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Influence of match status and possession status on the physical and technical characteristics of elite youth female soccer match-play

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ABSTRACT

This study compared the influence of match status (drawing, losing, or winning) and possession status (in-possession, out-of-possession, or ball-out-of-play) on the physical and technical characteristics of U14 and U16 elite youth female soccer match-play. Data were collected from 189 female academy players during 45 competitive matches, resulting in 387 match observations. Linear mixed models estimated relative; total distance, high-speed running (≥3.00 m·s^{-1}), very high-speed running (≥4.83 m·s^{-1}), and sprinting (≥5.76 m·s^{-1}) distance according to match status and possession status, and 21 technical variables according to match status. Differences in physical and technical characteristics were observed between and within age-groups, dependent upon match status and possession status. Regardless of match status, both age-groups covered greater distances when the ball was in-play compared to ball-out-of-play (107–130 vs 58–68 m·min^{-1}). U16s covered greater distances when out-of-possession than in-possession, regardless of match status. Whilst U14s covered greater distances out-of-possession when drawing or losing only. Differences in physical and technical characteristics when drawing, losing, or winning, suggest a change in playing style according to match status, likely in an attempt to influence or maintain the score-line. These findings have practical implications for coaching, talent identification and development practices within youth female soccer.

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Match analysis; contextual factors; situational variables; performance analysis; football

Introduction

Developing an evidence-based understanding of the match-play characteristics of soccer is important for practitioners to implement population-specific training practices. Therefore, understanding how match-play characteristics may vary within and between matches is crucial given the potential implications for practice (Dalton-Barron et al., 2020; Trewin et al., 2017). Whilst there has been an increase in research exploring the match-play characteristics of female soccer (Okholm Kryger et al., 2021), this research has predominantly reported whole-match characteristics (Harkness-Armstrong et al., 2022b). This is problematic, as the application of findings from whole-match analysis can be limited due to the intermittent nature of the game and the potential influence of contextual factors (e.g., match status, quality of team or opposition). Furthermore, previous research has found certain contextual factors, such as; environment (Benjamin et al., 2020; Bohner et al., 2015; Trewin et al., 2018), team or opposition quality (Hewitt et al., 2014; Ibáñez et al., 2018; Póvoas et al., 2020), congestion of fixtures (McCormack et al., 2015; Trewin et al., 2018), and playing surface (Garcia-Unanue et al., 2020; Ibáñez et al., 2018; Vescovi & Falenchuk, 2019), have an impact upon the match-play characteristics of female soccer. However, there are important methodological limitations within the relatively limited body of literature exploring the effects of contextual factors on match-play characteristics of female soccer players, which limits the potential practical applications of findings to female soccer populations.

Firstly, studies have predominantly quantified the effect of contextual factors on either physical (Hewitt et al., 2014; Trewin et al., 2018; Vescovi & Falenchuk, 2019) or technical (Garcia-Unanue et al., 2020; Ibáñez et al., 2018; Kubayi & Larkin, 2020) match-play characteristics. However, match-play performance is the combination of physical, technical and tactical characteristics, and thus aspects of performance should not be considered in isolation (Bradley & Ade, 2018; Paul et al., 2015). Secondly, studies which quantified the influence of contextual factors on physical characteristics included only a single-team sample (Benjamin et al., 2020; Bohner et al., 2015; Hewitt et al., 2014; Trewin et al., 2018). Consequentially, physical characteristics may be influenced by individual team playing styles, and are therefore not generalisable to the wider female soccer population. Thirdly, studies quantifying physical or technical characteristics have predominantly quantified contextual factors in isolation (e.g., match outcome, opposition quality, environment), which is likely due to limited sample sizes or low number of match observations within respective studies. However, given the complex, multifaceted nature of match-play performance, quantifying the effect of a single contextual factor may not be appropriate (Dalton-Barron et al., 2020; Paul et al., 2015; Trewin et al., 2017). Therefore, caution is required

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when interpreting the influence of isolated contextual factors, and where possible, future research should quantify the effect of combined or multiple contextual factors (e.g., match outcome and opposition quality; win vs higher ranked opposition) (Trewin et al., 2018). As such, research is warranted which addresses these important methodological limitations, to gain a holistic understanding of the impact of contextual factors on female soccer match-play characteristics. Furthermore, all studies to date have explored the influence of contextual factors on female soccer match-play characteristics of senior populations (Harkness-Armstrong et al., 2022b). Given the differences between youth and senior physical and technical match-play characteristics (Harkness-Armstrong et al., 2020, 2021), it would be inappropriate to inform practices with youth players from an evidence-base involving only senior populations. Therefore, there is a need to understand how youth match-play characteristics, may be influenced by contextual factors to facilitate population-specific practices, including; optimal preparation for match-play within respective age-groups (e.g., designing age-specific training practices which are representative of match-play) (Pinder et al., 2011) preparation of players transitioning between age-groups (e.g., training prescription which prepares players for differing match-play characteristics) (Harkness-Armstrong et al., 2021) or informing talent identification processes (e.g., aiding interpretations of player match-observations, benchmarks for selection or recruitment) (Datson et al., 2020; Ford et al., 2020) within the talent pathway.

Given the developmental nature of youth soccer match-play, contextual factors should not be result-orientated (i.e., match outcome; draw, loss or win) as typically observed within research involving senior populations (Trewin et al., 2018; Vescovi & Falenchuk, 2019). Rather, contextual factors should provide insight into the fluctuating demands of match-play and the subsequent opportunities youth players may have during matches. For example, opportunities to perform specific technical actions or exposure to high-intensity movements during match-play. Therefore, research should aim to understand how situation-specific contextual factors, such as match status (drawing, losing, or winning) or possession status (in-possession, out-of-possession, or ball-out-of-play), which are reflective of the current state of match-play affect the match-play characteristics. Additionally, understanding how the influence of contextual factors may differ between age-groups has implications for practices across the talent pathway, for example, informing long-term athletic development (e.g., age-appropriate training approaches for field-based and athletic conditioning practices), and preparations for transition across the talent pathway.

Therefore, the aims of the current study were to: 1) quantify the physical characteristics of match-play for U14 and U16 elite youth female soccer according to match status (drawing, losing or winning) and possession status (in-possession, out-of-possession or ball-out-of-play), 2) quantify the technical characteristics of match-play for U14 and U16 elite youth female soccer according to match status, and 3) compare the physical and technical characteristics between and within age-groups when considering the match and possession status. The current study will also address previous limitations within the literature, including; adopting a multi-club approach, exploring the influence of combined contextual factors on physical performance, using contextual factors which are situation-specific, and presenting both physical and technical match-play characteristics. This will provide practitioners with an understanding of how performances may vary within elite youth female soccer match-play, and facilitate the development and implementation of population-specific practices within this population.

Materials and methods

Participants

A total of 189 elite youth female soccer players, competing at either U14 ($n = 81$; 12.9 ± 0.7 years, 1.59 ± 0.06 m, 48.5 ± 8.9 kg) or U16 ($n = 108$; 15.0 ± 0.6 years, 1.62 ± 0.06 m, 56.1 ± 6.4 kg) age-groups (U14 $n = 5$; U16 $n = 6$) within female academies (Tier 1 $n = 5$; Tier 2 $n = 1$) in England participated in the study. Both U14 and U16 age-groups are standard competitive age-groups within female academies, determined by players' chronological age. Participants were considered elite, as female academies are the highest standard of domestic youth female soccer in England. Both age-groups trained for a total of six hours per week and competed in a weekly competitive match as part of a dedicated fixture programme against other female academies. The structure of weekly training sessions differed between academies, as either two three-hour sessions or three two-hour sessions. Similarly, design and delivery of sessions also varied between female academies, however, weekly training typically consisted of four hours of pitch-based soccer training, and two hours of strength and conditioning sessions. The study received ethics approval from Leeds Beckett University Ethics Committee (#62064), and all players (and parents/guardians) provided written informed consent before participation.

Procedures

During the 2018–19 and 2019–20 seasons, data were collected from 45 competitive matches (U14 $n = 24$; U16 $n = 21$) in The Football Association's Girls' England Talent Pathway League. Due to league regulations, match duration (U14: 35-min halves; U16: 40-min halves), pitch dimensions (U14: 75×45 m; U16: 91×56 m), and ball size (U14: size 4; U16: size 5) differed between age-groups. Subsequently, observed match duration was $76{:}50 \pm 5{:}05$ min and $82{:}58 \pm 03{:}27$ min, for U14 and U16 age-groups, respectively. The outcome of matches included; draw (U14 $n = 7$; U16 $n = 5$), loss (U14 $n = 8$; U16 $n = 10$) and win (U14 $n = 9$; U16 $n = 6$), location of matches included; home (U14 $n = 12$; U16 $n = 12$) and away (U14 $n = 12$; U16 $n = 9$), and playing surface was either; artificial turf (U14 $n = 9$; U16 $n = 13$) or grass (U14 $n = 15$; U16 $n = 8$).

A total of 577 (U14: $n = 279$; mean per player $= 3.5 \pm 1.3$; range = 1–8; U16: $n = 298$; mean $= 2.9 \pm 1.7$; range = 1–7) player observations were obtained across the 45 matches. However, due to the permission of return and rolling substitutions within female academy match-play, and subsequently players frequently rotating playing positions within matches, there were a limited number of whole-match player observations (U14 $n =$ 53; U16 $n = 66$). Therefore, in order to maximise the available

dataset for the current study, and be consistent with previous methods quantifying match-play characteristics of youth female soccer (Harkness-Armstrong et al., 2020, 2021), positional observations were derived from player observations. This approach derives a whole-match positional observation from any number of part-match observations from players, who contribute the physical and technical data for their respective playing time playing in the position to an overall positional observation. For example, a player may play the first half as a right back which contributes to the overall right back observation, and the second half as a centre back which contributes to the overall centre back observation. Positional observations were only included within the dataset if both physical and technical data were collected for the full-match (i.e., for all players contributing to the overall positional observation). Thus, a total of 387 positional observations (U14 $n = 210$; U16 $n = 177$) were derived from player observations. A breakdown of positional observations, and percentage of observations according to each level of match status and possession status, contributing to the positional observations analysed within the current study can be found in Table 1.

Matches were recorded by the lead researcher using a video camera (Panasonic HC-V750, Panasonic, Japan) mounted on a tripod, which was positioned in-line with the centre of the pitch. Following each match, recordings were transferred to a computer, imported to Nacsport Pro Plus software (Nacsport, Spain), and analysed using a customised coding template. The 21 technical variables, including 5 team possession-based variables (number of possessions, average duration (s), touches and passes per possession), 10 in-possession individual player variables (average possession duration (s), offensive touch, passes, successful passes (%), first touch passes, successful first touch passes (%), dribbles, successful dribble (%), crosses, shots), and 6 out-of-possession individual player variables (defensive touch, aerial challenges, blocks, clearances, interceptions, tackles) chosen for this study were consistent with previous literature (Harkness-Armstrong et al., 2020; Liu et al., 2013; Varley et al., 2017; Yi et al., 2018). The operational definitions for the technical variables are presented in Supplementary Material S1. All match-analyses were completed by the lead researcher. To determine intra-operator reliability and inter-operator agreements, the following procedures were conducted, which are common practice within match analysis literature (O'Donoghue, 2010). To determine intra-operator reliability, one randomly chosen match was analysed twice. Technical variables demonstrated very good levels of intra-operator agreement ($\kappa = 0.98$). One randomly chosen half of a match was coded by a staff member within a participating female academy. Overall, the technical variables demonstrated very good levels of inter-operator agreement ($\kappa = 0.98$), with very good level of agreement for; team-possession variables ($\kappa = 0.83$), out-of-possession variables ($\kappa = 0.82$) and in-possession variables ($\kappa = 0.84$).

Physical data were collected via 10 Hz global positioning units (GPS; Optimeye S5, Catapult Sports, Melbourne, Australia). The validity and reliability of these devices for application within team sports have been described elsewhere (Scott et al., 2016). Before match warm-up routines, GPS units (11.9 ± 0.1 satellites; 0.71 ± 0.06 horizontal dilution of precision) were switched on and placed within a bespoke harness worn underneath the playing shirt, which fits the device to the upper back of each player. GPS data were downloaded post-match using Openfield software (Catapult Sports, Melbourne, Australia). Raw GPS data files of player observations were subsequently exported, and positional observations created from the relevant player observations. Positional GPS data files were then aligned with the technical data, and match status and possession status was added to every GPS data point. The positional match files were then imported to RStudio, and match totals of physical variables for each positional observation were quantified for subsequent analyses. The physical variables chosen for the current study were; total distance (TD), high speed running (HSR; $\geq 3.00\ m \cdot s^{-1}$), very high-speed running (VHSR; $\geq 4.83\ m \cdot s^{-1}$), and sprinting (SPR; $\geq 5.76\ m \cdot s^{-1}$), which were reflective of the velocity thresholds established by Harkness-Armstrong et al. (Harkness-Armstrong et al., 2022a) for application with youth female soccer players. Variables were presented as relative distances ($m \cdot min^{-1}$) to facilitate comparisons between observations with differing match durations, match status and possession status durations.

Table 1. Number and percentage of positional observations, according to match status (drawing, losing or winning), and possession status (in-possession, out-of-possession or ball-out-of-play).

			Drawing (%)			Losing (%)			Winning (%)		
Age Group	Playing Position	Observations (n)	IP	OOP	BOP	IP	OOP	BOP	IP	OOP	BOP
U14	CD	37	10.5	10.7	14.3	7.5	8.2	10.9	11.0	10.6	16.1
	WD	45	11.3	11.3	15.7	8.2	9.2	12.6	9.2	8.9	13.6
	CM	57	11.2	11.0	15.7	9.3	9.8	13.9	8.6	8.2	12.2
	WM	38	11.5	11.2	14.8	8.7	9.0	12.3	9.6	9.0	13.9
	FWD	33	12.6	12.8	16.9	8.3	8.4	12.4	8.0	8.2	12.5
	All	210	11.4	11.4	15.5	8.5	9.0	12.6	9.2	8.9	13.5
U16	CD	36	9.1	10.6	14.3	9.7	11.3	15.0	9.2	8.4	12.4
	WD	36	9.0	10.2	13.6	9.7	11.3	14.3	9.8	9.0	13.0
	CM	45	9.2	10.2	13.8	9.5	10.6	13.9	10.2	9.3	13.4
	WM	37	8.7	10.0	13.2	10.2	11.7	15.2	9.6	8.8	12.6
	FWD	23	8.3	9.5	12.6	12.3	14.8	17.4	7.6	7.0	10.4
	All	177	8.9	10.1	13.6	10.1	11.6	14.9	9.5	8.7	12.6

Age-group: U=under. Playing position: CD=central defender; WD=wide defender; CM=central midfielder; WM=wide midfielder; FWD=forward. Possession status: IP=in-possession; OOP=out-of-possession; BOP=ball-out-of-play.

Statistical analyses

All statistical analyses were conducted using RStudio (RStudio Team, 2018). Three linear mixed models (lme4 package) were developed to quantify differences in physical and technical variables, according to possession status and/or match status. The assumptions of linearity and normality of distributions of each linear mixed model were verified visually, and homogeneity of variance assessed using Levene's Test ($p \geq 0.05$).

The first model estimated physical characteristics, and included; a physical variable (TD, HSR, VHSR, or SPR) as a dependent variable; an interaction between age-group (U14 or U16), possession status (in-possession, out-of-possession, ball-out-of-play) and match status (drawing, losing or winning) as fixed effects, with position, team, and fixture IDs, as random effects to account for repeated-measures. The second model which quantified player technical characteristics, included; a technical variable (e.g., pass, interception, tackle) as a dependent variable; an interaction between age-group and match status (fixed effects); and position, team, and fixture IDs (random effects). Whilst the third model quantified team technical characteristics, and included; a technical variable (e.g., duration of possessions, touches per possession, passes per possessions) as a dependent variable; an interaction between age-group and match status (fixed effects), and team and fixture IDs (random effects).

Estimated means for each physical and technical variable were derived from the respective models (emmeans package), and presented as mean (±SE). Tukey's pairwise comparisons were conducted to quantify differences between levels of fixed effects within respective models, with statistical significance set at $p < 0.05$. Effect size (ES) was also calculated to determine magnitude of the difference in estimated means (effsize package), and classified as trivial (<0.2), small (0.2–0.59), moderate (0.6–1.19), large (1.2–1.99) or very large (>2.0) (Batterham & Hopkins, 2006). Effect sizes were presented with 90% confidence intervals. An effect was considered unclear if confidence intervals included substantial (<0.2) positive and negative value (Hopkins et al., 2009).

Results

Physical characteristics

The relative TD, HSR, VHSR and SPR distances ($m \cdot min^{-1}$) covered by U14 and U16 elite youth female soccer players during match-play, according to match status and possession status are presented in Table 2.

Comparisons within age-groups: Possession status

Both age-groups performed greater TD ($p < 0.001$, very large ESs = 3.28–3.96), HSR ($p < 0.001$, large – very large ESs = 1.72–2.83), VHSR ($p < 0.001$, moderate – large ESs = 0.74–1.56), and SPR ($p < 0.01$, small – moderate ESs = 0.44–1.07) when in-possession or out-of-possession, compared to ball-out-of-play.

The differences in distances covered in-possession and out-of-possession, according to match status are presented in Figure 1. When drawing and losing, both age-groups covered greater TD (drawing: small ESs = 0.25–0.36; losing: small ESs = 0.43–0.44) and HSR (drawing: small ESs = 0.33–0.53; losing: 0.46–0.53) when out-of-possession. U16s covered greater VHSR distances out-of-possession when drawing (small ES = 0.34 ± 0.18), whilst both age groups performed more VHSR distance out-of-possession when losing (small ESs = 0.28–0.44). There were no differences in SPR when drawing or losing for either age-group. When winning, U16s covered greater TD, HSR, VHSR and SPR distances (small ESs = 0.22–0.43) when out-of-possession. There were no differences in distances covered in-possession or out-of-possession when winning for U14s.

Comparisons within age-groups: Match status

The comparisons of distances covered between drawing, losing and winning, according to possession status are presented in Figure 2.

When in-possession, both age-groups covered greater TD, HSR, and VHSR (small ESs = 0.21–0.53) when drawing compared to losing, and U14s also performed more SPR (small ES = 0.22 ± 0.20) when drawing compared to losing. U14s performed greater TD and HSR ($p < 0.05$; small ESs = 0.46–0.48) when drawing compared to winning, whilst U16s covered more VHSR (small ES = 0.21 ± 0.21) when winning compared to drawing. When winning, U16s performed more TD and HSR (small – moderate ESs = 0.51–0.64), and both age-groups covered greater VHSR (small ESs = 0.21–0.29) compared to losing.

Considering distances covered out-of-possession, both age-groups performed more TD and HSR (small ESs = 0.26–0.46) when drawing compared to losing. U14s covered more TD, HSR, VHSR and SPR (small - moderate ESs = 0.21–0.66) when drawing compared to winning, whilst U16s performed more VHSR and SPR (small ESs = 0.21) when winning compared drawing. U14s performed greater TD, HSR and VHSR (small ESs = 0.23–0.40) when losing compared to winning. In contrast, U16s covered more TD, HSR, VHSR and SPR (small ESs = 0.34–0.58) when winning compared to losing.

When the ball was out-of-play, both age-groups covered more TD (small ESs = 0.36–0.49) when drawing compared to losing, and more TD (small – moderate ESs = 0.42–0.64) and HSR (small ESs = 0.30–0.34) when winning compared to losing.

Comparisons between age-groups: Match status and possession status

No differences were observed between age-groups when drawing. When losing, U14s covered more TD during ball-out-of-play (3.8 $m \cdot min^{-1}$; small ES = 0.27 ± 0.34), whilst U16s performed more SPR when in-possession (0.6 $m \cdot min^{-1}$; small ES = 0.21 ± 0.25). When winning, U16s performed greater TD (in-possession: 8.7 $m \cdot min^{-1}$, moderate ES = 0.63 ± 0.34; out-of-possession: 11.1 $m \cdot min^{-1}$, $p < 0.05$, moderate ES = 0.80 ± 0.34), HSR (in-possession: 7.1 $m \cdot min^{-1}$, small ES = 0.50 ± 0.31; out-of-possession: 11.1 $m \cdot min^{-1}$, $p < 0.01$, moderate ES = 0.78 ± 0.31), VHSR (in-possession: 1.7 $m \cdot min^{-1}$, small ES = 0.28 ± 0.25; out-of-possession: 4.0 $m \cdot min^{-1}$, $p < 0.01$, moderate ES = 0.68 ± 0.25) and SPR (in-possession: 0.8 $m \cdot min^{-1}$, small ES = 0.30 ± 0.24; out-of-possession: 1.6 $m \cdot min^{-1}$, $p < 0.01$, moderate ES = 0.60 ± 0.24) when in-possession and out-of-possession, compared to U14s.

Table 2. Estimated mean (±SE) of relative total distance, high-speed running, very high-speed running and sprinting distance (m·min^{-1}) covered by U14 and U16 elite youth female soccer players during matches, according to possession status (in-possession, out-of-possession, ball-out-of-play) and match status (drawing, losing or winning).

		Drawing			Losing			Winning		
Variable	Age Group	In-Possession	Out-of-Possession	Ball-Out-of-Play	In-Possession	Out-of-Possession	Ball-Out-of-Play	In-Possession	Out-of-Possession	Ball-Out-of-Play
TD	U14	114.3 ± 1.8	117.0 ± 1.8	66.7 ± 1.8	106.9 ± 2.0	112.2 ± 2.0	62.6 ± 2.0	108.1 ± 2.0	109.8 ± 2.0 *	67.8 ± 2.0
(m·min^{-1})	U16	115.6 ± 1.8	118.9 ± 1.8	64.6 ± 1.8	107.6 ± 2.1	112.5 ± 2.1	57.8 ± 2.1	117.3 ± 2.0	120.3 ± 2.0	66.9 ± 2.0
	vs	Unclear ES = −0.06 ± 0.30	Trivial ES = −0.17 ± 0.30	Trivial ES = 0.15 ± 0.30	Unclear ES = 0.01 ± 0.34	Unclear ES = 0.00 ± 0.34	Small ES = 0.27 ± 0.34	Moderate ES = −0.63 ± 0.34	Moderate ES = −0.80 ± 0.34	Unclear ES = 0.06 ± 0.34
HSR	U14	44.6 ± 1.5	48.1 ± 1.5	11.1 ± 1.5	37.0 ± 1.8	43.6 ± 1.8	9.1 ± 1.8	38.0 ± 1.8	38.8 ± 1.8 **	12.9 ± 1.8
(m·min^{-1})	U16	43.5 ± 1.5	49.0 ± 1.5	9.6 ± 1.5	37.6 ± 1.8	42.7 ± 1.8	7.4 ± 1.8	45.7 ± 1.8	49.3 ± 1.8	12.1 ± 1.8
	vs	Trivial ES = 0.12 ± 0.27	Trivial ES = −0.08 ± 0.27	Trivial ES = 0.09 ± 0.27	Unclear ES = −0.03 ± 0.31	Unclear ES = 0.11 ± 0.31	Unclear ES = 0.09 ± 0.31	Small ES = −0.50 ± 0.31	Moderate ES = −0.78 ± 0.31	Unclear ES = 0.05 ± 0.31
VHSR	U14	8.1 ± 0.4	8.3 ± 0.4	1.1 ± 0.4	5.5 ± 0.6	7.7 ± 0.6	0.9 ± 0.6	7.0 ± 0.6	6.0 ± 0.6 **	0.9 ± 0.6
(m·min^{-1})	U16	7.7 ± 0.5	9.0 ± 0.5	0.6 ± 0.5	6.9 ± 0.6	8.0 ± 0.6	0.9 ± 0.6	8.8 ± 0.6	9.9 ± 0.6	0.9 ± 0.6
	vs	Trivial ES = 0.11 ± 0.27	Trivial ES = −0.08 ± 0.20	Trivial ES = 0.08 ± 0.20	Trivial ES = −0.19 ± 0.26	Unclear ES = −0.03 ± 0.26	Unclear ES = 0.01 ± 0.26	Small ES = −0.28 ± 0.25	Moderate ES = −0.68 ± 0.25	Unclear ES = −0.02 ± 0.25
SPR	U14	2.3 ± 0.2	2.0 ± 0.2	0.2 ± 0.2	1.5 ± 0.3	1.9 ± 0.3	0.2 ± 0.3	1.9 ± 0.2	1.4 ± 0.2 **	0.1 ± 0.2
(m·min^{-1})	U16	2.6 ± 0.2	2.5 ± 0.2	0.1 ± 0.2	2.2 ± 0.3	2.2 ± 0.3	0.3 ± 0.3	2.8 ± 0.3	3.1 ± 0.3	0.2 ± 0.3
	vs	Trivial ES = −0.17 ± 0.19	Trivial ES = −0.09 ± 0.19	Trivial ES = 0.04 ± 0.19	Small ES = −0.21 ± 0.25	Trivial ES = −0.08 ± 0.25	Unclear ES = −0.00 ± 0.25	Small ES = −0.30 ± 0.24	Moderate ES = −0.60 ± 0.24	Unclear ES = −0.04 ± 0.24

Relative distances; TD = total distance; HSR = high-speed running; VHSR = very high-speed running; SPR = sprinting; ES = effect size. Statistical significance ($p < 0.05$*, $p < 0.01$**, $p < 0.001$***) between U14 and U16 age-groups.

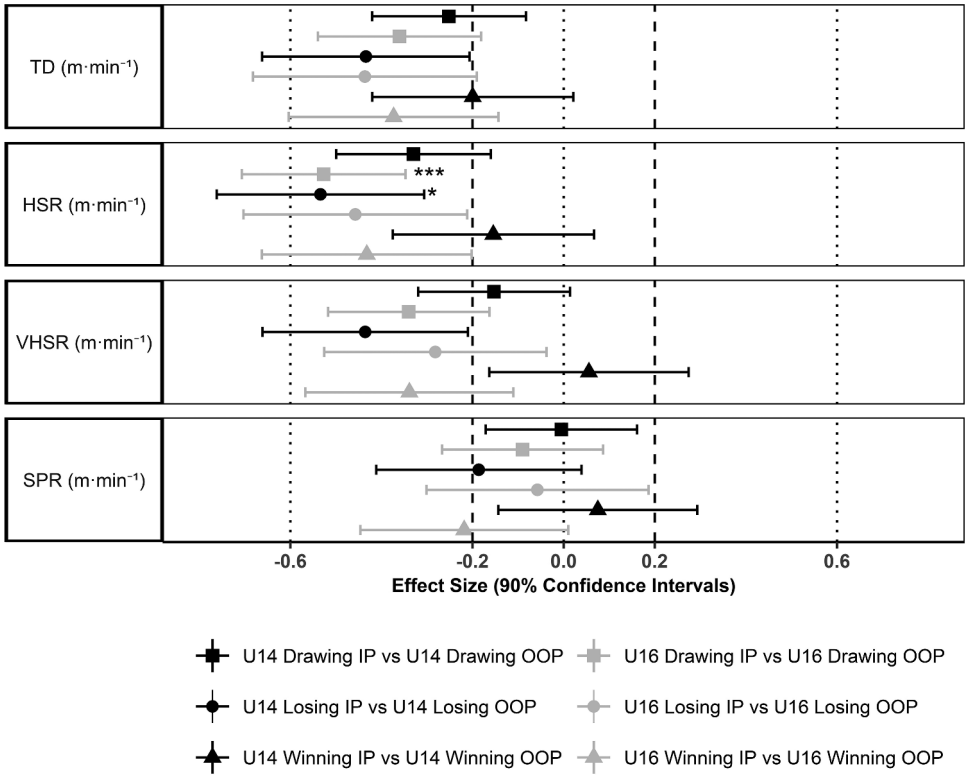

Figure 1. Effect size of differences in estimated mean and statistical significance of relative total distance (TD), high-speed running (HSR), very high-speed running (VHSR) and sprinting (SPR) distances covered when in-possession (IP) or out-of-possession (OOP), when drawing, losing or winning for U14 and U16 elite youth female soccer match-play. *Significant difference ($p < 0.05$*, $p < 0.01$**, $p < 0.001$***).

Technical characteristics

Comparisons within age-groups

The team possession-based technical characteristics, according to match status are presented in Table 3. The percentage of match-play which U14s were in-possession, was greatest when drawing compared to losing and winning (small – moderate ESs = 0.54–0.62), whilst U16s were in-possession more when drawing and losing compared to winning (small – moderate ESs = 0.54–0.70). U16s had a lower percentage of match-play out-of-possession when losing compared to drawing and winning (moderate ESs = 0.69–0.78). The percentage of ball-out-of-play was higher for both age-groups when winning compared to drawing (small – moderate ESs = 0.48–0.69), but also when losing compared to drawing for U14s (moderate ES = 0.69 ± 0.67).

The number of team possessions were greatest when losing for U16s (small – moderate ESs: 0.57–1.04), whilst the number of team possessions were lowest when winning for U14s (moderate ESs = 0.78–0.82). U14s had a longer duration of team possession when drawing compared to losing (small ES = 0.51 ± 0.70). Whilst occurrences of ball-out-of-play were longer in duration for U16s when winning compared to drawing (small ES = 0.54 ± 0.64). U14s had fewer touches per possession and passes per possession when losing compared to winning (small – moderate ES = 059–0.66), whilst U16s had the least passes per possession when winning (moderate ESs = 0.65–0.67). No other differences were observed within either age-group for team possession-based variables.

The effect size of difference between estimated means of player technical characteristics within U14 and U16 age-groups, according to match status are presented in Figure 3. Considering differences in in-possession technical characteristics, U16s had a longer average possession duration (small ESs = 0.25–0.31) but performed fewer offensive touches and passes (small ESs = 0.24–0.30) when winning compared to drawing and losing, respectively. U14s had a lower successful pass percentage when drawing compared to losing, and lower successful first touch pass percentage when drawing compared to both losing and winning (small ESs = 0.21–0.22). U16s attempted fewer dribbles when drawing compared to losing (small ES = 0.21 ± 0.23), whilst U14s had a lower successful dribble percentage when losing compared to drawing and winning (small ESs = 0.20–0.27). U14s also attempted more crosses when losing than winning (small ESs = 0.24 ± 0.24).

The only differences in out-of-possession technical characteristics within age-groups, were that U14 attempted more aerial challenges when drawing compared to losing (small ES = 0.24 ± 0.24), and U16s performed more clearances when drawing and winning compared to losing (small ESs = 0.21–0.24).

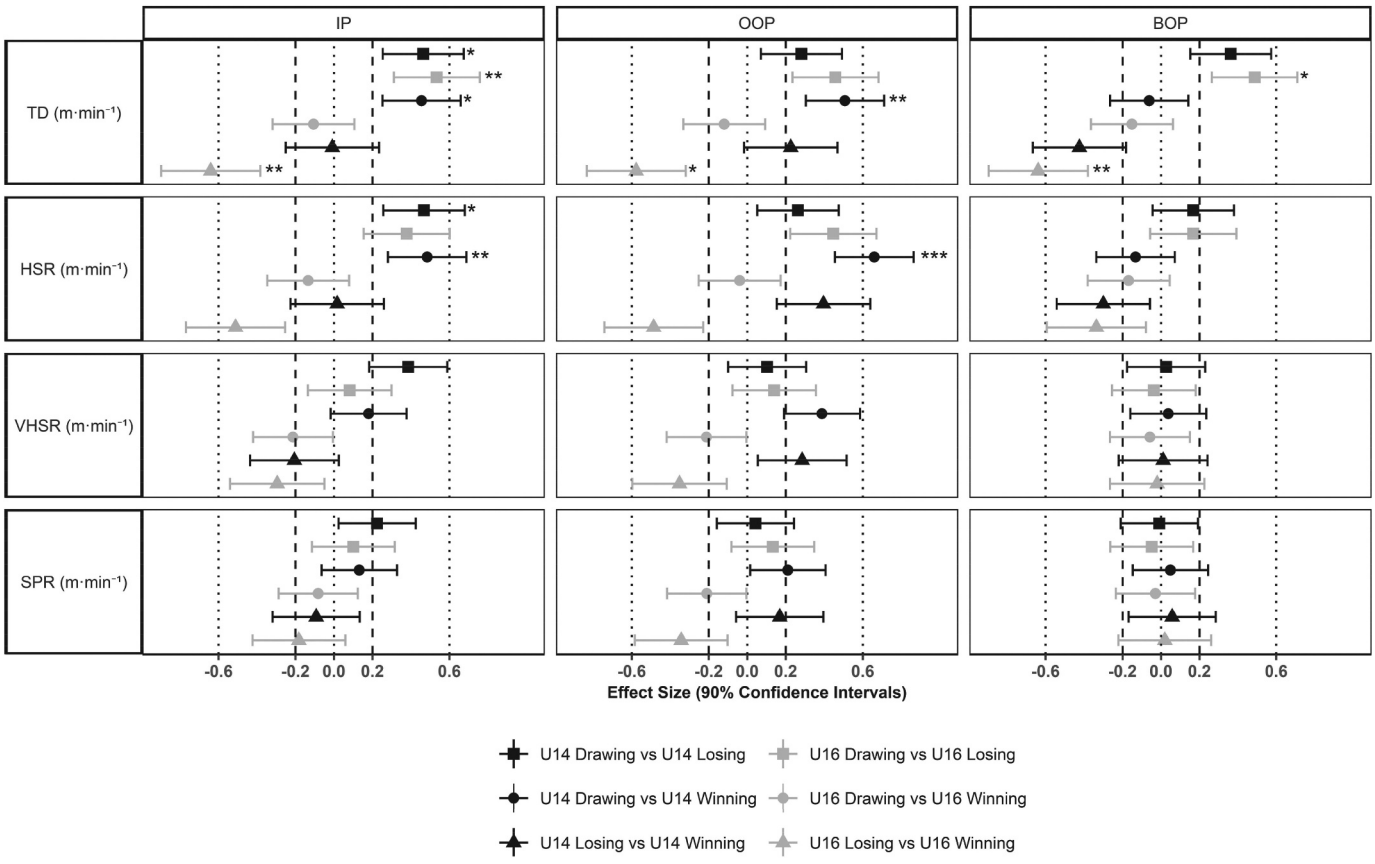

Figure 2. Effect size of differences in estimated mean and statistical significance of relative total distance (TD), high-speed running (HSR), very high-speed running (VHSR) and sprinting (SPR) distances covered when in-possession (IP), out-of-possession (OOP) or ball is out-of-play (BOP), between drawing, losing and winning for U14 and U16 elite youth female soccer match-play. **Significant difference ($p < 0.05$*, $p < 0.01$**, $p < 0.001$***).*

Comparisons between age-groups

Considering differences in in-possession technical characteristics; when drawing, U16s had a longer average possession duration (small ES = 0.31 ± 0.19) and greater successful pass percentage (small ES = 0.23 ± 0.13), whilst U14s attempted more dribbles (small ES = 0.25 ± 0.13). U14s made more offensive touches when winning (small ES = 0.30 ± 0.17), attempted more crosses when losing and winning (small ESs = 0.25–0.25), and attempted greater shots regardless of match status (small ESs = 0.20–0.34), compared to U16s.

Differences in out-of-possession technical characteristics between age-groups found U14s performed more defensive touches (small ESs = 0.20–0.39) and tackles (small ESs = 0.25–0.36) than U16s, regardless of match status. U14s also made more interceptions (small ESs = 0.20–0.23) when losing and winning, whilst U16s attempted more aerial challenges (small ES = 0.37 ± 0.19) when drawing.

Discussion

The aim of the current study was to quantify the physical and technical characteristics of U14 and U16 elite youth female soccer match-play according to match status and possession status, and compare the physical and technical characteristics between and within age-groups according to match status and possession status. This was the first known study to; (a) quantify the effects of contextual factors on elite youth female soccer match-play, (b) adopt a multi-club approach to explore the influence of contextual factors on the physical characteristics of female soccer match-play, c) explore the influence of match status and possession status on characteristics of female soccer match-play, and (d) explore the interaction of match status and possession status on soccer match-play characteristics. There were differences in physical and technical characteristics, dependent upon match and possession status, and these differed between age-groups. U16s covered greater distances when out-of-possession in comparison to in-possession, regardless of match status, whilst U14s covered greater distances out-of-possession except when winning. The differences in technical and physical characteristics when drawing, losing or winning, suggests that both U14 and U16 age-groups change their playing style in an attempt to change or maintain the current match status. The findings of the current study have practical implications for training practices within elite youth female soccer.

The distances covered by U14 and U16 players whilst the ball was in-play (in-possession or out-of-possession), unsurprisingly, were significantly greater than ball-out-of-play. This is consistent with previous research in male soccer (Mernagh et al., 2021; Riboli et al., 2021; Wass et al., 2020). However, elite youth female soccer players performed approximately two-three times the TD during ball-out-play compared to (≥U18) elite male players (58–68 m·min^{-1} vs 16–30 m·min^{-1})

Table 3. Estimated mean (±SE) of team possession-based technical characteristics by U14 and U16 elite youth female soccer players during matches, according to match status (drawing, losing or winning).

		In-Possession			Out-of-Possession			Ball-Out-of-Play		
Technical Characteristics	Age-Group	Drawing	Losing	Winning	Drawing	Losing	Winning	Drawing	Losing	Winning
Percentage of Match-Play (%)	U14	32.4 ± 2.4	30.0 ± 2.6	30.3 ± 2.6	30.1 ± 1.4	28.4 ± 1.7	28.8 ± 1.7	39.0 ± 1.9	42.7 ± 2.2	42.7 ± 2.2
	U16	29.5 ± 2.4	30.1 ± 2.6	27.3 ± 2.6	31.9 ± 1.4	29.0 ± 1.7	31.6 ± 1.7	39.2 ± 1.9	41.4 ± 2.3	41.7 ± 2.3
	vs	Moderate ES = 0.75 ± 0.71	Unclear ES = −0.03 ± 0.88	Moderate ES = 0.76 ± 0.91	Unclear ES = −0.47 ± 0.85	Unclear ES = −0.15 ± 1.00	Unclear ES = −0.72 ± 1.02	Unclear ES = −0.04 ± 0.74	Unclear ES = 0.23 ± 0.90	Unclear ES = 0.18 ± 0.92
Number of Possessions (n·min^{-1})	U14	2.3 ± 0.1 *	2.3 ± 0.1	2.1 ± 0.1	2.3 ± 0.1	2.1 ± 0.1	2.3 ± 0.1	1.6 ± 0.1	1.7 ± 0.1	1.7 ± 0.1
	U16	2.0 ± 0.1	2.1 ± 0.2	1.9 ± 0.1	2.0 ± 0.1	2.0 ± 0.1	2.0 ± 0.1	1.5 ± 0.1	1.6 ± 0.1	1.5 ± 0.1
	vs	Large ES = 1.40 ± 0.71	Moderate ES = 0.87 ± 0.88	Moderate ES = 1.10 ± 0.90	Moderate ES = 1.00 ± 0.63	Unclear ES = 0.40 ± 0.80	Moderate ES = 1.07 ± 0.82	Unclear ES = 0.38 ± 0.61	Unclear ES = 0.58 ± 0.79	Moderate ES = 0.69 ± 0.81
Duration of Possession (s)	U14	9.2 ± 1.1	8.5 ± 1.1	9.0 ± 1.1	8.1 ± 0.5	8.1 ± 0.6	7.6 ± 0.6	15.0 ± 0.6	15.6 ± 0.8	15.3 ± 0.8
	U16	9.3 ± 1.1	9.4 ± 1.1	9.2 ± 1.1	9.4 ± 0.5	9.2 ± 0.6	9.4 ± 0.6	15.7 ± 0.6	16.5 ± 0.8	17.1 ± 0.8
	vs	Unclear ES = −0.13 ± 0.73	Moderate ES = −0.74 ± 0.92	Unclear ES = −0.12 ± 0.94	Moderate ES = −1.11 ± 0.89	Moderate ES = −0.91 ± 1.03	Large ES = −1.56 ± 1.05	Unclear ES = −0.28 ± 0.56	Unclear ES = −0.36 ± 0.73	Moderate ES = −0.73 ± 0.75
Touches Per Possession (n·min^{-1})	U14	6.7 ± 0.9	6.3 ± 0.9	6.9 ± 0.9	-	-	-	-	-	-
	U16	6.7 ± 0.9	6.8 ± 0.9	6.4 ± 0.9	-	-	-	-	-	-
	vs	Unclear ES = 0.03 ± 0.71	Unclear ES = −0.49 ± 0.90	Unclear ES = 0.53 ± 0.92	-	-	-	-	-	-
Passes Per Possession (n·min^{-1})	U14	1.8 ± 0.3	1.7 ± 0.3	1.9 ± 0.3	-	-	-	-	-	-
	U16	1.9 ± 0.3	1.9 ± 0.3	1.7 ± 0.3	-	-	-	-	-	-
	vs	Unclear ES = −0.35 ± 0.61	Moderate ES = −0.77 ± 0.79	Unclear ES = 0.47 ± 0.82	-	-	-	-	-	-

ES = effect size. Statistical significance ($p < 0.05$*) between U14 and U16 age-groups.

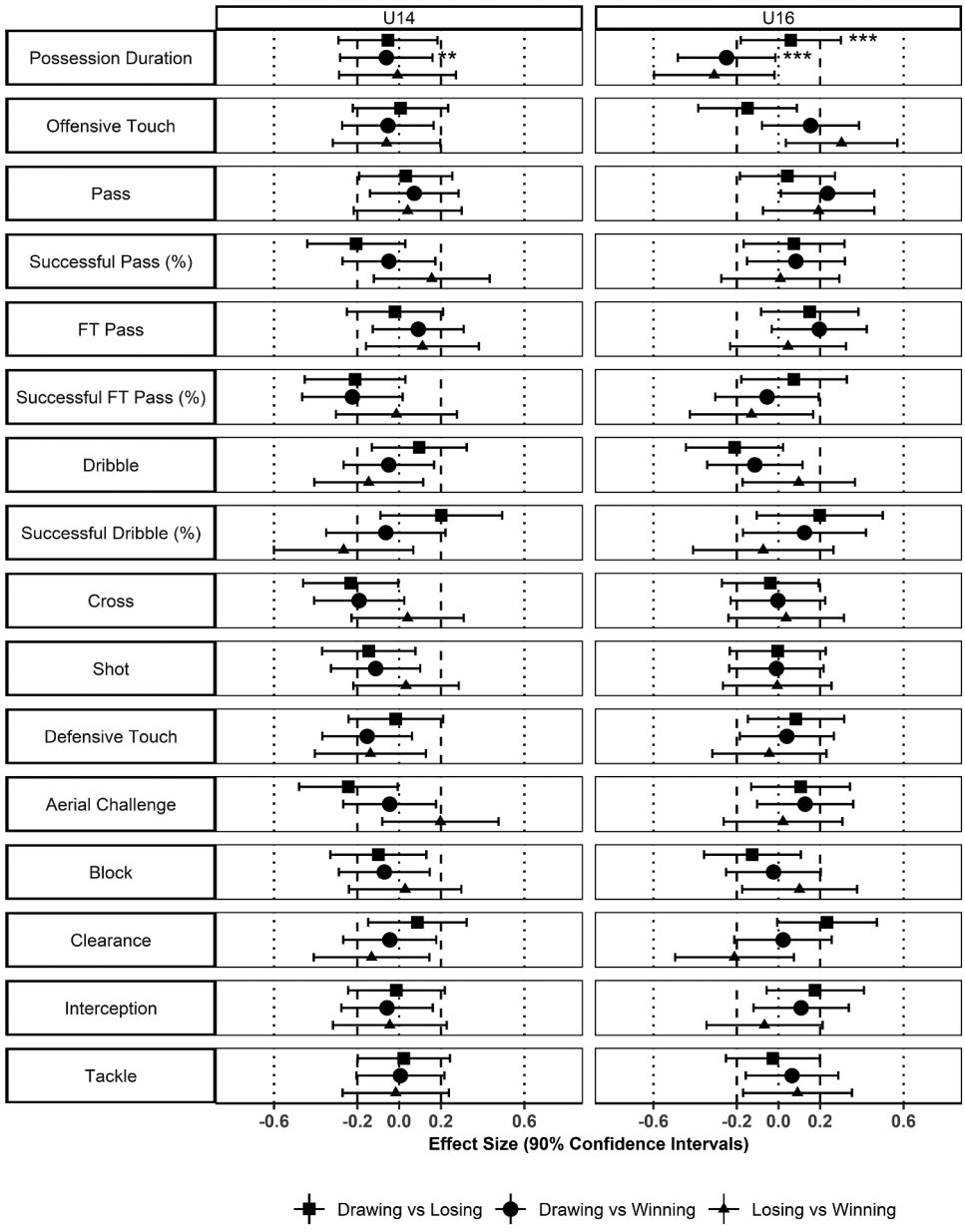

Figure 3. Effect size of differences in estimated mean and statistical significance of player technical variables between drawing, losing or winning for U14 and U16 elite youth female soccer match-play. **Significant difference ($p < 0.05$*, $p < 0.01$**, $p < 0.001$***).*

(Mernagh et al., 2021; Wass et al., 2020). This difference may be a contribution of; the high number of substitutions and positional rotations in youth female soccer which occur during ball-out-play (Harkness-Armstrong et al., 2021), direct coaching intervention during youth female match-play (e.g., instruction, management), differentiation in tactics or strategies, or potentially a lack of tactical understanding by youth female players and subsequent recovery into position ahead of restarting play. However, as these were not directly quantified within this study, further investigation is warranted to understand the underpinning reasons for comparatively higher distances covered whilst the ball is out-of-play. Given the high proportion of ball-out-of-play within elite youth female soccer match-play (39.0–42.7%), relative distances covered when the ball was in-play, provide a more appropriate marker to inform population-specific conditioning practices than the whole-match relative distances reported in Harkness-Armstrong et al. (2021). (U14 = 107–117 m·min^{-1}; U16 = 108–120 m·min^{-1}; *vs.* 93 m·min^{-1}), whilst ball-out-of-play data may be useful for informing rest/recovery periods within respective drills or conditioned games.

Furthermore, Harkness-Armstrong et al. (2021) reported peak physical characteristics to inform practices to prepare elite youth female soccer players for the most physically demanding periods of match-play. However, as the peak periods (i.e., 1–10-minute durations quantified via moving averages) are inclusive of ball-out-of-play time, the peak relative distances may be influenced by the lower relative distances covered during ball-out-of-play periods. Therefore, the peak characteristics reported by Harkness-Armstrong et al. (2021) may not provide an appropriate benchmark for informing practices to prepare players for the most physically demanding periods of match-play. For example, the relative TD covered

during the 1-minute peak period (1-min: U14 = 157–166 m·min^{-1}; U16 = 159–171 m·min^{-1}) is inclusive of both ball-in-play and ball-out-of-play time (Harkness-Armstrong et al., 2021), equates to an average speed of 2.6–2.8 m·s^{-1} and 2.7–2.9 m·s^{-1} for U14s and U16s, respectively. Neither of these average speeds exceed the HSR threshold (3.00 m·s^{-1}) adopted within the current study and therefore are likely not an appropriate benchmark for informing practices to prepare players for the most physically demanding periods of match-play. Whereas the quantification of ball-in-play relative distances during the peak periods may provide a more appropriate benchmark. Hypothetically, if assuming the ball-out-of-play proportion during the 1-min peak period is similar to the values observed in the current study (39.0–42.7%), U14s and U16s would perform an average speed of ~ 4.3–4.8 m·s^{-1} and ~ 4.5–4.9 m·s^{-1}, whilst the ball is in-play during the most physically demanding minute of match-play. The average speed or relative distances covered during ball-in-play time during peak periods may provide a more appropriate benchmark for informing practice. Therefore, future research adopting a moving average approach to quantify the peak physical characteristics of match-play should explore the influence of ball in-play and ball-out-of-play on relative distances covered during peak periods. Furthermore, given the complex multi-faceted nature of performance (Dalton-Barron et al., 2020) future research should explore the influence of technical and tactical characteristics, and other contextual factors (e.g., match status, possession status) on the peak physical characteristics observed during match-play.

An additional novelty of the current study was to explore the effect of possession status (according to match status) on physical characteristics of match-play, data relative to possession status (and match status) was analysed. This differs to the existing body of literature quantifying the effects of possession status on physical match-play characteristics, which report; absolute data (Bradley et al., 2013; da Mota GR et al., 2016; Datson et al., 2017), data relative to total ball-in-play time (Lorenzo-Martinez et al., 2021), or selectively reports variables relative to possession status (i.e., VHSR only) (Varley et al., 2017). Consequently, these approaches may provide misleading results regarding the influence of possession status on match-play characteristics, as they do not account for the time in-possession or out-of-possession. Therefore, future research should implement the approach adopted within the current study when exploring the influence of possession status within team sports.

The influence of possession status on physical characteristics of elite youth female soccer players, differed between age-groups, and was dependent upon match status. When drawing and losing, both age-groups performed greater TD and HSR when out-of-possession compared to in-possession. This could either be due to physical-tactical movements when out-of-possession (i.e., recovery runs or tracking opposition players, pressing, or covering teammates) (Ade et al., 2016; Ju et al., 2021) requiring greater distances to be covered than movements when in-possession (i.e., support play, moving to receive a pass or exploit space, or progressing up the pitch) (Ju et al., 2021) or that players are performing out-of-possession movements more frequently in comparison to movements in-possession. However, when winning, there were differences between age-groups for all in-possession and out-of-possession distances. Furthermore, U16s covered more TD, HSR, VHSR and SPR distances when out-of-possession compared to in-possession, yet U14s covered similar distances in-possession and out-of-possession. Previous research in male soccer has observed similar improvements, with defensive physical-tactical actions (e.g., delaying opponents, defensive coverage) increasing between youth age-groups (Borges et al., 2017). However, it is not possible within the current study to determine whether the differences between female youth age-groups are due to differing tactics, psychological characteristics, or other contributing factors, and furthermore, why the influence of possession status only differs when winning. Therefore, future research should aim to; further explore why possession status differs between age-groups when winning, in addition to exploring how possession status may differ depending on other contextual factors (i.e., team and opposition quality, team success, formation) (Bradley et al., 2011; Brito Souza et al., 2020; Hoppe et al., 2015), and incorporate position-specific analysis, to understand how the influence of possession status may differ between positions (Gregson et al., 2010; Lorenzo-Martinez et al., 2021; Riboli et al., 2021) to inform position-specific practices. Practitioners should have an understanding of how possession status (according to match status) impacts the physical characteristics of elite youth female soccer players, and inform practices accordingly, for example; tailoring preparation for- and recovery from matches, implementing tactical strategies or substitutions within match-play depending upon possession and match status.

The differences in technical and physical characteristics according to match status, suggests that the playing style of both age-groups may differ whether teams are drawing, losing or winning. At U16, the percentage of match-play in-possession was lowest when winning, which is consistent with previous male research (Konefał et al., 2018; Lago, 2009; Lago-Peñas et al., 2010), and number of team possessions were lowest when winning, which implies less time in-possession, but fewer turnovers of possession and consequently, greater ball retention when winning. However, when combined with fewer passes per team possession, longer average player possession duration, fewer offensive touches and passes, this indicates a change in playing style. Players potentially attempt to "slow down" the intensity of possession in an effort to control the pace of the game and maintain current match status. Implementation of a more defensive strategy would be consistent with previous male soccer research (Bradley et al., 2014; Lago, 2009; Lago-Peñas et al., 2014). Furthermore, an increase in the physical characteristics of U16s in-possession when winning was observed, with greater TD and HSR distances, which supports previous research in small-sided games (SSG) in male soccer (Badari et al., 2021); that when winning, players increase their offensive support for players on the ball. In contrast, when losing, U16s covered the least distances, had a higher number of team possessions and attempted more dribbles. These results support previous research in SSG of male soccer, in which losing resulted in less offensive support by teammates

(Badari et al., 2021), which may provide greater opportunities for players to engage in 1v1 situations, and consequently contribute to a higher turnover of possession.

In contrast to U16s and previous male literature (Bradley et al., 2014; Lago, 2009), U14s had the greatest percentage of match-play in-possession when drawing. Furthermore, U14s tended to have a more offensive playing style in-possession than U16s; attempting more shots regardless of match status, more crosses when losing and winning, and a greater number of dribbles when drawing. The differentiation in playing style, may be consequential of differing tactical behaviours between youth age-groups (Borges et al., 2017; da Costa IT et al., 2010; Olthof et al., 2015). When losing, U14s had a shorter average duration of team possession, fewer touches and passes per possession, whilst players attempted more crosses and had a lower success rate when dribbling. Similar to U16s, this data suggests a higher turnover of possession when losing, as players try to change the match status by delivering more crosses and attempting dribbles which may have a lower likelihood of success. Practitioners can use these results to inform age-group specific coaching interventions, for example, designing situation-specific conditioned games for preparation for match-play, informing offensive and defensive tactics or strategies, or informing talent identification practices across the talent pathway which involve match-play observations.

Regardless of match status, U14s performed more defensive touches and tackles than U16s, and intercepted more passes than U16s when losing and winning. This is in contrast to SSG research in male soccer which found greater defensive tactical behaviours in older youth players (Borges et al., 2017), which would suggest U16s would have better tactical positioning to initiate defensive interactions with opposition players and perform defensive actions. However, as highlighted within previous research, the greater number of defensive touches at U14s may be consequential of smaller pitch dimensions, and thus less distance required to cover to engage with opponents than U16s (Harkness-Armstrong et al., 2020). When comparing within age-groups, U16s performed less clearances when losing, potentially in an attempt to regain possession and initiate an attack to change the match status. However, the decision to not clear the ball, when it may be more appropriate to (e.g., opposition pressure, area on the pitch, limited support), may also contribute to the higher turnovers observed when losing. This is supported by the lower distances covered in-possession and out-of-possession when losing, which may result in limited support for the player in possession of the ball (Borges et al., 2017). Practitioners may aim to develop youth players' ability to retain the ball, physical-tactical movements to provide support for teammates, or players' decision-making, by designing situation-specific conditioned games. As previously discussed, U14s covered less distances when losing, and attempted more aerial challenges when drawing, but these occurrences were still fewer than U16s. Practitioners should be aware of the increased exposure to aerial challenges when drawing, and between age-groups, particularly regarding injury risk or monitoring process surrounding heading and concussions.

Whilst the current study has novelty within youth female soccer and beyond, and has addressed some of the key limitations within previous research, primarily, the quantification of physical or technical match-play characteristics in isolation (Harkness-Armstrong et al., 2020, 2021, 2022b), there are limitations to acknowledge. Firstly, due to the limited and inconsistent facilities available at match venues (e.g., fence/barrier surrounding playing area obstructing recording, inappropriate distance from pitch, no safe access to appropriate viewing area) recording match footage via a tactical angle was not possible. This may have impacted the video quality (e.g., obstruction of view of ball), however the intra- and inter-operator reliability assessments showed very-good levels of agreement. Secondly, due to the level of analysis conducted within this study there were insufficient positional observations to perform position-specific analyses. Previous research has found the physical and technical characteristics of match-play differ between positions and therefore are not generalisable to an age-group average (Harkness-Armstrong et al., 2021, 2022b). Future research should aim to increase the number of match observations, and conduct position-specific analyses. Thirdly, the current study did not consider tactical characteristics, or other potentially important contextual factors which may impact the influence of match status or possession status. For example, time-period of match-play (Harkness-Armstrong et al., 2022b), current score-line (Lago-Peñas et al., 2014; Redwood-Brown et al., 2019), or formation (Bradley et al., 2011). Future research should explore the influence of other contextual factors on elite youth female soccer match-play characteristics, whilst researchers should also consider which contextual factors may have the most practical importance to practitioners within specific populations (i.e., youth or senior, elite, sub-elite or amateur). Lastly, it was not possible to explore the effect of match status and possession status on peak characteristics, due to the high turnover of possession and low duration of possessions observed (Harkness-Armstrong et al., 2021). Therefore, future research should aim to explore how elite youth female soccer peak characteristics vary dependent upon match status, or other contextual factors (González-García et al., 2023; Riboli et al., 2021).

In conclusion, this is the first study to explore the effect of contextual factors (match status, possession status) on elite youth female soccer match-play characteristics. Findings identified differences in the physical and technical characteristics between and within age-groups according to match status and/or possession status. For example, both age-groups typically covered greater distances when out-of-possession compared to in-possession, however there were differences observed between age-groups when winning. Furthermore, match status appeared to lead to changes in playing styles at both age-groups, likely in an attempt to maintain or change the current score-line or match status. Regardless of match status, U14s had a more offensive playing style in-possession than U16s. Practitioners should consider how players have different opportunities to perform technical actions depending upon the match status within match-play, when informing population-specific practices, including; designing coaching practices, implementing specific tactical strategies within match-play, talent development processes across the talent pathway, and talent identification processes when observing/analysing players' performances within female academy match-play.

Practitioners should also have an understanding of how physical characteristics may differ depending upon possession status and match status, which can inform; tailored preparation for match-play, recovery practices following match-play, practices regarding injury risk or rehabilitation processes regarding return to play. Furthermore, players transitioning between U14 and U16 age-groups are exposed to differing physical and technical characteristics, which can differ dependent upon match status and possession status, and this may need to be considered when preparing players to transition between age-groups.

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