in all age groups.

Reeschke et al. (2023) (209)	*Country* = Germany *PS* = Regional *AG* = U17 *n* = 39 (*team/club:* n = 1)	14.9 ± 0.8 yrs	Describe heading frequency and characteristics during competitive match-play and training.	*Data Collection*: Video recordings, computerised notational analysis (REDCap, REDCap Consortium, USA). *Outcome Variables*: Match/training exposure (h), total headers (n), headers per match (n), headers per player ($n \cdot h^{-1}$, IR). Header characteristics: heading duel (%; with, without), playing position (%; GK, DEF, MID, FWD), match situation (%; free-play, throw-in, corner-kick, free-kick, goal-kick), flight of ball (%; <5, 5-20, 20-50, >50m), impact location (%; frontal, temporal, parietal, occipital, facial). *Comparison Groups*: Type (competitive match, training session). *Observations*: Matches (n = 54; 2 x 40mins), training (n = 134). Individual observations (NS). Inclusion criteria (NS).	More headers performed during training compared to matches. Most headers occurred during open play, followed by throw-ins, and goal-kicks. More headers were performed without opposition. MID performed most headers.
Sandmo et al. (2020) (210)	*Country* = Norway *PS* = National *AG* = U12, U13, U14, U15, U16, U17, U18 *n* = NS (*team/club:* n = NS)	NS	Quantify heading exposure during competitive match-play, according to gender and age.	*Data Collection*: Manual notational analysis. *Outcome Variables*: Match exposure (hrs), total headers ($n \cdot h^{-1}$), head impact incidents (n; IR), heading rates ($n \cdot h^{-1}$; short, long, total). *Comparison Groups*: Age group (U12, U13, U14, U15, U16, U17, U18). *Observations*: Matches (U12 n = 12, U13 n = 28, 2x 15mins, 7-a-side; U14 n=12, U15 n=14, 9-a-side, 2 x 20mins; U16 n=12, U17 n = 12, 2 x 25mins, 11-a-side; U18 n = 14, 2 x 30mins, 11-a-side).	Number of headers performed increased with age.
Wahlquist et al. (2023) (211)	*Country* = USA *PS* = Regional *AG* = U12, U13, U14 *n* = 828 (*team/club:* n = NS)	NS	Compare ball-head impact exposure during a competitive weekend tournament according to age groups.	*Data Collection*: Video camera (Brave 6, AKASO, USA), computerised notational analysis (NS). *Outcome Variables*: Ball-head impacts (n), ball-head impacts per player (n), ball-head impacts per match (n). *Comparison Groups*: Age group (U12 n = 240, U13 n = 300, U14 n = 288). *Observations*: Matches (n = 10 per age group).	The number of ball-head impacts increased with age.

NS = not specified. PS = playing standard. AG = age group. AU = Arbitrary Units. HR = Heart Rate. TD = Total Distance. HSR = High-Speed Running. VHSR = Very High-Speed Running. SPR = Sprint. LSR = Low-Speed Running. MSR = Moderate-Speed Running. GPS = Global Positioning System. GK = Goalkeeper. CD = Central Defender. WD = Wide Defender. CM = Central Midfielder. MID = Midfielder. WM = Wide Midfielder. FWD = Forward. RPE = Rate of Perceived Exertion. HR_{MAX} = Maximum Heart Rate.

Appendix 5. Characteristics, aim, methods, and key findings of nutrition studies (n=12)

Study	**Cohort/ sample size (n)**	**Participant characteristics: age, height, body mass**	**Aim**	**Methods**	**Key findings**
Braun et al. (2018) (215)	*Country* = Germany *PS* = National *AG* = NS, *n* = 56 (*team/club*: n = NS)	14.8 ± 0.7 yrs 1.66 ± 0.06 m 56.8 ± 6.1 kg	To analyse the nutritional status, blood parameters, energy intake, and energy expenditure of young elite female football players when under- and over-reporters are excluded from analysis.	*Data Collection*: Seven-day food diary (EBIspro, Willstätt-Legelshurst, Germany), seven-day activity log (BA-418 MA, Tanita, The Netherlands), blood haemoglobin and haematocrit test kit (Sysmex KX-21N, Germany), iron test (Cobas 400, Germany), ferritin (Elecsys 2010; Roche, Germany), Vitamin D test (ADVIA Centaur Vitamin D test, Siemens Healthcare, Germany). *Outcome Variables*: BMI (kg.m-^{2}), lean body mass and fat mass (%)), training duration (min.day^{-1}), energy intake and expenditure (kcal.day^{-1}), energy balance (kcal.day^{-1}), energy availability (kcal.kg^{-1} lean body mass), macronutrients (g.day^{-1}), micronutrients (g.day^{-1}), biochemical markers (ferritin (µg.L^{-1}), haemoglobin (g.dL^{-1}), 25-hydroxyvitamin D (nmol.L^{-1}). *Comparison Groups*: Under-reporters (n = 19), average-reporters (n = 32), over-reporters (n = 5).	Average-reporters were in energy balance, but 53% were not meeting the minimum energy availability requirements. 31% of players did not meet carbohydrate requirements and 34% of players did not meet protein requirements. No player met the daily recommendations for vitamin D intake, and 38% had inadequate vitamin D status based on serum 25(OH)D levels. A significant proportion of players did not meet recommended intakes for vitamin B12 (53%), folate (75%), vitamin A (53%), calcium (59%), phosphorus (38%), and iron (69%). 59% of players had low ferritin levels, with 17% classified as severe.
Chapelle et al. (2016) (216)	*Country* = Belgium *PS* = National *AG* = U19, *n* = 18 (*team/club*: n = 1)	17.6 ± 0.4 yrs 1.68 ± 0.04 m 61.4 ± 5.2 kg	To evaluate the hydration status in elite youth female soccer players during an official tournament and to identify a possible relationship between pre-training hydration status and fluid intake.	*Data Collection:* Clinical refractometer (Atago, Pal-USG-CAT-10S, Tokyo, Japan), digital scale (All Scales Europe, WLT 60/120/X/L3, Veen, Netherlands), digital hygrothermometer (Hygrotest 6200, Testo, Ternat, Germany). *Outcome Variables:* USG (g.mL^{-1}), fluid intake (L), mean ambient temperature (°C), mean relative humidity (%). *Comparative Groups:* Hydration status (euhydrated, minimally hypohydrated and hypohydrated). Game type and day (training (1/2/3), match (1/2/3)).	From days 1 to 4, between 44% and 78% players were at least minimally hypohydrated. On day 5 (rest day), all players were hypohydrated. Following an information session on day 5, the proportion of euhydrated players increased to 89% on both day 6 (training day) and day 7 (match day). On the final day (rest day), all players were either minimally hypohydrated or hypohydrated. A moderate negative correlation was found between fluid intake during training and urine specific gravity, with hypohydrated players tending to drink less during training.

Cherian et al. (2018) (217)	*Country* = India *PS* = Regional *AG* = U12, U16, *n* = 19 (*team/club*: n = NS)	U12: 10.7 ± 0.5 yrs 1.50 ± 0.34 m 41.2 ± 4.0 kg U16: 13.5 ± 1.5 yrs 1.56 ± 0.04 m 48.7 ± 6.5 kg	To evaluate energy expenditure, energy intake, and nutrient adequacy of Indian junior soccer players.	*Data Collection:* Skinfold callipers (Holtain calipers, Crymych, United Kingdom), BODPOD (Life Measurement, Inc, Concord, CA), portable metabolic analyzer (Oxycon mobile; VIASYS Healthcare GmbH, Höchberg, Germany), heart rate monitor (POLAR-PE-3000, Kempele, Finland), time allocation pattern. *Outcome Variables:* Energy expenditure (kcal.day^{-1}), energy intake (kcal.day^{-1}), energy balance (kcal.day^{-1}), energy availability (kcal.day^{-1}), carbohydrate (g.kg^{-1}), protein (g.kg^{-1}), fat (% calories), Pre-exercise CHO (g.kg), during exercise CHO (g.h^{d}), post-exercise CHO (g.kg^{e}), post-exercise protein (g^{e}), nutrient density – CHO (g.1000 kcal), protein (g.1000 kcal), fat (g.1000 kcal). Intake of players (low, adequate, excess (%)). *Comparative Groups:* Age group (U12, U16).	Female players were in negative energy balance, although differences between intake and expenditure were not significant. Low energy availability (<30 kcal·kg^{-1} fat-free mass) was observed in 58% of players. CHO accounted for >60% of energy intake in 73.7% of girls. Over 95% of players consumed <1 g·kg^{-1} CHO before training while 100% consumed >1.2 g·kg^{-1} CHO after training. Protein intake was generally adequate, but fat intake was lower than recommended in nearly half the players.
Düppe et al. (1996) (218)	*Country* = Sweden *PS* = National & regional *AG* = U13 - U17, *n* = 62 (*team/club*: n = 3)	NS	To examine the BMD of female youth football players with different training histories, and their respective controls.	*Data Collection:* Dual-energy X-ray absorptiometry (Lunar DPX machines). *Outcome Variables:* Menarcheal age (yrs), BMD (g.cm^{2}), total body fat content (%), lean body mass (kg), BMI (kg.cm^{2}). *Comparative Groups:* Playing status (control group, active football players).	Youth female football players had significantly greater BMD than controls for the total body (+2%) and trochanter (+5%), and non-significant increases at the femoral neck (+8%) and Ward's triangle (+7%). These findings suggest that football participation positively affects skeletal development at key weight-bearing sites during adolescence.
Francescato et al. (2019) (219)	*Country* = Italy *PS* = National *AG* = U17, *n* = 7 (*team/club*: n = NS)	NS	To explore pre- and post- exercise hydration status, urine parameters, and performances in adolescent elite female football players undergoing an intensity-matched training session.	*Data Collection:* Digital balance scale (EP1270, Laica, Italy), Ergotester (Globus, Italy), refractometry device (iChem®VELOCITYTM system; Beckman Coulter, Inc), urine electrolyte composition (Cobas 8000 ISE module instrumentation, Roche Diagnostics, USA). *Outcome Variables:* Flight time (s), total distance (m), height (cm), Body mass (kg), body mass change (kg), water drunk (kg), sweat loss (kg), change in body mass (%), water drunk (%body mass), sweat loss (%body mass), USG (gm.L^{-1}), electrolyte concentration (Na^{+}, K^{+}, Cl^{-}) (mmol.L^{-1}). Test type (Yo-Yo IR1 Test, CMJ test). *Comparative Groups:* Pre training session, post training session. Hydration status (consumed water *ad* libitum, consumed water equivalent to 70% of sweat loss from LIB session).	Adolescent female soccer players maintained hydration effectively with ad libitum drinking, showing minimal body mass loss (<1%). There were no significant differences in performance outcomes between the ad libitum and controlled hydration strategies. Ad libitum drinking was sufficient for maintaining hydration in female players.
Gibson et al. (2011) (220)	*Country* = Canada *PS* = Regional *AG* = NS, *n* = 33 (*team/club*: n = NS)	15.7 ± 0.7 yrs 1.64 ± 0.06 m 60.9 ± 8.2 kg	To evaluate the nutritional status of Canadian junior elite female football players and compare this	*Data Collection:* Stadiometer (Tanita HR 100 stadiometer), digital scale (model FG-150K, Island Scales, Victoria, BC, Canada), skinfold calipers (Harpenden skinfold calipers), phlebotomy (Vit D monitoring).	Mean energy intake was 2,079 ± 460 kcal.day^{-1}, and estimated energy expenditure was 2,546 ± 190 kcal.day^{-1}. 51.5% of players consumed <5g.kg^{-1} carbohydrate,

			against established sport and population-based dietary recommendations.	*Outcome Variables:* Absolute reported energy intake and estimated expenditure (kcal.day^{-1}), relative energy intake and estimated expenditure (kcal.kg^{-1}). Macronutrients – carbohydrate (total (g), fibre (g), body weight (g.kg^{-1}), total energy intake (%)), protein (total (g), body weight (g.kg^{-1}), total energy intake (%)), fat (total (g), saturated fat (%), body weight (g.kg^{-1}), total energy intake (%)), Vitamin B_1, B_2, B_6, C, E, Niacin, Pantothenic acid, Calcium, Phosphorus, Magnesium, Iron, Zinc (mg.day^{-1}), Vitamin B_{12}, A, Folate, Copper (mg.day^{-1}), Vitamin D (IU.day^{-1}). *Comparative Groups:* N/A	27.3% consumed <1.2g.kg^{-1} protein, and 21.2% consumed <25% of energy intake from fat. A substantial proportion of athletes did not meet dietary reference intakes for pantothenic acid (54.5%), vitamin D (100%), folate (69.7%), vitamin E (100%), and calcium (66.7%). 89.3% of players had low serum ferritin (iron) levels and 50.0% had sub-optimal 25-hydroxyvitamin D levels (below 75–80 nmol/L), though none were deficient by clinical standards.
Gibson et al. (2012) (221)	*Country* = Canada *PS* = Regional *AG* = U15, U16, U18, *n* = 34 (*team/club*: n = 3)	15.7 ± 0.7 yrs	To investigate the pretraining hydration status, fluid balance, and sweat sodium loss in female Canadian junior football players in a cool environment.	*Data Collection:* Refractometer (PAL 10s Pocket Refractometer, ATAGO Tokyo, Japan), digital scale (AND FG-150K scale), HR monitor (Polar Systems, USA), thermal environmental monitor (QuestTemp 36, Quest technologies), centrifuge (Centrifuge Model 225A, Fisher Scientific Instruments, Dubque, Iowa, USA), conductivity analyser (Wescor Sweat Chek 3120 Conductivity Analyser, Logan, Utah, USA). *Outcome Variables:* Mean ambient temperature (°C), mean relative humidity (%), mean HR (beats.min^{-1}), HR_{MAX} (%). HR intensity – very light (<35% HR_{MAX}), light (35% - 54% HR_{MAX}), moderate (55% - 69% HR_{MAX}), hard (70% - 89% HR_{MAX}), very hard (>90% HR_{MAX}) (min.s). Body mass pre/post-training (kg), body mass lost (%), fluid intake (L), total sweat lost (L), sweat sodium loss (g), mean Na+ concentration (mmol.L^{-1}), USG (g.mL^{-1}). *Comparative Groups:* Age group (U15 n = 16, U16 n = 12, U18 n = 6). Training session (T1, T2, T2a, T2b). Regional site (low back, forearm, scapula, chest, thigh).	45% of players presented to training in a hypohydrated state as indicated by USG (>1.020). Mean body mass loss during training was 0.84% ± 0.07% and sweat loss was 0.69 ± 0.54 L. Despite fluid being available, fluid intake was low (63.6% of players consumed <250 mL). Mean sweat sodium concentration was 48 ± 12 mmol·L^{-1}. Despite low sweat and moderate sodium losses, players failed to consume sufficient fluids to avoid mild fluid and sodium deficits during training.
Klentrou et al. (2021) (222)	*Country* = Canada *PS* = Regional *AG* = NS, *n* = 13 (*team/club*: n = NS)	14.3 ± 1.3 yrs 1.65 ± 0.05 m 59.1 ± 7.5 kg	To investigate the effects of Greek Yoghurt consumption on bone biomarkers during five-day period of intense training in adolescent female football players.	*Data collection:* Portable stadiometer (SECA-217, Canada), bioelectrical impedance analysis (Biospace.228, Los Angeles, CA, USA), food frequency questionnaire (Block 2014.1_6Mo, Nutrition Quest), ELISA assay (Human Estradiol E2 kit). *Outcome variables*: Body mass (%), body fat (%), energy (kcal), fat (g·kg^{-1}·d^{-1}), carbohydrate (g·kg^{-1}·d^{-1}), protein (g·kg^{-1}·d^{-1}), total osteocalcin (ng·mL^{-1}), undercarboxylated osteocalcin (ng·mL^{-1}), relative undercarboxylated osteocalcin to total osteocalcin (%), C-terminal telopeptide of type 1 collagen (ng·mL^{-1}), osteoprotegerin (pg·mL^{-1}), receptor activator nuclear factor kappa-ß ligand (pg·mL^{-1}).	Consuming Greek yogurt during five days of intense football training in adolescent female athletes did not significantly alter key bone biomarkers compared to an isocaloric carbohydrate control.

				Intervention: Dietary condition (Greek Yoghurt condition - 160g of Greek Yoghurt, CHO condition - 30g of isocaloric carbohydrate pudding) consumed immediately after training. *Comparative groups:* Dietary condition (Greek Yoghurt, CHO, habitual condition). Group completed each condition.	
McHaffie et al. (2023) (223)	*Country* = England *PS* = National *AG* = U18, *n* = 23 (*team/club:* n = 1)	17.9 ± 0.5 yrs 1.68 ± 0.05 m 61.6 ± 6.1 kg	To quantify energy and carbohydrate intake, physical loading and estimated energy availability in elite national team adolescent female football players during a 10-day training and game schedule, which included two match days on day six and nine.	*Data Collection:* Bioelectrical impendence analysis (50kHz MC-980MA PLUS; Tanita Corp., Tokyo, Japan), GPS Units (Apex, STATSports, Newry, Northern Ireland), self-reported activity diary (Microsoft Form, Microsoft, Washington, DC, USA), Threema messaging app (Threema GmbH, Pfäffikon, Switzerland), Nutritics software (Nutritics, v5, Dublin, Ireland). *Outcome Variables:* Duration (min), total distance (m), distance covered at speed zone 1 (3.46-5.28 $m.s^{-1}$), 2 (5.29-6.25 $m.s^{-1}$), 3 (>6.26 $m.s^{-1}$) (m), maximum speed ($m.s^{-1}$), frequency of accelerations/decelerations (n), RPE (n/10). Energy intake ($kcal.day^{-1}$), relative energy intake ($kcal.kg.day^{-1}$), adjusted energy intake ($kcal.day^{-1}$), adjusted relative energy intake ($kcal.kg.day^{-1}$), carbohydrate intake ($g.day^{-1}$) relative carbohydrate intake ($g.kg.day^{-1}$). Body mass (kg), body fat (%), fat mass (kg), FFM (kg), water weight (kg), water weight percentage (n). Energy availability (kcal.kg $FFM^{-1}.day^{-1}$), adjusted energy availability (kcal.kg $FFM^{-1}.day^{-1}$). *Comparative Groups:* Day (Match Day -5/-4/-3/-2/-1A/MDa/+1A/-1B/MDb/MD+1B)	Adolescent female football players commonly under-fuelled for the demands of intensive training and matches, particularly in terms of carbohydrate intake, with only 8% of days meeting recommended guidelines. After adjusting for potential dietary under-reporting by increasing energy intake estimates by 22%, only 5% of players were classified as having low energy availability. Despite this adjustment, carbohydrate intake remained insufficient on most days, suggesting that the prevalence of low energy availability amongst female team sport athletes may be over-estimated. However, players are still likely under-fuelling carbohydrates intake relative to the demands of intensive training and game schedules.
McKinlay et al. (2022) (224)	*Country* = Canada *PS* = Local *AG* = NS, *n* = 13 (*team/club*: n = NS)	14.3 ± 1.3 yrs 1.66 ± 0.1 m 59.1 ± 2.1 kg	To examine the effects of increased dairy protein consumption with plain Greek yoghurt on performance and recovery indices during an intensified football training camp in adolescent female football players.	*Data collection:* Portable stadiometer (SECA – 217, Canada), Bioelectrical impedance analysis (InBody520, Biospace Co. Ltd., S. Korea), Brower timing TCi-system (Brower Timing Systems, USA), force plates (Hawkins Dynamics, USA), multiplex magnetic bead kits (Milliplex EMD Millipore, USA), Reagent kit (Pointe Scientific INC, USA – Cat. #C7522), ELISA kits (Human Estradiol E2 kit, USA). *Outcome variables:* Body mass (kg), body fat (%), Energy intake (kcal), carbohydrate intake ($g·kg^{-1}·day^{-1}$), protein intake ($g·kg^{-1}·day^{-1}$), fat intake ($g·kg^{-1}·day^{-1}$), broad jump/CMJ distance (cm), 10m/20m sprint (s), 505 R/L foot split (s), Beep-Test distance (m), interleukin 6 ($pg·ml^{-1}$), tumour necrosis factor alpha ($pg·ml^{-1}$), interleukin 10 ($pg·ml^{-1}$), C-reactive protein ($pg·ml^{-1}$), insulin-like growth factor-1 ($ng·ml^{-1}$), creatine kinase ($u·L^{-1}$). *Intervention:* Dietary condition (Greek Yoghurt condition - 160g of Greek yoghurt, CHO condition - 30g of isocaloric carbohydrate pudding) consumed immediately after training.	Intensified training resulted in significant reductions in CMJ, broad jump, and aerobic capacity, with no performance benefits observed from Greek yoghurt consumption. However, Greek yoghurt intake resulted in a significantly greater post-training increase in the anti-inflammatory cytokine interleukin 10. This suggests that while Greek yogurt does not enhance performance recovery, it may support the acute anti-inflammatory response during periods of intensified training in adolescent athletes.

				Comparative groups: Dietary condition (Greek Yoghurt n = 13, CHO n = 13). Groups completed each condition.	
Paludo et al. (2023) (225)	*Country* = Cyprus *PS* = Regional *AG* = U18, *n* = 19 (*team/club*: n = 1)	14.6 ± 1.42 yrs 1.45 ± 0.06 m 54.3 ± 7.64 kg	To describe the menstrual status, perception of menstrual status, risk of LEA and presence of orthorexia nervosa in a youth female football team.	*Data Collection:* Questionnaire (LEAF-Q, ORTO-R-GR), handgrip dynamometer (Takei Scientific Instruments CO., Ltd., Tokyo, Japan), Optojump photelectric cells (Microgate, Bolzano, Italy), treadmill (h/p/Cosmos Quasar med, H-P-Cosmos Sports and Medical GmbH, Nussdorf-Traunstein, Germany). *Outcome Variables:* Body fat (%), age of sport specialisation (y), time training soccer (y), LEAF-Q (score), ORTO-R (score), SJ (cm), CMJ (cm), R/L-handgrip (kg), RT (min), VO_{2MAX} ($ml.kg.min^{-1}$). *Comparative Groups:* Risk of LEA (At risk, at low risk)	The prevalence of risk of LEA was 26.3% and players at risk ad higher scores for orthorexia nervosa. Neither risk of LEA or orthorexia nervosa impacted physical performance significantly during pre-season. 66.7% of players perceived that the menstrual period affected game performance, yet 83.3% did not communicate with coaches about their menstrual cycle
Soto-Celix et al. (2021) (226)	*Country* = Spain *PS* = National *AG* = U16, *n* = 17 (*team/club*: n = 1)	15.6 ± 1.46 yrs 1.59 ± 0.07 m 54.6 ± 8.00 kg	To analyse differences in food consumption habits, body composition parameters and physical performance among young football players.	*Data Collection:* Digital balance scale (SECA, Hamburg, Germany), stadiometer (SECA, Hamburg, Germany), DXA (Lunar Prodigy Primo, HE Healthcare, USA), timing gate (Microgate Polifemo Radio Light, Bolzano, Italy), Optojump photocell system (Microgate Polifemo Radio Light, Bolzano, Italy). *Outcome Variables:* Food consumption – milk and dairy products, meat, fish and eggs, legumes, cereals, tubers, vegetables and fruits, oils ($g.day^{-1}$), BMI ($kg.m^2$), muscle mass (kg), fat (%), 5m/10m/40m sprint (s), 505-agility test (s), CMJ (cm), CMJ dom/non-dom leg (cm), horizontal jump dom/non-dom leg (cm). *Comparative Groups:* NS.	Female soccer players showed distinctive dietary patterns, including relatively low consumption of pork and bread, but had higher intake of mollusks, shellfish, and fruits. Water intake was lower than recommended levels. Female players demonstrated lower sprint speed, change of direction ability, and jump performance than males, likely due to variations in body composition, lean mass, and maturation status.

NS = not specified. PS = playing standard. AG = age group. AU = Arbitrary Units. BMI = Body Mass Index. USG = Urine Specific Gravity. CHO = Carbohydrates. BMD = Bone Mineral Density. CMJ = Countermovement Jump. Yo-Yo IR1 = Yo-Yo Intermittent Recovery test Level 1. HR_{MAX} = Maximum Heart Rate. FFM = Fat Free Mass. RPE = Rate of Perceived Exertion. LEA = Low Energy Availability. LEAF-Q = Low Energy Availability in Females Questionnaire.

Appendix 6. Characteristics, aim, methods, and key findings of physical qualities studies (n=98).

Study	Cohort/ sample size (n)	Participant characteristics: age, height, body mass	Aim	Methods	Key findings
Anthropometrics & Physical Characteristics (n=56)					
Anauate-Nicoloa et al. (2010) (228)	*Country* = Brazil *PS* = Regional *AG* = 12 – 15, *n* = 36 (*team/club:* n = NS)	13.2 ± 1.1 yrs 1.56 ± 0.05 m 49.3 ± 7.5 kg	To understand the association between sexual maturation and the lactate threshold of football athletes from 12 to 15 years of age.	*Data Collection:* Skinfold calipers (Cescorf adipometer), heart rate monitor (Polar mark, Polar Electro), The Tanner Scale. *Outcome Variables:* Blood concentration of lactate (mmol), BMI (kg.m^2), sum of skinfolds (mm; triceps and calf), age (yrs), height (cm). *Comparative Groups:* Maturation stage (pre-pubescent, pubescent, post-pubescent).	There were significant differences in body mass and sum of skinfolds between pre-pubescent, pubescent and post-pubescent groups. However, growth variables and sexual maturation have little to no association with lactate threshold.
Andrade et al. (2021) (229)	*Country* = Brazil *PS* = National *AG* = U13, U15, U18, *n* = 93 (*team/club:* n = NS)	U13: 11.8 ± 0.7 yrs 1.51 ± 0.06 m 40.8 ± 7.5 kg U15: 13.7 ± 0.5 yrs 1.60 ± 0.05 m 54.0 ± 7.4 kg U18: 16.1 ± 0.9 yrs 1.60 ± 0.07 m 55.7 ± 9.0 kg	To assess initial peak torque values and establish comparisons of bilateral strength deficit, hamstring to quadriceps peak torque ratio and hamstring to quadriceps angle-specific ratio in youth female football players.	*Data Collection:* Questionnaire (NS), stadiometer (Filizola, São Paulo, Brazil), isokinetic dynamometer (Biodex System 3, Biodex Medical System, Shirley, NY, USA). *Outcome Variables:* Peak torque 60°/s, 240°/s (Nm), Total Work 60°/s, 240°/s (J), Average Power 240°/s (Watts), torque rated 30° at 60°/s (N), flexors/extensors at 60°/s (%), flexors/extensors 30° at 60°/s (%). *Comparative Groups:* Age group (U13 n = 35, U15 n = 36, U18 n = 22). Leg dominance (dominant, non-dominant).	The dominant and non-dominant limbs demonstrated symmetrical strength in the knee joint muscles. Knee conventional balance ratio also demonstrated no differences between dominant and non-dominant limbs and age groups. All age groups presented conventional balance ratio lower than the literature recommendation. A significant increase was observed in all measured parameters of knee extensor muscles, for both lower limbs from U13 to U15.
Becerra-Patiño et al. (2023) (230)	*Country* = Colombia *PS* = Regional *AG* = U17, *n* = 23 (*team/club:* n = 1)	17.1 ± 0.9 yrs 1.64 ± 0.05 m 56.6 ± 7.5 kg	To study the relationship between the physical variables of SJ, CMJ, CMJ with arms, right leg-left leg asymmetry, hamstring strength, change of direction, and speed at	*Data Collection:* Omron scale (Kyoto, Japan), portable stadiometer (Seca 213, Hamburg, Germany), video camera via cellular app (My Jump 2, Carlos Balsalobre), COD-timer iPhone app (NS), Runmatic iPhone app (Carlos Balsalobre). *Outcome Variables:* SJ (cm), CMJ (cm), CMJ with arms (cm), contact asymmetry, flight asymmetry, Nordics (n), average speed (m.s^{-1}), contact time (s), COD deficit, time 0-5m, 5-10m, 10-15m (s). Total time 15 m (s).	There were no differences presented in SJ, CMJ, CMJ with arms, asymmetries, hamstring strength, and COD Timer performances between starting and non-starting players.

			distances of 5, 10, and 15 m based on whether a player is a starter or non-starter in a Colombian youth female football team.	*Comparative Groups:* Playing status (starting players, non-starting players).	
Bishop et al. (2020) (231)	*Country* = Brazil *PS* = National *AG* = U17, *n* = 18 (*team/club:* n = 1)	15.9 ± 0.8 yrs 1.65 ± 0.07 m 57.8 ± 7.0 kg	To compare inter-limb asymmetry and determine how consistently asymmetry favours the same limb during different VJ tests.	*Data Collection:* Portable force platform (400Hz, AccuPower, AMTI, Graz, Austria). *Outcome Variables:* Jump height (cm) in SJ, DJ and CMJ, peak force (N) in SJ, DJ and CMJ, concentric impulse (N.s) in SJ, DJ and CMJ, peak power (W) in SJ, DJ and CMJ, asymmetry (%) in SJ, DJ and CMJ. *Comparative Groups:* Asymmetry (Right leg, left leg). Playing status (starting, non-starting).	There were significantly larger mean asymmetry values for concentric impulse in the SJ compared to the CMJ and DJ. There were no other significant differences in asymmetry. Overall, this study concludes there are no significant differences between starting and non-starting players.
Bishop et al. (2021) (232)	*Country* = England *PS* = Regional *AG* = U12, *n* = 19 (*team/club:* n = 1)	10.0 ± 1.1 yrs 1.41 ± 0.08 m 35 ± 7.1 kg	To compare inter-limb asymmetries between the unilateral SJ, CMJ and DJ tests and to determine how consistently asymmetry favours the same limb across each test for common metrics.	*Data Collection:* Electronic timing gates (Brower Timing Systems, Draper, UT), Video analysis (My Jump iPhone application). Fixed tape measure. *Outcome Variables:* Crossover hop (cm), single-leg CMJ (cm), triple hop (cm), single-leg hop (cm), 5m/10m/20m sprint (s). *Comparative Groups:* Asymmetry (Right leg, left leg).	Between limb differences were greater in the single leg CMJ compared to all horizontal hop tests. Significant relationships were present between asymmetries in the single leg CMJ and sprint performance. However, no relationships were found between asymmetries in the horizontal hop tests and sprint performance.
Brännström et al. (2017) (233)	*Country* = Sweden *PS* = National *AG* = U17, *n* = 19 (*team/club:* n = 1)	15.3 ± 0.7 yrs 1.65 ± 0.04 m 57.2 ± 7.4 kg	To explore how serum vitamin D levels relate to bone and muscle quality and function in young female football players.	*Data Collection:* Serum separator tubes (SST II; BD Vacutainer Systems, Becton-Dickinson, NJ, USA), automatic immune analyser (Liaison XL, Diasorin, Saluggia, Italy), (Architect, Abbott, IL, USA) and (Cobas E601, Roche Diagnostics, Basel, Switzerland), isokinetic dynamometer (Biodex 3 System, Biodex Medical Systems, Shirley, NY, USA), photoelectric system (IVAR test system, Spintest LCC, Tallin, Estonia), DXA (Lunar iDXA, GE Healthcare, Madison, WI, USA). *Outcome Variables:* 25(OH)D (nmol 1^{-1}), PTH (pmol 1^{-1}), whole body area BMD (g cm^{-2}), L1-L4 areal BMD (g.cm^{-2}), Serum markers – ß-Crx (ng1^{-1}), osteocalcin (mg1^{-1}), lean mass index (kgm^{-2}), fat mass index (kgm^{-2}), peak torque 1.6 rad s^{-1} (nm), time to peak torque (ms), CMJ height (cm), 20m sprint (s). *Comparative Groups:* N/A	25(OH) D was not significantly correlated with most of the parameters of bone and muscle quality or function, except the knee extension time to peak torque. Overall, vitamin D levels were markedly low in adolescent female football players. Despite this, there was no correlation between vitamin D levels and measures of bone and muscle.
Castagna et al. (2013) (234)	*Country* = Italy *PS* = National *AU* = U19, U17,	U19: 16.9 ± 0.9 yrs 1.66 ± 0.04 m 61.7 ± 3.6 kg	To assess the construct validity of VJ testing in Italian	*Data Collection:* Optical measurement system (Optojump, Microgate, Bolzano, Italy).	Female national team players showed VJ performance significantly higher than U17 players. CMJ:SJ improved from U17

	n = 41 (*team/club:* n = 2)	U17: 14.7 ± 0.4 yrs 1.64 ± 0.06 m 58.0 ± 6.4 kg	football elite-standard players.	*Outcome Variables:* SJ (cm), CMJ (cm), CMJ-SJ (%), CMJ-SJ (cm), CMJ:SJ. *Comparative Groups:* Age group (U19 n = 20, U17 n = 21).	(1.03 ± 0.09) to U19 (1.05 ± 0.12) female players.
Cherian et al. (2018) (235)	*Country* = India *PS* = Regional *AG* = U12, U16, *n* = 19 (*team/club:* n = NS)	U12: 10.7 ± 0.5 yrs 1.51 ± 0.03 m 41.2 ± 4.0 kg U16: 13.5 ± 1.5 yrs 1.56 ± 0.04 m 48.7 ± 6.6 kg	To gather data on the resting metabolic rate of junior football players and compare measured and predicted RMR. Using chosen regression models from non-athletic adults, children, and adult athletes to determine how suitable these models are for adolescent football players.	*Data Collection:* Anthropometric rod (SECA-242, Germany), digital scale (SECA-882, Germany), skinfold calipers (Holtain calipers, UK), precalibrated oxycon mobile (VIASYS Healthcare, Germany), real-time heart rate monitor (POLAR-PE-3000, Finland). *Outcome Variables:* Resting metabolic rate (kcal.day^{-1}), BMI (kg.m^{2}), body composition (fat %) (fat kg) (FFM kg) (FFM:fat), *Comparative Groups:* Age group (U12 n = 9, U16 n = 10).	A general increase in resting metabolic rate between age groups was found. Despite this, no differences existed in resting metabolic rate when adjusted for FFM among youth female football players.
Datson et al. (2020) (236)	*Country* = England *PS* = Regional *AG* = U13-U16, *n* = 228 (*team/club:* n = NS)	12.7 – 15.3 yrs 1.42 – 1.88 m 33.4 – 85.6 kg	To ascertain the predictive value of relevant physical performance measures for determining future career progression in youth elite female football players.	*Data Collection:* Stadiometer (Seca 217, Germany), digital scales (Seca 876, Germany), skinfold calipers (Harpenden, UK), jump mat (KMS Innervations, Australia), electronic timing gates (Brower TC Timing System, USA), steel tape measure (Stanley, UK). *Outcome Variables:* CMJ height (cm), 10m sprint (s), 30m sprint (s), Yo-Yo IR1 distance (m). *Comparative Groups:* Playing status (selected for competitive international squads, not selected).	Results showed that predicted probabilities of future selection to the international squad increased with higher Yo-Yo IR1 distances, from 4.5% (95% confidence interval, 0.8 to 8.2%) for a distance lower than 440m to 64.7% (95% confidence interval, 47.3 to 82.1%) for a score of 2040m.
Datson et al. (2022) (237)	*Country* = England *PS* = National *AG* = U13, U15, U17, U19, *n* = 479 (*team/club:* n = NS)	NS	To present reference standards for physical performance test outcomes relevant to elite female football players.	*Data Collection:* Jump mat (KMS Innervations, Australia), electronic timing gates (Brower TC Timing System, USA), 50m steel tape (Stanley, UK). *Outcome Variables:* 5m sprint (s), 30m sprint (s), CMJ height (cm), Yo-Yo IR1 distance (m). *Comparative Groups:* Chronological age (13, 15, 17, 19, 21, 23, U25, 27, 29 years).	Physical test performance improved non-linearly with chronological age for each physical test performance measure until approximately 25 years.
De Marco et al. (2023) (238)	*Country* = Australia *PS* = National *AG* = U13, U14, U15, U19, *n* = 44 (*team/club:* n = 3)	U13: 11.9 ± 0.79 yrs 44.7 ± 5.1 kg U14: 13.3 ± 0.6 yrs 50.7 ± 8.2 kg	To evaluate the link between relative lower-body strength, linear sprint time, and COD ability in elite youth female football players.	*Data Collection:* Portable force plate (1000Hz, 2-axis force plate PS-2142, Passport, Victoria, Australia), dual-beam timing gates (Swift Performance Equipment, Queensland, Australia). *Outcome Variables:* Isometric mid-thigh pull (N.BW^{-1}), 10m sprint time (s), 30m sprint time (s), COD deficit (s).	Relative isometric mid-thigh pull strength showed a moderate negative correlation with 10 m sprint times (r = −0.315) and 30 m sprint times (r = −0.347). However, there was no significant connection with COD deficit (r = −0.227). This suggests that sprint performance is associated with

		U15: 14.5 ± 0.5 yrs 55.4 ± 7.8 kg U19: 15.7 ± 0.9 yrs 58.3 ± 5.4 kg		*Comparative Groups:* Age group (U13 n = 11, U14 n = 12, U15 n = 11, U19 n = 10)	lower-body strength, whereas COD ability is not.
De Oliveira et al. (2023) (239)	*Country* = Brazil *PS* = NS *AG* = U17, *n* = 21 (*team/club:* NS)	15.7 ± 1.35 yrs 1.62 ± 0.05 m 56.4 ± 5.0 kg	To compare the athletic profile of female football players from adult and youth categories of a professional football club.	*Data Collection:* Photocells (Speed Test 6.0 CEFISE, Nova Odessa, SP, Brazil), force platform (NS). *Outcome Variables:* BMI (kg.m^2), VJ height (cm), flight time (s), contact time (s). Yo-Yo IR1 distance (m), VO_2 Max, 10m velocity (m.s^{-1}), 20m velocity (m.s^{-1}). 505 acceleration tests (m.s^{-1}). *Comparative Groups:* Age group (Senior n = 21, youth (U17) n = 21). Asymmetry (Left, Right).	There were no significant differences between groups for any of the measured parameters.
Doyle et al. (2021) (240)	*Country* = Ireland *PS* = International *AG* = U17, U19, *n* = 45 (*team/club:* n = 2)	U17: 16.5 ± 0.4 yrs 1.67 ± 0.06 m 59.8 ± 7.0 kg U19: 17.8 ± 0.6 yrs 1.66 ± 0.06 m 61.5 ± 7.8 kg	To compare the anthropometric physical performance characteristics of Irish female international footballers at U17, U19, and Senior age groups.	*Data Collection:* Portable stadiometer (Marsden, HM-250P, Leicester, Rotherham, England), portable scale (Seca, mode 769, Hamburg, Germany), portable dual force plate system (1000Hz, Foredecks, FD 4000, London, United Kingdom), optical measurement system (Optojump, Microgate, Bolzano, Italy), photocell timing gates (Witty-gate, Microgate, Italy). *Outcome Variables:* Yo-Yo IR1 distance (m), CMJ (cm), reactive strength index (m.s^{-1}), 10m, 20m, 30m sprint (s). *Comparative Groups:* Age group (U17 n = 24, U19 n = 21, Senior n = 10).	Anthropometric variables were similar between U17 and U19 age groups. U19 players were faster than U17 players. Trivial differences between U17 and U19 for CMJ and RSI were reported. No differences were stated between U17 and U19 for Yo-Yo IR1.
Emmonds et al. (2017) (76)	*Country* = England *PS* = National *AG* = U10, U12, U14, U16 *n* = 157 (*team/club:* n = 3)	U10: 1.35 ± 0.08 m 29.7 ± 5.1 kg U12: 1.47 ± 0.09 m 37.65 ± 8.0 kg U14: 1.59 ± 0.07 m 50.1 ± 6.7 kg U16: 1.63 ± 0.06 m 56.8 ± 7.1 kg	To evaluate the strength profiles of elite female youth footballers (U10 to U16) using the isometric mid-thigh pull, while considering their maturation status.	*Data Collection:* Stadiometer (132 Seca Alpha, Hamburg, Germany), portable force platform (1000Hz, AMTI, ACP, Watertown, MA). *Outcome Variables:* Peak force (N), impulse at 100ms (N.s^{-1}), impulse at 300ms (N.s^{-1}), relative peak force (N.s^{-1}.kg^{-1}), relative impulse at 100ms (N.s^{-1}.kg^{-1}), relative impulse at 300ms (N.s^{-1}.kg^{-1}). *Comparative Groups:* Age group (U10 n = 30, U12 n = 38, U14 n = 43, U16 n = 46). PHV (Pre n = 51, Circa n = 37, Post n = 69).	Peak force and impulse were greater in more mature and older players. However, when peak force was considered relative to body mass, performance was similar between age groups, yet lower at circa-PHV compared to pre-PHV.
Emmonds et al. (2020) (241)	*Country* = England *PS* = Regional	U10: 9.3 ± 0.5 yrs 1.35 ± 0.07 m 29.6 ± 4.8 kg	To examine how seasonal changes affect physical performance in U10,	*Data Collection:* Weighing scales (Seca Alpha, model 770), stadiometer (Seca Alpha, model 132), portable force platform (1000Hz, AMTI; ACP, Watertown, MA), portable photoelectric	U10's and U12s had decrements in CMJ, sprint and COD from pre to post-season. Whereas U14s and U16s improved sprint, CMJ, relative strength and COD

	AG = U10, U12, U14, U16, *n* = 113 (*team/club:* n = 3)	U12: 11.3 ± 0.5 yrs 1.48 ± 0.09 m 38.2 ± 8.2 kg U14: 13.2 ± 0.7 yrs 1.59 ± 0.08 m 49.3 ± 7.3 kg U16: 15.1 ± 0.7 yrs 1.64 ± 0.06 m 56.9 ± 7.3 kg	U12, U14 and U16 elite female youth footballers.	cell system (Optojump; Microgate, Bolzano, Italy), timing gates (Brower Timing Systems; IR Emit, Draper, UT, USA). *Outcome Variables:* Peak force (N), relative peak force ($N.s^{-1}.kg^{-1}$), 10m sprint (s), 30m sprint (s), CMJ (cm), COD (s), Yo-Yo IR1 (m). *Comparative Groups:* Age group (U10 n = 20, U12 n = 30, U14 n = 31, U16 n = 32). Season (Pre-mid, Mid-post, Pre-post).	from pre to post-season. U12s, U14s and U16s improved Yo-Yo IR1 performance from pre to post-season.
Emmonds et al. (2020)* (242)	*Country* = England *PS* = National *AG* = U10, U12, U14, U16, *n* = 157 (*team/club:* n = 3)	U10: 9.1 ± 0.6 yrs 1.32 ± 0.06 m 28.3 ± 4.5 kg U12: 11.8 ± 0.3 yrs 1.51 ± 0.05 m 40.5 ± 4.9 kg U14: 12.8 ± 0.6 yrs 1.57 ± 0.05 m 49.0 ± 5.0 kg U16: 15.2 ± 0.7 yrs 1.66 ± 0.07 m 57.5 ± 7.5 kg	To study how maturity status impacts the physical traits of elite female youth footballers.	*Data Collection:* Portable force platform (1000Hz, ACP; AMTI, Watertown, MA, USA). Portable photoelectric cell system (Optojump; Microgate, Bolzano, Italy), timing gates (Brower Timing Systems; IR Emit, Draper, UT, USA). *Outcome Variables:* Peak force (N), relative peak force ($N.s^{-1}.kg^{-1}$), CMJ (cm), 10m sprint (s), 30m sprint (s), 505 COD dominant (s), 505 COD non-dominant (s), Yo-Yo IR1 (m). *Comparative Groups:* Maturity offset group (-2.5 n = 24, -1.5 n = 30, -0.5 n = 19, 0.5 n = 22, 1.5 n = 36, 2.5 n = 27).	More mature players showed improvements in speed, change of direction, lower-body power, and aerobic fitness. However, these traits developed unevenly at different stages of growth.
Emmonds et al. (2018) (75)	*Country* = England *PS* = Regional *AG* = U10, U12, U14, U16, *n* = 157 (*team/club:* n = 3)	U10: 9.25 ± 0.58 yrs 1.35 ± 0.08 m 29.7 ± 5.1 kg U12: 11.4 ± 0.98 yrs 1.47 ± 0.09 m 37.6 ± 8.0 kg U14: 13.2 ± 0.65 yrs 1.59 ± 0.07 m 50.1 ± 7.6 kg	To evaluate the anthropometric and performance characteristics of high-level youth female football players by annual-age category (Under 10 (U10)–U16).	*Data Collection:* Stadiometer (132 Seca Alpha, model 2251821009, Germany), scales (Seca Alpha, model 770, Germany), portable force platform (1000Hz, AMTI, ACP, Watertown, MA), portable photoelectric cell system (Optojump; Microgate, Bolzano, Italy), timing gates (Brower Timing Systems, IR Emit, USA). *Outcome Variables:* Peak force (N), relative peak force ($N.s^{-1}.kg^{-1}$), CMJ (cm), 10m sprint (s), 30m sprint (s), 505 COD dominant (s), 505 COD non-dominant (s), Yo-Yo IR1 (m). *Comparative Groups:* Age group (U10 n = 30, U12 n = 38, U14 n = 43, U16 n = 46).	Height, body mass, absolute strength, jump height, COD, and distance on the Yo-Yo IR1 were significantly greater in older players. Relative strength did not differentiate between age categories. Both speed and change of direction time were most likely to very likely lower in older players. However, only most likely trivial–possibly trivial differences were observed in relative strength between age groups. Findings suggest that physical characteristics except for relative strength differentiate by age categories.

		U16: 15.05 ± 0.64 yrs 1.64 ± 0.06 m 56.8 ± 7.2 kg			
Eustace et al. (2019) (98)	*Country* = England *PS* = National *AG* = U18, *n* = 17 (*team/club:* n = 1)	16.9 ± 1.1 yrs 1.66 ± 0.04 m 60.07 ± 4.48 kg	To compare traditional and angle-specific isokinetic strength of eccentric knee flexors and concentric knee extensors in female senior professional and youth football players.	*Data Collection:* Stationary cycle ergometer (60W, Monark, 824E, Sweden), bilateral isokinetic dynamometer (System 4, Biodex Medical Systems, Shirley, New York, USA). *Outcome Variables:* Peak torque (Nm), dynamic control ratio, angle of peak torque, functional range (º), angle-specific torque ($N.s^{-1}$), angle-specific dynamic control ratio, angular velocity ($º.s^{-1}$). *Comparative Groups:* Asymmetry (dominant, non-dominant).	Non-dominant eccentric knee flexors PT and AST values were much lower than those of the dominant side at different speeds and joint angles.
Fagundes et al. (2022) (243)	*Country* = Brazil *PS* = Regional *AG* = U17, *n* = 142 (*team/club:* n = NS)	14.9 ± 1.6 yrs 1.64 ± 0.07 m 56.5 ± 7.7 kg	To compare the bone mass content, bone mass density and lean mass of young female football players (odd-impact loading exercise), handball players (high-impact loading exercises) and non-athletes.	*Data Collection:* Dual-emission x-ray absorptiometry system (DXA, software version 12.3, Lunar DPX, Wisconsin, USA). *Outcome Variables:* Bone mass content (g), bone mass density ($g.cm^2$), lean mass (g). Area (upper limbs, lower limbs, trunk, ribs, pelvis, spine, total). *Comparative Groups:* Sport (handball players n = 115, football players n = 142, non-athletes n = 136).	Handball players presented significantly higher bone mass content values than football players for upper limbs and lower limbs, trunk and ribs, spine and total bone mass. Non-athletes presented significantly lower bone mass content for lower limbs, trunk, ribs, pelvis, spine and total bone mass than both handball and football players. Football players presented significantly higher bone mass density than non-athletes for all measurements. Summary – handball players had highest bone mass, although football players presented higher bone mass than non-athletes.
Fältström et al. (2022) (244)	*Country* = Sweden *PS* = Regional *AG* = 12 yrs, 13 yrs, 14 yrs, 15 – 17 yrs, *n* = 418 (*team/club:* n = 27)	12 yrs: 12.7 ± 0.2 yrs 1.60 ± 0.06 m 48.0 ± 7.5 kg 13 yrs: 13.4 ± 0.3 yrs 1.61 ± 0.07 m 51.0 ± 7.7 kg 14 yrs: 14.5 ± 0.3 yrs 1.65 ± 0.06 m 57.0 ± 7.6 kg 15 – 17 yrs: 15.8 ± 0.6 yrs	To establish normative values of (ROM), strength, and functional performance and investigate changes over 1 year in adolescent female football players.	*Data Collection:* Digital inclinometer (Clinometer, Plaincode, Stephanskirchen, Germany), pressure sensor (Stabilizer Pressure Bio-Feedback, Chattanooga, Group Inc, Hixon, TN), force gauge (RS Pro Digital Force Guage, RS Components Ltd., Corby, UK), hand-held dynamometer (MicroFet2, Hoggan Health Industries inc. West Jordan, UT, USA). *Outcome Variables:* BMI ($kg.m^2$), age at menarche (yrs), football matches/week (n), football training (h/week), other training with football team (h/week), ROM (°). *Comparative Groups:* Age group (12 yrs n = 97, 13 yrs n = 157, 14 yrs n = 91, 15-17 yrs n = 73). Asymmetry (dominant, non-dominant).	ROM was similar across age groups, except for internal and external hip rotation, where older players had decreased ROM. Older players were stronger in the hip muscles and knee extensors, but not when normalised to body mass. No significant differences were observed between dominant and non-dominant legs. The test results changed slightly over 1 year with improvements especially in hip abduction strength and in the square hop test.

		1.68 ± 0.06 m 61.0 ± 7.6 kg			
Ferry et al. (2011) (245)	*Country* = France *PS* = National *AG* = U18, *n* = 32 (*team/club:* n = 1)	16.2 ± 0.7 yrs 1.65 ± 0.06 m 57.1 ± 6.1 kg	To investigate hip geometry in adolescent football players and swimmers compared to a control group.	*Data Collection:* Dual-energy X-ray absorptiometry (DXA, Hologic QDR 4500 series; Waltham, MA, USA), frequency questionnaire (NS). *Outcome Variables:* BMI (kg.m^2), calcium intake (mg.day^{-1}), whole body total lean mass (kg), whole body total fat mass (kg, %), hip structural analysis parameters (*Z-score*), BMD (g.cm^2), bone mineral content (g). *Comparative Groups:* Sport (swimmers n=26, football players n=32, control group n=15)	Specific bone mineral densities were significantly higher in football players compared with swimmers. At all bone sites, every parameter reflecting strength (cross-sectional moment of inertia, Z-score, buckling ratio) favoured football players. Sports with high impacts are likely to improve bone strength and bone geometry.
Ferry et al. (2013) (246)	*Country* = France. *PS* = National *AG* = U18, *n* = 32 (*team/club:* n = 1).	16.2 ± 0.7 yrs 1.65 ± 0.06 m 57.1 ± 6.1 kg	To investigate the changes in hip structural parameters in high level adolescent football and swimmers after a season of training and competition.	*Data collection:* Dual-energy X-ray absorptiometry (DXA, Hologic QDR 4500 series; Waltham, MA, USA). *Outcome Variables*: Bone mineral content (g), BMD (g/cm^2), hip structural analysis parameters (*Z-score*). *Intervention:* Training consisted of 225 sessions (2hr each day Mon - Fri) across 39-week season. *Comparative Groups*: Pre vs post intervention. Sport (swimmers n=26, football players n=32, control group n=15).	Significant increases in bone density were seen after the 8-month training intervention. The training intervention induced bone geometry improvement, which would have increased the bone's resistance to loading.
Haag et al. (2016) (247)	*Country* = Germany *PS* = Regional *AG* = U15-U17, *n* = 18 (*team/club:* n = 1)	*Back pain:* 15.9 ± 1.0 yrs 1.67 ± 0.04 m 61.1 ± 7.5 kg *Without back pain:* 15.8 ± 0.7 yrs 1.64 ± 0.06 m 58.4 ± 7.8 kg	To determine if a test battery can differentiate footballers with back pain from those without, and to identify those who are at higher risk.	*Data Collection:* Isokinetic dynamometer (Tergumed 700, Proxomed, Alzenau, Germany), Swiss Olympic Test (Tschopp et al.). *Outcome Variables:* Isometric muscle strength (flexion, extension, rotation R/L, lateral flexion L/R) (N), Swiss Olympic test (ventral, dorsal, lateral L/R), (static, dynamic), (s), Y-Balance test (anterior L/R, posterior medial L/R, posterior lateral L/R), (cm). *Comparative Groups:* Back pain (with n = 10, without n = 8).	Participants without any back pain showed non-significant better performance in the Swiss Olympic test and the Y-Balance test. In the dynamic lateral isometric muscle strength test, participants without back pain had a statistically significant better result than the other cohort.
Gradidge et al. (2018) (248)	*Country* = South Africa *PS* = National *AG* = 12-18 yrs, *n* = 82 (*team/club*: n = NS)	14.1 ± 1.1 yrs 1.56 ± 0.01 m 49.5 ± 7.3 kg	To explore differences between genders in heart structure and athletic performance among competitive adolescent footballers in South Africa and identify factors related to explosive jump height and heart shape.	*Data Collection:* Stadiometer (Seca 217, UK), digital scale (Seca 844, UK), sphygmomanometer and stethoscope (Omron, Canada), echocardiography (2.5-3.5 MHz cardiac transducer, Mindray DP-6600, Shenzhen, China), ECG (Schiller AT 6 ECG machine, Schiller AG, Switzerland). *Outcome Variables:* BMI (kg.m^2), body fat (kg), lean mass (kg), ejection fraction (%), interventricular thickness (mm), left ventricular end-diastolic diameter (mm), resting heart rate (beats.min^{-1}), peak heart rate (beats.min^{-1}), systolic blood pressure (mmHg), diastolic blood pressure (mmHg), VJ height (cm), trunk flexibility (cm).	Lower VJ scores are related to lower muscle mass and increased body fat.

				Comparative Groups: NS	
Kobus et al. (2022) (249)	*Country* = Cyprus *PS* = National *AG* = 12-17 yrs, *n* = 19 (*team/club:* n = 1)	NS	To assess how prevalent headaches are among young female athletes and to explore at their effects on physical performance.	*Data Collection:* Stadiometer (Seca GmbH), bioelectrical impedance analyser (BC418MA; Tanita), treadmill (h/p/Cosmos Quasarmed, H-P-Cosmos Sports & Medical GmbH, Nussdorf-Traunstein, Germany), photoelectric cell system (Optojump, Microgate, Bolzano, Italy), dynamometer (Takei), Sit and reach bench. *Outcome Variables:* BMI (kg.m^2), SJ (cm), CMJ (cm), sit and reach (cm), handgrip strength L/R (kgf), VO_2 Max (ml.kg.min^{-1}). *Comparative Groups:* Headache n = 8, headache-free n = 11.	Females from the headache group had significantly higher results in the sit-and-reach test than females from the control group.
Kottaras et al. (2022) (250)	*Country* = Canada *PS* = Regional *AG* = U16, *n* = 20 (*team/club*: n = NS)	14.8 ± 1.3 yrs 1.63 ± 0.05 m 55.7 ± 7.7 kg	To examine potential differences in resting concentrations of bone turnover markers and osteokines reflecting bone formation and resorption between adolescent female athletes of no-impact (swimmers) and high-impact (football) sports, compared with non-athletic controls.	*Data Collection:* Bioelectrical impedence analysis (InBody520; BioSpace Co Ltd, Madison, MI), stadiometer (Seca-217), ELISA kit (cat.# E-EL-H0835, Elabscience, China), (cat.# DSST00; R&D, Minneapolis, MN, USA) and (cat.# abx250337, Abbexa, Cambridge, UK), microbead multiplex kit (cat.# HBNMAG-51K-08, EMD Millipore, Darmstad, Germany), microbead single plex kit (cat.# HRNKLMAG-51K-01, EMD Millipore, Darmstad, Germany). *Outcome Variables:* BMI (kg.m^2), body fat (%), carboxyl terminal crosslinking telopeptide of type I collagen (ng.mL^{-1}), P1NP (ng.mL^{-1}), total osteocalcin (OC) (ng.mL^{-1}), sclerostin (pg.mL^{-1}), osteoprotegerin (pg.mL^{-1}), RANKL (pg.mL^{-1}). *Comparative Groups:* Sport (Swimmers n = 20, football players n = 20, non-athletes n = 20).	Soccer players had significantly higher P1NP, total OC and osteoprotegerin compared to both, swimmers and controls, with no differences in type I collagen, sclerostin and RANKL. These results suggest that bone formation is significantly higher in adolescent females engaged in high-impact sports like soccer compared to swimmers and controls.
Lilić et al. (2022) (251)	*Country* = Serbia *PS* = National *AG* = U16, *n* = 16 (*team/club:* n = NS)	14.5 ± 1.0 yrs 1.70 ± 0.04 m 61.4 ± 11.3 kg	To measure the link between body composition and explosive power in female teenage football players and evaluate how body composition affects explosive power.	*Data Collection:* Anthropometer (Seca 220; Seca Corporation, Hamburg, Germany), multi-frequency bioelectrical impedance (digital Inbody 770, Biospace Co. Ltd, Seould, Korea), portable force plate (500Hz, Quattro Jump, Type 9290 AD, Kistler, Switzerland). *Outcome Variables:* Muscle mass (%), body fat mass (kg)(%), CMJ height (cm), CMJ Relative maximal F (%BW), CMJ Relative maximal P (W/kg), SJ Jump Height from Take Off V (cm), SJ Relative maximal F (%BW), SJ Relative maximal P (W/kg). *Comparative Groups:* Jump type (SJ, CMJ).	Body composition measures were correlated with a range of explosive power variables. Lower body fat mass and percentage body fat showed a better performance in CMJ height, SJ height, relative maximal force, and relative maximal power. Higher values of muscle mass led to better results in CMJ and SJ height. The results suggest the influence of body composition on explosive power parameters in adolescent female football players.
Lozano-Berges et al. (2018) (252)	*Country* = Spain *PS* = Regional *AG* = U14, *n* = 36 (*team/club:* n = 8)	12.7 ± 0.6 yrs 1.55 ± 0.07 m 49.3 ± 8.2 kg	To examine and compare bone mass variables at the 4 and 38% sites of the tibia length and geometric variables at the 38%	*Data Collection:* Stadiometer (Seca 225, Seca, Hamburg, Germany), scales (Seca 861, Seca, Hamburg, Germany), calcium food frequency questionnaire (NS), Stratec XCT-2000 L pQCT scanner (Stratec Medizintechnik, Pforzheim, Germany).	Female footballers showed a 13.8 to 16.4% increase in bone strength index, cortical thickness, X-axis fracture load, and polar strength strain index compared to controls. Additionally, at the 38% tibial site, they had 15.8% higher trabecular

			site of the tibia length between adolescent football players and controls separated by gender.	*Outcome Variables:* BMI (kg.m^2), tibia length (mm), muscle CSA (mm^2), fat CSA (mm^2), daily calcium intake (mg), maturity offset (yrs), training years (yrs), age PHV (yrs), training hours (h.week^{-1}), total volumetric bone mineral content (g), trabecular volumetric bone mineral content (g), total cross-sectional area (mm^2), trabecular cross-sectional area (mm^2), bone strength index (mg/mm), cortical cross-sectional area (mm2), cortical thickness (mm), periosteal circumference (mm), endosteal circumference (mm), fracture load in axe X (N), strength strain index in polar (mm^3). *Comparative Groups:* Player type (footballer n = 36, control n = 22).	volumetric and cortical bone mineral content, along with a larger cortical cross-sectional area.
Lozano-Berges et al. (2022) (253)	*Country* = Spain *PS* = Regional *AG* = U14, *n* = 22 (*team/club:* n = 3)	*Insufficient:* 12.6 ± 0.6 yrs 1.55 ± 0.06 m 47.5 ± 7.6 kg *Sufficient:* 12.6 ± 0.6 yrs 1.55 ± 0.08 m 50.0 ± 10.9 kg	To evaluate changes in body composition, physical fitness, and bone health indicators in young female football players, while considering their Vitamin D levels.	*Data Collection:* Stadiometer (Seca 225, Seca, Hamburg, Germany), scales (Seca 861, Seca, Hamburg, Germany), dual-energy x-ray absorptiometry (DXA) (QDR-Explorer, Hologic Corp., Software version 12.4, Bedford, MA, USA), tomography scanner (Stratec XCT-2000 L, pQCT; Stratec Medizintechnik, Pforzheim, Germany), strain gauge (MuscleLab, Force Sensor, Stathelle, Norway), optical measurement system (Photocells, Byomedic fotoelectric cells, Barcelona, Spain), electrochemiluminescence immunoassays (ECLIA) (Elecsys 2010, Roche Diagnostics, GmbH, Grenzach-Wyhlen, Germany). *Outcome Variables:* BMI (kg.m^2), maturity offset (yrs), training hours (h.week^{-1}), subtotal body bone mineral density (g.cm^2), subtotal lean mass (kg), body fat (%), bone strength index (mg.mm), polar strength strain index (mm^3), maximum isometric knee extension force R/L (kg), 30m sprint (s), long jump (m), VO_2 Max (mL.kg.min^{-1}), Procollagen type I N-terminal propeptide (µg/mL), osteocalcin (µg/mL), C-terminal cross-linked telopeptide (µg/mL), osteocalcin and C-terminal cross-linked telopeptide ratio, 25(OH)D (ng/mL), calcium (mg/dL). *Comparative Groups:* Serum 25-Hydroxyvitamin D concentration (25(OH)D) concentration (sufficient n = 11, insufficient n = 11).	Adequate serum 25(OH)D levels may lead to more gains in bone mineral density for young female football players. Those with enough Vitamin D performed better in physical fitness tests. However, these results should be viewed carefully as the study did not have group-by-time interactions for fitness variables and lacked a control group.
Mainer-Pardos et al. (2021) (254)	*Country* = Spain *PS* = National *AG* = U14, U16, U18, *n* = 80 (*team/club:* n = 1)	U14: 13.1 ± 0.5 yrs 1.54 ± 0.08 m 48.8 ± 7.8 kg U16: 14.2 ± 1.6 yrs 1.58 ± 0.07 m 51.8 ± 7.8 kg	To examine how sprint performance varies by age in adolescent female football players (U14-U18) and to evaluate how body mass, BMI, and biological	*Data Collection:* Portable stadiometer (Seca 225, Seca, Hamburg, Germany), portable body composition analyser (TANITA BC-418, MA; Tanita Corp., Tokyo, Japan), photoelectric cells (Microgate, Bolzano, Italy). *Outcome Variables:* 10m sprint (s), 20m sprint (s), 30m sprint (s), 40m sprint (s), 20m flying (s).	Older football players showed significantly better performance in all split sprint times compared with younger age groups. However, in all split sprint times, there were no significant changes between U16 and U18. BMI and body mass were significantly correlated with 40m sprint and 20m flying respectively.

		U18: 16.7 ± 0.6 yrs 1.60 ± 0.06 m 56.1 ± 6.5 kg	maturation affect sprint results.	*Comparative Groups:* Age group (U14 n = 20, U16 n = 37, U18 n = 23).	
Manson et al. (2014) (255)	*Country* = New Zealand *PS* = International *AG* = U17, U20, *n* = 36 (*team/club:* n = NS)	U17: 15.6 ± 1.0 yrs 1.64 ± 0.05 m 58.0 ± 5.5 kg U20: 17.8 ± 0.71 yrs 1.67 ± 0.07 m 62.2 ± 7.2 kg	To identify the physical profiles of FIFA-eligible elite female football players aged 14 to 36 years, focusing on sprint speed and movement and strength measured by isokinetic tests, one-legged jump performance, and maximum aerobic speed. The goal is to find differences based on age and playing time.	*Data Collection:* Isokinetic dynamometer (Cybex Norm; Phoenix Healthcare, Nottingham, United Kingdom), nonmotorized treadmill (NMT; Woodway; Force 3.0, Waukesha, WI, USA), 30:15 intermittent fitness test. *Outcome Variables:* Absolute peak torque ($N.m^{-1}$), relative peak torque ($N.m^{-1}$), velocity ($ms.^{-1}$), intermittent fitness test ($m.s^{-1}$), VO_2 Max ($ml.kg^{-1}.min^{-1}$), peak vertical force absolute (N), relative ($N.kg^{-1}$), peak horizontal force absolute (N), relative ($N.kg^{-1}$), peak power absolute (W), relative ($W.kg^{-1}$), contact time (ms), flight time (ms), step frequency (Hz), step length (m), SL lat jump (cm), SL horr jump (cm). *Comparative Groups:* Age group (U17 n = 18, U20 n = 18). Playing status (starters, non-starters).	Physical qualities of players increase with age before reaching a plateau, evidenced by little to no differences in physiological capacities between U20 and senior international players. Starters tended to be significantly faster and have a higher maximal aerobic velocity along with greater eccentric leg strength compared to non-starters.
Martinho et al. (2023) (256)	*Country* = Portugal *PS* = NS *AG* = U13, U15, U17, *n* = 441 (*team/club:* n = NS)	U13: 12.5 ± 0.9 yrs 1.55 ± 0.08 m 51.3 ± 14.7 kg U15: 14.1 ± 0.5 yrs 1.60 ± 0.06 m 55.8 ± 9.8 kg U17: 15.9 ± 0.45 yrs 1.62 ± 0.06 m 57.5 ± 9.0 kg	To assess the growth patterns and skeletal maturity of U13, U15, and U17 female football players.	*Data Collection:* Stadiometer (Harpenden stadiometer, model 98.603, Holtain Ltd, Crosswell, UK), digital scale (SECA balance, model 770, Hanover, MD, USA), Lange caliper (Beta Technology, Ann Arbor, MI, USA). *Outcome Variables:* Skeletal age (yrs), body mass (kg), fat mass (%), FFM (kg). *Comparative Groups:* Age group (U13 n = 51, U15 n = 261, U17 n = 129).	Across all competitive age groups, average heights were similar to the median values of the general population. Average body weights ranged from the 50th to 75th percentiles. Fat mass estimates, adjusted for age and maturity, varied between 18.0% and 28.2%. The number of skeletally mature players increased with age. There were 0% in U13, 8% in U15, and 49% in U17. In each group, early maturing girls tended to be the heaviest, while late maturing peers were the lightest.
McCulloch et al. (1992) (227)	*Country* = Canada *PS* = Regional *AG* = U13-U17, *n* = 12 (*team/club:* n = NS)	15.3 ± 1.2 yrs 1.64 ± 0.04 m 56.4 ± 4.1 kg	To compare bone density and bone mineral content in adolescent males and females, we looked at three groups: those involved in weight-bearing football training, those participating in non-weight-bearing swimming training,	*Data Collection:* CT scanner (GE 9800, General Electric, Milwaukee), single photon absorptiometry unit (Norland SPA, Norland Instruments, Fort Atkinson, WI), skinfold caliper (Harpendon, HaB International Ltd., Warwickshire, UK). *Outcome Variables:* Total calories (Kcal), vitamin D (IU), Calcium (mg), trabecular bone density (HU), bone mineral content ($g.cm^{-2}$), sum of skinfolds (triceps, subscapular, supraspinal, abdominal, front thigh, calf and biceps) (mm). *Comparative Groups:* Sport (football players n = 23, swimmers n = 20, control n = 25).	The swimmers had the lowest OS Calcis density, whereas the football players had the highest bone density at this weight-bearing site. No significant differences with respect to distal radius bone mineral content were observed among activity groups.

			and a non-athletic control group.		
Mollinedo-Gomez et al. (2023) (108)	*Country* = Spain *PS* = Regional *AG* = U12, *n* = 13 (*team/club:* n = 1)	11.1 ± 0.6 yrs 1.42 ± 0.06 m 37.8 ± 10.2 kg	To detect asymmetries in football players through a battery of tests, to analyse the asymmetries of the dominant and non-dominant side, and to compare the correlation between both sexes.	*Data Collection:* Optical measurement system (Microgate, Bolzano, Italy), photoelectric cells (Microgate, Bolzano, Italy). *Outcome Variables:* BMI (kg.m^2), unilateral CMJ (cm), Single-hop test (cm), triple-hop test (cm), single-leg CMJ (cm), 505 COD (s). *Comparative Groups:* Leg asymmetry (dominant, non-dominant).	No differences were found between dominant and non-dominant leg. 36% of the sample of players had an asymmetry index of >10%, which is a factor of increased likelihood of lower limb injury. The highest asymmetry was detected at 20% in the single-leg CMJ test, which may be the most suitable jump test for identifying asymmetries.
Mujika et al. (2009) (257)	*Country* = Spain *PS* = National *AG* = U19, *n* = 34 (*team/club*: n = NS)	17.3 ± 1.6 yrs 1.64 ± 0.05 m 57.5 ± 7.6 kg	To assess the fitness profiles of elite and non-elite male and female football players. This will help with identifying talent and shaping specific training strategies.	*Data Collection:* Skinfold calipers (Holtain Ltd., Crymych, UK), photocell gates (Timer S4, Alge-Timing, Lustenau, Austria). *Outcome Variables:* Sum of skinfolds (triceps, subscapular, suprailiac, abdominal, front thigh, medial calf) (mm), Yo-Yo IR1 (m), CMJ (cm), arm-swing CMJ (cm), 15m sprint (m.s^{-1}), agility 15m (m.s^{-1}), ball dribbling 15m (m.s^{-1}). *Comparative Groups:* Age group (senior n = 17, junior n = 17).	Significant differences were found in Yo-Yo IR1 and VJ (CMJ, arm swing CMJ) performances between junior and senior players. A higher sum of skinfolds, body mass and height were found to have a significantly negative effect on Yo-Yo IR1 performance respectively.
Norikazu et al. (2015) (258)	*Country* = Japan *PS* = National *AG* = U12, U13, U14, U15, U16, U17, U18, *n* = 103 (*team/club:* n = NS)	12 yrs: 12.4 ± 0.2 yrs 1.55 ± 0.05 m 42.9 ± 5.2 kg 13 yrs: 13.6 ± 0.3 yrs 1.56 ± 0.06 m 46.7 ± 6.4 kg 14 yrs: 14.6 ± 0.3 yrs 1.59 ± 0.05 m 49.0 ± 5.1 kg 15 yrs: 15.5 ± 0.3 yrs 1.57 ± 0.06 m 49.8 ± 5.7 kg 16 yrs: 16.2 ± 0.1 yrs 1.62 ± 0.06 m 55.8 ± 6.6 kg	To explore how age affects COD performance and its components in well-trained female footballers, and to see how COD performance relates to motor skills and body measurements in different age groups.	*Data Collection:* Stadiometer and body composition analyser (MC-190EM, Tanita C, Tokyo, Japan), timing gates (Brower Timing, Draper, UT, USA), stopwatch (SVAE101, Seiko Inc, Tokyo, Japan). *Outcome Variables:* Lean body mass (kg), 10m sprint (s), 5-step bounding (m), 10m x 5 COD (s). *Comparative Groups:* Age group (12 yrs n = 10, 13 yrs n = 10, 14 yrs n = 13, 15 yrs n = 23, 16 yrs n = 23, 17 yrs n = 11, 18 yrs n = 13, senior n = 33).	Significant differences related to age were found in COD performance, sprint speed, and bounding distance. Post hoc comparisons showed that 17-year-old players had better COD performance than 16-year-olds. However, there were no significant differences in sprint speed or bounding distance between the age groups. A weak link was found between COD performance and bounding distance in players aged 15 to 18.

		17 yrs: 17.5 ± 0.4 yrs 1.62 ± 0.04 m 55.6 ± 4.1 kg 18 yrs: 18.6 ± 0.2 yrs 1.65 ± 0.03 m 58.1 ± 4.1 kg			
Nyland et al. (1997) (259)	*Country* = USA *PS* = Regional *AG* = U18, *n* = 16 (*team/club:* n = 1)	16.4 ± 1.1 yrs 1.65 ± 0.1 m 62.9 ± 11.0 kg	To explore differences in body measurements, physical fitness, agility, playing experience, history of lower limb injuries, and shoe use between adolescent male and female football players, compared to age- and gender-matched standard data.	*Data Collection:* Skyndex calipers (Cramer Products, Gardner, KS), isokinetic dynamometer (Biodex 2000, model 875110, Biodex Corp, NY). *Outcome Variables:* Body comp (%fat), flexed arm hang (s), pull-ups (n), flex knee sit up (reps/min), modified push up (n), sit and reach (cm), flexibility (°), concentric isokinetic peak knee torque (Nm) (flexion/extension torque ratio), standing single-leg broad jump (cm). *Comparative Groups:* NS.	Girls had greater musculotendinous extensibility compared to boys. No differences were found for abdominal muscle endurance. Girls had less ankle plantar flexor extensibility.
O'Brien et al. (2020) (260)	*Country* = Australia *PS* = National *AG* = U10-U17, *n* = 77 (*team/club:* n = NS)	*Sampling:* 11.1 ± 0.6 yrs 1.43 v 0.08 m 35.6 ± 6.3 kg *Specialisation:* 13.3 ± 0.8 yrs 1.57 ± 0.07 m 48.3 ± 8.1 kg *Investment:* 16.2 ± 0.9 yrs 1.64 ± 0.05 m 58.3 ± 5.4 kg	To examine the anthropometric, physical fitness, motor competence, dribbling and decision-making characteristics of male and female soccer players within different age cohorts	*Data Collection:* Smart Speed Timing Gate System (Fusion Sport, Australia), iPad Mini (Model A1432, Apple Inc., USA), stadiometers (Stature: Seca 213, United Kingdom; sitting height: Holtain Harpenden 607 VR, Wales), bioelectrical impedance scales (TANITA TBF-522 Composition Analyser/Scale, USA), The Körperkoordinations Test für Kinder (Kiphard and Schilling 2007), yardstick (for CMJ). *Outcome Variables:* Age at peak height velocity (yrs), motor competence (balancing backwards, moving sideways, jumping sideways) (n), Ugent dribble (s), VJ (cm), 5m sprint (s), 30m sprint (s), T-test (s), Yo-Yo IR1 (m), decision making score (%), decision making response time (s). *Comparative Groups:* Developmental stage (sampling 9-11yrs n = 21, specialisation 12-14yrs n = 36, investment 15-18yrs n = 20).	Players in the investment group generally demonstrated an increased performance across physical fitness parameters, however scored lower on motor competence parameters compared to the sampling and specialisation groups.
Oyón et al. (2016) (261)	*Country* = Spain *PS* = Regional *AG* = 12-15 yrs, *n* = 21 (*team/club*: n = NS)	13.48 yrs 1.58 ± 0.06m 48.8 ± 8.2 kg	To evaluate the physical fitness of players at the Reus Deportiu Football School, monitor their progress over the season influenced by	*Data Collection:* Skinfold calipers (Holtain Skinfold Caliper), weighing scale (Añó Sayol Weighing Scale), height measuring rod (Añó Sayol height measuring rod), electrocardiographic monitoring (EK-41 Hellige Cardiotest and Hellige Servomed Monitor, Taktell Piccolo Wittner Serie 830 Metronome, Riester Sphygmomanometer), stopwatch (Casio Stopwatch).	Body mass, height, body fat percentage and maximal oxygen uptake increased throughout the season.

			training, growth, and maturation.	*Outcome Variables:* Body fat (%), BMI (kg.m^2), sum of skinfolds (triceps, sub-scapular, suprailiac, abdominal, anterior thigh, leg) (mm), systolic arterial blood pressure (mmHg), diastolic arterial blood pressure (mmHg), final heart rate (beats.min^{-1}), VO_2 Max (l/min) (ml.kg.min^{-1}). *Comparative Groups:* Season (pre-season, post-season).	
Pambo et al. (2021) (262)	*Country* = Ghana *PS* = National *AG* = U18, *n* = 43 (*team/club:* n = NS)	16.6 ± 1.1 yrs 1.63 ± 0.06 m 56.4 ± 6.8 kg	To study the heart profiles of Ghanaian adult and adolescent female football players, using ECG and echocardiography to identify common findings among a group of West African female footballers.	*Data Collection:* Electrocardiographic monitoring (Welch Allyn, United Kingdom), cardiac ultrasound machines (GE Vivid E by General Electric, China and CX50 by Philips, The Netherlands). *Outcome Variables:* Heart rate (beats.min^{-1}), PR interval (ms), QRS (Q-wave, R-wave and S-wave) duration (ms), R/S voltage (S1 + R5) (mm), QTc interval (ms), first-degree atrioventricular block (PR interval >200 ms), sinus bradycardia (HR <60 bpm), Sokolow-Lyon criteria for left ventricular hypertrophy (T-R), incomplete right bundle branch block (QRS >100ms, >120 ms), interventricular septal wall thickness (mm), posterior wall thickness (mm), Maximum left ventricular wall thickness (mm), left ventricular end-diastolic/systolic dimensions (mm), left ventricular mass (g), left ventricular mass index (g.m^2). *Comparative Groups:* Age group (senior n = 32, adolescent n = 43).	T-wave inversions in lateral leads (V5, V6) were found in 8% of participants. Voltage-based signs of left ventricular hypertrophy were seen in 35%. About 2.7% showed a left ventricular wall thickness of 12 mm or more, and no measurements went beyond 13 mm. None of the players had a left ventricular cavity dimension over 60 mm. Overall, Ghanaian female footballers showed a significant prevalence of left ventricular hypertrophy and repolarization abnormalities.
Pardos-Mainer et al. (2021) (263)	*Country* = Spain *PS* = National *AG* = U14, U16, U18, *n* = 54 (*team/club*: n = 3)	U14: 13.7 ± 0.6 yrs 1.54 ± 0.08 m 48.9 ± 7.9 kg U16: 14.9 ± 0.5 yrs 1.60 ± 0.05 m 53.6 ± 8.1 kg U18: 16.9 ± 0.5 yrs 1.62 ± 0.09 m 57.7 ± 9.3 kg	To examine differences between the limbs in three age groups of adolescent female football players, and to investigate their link to physical performance measures within each age group.	*Data Collection:* Optical measurement system (Optojump, Microgate, Bolzano, Italy), standard measuring tape (30m M13; Stanley, New Britain, CT, USA), photoelectric cells (Microgate, Bolzano, Italy). *Outcome Variables:* Single leg CMJ L/R (cm), single leg hop L/R (cm), 180° COD L/R (s), 10m, 20m, 30m, 40m sprint (s), asymmetry (%). *Comparative Groups:* Age group (U14 n = 15, U16 n = 21, U18 n = 18). Asymmetry (left leg, right leg).	Players in the U18 and U16 categories performed much better in the 180° left change of direction test than their U14 counterparts. U18 athletes also showed clear differences in single leg hop tests on the left side. Meanwhile, U16 players had better 40-meter sprint times compared to U14 players. Although some differences were noted in jumping and change of direction tests among adolescent female footballers, these did not negatively affect their overall physical performance.
Petrovic et al. (2022) (264)	*Country* = Serbia *PS* = International *AG* = U19, *n* = 45 (*team/club*: n = NS)	17.8 ± 1.2 yrs 1.66 ± 0.07 m 59.6 ± 5.8 kg	To study how common ACE and ACTN3 gene variations are in young female football players, and to look at how these	*Data Collection:* Scale (InBody 370, InBody, Seoul, Korea), stadiometer (Seca 214 Portable Stadiometer, Cardinal Health, USA), electrocardiographic machine (Schiller Cardiovit AT101, Schiller, Baar, Switzerland), Genomic DNA extraction (PureLink genomic DNA, Invitrogen), ViA 7 machines (Applied Biosystems).	No significant differences were found in the distribution of ACE and ACTN3 genotypes or allele frequencies between elite female football players and the control group. Additionally, the ACE gene insertion and the ACTN3 gene nonsense mutation did not significantly affect

			variations relate to body composition, blood pressure, and electrocardiogram readings.	*Outcome Variables:* BMI (kg.m^{2}) (%), heart rate (beats.min^{-1}), systolic blood pressure (mmHg) (%), diastolic blood pressure (mmHg) (%), ECG wave representing ventricular depolarisation (s), QT interval corrected to the heart rate (ms), Sokolow-Lyon voltage for left ventricular hypertrophy (mm). *Comparative Groups:* Genotype (DD n = 19, ID n = 18, II n = 8), (RR n = 9, RX n = 26, XX n = 10). Age group and sport (Adolescents and footballers n = 45, seniors and control group n = 60)	resting blood pressure or ECG findings. While players with the ACE DD and ACTN3 XX polymorphisms had increased Sokolow-Lyon voltage values that suggested left ventricular hypertrophy, these changes did not reach statistical significance.
Philp et al. (2020) (265)	*Country* = England *PS* = Regional *AG* = U14, U16, U18, *n* = 34 (*team/club*: n = 1)	14.7 ± 1.6 yrs	To find performance benchmarks for the modified Star Excursion Balance Test and related limb symmetry index scores in healthy adolescent female football players, and to explore the possible link between these measures and age.	*Data Collection:* Health status questionnaire (NS), Y Balance Test kit (Functional Movement Systems). *Outcome Variables:* Modified Star Excursion Balance Test subcomponent (posterolateral, posteromedial) distance (cm), composite modified Star Excursion Balance Test score (cm), limb symmetry index (%). *Comparative Groups:* Age group (U14 n = 12, U16 n = 14, U18 n = 8). Leg asymmetry (dominant, non-dominant).	No significant differences were found between the dominant and non-dominant leg distance scores in any specific reach direction or in the overall results of the modified Star Excursion Balance Test. The average total distance scores for the dominant leg ranged from 231.5 to 250.4 cm, while scores for the non-dominant leg ranged from 234.3 to 253.3 cm across all age groups. The limb symmetry index values averaged between 97.8% and 100.5%. Age accounted for about 8% of the differences in total distance scores for both legs and in the limb symmetry index measurements.
Poehling et al. (2021) (266)	*Country* = Canada *PS* = National *AG* = U15, U17, *n* = NS (*team/club:* n = NS)	NS	To study the growth of physical performance metrics, we will use a national program's database that includes elite and international-level female football players aged 12 to 34 years.	*Data Collection:* Dual-beam timing lights (Swift Performance Equipment, Lismore, Australia), contact mat (SpeedMat, Swift Performance Equipment, Lismore, Australia), tape measure and yardstick (for broad jump). *Outcome Variables*: Final velocity in the 30−15 intermittent fitness test (m.s^{-1}), 10m sprint (s), 40m sprint (s), max speed (m.s^{-1}), SJ (cm), broad jump (cm), CMJ (cm). *Comparative Groups:* Age group (youth n = NS, senior n = NS).	In youth players, significant improvements were identified in maximal speed (30−40 m split), broad jump, countermovement jump, final velocity 30−15 intermittent fitness test, and a decrease in squat jump height with increasing age.
Ramos et al. (2021) (267)	*Country* = Brazil *PS* = National *AG* = U15, U17, *n* = 193 (*team/club:* n = NS)	U15: 14.7 ± 0.5 yrs 1.62 ± 0.07 m 57.3 ± 7.4 kg U17: 16.5 ± 0.5 yrs 1.65 ± 0.08 m 59.2 ± 8.7 kg	To compare body measurements, lower limb strength, sprint speed, and endurance among female football players from Brazil, focusing on age groups from U15 to senior level.	*Data Collection:* Skinfold calipers (Holtain Ltd., Crymych, United Kingdom), timing mat (Multisprint, Hidrofit, Belo Horizonte, Brazil), height measurement (Filizolla, São Paulo, Brazil). *Outcome Variables:* Sum of skinfolds (triceps, biceps, subscapular, suprailiac, abdominal, front thigh, and medial calf) (mm), CMJ (cm), SJ (cm), 20m sprint (m.s^{-1}), Yo-Yo IR1 distance (m),	Both senior and U20 players showed significantly higher CMJ and SJ compared with the U15 and U17. U20 were significantly better in the Yo-Yo IR1 than the younger groups. When comparing selected and non-selected players, no significant differences were identified in anthropometric measures. However, selected players from U17, U20, and Senior teams showed

		U20: 18.6 ± 0.6 yrs 1.67 ± 0.07 m 61.1 ± 7.6 kg		*Comparative Groups:* Age group (U15 n = 46, U17 n = 49, U20 n = 98, Senior n = 38). Playing status (selected, non-selected).	significantly better performance in Yo-Yo IR1 than non-selected players.
Raya-González et al. (2021) (268)	*Country* = Portugal *PS* = NS *AG* = U17, *n* = 16 (*team/club:* n = 1)	15.5 ± 1.5 yrs 1.59 ± 0.07 m 54.6 ± 7.8 kg	To study movement differences in female footballers during jumping, COD, and ROM assessments and to explore possible links between these differences and the risk of injury.	*Data Collection:* Dual-energy X-ray absorptiometry (DXA, (GE Healthcare, Madison, WI, USA), optical measurement system (Optojump Next; Microgate, Bolzano, Italy), photocell (Microgate, Bolzano, Italy), metric tape (for lateral and standing broad jump). *Outcome Variables:* 505-COD dom/non-dom (s), CMJ dom/non-dom (cm), SBJ dom/non-dom (cm), lateral jump dom/non-dom (cm), ROM (hip flexion with extended knee) dom/non-dom (°), ROM (hip abduction with flexed knee) dom/non-dom (°), ROM (ankle flexion with extended knee) dom/non-dom (°), ROM (ankle flexion with flexed knee dom/non-dom (°), muscle mass dom/non-dom (kg). *Comparative Groups:* Asymmetry (dominant, non-dominant).	Significant lower asymmetries in the change-of-direction test were observed in comparison to those observed in jumping and ROM tests; significant lower asymmetries in muscle mass were also reported compared to those found in the change-of-direction and countermovement jump tests. An increased risk of injury was observed across CMJ and hip flexion with extended knee ROM in relation to increasing asymmetry values.
Romero-Caballero et al. (2021) (269)	*Country* = France *PS* = Local *AG* = U19, *n* = 17 (*team/club*: n = NS)	15.4 ± 1.3 yrs 1.62 ± 0.06 m 56.7 ± 9.5 kg	To assess the physical fitness of young and amateur football players, we will use sport-specific tests including lower limb extensor strength with the CMJ and evaluating aerobic capacity with an incremental running test.	*Data Collection:* MyJump2 iOS app (iPhone 8 and iPad Pro, both equipped with slow motion function camera at 240 fps). *Outcome Variables:* CMJ (cm), Leger level (n), Max speed Leger ($m.s^{-1}$), VO_2 Max ($ml.kg.min^{-1}$). *Comparative Groups:* Age group (Senior n = 19, U19 n = 17). Competitive level (national, regional, local). Playing position (Goalkeeper, central defender, fullback, midfielder, winger, striker).	Senior players significantly outperformed U19s across CMJ, Leger level and Max speed Leger tests. There were no differences between the two groups in the VO_2 Max test. The playing position analysis did not show significant differences in the CMJ. However, in the Leger test, fullbacks, midfielders and wingers obtained better results than the goalkeepers.
Rusu et al. (2023) (270)	*Country* = Romania *PS* = NS *AG* = U16, *n* = 18 (*team/club:* n = NS)	14.7 ± 1.3 yrs 1.63 ± 0.17 m 53.9 ± 10.1 kg	To examine the relationship between sleep quality and muscle force.	*Data Collection:* Validated Sleep Quality Scale (SQS) questionnaire (Cleveland Adolescent Sleepiness Questionnaire (CASQ)), dynamometer (BioFET, MusTec Muscle Dynamic Technology b.v., Louis Christijnstraat 1, 1325 PC Almere, The Netherlands). *Outcome Variables:* Sleep quality scale score (SQS) (n), CASQ score (n), knee extensors L/R medium of maximal force (N), maximal force (N), duration of maintained maximal force (s), knee flexors L/R medium of maximal force (N), maximal force (N), duration of maintained maximal force (s), asymmetry L/R (%). *Comparative Groups:* Questionnaire type (SQS, CASQ).	More than 83% of participants scored below 50% on the maximal SQS score and all participants scored less than 40 points (50%) on the CASQ's maxim score, meaning a small level of sleepiness. Muscle asymmetry is minimal and does not correlate with sleep quality or sleepiness. There was no correlation between muscle force parameters and sleep quality.
Sánchez Garcia et al. (2022) (271)	*Country* = Spain *PS* = Regional *AG* = U18,	16.2 ± 1.7 yrs 1.64 ± 0.07 m 61.9 ± 6.4 kg	To analyse the effects of the different phases of the	*Data Collection:* Mobile app (Menstrual Calendar and Cycle, Period Tracker), contact platform (Globus Ergo System R	No significant differences were found in any variable of performance or sleep,

	n = 12 (*team/club:* n = NS)		menstrual cycle on determinant variables of performance and well-being in youth football players	contact platform, Codogné, Italy), photocell (WittySEM, Microgate, Photocells, Bolzano, Italy). *Outcome Variables:* 40m sprint (s), V-cut agility (s), jump non-dominant leg (cm), jump dominant leg (cm), SJ (cm). *Comparative Groups:* Menstrual cycle (menstrual phase, follicular phase, luteal phase).	fatigue, stress and muscle pain between the phases of the menstrual cycle.
Swanson et al. (2023) (272)	*Country* = USA *PS* = Local *AG* = U14, U15, U16, U17, U18, *n* = 59 (*team/club:* n = NS)	15.0 ± 1.5 yrs 1.64 ± 0.08 m 54.6 ± 9.2 kg	To determine the influence of acute, chronic, and acute:chronic sleep duration on aerobic performance in female youth football athletes.	*Data Collection:* Electronic scale (Health-O-Meter Professional, Sunbeam Products, McCook, IL), stadiometer (Seca 216, SECA, Chino, CA), cycle ergometer (Velotron; Racermate, Seattle, WA), metabolic cart (Cosmed Quark CPET, Italy), heart rate monitor (Garmin HRM-Dual, Garmin, Olathe, KS). *Outcome Variables:* Prior night sleep (h), prior month sleep (h), VO_2 Max (ml.kg.min^{-1}), time to exhaustion (min), VO_2 ventilatory threshold (ml.kg.min^{-1}), time to ventilatory threshold (min). *Comparative Groups:* Age group (U14 n = 14, U15 n = 9, U16 n = 16, U17 n = 9, U18 n = 11).	No statistically significant differences in VO_2 max, time to exhaustion, or VO_2 at ventilatory threshold (VO_2VT) were found between participants who slept 8 hours or more and those who slept less than 8 hours the night before testing. However, individuals who averaged 8 hours or more of sleep in the previous month showed significantly higher VO_2 max and VO_2VT. Additionally, participants with a higher acute:chronic sleep ratio had significantly greater time to exhaustion, but their VO_2 max and VO_2VT were unaffected.
V.Martinho et al. (2020) (273)	*Country* = Portugal *PS* = NS *AG* = U12 – U18, *n* = 228 (*team/club:* n = NS)	14.6 ± 1.1 yrs	To study how chronological age, skeletal maturity, training history, and body size affect differences in left ventricular mass among adolescent female football players, using an allometric modelling framework.	*Data Collection:* Stadiometer (model 98.603, Holtain Limited Crosswell, Crymych, UK), digital scale (SECA, model 770, Hanover, MD, USA), lange caliper (Beta Technology Incorporated Cambridge, Maryland, USA), ultrasound machine (1.5 to 3.6 MHz transducer, GE Vingmed Ultrasound, Horten, Norway). *Outcome Variables:* Training experience (yrs), skeletal age (yrs), skeletal maturity (delayed, average, advanced, mature), body surface area (m^2), fat mass (%), FFM (kg), left ventricular internal dimension at end of the diastole (mm), interventricular septal wall thickness at end of the diastole (mm), posterior wall thickness at end of the diastole (mm), left ventricular mass (g), left ventricular mass index (g.m^{-2}). *Comparative Groups:* Skeletal maturity status (late n = 25, average n = 51, early n = 87, mature n = 65).	FFM was the most prominent single predictor of left ventricular mass with its scaling coefficient k = 0.924 suggesting geometric similarity. Body mass, fat free mass and training experience had a direct relationship with left ventricular mass. Average and early maturing players were found to have smaller left ventricular mass compared to later maturing players.
Vargas et al. (2019) (274)	*Country* = Brazil *PS* = Regional & National *AG* = U13, U15, U17, *n* = 47 (*team/club:* n = NS)	U13: 12.2 ± 0.8 yrs 1.53 ± 0.06 m 44.9 ± 8.4 kg U15: 14.0 ± 0.6 yrs 1.61 ± 0.06 m 54.8 ± 7.0 kg	To compare the strength and power of knee flexors and extensors, as well as functional strength balance ratios and muscle symmetry, among female football players of	*Data Collection:* Stationary bike (25W, Cybex Inc., Ronkonkoma, NY, USA), dynamometer (System 4 Biodex Medical Systems Inc., Shirley, NY, USA). *Outcome Variables:* Training experience (yrs), extensor peak torque at 60°/s, 240°/s (N.m), extensor average power at 240°/s (W), flexor peak torque at 60°/s, 240°/s (N.m), flexor average power at 240°/s, eccentric contraction extensor peak	There was a significant difference in muscular strength values between U13 and U15 groups (U15 higher) and between U17 and Pro groups (Pro higher). The conventional balance ratio for the dominant limb was higher in U13 than in all other groups. The conventional balance ratio values encountered were lower than the literature recommendation

		U17: 15.8 ± 0.7 yrs 1.63 ± 0.06 m 57.6 ± 9.1 kg	different ages and competitive levels.	torque at 240°/s (N.m), eccentric contraction flexor peak torque at 240°/s (N.m), conventional ratio (%). *Comparative Groups:* Age group (U13 n = 14, U15 n = 19, U17 n = 14, Professionals (U18+) n = 19). Limb asymmetry (dominant, non-dominant).	for U15, U17 and Pro groups for dominant limb and for all groups for nondominant limbs.
Vescovi et al. (2011) (275)	*Country* = USA *PS* = Regional and National *AG* = U12, U13, U14, U15, U16, U17, U18, U19, *n* = 362 (*team/club:* n = NS)	*Youth:* 12.6 ± 0.5 yrs *High school:* 15.3 ± 1.0 yrs *College:* 19.4 ± 1.1	To identify performance traits linked to linear sprinting, CMJ, and agility in elite female youth football players between the ages of 12 and 21.	*Data Collection:* Infrared timing gates (Brower Timing, Utah), electronic timing mat (Just Jump System, Probotics Inc., Hunstville, Alabama, USA). *Outcome Variables:* Sprint speed ($m.s^{-1}$), CMJ height (cm), Illinois agility test time (s), Pro-agility test time (s). *Comparative Groups:* Age group (U12 n = 33, U13 n = 45, U14 n = 59, U15 n = 72, U16 n = 64, U17 n = 28, U18 n = 34, U19 n = 27, U20 n = 27, U21 n = 25).	CMJ height and agility performance showed improvements up to around 15 to 16 years of age. Players aged 14 to 17 did better than those aged 12 to 13 in all physical tests. In addition, athletes aged 18 to 21 achieved better results in the second and fourth 9.1m sprint segments, overall, 36.6m sprint speed, and performance on the Illinois agility test compared to the 14 to 17-year-old group.
Wright et al. (2019) (276)	*Country* = England *PS* = NS *AG* = U13, U15, U17 *n* = 86 (*team/club:* n = NS)	*1st season:* U13: 11.0 ± 0.9 yrs 1.44 ± 0.09 m 39.0 ± 8.5 kg U15: 14.0 ± 0.6 yrs 1.57 ± 0.06 m 54.0 ± 12.0 kg U17: 15.0 ± 0.4 yrs 1.64 ± 0.07 m 57.0 ± 6.9 kg *2nd season:* U13: 11.0 ± 1.0 yrs 1.47 ± 0.09 m 38.0 ± 6.2 kg U15: 14.0 ± 0.6 yrs 1.57 ± 0.07 m 53.0 ± 9.4 kg U17: 16.0 ± 0.6 yrs 1.64 ± 0.06 m 60.0 ± 9.0 kg	To examine both short-term progress (within a single season) and long-term progress (over four seasons) of football-specific fitness in female youth players, based on their maturation status.	*Data Collection:* Electronic scales (Seca Medical Measuring Systems, Germany), Yo-Yo IR1 (NS). *Outcome Variables:* Yo-Yo IR1 performance (m), maturity offset (age from peak-height velocity). *Comparative Groups:* Season (1st season, 2nd season, 3rd season, 4th season). Age group 1st season (U13 n = 20, U15 n = 18, U17 n = 12), 2nd season (U13 n = 22, U15 n = 17, U17 n = 13), 3rd season (U14 n = 16, U16 n = 17), 4th season (U14 n = 16, U16 n = 14).	Small fitness improvements between July and September were "very likely," while improvements between September and May were found to be "possibly" trivial. Within-player variation (typical error) was 23%, and between-player variation was 38%. Moderate improvements over three years were "most likely" and moderately linked to maturation.

		3rd season: U14: 13.0 ± 0.6 yrs 1.59 ± 0.09 m 47.0 ± 11.0 kg U16: 15.0 ± 0.5 yrs 1.66 ± 0.05 m 59.0 ± 6.8 kg 4th season: U14: 13.0 ± 0.6 yrs 1.61 ± 0.08 m 51.0 ± 9.1 kg U16: 15.0 ± 0.7 yrs 1.67 ± 0.06 m 59.0 ± 6.8 kg			
Wright et al. (2019) (277)	*Country* = England *PS* = NS *AG* = U13, *n* = 14 (*team/club:* n = NS)	12.1 ± 0.9 yrs 1.48 ± 0.09 m 38.8 ± 6.9 kg	To monitor the growth of sprint-related physical abilities in players over a 3-year period in a girls' football centre of excellence program.	*Data Collection:* Timing gates (Smart speed, Fusion Sport, Australia). *Outcome Variables:* 5m acceleration (s), 20m speed (s), COD speed (s), repeated-sprint ability (s), maturity offset (Yrs from peak height velocity) (n), change in performance (standardised units). *Comparative Groups:* Season (1st season, 2nd season, 3rd season).	Average performance improvements over the three-year period were seen in speed (5.9%; ES = 1.3) and repeated sprint ability (4.0%; ES = 1.0). Both were considered 'most likely large.' Acceleration (8.8%; ES = 1.1) and change of direction (COD) speed (8.3%; ES = 1.4) showed improvements classified as 'most likely very large.' During the first two years, improvements varied from 'most likely moderate' to 'very large.' Between years two and three, only small gains in COD speed and 20-m sprint speed were noted, both classified as 'likely.' Importantly, individual differences in response were clear only for COD speed, with changes rated as moderate and small in the final year.
Zhang et al. (2022) (278)	*Country* = China *PS* = NS *AG* = U16, *n* = 24 (*team/club:* n = 1)	14.8 ± 0.4 yrs 1.67 ± 0.05 m 53.3 ± 6.2 kg	To find the optimal cut-off score on the functional movement screen for predicting sports injury risk in female youth football players, and to examine the	*Data Collection:* Light timing system (Swift EZE Jump, Version 2.5.28, Brisbane, Australia), force plate (Kistler, Version 2822A1-1, Winterthur, Switzerland), functional movement screen test (NS). *Outcome Variables:* BMI (kg.m^2), functional movement screen score (n), Y-balance test score (n), sprint 0-10m, 10-20m, 0-20m (s), CMJ (cm), standing leg jump (cm).	Moderate correlations were found between total functional movement screen scores and 10-to-20-meter sprint times. There were also correlations between specific components of the screen: the in-line lunge related to 0-to-20-meter sprint time, shoulder mobility connected with 0-to-10-meter sprint time,

			connections between functional movement quality, measured by the functional movement screen and Y-Balance Test, and sprinting and jumping performance.	*Comparative Groups:* Playing position (striker n = 7, midfield n = 6, fullback n = 8, goalkeeper n = 3).	and trunk stability push-up was linked to 10-to-20-meter sprint time. These findings suggest that players with higher sprinting ability, often strikers and midfielders, showed better functional movement quality than slower-positioned players like goalkeepers.
Intervention Studies (n=17)					
Gonzales-Garcia et al. (2019) (279)	*Country* = Spain *PS* = National *AG* = NS, *n* = 24 (*team/club:* *n* = 1)	16.8 ± 1.6 yrs 1.64 ± 0.06 m 58.4 ± 6.3 kg	To compare 7-week hip thrust or back squad training intervention on performance.	*Data collection:* My Jump 2 app (iOS 11 1.1, Apple, California), timing gates (DSD Sport System, Spain), My Lift app (iOS 11 1.1, Apple, California), accelerometer (PUSH, PUSH Inc, Canada), anthropometric testing (skinfolds). *Outcome variables:* CMJ (cm), 0-10m, 0-20m, 10-20m sprint (s), agility T-test, mean concentric velocity back squat and hip thrust (60, 80% 1RM), power in back squat and hip thrust (60, 80% 1RM), body fat (%), body muscle mass (%), mass (kg). *Intervention*: Hip thrust or back squat (7 weeks, 2x per week: 4 x 12 (60%)/10 (70%)/10 (70%)/8 (80%)/8 (80%)/6 (85%)/4 (90%)) *Comparative groups:* Hip thrust (n = 8), back squat (n = 8), control (n = 8)	The hip thrust group showed greater improvements in the 10m sprint, 20m sprint and barbell velocity at 80% 1RM during hip thrusts. The back squat group showed greater improvements in barbell velocity at 80% 1RM during back squats.
Hammami et al. (2023) (280)	*Country* = Tunisia *PS* = Regional *AG* = U15, *n* = 52 (*team/club*: *n* = NS)	14.3 ± 0.3 yrs 1.61 ± 0.08 m 60.4 ± 8.4 kg	To evaluate the effects of a season-long training regime on anthropometric and physical performance characteristics, agility, and football skills in young female North African elite football players.	*Data collection:* Skinfold caliper (Harpenden, British Indicators Ltd), Optojump (1000Hz, Microgate, Italy), Infrared photoelectric cell (Cell Kit Speed, Brower, USA), Yo-Yo IR1. *Outcome variables:* Height (cm), weight (kg), body fat (%), Jumping measurements (CMJ, SJ, 5JT) (cm), Running speed (5m, 10m, 30m sprint) (s), Agility (T-test with/without ball) (s), Loughborough football passing test (s), Yo-Yo IR1(m). *Intervention:* 1 season of training (10 months). *Comparative groups:* Control group (n = 26), Football group (n = 26).	Elite football players showed significant improvements across a competitive season in anthropometric measures ((height, weight and body fat) and performance (CMJ, SJ, 5JT, sprint, agility and LSPT).
Isla et al. (2021) (281)	*Country* = Spain *PS* = National *AG* = NS, *n* = 38 (*team/club:* *n* = 1)	13.9 ± 0.8 yrs 1.58 ± 0.06 m 50.6 ± 7.7 kg	To assess the effectiveness of a 12-week neuromuscular warm-up program on strength, jumping and dynamic balance performance in in youth female football players.	*Data collection:* PUSH^{TM}Band technology (200Hz, PUSH Inc., Toronto, Canada), iPhone PUSH app (v.1.10.4.), My Jump 2 app (iOS 11 1.1, Apple, California), Y-balance measurements (Octobalance System, Check Your Motion, Albacete, Spain). *Outcome variables:* Back squat ($m \cdot s^{-1}$), Hip thrust ($m \cdot s^{-1}$), CMJ (cm), Y-Balance (frontal,postero lateral, postero medial, right leg, left leg) (cm).	Participants in experimental group improved squat and hip thrust execution speed, bilateral and unilateral countermovement jump height, and dynamic balance compared to the control group.

				Intervention: Neuromuscular activation program (2x per week for 12 weeks) Low intensity running (pt1), Body weight squat x2, Frontal lunge x1, Lateral lunge x1, Double leg jumps, Diagonal in and out hops (pt2), 5kg disc squat, 5kg frontal lunge, 5kg continuous CMJ, 5kg single leg bridge (pt3). *Comparative groups:* Intervention group (n = 21). Control group (n = 17).	
Lesinski et al. (2021) (282)	*Country* = Germany *PS* = National AG = U17, *n* = 36 (*team/club: n* = 2)	*Strength endurance training:* 15.3 ± 0.5 yrs 1.65 ± 0.05 m 57.0 ± 6.6 kg *Power training:* 15.4 ± 0.6 yrs 1.71 ± 0.05 m 61.8 ± 7.2 kg	To examine the long-term effects of strength endurance training vs. power training on physical fitness and body composition over the course of a football season in young female elite football players.	*Data collection:* Bioelectrical impedance analysis system (InBody 720; Biospace), Cybex Eagle Leg Press (Cybex International), optoelectric cell system (Optojump; Microgate, Italy), photocell timing gates (Witty-gate, Microgate, Italy), Y-balance test tool (Move2Perform, Evansville, IN, USA). *Outcome variables:* Maturity offset (y), BMI ($kg.m^2$), fat mass (%), total lean mass (kg), R/L leg lean mass (kg), trunk lean mass (kg), CMJ (cm), DJ height (cm), DJ performance index ($m.s^{-1}$), DJ contact time (ms), ventral Bourban test (s), T-test (s), 10m/20m sprint (s), Y-balance test total score dominant/non-dominant leg (%), kicking velocity dominant/non-dominant ($m.s^{-1}$), 1RM leg press relative ($kg.kg^{-1}$ body mass). *Intervention:* Strength endurance training group 60 min session involving free weights & machine-based exercises (1–3 sets with 20–40 repetitions per exercise at slow movement velocity 50-60% 1RM). Power training group 60 min session involving the same but performed 1–6 sets with 3–8 repetitions with the intention to move load as fast as possible (50-95% of 1RM). *Comparative groups:* Training type (strength endurance training group n=19, power training group n=17). Leg asymmetry (dominant leg, non-dominant leg).	The strength endurance training group showed significantly greater improvements in ventral Bourban and T-test performances compared with the power training group. The power training group demonstrated significantly greater improvements in 1RM leg press, DJ, 10-m, and 20-m sprint performances. No significant between-group differences for CMJ, Y-balance test, kicking performance, and body composition were observed at post-test.
Lindblom et al. (2012) (283)	*Country* = Sweden *PS* = NS *AG* = NS, *n* = 41 (*team/club: n* = 4)	*Int Group:* 14.2 ± 0.7 yrs 1.64 ± 0.06 m 53.9 ± 8.6 kg *Cntrl Group:* 14.2 ± 1.1 yrs 1.64 ± 0.06 m 52.5 ± 7.4 kg	To study the effect of a neuromuscular warm-up programme on performance tests in youth female football.	*Data collection:* Infrared contact mat (MuscleLab 4010, Ergotest Technology), Timing gates using photoelectric cells (MuscleLab 4010, Ergotest Technology). *Outcome variables:* Posterolateral R/L (cm), posteromedial R/L (cm), anterior R/L (cm), composite score R/L (cm), CMJ (cm), triple-hop distance (cm), Illinois agility test (s), 10m/20m sprint (s). *Intervention:* Intervention was a 15-min neuromuscular warm-up program carried out twice a week during an 11-week study period.	Significant minor positive changes were observed in the control group compared to the intervention group for a sub-score of the star excursion balance test and in the modified Illinois agility test. No improvement was seen in the intervention group from baseline to follow-up.

				Comparative groups: Intervention group (n = 23) Vs Control group (n = 18).	
Mathisen et al. (2015) (284)	*Country* = Norway *PS* = Regional *AG* = NS, *n* = 19 (*team/club:* n = NS)	*Training group:* 15.5 ± 0.7 yrs 1.63 ± 0.03 m 58.0 ± 7.0 kg *Control group:* 15.1 ± 0.5 yrs 1.64 ± 0.02 m 56.0 ± 4.7 kg	To investigate the effects of an eight-week short burst speed and change-of -direction training programme on sprint and agility performance in youth female football players.	*Data collection:* Electronic photocell timing gates (Brower Timing System, USA). *Outcome variables:* 10m/20m sprint (s), Agility (s). *Intervention:* Training program - eight sprints over 20m straight and change of direction (32 total sprints per session). One hour training per week for 8 weeks. *Comparative groups:* Training group (n = 10) Vs Control group (n = 9). Pre and Post training program.	The training program resulted in improvements in 10-m sprint, 20-m sprint, and agility performance in youth female football players. Results show that one hour of short-burst high-speed exercises during pre-season, was sufficient to enhance straight-line sprinting up to 20m and agility beyond the improvements seen with traditional football training based on technical drills and small-sided games.
Ortega et al. (2020) (285)	*Country* = Columbia. *PS* = NS *AG* = NS, *n* = 50 (*team/club:* *n* = NS)	13.6 ± 1.2 yrs 1.57 ± 0.06 m 46.7. ± 5.3 kg	To examine the effects of strength and velocity training programmes on physical fitness parameters, including strength, power, and speed, in youth female football players.	*Data collection*: Optojump (1000Hz; Microgate, Germany), infared-light photocell systems (WL34-R240, Sick, Germany), linear velocity transducer (T-FORCE Dynamic Measurement System 2, Ergotech Consulting, Spain), Smith machine (NS), cycle ergometer (835E, Monark Exercise, Sweden), DXA scanner (Electric Lunar, TBC). *Outcome variables*: BMI ($kg \cdot m^{-1}$), fat and fat-free mass index ($kg \cdot m^{-1}$), fat-free mass index ($kg \cdot m^{-1}$), bone mineral content (g) and density (g), maximal velocity over 30m (s), relative maximal power ($W \cdot kg^{-1}$) and velocity (RPM) on the cycle-ergometer, CMJ (cm), SJ (cm), maximal squat power (W), average propulsive velocity in squats ($m \cdot s^{-1}$), 1RM squat (kg) . *Intervention*: Velocity training (12 weeks, 3x per week: velocity-controlled squats 65% 1RM at 0.7 $m \cdot s^{-1}$ and cycle-ergometer 65% until 20% reduction in maximal RPM), strength training (12 weeks, 3x per week: maximal velocity squats 80% 1RM and cycle-ergometer 80% until 80% loss in maximal RPM), control group (typical football training). *Comparative groups:* Velocity training (n = 15), strength training group (n = 13), control (n = 17).	All groups saw significant improvements in physical characteristics. The velocity group had greatest improvements in CMJ, maximal squat power, and maximal cycle velocity. Both velocity and strength groups showed similar improvements in the 1RM squat.
Pardos-Mainer et al. (2019) (286)	*Country* = Spain *PS* = National *AG* = NS, *n* = 36 (*team/club:* *n* = NS)	12.7 ± 0.6 yrs 1.56 ± 0.07 m 52.5 ± 8.3 kg	To examine the effect of the FIFA 11+ injury prevention programme compared with a standard warm-up on unilateral jump performance, dynamic balance, change of direction ability, and lower limb	*Data collection:* Standard measuring tape (30m M13; Stanley, New Britain), optical measurement system (Optojump, Microgate, Bolzano, Italy), LegMotion system (LegMotion, your Motion, Spain), OctoBalance device (OctoBalance, Check your Motion, Spain), Photocell timing gates (Witty-gate, Microgate, Italy). *Outcome variables:* Standing broad jump (m), one-legged horizontal jump R/L (m), CMJ R/L (cm), DJ R/L (cm). Weight-bearing dorsiflexion R/L (cm), Y-Balance test	The FIFA 11+ programme significantly improved unilateral jumping performance and dynamic balance in adolescent female football players Lower extremity asymmetries were reduced across several tests, although no improvements were observed in change of direction performance.

			asymmetries in adolescent female football players.	anterior/posteromedial/posterolateral direction R/L (cm), 25m sprint test (V-cut) (s), 180° COD test R/L (s). *Intervention*: Control group - performed their habitual warm-up. Experimental group - carried out an additional injury prevention programme (FIFA 11+) twice per week for 10 weeks at the beginning of each training session. *Comparative groups:* Control group (n = 17) Vs Experimental group (n = 19)	
Pardos-Mainer et al. (2020) (287)	*Country* = Spain *PS* = National *AG* = NS, *n* = 37 (*team/club: n* = NS)	*Experimental Group:* 16.2 ± 0.9 yrs 1.60 ± 0.05 m 55.9 ± 5.5 kg *Control Group:* 15.6 ± 0.9 yrs 1.60 ± 0.05 m 54.1 ± 8.8 kg	To evaluate the effects of an 8-week combined strength and power training programme on physical performance and interlimb asymmetries in adolescent female football players.	*Data collection:* Standard measuring tape (30m M13; Stanley, New Britain), optical measurement system (Optojump, Microgate, Bolzano, Italy), dual beam photocell systems (Microgate, Italy). *Outcome variables:* Standing broad jump (m), one-legged horizontal jump R/L (m), CMJ R/L (cm), 10/20/30/40m sprint (s), 180° COD test R/L (s), 25m sprint yest (V-cut) (s). *Intervention:* Experimental group - performed combined strength and power training session (35min) 2x a week for 8-weeks. Session consisted of diver, forward lunge, backward lunge, plank and lumbar bridge. All exercises and repetitions had to be completed before the following training set. *Comparative groups:* Control group (n = 18) Vs Experimental (n = 19). Pre Vs Post intervention.	The experimental group showed significant improvements in sprint speed and COD performance compared to the control group following the 8-week strength and power training programme.
Rubley et al. (2011) (288)	*Country* = USA *PS* = Local *AG* = NS, *n* = 16 (*team/club: n* = NS)	13.4 ± 0.5 yrs 1.62 ± 0.06 m 50.8 ± 5.1 kg	To measure the effects of a 14-week low-frequency, low-impact plyometric training programme on VJ height and kicking distance in female adolescent football players.	*Data collection:* Gill Wind Gauge (Gill Athletics, USA), Vertec (Sports Imports, USA), Adidas Tango Supreme (size 5, Adidas USA). *Outcome variables:* Kicking distance (m), VJ (cm). *Intervention:* Plyometric training group - various types of jumps, hops, skips, footwork, and sprint drills. Training in the first 6 weeks included single-leg forward hops over 6-inch cones, double-leg hops over 10-inch hurdles, lateral hops over 10-inch hurdles, and lateral shuffles over a 12-inch box. Training in the final 6 weeks included 10-inch box jump-ups, 10-inch depth jumps, and cutting drills. 14-week total intervention. *Comparative groups:* Control group (n = 6) Vs Plyometric training group (n = 10). Pre-test vs 7-weeks vs 14-weeks.	No significant differences in kicking distance or VJ height were observed between groups at pre-test or 7 weeks. However, after 14 weeks, the plyometric group had significantly greater kicking distance and VJ height compared to the control group.
Sanchez et al. (2022) (398)	*Country* = Spain *PS* = National *AG* = NS,	*Jump Group:* 16.0 ± 2.3 yrs 1.62 ± 0.06 m 60.7 ± 6.3 kg	To assess the effects of a 12-week jump-training programme on CMJ height and	*Data collection:* Stadiometer (Seca 202, Seca, Germany), Scale (BC-418MA, TANITA, USA), contact mat (Optogait, Italy), electronic timing gates (WittySEM, Microgate, Italy),	The jump training group achieved significant improvements in both CMJ, and maximal kicking velocity

	n = 19 (*team/club: n* = 1)	*Control Group:* 16.0 ± 2.7 yrs 1.64 ± 0.07 m 56.5 ± 12.8 kg	maximal kicking velocity in youth female football players.	Adidas Starlancer (size 5, Adidas, USA), radar gun (Sports Radar SR-3600, USA). *Outcome variables:* BMI (kg.m^2), breast/pubic hair maturity stage (Tanner scale) (0-5), weekly time in physical education/other sport or football (hr), football experience (yr), CMJ (cm), four bound test for distance (cm), 20m sprint (s), maximal kicking velocity (m.s^{-1}), Yo-Yo IR1 (m). *Intervention:* Training program consisted of 7 jumping actions starting with 2 sets of 4 in the first week and building up to 2x5 in week 2, 2x6 in week 3 and 2x5 in week 4. *Comparative groups:* Jump training group (n = 8) Vs Control group (n = 6).	performance compared to the control group.
Singha et al. (2023) (290)	*Country* = India *PS* = Regional *AG* = NS, *n* = 60 (*team/club: n* = NS)	*Experimental Group:* 1.53 ± 0.06 m 40.9 ± 2.2 kg *Control group:* 1.52 ± 0.06 m 40.3 ± 2.1 kg	To investigate the effects of 6 weeks of training on body composition, physical fitness and physiological variables in 16–18-year-old female football players.	*Data collection:* Stadiometer (Seca 220, UK), electronic scale (Seca Alpha 770, UK), Skinfold caliper (Cescorf, Brazil), flexible non stretch tape (Cescorf, Brazil), Grip dynamometer (Baseline, USA), sit and reach box (Baseline, USA), sphygmomanometer (Omron, Japan), spirometer (Micro I Spirometer, Japan). *Outcome variables:* BMI (kg.m^2), body surface area (m^2), Body fat (%), total fat mass (kg), lean body mass (kg), waist circumference (cm), hip circumference (cm,) waist:hip, flexibility (cm), highest power output (watt), lowest power output (watt), average power output (watt), anaerobic capacity (watt), fatigue index (watt/sec), systolic blood pressure (mm Hg), diastolic blood pressure (mm Hg), pulse pressure (mm Hg), mean pressure (mm Hg), resting heart rate (beats.min^{-1}), HR max (beats.min^{-1}), recovery heart rate in 1st min (beats.min^{-1}), force expiratory volume in 1st sec/force vital capacity, pear expiratory flow rate (l). *Intervention:* Training includes speed training, strength and power training, flexibility training, interval training, endurance training, techniques and tactics (2 hrs/day, 5day/week, for 6 weeks). *Comparative groups:* Control group (n = 30) Vs Experimental group (n = 30).	After 6-weeks of training, the experimental group showed a significant decrease in body mass, body fat, systolic blood pressure as well as a significant increase in anaerobic power, strength, VO_{2max} force expiratory volume in 1st sec, force vital capacity and pear expiratory flow rate.
Steffen et al. (2013) (291)	*Country* = Canada *PS* = National *AG* = U16, U18, *n* = 226 (*team/club:* n = 31/19)	*Control Group:* 1.64 ± 0.06 m 60.0 ± 7.9 kg *Regular Group:* 1.62 ± 0.07 m 58.9 ± 10.4 kg *Comprehensive Group:* 1.65 ± 0.07 m	To assess whether different delivery methods of the FIFA 11+ injury prevention programme to coaches could improve player performance, and to examine the effect of player adherence on performance and	*Data collection:* Balance Pad (Airex, Airex Technologies Ltd., London, United Kingdom). *Outcome variables:* Practice/match time (hr), single leg balance R/L (s), star excursion balance test posterolateral/posteromedial/anterior R/L (cm), single leg triple-hop R/L (cm), Jumping over bar (n). *Intervention:* Twenty-minute warm-up program consisting of 15 different exercises divided into 3 parts.	High player adherence to the 11+ resulted in significant improvements in functional balance and reduced injury risk. The comprehensive group showed significant improvements in single-leg balance and anterior reach of the Star Excursion Balance Test compared to the control group. Players with high adherence to the FIFA 11+ showed greater improvements in five of six Star Excursion Balance Test reach distances

		58.7 ± 6.6 kg	injury risk in elite youth female football players.	*Comparative groups:* Control group (n = 80) Vs Regular group (n = 68) Vs Comprehensive group (n = 78).	in the star excursion balance test and had a significantly lower injury risk compared to players with lower adherence
Vargas et al. (2018) (292)	*Country* = Brazil *PS* = Regional & national *AG* = NS, *n* = 20 (*team/club:* *n* = NS)	16.2 ± 0.9 yrs 1.67 ± 0.08 m 59.8 ± 8.9 kg	To investigate whether tDCS increased the isometric muscle strength of quadriceps in adolescent female football players.	*Data Collection:* Dynamometer (MicroFet2; Hoggan Health Industries, West Jordan, UT, USA), DC generator (Activadose II, New York, NY, USA). *Outcome Variables:* Quadriceps strength ($N.Kg^{-1}$). *Intervention:* One active anodal tDCS group and one simulated anodal tDCS group. Active and simulated groups were then switched in week 2 of study so participants experienced both groups. *Comparative Groups:* tDCS group (active anodal tDCS group, simulated anodal tDCS group). Asymmetry (dominant leg, non-dominant leg). tDCS intervals (baseline, 20 min of stimulation, 30 min after stimulation, 60 min after stimulation).	tDCS significantly increased isometric quadriceps strength in the dominant limb, with effects lasting up to 60 minutes post-stimulation. No significant improvements were observed in the non-dominant limb.
Vescovi et al. (2010) (293)	*Country* = USA *PS* = Local *AG* = NS, *n* = 31 (*team/club*: *n* = 4)	*Prevent Injury Enhance Performance group:* 15.7 ± 1.2 yrs 1.65 ± 0.05 m 57.4 ± 4.2 kg *Control Group:* 16.8 ± 0.4 yrs 1.64 ± 0.06 m 58.7 ± 4.6 kg	To investigate the effects of 1a 12-week Prevent Injury Enhance Performance programme on physical performance measures in adolescent female football players.	*Data collection:* Infrared timing gates (Brower Timing, USA), electronic timing mat (Just Jump System, Probotics Inc, USA). *Outcome variables:* CMJ (cm), Illinois agility test & pro agility test (s), 9.1, 18.2, 27.3 & 36.6m sprint (s). *Intervention:* 12-week intervention, intervention group performed the Prevent Injury Enhance Performance program 3x per week. *Comparative groups:* Intervention group (n = 15) Vs Control group (n = 16). Compared at baseline, 6 weeks and 12 weeks.	Non-significant improvements in 27.3m and 36.6m sprint times were observed during the first 6-weeks for the intervention group but these reverted to baseline values by 12-weeks. There was no significant change in the CMJ height for the intervention group. Performance on the Illinois and pro-agility tests declined in both control and experimental groups across the 12-weeks.
Whittaker et al. (2015) (294)	*Country* = Canada *PS* = National *AG* = NS, *n* = 18 (*team/club:* n = 4)	15.2 ± 0.79 yrs	To determine the impact of different levels of exposure to the FIFA 11+ injury prevention program on the structure of select trunk and leg muscles in adolescent female football players.	*Data collection:* USI System (5.0 MHz, MyLab 25, Biosound Esaote Inc, USA). *Outcome variables:* BMI ($kg.m^2$). Contraction changes - external oblique R/L (mm), internal oblique R/L (mm), transversus abdominis R/L (mm), rectus abdominis R/L (mm), inter-recti distance (mm), L45 multifidus R/L (mm), gluteus medius R/L (mm), gluteus minimus R/L (mm), vastus medialis R/L (cm^2). *Intervention:* 20-min warmup program, consisting of 15 exercises grouped into 3 parts – running exercises combined with active stretching (pt 1), controlled partner contacts, planting and cutting movements (pt 3), and conditioning	Both low (mean = 149 ± 9 exercises/year) and high (mean = 314 ± 15 exercises/year) 11 + exposure groups demonstrated significant post-season decreases in inter-recti distance at rest and during an active straight leg raise. No other between or within group differences existed. This suggests that the FIFA 11+ programme has potential benefits for trunk muscle function.

				exercises that incorporate strength, agility, and balance (pt 2). *Comparative groups:* Exposure group (n = 9), Control group (n = 9).	
Wright et al. (2016) (295)	*Country* = England *PS* = Regional *AG* = NS, *n* = 37 (*team/club:* n = NS)	13.4 ± 1.6 yrs 1.56 ± 0.09 m 50.4 ± 13.4 kg	To evaluate group and individual responses to an 8-week, mixed-methods, high-intensity interval training programme in youth female football players, and to examine how maturity status (relative to peak height velocity) influenced training responses.	*Data collection:* Photelectric timing gates (Smartspeed, Fusion Sport, Australia), RPE centiMAX scale (CR100). *Outcome variables:* Chronological age (yrs), maturity offset (yrs), stature (cm), body mass (kg), 20m Sprint (s), T-test (s), repeated-sprint ability mean (s), Yo-YoIR1 (m). *Intervention:* Training divided into two 4-week blocks, Block 1 – longer duration HIIT/ Block 2 – Sprint based interval training. *Comparative groups:* Before peak-height velocity, at peak height velocity, after peak height velocity.	Players showed significant reductions in repeated-sprint ability both before and at peak height velocity. Additionally, a significant decrease in in COD speed was observed at peak height velocity.
Relative Age Effects (n=18)					
Baxter-Jones et al. (2020) (296)	*Country* = Canada *PS* = Regional *AG* = U12, U13, U14, U15, *n* = 64 (*team/club:* n = 1)	U12: 12.1 ± 0.5 yrs 1.56 ± 0.07 m 45.2 ± 8.5 kg U13: 12.7 ± 0.2 yrs 1.58 ± 0.05 m 47.1 ± 5.2 kg U14: 13.6 ± 0.3 yrs 1.63 ± 0.11 m 55.6 ± 6.4 kg U15: 14.4 ± 0.5 yrs 1.59 ± 0.07 m 54.7 ± 11.7 kg	To compare birth month, growth and maturity variables between players selected and deselected on to provincial sports teams.	*Data Collection*: Questionnaire (Sports Participation Activities), portable stadiometer (Seca Portable Stadiometer, Hamburg, Germany), portable digital scale (Toledo Scale Company, Thunder Bay, Canada). *Outcome Variables*: Chronological age, biological age, relative age, birth month quartiles (%). Anthropometrics - height (cm, *z-score*), body weight (kg, *z-score*), predicted adult height (cm). *Comparative Groups*: Age groups (U12 n = 12, U13 n = 21, U14 n = 24, 15 n = 7). Selection status (selected, de-selected). Sport (hockey, basketball, football, volleyball).	There were no differences observed between selected and deselected players in any age group.
Bennett et al. (2023) (297)	*Country* = Australia *PS* = National and regional *AG* = U14, U16, *n* = 12,527 (*team/club:* n = NS)	NS	To explore the prevalence of RAE in Australia's football talent pathway	*Data Collection*: Secondary data (Football Federation Australia). *Outcome Variables*: Birth quartile (n, %), probability of selection (%). *Comparative Groups*: Playing standard (all players in member federation n = 12,527, national premier league n = 1779, national youth championship n = 283).	In two (of six) member federations, there was a lower probability of being born in Q1 than Q4. There was a significantly higher probability of member federations within a larger talent pool selecting players who were born in the first half of the year.

Brustio et al. (2023) (298)	*Country* = Italy *PS* = International *AG* = U17, U19, *n* = 681 (*team/club:* n = 1)	NS	To determine the transition from youth-to-senior level, the prevalence of RAE when considering playing position, and the quartile rate on this transition in Italian football national teams.	*Data Collection*: Secondary data (Federazione Italiana Giuoco Calcio) *Outcome Variables*: Youth-to-senior transition rate, birth quartile (n, %), probability of selection (%). *Comparative Groups*: Age group (U17 n = 416, U19 n = 265, senior). Playing position (GK, DEF, MID, FWD).	Out of the 61 players who represented the senior team, 42 (69%) were selected from the youth squads, with 53% players representing both youth age groups. The likelihood of being selected in Q1 was significantly higher than Q4 in both U17 and U19 age groups. Position-specific RAE was presented for DEF and MID in U17s, but no position-specific RAE at U19s. Q4 had the largest proportion of youth-to-senior selection rate, which was only significantly different to Q3.
Ginés et al. (2023) (299)	*Country* = Spain *PS* = National *AG* = U12, U14, U16, *n* = 61 (*team/club:* n = NS)	U12: 11.9 ± 0.5 yrs U14: 12.2 ± 0.4 yrs U16: 12.8 ± 0.5 yrs	To compare the birth distribution, maturity status, and anthropometric characteristics of players from elite and nonelite academies	*Data Collection*: Questionnaire, anthropometric testing *Outcome Variables*: Birth quartile (n, %), age (yrs), height (cm), body mass (kg), BMI (kg.m^2). *Comparative Groups*: Playing standard (elite n = 41, non-elite n = 20). Age groups (U12 n = 21, U14 n = 17, U16 n = 23). Maturity status (early, on-time, late).	RAE was present in elite academies but not non-elite academies. However, no differences were observed within the age groups. In elite academies, there was a greater proportion of early maturing players in Q3 and Q4, and a higher proportion of late maturing players in Q2 and Q3 compared to non-elite academies.
Götze et al. (2021) (300)	*Country* = Germany *PS* = National & international *AG* = U19, *n* = 40 (*team/club:* n = 1)	NS	To investigate RAE in players competing at the top two German football leagues and German national teams.	*Data Collection*: Secondary data (Deutscher Fussball-Bund). *Outcome Variables*: Birth quartile (n, %). *Comparative Groups*: Playing standard (top domestic senior league n = NS, second domestic senior league n = NS, senior international n = NS, U20 international n = NS, U19 international n = NS).	No statistically significant RAE was observed at the U19 age group.
Grossman et al. (2013) (301)	*Country* = Germany *PS* = National *AG* = U15, U17, U19, *n* = NS (*team/club:* n = 1)	NS	To investigate RAE in youth national teams.	*Data Collection*: Secondary data (Deutscher Fussball-Bund). *Outcome Variables*: Median date of birth. *Comparative Groups*: Age group (U15 n = NS, U17 n = NS, U19 n = NS)	Non-significant RAE was observed in all age groups, however, no between age group differences.
Korgaokar et al. (2018) (302)	*Country* = USA. *PS* = Regional *AG* = U14, U15, U16, U17 and U18, *n* = 7294 (*team/club:* n = 73)	NS	To determine if birthdate distribution among elite female youth football players competing in the Elite Clubs National League differed from the general population	*Data Collection*: Secondary data (Elite Clubs National League). *Outcome Variables*: Birth quartile (n, %), half-year birth distribution. *Comparative Groups*: Age group (U14 n = NS, U15 n = NS, U16 n = NS, U17 n = NS, U18 n = NS).	There was an overrepresentation of Q1 players and underrepresentation of Q4 players in all age groups (compared to the general population). For all age groups except U18s, the majority of players were born in the first half of the season (i.e. Q1 and Q2). The magnitude of the effect decreased as age increased.

Lagestad et al. (2018) (303)	*Country* = Norway *PS* = Local & regional *AG* = U14, U15, *n* = 545 (*team/club:* n = 1)	NS	To examine the RAE at different selection stages of the regional team in 2015/16 season.	*Data Collection*: Secondary data (Troendelag Regional Football Association). *Outcome Variables*: Median date of birth, half-year birth distribution. *Comparative Groups*: Selection stage (1st, 2nd, 3rd). Age group (U14 n = 277, U15 n = 268).	Most of the U14 (72%) and U15 (67%) players in the regional team (3rd selection stage) were born in the first half of the year. As the selection process advances, the variation of birth dates significantly reduces.
Li et al. (2019) (304)	*Country* = China *PS* = National *AG* = U18, *n* = 537 (*team/club:* n = 34)	NS	To examine the presence of RAEs in elite Chinese football players.	*Data Collection*: Secondary data (Chinese Football Association, China National Games Organization Committee). *Outcome Variables*: Birth quartile (n, %), half-year birth distribution. *Comparative Groups*: Age group (U18, senior).	RAE was observed in the U18 age group, with 57% of players born in the first half of the selection year.
Matušica et al. (2023) (305)	*Country* = European countries *PS* = International *AG* = U17, U19, *n* = 294 (*team/club:* n = NS)	NS	To examine RAE in elite youth football competitions.	*Data Collection*: Secondary data (UEFA). *Outcome Variables*: Birth quartile (n, %). *Comparative Groups*: Age group (U17 n = 134, U19 n = 160).	In the UEFA Women's European Championships 2022, RAE was observed in both age groups. Q1 was significantly dominant compared to Q4 in U17s (Q1 = 35%; Q4 = 16%), and Q2 was significantly dominant compared to Q4 in U19s (Q2 = 36%; Q4 = 16%).
Pedersen et al. (2022) (306)	*Country* = Global *PS* = International *AG* = U17, *n* = 2016 (*team/club:* n = NS)	NS	To investigate the variations in RAE in FIFA World Cup tournaments.	*Data Collection*: Secondary data (FIFA). *Outcome Variables*: Birth quartile (n, %). *Comparative Groups*: Age group (U17 n = 2016, U20 n = NS, senior n = NS). Year of competition (biennial, 2008 – 2018)	RAE was not observed in tournaments between 2008 and 2012 but was present in 2014 and 2018 competitions with an increasing proportion of Q1 players across time.
Ribeiro et al. (2023) (307)	*Country* = Global *PS* = International *AG* = U17, *n* = 336 (*team/club:* n = NS)	NS	To analyse the RAE in 2018/19 FIFA Women's World Cups, according to age group, playing position, progression in the competition, and continental governing bodies.	*Data Collection:* Secondary data (FIFA). *Outcome Variables*: Birth quartile (n, %). *Comparative Groups*: Age group (U17 n = 336, U20 n = NS, senior n = NS). Playing position (GK, DEF, MID, FWD). Continental governing body (AFC, CONCAF, CONCACAF, CONMEBOL, OFC, UEFA).	There was a significant overrepresentation of players born in Q1 in U17s, with position-specific RAE observed across all playing positions except GKs.
Romann et al. (2013) (308)	*Country* = Global *PS* = International *AG* = U17, *n* = 672 (*team/club:* n = 23)	1.65 ± 0.06 m	To examine the prevalence of RAEs in national teams in the 2008 and 2010 FIFA Women's World Cup and by playing positions.	*Data Collection:* Secondary data (FIFA). Outcome *Variables*: Birth quartile (n, %), height (cm). *Comparative Groups*: Country (Brazil, Canada, Chile, Colombia, Costa Rica, Denmark, England, France, Germany, Ghana, Ireland, Japan, Korea DVR, Korea Republic, Mexico, New Zealand, Nigeria, Paraguay, South Africa, Spain, Trinidad and Tobago, USA, Venezuela). Continental	Only four (of 23) countries had significant RAEs (Trinidad and Tobago, Ghana, Nigeria and Ireland). Q1 players were significantly over-represented compared to Q4 payers for UEFA and CONCACAF as well as GK and DEF in these governing bodies. The opposite was found for the CONCAF

				governing body (AFC, CONCAF, CONCACAF, CONMEBOL, OFC, UEFA). Playing position (GK, DEF, MID, FWD).	governing body where Q4 players were significantly over-represented compared to Q1 players, but the same trend was also seen for GK and DEF.
Sedano et al. (2015) (309)	*Country* = Spain *PS* = Regional *AG* = U17, U19, *n* = 278 (*team/club:* n = 1)	NS	To examine RAE in Spanish female football, and if playing positions modified the prevalence and size of RAEs.	*Data Collection:* Secondary data (Spanish Royal Federation of Football). *Outcome Variables*: Birth quartile (n, %), half-year birth distribution. *Comparative Groups*: Competitive level (regional team, international teams, senior domestic top-, second, and third tier). Playing position (GK, DEF, MID, FWD).	RAE was observed in the U17 & U19 regional teams, with a significant over-representation in Q1 and Q2 compared to Q3 and Q4. Significant RAE was observed for GK and DEF regarding half-year birth distribution.
Simon et al. (2022) (310)	*Country* = Luxembourg *PS* = Local *AG* = U15, U19, *n* = 396 (*team/club:* n = NS)	U15: 12.9 ± 1.2 yrs U19: 16.5 ± 1.1 yrs	To determine the prevalence of RAE in Luxembourgish youth football.	*Data Collection*: Secondary data (Luxembourgish Football Federation). *Outcome Variables*: Birth quartile (n, %), half-year birth distribution. *Comparative Groups*: Age group (U15 n = 299, U19 n = 97). Success of teams (U15 only; top 6, bottom-6).	No RAE was observed in either age group, or within top or bottom 6 teams in the U15 age group.
Smith et al. (2022) (311)	*Country* = Canada *PS* = Local and regional *AG* = 10 - 16 yrs, *n* = 2327 (*team/club:* n = NS)	NS	To examine dropout across a seven-year period with respect to RAE.	*Data Collection*: Secondary data (Ontario Football). *Outcome Variables*: Birth quartile (n, %), half-year birth distribution. *Comparative Groups*: Chronological age (10, 11, 12, 13, 14, 15, 16yrs n = NS). Playing standard (recreational n = NS, competitive n = NS).	RAE was present across the 7-year period, with a significant over-representation of competitive players born in Q1 compared to Q4.
Van den Honert et al. (2012) (312)	*Country* = Australia *PS* = National *AG* = U15/U17, *n* = 268 (*team/club:* n = 1)	NS	To examine RAE in talented players in Australia, and whether RAE changes with age.	*Data Collection:* Secondary data (Football Federation Australia). *Outcome Variables*: Birth quartile (n, %). *Comparative Groups*: Age group (U15/U17 n = 268, seniors n = NS).	No statistically significant RAE was present in a combined sample of U15/U17 age groups for players competing in national youth championships.
Vincent et al. (2006) (313)	*Country* = USA *PS* = Regional and national *AG* = U17, U19, *n* = 875 (*team/club:* n = NS)	NS	To investigate RAE of state, regional and national team players within the Olympic Development Program.	*Data Collection*: Secondary data (US Youth Football Federation, United States Football Federation). *Outcome Variables*: Birth quartile (n, %). *Comparative Groups*: Playing standard (regional n = 804, national n = 71).	No RAE was observed in U17 state or U17 regional teams. However, significant RAE was observed in the U19 US national team with Q1 being most represented.
Testing Studies (n=7) Sally					
Castagna et al. (2010) (314)	*Country* = Italy *PS* = Regional *AG* = NS, *n* = 26	12.1 ± 0.9 yrs 1.55 ± 0.05 m 50.0 ± 9.2 kg	To assess the criterion validity and the accuracy in	*Data collection:* Portable lightweight breath-by-breath gas analyser (K4b2; Cosmed, Rome, Italy), HR monitors (Polar NV, Finland), portable CD player (Az1030 CD player; Phillips, The Netherlands).	The multistage fitness test significantly underestimated $\dot{V}O_2$peak by 23% in young female football players Despite this underestimation, directly measured

	(*team/club:* n = 1)		estimating maximal aerobic power ($\dot{V}O_2$max) of a shuttle running field test (multistage fitness test) in female football players.	*Outcome variables:* Estimated VO_2 Max (ml·kg^{-1}·min^{-1}), VO_2 Max (ml·kg^{-1}·min^{-1}), HR (beats·min^{-1}), VO_2peak (ml·kg^{-1}·min^{-1}). *Comparative groups:* Data collection method (with gas analysis; multistage fitness test (MSFT) peak oxygen uptake), estimated (without gas analysis; MSFT). Group completed each condition.	$\dot{V}O_2$peak significantly related to multistage fitness test performance (i.e. distance covered), indicating that this test may serve as an indirect measure of individual $\dot{V}O_2$max in this population.
Fältström et al. (2023) (315)	*Country* = Sweden *PS* = NS *AG* = NS, *n* = 49 (*team/club:* n = NS)	14.0 ± 0.8 yrs	To study the side hop test regarding validity, reliability, and movement quality in relation to sex, age and ACL-reconstruction in football players.	*Data collection:* Video camera (50fps Panasonic HC-V500, 50fps Sony HDR-CS260, 50fps GoPro Hero5). *Outcome variables:* BMI (kg.m^2), side hop test valid hops frequency (n), times the non-hopping limb touched the floor (n), times the hopping limb touched the strips (n). *Comparative groups:* Age group (female youth n = 49, senior n = 46). Knee health (knee-healthy, ACL re-constructed females).	All reliability measures were excellent (ICC 0.92−1.0). Youth female players exhibited significantly more movement flaws than senior age groups, especially in double hops/foot turns with the hopping limb.
Jastrzębska et al. (2023) (109)	*Country* = Poland *PS* = Regional *AG* = U12, *n* = 14 (*team/club:* n = NS)	11.6 ± 0.6 yrs 1.53 ± 0.09 m 45.0 ± 9.3 kg	To investigate the usefulness of the running-based anaerobic sprint test in anaerobic performance estimation, and the effect of an 8-week training period in female U12 football players on anaerobic performance.	*Data collection:* Cycle ergometer (Monark 895E, Monark, Sweden), Smart Speed telemetric chronometer (Fusion, Australia). *Outcome variables:* BMI (kg.m^2), relative Power (W.kg^{-1}), peak power (W), mean power (W), minimum power (W), relative work (J.kg^{-1}), time to achieve peak power (s), time of maintaining peak power (s). *Comparative groups:* Playing status (female football players n = 14, untrained females n = 12). Pre and post 8-week period.	An 8-week training programme led to a significant increase in the anaerobic performance of the football players. Peak, average, and relative power were significantly improved in both the Wingate and running-based anaerobic sprint test. There was a strong, statistically significant correlation between the two tests, supporting the running-based anaerobic sprint test as a valid, field-based alternative to the lab-based Wingate test for assessing anaerobic power in young female football players.
Lesinski et al. (2016) (316)	*Country* = Germany *PS* = NS *AG* = NS, *n* = 19 (*team/club:* n = NS)	14.7 ± 0.6 yrs 1.65 ± 0.05 m 57.6 ± 6.2 kg	To verify concurrent validity of the Gyko inertial sensor system alongside a force plate and Optojump device for the assessment of vertical jump height.	*Data collection:* Gyko inertial system and GykoRePower Software (Microgate, Italy), personal computer (Lenovo, model T530 & Sony Vaio, Model PCG-51113 M), Kistler force-plate (1000Hz, Kistler, Switzerland), photoelectric cell system (1000Hz, Optojump, Microgate, Italy),. *Outcome variables:* Jump height (cm). *Comparative groups:* Data collection method (Kistler force plate, Gyko system).	The Gyko system cannot be used interchangeably with a Kistler force-plate and the Optojump device in trained youth female football players due to systematic and random measurement biases.
Pardos-Mainer et al. (2019) (317)	*Country* = Spain *PS* = National, regional *AG* = U16, U18, *n* = 60	U16: 14.2 ± 1.6 yrs 1.58 ± 0.07 m 51.8 ± 7.8 kg	To assess the reliability, sensitivity and performance changes across the season of jumping,	*Data collection:* Timing gate (Microgate, Italy), photoelectric cell system (Optojump, Microgate, Italy), dual beam photocell systems (Microgate, Italy).	Jumping, linear sprinting and change of direction ability tests demonstrated good reliability and sensitivity in U16 and U18 female football players. These tests were effective in detecting moderate to large

	(*team/club:* n = 1)	U18: 17.1 ± 0.8 yrs 1.60 ± 0.06 m 58.4 ± 10.1 kg	linear sprinting and change of direction ability tests in adolescent female football players.	*Outcome variables:* CMJ (cm), unilateral CMJ (cm), single leg hop test (cm), 10/20/30/40m Sprint (s), 180° COD V-cut - 25m sprint test (s). *Comparative groups:* Age group (U16 n = 37, U18 n = 23). Test (reliability) (Jumping, linear sprinting, COD ability).	performance changes across a season, making them useful tools for monitoring physical performance in this population.
Sonesson et al. (2021) (318)	*Country* = Sweden *PS* = NS *AG* = NS, *n* = 49 (*team/club:* n = 8)	14.0 ± 0.8 yrs 1.64 ± 0.07 m 55.0 ± 9.0 kg	To evaluate the correlation between seven different performance tests and two neuromuscular control tests in youth football players and to evaluate the influence of age groups on test results.	*Data collection:* Photoelectric cells (MuscleLab 4010, Ergotest Technology, Norway), infrared contact mat (MuscleLab 4010, Ergotest Technology, Norway), video camera (50fps, GoPro Hero 5 cameras). *Outcome variables:* Agility t-test (s), 505 agility test (s), side hop (cm), CMJ (cm), 10/20m sprint (s), tuck Jump assessment (n), drop VJ (n). *Comparative groups:* Age group (U13 n = NS, U14 n = NS, U15 n = NS). Performance test (agility, jumping and sprint ability).	Sprint performance was significantly correlated with agility and jump performance; however, drop vertical jump did not correlate with the other performance tests. No significant differences across age groups were observed.
Wright et al. (2020) (319)	*Country* = England *PS* = Regional *AG* = NS, *n* = 33 (*team/club:* n = NS)	15.0 ± 1.0 yrs 1.63 ± 0.07 m 55.0 ± 9.0 kg	To understand the validity of differential ratings of perceived exertion as measures of training and match internal loads in youth female football players.	*Data collection:* Touch screen tablet application (Iconia One 7 B1-750, Acer Inc, Taiwan), CentimMax scale (CR100). *Outcome variables:* Differential RPE for breathlessness and leg muscles exertion rating (score, n). *Comparative groups:* Training type (football, resistance and fitness). RPE scale (differential RPE for breathlessness, differential RPE leg muscles exertion rating).	Significant differences in differential rating of perceived exertion scores following physical training sessions, coupled with low shared variance across all training types and matches, suggest that differential rating of perceived exertion scores for breathlessness and differential rating of perceived exertion scores for leg muscle exertion capture unique sensory inputs in female football players.

NS = not specified. PS = playing standard. AG = age group. AU = Arbitrary Units. BMI = Body Mass Index. SJ = Squat Jump. CMJ = Countermovement Jump. VJ = Vertical Jump. SBJ = Standing Broad Jump. COD = Change of Direction. BMD = Bone Mineral Density. RMR = Resting Metabolic Rate. FFM = Fat Free Mass. Yo-Yo IR1 = Yo-Yo Intermittent Recovery Test Level 1. PHV = Peak Height Velocity. ROM = Range of Motion. RANKL = Receptor Activator Nuclear Factor Kappa-β Ligand. OC = Osteocalcin. P1NP = Amino-terminal Propeptide of Type-1 Collagen. ECG = Electrocardiogram. GK = Goalkeeper. DEF = Defender. MID = Midfielder. FWD = Forward. RPE = Rate of Perceived Exertion. HR_{MAX} *= Maximum Heart Rate. RAE = Relative Age Effects.*

Appendix 7. Characteristics, aim, methods, and key findings of psychology studies (n=28)

Study	**Cohort/ sample size (n)**	**Participant characteristics: age, height, body mass**	**Aim**	**Methods**	**Key findings**
Ando et al. 2023 (327)	*Country* = Japan *PS* = National *AG* = U18, *n* = 17 (*team/club:* n = NS)	17.2 ± 0.7 yrs 54.2 ± 5.0 kg	To investigate the impact of consecutive summer matches on the cognitive functions of female football players.	*Data collection:* Refractometer (PAL-09S; Shiro Sangyo, Osaka, Japan), cognitive function assessment (Go/No-Go task, Schuhfried GmbH, Austria). *Outcome variables:* Reaction time (ms), body weight (kg), USG (au), accuracy (%). *Comparative groups:* Hydration status (dehydration, normal). Time period (pre-game, 1st game, 2nd game, 1st rest, 3rd game, 4th game, 2nd rest, 5th game).	Cognitive function improved over the course of the tournament. Symptoms of dehydration were not found to be associated with impaired cognitive function.
Beavan et al. 2022 (328)	*Country* = Germany *PS* = National *AG* = U14, U15, U17, *n* = 157 (*team/club:* n = 5)	NS	To explore the age-related developmental patterns of executive functions within a female-only cohort of highly talented soccer players. To measure the influence of playing position on these players' cognitive development.	*Data collection:* Determination test (Schuhfried GmbH, Austria), response inhibition test (Schuhfried GmbH, Austria), cognitive function assessment (Go/No-Go task, Schuhfried GmbH, Austria), N-Back Nonverbal Test (Schuhfried GmbH, Austria), 180°-multiple objects tracking task (SAP, Walldorf, Germany), 360°-multiple objects tracking task (Anton Paar SportsTec GmbH, Austria). *Outcome variables:* Determination test correct answer (n), determination test resction time (ms), Go/No-Go reaction time (ms), Go/No-Go errors (n), N-Back test correct answers (n), N-back test response time (ms), 180°-multiple objects tracking task accuracy (au) 360°-multiple objects tracking task accuracy (au). *Comparative groups:* Age group (U14 n = 7, U15 n = 70, U17 n = 80).	Player's cognitive ability developed before reaching early adulthood. Age has a negatively accelerated relationship with executive functions and doesn't differ between playing position.
Burton et al. 2011 (329)	*Country* = USA *PS* = Regional *AG* = U15, *n* = 214 (*team/club:* n = NS)	14.6 yrs	To examine self-talk dimensions in sport, identify whether motivation styles are represented in this sample and compare profiles on self-talk dimensions and related constructs.	*Data collection:* Self-talk assessment (Soccer Self-Talk Practices Questionnaire), confidence assessment (Trait Sport Confidence Inventory), achievement goal orientations assessment (The Task and Ego Orientation in Sport Questionnaire), perfectionism in sport assessment (Multidimensional Perfectionism Scale), trait anxiety assessment (Sport Anxiety Scale). *Outcome variables:* Self-Confidence and Task- and Ego-Orientation Z-Scores (au), self-talk frequency (positive, negative) (au), self-talk effectiveness (au), trait anxiety scores (somatic anxiety, worry, concentration disruption) (n), *Comparative groups:* Motivational style (mastery orientation, success orientation, failure orientation).	Four motivational styles identified (social, failure, mastery and success-oriented-plus). Success orientated players significantly outperformed mastery-oriented players. Mastery and success oriented motivational styles utilised self-talk significantly more effectively than other styles.

Burton et al. 2013 (330)	*Country* = USA *PS* = Regional *AU* = U15, *n* = 211 (*team/club:* n = NS)	14.6 yrs	To examine the role of "perceived effectiveness" as a relevant self-talk attribute using an exploratory instrument designed to measure multiple self-talk dimensions/attributes as well as psychosocial correlate variables.	*Data collection:* Self-talk assessment (Soccer Self-Talk Practices Questionnaire), confidence assessment (Trait Sport Confidence Inventory), achievement goal orientations assessment (The Task and Ego Orientation in Sport Questionnaire), perfectionism in sport assessment (Multidimensional Perfectionism Scale), trait anxiety assessment (Sport Anxiety Scale). *Outcome variables:* Positive self-talk frequency (au), frequency of counter arguments to refute negative thoughts (au), performance impairment frequency (au), self-talk strategy frequency (au). *Comparative groups:* Self-talk effectiveness profile (ineffective n = 46, strategy users n = 63, effective n = 102).	An effective self-talk profile demonstrated significantly more positive psychosocial outcomes compared to ineffective and strategy self-talk profiles.
Che et al. 2023 (331)	*Country* = China *PS* = Regional *AG* = U13-U18, *n* = 24 (*team/club:* n = NS)	14.35 ± 0.42 yrs	To measure the heart rate variability of adolescent soccer players during MOT tasks to investigate the association of flow experience with learning efficiency in 3D-multiple object tracking.	*Data collection:* 180°-MOT task (SAP, Walldorf, Germany), 360°-MOT task (Anton Paar SportsTec GmbH, Austria), VR headset (90Hz, HTC Vive™, HTC Corporation, Taiwan, China), ECG recording (SOMNOtouch™ RESP, SOMNOmedics, Germany). *Outcome variables:* Speed ratio, time-between RR intervals (ms), percent of high frequency (%), percent of low frequency (%), percent of heart rate variability frequency domain (%). *Comparative groups:* MOT task type (2D, 3D). Trial time period (first period, mid period, last period).	Players demonstrated significantly higher learning efficiency in 3D-MOT tasks in VR through a higher flow experience.
Duguay et al. 2020 (332)	*Country* = Canada *PS* = Local *AG* = U14-U18, *n* = 68 (*team/club:* n = 15)	NS	To use social network analysis to visualise and quantify examine teamwork leadership across multiple levels.	*Data collection:* Leadership nominations network (roster-based questionnaire completed by players). *Outcome variables:* Leadership influence – dichotomised indegree centrality score (au). *Comparative groups:* Leadership status (formal leader, informal leader, no leadership status). Team (team 1, team 2, team 3, team 4).	Leadership was shared within the teams. Showed that skill nomination and formal leadership status significantly predicted how often participants looked to their teammates for leadership.
Fältström et al. 2022 (333)	*Country* = Sweden *PS* = Regional *AG* = U13-U19, *n* = 419 (*team/club:* n = 27)	13.9 ± 1.1yrs 1.63 ± 0.07m 53 ± 9.0kg	To report descriptive characteristics of lifestyle factors in adolescent female football players and potential changes over 1 year.	*Data collection:* Demographics, lifestyle factors, football related factors, sleeping habits questionnaire (NS), coping assessment (Brief COPE questionnaire). *Outcome variables:* Lifestyle factors: smoking, snus, alcohol, skipping breakfast/lunch/dinner, protein supplements, medication (never, rarely, a few times/year, a few times/month, several times/week) (n). Sleeping habits: sleeping hours (6-7.5hrs, 8hrs, 8.5-10hrs), sleeping problems, tiredness, daytime consequences (never, rarely, a few times/year, a few times/month, several times/week) (n). Well-being and passion: stress (never, sometimes/month, some days/week, most days/week) (n), education in sport psychology, regular contact with sport psychology consultant (yes in school, yes with the team, yes	Many of the participants were found to have insufficient sleeping habits, skip breakfast and lunch as well as experience stress. These factors increased from baseline to the 1-year follow-up.

				private, yes other, several options) (n). Brief COPE (au). Passion scale (n). General Health Questionnaire (au). *Comparative groups:* Age (12 yrs n = 97, 13 yrs n = 158, 14 yrs n = 91, 15-17 yrs n = 73). Time period (baseline, 1-year follow-up).	
Forsman et al. 2016 (334)	*Country* = Finland *PS* = NS *AG* = U10-U15, *n* = 358 (study 1), 261 (study 2) (*team/club:* n = NS)	NS	To create a valid, self-reported, game-specific soccer competence scale.	*Data collection:* Sports performance (Perceived Game-Specific Soccer Competence Scale, The Tactical Skills Inventory for Sport). Motivation levels (The Psychological Skills Inventory motivation subscale). Photocells (Newtest Oy, Finland). *Outcome variables:* Competence, tactical skills, motivation, technical skills and speed and agility characteristics mean score (au). *Comparative groups:* NS	Results of factor analyses, tests of internal consistency and correlations between Perceived Game-Specific Soccer Competence Scale subscales, performance measures and motivation supported the reliability and validity of the Perceived Game-Specific Soccer Competence Scale.
Harris et al. 2020 (335)	*Country* = USA *PS* = Regional *AG* = U13, *n* = 3 (*team/club:* n=NS)	NS	To determine whether a BST package increased the accuracy of youth female soccer athletes performing a specific zigzag movement pattern.	*Data collection:* Camera (GoPro HERO6 video camera), measuring tape (NS). *Outcome variables:* Correct steps performed (%). *Comparative groups:* Player to player comparison. Session (1-24). Session stage (baseline, BST, generalisation, maintenance).	Results showed a significant improvement in the number of steps the participants performed correctly relative to baseline, as well as maintenance of skills at follow-up.
Höner et al. 2019 (336)	*Country* = Germany *PS* = Regional and National *AG* = U12, *n* = 499 (*team/club*: n = NS)	11.4 ± 0.3 yrs 1.49 ± 0.07 m 38.5 ± 6.0 kg	To analyse the prognostic relevance of motor tests for players' future selection level in female soccer and assess the role of sex as a moderator variable.	*Data collection:* Timing gate (Brower TC Timing, Draper, USA). *Outcome variables:* 20m sprint (s), agility test (s), dribbling test (s), ball control test (s), shooting test (au). *Comparative groups:* Playing standard (national team, regional association team, not further selected).	Players' performance in motor diagnostics significantly discriminated between all 3 selection levels. Future national team players significantly outperformed non-selected players.
Kontos et al. 2011 (337)	*Country* = USA *PS* = Regional *AG* = U13-U18, *n* = 27 (*team/club:* n = 4)	15.8 ± 0.6 yrs 1.65 ± 0.05 m 56.0 ± 6.1 kg	To investigate the relationship between soccer heading and computerized neurocognitive performance and symptoms in female and male youth soccer players.	*Data collection:* Immediate Post concussion Assessment and Cognitive Testing (NS). *Outcome variables:* Headers in games (n), headers in practices (n), verbal memory score (n, %), visual memory score (n, %), motor processing speed score (n), reaction time (s), symptoms (n). *Comparative groups:* Heading exposure (low, moderate, high).	No significant differences in neurocognitive performance or symptoms among low, moderate, and high-exposure header groups.
Kuettel et al. 2022 (338)	*Country* = Denmark *PS* = National *AG* = U15-16, U17, U18, U19, *n* = 57 (*team/club:* n = NS)	NS	To investigate gender differences in mental health among Danish youth soccer players. To discover the mental health profiles of players and explore how career progression and mental health are related.	*Data collection:* Mental well-being assessment (Short Warwick-Edinburg Mental Well-Being Scale – seven item version), anxiety assessment (Generalised Anxiety Disorder questionnaire), depression assessment (Centre for Epistemological Study Depression Scale). *Outcome variables:* Well-being score (n), anxiety score (n) depression score (n). Symptoms (minimal/mild, moderate symptoms, severe symptoms) (n).	Players scored significantly lower on mental well-being as well as presenting four times higher odds of expressing symptoms of anxiety & depression. Findings suggest that the transition to senior football presented mental health challenges for female players.

				Comparative groups: Age group (U15-16 n = 25, U17 n = 12, U18 n = 11, U19 n = 9).	
Leyhr et al. 2020 (339)	*Country* = Germany *PS* = National *AG* = U12, U13, U14, U15, *n* = 737 (*team/club:* n = NS)	NS	To investigate the long-term prognostic validity of elite female soccer players' adolescent motor performance for future success in adulthood.	*Data collection:* Timing gate (Brower TC Timing, Draper, USA). *Outcome variables:* 20m sprint (s), agility test (s), dribbling test (s), ball control test (s), shooting test (au). *Comparative groups:* Age group (U12, U13, U14, U15). Adult performance level (professional, non-professional).	Motor performance development itself cannot adequately predict players' future success in adulthood.
Miller et al. 2004 (340)	*Country* = Norway *PS* = International *AG* = U12-U14, *n* = 202 (*team/club:* n = NS)	NS	To investigate the influence of perceived motivational climate and gender on sports-personship behaviour of competitive youth football players.	*Data collection:* Motivational climate assessment (Perceived Motivational Climate in Sport Questionnaire), sports-personship orientation assessment (Multidimensional Sports-Personship Orientation Scale). *Outcome variables:* Motivational climate score (n), Sports-personship score (n). *Comparative groups:* NS	Players perceiving a high mastery climate endorsed sports-personship more.
Miller et al. 2005 (341)	*Country* = Norway *PS* = International *AG* = U16, *n* = 340 (*team/club:* n = NS)	NS	To investigate the differential effect of perceived coach-created performance and mastery climates on moral functioning, team moral atmosphere perceptions, and the legitimacy of injurious acts among competitive youth football players.	*Data collection:* Motivational climate assessment (Perceived Motivational Climate in Sport Questionnaire), moral functioning and atmosphere assessment - four component model (Kavussanu & Roberts, 2001). *Outcome variables:* Motivational climate (mastery, performance) score (n), moral functioning (judgement, reasoning, intention, behaviour) score (n), moral atmosphere (teammates, coach) score (n). *Comparative groups:* NS	High performance/mastery climate significantly predicted lower moral judgment as well as the legitimacy of using physical intimidation. Perceiving a performance climate significantly predicted overall low sport morality. Findings further emphasize the low moral effect of a high perceived coach-created performance climate in competitive youth football.
Møllerløken et al. 2017 (342)	*Country* = Norway *PS* = Regional *AG* = U15-U17, *n* = 128 (*team/club:* n = 17)	15.7 yrs	To directly compare players' and coaches' perceptions of the motivational climate within their respective teams.	*Data collection:* Motivational climate assessment (Perceived Motivational Climate in Sport Questionnaire). *Outcome variables:* Motivational climate (mastery, performance) score (n), lower-order factors (cooperative learning, effort and development, role importance, intra-team member rivalry, uneven recognition, intolerance of mistakes) score (n). *Comparative groups:* Players n = 128, coaches n = 29.	Significant differences were found between players and coaches' perception of motivational climate. Players perceived motivation as more performance-oriented and less mastery oriented.
Moore et al. 2020 (343)	*Country* = USA *PS* = Local *AG* = U12-U14, *n* = 97 (*team/club:* n = NS)	NS	To examine the possible effect of coach-fostered caring, task-, and ego-involving climates on athletes' definitions of success in sport.	*Data collection:* Success perception assessment (Perceptions of Success Questionnaire), task and ego-involving motivational climate assessment (The Motivational Climate in Youth Sport Scale), caring climate perception assessment (The Caring Climate Scale). *Outcome variables:* Ego-involving motivational climate score (n), task-involving motivational climate score (n), caring climate score (n), ego goal orientation score (n), task goal orientation score (n).	Females' focus on achieving task goals was strongly influenced by their perception of a supportive and encouraging climate. The experience of the Olympic development program had less influence on players goal-oriented mindset than club team.

				Comparative groups: Birth year (2002 n = 59, 2003 n = 38).	
Morales-Sánchez et al. 2022 (344)	*Country* = Spain *PS* = Regional *AG* = U14-U19, *n* = 50 (*team/club:* n = 6)	NS	To analyse whether the perception of the motivational climate in young soccer players determines the level of competitive anxiety and self-confidence.	*Data collection:* Anxiety symptoms assessment (Competition Anxiety State Inventory-2), motivational climate assessment (Perceived Motivational Climate in Sport Questionnaire-2), self-confidence assessment (Self-confidence in Sport Competition Questionnaire). *Outcome variables:* Motivational climate (ego, task) score (n), anxiety symptoms (cognitive, somatic, self-confidence) score (n), confidence assessment (self-confidence, insecurity) score (n). *Comparative groups:* NS.	The perception of the motivational climate was positively related to cognitive anxiety and insecurity, and inversely to self-confidence. Players showed a greater intensity in the relationships related to ego climate and lower scores in self-confidence, as well as higher scores in insecurity.
Munroe-Chandler et al. 2005 (345)	*Country* = Canada *PS* = Local *AG* = U13, *n* = 13 (*team/club:* n = 1)	12.54 ±0.66 yrs	To determine the effectiveness of a cognitive general imagery intervention on three distinct soccer strategies in a young elite female soccer team.	*Data collection:* Sport imagery assessment (Sport Imagery Questionnaire), imagery assessment (Imagery Assessment Questionnaire), video camera (NS). *Outcome variables:* Imagery score (n), cognitive general imagery score (n), cognitive specific imagery score (n), motivational general-arousal score (n). *Intervention:* Imagery intervention – Three different imagery scripts (1 defending free kicks, 2 taking a free kick, 3 defending a corner kick). *Comparative groups:* Intervention period (baseline, post-intervention). Time period (weeks 1-8).	Use of Cognitive general and cognitive specific imagery as well as motivational general-arousal imagery significantly increased from baseline to post intervention.
Olmedilla et al. 2021 (346)	*Country* = Spain *PS* = Regional *AG* = U15-U19, *n* = 175 (*team/club*: n = NS)	17.02 ± 1.50 yrs	To determine if there are differences in the psychological profile of youth soccer players related to sports performance.	*Data collection:* Psychological characteristics assessment (Psychological Characteristics Questionnaire Related to Sports Performance). *Outcome variables:* Stress control score (n), influence of performance evaluation score (n), motivation score (n), mental ability score (n), team cohesion score (n). *Comparative groups:* NS	Players reported feeling more attracted and identified with the group, in reference to both informal and sports relationships. Players with high team cohesion show a greater tendency to work in groups and strengthen the team.
Ommundsen et al. 2005 (347)	*Country* = Norway *PS* = International *AG* = U12-U19, *n* = 488 (*team/club:* n = NS)	13.9±1.8 yrs	To examine the relationship between the perceived motivational climate, achievement goals, perfectionism and indices of peer relationships in a sample of young female Norwegian soccer players.	*Data collection:* Motivational climate assessment (Perceived Motivational Climate in Sport Questionnaire), task and ego orientation assessment (Perception of Success in Sport Questionnaire), adaptive and maladaptive perfectionism assessment (The Multidimensional Perfectionism Scale), quality of friendship assessment (Sport Friendship Quality Scale). *Outcome variables:* Achievement goals (task, ego) score (n), motivational climate (mastery, performance) score (n), perfectionism (maladaptive, adaptive) score (n), quality of friendship (loyalty & free discuss, companionship, conflict) score (n), peer acceptance score (n).	Female players reported good relations with their peers in soccer. Findings suggest that qualities of motivation have a systematic relationship with peer acceptance and friendship qualities of friendship in female youth soccer.

				Comparative groups: NS	
Perroni et al. 2018 (348)	*Country* = Italy *PS* = NS *AG* = U17, *n* = 16 (*team/club:* n = 1)	16.3 ± 0.6 yrs 1.66 ± 0.10 m 55.7 ± 5.9 kg	To evaluate the eventual technical differences of female soccer players, and relationship among anthropometrics characteristics, soccer experiences, and soccer performances.	*Data collection:* Fixed stadiometer and weighing scale (Seca 702, Seca GmbH & Co. KG, Hamburg, Germany). Juggling test (left/right foot, chest, head), speed dribbling (with/without ball), long passing, short passing, shooting (dead ball, from pass), heading (front of middle of goal, from right goalpost). *Outcome variables:* Speed dribbling test (s), juggling (points) (n), heading (points) (n). *Comparative groups:* Speed dribbling test (with ball, without ball).	Significant correlations were found between player height and head-left foot-right foot juggling order as well as BMI.
Price et al. 2011 (349)	*Country* = USA *PS* = National *AG* = U15-U18, *n* = 191 (team/club: n = NS)	16.1 ± 1.0 yrs	To examine peer leadership in sport using transformational leadership theory as a framework.	*Data collection:* Perceived soccer competence, perceived behavioural conduct and perceived peer acceptance assessments (Self-Perception Profile for Adolescents), intrinsic motivation assessment (Motivational Orientation in Sport scale), peer leadership assessment (Sport Leadership Behaviour Inventory), team cohesion assessment (The Group Environment Questionnaire), collective efficacy assessment (The Collective Efficacy Questionnaire for Sports). *Outcome variables:* Personal characteristics - perceived soccer competence, intrinsic motivation, perceived peer acceptance, perceived behavioural conduct (score) (n). Peer leadership behaviours - instrumental leadership, prosocial leadership, instrumental/prosocial leadership (score) (n). Team outcomes – task cohesion, social cohesion, collective efficacy (score) (n). *Comparative groups:* NS	Peer leaders were characterised by higher perceived soccer competence, peer acceptance, behavioural conduct, and intrinsic motivation. Effective peer leadership was associated with players who reported greater task and social cohesion and collective efficacy.
Scanlan et al. 1979 (350)	*Country* = USA *PS* = Regional *AG* = U10-U12, *n* = 192 (*team/club:* n = 16)	NS	To examine the factors affecting the pre- and postgame performance expectancies of young female soccer players. To identify the determinants of post-game team performance expectancies.	*Data collection:* Performance expectancy measurement (questionnaire) completed pre-game and post-game. Competitive trait anxiety assessment (Sport Competition Anxiety Test). *Outcome variables:* Game outcome expectancy (win, tie, loss) (n). *Comparative groups:* Game stage (pre-game, post-game, adjusted post-game).	Soccer ability and self-esteem were found to be related to personal performance expectancies, but competitive trait anxiety was not. Winning players evidenced higher team expectancies than players who tied or lost.
Scanlan et al.1979* (351)	*Country* = USA *PS* = Regional *AG* = U10-U12, *n* = 192 (*team/club*: n = 16)	NS	To examine the intrapersonal and situational factors related to the stress experienced by 10- to 12-year-old girls participating in competitive youth soccer.	*Data collection:* Competitive trait anxiety assessment (Sport Competition Anxiety Test), self-worth assessment (Rosenberg Self-Esteem Scale), popularity with peer's assessment (Piers-Harris Self-Concept Test), self-esteem regarding home environment assessment (Coopersmith Self-Esteem Inventory). *Outcome variables:* Anxiety state level (n). *Comparative groups:* Game stage (pre-game, post-game, adjusted post-game). Game outcome (win, tie, loss).	Higher pregame stress was related to high levels of competitive trait anxiety and basal state anxiety as well as low self- esteem and team performance expectancies. The most important intrapersonal factor related to postgame stress was the amount of fun experienced during the game.

Steffen et al. 2009 (352)	*Country* = Norway *PS* = Regional *AG* = U17, *n* = 1430 (*team/club:* n = 113)	15.4 ± 0.8 yrs	To examine whether psychological player characteristics assessed by a self-administered questionnaire represent risk factors for injury.	*Data collection:* Success perception assessment (Perception of Success Questionnaire), motivational climate assessment (Perceived Motivational Climate in Sport Questionnaire), history of stressors assessment (Life Event Scale for Collegiate Athletes), coping assessment (Brief COPE questionnaire). *Outcome variables:* Perception of success (task, ego) score (n), motivational climate (mastery, performance) score (n), life event scale (sum score) score (n), sport anxiety scale (somatic, worry, concentration) score (n), Brief COPE (problem, emotion, behaviour) score (n). Number of acute time loss injuries (n). *Comparative groups:* Injury status (previously injured, injured 2005 season). Injury type (contusion, sprain, strain, dislocation, fracture, pain, other). Injury location (head/neck, upper/lower body, hip, groin, thigh, knee, lower leg, ankle, foot).	A perceived mastery climate and a high level of life stress were significant predictors for new injuries in a cohort of young female football players.
Stephens et al. 2000 (353)	*Country* = USA *PS* = NS *AG* = U11, U12, U13, *n* = 102 (*team/club:* n = 5)	U11: 10.4 ± 0.5 yrs U12: 11.2 ± 0.4 yrs U13: 12.3 ± 0.6 yrs	To determine predictors of likelihood to aggress in youth soccer.	*Data collection:* Goal orientation assessment (The Task and Ego Orientation in Sport Questionnaire), perceived ability assessment (Eccles and Harold 1991), perception of coach's goal orientation assessment (Player's Perception of Coach), judgements about moral behaviour (The Judgements About Moral Behaviour in Youth Sport Questionnaire). *Outcome variables:* Task orientation score (n), ego orientation score (n), perceived competence score (n), perception of coach's task/ego score (n), likelihood to aggress score (n), moral orientation score (n). *Comparative groups:* Age group (U11 n = 32. U12 n = 17, U13 n = 3). Team type (all girls team, coed girls team).	In general, the likelihood to aggress increased across all age groups.
Stephens et al. 1996 (354)	*Country* = USA *PS* = Regional *AG* = U12-U14, *n* = 212 (*team/club:* n = 21)	11.5 ± 1.2 yrs	To investigate aggression in young soccer participants.	*Data collection:* Goal orientation assessment (The Task and Ego Orientation in Sport Questionnaire), perception of coach's goal orientation assessment (Player's Perception of Coach), judgements about moral behaviour (The Judgements About Moral Behaviour in Youth Sport Questionnaire). *Outcome variables:* Ego orientation score (n), perception of coach's task/ego score (n), perception of team's pro-aggressive norms score (n), likelihood to aggress score (n), moral orientation score (n). *Comparative groups:* NS	Results suggest that young athletes' aggressive behaviour is related to their team's moral atmosphere, including team aggressive norms, players' perceptions of these team norms and coach characteristics, and players' moral motives for behaviour.

NS = not specified. PS = playing standard. AG = age group. AU = Arbitrary Units. BMI = Body Mass Index. USG = Urine Specific Gravity. MOT = Multiple Object Tracking. VR = Virtual Reality. BST = Behavioural Skills Training.

Appendix 8. Characteristics, aim, methods, and key findings of training load studies (n=4)

Study	**Cohort/ sample size (n)**	**Participant characteristics: age, height, body mass**	**Aim**	**Methods**	**Key findings**
Lesinski et al. 2017 (59)	*Country* = Germany *PS* = National *AG* = U17 *n* = 17 (*team/club:* n = 1)	15.3 ± 0.5 yrs 1.65 ± 0.06 m 56.2 ± 6.7 kg	To describe seasonal variations in training, anthropometry, body composition and physical fitness across a competitive season.	*Data Collection:* Body composition analyser (InBody 720 system, Biospace, South Korea), leg press machine (Cybex Eagle, Cybex International, USA), optical measurement system (Optojump, Microgate, Italy), timing gates (WITTY; Microgate, Italy), Y-balance test tool (Move2Perform, USA), Doppler radar gun (Sport 2, Stalker, USA). *Outcome Variables:* Training volume (h), training sessions (n), training days (n), height (cm), body mass (kg), BMI (kg.m^2), fat mass (%), total lean mass (kg), right/left leg lean mass (kg), trunk lean mass (kg), percentage change (%: SJ, CMJ, DJ, ventral Bourban test, 1RM leg press, 10m sprint, t-agility test, shuttle run test, Y-balance test total score dominant/non-dominant leg), kicking velocity dominant/non-dominant leg). *Comparative Groups:* Season period (preparation period 1, competition period 1, transition period, preparation period 2, competition period 2), training type (resistance, sprint, coordination, flexibility, endurance, tactical, technical, matches).	Training volume was highest during preparation periods in the season. Across the season, the volume of sport-specific training was higher than non-specific training. The type of training differed according to the time of the season, with endurance and resistance training higher during preparation periods and sprint and tactical training higher during competition periods. DJ, Y-balance, shuttle run and kicking performance improved across the season.
Los Arcos et al. (2023) (60)	*Country* = Spain *PS* = National *AG* = U12 *n* = 12 (*team/club:* n = 1)	12.5 ± 0.70 yrs	Compare physical, tactical and emotional characteristics during SSGs with and without field obstacles.	*Data Collection:* 10Hz GPS units (WIMU PRO, RealTrack Systems, Spain), questionnaire (BECS scale of perceived enjoyment and competence). *Outcome Variables:* Distance between players (m; approximate entropy), stretch-index (m; approximate entropy), spatial exploration index (m; approximate entropy), longitudinal synchronisation (%), lateral synchronisation (%), TD (m), TD covered (m) in speed zones (walking: 0–1.67, jogging: >1.67–3.20, running: >3.20–4.30, HSR: >4.30 m·s^{-1}), perceived competence and enjoyment (AU). *Comparative Groups:* SSG type (with field obstacles, without field obstacles).	Players' exploration of space during SSGs with obstacles was lower than without and also led to increased regularity in tactical behaviours. Greater TD and TD in speed zones covered in SSGs with obstacles.
Rumpf et al. (2014) (61)	*Country* = Germany *PS* = Local, Regional, National *AG* = U15, U17, U19 *n* = 259	14.4 ± 1.7 yrs 1.64 ± 0.07 m 52.5 ± 9.1 kg	Describe training profiles and motivation players according to age group and playing standard.	*Data Collection:* Online survey (LimeSurvey, LimeSurvey GmbH, Germany). *Outcome Variables:* BMI (kg·m^2), years of training (n), training per week (h), matches per month (n), training content (hrs·week^{-1}; endurance, sprint, technical/tactical, strength, warm-up, cool-down, other), motivation (AU) during training/matches.	Volume of training increased between age groups, whilst differences in motivation during training and matches were observed across playing standard.

	(*team/club:* n = NS)			*Comparative Groups:* Playing standard (high level, low level), age group (U15, U17, U19).	
Williams et al. (2017) (62)	*Country* = England *PS* = Regional *AG* = U12, U13, U14, U15, U16, U17 *n* = 104 (*team/club:* n = NS)	13.4 ± 1.7 yrs	Quantify and compare the prevalence of NFOR and OT between male and female elite youth football players.	*Data Collection:* Questionnaire. *Outcome Variables:* Training hours per day (n), days per week of training (n), years playing (n), episodes of NFOR (n), duration of episodes of NFOR (months), perceptions (AU) of tiredness, recovery, appetite, anxiety, mood state, coach pressure and decision-making autonomy, illness (n). *Comparative Groups:* NFOR status (never having presented as NFOR, previously reported having been NFOR, and presently reporting having NFOR),	No player described experiencing OT, but 9% of players reported current NFOR, with 33% reported experiencing repeated bouts of NFOR. Although players had high volumes of training load, this was not a predictor of NFOR. Players experiencing NFOR perceived greater tiredness, muscle soreness, loss of appetite, and poor mood state.

NS = not specified. PS = playing standard. AG = age group. AU = Arbitrary Units. NFOR = Non-Functional Overreaching. BMI = Body Mass Index. OT = Over Training. CMJ = Countermovement Jump. SJ = Squat Jump. DJ = Drop Jump. TD = Total Distance. HSR = High-speed Running. SSGs = Small Sided Games. 1RM = One Rep-Max.