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Session and drill-specific physical characteristics of youth women's football training

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ABSTRACT
This study quantified and compared session and drill-specific physical characteristics between U10, U12, U14 and U16 youth women's footballers. Data were collected during 80 training sessions using 10 Hz GPS, totalling 825 training observations and 2298 drill-specific observations from 116 players representing two of the English Football Association's Emerging Talent Centres. Linear mixed modelling estimated session and drill-specific; 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), maximum velocity ($m \cdot s^{-1}$) and number of accelerations and decelerations (>1 $m \cdot s^{-2}$, >2 $m \cdot s^{-2}$, >3 $m \cdot s^{-2}$). During sessions, U16s covered more TD than U14s, whilst both U14s and U16s covered greater HSR, VHSR and SPR distances compared to U10s and U12s, and U10s performed more accelerations (>1 $m \cdot s^{-2}$) than U12s and U14s and more decelerations (>1 $m \cdot s^{-2}$) than all other age groups. All age groups had higher physical outputs during SSGs compared to possession and technical drills. Differences in session physical characteristics observed between age groups and between and within age groups for drill-specific physical characteristics, highlight that physical characteristics during training are age- and drill-dependent within youth women's football. These findings have practical implications for informing coaching and talent development practices within youth women's football.

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Soccer; female; external load; locomotor characteristics; activity profile

Introduction

The purpose of training is typically to expose players to sufficient and appropriate stimuli to facilitate adaptations which adequately prepare them for the demands of match-play (Morgans et al., 2014). However, depending upon the population (e.g., youth), the primary intention may instead be for long-term athletic or talent development. Regardless of the specific purpose of training, a critical understanding of current training demands and how to manipulate training environments to achieve desired performance outcomes is required to underpin the design and delivery of training sessions or coaching practice. Therefore, developing an evidence-base examining training is of applied importance. However, in comparison to the evidence base involving men's football populations (Miguel et al., 2021; Silva et al., 2023; Teixeira et al., 2021), relatively limited research has investigated women's football training (Costa et al., 2022).

Research has previously quantified the physical characteristics (i.e., external load representing the work performed by players (e.g., total distance covered; number of accelerations), and/or internal load representing the psychophysiological response to the work performed (e.g., mean heart rate; rate of perceived exertion)) of senior women's football training in international (Doyle et al., 2022; Passos Ramos et al., 2019), domestic (Karlsson et al., 2023; Romero-Moraleda et al., 2021) and collegiate (Gentles et al., 2018; McFadden et al., 2020) competitive standards. Higher training demands (e.g., volume and intensities) are typically reported for players competing at higher playing standards (e.g., top-tier domestic vs second-tier domestic (Myhill et al., 2022); first-team vs reserve team (Casamichana et al., 2025)). Variations in training characteristics have been observed between and within training microcycles in both domestic (e.g., pre-season (Casamichana et al., 2025); pre-season vs in-season (Mara et al., 2015); in-season (Karlsson et al., 2023; Myhill et al., 2022)) and international (e.g., camps and fixtures (Doyle et al., 2022)) playing standards, demonstrating the implementation of periodisation strategies for informing the design and delivery of training within

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senior women's football populations. However, training characteristics have also been reported to differ depending upon starting status (Doyle et al., 2022) and playing position (Doyle et al., 2022; Ishida et al., 2022; Romero-Moraleda et al., 2021) of players. Previous research has found training characteristics of more successful teams to be more reflective of match-play characteristics when compared to less successful teams (top vs bottom half league rankings) (Savolainen et al., 2024), suggesting that training in more successful teams may better prepare players for the physical demands of match-play.

Within training sessions, coaches and practitioners can implement a variety of training activities to expose players to differing physical, technical, tactical or psychosocial characteristics. Consistent with the literature quantifying training-level characteristics, there is a greater body of research investigating drill-specific characteristics in men's football populations (Barrett et al., 2020; Marris et al., 2022) as opposed to women's football populations (Emmonds et al., 2023; Romero-Moraleda et al., 2021). Romero-Moraleda et al. (2021) quantified drill-specific physical characteristics of senior international players and observed differences between match-play physical characteristics and drill-specific physical characteristics (e.g., distance covered, number of accelerations and decelerations) for warm-up activities, small-sided games (SSGs) and technical-tactical training activities. Furthermore, friendly matches (or match simulations) were the only training activity which consistently replicated or exceeded match-play characteristics. Emmonds et al. (2023) observed similar drill-specific physical characteristics across training activities (i.e., possession, position-specific training, SSGs, tactical and technical) of senior domestic women's football competitive standards. Furthermore, coaches can manipulate the constraints of training activities to elicit different characteristics (Ibáñez et al., 2020), for example, number of players, playing area and numerical balance (i.e., teammates vs opposition). Understanding how training characteristics may differ at both the session-level and training activity-level, and how to manipulate activities to elicit specific characteristics, can help inform the structure, design and delivery of coaching practice and training environments.

Whilst there is a limited but growing body of research quantifying training characteristics of women's football players, this predominantly focuses upon senior populations. The few studies involving youth women's football players have investigated research questions in isolation (e.g., training load of U19s during domestic vs international playing periods (Andersen et al., 2023); starters vs substitutes' training load of U16s during an international tournament (González-García & Romero-Moraleda, 2024); seasonal training load of U17 domestic players (Lesinski et al., 2017)), and adopted differing methodological approaches to quantify training load (i.e., number of hours of training (Lesinski et al., 2017); session rate of perceived exertion (RPE) (González-García & Romero-Moraleda, 2024; Wright et al., 2020); global positioning system (GPS)-derived variables (González-García & Romero-Moraleda, 2024)). As such, it is both challenging to compare findings and to draw conclusions from the existing research, and importantly, only one known study has quantified the external load of youth women's football players during training (González-García & Romero-Moraleda, 2024). This is problematic, as coaches and practitioners working within youth women's football may inappropriately draw on evidence derived from other populations (e.g., senior women's football) to inform the design and delivery of training due to the population-specific (e.g., physiological (Datson et al., 2022; Poehling et al., 2021; Ramos et al., 2021), biomechanical (Butcher et al., 2024; Ramachandran et al., 2024)) and contextual (e.g., training and competition structures, sport science and medicine provision/support) differences which exist between senior and youth women's football. Therefore, research which investigates the training characteristics of youth women's football is warranted. Furthermore, research has yet to examine whether age group differences exist in youth women's training characteristics (Adams et al., 2026). Therefore, this study aimed to quantify and compare session and drill-specific physical characteristics of U10, U12, U14 and U16 youth women's football training.

Methods

Participants

A total of 116 outfield youth women's 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 English Football Association's Emerging Talent Centres (ETCs). ETCs (n = 73) (The Football Association, 2025) are an entry point into the Women's and Girls' England Talent Pathway, aiming to identify and develop future potential players by providing high-quality training environments (The Football Association, 2024). ETCs must deliver a minimum of one training session per week including 90 min of pitch-based technical training, strength and conditioning/physical literacy provision and exposure to a variety of match formats (e.g., full-sided, small-sided and futsal) with a minimum of one competitive fixture every six-weeks (The Football Association, 2024). Players within ETCs also train and compete with a grassroots club. The provision of weekly training sessions differed between participating ETCs (ETC 1: 1× 90-min pitch-based session; ETC 2: 2× 90-min pitch-based sessions). The study received ethics approval from the University of Essex Research Ethics Committee (ETH2324-0051) and all players (and parents/guardians) provided written informed assent (and consent for parents/guardians) before participation.

Sample size estimation and justification

No formal sample size calculation was performed for this study, rather sample size justification was based upon resource limitations and time constraints (e.g., location of ETCs in relation to research institution, conflicting ETC training schedules and number of GPS units) (Lakens, 2022). A post-hoc sensitivity analysis was conducted to facilitate appropriate interpretation of statistical analysis outputs (Lakens, 2022).

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 to May 2024). All training sessions were scheduled for a 90-min duration (mean = 88.6 ± 7.2 min) 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 × 27 m); ETC 2: three age groups with pitch dimensions not exceeding half of the pitch (55 × 37 m)). 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 10 Hz 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 physical characteristics within team sports (Beato & de Keijzer, 2019; Beato et al., 2018). Players were assigned a specific GPS unit for the duration of the study and thus wore the same unit across all respective observations. The GPS units were activated before being inserted into a pouch located on the upper back of a bespoke vest. 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; R Foundation for Statistical Computing, Vienna, Austria).

The categorisation of individual drills was informed by previous research (Cushion et al., 2012; Emmonds et al., 2023; Ford et al., 2010), and conducted in-situ by one researcher (TA). Only warm-up drills, technical drills (i.e., individual or group drills isolating technical skills in a limited or no-pressure environment), possession drills (i.e., no goals/targets in which retention of possession rather than scoring is the primary objective), small-sided games (SSGs, i.e., a game with a reduced number of players, pitch size and specific rules with both teams scoring) and match simulations (i.e., game played realistic to regulation match-rules) were observed. However, match simulations (due to the low number of drill observations), phase of play drills (due to a single observation) and warm-up drills were excluded from subsequent analysis. A total of 2373 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 ± 6.9; range = 4–35; U14: n = 854; mean per player = 23.7 ± 8.5; range = 1–38; U16: n = 184; mean per player = 12.3 ± 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 $m \cdot s^{-1}$), sprinting (SPR; >5.76 $m \cdot s^{-1}$) distances (m) (Harkness-Armstrong, Till, Datson, & Emmonds, 2022) and maximum velocity ($m \cdot s^{-1}$). Frequency of accelerations (n) and decelerations (n) in three different zones were also quantified; 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 0.5 s. Variables were also presented relative to the duration of the session or drill (i.e., $m \cdot min^{-1}$; $n \cdot min^{-1}$) to facilitate comparisons between observations with differing 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 (Harkness-Armstrong, Till, Datson, & Emmonds, 2022), 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 women's football players (8.26 $m \cdot s^{-1}$ (Harkness-Armstrong, Till, Datson, & Emmonds, 2022)). Thus, a total of 7% of the 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 2298 drill observations included for data analysis (Table 1).

Statistical analysis

Statistical analyses were conducted using RStudio. 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 physical characteristics for training sessions and included a physical variable (e.g., TD, HSR) as the 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 physical characteristics for drills and included a physical variable as the dependent variable, age group and drill category (possession, SSG or 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 $p < 0.05$ for pairwise comparisons. The minimum detectable effect (MDE) was determined for all pairwise comparisons across both linear mixed models (Supplementary Material Tables 1–3). The MDE represents the smallest effect that could be detected as statistically significant given the observed variability and alpha (0.05). Effects below the MDE should be interpreted with caution, due to limited sensitivity to reliably detect statistically significant effects of this magnitude. 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, the effects were considered unclear.

Results

Training sessions

Training sessions: Absolute data

The absolute physical variables for each age group are presented in Table 2. The age group comparisons (statistical significance and ES) are presented in Figure 1.

U16s covered more TDs compared to U14s (420 m; moderate ES: 0.95 ± 0.49). U16s covered greater HSR distance than U10s (149 m; moderate ES: 1.01 ± 0.61) and U12s (214 m; $p < 0.05$; large ES: 1.46 ± 0.51), and U14s covered more than U12s (160 m; moderate ES: 1.09 ± 0.43). U16s covered greater VHSR distance than U10s (36 m; $p < 0.05$; large ES: 1.36 ± 0.48) and U12s (46 m; $p < 0.001$; large ES: 1.71 ± 0.40), and U14s covered more than U10s (40 m; $p < 0.01$; large ES: 1.52 ± 0.45) and U12s (50 m; $p < 0.001$; large ES: 1.88 ± 0.33). U14s and U16s covered greater SPR distance than U10s (U14: 13 m; moderate ES: 1.14 ± 0.48; U16: 16 m; $p < 0.05$; large ES: 1.42 ± 0.51) and U12s (U14: 9 m; $p < 0.001$; large ES: 1.69 ± 0.36; U16: 22 m; $p < 0.001$; large ES: 1.97 ± 0.43).

U16s achieved a higher maximum velocity 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 also achieved a higher maximum velocity than 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 (≥1 $m \cdot s^{-2}$) than U12s (n = 6.0; moderate ES: 0.62 ± 0.41) and U14s (n = 5.9; moderate ES: 0.61 ± 0.41). U16s performed more accelerations (≥2 $m \cdot s^{-2}$) than all other age groups (U10: n = 1.0; small ES: 0.39 ± 0.30; U12: n = 1.4; small ES: 0.55 ± 0.26; U14: n = 1.1; small ES: 0.43 ± 0.26). There were no differences observed between the age groups in the number of accelerations (≥3 $m \cdot s^{-2}$). U10s performed more decelerations (≥1 $m \cdot s^{-2}$) than all other age groups (U12: n = 13.3; $p < 0.05$; large ES: 1.31 ± 0.43; U14: n = 12.2; $p < 0.05$; large ES: 1.20 ± 0.43; U16: n = 8.5; moderate ES: 0.84 ± 0.48). U10s also performed more decelerations than U12s at ≥2 $m \cdot s^{-2}$ (n = 0.2; small ES: 0.22 ± 0.16) and ≥3 $m \cdot s^{-2}$ (n = 0.2; small ES: 0.22 ± 0.16).

Training sessions: Relative data

Table 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 2.

U16s covered more TD than U10s (5.1 $m \cdot min^{-1}$; 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: 1.9 $m \cdot min^{-1}$; moderate ES: 1.06 ± 0.58; U16: 2.4 $m \cdot min^{-1}$; large ES: 1.31 ± 0.62) and U12s (U14: 2.1 $m \cdot min^{-1}$; $p < 0.05$; moderate ES: 1.15 ± 0.44; U16: 2.5 $m \cdot min^{-1}$; $p < 0.05$; large ES: 1.40 ± 0.52). U14s and U16s covered more VHSR distance compared to U10 (U14: 0.6 $m \cdot min^{-1}$; $p < 0.01$; large ES: 1.63 ± 0.44; U16: 0.5 $m \cdot min^{-1}$; $p < 0.05$; large ES: 1.42 ± 0.48) and U12s (U14: 0.6 $m \cdot min^{-1}$; $p < 0.001$; large ES: 1.81 ± 0.33;

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

Table 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 ± 81.0	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

U16: 0.6 $m \cdot min^{-1}$; $p < 0.001$; large ES: 1.60 ± 0.40). U14s and U16s covered greater SPR distance compared to U10s (U14: 0.2 $m \cdot min^{-1}$; moderate ES: 1.19 ± 0.46; U16: 0.2 $m \cdot min^{-1}$; $p < 0.05$; large ES: 1.47 ± 0.50) and U12s (U14: 0.2 $m \cdot min^{-1}$; $p < 0.001$; large ES: 1.69 ± 0.35; U16: 0.3 $m \cdot min^{-1}$; $p < 0.001$; 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 the 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.

Training drills

The distribution of drill types, mean (±SD) and range of durations and are presented in Table 4.

The relative physical characteristics for each age group according to the training drill are presented in Table 5. The comparisons within age groups are presented in Figure 3A (U10s and U12s) and Figure 3B (U14s and U16s), and comparisons between age groups are presented in Figure 4.

Training drills: Within age groups

During possession drills, U10s covered more TD (13.1 $m \cdot min^{-1}$; large ES: 1.43 ± 0.61), HSR distance (3.7 $m \cdot min^{-1}$; moderate ES: 0.96 ± 0.59), achieved a higher maximum velocity (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 (18.3 $m \cdot min^{-1}$; very large ES: 2.00 ± 0.63) and HSR distance (4.5 $m \cdot min^{-1}$; moderate ES: 1.17 ± 0.60), achieved higher maximum velocity (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 technical drills.

U12s covered a greater TD (11.5 $m \cdot min^{-1}$; $p < 0.05$; large ES: 1.25 ± 0.35) and performed more accelerations (≥1 $m . s^{-2}$; 0.09 $n \cdot min^{-1}$; small ES: 0.35 ± 0.17) and decelerations (≥1 $m . s^{-2}$; 0.09 $n \cdot min^{-1}$; small ES: 0.32 ± 0.17) during possession drills compared to technical drills. Similarly, U12s covered more TD (15.9 $m \cdot min^{-1}$; $p < 0.01$; 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 physical characteristics 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 (0.3 $m \cdot min^{-1}$; small ES: −0.38 ± 0.25) compared to technical drills. U14s covered more TD (22.2 $m \cdot min^{-1}$; $p < 0.001$; very large ES: 2.42 ± 0.41), HSR distance (6.3 $m \cdot min^{-1}$; $p < 0.01$; large ES: 1.67 ± 0.39) and VHSR distance (0.4 $m \cdot min^{-1}$; moderate ES: 0.61 ± 0.25) achieved higher maximum velocity (0.55 $m \cdot s^{-1}$; $p < 0.05$; moderate ES: 1.01 ± 0.28) and performed a greater number of accelerations (≥1 $m \cdot s^{-2}$; 0.12 $n \cdot min^{-1}$; small ES: 0.45 ± 0.20) and decelerations (≥1 $m \cdot s^{-2}$; 0.18 $n \cdot min^{-1}$; moderate ES: 0.62 ± 0.20) during SSGs in comparison to technical drills. Furthermore, U14s covered greater TD (19.2 $m \cdot min^{-1}$; $p < 0.001$; very large ES: 2.10 ± 0.37), HSR (6.2 $m \cdot min^{-1}$; $p < 0.001$; large ES: 1.63 ± 0.35) and VHSR distances (0.7 $m \cdot min^{-1}$; $p < 0.01$; moderate ES: 1.00 ± 0.23) achieved a higher maximum velocity (0.53 $m \cdot s^{-1}$; $p < 0.01$; moderate ES: 0.98 ± 0.25) and decelerations performed (≥1

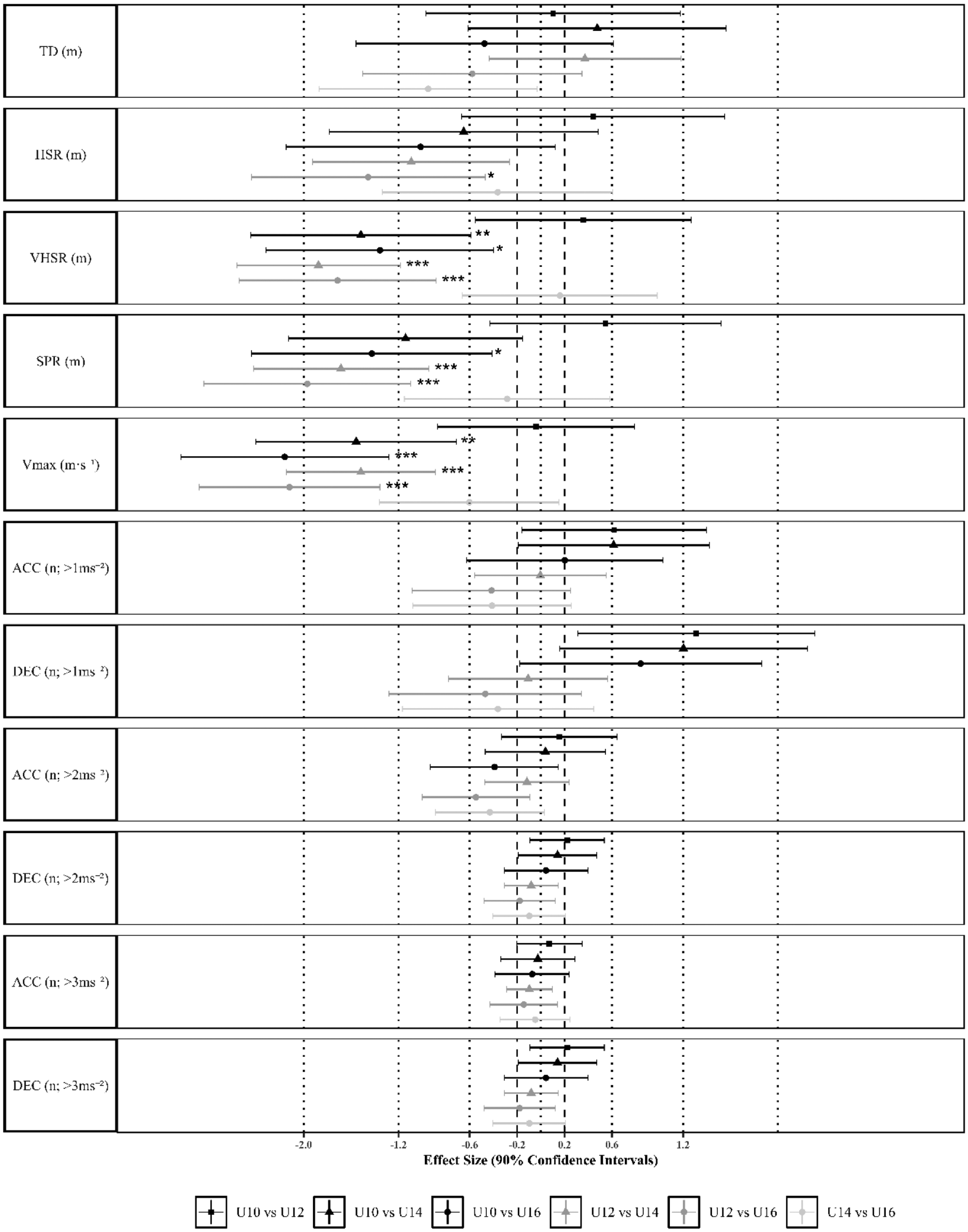

Figure 1. Effect size of differences in estimated mean and statistical significance of total distance (TD), high-speed running (HSR), very high-speed running (VHSR), sprinting distances covered, maximum velocity (Vmax) and number of accelerations (ACC) and decelerations (DEC) performed during training sessions between U10, U12, U14 and U16 youth female footballers. **Statistically significant difference ($p < 0.05$*, $p < 0.01$**, $p < 0.001$***).*

Table 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 · min^{-1})	39.79 ± 2.30	42.44 ± 1.62	41.32 ± 1.60	44.88 ± 2.02
HSR Distance (m · min^{-1})	5.86 ± 1.03	5.69 ± 0.78	7.77 ± 0.78	8.22 ± 0.91
VHSR Distance (m · min^{-1})	0.39 ± 0.21	0.33 ± 0.19	0.95 ± 0.19	0.88 ± 0.20
SPR Distance (m · min^{-1})	0.12 ± 0.09	0.05 ± 0.09	0.27 ± 0.09	0.31 ± 0.09
Accelerations ≥ 1 m · s^{-2} (n · min^{-1})	0.52 ± 0.04	0.50 ± 0.03	0.51 ± 0.03	0.54 ± 0.04
Decelerations ≥ 1 m · s^{-2} (n · min^{-1})	0.62 ± 0.04	0.49 ± 0.03	0.51 ± 0.03	0.54 ± 0.04
Accelerations ≥ 2 m · s^{-2} (n · min^{-1})	0.06 ± 0.01	0.06 ± 0.01	0.07 ± 0.01	0.08 ± 0.01
Decelerations ≥ 2 m · s^{-2} (n · min^{-1})	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00
Accelerations ≥ 3 m · s^{-2} (n · min^{-1})	0.01 ± 0.00	0.00 ± 0.00	0.01 ± 0.00	0.01 ± 0.00
Decelerations ≥ 3 m · s^{-2} (n · min^{-1})	0.01 ± 0.00	0.01 ± 0.01	0.01 ± 0.00	0.01 ± 0.00

m · 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 (4.1 m · min^{-1}; moderate ES: 1.07 ± 0.68) and performed more decelerations (≥1 m · s^{-2}; 0.19 n. min^{-1}; moderate ES: 0.67 ± 0.42) during technical drills compared to possession drills. During SSGs, U16s covered more TD (8.5 m · min^{-1}; moderate ES: 0.93 ± 0.49), achieved a higher maximum velocity (0.46 m · s^{-1}; moderate ES: 0.85 ± 0.34) and performed more decelerations (≥1 m · s^{-2}; 0.10 n · min^{-1}; small ES: 0.36 ± 0.27) compared to technical drills. U16s covered greater TD (10.5 m · min^{-1}; moderate ES: 1.15 ± 0.65), HSR distance (4.4 m · min^{-1}; moderate ES: 1.16 ± 0.63) and VHSR distance (0.5 m · min^{-1}; moderate ES: 0.76 ± 0.45) achieved greater maximum velocity (0.70 m · s^{-1}; large ES: 1.28 ± 0.48), but performed fewer accelerations (≥1 m . s^{-2}; 0.14 n. min^{-1}; small ES: 0.51 ± 0.39) during SSGs compared to possession drills.

Training drills: Between age groups

During SSGs, U14s covered more TD than U10s (11.9 m · min^{-1}; large ES: 1.30 ± 0.63) and U12s (7.6 m · min^{-1}; moderate ES: 0.83 ± 0.48), and U16s covered more than U10s (8.2 m · min^{-1}; moderate ES: 0.89 ± 0.63). Both U14s and U16s covered more HSR distance than U10s (U14: 8.2 m · min^{-1}; $p < 0.05$; very large ES: 2.17 ± 0.62; U16: 6.6 m · min^{-1}; large ES: 1.73 ± 0.64) and U12s (U14: 6.9 m · min^{-1}; $p < 0.01$; large ES: 1.83 ± 0.47; U16: 5.3 m · min^{-1}; large ES: 1.39 ± 0.52). U14s covered greater VHSR distance compared to U10s (0.9 m · min^{-1}; $p < 0.05$; large ES: 1.28 ± 0.35), U12s (1.0 m · min^{-1}; $p < 0.001$; large ES: 1.36 ± 0.29) and U16s (0.3 m · min^{-1}; small ES: 0.37 ± 0.30), whilst U16s covered more than U10s (0.6 m · min^{-1}; moderate ES: 0.91 ± 0.37) and U12s (0.7 m · min^{-1}; moderate ES: 0.99 ± 0.32). Both U14s and U16s achieved a higher maximum velocity 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 (≥1 m · s^{-2}; 0.07 n · min^{-1}; small ES: 0.27 ± 0.24). U10s and U14s performed more decelerations (≥1 m · 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: 11.3 m · min^{-1}; large ES: 1.97 ± 0.73; U12s: 18.0 m · min^{-1}; large ES: 1.24 ± 0.52; U14s: 9.9 m · min^{-1}; moderate ES: 1.09 ± 0.55). All age groups covered more HSR distance compared to U10s (U12s: 5.4 m · min^{-1}; large ES: 1.43 ± 0.66; U14s: 6.4 m · min^{-1}; large ES: 1.67 ± 0.70; U16s: 10.7 m · min^{-1}; $p < 0.01$; very large ES: 2.82 ± 0.72), whilst U16s covered more than U12s (5.3 m · min^{-1}; large ES: 1.38 ± 0.53) and U14s (4.3 m · min^{-1}; moderate ES: 1.14 ± 0.55). Both U14s and U16s covered more VHSR distance than U10s (U14: 0.7 m · min^{-1}; moderate ES: 0.93 ± 0.40; U16: 0.7 m · min^{-1}; moderate ES: 0.95 ± 0.44) and U12s (U14 vs U12: 0.5 m · min^{-1}; moderate ES: 0.65 ± 0.27; U16: 0.5 m · min^{-1}; moderate ES: 0.68 ± 0.33). All age groups achieved a higher maximum velocity than U10s during technical drills (U12s: 0.89 m · s^{-1}; $p < 0.05$; large ES: 1.62 ± 0.43; U14s: 1.01 m · s^{-1}; $p < 0.01$; large ES: 1.85 ± 0.45; U16s: 1.24 m · s^{-1}; $p < 0.001$; very large ES: 2.27 ± 0.48), and U16s also achieved a higher maximum velocity than U12s (0.36 m · s^{-1}; moderate ES: 0.65 ± 0.36). U16s completed more accelerations (≥1 m · s^{-2}) compared to U12s (0.13 n · min^{-1}; small ES: 0.49 ± 0.29) and U14s (0.09 n · min^{-1}; small ES: 0.34 ± 0.30).

During possession drills, U12s covered more TD than U14s (7.1 m · 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 U10s (0.3 m · min^{-1}; small ES: 0.45 ± 0.33) and U12s (0.2 m · min^{-1}; small ES: 0.33 ± 0.25). U14s achieved a higher maximum velocity than U10s (0.32 m · s^{-1}; small ES: 0.58 ± 0.37). U16s performed more accelerations (≥1 m · s^{-2}) than U12s (0.14 n · min^{-1}; small ES: 0.52 ± 0.42), whilst U10s performed more decelerations (≥1 m · s^{-2}) than U12s (0.20 n · min^{-1}; moderate ES: 0.69 ± 0.32) and U14s (0.17 n · min^{-1}; moderate ES: 0.61 ± 0.32).

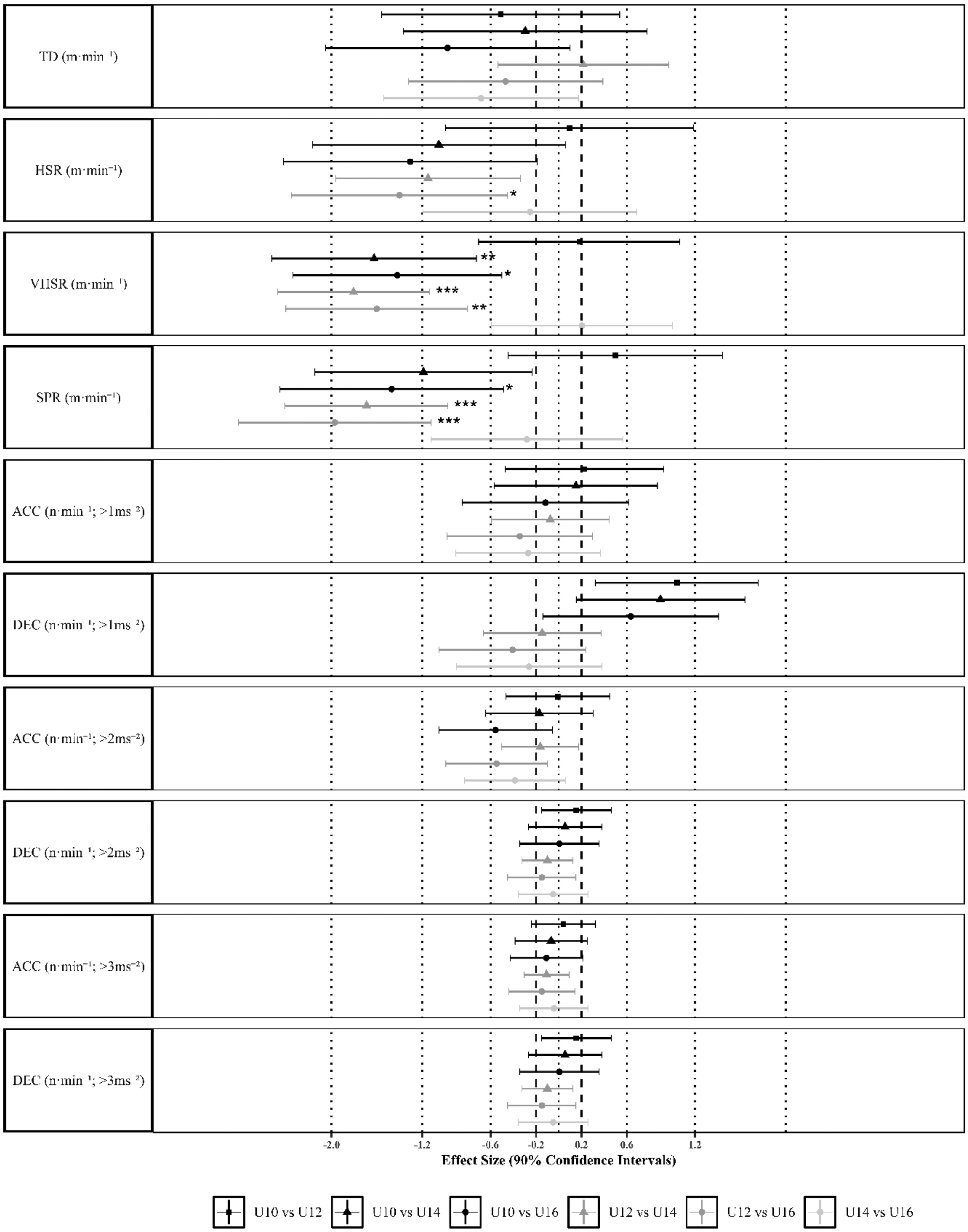

Figure 2. Effect size of differences in estimated mean and statistical significance of relative total distance (TD), high-speed running (HSR), very high-speed running (VHSR), sprinting (SPR) distances covered and number of accelerations (ACC) and decelerations (DEC) performed during training sessions between U10, U12, U14 and U16 youth female footballers. **Statistically significant difference ($p < 0.05$*, $p < 0.01$**, $p < 0.001$***).*

Table 4. Distribution of drills during training for U10, U12, U14 and U16 age groups.

	Drill	U10	U12	U14	U16
Proportion of session duration (%)	Possession	13.4	19.9	18.0	9.1
	SSG	12.8	16.0	20.7	31.7
	Technical	6.8	21.8	14.1	14.0
Mean ± SD duration (mins)	Possession	11.7 ± 5.6	15.2 ± 8.9	13.8 ± 8.8	22.4 ± 13.8
	SSG	12.3 ± 5.8	18.7 ± 9.2	18.7 ± 10.0	23.7 ± 13.0
	Technical	10.3 ± 3.5	16.7 ± 9.5	15.4 ± 9.8	16.0 ± 10.8
Range duration (mins)	Possession	4.0–21.0	4.0–44.0	5.5–46.6	7.9–46.6
	SSG	6.0–25.0	5.0–36.0	3.0–41.7	6.9–52.5
	Technical	5.0–16.0	4.0–42.0	3.0–40.6	4.0–40.6

Discussion

The aim of this study was to quantify and compare session and drill-specific physical characteristics between U10, U12, U14 and U16 age groups of youth women's footballers during training. Differences in session physical characteristics were observed between age groups and between and within age groups for drill-specific physical characteristics, suggesting session and drill-specific physical training characteristics of youth women's footballers are age- and drill-dependent. During sessions, U16s covered greater TD than U14s, and U14s and U16s covered more HSR, VHSR and SPR distances compared to U10s and U12s, whilst U10s performed more accelerations ($>1\ m \cdot s^{-2}$) than U12s and U14s, and more decelerations ($>1\ m \cdot s^{-2}$) than all other age groups. The highest physical outputs were typically observed during SSGs, regardless of age group; however, U16s had the lowest physical outputs during possession drills whilst the lowest physical outputs were observed during technical drills for all other age groups. This study provides novel insights into training demands in youth women's football, contributing to our currently limited understanding in this population, and the findings have practical implications for the design and delivery of training, talent development and identification practices and coach development within youth women's football.

During training sessions, U16s covered a greater (moderate ES) TD than U10s ($m \cdot min^{-1}$) and U14s (m; $m \cdot min^{-1}$), and U14s and U16s covered more (moderate–large) HSR, VHSR and SPR distances (m; $m \cdot min^{-1}$) and achieved a higher (moderate–very large ES) maximum velocity than U10s and U12s. The observed increases in session physical characteristics, which predominantly exist between U12 and U14 age groups as opposed to between consecutive age groups could be consequential of increased physical capabilities associated with growth and maturation, with more mature players demonstrating improved aerobic capacity, sprint speed, change of direction (Emmonds, Scantlebury, et al., 2020) and strength (Emmonds et al., 2017). As the age of young women's footballers PHV is typically ~12 years (Emmonds et al., 2017; Emmonds, Scantlebury, et al., 2020; Malina et al., 2021), this period of rapid change in growth and maturation may have implications for increases in external load between these age groups. Future research should incorporate maturity assessment (e.g., maturity offset, percentage of predicted adult height) to disentangle maturational from chronological age effects on training characteristics. However, the age-related increases in HSR, VHSR and SPR distances may also be reflective of the application of velocity thresholds which may be too excessive to fully capture HSR, VHSR or SPR of U10 and U12 players (Harkness-Armstrong, Till, Datson, & Emmonds, 2022). The adoption of fixed population-specific velocity thresholds (albeit established for U14s and U16 youth women's footballers) was to facilitate age group comparisons of physical characteristics. However, within applied contexts, application without the qualitative descriptors of movement (e.g., HSR or SPR) or adoption of individualised velocity thresholds may be a more appropriate approach depending upon the intended application of data (Harkness-Armstrong, Till, Datson, & Emmonds, 2022). Regardless, there are practical implications for coaches working with youth women's football players given the increased physical characteristics between U12s and U14s, including; long-term talent development practices, or utilising dual-banding age groups (U10s and U12s, U14s and U16s) for training given the similar physical characteristics. Additionally, future research should aim to explore the influence of contextual factors on training characteristics of youth women's football players, for example, seasonal variation (e.g., pre-season vs in-season) (Lesinski et al., 2017), periodisation strategies (Karlsson et al., 2023; Myhill et al., 2022), dual-banding approaches or youth players 'playing up' an age group (Kelly et al., 2021).

In contrast to the distance covered, fewer age group differences were observed for the number of accelerations and decelerations performed. U10s performed more (moderate ES) accelerations (n; $>1\ m \cdot s^{-2}$) than

Table 5. Estimated mean + SE of relative physical training characteristics across training drills for U10, U12, U14 and U16 age groups.

	U10			U12			U14			U16		
	POS	SSG	TEC	POS	SSG	TEC	POS	SSG	TEC	POS	SSG	TEC
TD ($m \cdot min^{-1}$)	47.2 ± 4.9	52.4 ± 5.1	34.1 ± 5.6	52.2 ± 2.7	56.9 ± 3.3	40.8 ± 2.7	45.1 ± 2.8	64.3 ± 2.9	42.2 ± 3.1	50.1 ± 5.6	60.6 ± 3.4	52.1 ± 4.0
HSR ($m \cdot min^{-1}$)	5.39 ± 2.06	6.19 ± 2.12	1.74 ± 2.31	6.42 ± 1.25	7.50 ± 1.43	7.17 ± 1.25	8.26 ± 1.25	14.4 ± 1.28	8.09 ± 1.38	8.36 ± 2.32	12.76 ± 1.50	12.42 ± 1.73
VHSR ($m \cdot min^{-1}$)	0.21 ± 0.25	0.32 ± 0.26	0.14 ± 0.28	0.29 ± 0.20	0.26 ± 0.21	0.33 ± 0.20	0.52 ± 0.20	1.21 ± 0.20	0.79 ± 0.21	0.43 ± 0.33	0.80 ± 0.25	0.95 ± 0.22
Vmax ($m \cdot s^{-1}$)	4.58 ± 0.23	4.76 ± 0.23	3.87 ± 0.26	4.75 ± 0.18	4.89 ± 0.20	4.76 ± 0.18	4.90 ± 0.18	5.43 ± 0.19	4.88 ± 0.19	4.88 ± 0.29	5.58 ± 0.20	5.12 ± 0.22
ACC ≥ 1 $m \cdot s^{-2}$ ($n \cdot min^{-2}$)	0.70 ± 0.09	0.70 ± 0.09	0.57 ± 0.10	0.64 ± 0.07	0.63 ± 0.07	0.54 ± 0.07	0.66 ± 0.07	0.70 ± 0.07	0.58 ± 0.07	0.77 ± 0.12	0.63 ± 0.08	0.67 ± 0.09
DEC ≥ 1 $m \cdot s^{-2}$ ($n \cdot min^{-2}$)	0.84 ± 0.09	0.78 ± 0.09	0.62 ± 0.10	0.65 ± 0.06	0.62 ± 0.06	0.56 ± 0.06	0.67 ± 0.06	0.74 ± 0.06	0.56 ± 0.06	0.79 ± 0.12	0.71 ± 0.07	0.60 ± 0.08

POS = Possession-based drill; SSG = small-sided games; TECH = technical drill. U = Under. TD = total distance; HSR = high-speed running; VHSR = very high-speed running; Vmax = maximum velocity; ACC = acceleration; DEC = deceleration.

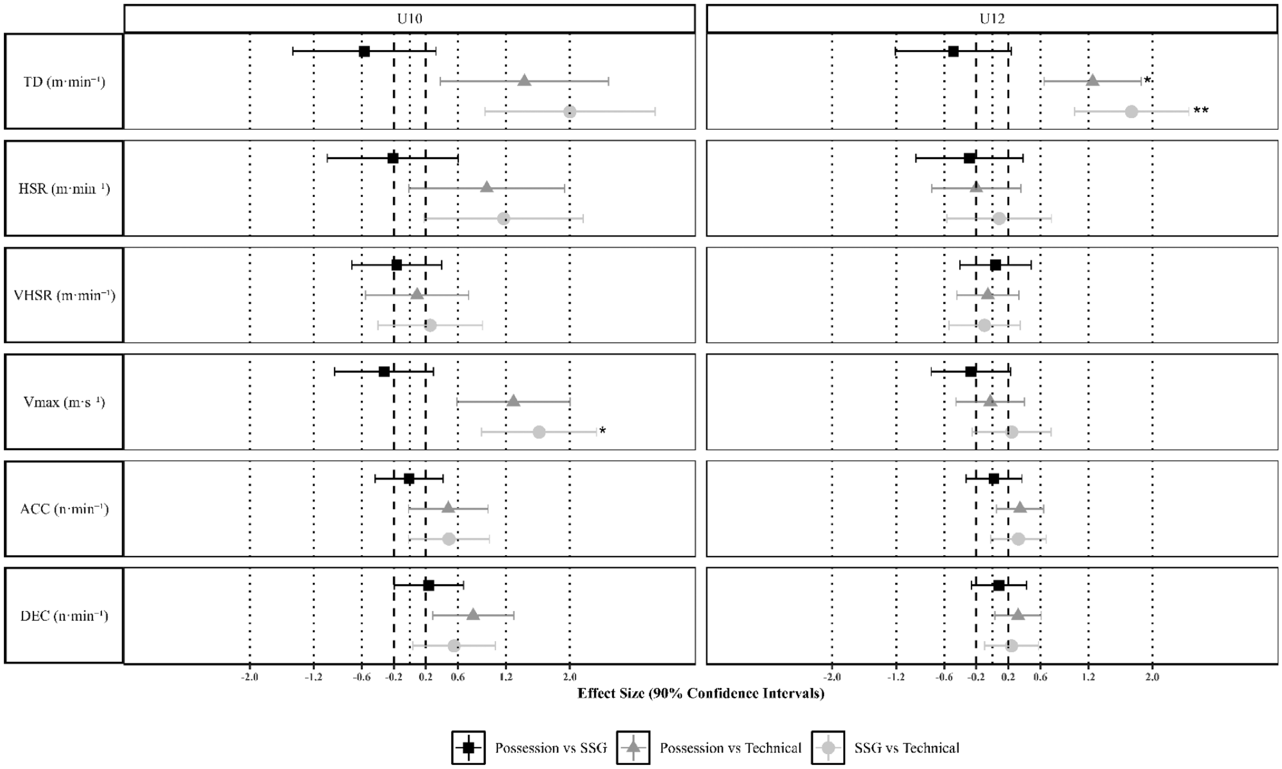

Figure 3A. Effect size of differences in estimated mean and statistical significance of relative total distance (TD), high-speed running (HSR), very high-speed running (VHSR) distances covered, maximum velocity (Vmax) and number of accelerations (ACC; >1 m · s^{-1}) and decelerations (DEC; >1 m · s^{-1}) between possession drills, small-sided games (SSG) and technical drills by U10 and U12 youth female footballers. **statistically significant difference ($p < 0.05$*, $p < 0.01$**, $p < 0.001$***).*

U12s and U14s, U16s performed more (small ES) accelerations (n; n · min^{-1}; >2 m · s^{-2}) than all other age groups, whilst U10s performed more (moderate ES) decelerations (n; n · min^{-1}; >1 m · s^{-2}) than all other age groups. Further, no differences between age groups were observed in the relative number of accelerations (≥1 m · s^{-2}; ≥3 m · s^{-2}) or decelerations (≥2 m · s^{-2}; ≥3 m · s^{-2}) performed. The lack of progressive exposure to accelerations and decelerations in youth women's football training sessions may have implications for increasing injury risks (Griffin et al., 2022), as observed within other women's football populations (i.e., inadequate progressive exposure and increased injury risk in senior women's football) (Moreno-Perez et al., 2025). These movement patterns occur frequently in elite female football due to the need to change direction over short distances, often less than 10 m after a bout of HSR or SPR. These rapid increases and decreases in velocity require the application and absorption of high forces in joints and soft tissue structures (Griffin et al., 2020). Deceleration can place players at greater risk of injury due to eccentric muscle actions and a decrease in joint stiffness (Hewit et al., 2011). Previous research highlights that performance characteristics develop with age, with a change of direction ability demonstrating the greatest changes between U12 and U14 age groups (Emmonds et al., 2018). Growth-related changes will affect muscle strength and co-ordination with improvements in motor control patterns as players mature. Therefore, coaches and practitioners should aim to prepare players with a progressive programme to improve acceleration and deceleration actions with anticipated and unanticipated tasks to work on technique and force distribution as well as decision making related to the sport (Griffin et al., 2022). These tasks can be a component in warm-ups but should also be implemented under fatigue to improve ability and capacity in an effort to reduce injuries (Griffin et al., 2022). Furthermore, coaches and practitioners should consider how to maximise player adherence through implementation of such injury prevention programmes (e.g., FIFA 11+) within their environment to not only reduce overall injury risk (Crossley et al., 2020; Hägglund et al., 2013) but also of ACL-related injuries, where the risk for youth women's football players is greater than their male counterparts (Bram et al., 2021; Childers et al., 2025; Waldén et al., 2011).

Youth women's football players covered a TD between 3594 and 3850 m during training sessions, which is lower than typically covered by senior women's players during training sessions (excluding MD-1:

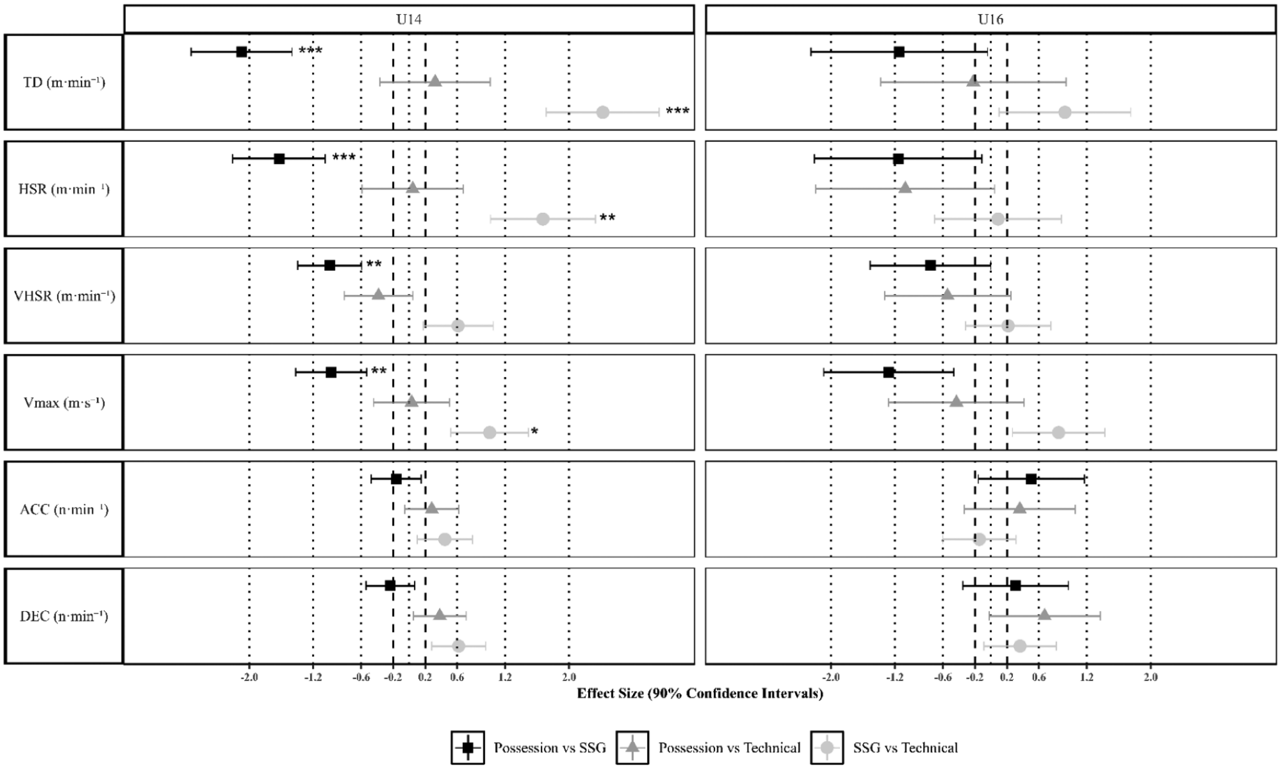

Figure 3B. Effect size of differences in estimated mean and statistical significance of relative total distance (TD), high-speed running (HSR), very high-speed running (VHSR) distances covered, maximum velocity (Vmax) and number of accelerations (ACC; >1 m · s^{-1}) and decelerations (DEC; >1 m · s^{-1}) 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***).*

4556–7336 m) (Myhill et al., 2022). However, when accounting for the duration of training, the discrepancy in relative TD covered during training sessions between youth and senior players reduced (youth: 39.8–44.8 m · min^{-1} vs senior: 44.5–61.48 m · min^{-1}) (Myhill et al., 2022). Acknowledging the greater number of training sessions (senior: 3–5 vs youth: 1–2) and longer duration of training sessions (youth: 89 min vs senior: 99–127 mins) (Myhill et al., 2022), there appears to be both a notable increase in the weekly volume of training load between youth and seniors. Therefore, preparing players for the increase in training volume and intensities between youth and senior environments should be a priority for coaches working with older youth age groups, whilst practitioners involved within senior environments should consider effective load management strategies for players transitioning from youth environments (Lundqvist et al., 2024), to minimise potential injury risks associated with such increases in training load (Martin-Garetxana et al., 2023, 2024).

Regardless of the population (i.e., youth or senior football), training environments should expose players to sufficient and appropriate stimuli to facilitate adaptations which adequately prepare them for the demands of match-play (Morgans et al., 2014). However, the absolute and relative session characteristics (U14 TD: 3430 m vs 7248 m; 41.3 m · min^{-1} vs 92.4 m · min^{-1}; U16 TD: 3850 vs 7679 m; 44.8 m · min^{-1} vs 92.6 m · min^{-1}) (Harkness-Armstrong et al., 2021) were notably less than previously reported data for youth women's football match-play characteristics (Harkness-Armstrong et al., 2023), suggesting the demands of training in youth women's football may not be sufficient to prepare players for the demands of match-play. Within the current population, limited training sessions (e.g., one session per week) may be a key challenge for appropriate training prescription and ensuring sessions provide sufficient stimuli to facilitate adaptation to adequately prepare players for the demands of match-play. Therefore, coaches and practitioners should critically reflect upon the required number and/or hours of training sessions or alternative approaches to elicit appropriate stimulus for adaptation. For example, no drill-specific characteristics were reflective of the demands of match-play (e.g., SSG; U14 TD: 64.3 m · min^{-1} vs 92.4 m · min^{-1}; U16 TD 60.6 m · min^{-1} vs 92.6 m · min^{-1}) (Harkness-Armstrong et al., 2021); therefore, coaches and practitioners may need to include conditioning drills which are explicitly designed to expose players to high-intensity movements (e.g., distances, speeds and accelerations). Lastly, future

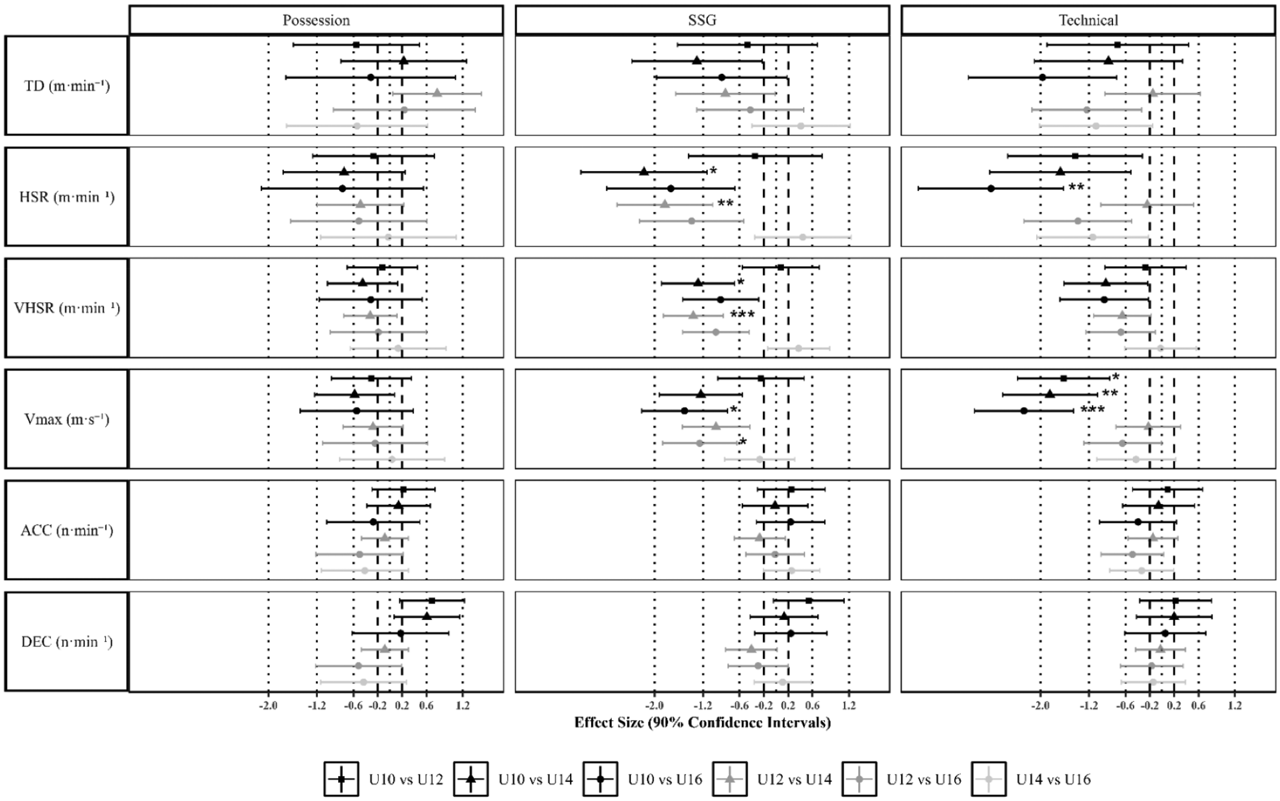

Figure 4. Effect size of differences in estimated mean and statistical significance of relative total distance (TD), high-speed running (HSR), very high-speed running (VHSR) distances covered, maximum velocity (Vmax) and number of accelerations (ACC; >1 m · s^{-1}) and decelerations (DEC; >1 m · s^{-1}) 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***).*

research which quantifies and compares the match-play characteristics of the various match-formats (e.g., full-sided, small-sided and futsal) within this population is warranted to understand how match-play characteristics may differ, how representative training characteristics are to each match-format, and to understand the potential comparison to other youth competitive standards (e.g., older youth, international) and senior football environments which these players may progress into.

Consistent with session physical characteristics, the drill-specific physical characteristics of youth women's football players were both age-dependent and drill-dependent. The physical characteristics during technical drills typically increased progressively between age groups (i.e., U10 > U12 > U14 >U16). During SSGs, similar physical characteristics were observed for U10s and U12s, whilst U14s and U16s had higher physical characteristics than both age groups, except for the number of accelerations and decelerations. Age-related increases may be reflective of the increased physical capabilities between age groups in youth women's football (Emmonds et al., 2018; Emmonds, Sawczuk, et al., 2020; Emmonds, Scantlebury, et al., 2020). In comparison to senior women's players, all youth age groups covered less TD during possession drills (45.1–52.2 m · min^{-1} vs 57.3 m · min^{-1}), technical drills (34.1–52.1 m · min^{-1} vs 69.2 m · min^{-1}) and SSGs (52.4–64.3 m · min^{-1} vs 66.5–67.4 m · min^{-1}) (Emmonds et al., 2023). Increases between youth and senior players may be consequential of increased physical capabilities (Datson et al., 2022), but likely also due to larger playing areas for drills than observed in youth environments (i.e., simultaneous training sessions for multiple age groups on one pitch). Furthermore, due to greater technical expertise, senior players may have a higher proportion of ball-in-play time during training drills, which may increase the physical characteristics during training drills as previously observed in match-play research (Harkness-Armstrong et al., 2023). Future research should quantify drill-specific training physical characteristics relative to ball-in-play time and investigate the influence of possession status (i.e., in possession, out of possession, ball-out-of-play data) on physical characteristics during playing format training activities (i.e., SSGs, possession drills). Understanding the proportion of ball-out-of-play time and therefore work:rest periods and the respective physical characteristics during training activities may provide more appropriate benchmarks for informing training drills than the whole-drill data reported in the current study.

The highest physical outputs in senior women's football training occur during technical drills, whilst the lowest physical outputs occur during possession drills (Emmonds et al., 2023). In contrast, SSGs typically elicited the greatest physical outputs across youth all-groups, and the lowest physical outputs were observed during technical drills for U10s, U12s and U14s, and possession drills for U16s. Therefore, in youth women's football environments, SSGs may be a more beneficial stimulus than possession or technical drills for developing physical characteristics. However, future research is warranted which investigates the influence of task constraints (e.g., number of players, playing area) on drill-specific physical characteristics (Ibáñez et al., 2020), to gain an understanding of how manipulation of different constraints may impact specific physical characteristics. Given the limited training opportunities within youth women's football environments (i.e., one to two training sessions per week), understanding how to maximise training activities as talent development opportunities are important for the planning, delivery and review of coaching practices and coaching curriculum within this population. Furthermore, technical, tactical and psychosocial characteristics were not quantified in this study. Therefore, future research is warranted which quantifies and compares technical, tactical and psychosocial characteristics between drill types in youth women's football, and the influence of task constraints on such characteristics (Clemente & Sarmento, 2020; Ometto et al., 2018), to inform the design and delivery of holistic coaching practices.

A further novelty of the current study is that it is the first to describe training drill distribution in youth women's football (Mulvenna et al., 2025), and as such, there are key findings (peripheral to the study aims) to highlight. Firstly, acknowledging the exclusion of warm-up activities and the limited observations of other drill types (match simulations, phase of play drills), training activities only contributed to between 33 and 57.7% of training session durations (U10: 33.0%; U12: 57.7%; U14: 52.8%; U16: 54.8%), which is lower than the previous research in youth men's football (63.2% (O'Connor et al., 2018); 81.5% (Ahmad et al., 2021)). Consequently, women's youth footballers, particularly those in the youngest age group, appear to be spending large proportions of training sessions in periods of inactivity (e.g., interaction with coaches, transitioning between drills, drink breaks) which may have implications for physical, technical and psychosocial talent development. Secondly, the distribution of training activities appeared to be dependent upon age group. Whilst U10s had the lowest proportion of time spent on training activities, they spent more time on playing formats (i.e., SSG, possession; 26.2%) than technical drills (6.8%). In contrast, U12s spent most time in technical drills (21.8%), followed by possession drills (19.9%) and SSGs (16.0%). Both U14s and U16s spent most time in SSGs (20.7%; 31.7%), but U14s spent more time within possession drills than the technical drills (18.0 vs 14.1%), and vice-versa for U16s (14.0 vs 9.1%). There are some consistencies with wider women's football research, with Emmonds et al., 2023 reporting that older youth (U21; The Football Association's Women's Super League Academies) and senior players (second domestic tier; The Football Association's Women's Championship) predominantly performed SSGs, technical drills and possession drills during training, but that these also differed between competitive standards. However, in contrast to older youth and senior women's football (first domestic tier; The Football Association's Women's Super League), no position-specific, tactical or conditioning drills were observed across any age group (Emmonds et al., 2023), with only limited instances of match simulations and phase of play drills occurring. This may be consequential of a shorter data collection period, ETCs delivering sessions within a more structured pre-defined coaching curriculum (The Football Association, 2024) or due to the limited training opportunities provided to youth players (e.g., one to two training sessions per week), in comparison to semi-professional older youth age groups (e.g., three to four training sessions per week) or professional senior players (e.g., five or more training sessions per week) (Myhill et al., 2022). Regardless, coaches and practitioners should reflect on the diversities of playing opportunities provided to youth players, and consider the implications for talent development and identification, and supporting their progression/transition into older youth and senior playing environments. Further, to better understand the playing opportunities available in training, future research is warranted which investigates the structure of training sessions (e.g., frequency, duration, percentage and sequence of training activities) and supporting coaching behaviours and their potential influence on training characteristics. Such evidence would help inform the design and delivery of coaching practice, talent development practices and coach education and development opportunities within youth women's football.

Whilst the current study provides novel insights into the training demands of youth women's football, there are limitations of the current study which should be considered. Firstly, only two ETCs participated in this study due to the practical challenges associated with data collection in this population (e.g., location of/distance from research institution to training venues, limited number of GPS units, conflicting ETC training schedules). Consequently, there was a limited number of potential participating players. Further, only one of the ETCs had a U10 age group (n = 15), whilst fewer U16 players (n = 22) agreed to participate in comparison to other age groups (U12: n = 40; U14: n = 39). Consequently, a smaller number of training and drill observations were obtained for these age groups. Future research should aim to adopt a larger multi-club sample and to increase the number of participants within respective age groups to both increase the sensitivity of analyses to reliably detect statistically significant differences in effects of smaller magnitudes, and to ensure findings are representative of the wider population (Harkness-Armstrong, Till, Datson, Myhill, et al., 2022). Secondly, the maturity status of players was not assessed within this study. More mature youth women's football players have been shown to have improved physical capabilities (e.g., aerobic capacity, sprint speed and change of direction) (Emmonds, Scantlebury, et al., 2020). Therefore, individual differences in maturity timing between players may have contributed to within and between age group variability of external load. Future research quantifying external load within youth women's football should incorporate maturity assessment. Thirdly, player positions were not accounted for in the analysis nor potential position-specific differences explored. Whole squads participated (except U16s) and therefore a variety of playing positions will have contributed to observations; however, the representation of playing positions within each age group was not obtained. Future research should report the positional contribution for samples (player and observations) and given that position-specific differences exist in match-play characteristics (Harkness-Armstrong et al., 2020, 2021), explore whether position-specific differences may also exist in training characteristics (Passos Ramos et al., 2019). Lastly, as the categorisation of training drills was recorded in-situ by one researcher (TA), recording information relating to session design and activity structures (e.g., task constraints used across different drills; number of players, obstacles, scoring rules or touch limitations) was not possible due to simultaneous age group sessions. Given that different task constraints influence the physical characteristics of other football populations (Gonçalves et al., 2017; Ibáñez et al., 2020; Ponce-Bordón et al., 2022), it is therefore important that future research, at a minimum, describes task-constraints for drill observations, but also aims to explore the potential influence on drill-specific physical characteristics of youth female footballers.

Practical implications

There are key recommendations for different stakeholders working with youth women's football players. Firstly, training curricula within youth women's football environments should be age-specific, structured and progressive to expose players to sufficient and appropriate stimuli which facilitate adaptations that adequately prepare them for the demands of match-play and reduce the risk of injury. Further, coaches and practitioners should implement training activities which represent the demands of match-play (i.e., train as you play) and ensure these are increasingly progressive between age groups. In environments where facilities are limited and thus pitch space is restricted, additional conditioning-based activities should be embedded into training which are explicitly designed to elicit high-speed movements not possible within training activities conducted in a restricted space (i.e., SSGs). Secondly, coaches and practitioners within senior environments should implement load management strategies which support players transitioning from youth environments, to minimise the potential injury risk associated with increases in training load (i.e., frequency, volume and intensity). Lastly, coaches and coach developers should reflect on desired activity structure and supporting coach behaviours, considering how to implement a variety of training activities and manipulate training characteristics (i.e., physical, technical, tactical and psychosocial) to provide a diversity of learning and developmental opportunities which facilitate holistic talent development within youth women's football environments.

Conclusion

This is the first study to quantify session and drill-specific physical characteristics of youth female football players during training. Differences were observed between age groups for session physical characteristics and between and within age groups for drill-specific physical characteristics. Typically, session and drill-specific physical characteristics increase between younger and older age groups for sessions and across drill types. Coaches and practitioners may use the session and drill-specific data to inform the design and delivery of age-specific and progressive training curriculum for talent development, prepare youth players for the demands of match-play, and to support progression between youth age groups and into senior environments. Future research should aim to investigate the influence of different task constraints on drill-specific physical characteristics, quantify position-specific physical characteristics for training, and compare training and competition demands to understand the representativeness of training activities. Such insights would provide further contextualised understanding to aid the design and delivery of training practices within youth women's football populations.

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References

Adams, T., Waterworth, S., Lewis, T., Datson, N., Harkness-Armstrong, C., Lowry, R., Freeman, P., & Harkness-Armstrong, A. (2026). The performance, health and development of youth women's footballers: A systematic scoping review. *International Journal of Sports Science & Coaching*. https://doi.org/10.1177/17479541251411068

Ahmad, M. F., Low, J. F. L., & Nadzalan, A. M. (2021). The microstructure of practice activities engaged by elite youth soccer players. *International Journal of Human Movement and Sports Sciences*, *9*(6), 1306–1313. https://doi.org/10.13189/saj.2021.090626

Andersen, T. R., Kästner, B., Arvig, M., Larsen, C. H., & Madsen, E. E. (2023). Monitoring load, wellness, and psychological variables in female and male youth national team football players during international and domestic playing periods. *Frontiers in Sports and Active Living*, *5*. https://doi.org/10.3389/fspor.2023.1197766

Barrett, S., Varley, M. C., Hills, S. P., Russell, M., Reeves, M., Hearn, A., & Towlson, C. (2020). Understanding the influence of the head coach on soccer training drills—an 8 season analysis. *Applied Sciences*, *10*(22), 8149. https://doi.org/10.3390/app10228149

Beato, M., Coratella, G., Stiff, A., & Iacono, A. D. (2018). The validity and between-unit variability of GNSS units (STATSports Apex 10 and 18 Hz) for measuring distance and peak speed in team sports. *Frontiers in Physiology*, *9*, 1288. https://doi.org/10.3389/fphys.2018.01288

Beato, M., & de Keijzer, K. L. (2019). 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. *Biology of Sport*, *36*(4), 317–321. https://doi.org/10.5114/biolsport.2019.88754

Bram, J. T., Magee, L. C., Mehta, N. N., Patel, N. M., & Ganley, T. J. (2021). Anterior cruciate ligament injury incidence in adolescent athletes: A systematic review and meta-analysis. *The American Journal of Sports Medicine*, *49*(7), 1962–1972. https://doi.org/10.1177/0363546520959619

Butcher, A. J., Ward, S., Clissold, T., Richards, J., & Hébert-Losier, K. (2024). Maturation and biomechanical risk factors associated with anterior cruciate ligament injury: Is there a link? a systematic review. *Physical Therapy in Sport*, *68*, 31–50. https://doi.org/10.1016/j.ptsp.2024.06.002

Casamichana, D., Barreira, J., Castellano, J., Barba Balda, E., Erkizia, B., & Nakamura, F. (2025). Comparative analysis of weekly and accumulated pre-season external load in a professional women's soccer team and its reserve team. *Sport Sciences for Health*, *21*(2), 787–795. https://doi.org/10.1007/s11332-024-01315-4

Childers, J., Eng, E., Lack, B., Lin, S., Knapik, D. M., Kaplan, D. J., Jackson, G. R., & Chahla, J. (2025). Reported anterior cruciate ligament injury incidence in adolescent athletes is greatest in female soccer players and athletes participating in club sports: A systematic review and meta-analysis. *Arthroscopy: The Journal of Arthroscopic & Related Surgery*, *41*(3), 774–784. e2. https://doi.org/10.1016/j.arthro.2024.03.050

Clemente, F. M., & Sarmento, H. (2020). The effects of small-sided soccer games on technical actions and skills: A systematic review. *Human Movement*, *21*(3), 100–119. https://doi.org/10.5114/hm.2020.93014

Costa, J. A., Rago, V., Brito, P., Figueiredo, P., Sousa, A., Abade, E., & Brito, J. (2022). Training in women soccer players: A systematic review on training load monitoring. *Frontiers in Psychology*, *13*, 943857. https://doi.org/10.3389/fpsyg.2022.943857

Crossley, K. M., Patterson, B. E., Culvenor, A. G., Bruder, A. M., Mosler, A. B., & Mentiplay, B. F. (2020). Making football safer for women: A systematic review and meta-analysis of injury prevention programmes in 11 773 female football (soccer) players. *British Journal of Sports Medicine*, *54*(18), 1089–1098. https://doi.org/10.1136/bjsports-2019-101587

Cushion, C., Harvey, S., Muir, B., & Nelson, L. (2012). Developing the coach analysis and intervention system (CAIS): Establishing validity and reliability of a computerised systematic observation instrument. *Journal of Sports Sciences*, *30*(2), 201–216. https://doi.org/10.1080/02640414.2011.635310

Datson, N., Weston, M., Drust, B., Atkinson, G., Lolli, L., & Gregson, W. (2022). Reference values for performance test outcomes relevant to English female soccer players. *Science and Medicine in Football*, *6*(5), 589–596. https://doi.org/10.1080/24733938.2022.2037156

Doyle, B., Browne, D., & Horan, D. (2022). Quantification of internal and external training load during a training camp in senior international female footballers. *Science and Medicine in Football*, *6*(1), 7–14. https://doi.org/10.1080/24733938.2021.1886320

Emmonds, S., Dalton Barron, N., Myhill, N., Barrett, S., King, R., & Weaving, D. (2023). Locomotor and technical characteristics of female soccer players training: Exploration of differences between competition standards. *Science and Medicine in Football*, *7*(3), 189–197. https://doi.org/10.1080/24733938.2022.2089723

Emmonds, S., Morris, R., Murray, E., Robinson, C., Turner, L., & Jones, B. (2017). The influence of age and maturity status on the maximum and explosive strength characteristics of elite youth female soccer players. *Science and Medicine in Football*, *1*(3), 209–215. https://doi.org/10.1080/24733938.2017.1363908

Emmonds, S., Sawczuk, T., Scantlebury, S., Till, K., & Jones, B. (2020). Seasonal changes in the physical performance of elite youth female soccer players. *Journal of Strength and Conditioning Research*, *34*(9), 2636–2643. https://doi.org/10.1519/JSC.0000000000002943

Emmonds, S., Scantlebury, S., Murray, E., Turner, L., Robsinon, C., & Jones, B. (2020). Physical characteristics of elite youth female soccer players characterized by maturity status. *Journal of Strength and Conditioning Research*, *34*(8), 2321–2328. https://doi.org/10.1519/JSC.0000000000002795

Emmonds, S., Till, K., Redgrave, J., Murray, E., Turner, L., Robinson, C., & Jones, B. (2018). Influence of age on the anthropometric and performance characteristics of high-level youth female soccer players. *International Journal of Sports Science & Coaching*, *13*(5), 779–786. https://doi.org/10.1177/1747954118757437

Ford, P. R., Yates, I., & Williams, A. M. (2010). An analysis of practice activities and instructional behaviours used by youth soccer coaches during practice: Exploring the link between science and application. *Journal of Sports Sciences*, *28*(5), 483–495. https://doi.org/10.1080/02640410903582750

Gentles, J. A., Coniglio, C. L., Besemer, M. M., Morgan, J. M., & Mahnken, M. T. (2018). The demands of a women's college soccer season. *Sports*, *6*(1), 16. https://doi.org/10.3390/sports6010016

Gonçalves, B., Esteves, P., Folgado, H., Ric, A., Torrents, C., & Sampaio, J. (2017). Effects of pitch area-restrictions on tactical behavior, physical, and physiological performances in soccer large-sided games. *Journal of Strength and Conditioning Research*, *31*(9), 2398–2408. https://doi.org/10.1519/JSC.0000000000001700

González-García, J., & Romero-Moraleda, B. (2024). 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. *Applied Sciences*, *14*(17), 8066. https://doi.org/10.3390/app14178066

Griffin, J., Horan, S., Keogh, J., Andreatta, M., & Minahan, C. (2022). Time to be negative about acceleration: A spotlight on female football players. *Journal of Strength and Conditioning Research*, *36*(11), 3264–3271. https://doi.org/10.1519/JSC.0000000000004061

Griffin, J., Larsen, B., Horan, S., Keogh, J., Dodd, K., Andreatta, M., & Minahan, C. (2020). Women's football: An examination of factors that influence movement patterns. *Journal of Strength and Conditioning Research*, *34*(8), 2384–2393. https://doi.org/10.1519/JSC.0000000000003638

Hägglund, M., Atroshi, I., Wagner, P., & Waldén, M. (2013). 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. *British Journal of Sports Medicine*, *47*(15), 974–979. https://doi.org/10.1136/bjsports-2013-092644

Harkness-Armstrong, A., Till, K., Datson, N., & Emmonds, S. (2020). Technical characteristics of elite youth female soccer match-play: Position and age group comparisons between under 14 and under 16 age groups. *International Journal of Performance Analysis in Sport*, *20*(6), 942–959. https://doi.org/10.1080/24748668.2020.1820173

Harkness-Armstrong, A., Till, K., Datson, N., & Emmonds, S. (2021). Whole and peak physical characteristics of elite youth female soccer match-play. *Journal of Sports Sciences*, *39*(12), 1320–1329. https://doi.org/10.1080/02640414.2020.1868669

Harkness-Armstrong, A., Till, K., Datson, N., & Emmonds, S. (2022). Determining age-specific velocity thresholds for elite youth female soccer players. *Science and Medicine in Football*, *6*(5), 581–588. https://doi.org/10.1080/24733938.2021.1991585

Harkness-Armstrong, A., Till, K., Datson, N., & Emmonds, S. (2023). Influence of match status and possession status on the physical and technical characteristics of elite youth female soccer match-play. *Journal of Sports Sciences*, *41*(15), 1437–1449. https://doi.org/10.1080/02640414.2023.2273653

Harkness-Armstrong, A., Till, K., Datson, N., Myhill, N., & Emmonds, S. (2022). A systematic review of match-play characteristics in women's soccer. *PLOS ONE*, *17*(6), e0268334. https://doi.org/10.1371/journal.pone.0268334

Hewit, J., Cronin, J., Button, C., & Hume, P. (2011). Understanding deceleration in sport. *Strength & Conditioning Journal*, *33*(1), 47. https://doi.org/10.1519/SSC.0b013e3181fbd62c

Ibáñez, S. J., Pérez-Goye, E., García-Rubio, J., & Courel-Ibáñez, J. (2020). Effects of task constraints on training workload in elite women's soccer. *International Journal of Sports Science & Coaching*, *15*(1), 99–107. https://doi.org/10.1177/1747954119891158

Ishida, A., Travis, S. K., Draper, G., White, J. B., & Stone, M. H. (2022). Player position affects relationship between internal and external training loads during Division I collegiate female soccer season. *Journal of Strength and Conditioning Research*, *36*(2), 513–517. https://doi.org/10.1519/JSC.0000000000004188

Karlsson, U. B., Vagle, M., Wiig, H., & Luteberget, L. S. (2023). Training load quantification in women's elite football: A season-long prospective cohort study. *International Journal of Sports Physiology and Performance*, *18*(6), 603–614. https://doi.org/10.1123/ijspp.2022-0272

Kelly, A., Wilson, M. R., Jackson, D. T., Goldman, D. E., Turnnidge, J., Côté, J., & Williams, C. A. (2021). A multidisciplinary investigation into "playing-up" in academy football according to age phase. *Journal of Sports Sciences*, *39*(8), 854–864. https://doi.org/10.1080/02640414.2020.1848117

Lakens, D. (2022). Sample size justification. *Collabra Psychology*, *8*(1): Article 33267. https://doi.org/10.1525/collabra.33267

Lesinski, M., Prieske, O., Helm, N., & Granacher, U. (2017). Effects of soccer training on anthropometry, body composition, and physical fitness during a soccer season in female elite young athletes: A prospective cohort study. *Frontiers in Physiology*, *8*. https://doi.org/10.3389/fphys.2017.01093

Lundqvist, C., Gregson, W., Bonanno, D., Lolli, L., & DiSalvo, V. (2024). A worldwide survey of perspectives on demands, resources, and barriers influencing the youth-to-senior transition in academy football players. *International Journal of Sports Science & Coaching*, *19*(1), 162–170. https://doi.org/10.1177/17479541221135626

Malina, R. M., Martinho, D. V., Valente-Dos-Santos, J., Coelho-E-Silva, M. J., & Kozieł, S. M. (2021). Growth and maturity status of female soccer players: A narrative review. *International Journal of Environmental Research and Public Health*, *18*(4), 1448. https://doi.org/10.3390/ijerph18041448

Mara, J. K., Thompson, K. G., Pumpa, K. L., & Ball, N. B. (2015). Periodization and physical performance in elite female soccer players. *International Journal of Sports Physiology and Performance*, *10*(5), 664–669. https://doi.org/10.1123/ijspp.2014-0345

Marris, J., Barrett, S., Abt, G., & Towlson, C. (2022). Quantifying technical actions in professional soccer using foot-mounted inertial measurement units. *Science and Medicine in Football*, *6*(2), 203–214. https://doi.org/10.1080/24733938.2021.1910333

Martin-Garetxana, I., Ciaurri, J., Gil, S. M., Monasterio, X., Ugarte, A., Lekue, J. A., & Larruskain, J. (2023). What are the load and wellness of young second-team football players when transitioning to the first team? A comparison of 2 consecutive preseasons. *International Journal of Sports Physiology and Performance*, *18*(7), 726–733. https://doi.org/10.1123/ijspp.2022-0324

Martin-Garetxana, I., Ortuzar, I., Urkiza, I., Lekue, J. A., Monasterio, X., Gil, S. M., & Larruskain, J. (2024). Lost in transition: Exploring injury risk in academy footballers shifting between the second and first teams. *Journal of Science & Medicine in Sport*, *27*(3), 154–159. https://doi.org/10.1016/j.jsams.2023.11.009

McFadden, B. A., Walker, A. J., Bozzini, B. N., Sanders, D. J., & Arent, S. M. (2020). Comparison of internal and external training loads in male and female collegiate soccer players during practices vs. games. *Journal of Strength and Conditioning Research*, *34*(4), 969–974. https://doi.org/10.1519/JSC.0000000000003485

Miguel, M., Oliveira, R., Loureiro, N., García-Rubio, J., & Ibáñez, S. J. (2021). Load measures in training/match monitoring in soccer: A systematic review. *International Journal of Environmental Research and Public Health*, *18*(5), 2721. https://doi.org/10.3390/ijerph18052721

Moreno-Perez, V., Carles Bové, B., Courel-Ibáñez, J., Del Coso, J., Beato, M., Ferrer Vidal-Barraquer, E., & Font, G. R. (2025). Non-contact injury incidence in professional women's football depends on the starting status of the player. *Biology of Sport*, *42*(3), 99–107. https://doi.org/10.5114/biolsport.2025.145916

Morgans, R., Orme, P., Anderson, L., & Drust, B. (2014). Principles and practices of training for soccer. *Journal of Sport and Health Science*, *3*(4), 251–257. https://doi.org/10.1016/j.jshs.2014.07.002

Mulvenna, C., Evans, N., Brady, A., McCall, A., Datson, N., Emmonds, S., & Okholm Kryger, K. (2025). A scoping review of the research supporting coaching practice in women's football – as the game grows the research strives to keep up. *Science and Medicine in Football*, 1–10. https://doi.org/10.1080/24733938.2025.2488525

Myhill, N., Weaving, D., Barrett, S., King, R., & Emmonds, S. (2022). A multi-club analysis of the locomotor training characteristics of elite female soccer players. *Science and Medicine in Football*, *6*(5), 572–580. https://doi.org/10.1080/24733938.2022.2114603

O'Connor, D., Larkin, P., & Williams, A. M. (2018). Observations of youth football training: How do coaches structure training sessions for player development? *Journal of Sports Sciences*, *36*(1), 39–47. https://doi.org/10.1080/02640414.2016.1277034

Ometto, L., Vasconcellos, F. V., Cunha, F. A., Teoldo, I., Souza, C. R. B., Dutra, M. B., O'Sullivan, M., & Davids, K. (2018). How manipulating task constraints in small-sided and conditioned games shapes emergence of individual and collective tactical behaviours in football: A systematic review. *International Journal of Sports Science & Coaching*, *13*(6), 1200–1214. https://doi.org/10.1177/1747954118769183

Passos Ramos, G., Datson, N., Mahseredjian, F., Lopes, T. R., Coimbra, C. C., Prado, L. S., Nakamura, F. Y., & Penna, E. M. (2019). Activity profile of training and matches in Brazilian Olympic Female Soccer Team. *Science and Medicine in Football*, *3*(3), 231–237. https://doi.org/10.1080/24733938.2019.1615120

Poehling, R. A., Tsai, M. C., Manson, S. A., Koehle, M. S., & Meylan, C. M. P. (2021). Physical performance development in a female national team soccer program. *Journal of Science & Medicine in Sport*, *24*(6), 597–602. https://doi.org/10.1016/j.jsams.2020.12.009

Ponce-Bordón, J. C., García-Calvo, T., López-Gajardo, M. A., Díaz-García, J., & González-Ponce, I. (2022). How does the manipulation of time pressure during soccer tasks influence physical load and mental fatigue? *Psychology of Sport & Exercise*, *63*, 102253. https://doi.org/10.1016/j.psychsport.2022.102253

Ramachandran, A. K., Pedley, J. S., Moeskops, S., Oliver, J. L., Myer, G. D., & Lloyd, R. S. (2024). Changes in lower limb biomechanics across various stages of maturation and implications for ACL injury risk in female athletes: A systematic review. *Sports Medicine*, *54*(7), 1851–1876. https://doi.org/10.1007/s40279-024-02022-3

Ramos, G. P., Nakamura, F. Y., Penna, E. M., Mendes, T. T., Mahseredjian, F., Lima, A. M., Garcia, E. S., Prado, L. S., & Coimbra, C. C. (2021). Comparison of physical fitness and anthropometrical profiles among Brazilian female soccer national teams from U15 to senior categories. *Journal of Strength and Conditioning Research*, *35*(8), 2302–2308. https://doi.org/10.1519/JSC.0000000000003140

Romero-Moraleda, B., Nedergaard, N. J., Morencos, E., Casamichana, D., Ramirez-Campillo, R., & Vanrenterghem, J. (2021). External and internal loads during the competitive season in professional female soccer players according to their playing position: Differences between training and competition. *Research in Sports Medicine*, *29*(5), 449–461. https://doi.org/10.1080/15438627.2021.1895781

Savolainen, E. H. J., Ihalainen, J. K., & Walker, S. (2024). Female soccer players' in-season weekly training load and intensity: Comparison between national league's top and bottom-half ranked teams. *Journal of Human Kinetics*, *95*, 187–198. https://doi.org/10.5114/jhk/189657

Silva, H., Nakamura, F. Y., Castellano, J., & Marcelino, R. (2023). Training load within a soccer microcycle week-a systematic review. *Strength & Conditioning Journal*, *45*(5), 568. https://doi.org/10.1519/SSC.0000000000000765

Teixeira, J. E., Forte, P., Ferraz, R., Leal, M., Ribeiro, J., Silva, A. J., Barbosa, T. M., & Monteiro, A. M. (2021). Monitoring accumulated training and match load in football: A systematic review. *International Journal of Environmental Research and Public Health*, *18*(8), 3906. https://doi.org/10.3390/ijerph18083906

The Football Association. (2025). Operating criteria - girl's emerging talent centres 2024/25 season.

The Football Association. (2024). Girls' emerging talent centre national directory 2024–25. Retrieved August 6, 2025, from https://www.englandfootball.com/england/youth/womens-talent-pathway/emerging-talent-centres

Waldén, M., Hägglund, M., Werner, J., & Ekstrand, J. (2011). The epidemiology of anterior cruciate ligament injury in football (soccer): A review of the literature from a gender-related perspective. *Knee Surgery, Sports Traumatology, Arthroscopy*, *19*(1), 3–10. https://doi.org/10.1007/s00167-010-1172-7

Wright, M. D., Songane, F., Emmonds, S., Chesterton, P., Weston, M., & Mclaren, S. J. (2020). Differential ratings of perceived match and training exertion in girls' soccer. *International Journal of Sports Physiology and Performance*, *15*(9), 1315–1323. https://doi.org/10.1123/ijspp.2019-0595