Review

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The performance, health and development of youth women's footballers: A systematic scoping review

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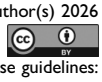

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Abstract

The primary aim of this scoping review was to summarise the current scientific literature on the performance, health and development of youth women's footballers. The review provides a summary of the research topics, including methodological approaches adopted and key findings, and identifies gaps in the literature. A systematic search of electronic databases was conducted in December 2023 and June 2025, with keywords relating to the population, football, and performance, health and development. Studies which involved youth women's footballers playing at any competitive standard, and quantified at least one aspect of performance, health or development were included. Of the 16,473 studies identified in the database searches, 294 studies met the eligibility criteria to be included in the review. Of the eight research topics investigating the performance, health and development of youth women's footballers, physical qualities was the most investigated ($n = 119$; 40%), followed by injury ($n = 49$; 17%), biomechanics ($n = 40$; 14%), psychology ($n = 31$; 11%), match-play ($n = 20$; 7%), nutrition ($n = 14$; 5%), fatigue and recovery ($n = 13$; 4%) and training load ($n = 8$; 3%). Players competing in regional (42%) and national competitions (32%), and within an U17 age-group (23%) were the most investigated. Over half of all studies (56%) were published from 2020 onwards, demonstrating recent rapid growth in youth women's football literature. This comprehensive resource can be used to inform practices supporting the performance, health and development of youth women's footballers across various competitive standards. Furthermore, multiple research areas are highlighted as underdeveloped, and areas for future research concerning this population to explore.

Keywords

Adolescence, biomechanics, female, injury, psychology, soccer

Introduction

Women's football has seen rapid growth within recent years. To support the sustainable development across competitive standards, women's football strategies have been implemented by global (i.e., FIFA[1]), continental (e.g., OFC,[2] UEFA[3]) and national governing bodies (e.g., The FA,[4] Irish FA[5]). Consequentially, there has been increased investment, provision and support provided across playing standards, from grassroots; increasing the number of organised women's clubs to create new playing opportunities and consequentially increasing participation rates,[6] to elite environments; professionalising senior domestic environments,[7] an increase in the number of teams competing at senior international major tournaments (e.g., 2023 FIFA Women's World Cup; 2028 Olympics), and the establishment of new elite competitions (e.g., FIFA Women's Champions Cup 2026; FIFA Women's Club World Cup 2028 [8]). Beyond the increased

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opportunities for players, the sport has seen increased and record-breaking attendances at international and domestic fixtures, increasing media coverage and viewership, and fan engagement.[7] The development of the sport can also be observed beyond applied environments, with a recent scoping review highlighting the recent rapid growth in the volume of scientific literature investigating women's football.[9]

The growth and development of the sport has also extended into youth environments, with women's football strategies inclusive of youth populations,[1–5] greater numbers of girls participating,[6] and global (e.g., FIFA Talent Development Scheme[10,11]), continental (e.g., UEFA Women's Football Development Programme[12]; CAF IMPACT Programme[13]) and national initiatives (e.g., The FA Emerging Talent Centre and Pro-Game Academies within England[14]; FAW National Academi within Wales[15]) which have increased investment, provision and support provided for youth players within talent development programmes (e.g., national talent pathways, domestic club youth academies).[16–18] Further, FIFA has emphasised the importance of women's clubs establishing clear talent pathways for the sustained growth and development of women's football.[7] Whilst the growth and development of youth women's football is apparent in applied environments, the same cannot be said for the body of scientific literature. Research investigating women's football has predominantly focussed upon senior populations,[9] and where research has attempted to systematically evaluate and summarise the scientific literature within women's football, reviews have either focussed upon isolated research areas and reported limited research conducted with youth players (e.g., matchplay[19]; menstrual cycle[20]; coaching practice[21]), or have intentionally excluded youth players within eligibility criteria.[22–24] Therefore, it is difficult to gain an overall perspective on the current state and extent of the scientific literature across youth women's football.

The lack of understanding of the current evidence-base in youth women's football is problematic for practitioners attempting to implement evidence-informed applied practices which support players regarding performance, health and development. Practitioners may inappropriately rely on informing practices based on a more developed evidence-base from different populations (e.g., senior women's, youth men's[25]). However, generalisations from one population to another (e.g., senior to youth women's football) are inappropriate due to both population (e.g., biological maturation,[26,27] physiological, biomechanical,[28,29] training age) and contextual differences (e.g., training and competition structures, provision and support relating to sport science and medicine, governance and regulations for applied environments, rules and regulations within competitions, employment/dual-career/education). Therefore, there is a need to understand the current state and extent of scientific literature within youth women's football, to both provide a critical and comprehensive resource for applied practitioners, but also to understand current gaps in understanding, and identify areas of future research.

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 women's footballers, 2) determine the methodological approaches adopted, 3) summarise the findings of research areas, and 4) identify gaps within the literature. In turn, being able to guide the focus of future research, to further benefit the performance, health and development of youth women's footballers.

Methods

Design and search strategy

This scoping review was conducted in accordance with the extension for Scoping Reviews (PRISMA-ScR; S1 Appendix).[30] A systematic search of electronic databases (CINAHL, EMBASE, IndMed, LILACS, MEDLINE, PubMed, Scopus, SPORTDiscus, Web of Science) was conducted on 17th December 2023, with no date or language restrictions applied. An updated search was conducted on 11th June 2025, to identify any additional studies published since the date of the original search. The search strategy included the terms for the population ('female' OR 'women's' OR 'girls' AND '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.[9,19,23,24,31] No review protocol was registered for this scoping review.

Study selection

After removing duplicate studies, a two-stage screening process was used. Initial screening consisted of two researchers (original search: TA, AHA; updated search: AHA, CHA) 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.

The eligibility criteria were guided by the elements of the Population, Concept, and Context (PCC) framework.[32] Studies were included if they involved youth women's football players (PPC Population), playing at any competitive standard (PPC Context, 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).[33] Studies must have quantified at least one aspect of performance, health or development (PPC Concept). Performance includes the technical, tactical, physiological and psychological characteristics of a player or team.[34] Health relates to the physical, mental and social well-being of the player.[35] Whilst development refers to the chronological and biological development of the player.[36] 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 women's football players in non-competitive environments (PPC Context, i.e., recreational, physical activity, school settings), senior women's (i.e., >19yrs), youth age-groups including players older than 19yrs (i.e., U20, U23), men's, mixed-gender, 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 women's football players (i.e., youth women's data grouped with men's,[37] non-competitive,[38] or senior women's[39] players' data) these studies were also excluded. Lastly, studies which used youth women's football players as participants, but did not investigate the performance, health and/or development of youth women's football players were excluded.[40]

Data extraction

One researcher extracted the data (original search: TA; updated search: AHA), which was checked by another member of the research team who had expertise in the respective research topic (biomechanics: CHA; fatigue and recovery: SW, ND; injuries: TL; match-play: AHA, ND; nutrition: SW; physical qualities: ND, SW, AHA; psychology: RL, PF; training load: AHA, ND). These topics aligned to a previous systematic scoping review of the sport science and medicine literature in another sport.[31] Studies were categorised into topics based on their primary aim and outcome variables; this process was completed independently by two researchers (original search: TA, AHA; updated search: AHA, CHA), with any disagreements resolved via discussion with the respective researcher with expertise in the topic (e.g., biomechanics; CHA). 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, number of teams/clubs, data collection tools, outcome variables, comparison groups), and key findings were extracted from the full-text. Where studies included irrelevant data (e.g., playing position data which grouped senior and youth players),[41] only the relevant data was extracted.

Data synthesis

Due to the nature of a scoping review in mapping, identifying and summarising the evidence within a topic, no statistical analysis was conducted.[30] To determine the methodological approaches adopted, findings and gaps within the literature, data relating to study and participant characteristics, and methodological approach were summarised across all studies and per topic using descriptive statistics (i.e., count, percentages, mean ± SD, or range), whilst data relating to key findings were qualitatively summarised according to topic.

Results and discussion

Search and selection of studies

A total of 16,473 studies were identified through the database searches. After removing duplicates ($n = 6{,}436$) and conducting the initial and full-text screening, 294 studies were deemed eligible for inclusion in this review (Figure 1).

Study characteristics

Study characteristics: research topics. Of the 294 studies included in this review, the performance, health and development of youth women's footballers were covered across eight research topics: biomechanics ($n = 40$; 14%), fatigue and recovery ($n = 13$; 4%), injury ($n = 49$; 17%), match-play ($n = 20$; 7%), nutrition ($n = 14$; 5%), physical qualities ($n = 119$; 40%), psychology ($n = 31$; 11%) and training load ($n = 8$; 3%) (Figure 2).

Study characteristics: publication year. There has been a steady increase in the number of studies investigating the performance, health and development of youth women's footballers (Figure 3), with 90% of studies ($n = 264$) published since 2010. Further, in the last five years, there has been a period of particularly rapid growth, with 56% ($n = 165$) of studies published between 2020 and 2025.

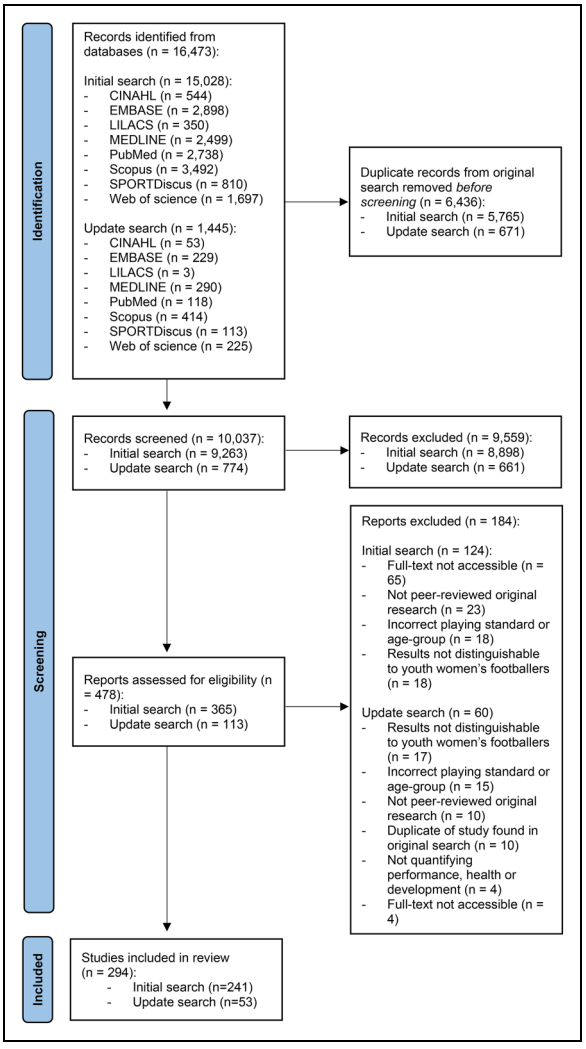

Figure 1. Flow of the selection process to determine eligible studies.

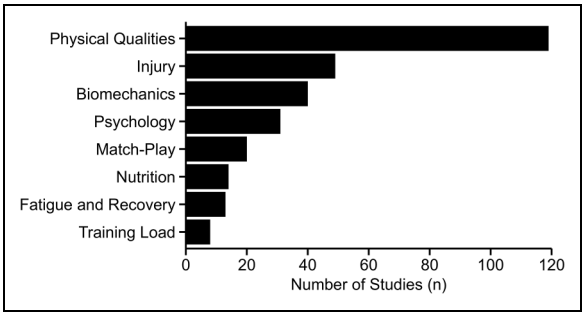

Figure 2. Number of studies within topics investigating the health, performance and development of youth women's footballers.

Similar to trends observed within senior women's football research,[9] there appears to be an increase in the volume of studies published in the year following a major global senior international competition (i.e., 2011, 2015, 2019, and 2023 FIFA Women's World Cups).

The earliest studies focussed on psychology (1979), injury (1985) and physical qualities (1992; Figure 4), which is reflective of the topics investigated in the early evidence-base within senior women's football research (sociology = 1939; psychology = 1975; injury = 1975).[9] In contrast, fatigue and recovery, training load and match-play are the least established topics within youth women's football research, which may be due to the increasing accessibility of technology (e.g., global positioning systems; GPS) within recent years. Lastly, the volume of research within recent years has predominantly investigated physical qualities, with the number of publications within the research topic progressively increasing since 2017.

Study characteristics: geography of studies. Studies were predominantly from European ($n = 162$; 55%) and North American ($n = 81$; 28%) countries, with South American ($n = 15$; 5%), Asian ($n = 13$; 4%), Oceania ($n = 10$; 3%) and African ($n = 7$; 2%) countries contributing a smaller proportion of the evidence-base. A total of 42 different countries were represented within this review (Figure 5). The majority of studies came from: USA ($n = 53$; 18%), England ($n = 31$; 11%), Spain ($n = 28$; 10%), Canada ($n = 27$, 9%), Sweden ($n = 20$; 7%), Norway ($n = 16$; 6%), Germany ($n = 15$; 5%), Denmark ($n = 10$; 3%), Australia ($n = 9$; 3%) and Brazil ($n = 9$; 3%). The large proportion of research published from these countries seem unsurprising when considered in the wider context of women's football. These countries are prominent women's football nations, with successful history in senior and youth global and continental international competitions (e.g., FIFA Women's World Cup, CONCACAF Women's Championship, UEFA European Championships), and are home to the most established professional senior women's football leagues (e.g., National Women's Super League in USA, Women's Super League in England, Liga F in Spain, Damallsvenskan in Sweden, Frauen Bundesliga in Germany).[42] However, caution may be required for practitioners using the evidence-base predominantly derived from such countries, with consideration given to the potential contextual differences (e.g., talent pathways and structures, investment, provision and support) which may exist between comparable youth women's football populations (e.g., international, national or regional competitive standards).[25]

The representation of countries according to research topic is presented in S1 Figure. As the largest topic, the physical qualities research topic also had the widest representation of countries ($n = 35$; 83%), inclusive of all six continents. Publications from European countries contributed to all research topics, with studies from England providing the largest contribution for the fatigue and recovery ($n = 6$; 46%) and match-play ($n = 4$; 20%) topics, whilst Spain had the largest contribution to physical qualities ($n = 18$; 15%). Within

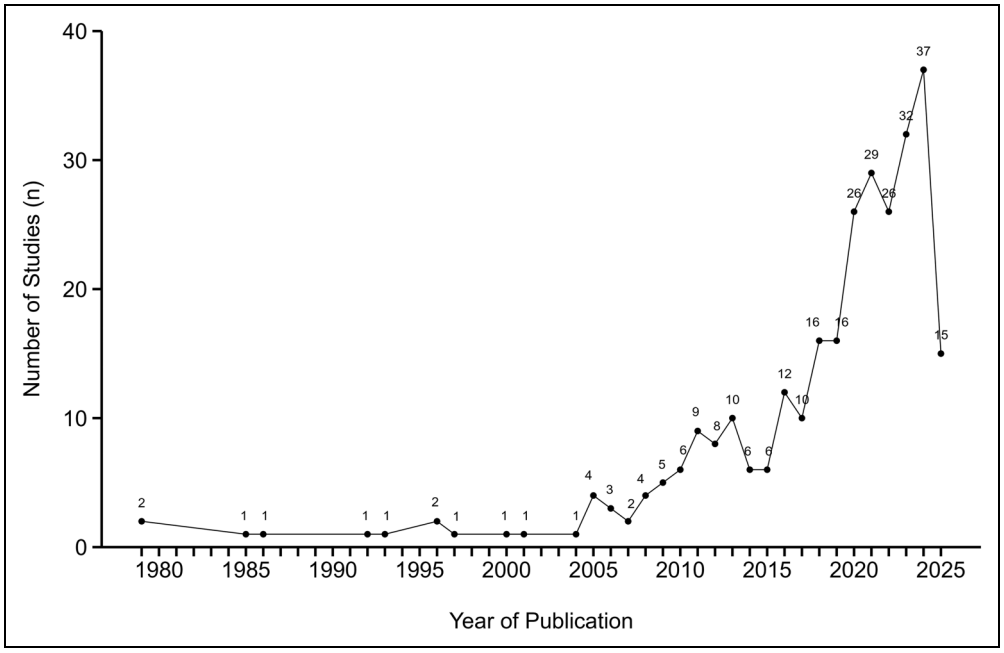

Figure 3. Number of studies published per year investigating the health, performance and development of youth women's footballers.

European countries, the focus of studies from individual countries was typically the investigation of physical qualities (e.g., Spain: $n = 18$; 64%; England: $n = 14$; 45%). However, studies from Scandinavian countries tended to focus on injuries (Sweden: $n = 10$; 50%; Norway: $n = 8$; 50%; Denmark: $n = 6$; 60%). Similarly, publications from North American countries contributed to all research topics, with the USA having the largest contribution to the biomechanics ($n = 20$; 50%), injury ($n = 11$; 22%) and psychology ($n = 10$; 32%) topics, and Canada leading the contribution for nutrition studies ($n = 4$; 29%). Studies from countries in under-represented continents (Africa, Oceania, Asia and South America) predominantly investigated physical qualities.

Participant characteristics

Participant characteristics: competitive standard. The competitive standard of players was reported in most studies ($n = 256$; 87%). Players participating in regional ($n = 124$; 42%) and national ($n = 95$; 32%) competitions were the most investigated, followed by international ($n = 32$; 11%) and local ($n = 30$; 10%) players. When considering competitive standards investigated within research topics (Figure 6), national players were the most investigated in physical qualities ($n = 49$; 41%), nutrition ($n = 7$; 50%) and training load ($n = 4$; 50%) studies, regional players were the most investigated in fatigue and recovery ($n = 11$; 85%), injury ($n = 24$; 49%), match-play ($n = 9$; 45%), and psychology ($n = 15$; 48%) studies, whilst local players were the most investigated in biomechanics studies ($n = 15$; 38%). The over-representation of local players in biomechanics studies (half of all studies involving local players) may be due to convenience sampling (e.g., ease of accessibility to participants), or logistical considerations for time-intensive, labour-intensive, or inconvenient data collection procedures (e.g., laboratory-based testing as opposed to field-based observational studies).[43] International players were predominantly involved in physical qualities studies ($n = 21$; 66%), notably anthropometrics and physical characteristics ($n = 12$; 38%) and studies investigating relative age effect (RAE) within international competitions ($n = 8$; 25%; e.g., FIFA Women's U17 World Cup; UEFA Women's U19 European Championships). The lack of international representation within the literature may be due to the challenge and difficulties in accessing these elite populations, exemplified by all anthropometric and physical characteristics studies involving international players consisting of a single nation/team sample (where stated) likely consequential of convenience sampling (e.g., researchers with applied roles or networks/connections within respective organisations). Furthermore, it is worth noting that no study investigated youth women's para-football formats of any competitive standard. Consequently, there is a clear gap in literature investigating disability formats of youth women's football, which is reflective of the gaps in senior women's football literature.[9] Future research should focus attention on disability formats of both youth and senior women's football, to start to develop an evidence-base for practitioners working with these players.

Participant characteristics: age-group. Age-group was not stated or indistinguishable for over a third of studies ($n = 108$;

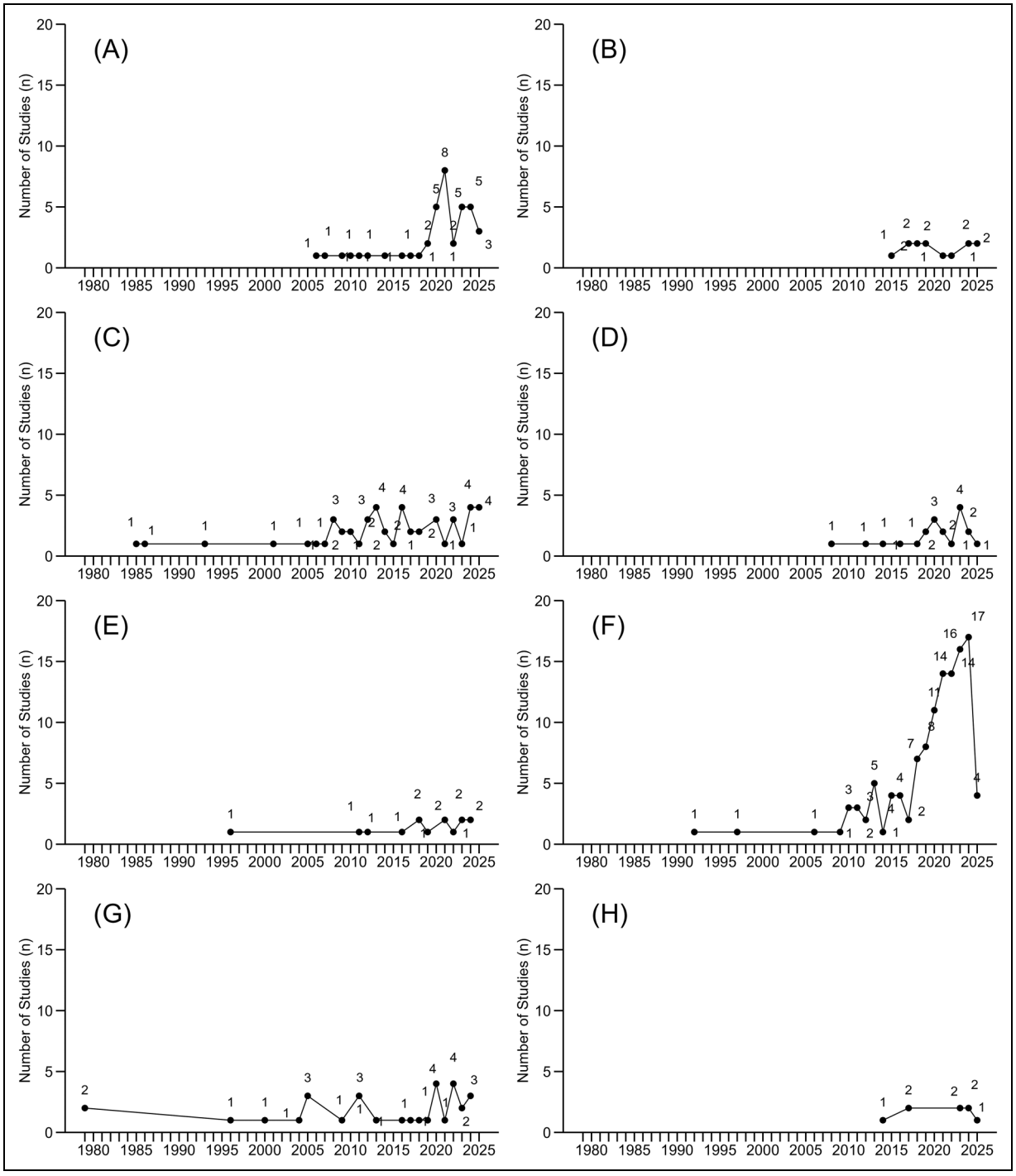

Figure 4. Number of studies published per year investigating the health, performance and development of youth women's footballers according to topic; A) biomechanics, B) fatigue and recovery, C) injury, D) match-play, E) nutrition, F) physical qualities, G) psychology, and H) training load.

38%). The U17 age-group was most investigated ($n = 67$; 23%), followed by U15 ($n = 58$; 20%), U14 ($n = 57$; 19%), and U16 ($n = 55$; 19%) age-groups (Fig. 7). Whilst research focussed upon older age-groups, there was a lower proportion of research at U18 ($n = 41$; 14%) and U19 ($n =$ 32; 11%) age-groups which may be due to the exclusion of studies which did not differentiate youth players' data from senior players (e.g., senior, college/university samples). There is a clear lack of research investigating younger youth women's football players (U10: $n = 6$; 2%; U11: $n =$

Figure 5. Geography of studies investigating the health, performance and development of youth women's footballers (grouped by continent; colour).

4; 1%), which may be due to these younger age-groups competing in participation or non-competitive environments (therefore not eligible for inclusion in this review), talent development environments (e.g., youth talent pathway structures; regional and national environments) starting for older age-groups,[44,45] or researchers' opting (consciously or subconsciously) to focus investigations on older age-groups instead.

Participant characteristics: number of participants. The number of players and teams/clubs participating in studies within each research topic is presented in Table 1. Most studies ($n = 284$; 97%) reported the number of participating players. Match-play had the highest proportion of studies not reporting the number of participating players ($n = 5$; 25%), which were predominantly studies quantifying heading frequency on a team-level, and therefore, instead reported the number of teams and matches observed.[46–49] Injury studies typically involved the largest number of participants, which may be unsurprising due to the large-scale epidemiology studies conducted at a league- or tournament-wide level.[50–52] This was followed by psychology studies,

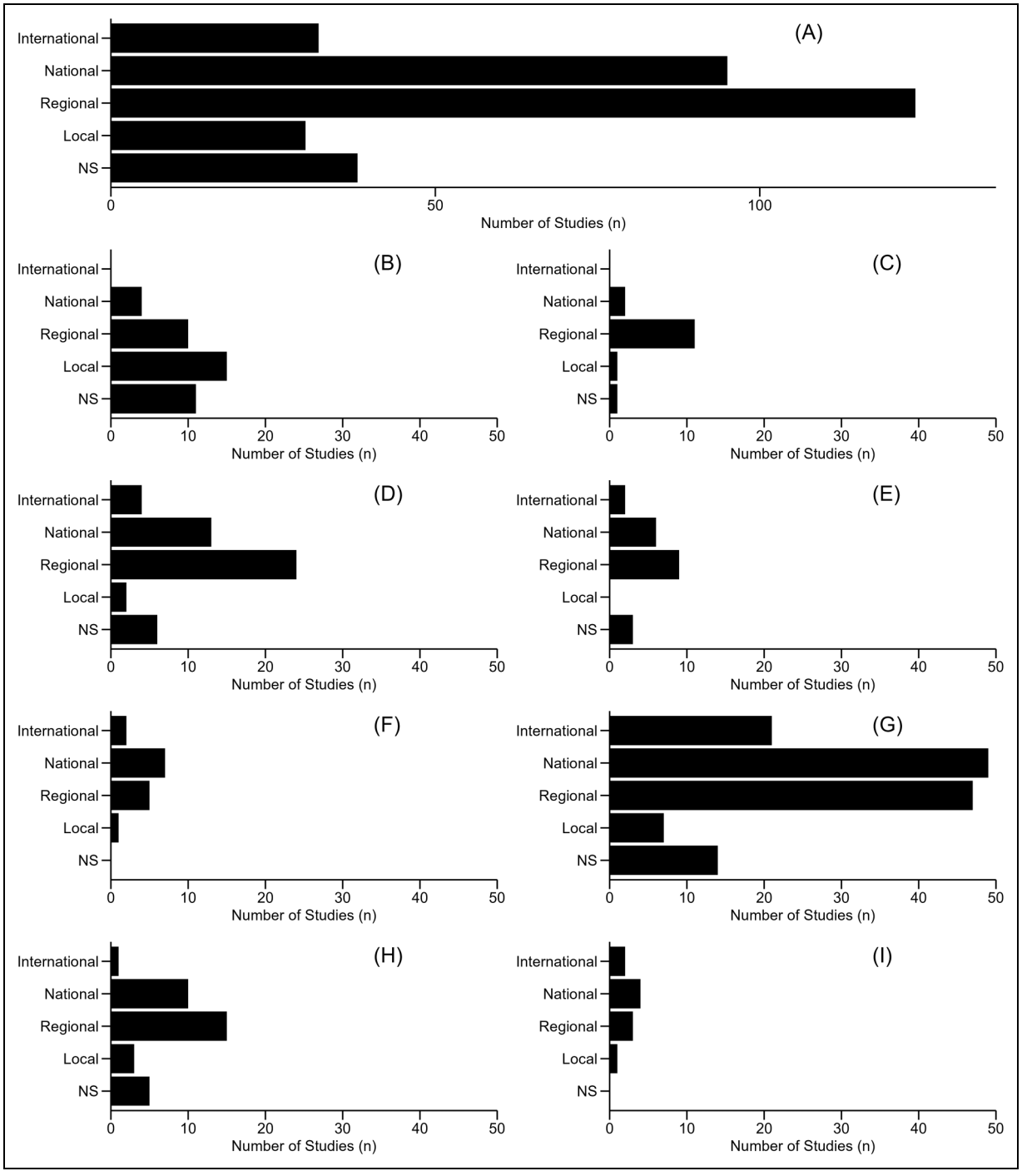

Figure 6. Competitive standard of players involved in studies investigating the health, performance and development of youth women's footballers (A), according to topic; B) biomechanics, C) fatigue and recovery, D) injury, E) match-play, F) nutrition, G) physical qualities, H) psychology, and I) training load.

where methodological approaches (e.g., questionnaires) facilitated larger sample sizes than those typically reported in observational or intervention-based research in other research topics. Lastly, when removing the studies investigating relative age effect (median = 537; range = 40–12,257), the median and range of participants involved in physical qualities reduced (median = 34; range = 12–673) to align more closely with the remaining research topics.

Of the 177 studies (60%) which reported the number of teams/clubs involved, 90 (51%) studies investigated single team/club samples. Further, for all research topics except injury, single team/club samples were

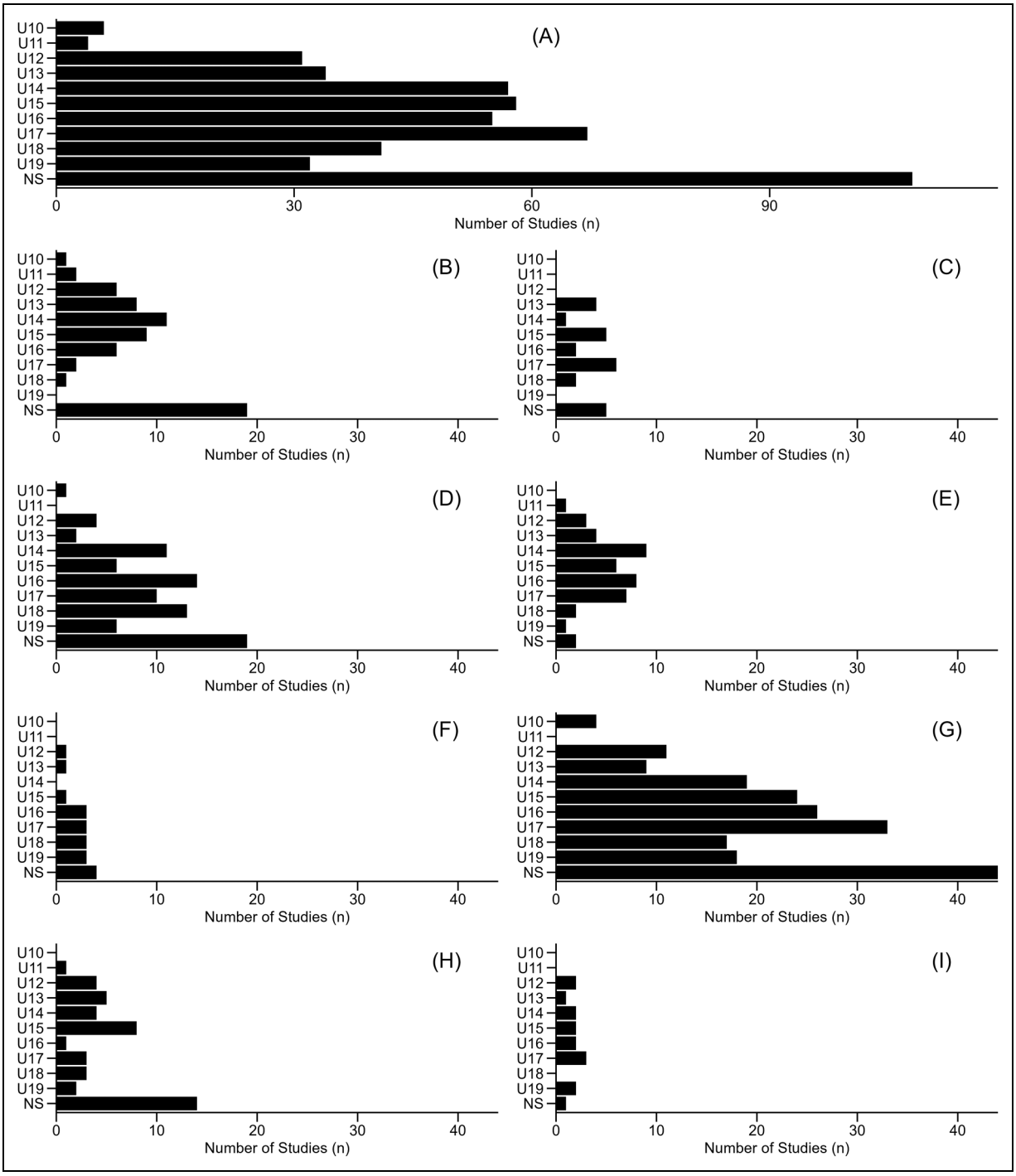

Figure 7. Age-groups involved in studies investigating the health, performance and development of youth women's footballers (A), and according to topic; B) biomechanics, C) fatigue and recovery, D) injury, E) match-play, F) nutrition, G) physical qualities, H) psychology, and I) training load.

the most investigated. Given the contextual differences that may exist between teams/clubs (e.g., training and competition structures, provision of/access to sports science and medicine support), results from single team/club samples may not be generalisable to the wider population. Therefore, where possible, future youth women's football research should adopt a multi-club approach.

Participant characteristics: comparison groups. Common comparisons were between; age-groups ($n = 94$; 32%), including comparisons between youth and senior populations (n

Table 1. Number of players and teams/clubs participating in studies within research topics.

	Number of Players		Number of Teams/Clubs	
	Median (Range)	Not Stated (*n*; %)	Median (Range)	Not Stated (*n*; %)
Biomechanics	21 (6–351)	0 (0%)	2 (1–33)	16 (40%)
Fatigue and Recovery	32 (15–93)	0 (0%)	1 (1–1)	9 (70%)
Injury	363 (24–19,147)	3 (6%)	27 (1–341)	14 (29%)
Match-Play	58 (12–828)	5 (25%)	3 (1–74)	3 (15%)
Nutrition	21 (7–205)	0 (0%)	1 (1–3)	8 (57%)
Physical Qualities	40 (12–12,527)	2 (2%)	1 (1–73)	49 (41%)
Psychology	175 (3–1430)	0 (0%)	4 (1–113)	16 (52%)
Training Load	18 (10–259)	0 (0%)	1 (1-1)	2 (25%)

= 28; 10%), genders ($n = 76$; 26%), playing positions ($n = 27$; 9%), and competitive standards ($n = 21$; 7%). Excluding intervention comparisons (e.g., pre- vs post-intervention), a variety of time periods were investigated ($n = 34$; 12%), predominantly between and within training sessions and/or matches ($n = 19$; 6%), and between and within seasons ($n = 15$; 5%). Less frequent comparisons included chronological age ($n = 12$; 4%), maturity status ($n = 5$; 2%), and stage of menstrual cycle ($n = 5$; 2%).

Biomechanics

Forty studies investigated the biomechanics of youth women's football (S1 Table) assessing jumping, landing and/or cutting ($n = 22$; 55%),[53–74] heading ($n = 14$; 35%),[75–88] kicking ($n = 2$; 5%),[89,90] postural control ($n = 1$; 3%)[91] and methodological aspects ($n = 1$; 3%).[92]

Biomechanics: jumping, cutting and landing. Regional ($n = 7$; 32%),[55,57,65,66,69,70,72] and local ($n = 6$; 27%)[53,54,56,62,73,74] players were most commonly investigated across the sub-topic, with only one study (5%) involving national players.[68] Eight studies (36%) did not state playing standard.[58–61,63,64,67,71] Common outcome variables included knee kinematics ($n = 16$; 73%)[55–57,59,60,62,63,65,67–74] and kinetics ($n = 8$; 36%),[56,57,61,65,69,71,73,74] ground reaction force ($n = 4$; 18%)[63,64,68,69] and jump performance ($n = 6$; 27%).[5862–64,67,72]

Most studies quantified jumping, cutting and/or landing biomechanics using force platforms ($n = 14$; 64%)[55–58,61,63–66,68,69,71,73,74] and 3D motion analysis ($n = 13$; 59%),[55–59,61,63,65,68,69,71,73,74] whereas four studies (18%) used 2D video analysis[62,67,70,72] and four (12%) used IMUs.[53–55,60] One study used a combination of a force plate and Swift speed mat to determine age-related changes in jump performance.[64] Studies found sex-specific movement strategies in jumping, cutting and landing movements[60,65,66] as well as age-related changes in landing asymmetry,[68] 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 programme.[56,61,67,69,73,74] Younger players showed greater improvements in knee valgus moment during a double leg jump task,[74] 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.[56] 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.

Biomechanics: heading. Players of local standard were most commonly investigated across this sub-topic ($n = 8$; 57%),[78,80,8184–88] followed by regional ($n = 3$; 21%)[75,76,79] and national standards ($n = 2$; 14%),[82,83] with only one study (7%) not reporting playing standard.[77] All studies bar one quantified head impact kinematics using inertial measurement units, in the form of trackers ($n = 8$; 57%)[75,76,79,80,82,83,86,87] or mouthpieces ($n = 5$; 36%).[77,78,81,84,85] Common outcome variables also included total number of headers or head impacts ($n = 9$; 64%),[75–77,79,81,84,85,87,88] and neck muscle strength ($n = 3$; 21%).[80,82,87] Two studies (14%) assessed balance and neurocognitive function.[86,88] Finally, variables were most commonly compared across ball-delivery method or game scenario ($n = 6$; 43%)[7577–79,81,84] or age-group ($n = 4$; 29%).[75–77,85]

Better heading technique (i.e., impact location, technique score) was associated with improved heading kinematics.[78,79] Head impact magnitudes differed depending on match scenario (e.g., goal kick, corner),[78,79,81,84,85] and ball characteristics.[83] Older players experienced a higher frequency of head impacts (>15 g) than younger players (U14 *vs.* U12).[76] Four studies assessed the effects of an intervention on heading kinematics.[80,82,86,87] These studies predominantly ($n = 3$) improved neck muscle strength, which subsequently led to improvements in heading kinematics.[80,82,87] Therefore, with guidance and restrictions

being introduced by national governing bodies (UEFA Heading Guidelines for youth players)[93] 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.

Fatigue and recovery

Thirteen studies[94–106] investigated the fatigue and recovery of youth women's football players (S1 Table), assessing muscular function ($n = 6$; 46%),[96–99,101,106] nervous system function ($n = 2$; 15%),[95,100] physical qualities ($n = 2$; 15%),[102,103] well-being ($n = 2$; 15%),[94,105] and vascular function ($n = 1$; 8%).[104]

A variety of outcome variables were used to investigate fatigue and recovery. Variables assessing neuromuscular function (e.g., muscular delay,[96] stiffness,[97] hamstring to quadriceps ratio,[98] strength and delayed onset of muscle soreness (DOMS),[101] knee flexion and valgus angle[106]) were quantified using a variety of equipment (e.g., dynamometer,[96,98,106] RPE,[101,106] electromyography (EMG),[96] contact mat,[97] force platform[99,106]). Variables assessing nervous system function (e.g., heart rate, heart rate delay,[95,100]) were quantified using a heart rate monitor[100] or electrocardiogram (ECG) electrodes.[95]

Studies investigated differences between age-groups ($n = 4$; 31%),[96–98,101] exposure to heading tasks ($n = 2$; 15%),[95,100] and training load ($n = 1$; 8%),[105] but the majority explored fatigue and recovery across various time periods ($n = 10$; 77%).[96–99,101–106] Ten studies (77%) investigated fatigue and recovery within an acute period, including; pre- vs post-match,[99101–104] pre- vs post-field-based soccer protocol,[96–98,106] and stage of tournament.[103,104] Two studies (22%) investigated fatigue and recovery over a longitudinal period, including a 3-month period,[105] and, competitive season[95]).

Following a football-simulation protocol, older age groups had less electromechanical delay,[96] and greater leg stiffness[97] 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.[98] 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 min for U15 players compared to 90 min 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.[98] As a result, more mature players, who are typically better prepared for higher physical demands given an increased playing exposure, are less susceptible to fatigue. Furthermore, following competitive match-play, U17 players were found to fully recover within a 168-h testing period, while U13 and U15 players continued to exhibit elevated creatine kinase levels and delayed onset muscle soreness beyond this period.[101] This indicates greater muscle damage and delayed recovery in younger players, which may suggest that younger age-groups are 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.

The fatigue and recovery of youth women's footballers has had limited investigation, and future research is required to address our gaps in understanding. 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., via 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. At the same time, attention could be given to adjusting the volume of training or fixtures of younger age-groups to accommodate for decreased recovery abilities.

Injury

A total of 49 studies investigated injuries within youth women's football (S1 Table), predominantly exploring epidemiology ($n = 22$; 45%)[50–52,107–125] and risk factors ($n = 17$; 35%),[126–142] with the remaining studies ($n = 10$; 20%) exploring the efficacy of injury interventions.[143–152]

Injury: epidemiology. Of the 22 studies which explored epidemiology in youth women's football, there was a range of playing standards investigated (local: $n = 2$, 9% [108,124]; regional: $n = 6$, 27% [111,118120–122,125]; national: $n = 6$, 27% [107,109112–114,117]; international: $n = 4$, 18% [51,52,110,119]; not stated: $n = 4$, 18% [50,115,116,123]). The most common outcome variables included injury type and location ($n = 18$; 82%),[50,51,107,109,110112–124] injury frequency ($n = 17$; 77%),[50–52,107,109–117,119–121,123,124] match and training exposure or load ($n = 8$; 36%)[50,107,110,112115–117,125] and injury severity and duration ($n = 6$; 27%).[50–52,107,110,114] Practitioners, including coaches and medical professionals,

collected data in 41% ($n = 9$) of studies.[52,107,110,113,114,116,117,119,120] Questionnaires or surveys were used in 41% ($n = 9$) of studies[52,108,111120–125] and self-report techniques (e.g., text message,[109] self-referral to a medical tent[50,51,115]) were employed in 18% ($n = 4$) of studies. One study used the International Classification of Diseases (ICD-10) alongside X-ray to diagnose injuries.[112]

Comparisons of age-group were most common across this sub-topic (60%; $n = 13$),[50–52,107,108,111–114,116,118,123,124] followed by game type (training and matches) ($n = 8$; 36%),[52,108113–115,121,122,125] injury status (injured and non-injured players) ($n = 7$; 32%),[114,115118–121,124] playing standard ($n = 5$; 23%),[109,114,118,120,124] and time period ($n = 4$; 18%) (year,[110,115] and (season))[52,114]). Further comparison groups such as playing position ($n = 1$; 6%),[122] injury type ($n = 1$; 5%),[123] and injury surveillance type (e.g., parental internet based or certified athletic trainer) ($n = 1$; 5%)[120] featured just once across the sub-topic, therefore warranting further investigation.

Younger age-groups typically experienced highest injury frequency, and thus greater injury risk.[50,52111–114,116,118,123] These findings align with existing literature on youth men's players, suggesting that higher injury rates relate to skeletal maturity factors (e.g., proximity to peak height velocity,[153] skeletal age falling behind chronological age,[154] immature skeleton[155]). However, two studies observed injury incidence increased with age.[51,107]

Studies which compared differences between matches and training presented inconsistent findings, with two reporting injury incidence was highest in training,[113,122] one observing more injuries in matches[52] and one reporting no difference.[121] Consideration should be given to the differing methodological approaches adopted within these studies (e.g., collected via survey or practitioners), and the contexts in which these studies occurred. For example, Sprouse et al.[52] investigated injury incidence during international camps, which is inclusive of competitive matches and training within a congested period (e.g., 7-day period), therefore training and match demands may not reflect those experienced in league-based or domestic environments. Further, as the observation period varied across studies (e.g., whole season,[107,109,114] tournaments[50,115,116]), findings from studies observing a shorter time-span cannot be generalised to longer footballing period formats, and vice-versa.

Injury: risk factors. Players within regional competitions were most frequently studied across this sub-topic ($n = 11$; 65%)[127129–133,138–142] followed by those from national competitions ($n = 5$; 29%).[126,128134–136] One study did not report playing standard.[140]

Common outcome variables included injury frequency ($n = 6$; 36%),[128135–138,141] injury location ($n = 8$; 47%),[126,129,132,136,138,139,141,142] injury severity (time loss due to injury) ($n = 6$; 36%),[128,129,135,136,138,139] injury history ($n = 4$; 24%),[126,127,130,131] training load ($n = 6$; 36%)[128,130,131,133,139,140] and physical performance outcomes (e.g., knee strength, jump height, hip and trunk strength,[127,129,130,134] $\dot{V}O_2$ max[129,141]). Methods of determining injury characteristics (e.g., injury location, severity, history etc.) and training load of players varied, including practitioner-reported injuries ($n = 4$; 24%[131,132,136,138]), questionnaires ($n = 9$; 53%[126,128,130,132,133,137,139,140,142]), and self-reported injuries ($n = 2$; 12%[135,141]). Questionnaires were also used to assess variables not directly related to injury, such as well-being (Brief-COPE questionnaire),[140] General Health Questionnaire (GHQ-12),[130,133,140] technical-tactical attributes[137] and perceptions of early football specialisation.[142] 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 (53%; $n = 9$).[126,128130–133,139–141] Typically, injury status reflected current injuries, but four studies specifically examined previous injury as a risk factor for future injury,[128,130,131,139] concluding that players with prior knee,[128,131] groin, or ankle[139] injury 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,[128] although lacked detail 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. Lastly, due to low ACL and acute knee injury rates (3.5 events), there was low statistical power in risk factor modelling (Cox regression analyses),[131] therefore results from the ACL risk factor model in this study should be interpreted cautiously.

Other comparison groups included playing standard,[127,137,142] playing surface (grass, artificial turf),[132,136,138] age-group,[136] type of sport,[135] and playing position.[132] 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,[136,138] while one reported significantly higher training injuries on grass, but no significant differences in matches.[132] This is in contrast with previous research on senior players which suggests the opposite.[156–158] This may potentially be due to grass pitches for youth players not being of (or maintained to) as high a standard as senior pitches.

Two of three studies exploring playing standard found that more skilled players had an increased risk of injury,[137,142] which aligns with previous research in youth men's football,[159] where greater exposure to contact events such as tackles and ariel duels is associated with higher

injury rates. 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.

Injury: interventions. Ten studies investigated the effects of interventions on injury outcomes in youth women's football (regional: $n = 7$, 70% [143,144,146,148,149,151,152]; national: $n = 2$, 20%;[145,147] not stated: $n = 1$; 10%).[150] Injury incidence was the most common outcome variable, included in 90% ($n = 9$) of studies.[144–152] Other outcome variables were more sporadically quantified, for example; compliance or adherence to intervention ($n = 4$; 40% [144148–150]), training and match load ($n = 3$; 30% [144,149,152]), injury location ($n = 3$; 30% [147,148,152]), injury type ($n = 3$; 30% [147,148,151]), physical qualities ($n = 3$; 30% [143,145,149]), and injury severity ($n = 2$; 20% [147,148]). Data collection of injury characteristics (frequency, type, severity, etc.) was predominantly conducted via practitioners such as coaches, therapists and other medical staff ($n = 5$; 50%),[146–149,151] followed by questionnaires and surveys ($n = 4$; 40%).[145,146,150,152]

Interventions varied, including warm-up programs ($n = 4$; 40%),[148–151] training programs ($n = 2$; 20%),[143,144] injury prevention strategies ($n = 1$; 10%)[150] and a change in ball ($n = 1$; 10%).[152] The longest intervention was two competitive seasons,[146] however, just over half of the studies had a season-long intervention ($n = 6$; 60%),[144,147,148150–152] with others lasting four months ($n = 2$; 20%).[143,149] Of the two remaining studies, one excluded the intervention group,[145] the other compared the effects of the intervention on trained and un-trained players.[146] Five studies reported significant reductions in injury rates for players in intervention groups,[143,147150–152] while two studies found no significant differences in injury rate between the intervention and control groups[144,148]; however, in one study, low compliance in one specific tertile of the intervention group partially explained the lack of effect,[144] 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 women's 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. Furthermore, future research should also explore which variables affect adherence and compliance to injury interventions to inform the design and delivery of interventions (e.g., what is delivered, when and how is it delivered, and by whom?).

Match-Play

Twenty studies quantified the match-play characteristics of youth women's football players (S1 Table). Of those studies, 40% ($n = 8$) investigated physical characteristics,[41160–166] 15% ($n = 3$) quantified both physical and technical characteristics,[167–169] 10% ($n = 2$) quantified only technical characteristics,[170,171] and the remaining 35% ($n = 7$) examined heading incidence.[46–49,172–174] No study attempted to quantify the tactical characteristics of youth women's football match-play and therefore future research is warranted in this area.

Match-Play: physical characteristics. Players in regional competitions were the most investigated playing standard in studies across this sub-topic ($n = 4$; 36%),[162,163,167,168] with two studies (11%) investigating international match-play.[41,161] Studies examining physical characteristics used a range of variables, such as, heart rate,[160,169] total distance,[41160–169] distance covered in different speed zones,[41160–169] and number of accelerations.[162,163,166] Studies predominantly used GPS devices, albeit of differing frequencies (i.e.,1 Hz,[160] 5 Hz,[166,169] 10 Hz,[41161–164,168] 15 Hz[165]), to quantify distance- and speed-based variables, whilst one study used 2D video-based motion analysis.[167] Consistent with research quantifying match-play physical characteristics of senior women's players,[19] there were discrepancies between studies in the speed thresholds and qualitative descriptors for speed zones. Further inconsistencies in the methodological approach were observed for the inclusion criteria for observations (e.g., whole match,[41,161,163,164,166,169] positional observations,[162,168] >70 min[167]). Therefore, caution is advised when interpreting and comparing results of studies, particularly the distances covered in speed zones.

Studies which involved multiple age-groups ($n = 6$; 55%),[41162–164,166,168] quantified age-group specific physical characteristics and consistently observed increasing physical characteristics with increasing age. However, when differing match durations between age-groups were accounted for, age-group differences were less pronounced. Therefore, future research should include both absolute and relative data when investigating match-play physical characteristics across youth-age-groups.[162] Five studies (45%) investigated time-based differences (e.g., match-half/match-periods,[160,163,166] segmental periods[164,167]), typically observing reductions in physical performance as the match progresses. All three studies (27%) which quantified position-specific physical characteristics[41,162,163] observed differences between playing positions. Given that physical characteristics of youth women's football appear to be position-specific, future research should 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[41,162,163] instead of DEF[166]). One study

found different ball characteristics did not influence physical characteristics,[167] whilst one study observed minimal differences in physical characteristics when manipulating the number of players (7v7 vs 8v8), and another reported physical characteristics 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).[168]

Match-play: technical characteristics. Of the four studies which reported playing standard, three involved players competing in regional competitions and one involved players within national competitions. The frequency of possession-based, offensive, and defensive technical actions during match-play were analysed in studies examining technical characteristics.[167–171] All five 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,[168,171] one of which also observed position-specific differences within and between age-groups.[171] 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.[168] 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 wider contextual factors which have been shown to influence technical characteristics in other populations. For example, contextual factors such as match status and outcome,[175] team and opposition quality,[176] and environmental factors,[177] have all been explored in senior women's football. Lastly, one study found more technical actions were performed by U11 players during a 7v7 match compared to an 8v8.[169] 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 women's football environments.

Match-play: heading. Of the six studies which reported playing standard, four involved regional players whilst two involved national players. All seven studies reported heading frequency during match-play,[46–49,172–174] with four further quantifying heading characteristics (e.g., impact location,[47,48,173] match situation[47,48,173]). All but one study[49] 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.[47–49,174] Midfielders tended to perform more headers than defenders and attackers regardless of age-group.[48,172,173] One study also quantified heading frequency during training, and observed significantly more headers were performed during training compared to match-play.[173] 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).

Nutrition

Fourteen studies[178–191] explored nutrition surrounding youth women's footballers (S1 Table). Topics varied, with studies assessing energy intake and expenditure,[178,180,186,187,189] hydration,[182,184] bone health,[181,185] food consumption,[188,190] nutritional status[183] and disordered eating behaviours.[191] Across studies, the most common outcome variables were; body mass measurements (e.g., fat mass, fat free mass, muscle mass (kg, %)).[178181–190] Macronutrient measurements were commonly presented in studies exploring energy intake, food consumption and nutritional status.[178,180,183,185,187,188,190] Outcome variables were compared between age-group,[180,184,187] playing position,[187] hydration status[179,182] and dietary condition[185,188] or between different game days and training sessions.[179,184,186,187]

Five studies used self-reported food diaries,[178,186] dietary recall methods[185,189] or remote food photography[187] 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,[178,180,186,187] carbohydrate,[178,186,187] protein,[178,183] or micronutrient requirements, specifically vitamin D, E, A and B12 as well as folate and calcium.[178,183] 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%.[186] Furthermore, prevalence of players with low energy availability significantly reduced (15% vs 5%) when using objective doubly labelled water derived measures compared to self-reported dietary intake.[187] Additionally, all studies had limited sample sizes, either a small sample or one age-group.[178,186] Despite the associations of energy availability with bone

health, women's football players were reported to have significantly higher bone mineral density compared to non-athletes[181] and short-term consumption of Greek yoghurt did not affect bone metabolism,[185] but had a possible effect on the acute anti-inflammatory response during periods of intense training.[188]

Two studies investigated hydration using urine specific gravity and found a significant proportion of players were hypohydrated before and during training sessions. Chapelle et al.[179] reported 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.[184] 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. 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.

One study[191] assessed disordered eating behaviours and found that approximately one in six players demonstrated risky eating behaviours. The prevalence was higher in older players (U19s) compared to younger players (U15s). While this study used a larger sample across multiple academies, it was limited by the self-report nature of the EAT-26 and absence of diagnostic follow-up.

These studies highlight significant nutritional gaps among youth women's football 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 using objective measures 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 youth women's football players.

Physical qualities

Of the 119 studies investigating the physical qualities of youth women's footballers (S1 Table), the majority quantified anthropometrics and physical characteristics ($n = 70$; 59% [37192–260]), followed by training interventions ($n = 22$; 18% [261–282]), relative age effect ($n = 20$; 17%,[283–302] and validity and reliability studies ($n = 7$; 6% [38303–308]).

Physical qualities: anthropometrics and physical characteristics. Of the 70 studies in this sub-topic, the majority involved regional ($n = 28$; 40%)[37,193,197,199,202,203,209,212,214,215,219,222,224,225,227,230,233,236,237,242,247,249,250,255,256,258,259] or national ($n = 28$; 40%) [194,196,198,200,201,204,205,207,213216–218,221,223,226,227,231,232,234,236,238–240,243,247,253,255,256] standard players, whilst only 12 (17%) and two (3%) studies investigated international[192,208,220,228,235,236,241,243,244,253,257,260] and local players[246,252], respectively. A number of different outcome variables were used, including; jump height or distance ($n = 39$; 56%),[37,192195–201,203,204,206,208,210–212,218,221,223,225,227,228,231,233,234,236,239,240,243–245,247,249–251,256,257,260,303] sprint time or distance ($n = 32$; 46%),[192195–197,199,200,203–206,208,210–212,226,227,231,232,234,236,239,240,243,244,247,249–251,256–258,260] force ($n = 15$; 21%) (e.g., peak force, peak torque),[192,194209–213,220,228,233,235,240,248,255,257] bone health ($n = 8$; 11%) (e.g., bone mineral density or content, bone length bone age),[214,216,217,224,225,229,230,254] cardiovascular variables ($n = 7$; 10%) (e.g., blood pressure, ventricular wall thickness),[193,218,237,238,240,241,254] range of motion ($n = 1$, 1%),[220] and menstrual cycle characteristics ($n = 1$, 1%).[207] A variety of data collection techniques were deployed across the sub-topic, with 33% ($n = 23$) of studies using a stadiometer (for anthropometric measurements),[192,194,197,203208–211,218,221,222,224–226,229,232,234,240,241,251–254] 27% ($n = 19$) using timing gates,[192,196,199,203–205,208,210–212,227,232,236,240,247,250,251,256,258] 17% ($n = 12$) using a dynamometer[194,200,213,215219–221,228,233,240,248,255] and 13% ($n = 9$) using skinfold callipers.[193,202,203,230,231,233,237,244,251] Studies measuring jump height and/or distance used optical measurement systems (e.g., photocells) ($n = 16$; 23%),[37,192,201210–212,221,225,227,231,234,239,245,247,249,250] jump, contact or timing mats ($n = 7$; 10%)[196,203,204,236,243,244,249,256] and force plates ($n = 4$; 6%).[208,223,260]

The most common comparative group was age-group with 44% ($n = 31$) of studies comparing variables between at least two age-groups.[194,201,202204–206,208–211,213,215,226–229,231,232,235,238,239,241–244,246,252,253,255,256,259] Of these, the U17 age category was the most common amongst studies ($n = 23$), with U10 being the least ($n = 4$).[209–212,235,253] Two studies worth noting compared variables between seven[232] and eight[256] 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.[309–311] Further comparison groups include asymmetry (right and left, or dominant and non-dominant limb)[37,198,199,206,213,215,239,242,245,248,255] which was used in 16% ($n = 11$) of studies, maturation stage[193,196,212,234,254] and playing

level[197,203,236,244,246] were used in five different studies (7%) each. Seven studies (10%) compared variables over a time period, such as pre- and post-season and training period,[211,217,227,237,240,258,259] all of these studies found significant changes in variables (increased performance) across their compared time period. Only four studies accounted for playing position,[192,236,246,260] with significant differences 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, primarily due to cross-sectional research 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[246,260] and so differences between outfield positions were difficult to determine. This may have implications for talent development and talent identification and recruitment practices.

Physical qualities: training interventions. Of the 22 studies investigating the efficacy of training interventions, participants were predominantly players competing in national competitions ($n = 11$; 50%),[261,262,266,268,269,272,273,275,277,278,281] followed by regional competitions ($n = 7$; 32%),[264,267,271,276,278,280,282] local competitions ($n = 2$; 9%),[274,279] and international competitions ($n = 1$; 5%).[263] Common outcome variables included, jump height and distance ($n = 16$; 73%),[261263–270,272–275,277,279,280] sprint time and distance ($n = 13$; 59%),[261,263265–267,269–273,275,279,282] balance variables generated from the Y-Balance test (e.g., left/right posterolateral movement) ($n = 5$; 23%),[268–270,272,277] force or strength ($n = 4$; 18%),[261–263,278] and power (W) ($n = 3$; 14%).[265,266,276] These variables were commonly quantified using timing gates ($n = 10$; 45%)[261,263,266269–272,275,279,282] and optoelectric cell systems ($n = 9$; 41%).[261,263,265,267271–273,280,305] Sport-specific items (i.e., footballs) were used in two studies (9%)[274,275] to quantify kicking distance and kicking velocity respectively.

Different intervention programs were used, including warm up and activation programs ($n = 4$; 184%),[268,270,277,281] neuromuscular or endurance programmes ($n = 2$, 9%),[261,262] injury prevention programs ($n = 2$; 9%),[272,279] transcranial direct current stimulations ($n = 1$; 5%),[278] and sprint ($n = 5$; 23%),[265,271,274,276,282] strength ($n = 5$; 23%),[263,266,269,272,276] jumping ($n = 2$; 9%)[264,275] and HIIT/football ($n = 2$; 9%)[267,280] training programs. The intervention period for the majority of studies ($n = 17$; 77%) lasted between 4–12 weeks.[261–266,268,270–273,275,276,279,280,282] Three studies (14%) had a season-long intervention duration[267,269,277] and one (5%) lasted only 2-weeks.[278] Most studies ($n = 14$; 64%) compared an intervention group against a control group,[263,267,268270–277,279–281] some compared pre- vs post-intervention ($n = 10$; 45%)[261–264,271,273,274,278–280] and others the effects of different types of training ($n = 6$; 27%).[261,262,265,266,269,280] Sixteen studies (73%) observed significant improvements in physical characteristics following an intervention,[261–263,265–269,271–277,280] two reported improvements in only the dominant limb,[264,278] whilst four either saw decrements or no significant changes in physical characteristics as a result of an intervention.[270,279,281,282]

Studies which introduced an intervention alongside players current training made it difficult to determine the effects of the intervention in isolation ($n = 14$; 64%).[264,265267–275,277,279,281] Furthermore, studies which did not account for baseline fitness levels saw vast differences in individual player physical characteristics ($n = 4$; 18%).[264,265,276,278] 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.

Physical qualities: relative age effects. Twenty studies investigated RAE in national ($n = 10$, 50% [284286–292,301,302]), international ($n = 7$; 33% [285,288293–297]), regional ($n = 5$; 25% [283,284,298,300,302]) and local ($n = 3$; 15% [291,299,300]) competitions. Studies predominantly conducted secondary analysis ($n = 18$; 90%) using data from regional ($n = 2$ [291,300]), national ($n = 12$ [284–286,286,288–290,292,294,294,298,299,301,302]), continental (e.g., UEFA; $n = 1$ [293]) or global governing bodies (i.e., FIFA; $n = 3$ [295–297]). The remaining two studies conducted primary data analysis, utilising a questionnaire (no specific details provided), and anthropometric testing.[283,287] The majority of studies ($n = 18$; 90%) explored birth distribution using birth quartiles[283–285,287,288,290,292,293,295–302] to investigate RAE, with half year birth distribution ($n = 6$; 33%),[290–292,298–300] selection probability ($n = 2$; 11%)[284,285] and predicted adult height ($n = 1$; 6%)[283] used less frequently.

Age-group was the most popular comparative group amongst studies ($n = 14$; 70%),[283,285,287289–293,295,296,299,301] followed by competitive level (e.g., regional, national, international; $n = 8$; 40%)[284286–288,294,298,300,302] and playing position ($n = 6$; 30%),[285,286,294296–298] whilst two studies compared data between geographical location and continental governing bodies (i.e., AFC, CAF, CONCACAF, CONMEBOL, OFC and UEFA[296,297]). Further comparison groups included: selection status ($n = 2$; 10%),[283,291] maturity status ($n = 2$; 10%),[286,287] year of competition ($n = 1$; 5%),[295] success of team ($n = 1$; 5%),[299] skill rating ($n = 1$; 5%),[286] and chronological age ($n = 1$; 5%).[300] RAE within different age-groups (U12 to U19) were explored, with the most common being U17 ($n = 12$; 60%)[285,286,289,290293–298,301,302] and U19 ($n = 9$; 45%)[285,286288–290,293,298,299,302] players. However, no significant

differences in RAE were determined between age-groups in seven studies.[283,285,287,289,294,299,301] Twelve (60%) of the twenty studies concluded there was a significant over-representation of players born in the first half of the year (birth quartiles Q1 and Q2)[285,286290–293,295–298,300,302] compared to the second half (Q3, Q4). However, six studies found no significant RAE.[283,288,289,294,299,301] The lack of significance in findings could be due to these studies choosing to only assess RAE in older age groups. Females tend to mature earlier compared to males,[312] and so age-related differences which may directly affect selection rate may be less pronounced in older age groups. Albeit, the two studies which assessed younger age groups (U12 [283,287]; U13 [283]; 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 mitigate biases in selection processes, which often occur with youth male players,[313] therefore developing a more equitable system for supporting the talent development of youth women's football players.

Physical qualities: 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,[303] side-hop test,[304] anaerobic sprint test[38] jumping, sprinting and agility tests[306,307]). One study assessed the validity of an inertial measurement system (Gyko, Microgate, Italy) and force plate (1000 Hz, Kistler, Switzerland) to determine performance changes across a season,[305] and another study determined differential RPE scales were reliable for measurement of training and match load.[308] Despite a variety of testing aims being presented, three studies compared age-group,[304,306,307] whilst two studies compared data collection technique.[303,305] Playing status[38] and training type[308] were stand-alone comparison groups in the other two studies. None of the seven studies (where it was applicable) used playing position as a comparative group, this with four studies reporting limited sample size by four studies.[38,106,303,305] Multiple studies only included one age-group,[38,106,303,305] limiting the generalisability of findings to the wider youth women's football population. Further limitations of studies included assumptions made on limb dominance,[304] an inability to determine maximum effort from participants in fitness tests.[307] For the study assessing equipment validity, the inertial measurement device was not intended for stand-alone use and so findings may be inaccurate.[305] Future research should aim to adopt a larger sample size and include competitive standard, age-group, and playing position as comparative groups to determine potential validity and reliability differences across the youth women's football population.

Psychology

Thirty-one studies investigated psychology surrounding youth women's footballers (S1 Table).[314–344] Studies most frequently examined motivational climate ($n = 6$; 21%)[329–333,336] and motor development and cognitive function ($n = 9$; 29%).[314,315321–324,327,337,341] As a result, most outcome variables were psychometric scales representing anxiety,[316,326,333,340,342] moral functioning,[344,330,343] leadership,[319,338] self-confidence,[316,333] motivation,[321,328,335,338] coach-athlete relationship,[328] and self-talk.[316,317] These latent constructs were operationalised using several different questionnaires and scales such as: The Psychological Skills Inventory motivation subscale,[321,345] Perceived Motivational Climate in Sport Questionnaire,[329–331,333,336,342,346] the Sport Motivation Scale[328] and the Task and Ego Orientation in Sport Questionnaire[316,317,344,343,346] to measure motivational constructs. The Go/No-Go Task[314,315,347] 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%),[315,320,326,327,343] time period (e.g., pre- and post-game) ($n = 4$, 14%)[314,318,320,334] and game or session stage ($n = 3$; 11%).[322,339,340]

Studies exploring cognitive function and motor development assessed: cognitive function over time,[314] the validation of soccer competence scale[321] and whether motor performance is a predictor for footballing success in adulthood.[327] 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,[333] peer acceptance,[336] and sporting behaviour,[329] determining that higher levels of intrinsic or self-determined motivation are positively related to biopsychosocial outcomes of football involvement. Age-group specific results were presented in five (18%) studies,[315,320,326,327,343] however direct comparisons between them were only made in two.[315,343]

None of the 31 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 women's 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 women footballers. Lastly, future research could explore performance-related psychological variables, such as visual exploratory activity (VEA) of players during training or matches[348] and explore whether VEA of youth women's 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 and informing training design and delivery.

Training load

Eight studies quantified the training load of youth women's footballers (S1 Table).[349–356] These studies involved participants competing in international competitions,[349,351] national competitions[353,354]; Rumpf et al.[355] also included local and regional players, whilst Williams et al.[356] and Idarraga and Valencia-Sánchez[352] only included regional players. The eight studies had distinct aims for investigating training load within youth women's football, including; describing seasonal variations in training, anthropometry, body composition and physical fitness,[353] comparing physical exposure, wellness and psychological variables during domestic and international playing period,[349] quantifying differences in internal and external load between starters and substitutes,[351] investigating training profiles and motivation across different age-groups and competitive standards,[355] determining the prevalence of non-functional overreaching and overtraining in elite youth players,[356] comparing the influence of obstacles in SSGs on tactical, physical and emotional responses of players,[354] evaluating a passing-skill training intervention,[350] and evaluating the effectiveness of psychokinetic games on tactical creativity.[352] Consequently, methodological approaches for data collection and outcome variables varied across the eight 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 women's 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 women's football environments.[308] 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.[162,164,41] 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[162,164]) or into senior female football environments.[357–360] 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).[359]

Limitations

This scoping review adhered to the PRISMA-ScR Checklist,[30] assessing several electronic databases, scoping studies with no date nor language restrictions, and utilising a broad range of search terms inclusive of performance, health and development. Further, two authors independently screened studies at both initial and full-text stage, with all extracted data checked independently by another member of the research team. As such, this study has comprehensively reviewed and summarised the scientific literature investigating the performance, health and development of youth women's football players. However, there are limitations which should be acknowledged. Firstly, whilst no language restrictions were imposed, the search terms were predominantly written in English, and therefore relevant studies written in non-English may have been excluded from this review. Secondly, the search strategy did not include grey literature, and therefore, this review does not consider unpublished (or non-peer-reviewed) evidence relating to the performance, health and development of youth women's football. Whilst population search terms related to youth and adolescents, some studies may have used U (e.g., U12, or U16) as their descriptor, and thus, these studies may not have been captured. Thirdly, due to the nature of this review and the quantity of eligible studies, it was not practically feasible to manually screen the reference list of included studies within the review. Therefore, it may be possible that additional eligible studies could have been identified through this process. Fourthly, studies were systematically categorised into topics based on their primary research aim. However, there may have been studies where secondary or tertiary aims could have been categorised into alternative topics. Lastly, there were a notable proportion of studies which either poorly reported or did not state key information (e.g., number of participants, number of teams/clubs represented within the sample, age-group(s) or competitive standard). Therefore, when conducting data extraction, this resulted in notable data reported as not stated (NS). Therefore, the distribution of studies within the literature may be misrepresented within the results of this scoping review (e.g., U17 may not have been the most investigated age-group). Future research across all topics should ensure methods are clearly detailed to facilitate understanding of the approach adopted, and the individuals participating within studies.

Implications for future research & applied practice

Throughout this scoping review, gaps in literature have been identified within respective topics and recommendations made for future research, both from the perspective of developing knowledge and understanding, and with regards to methodological approaches adopted.

Overall, there is a lack of research investigating international youth women's football players, and future research is warranted to understand the performance, health and development of players competing at the international standard. This insight would be useful for coaches and practitioners supporting and preparing players for involvement across competitive standards (e.g., domestic to international), and for understanding age-related differences which may exist (e.g., youth international to senior international environments) to aid transition and progression between environments. Overall, there is a lack of research which has consistently investigated multiple age-groups across youth women's football, instead primarily focussing on isolated age-groups, and particularly investigating U14–U17 age-groups. There is a need for research to investigate across age-groups, to understand potential age-related differences or considerations for applied practice, particularly due to the differences which can be placed on these age-groups from a talent development perspective (e.g., long-term talent development: learning to train, training to train, training to compete, training to win). There is no research which has investigated youth women's para-football formats, and therefore, a warranted area for future research. Importantly, the evidence-base was predominantly from Western European and North American countries, and thus translation and application for youth women's populations in other countries may be inappropriate (e.g., differing talent development pathways, training and competition structures, playing styles, provision and support). Therefore, greater diversity and representation within future research would facilitate a more global understanding of youth women's football, and aid translation and application within populations in currently underrepresented countries (i.e., South American, Asian, African, Oceanic).[361] Further, global, continental, and national governing bodies should prioritise supporting performance, health and development research within youth women's populations (i.e., in addition to senior women's populations, and participation-focussed research in youth populations), whilst also attempting to address key challenges in facilitating inclusive and diverse research (e.g., funding, resources, access to expertise, socio-cultural expectations of youth women's football).

Studies across all topics (except injury) predominantly involved single team/club samples, and future research should consider collaborative research (e.g., with national governing bodies) who can facilitate recruitment and participation for enabling multi-club approaches (e.g., league-wide) to understand potential team/club variation and facilitate more generalisable insights into youth women's football. There are discrepancies in the number of studies within respective topics, and regardless of methodological inconsistencies or considerations that exist and limit the transfer of knowledge or application findings within topics, the least investigated areas of research were training load, fatigue and recovery and nutrition. However, the body of research has predominantly investigated the performance, health and development of youth women's football in isolated topics. Therefore, to gain a more holistic understanding, future research should aim to adopt a more interdisciplinary approach to investigating the performance, health and development of the youth women's footballer.

This scoping review has provided a comprehensive summary of the current evidence-base within youth women's football, identifying gaps and recommending areas for future research. However, it is important that research attempts to bridge the gap with practitioners, setting an agenda for research investigating the performance, health and development within youth women's football which accounts for the needs of those working with this population. Therefore, the next steps are to engage with wider experts (academic, research, and applied practitioners) by conducting a Delphi study to gain consensus on the required areas for future research, using this scoping review as the basis for current understanding.

Conclusion

This study has scoped the peer-reviewed scientific literature investigating the performance, health and development of youth women's footballers. A total of 294 studies were included, and categorised into eight research topics: biomechanics, fatigue and recovery, injury, match-play, nutrition, physical qualities, psychology and training load. The most researched area was physical qualities, whilst the most investigated players were those competing in regional competitions and those competing in an U17 age-group. The study provides a comprehensive, critical and objective resource of the scientific research involving youth women's soccer players, which can be used to inform applied practices within this population. By determining the methodological approaches adopted, summarising the key findings and identifying the gaps within scientific literature, recommendations have been provided for future research. Further, the current needs, questions or challenges facing applied practitioners working within youth women's football in relation to our current understanding from the scientific literature is required, to establish consensus on priorities for future research.

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Supplemental material

Supplemental material for this article is available online.

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