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Determining age-specific velocity thresholds for elite youth female soccer players

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ABSTRACT

Purpose: This study aimed to establish age-specific velocity thresholds for Under (U)14 and U16 elite youth female soccer players.

Methods: Data was collected using 10 Hz GPS units during 50 matches from 187 players (U14 n = 89; U16 n = 98). Spectral clustering identified velocity thresholds for high-speed running (HSR), very high-speed running (VHSR), and sprinting (SPR), for 699 half-match observations (U14 n = 369; U16 n = 330). Linear mixed modelling determined youth (U14 and U16) and age-group (U14 or U16) velocity thresholds, and compared distances covered between these and existing senior thresholds. The effect of playing position and playing half on velocity thresholds was also quantified.

Results: Youth velocity thresholds of HSR ($\geq$3.00 m·s^{-1}), VHSR ($\geq$4.83 m·s^{-1}), and SPR ($\geq$5.76 m·s^{-1}) were estimated from the model. Age-group and playing position influenced velocity thresholds but playing half did not. Adoption of youth and age-group velocity thresholds resulted in greater distance covered at HSR, VHSR, and SPR (p < 0.001; moderate-large effect size [ES] = 0.86–1.97) compared to senior thresholds. Both age-groups covered similar distances (trivial-small ESs = 0.002–0.23) when adopting youth and age-group velocity thresholds.

Conclusion: These youth thresholds provide an alternative to arbitrary velocity thresholds within the literature, and thresholds derived from senior players or other populations, to inform appropriate quantification and interpretation of physical data within this population.

Introduction

The categorisation of movement into velocity zones, such as low-speed running (LSR), high-speed running (HSR), very high-speed running (VHSR), or sprinting (SPR), is common practice within research quantifying the physical characteristics of sports (Cummins et al. 2013). Quantifying distance covered or time spent within velocity zones can provide insight into the physical demands of training or match-play (Ramos et al. 2019a), to inform population-specific practices (e.g. training programme design) and optimally prepare players for the physical demands of match-play. However, a wide variety of velocity thresholds have been adopted across and within sports (Cummins et al. 2013), and specifically within female soccer (e.g. HSR: $\geq$3.46, $\geq$4.58, or $\geq$5.50 m·s^{-1}; SPR $\geq$5.56, $\geq$6.26, or $\geq$6.97 m·s^{-1}; Datson et al. 2017; Trewin et al. 2018a; Scott et al. 2020). Furthermore, research has adopted a variety of methods to determine velocity thresholds, including; adopting arbitrary thresholds from male soccer literature (Bradley et al. 2014; Datson et al. 2017), determining thresholds from physical fitness characteristics (Trewin et al. 2018a, 2018b), or using data-mining techniques on match-play data (Hewitt et al. 2014; Scott et al. 2020). The lack of a standardised approach is problematic, as limited comparisons can be made within the scientific literature and may consequently result in misinterpretation of training and match-play physical characteristics. An accurate understanding of match-play and training characteristics is essential in order to inform training prescription and

maximise athletic development of players. Subsequently, discourse exists regarding the most appropriate velocity thresholds to adopt for elite female soccer, and the methods utilised to establish thresholds (Bradley and Vescovi 2015; Datson et al. 2017; Kavanagh and Carling 2019; Lovell et al. 2019; Vescovi 2019). Confounding this challenge, is the lack of consideration of appropriate velocity thresholds for youth players.

Of the known research quantifying youth female soccer match-play, two different sets of senior-derived velocity thresholds have been adopted (e.g. HSR $\geq$3.46 m·s^{-1}, VHSR $\geq$5.29 m·s^{-1}, SPR $\geq$6.26 m·s^{-1}, derived from match-play data; HSR $\geq$4.34 m·s^{-1}, SPR $\geq$5.56 m·s^{-1}, derived from physical characteristics; Vescovi 2014; Ramos et al. 2019b; Harkness-Armstrong et al. 2021). However, adoption of senior-derived thresholds may lead to erroneous interpretations of youth physical data due to age-related improvements in physical performance characteristics (e.g. aerobic capacity and sprint speed; Bradley and Vescovi 2015; Ramos et al. 2019c; Emmonds et al. 2020a, 2020b). As senior-derived thresholds are not reflective of the lower physical capabilities of youth players, they may not quantify the true physical characteristics of youth players (Harkness-Armstrong et al. 2021). For example, given the lower maximal velocity achieved during match-play by youth players compared to senior players (U14: 6.39–6.83 m·s^{-1}; Harkness-Armstrong et al. 2021; U16: 6.61–7.03 m·s^{-1}; Vescovi 2014; Harkness-Armstrong et al. 2021; vs senior: 7.97–8.5 m·s^{-1}; Scott et al. 2020), it is likely that a senior-derived SPR

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threshold (e.g. ≥6.26, ≥6.97 m·s^{-1}; Datson et al. 2017; Scott et al. 2020) is too excessive to fully capture sprinting performed by youth players. Therefore, adopting senior-derived thresholds would likely result in miscategorisation of movement by youth players, specifically, underestimating higher-speed distances and overestimating lower-speed distances. This is problematic, as accurate understanding of physical characteristics is required to inform population-specific practices, including optimally preparing players for the demands of match-play, or talent identification and development. Thus, establishing age-adjusted velocity thresholds appropriate for the quantification of physical characteristics of elite youth female soccer is important.

When considering how male soccer literature has determined youth velocity thresholds, research has predominantly adopted arbitrary thresholds from senior male players (Varley et al. 2017; Goto and Saward 2020), or established age-group thresholds from physical performance tests (e.g. flying speed achieved within maximal sprint tests; Harley et al. 2010; Goto et al. 2015). Whilst there is logical validity to using physical performance tests (Park et al. 2019) there are several limitations to applying this approach for establishing youth female soccer velocity thresholds. For example, previous research identified within-season differences in physical performance characteristics of elite youth female soccer players (Emmonds et al. 2020a) thus, thresholds may vary depending upon whether physical testing was pre-, mid- or post-season. Furthermore, thresholds may; differ between teams or depend upon players available for physical testing, vary between seasons due to players transitioning between age-groups (Park et al. 2019), and/or depend upon which physical performance tests are utilised (Hunter et al. 2015). Considering these limitations, an alternative approach is to utilise a Spectral Clustering approach to derive velocity thresholds from match-play data of the population. Whilst this approach has not yet been adopted for youth populations, it has been deemed appropriate for determining velocity thresholds for soccer (Park et al. 2019), and recently established thresholds for senior female soccer, which have since been implemented within research (Scott et al. 2020). However, key suggestions for future research were: the inclusion of competitive match-play data, involvement of multiple teams, and to derive population-specific velocity thresholds, including youth populations (Lovell et al. 2019; Park et al. 2019).

Therefore, the aim of this study was to establish velocity thresholds for elite youth female soccer players, specifically for U14 and U16 age-groups. Spectral Clustering analysis was used to derive velocity thresholds from competitive match-play data of elite youth female soccer players from multiple teams, as opposed to deriving thresholds from physical performance tests, or simply adjusting thresholds previously used within other populations (e.g. senior or male youth players). A secondary aim was to explore the influence of age-group, playing position, and match-play half on velocity thresholds, to explore the influence of workload profiles on velocity thresholds. The current study will provide researchers and practitioners with sex- and age-specific velocity thresholds to assist with the quantification, categorisation and interpretation of match-play and training physical characteristics of youth female soccer.

Materials and methods

Participants

Two hundred and one elite youth female soccer players, representing six Regional Talent Centres (RTCs) in England, at either U14 (n = 93; 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, participated in this study. RTCs are the highest standard of domestic youth female soccer in England, therefore participants were considered elite. Both U14 and U16 are standard age-groups within RTC competitions and are determined by chronological age. The study received ethical approval from Leeds Beckett University Ethics Committee (reference number 62064). All players (and parents/guardians) provided informed consent prior to participation within this study.

Methodology

During the 2018–19 and 2019–20 seasons, data was collected across 50 competitive matches (U14: n = 26, U16: n = 24) in The Football Association's Girls' England Talent Pathway League. Match duration differed between age-groups (U14: 35-min halves; U16: 40-min halves), and subsequent observed match duration was 77:03 ± 5:02 min at U14, and 82:56 ± 3:16 min at U16. Pitch dimensions also varied between age-groups (U14: 75 × 45 m; U16: 91 × 56 m). Match characteristics included: match outcome (win n = 17; draw n = 12, loss n = 21), match location (home n = 28; away n = 22), and playing surface (artificial turf n = 26; grass n = 24).

Data was collected using 10 Hz global positioning system (GPS) units (Optimeye S5, Catapult Sports, Melbourne, Australia). The validity and reliability of these devices for use in team sports have been described elsewhere (Scott et al. 2016). GPS units (11.9 ± 0.1 satellites; 0.71 ± 0.06 horizontal dilution of precision; HDOP) were switched on prior to warm-up routines and placed within a bespoke harness fitting the unit to the upper back of the player. Following each match, data was downloaded using Openfield software (Catapult Sports, Melbourne, Australia), trimmed to match-play data only, and exported for subsequent analyses in RStudio (RStudio Team, 2018; R version 3.6.0, R Foundation for Statistical Computing, Vienna, Austria).

Consistent with previous methods (Park et al. 2019), and in order to maximise the available dataset for the model to establish youth velocity thresholds, a minimum of an entire half-match player observation (≥35 min at U14; ≥40 min at U16) was required to be included for analysis, inclusive of additional time. Data filtering excluded half-match observations which consisted of greater than 3% of missing or erroneous data (Park et al. 2019), which included raw data with; insufficient satellite connection (<8 satellites), poor HDOP quality (≥2.0), or velocity (≥8.26 m·s^{-1}) which exceeded reasonable capabilities of elite youth female soccer players, based on 30 m maximal sprint tests performed by U14 and U16 players from the wider RTC population (unpublished data). Following data filtering, a total of 699 half-match

Playing Position	U14			U16		
	1st Half	2nd Half	Total	1st Half	2nd Half	Total
Central Defenders	36	33	69	38	33	71
Wide Defenders	40	38	78	35	35	70
Central Midfielders	63	46	109	48	39	87
Wide Midfielders	29	32	61	35	23	58
Forwards	28	24	52	27	17	44
All	**196**	**173**	**369**	**183**	**147**	**330**

observations (U14: mean = 4.0; range = 1–11; U16: mean = 3.1; range = 1–11) were analysed (Table 1) from a total of 187 players (U14: n = 89; U16: n = 98).

Velocity thresholds for each half-match observation were computed from the raw velocity data, using Spectral Clustering analysis with a $\beta = 0.1$ smoothing factor. Detailed explanation of Spectral Clustering analysis can be found elsewhere (Park et al. 2019), in addition to the accompanying publicly available R script used to perform this anslysis (Lovell et al. 2019). In brief, this process involved categorising raw velocity data into 0.1 m·s^{-1} velocity bins, between 0 and 8.3 m·s^{-1}, which aligns with the maximal velocity possible within observations due to data filtering. The transitions between velocity bins were utilised by the Spectral Clustering algorithm, to establish a specified number of ordered partitions or velocity zones, using a $\beta = 0.1$ smoothing factor. Thus, four velocity zones and three subsequent velocity thresholds were computed for each half-match observation. Qualitative descriptors of velocity zones were included to facilitate understanding and inform application, and aligned to previous research (Park et al. 2019; Scott et al. 2020). These included LSR, HSR, VHSR, and SPR.

Statistical analysis

Firstly, a linear-mixed model (lme4 package) was developed to determine youth velocity thresholds. This model included: HSR, VHSR, or SPR velocity thresholds (computed by Spectral Clustering) as a dependent variable; age-group (U14 or U16), playing position (central defender; CD, wide defender; WD, central midfielder; CM, wide midfielder; WM, or forward; FWD), and match-play half (first or second) as fixed effects to explore their influence on velocity thresholds; and participant, fixture, and team ID, as random effects to account for within-subject variation and repeated measures. Estimated means for

HSR, VHSR, and SPR youth velocity thresholds were derived from the model (emmeans package). To quantify the influence of fixed effects on youth velocity thresholds, Tukey's pairwise comparisons were conducted to quantify differences between levels of age-group, playing position and match-play half.

A second linear mixed model was then developed to estimate distance covered in each velocity zone (dependent variables) when adopting either youth, age-group, or senior velocity thresholds (fixed effect). Age-group was also included as a fixed effect, and player ID as a random effect. To identify differences in distance covered between velocity thresholds, Tukey's pairwise comparisons were conducted. The assumptions of linearity and normality of distributions of both linear mixed models were verified visually, and homogeneity of variance assessed using Levene's Test ($p \geq 0.05$). Data were presented as mean (±SE) unless otherwise stated. Statistical significance was set at $p < 0.05$. Effect size (ES) was calculated to determine the magnitude of the difference (effsize package) and classified as trivial (<0.2), small (0.2–0.599), moderate (0.6–1.199), large (1.2–1.999) or very large (≥2.0) (Batterham and Hopkins 2006; Harkness-Armstrong et al. 2021). Effect size were presented with 90% confidence intervals, and an effect was considered unclear if both substantial positive and negative values were included within 90% confidence intervals.

Results

Table 2 presents the velocity thresholds computed from the first linear mixed model for youth (U14 and U16), and specific age-groups (U14 or U16), alongside previously established velocity thresholds for senior players (Park et al. 2019)/

Influence of age-group

When U14 and U16 age-group velocity thresholds were compared, small differences were observed as U16s had higher HSR (0.18 ± 0.14 m·s^{-1}, p = 0.213, small ES = 0.274 ± 0.371), VHSR (0.21 ± 0.11 m·s^{-1}, p = 0.075, small ES = 0.370 ± 0.339), and SPR (0.20 ± 0.07 m·s^{-1}, p = 0.017, small ES = 0.459 ± 0.293) thresholds compared to U14s.

Influence of playing position

Figure 1 presents the position-specific pairwise comparisons of estimates from the linear mixed model for HSR, VHSR, and SPR, respectively. Velocity thresholds estimated for CMs were lower than all other playing positions for HSR (0.21–0.54 m·s^{-1}, small-

Table 2. Youth and specific age-group velocity thresholds for elite female soccer players computed using a Spectral Clustering approach and estimated means (90% CI) from linear mixed model.

Velocity Thresholds	High-Speed Running (m·s^{-1})	Very-High Speed Running (m·s^{-1})	Sprinting (m·s^{-1})
Senior*	3.46	5.29	6.26
	(3.40–3.52)	(5.23–5.35)	(6.20–6.32)
Youth	3.00	4.83	5.76
	(2.87–3.13)	(4.73–4.93)	(5.69–5.83)
U16	3.09	4.94	5.86
	(2.91–3.28)	(4.80–5.08)	(5.77–5.96)
U14	2.91	4.73	5.66
	(2.73–3.08)	(4.59–4.86)	(5.56–5.75)

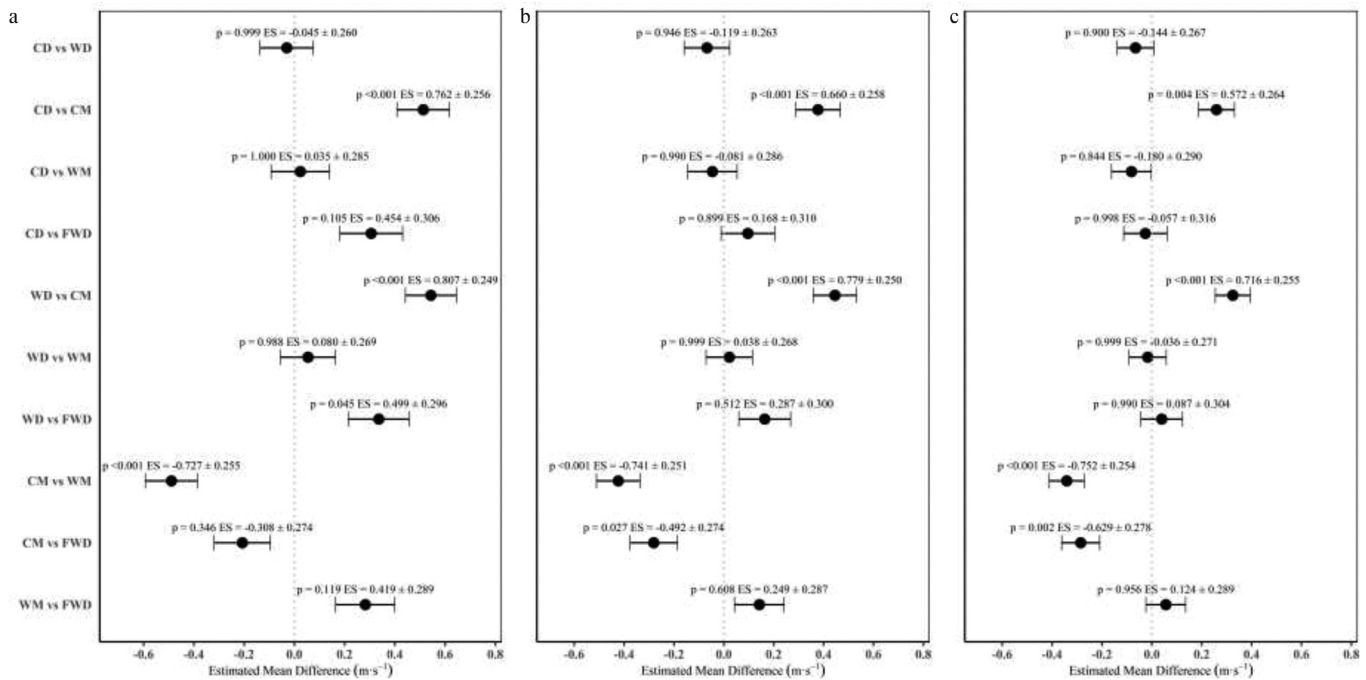*Senior velocity thresholds established by Park et al. (2019)

Figure 1. Estimated mean differences (±SE) for position-specific pairwise comparisons of A) high-speed running, B) very high-speed running, and C) sprinting velocity thresholds estimated from the linear mixed model. Effect size (ES ±90% CI) and p-values are also presented per comparison.*CD = central defenders, WD = wide defenders, CM = central midfielders, WM = wide midfielders, FWD = forwards.*

moderate ESs), VHSR (0.28–0.45 m·s^{-1}, small-moderate ESs) and SPR (0.26–0.34 m·s^{-1}, small-moderate ESs). Whilst thresholds estimated for FWDs were lower than CDs, WDs, and WMs for HSR (0.28–0.34 m·s^{-1}, small ESs), and lower than WDs and WMs for VHSR (0.14–0.16 m·s^{-1}, small ESs). No other substantial differences were observed between position-specific estimates at HSR, VHSR, and SPR.

Influence of match-play half

Playing half had no substantial effect, as velocity thresholds derived from first half observations were only trivially higher than second half observations, for HSR (0.04 ± 0.05 m·s^{-1}, p = 0.438, trivial ES = 0.061 ± 0.129), VHSR (0.03 ± 0.04 m·s^{-1}, p = 0.455, trivial ES = 0.058 ± 0.129), and SPR (0.06 ± 0.04 m·s^{-1}, p = 0.075, trivial ES = 0.139 ± 0.129).

Comparing youth, age-group and senior velocity thresholds

Figure 2 presents estimated distances covered during a half of elite youth female soccer match-play when adopting either senior, youth, or age-group velocity thresholds. At both age-groups, adopting youth thresholds resulted in less LSR (p < 0.001, large-very large ESs), and more HSR (p < 0.001, large ESs), VHSR (p < 0.001, moderate-large ESs), and SPR (p < 0.001, moderate ESs) compared to senior thresholds. Conversely, adopting youth thresholds resulted in similar distances covered for LSR (trivial ESs), HSR (trivial-small ESs), VHSR (trivial ESs), and SPR (trivial ESs) compared to adopting age-group thresholds.

Discussion

The aim of this study was to establish youth velocity thresholds for the appropriate quantification and categorisation of movement in elite youth female soccer. This was the first study to a) propose age-specific velocity thresholds for female youth players, b) derive velocity thresholds via Spectral Clustering from competitive match-play data, c) explore the influence of age-group, playing position and playing half on deriving velocity thresholds via Spectral Clustering, and d) adopt a multi-club approach to deriving velocity thresholds via Spectral Clustering, with a sample of 699 half-match observations from 187 players across 6 different RTCs. Youth velocity thresholds were notably lower compared to senior-derived thresholds (Park et al. 2019). Additionally, when considering the effect of workload profiles on velocity thresholds, age-group had a small effect and the effect of playing-position was position-dependent, whilst there was no difference in playing half. Finally, the determination of physical characteristics of elite youth female soccer match-play differed dependent upon whether youth or senior-derived thresholds (Park et al. 2019) were adopted. These findings have implications for researchers and practitioners quantifying and interpreting physical data of elite youth female soccer players.

Spectral Clustering analysis determined youth velocity thresholds of 3.00, 4.83, and 5.76 m·s^{-1} for HSR, VHSR, and SPR, respectively, which were 0.46–0.50 m·s^{-1} lower than the respective senior thresholds (Park et al. 2019). This supports previous suggestions that adoption of senior-derived velocity thresholds may be too excessive to accurately quantify the true movement characteristics of youth players (Harkness-Armstrong et al. 2021). The adoption of a multi-club approach
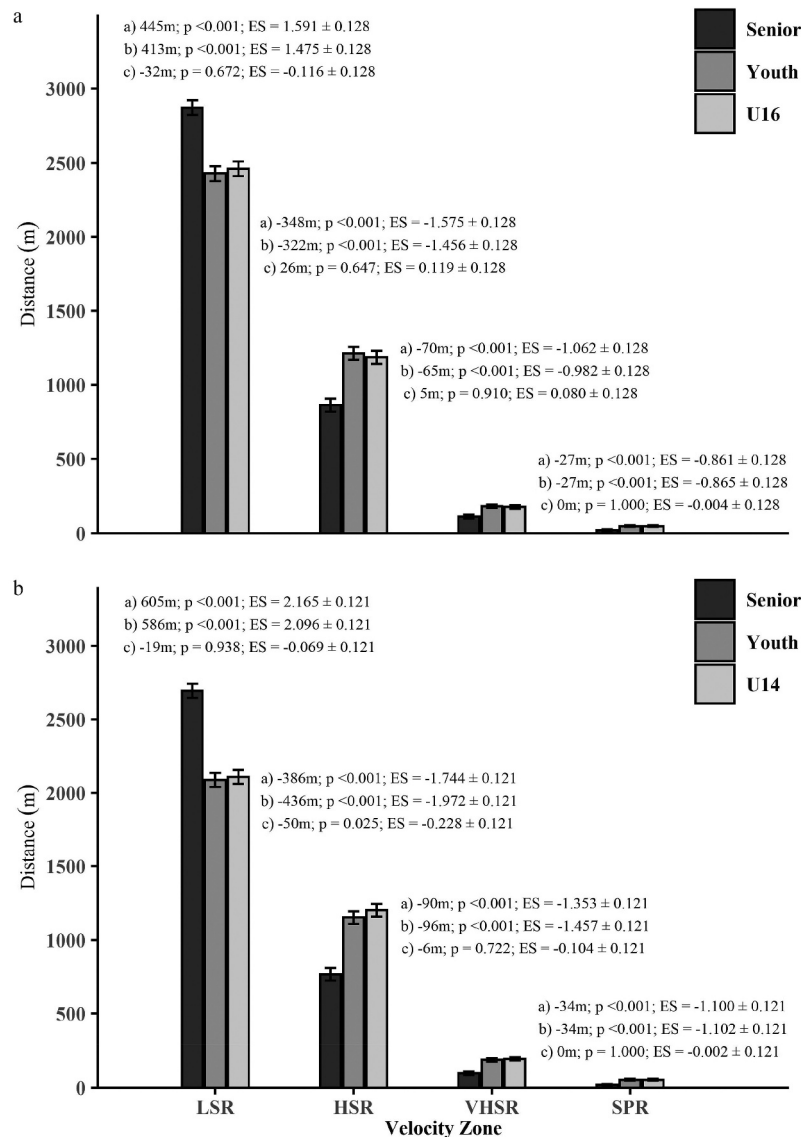
Figure 2. Distance (m) covered during a half of A) U16 and B) U14 elite youth female soccer match-play, within low-speed running (LSR), high-speed running (HSR), very high-speed running (VHSR) and sprinting (SPR) velocity zones, when using senior, youth or age-group velocity thresholds, estimated from the second linear mixed model. Estimated mean differences, p-values and effect size (ES ±90% CI) are also presented for a) senior v youth; b) senior v age-group; c) youth v age-group velocity threshold pairwise-comparisons.

utilising competitive match-play data to derive youth velocity thresholds addressed two important limitations of the study by Park et al. (2019), which were: the inclusion of a single team, and using non-competitive match-play data to compute senior female soccer thresholds (Lovell et al. 2019; Vescovi 2019).

The application and comparison of the youth velocity thresholds established and senior velocity thresholds (Park et al. 2019) to elite youth female soccer match-play data, sustained the notion that velocity thresholds are too excessive to quantify the true physical demands of youth players (Harkness-Armstrong et al. 2021). Comparisons found that adopting senior thresholds resulted in an overestimation of LSR (U14: 2694 vs 2089 m; U16: 2872 vs 2427 m), and an underestimation of HSR (U14: 766 vs 1152 m; U16: 864 vs 1212 m), VHSR (U14: 96 vs 186 m; U16: 112 vs 182 m) and SPR (U14: 18 vs 52 m; U16: 20 vs 47 m) distances. Therefore, we recommend adopting youth

thresholds when quantifying the physical characteristics of youth players. However, we also acknowledge there may be situations where adopting senior-derived thresholds may be more appropriate. For example, quantifying differences in physical demands between U14, U16, and senior match-play, to inform long-term athletic development strategies, talent development, or identification processes across the talent pathway (Datson et al. 2020), or preparation of players transitioning from youth to senior environments. (Ramos et al. 2019b). In these instances, we suggest the removal of qualitative descriptors associated with senior-derived velocity zones (i.e. HSR, VHSR, SPR), and to simply refer to distance covered above a specific velocity threshold. In addition, researchers and practitioners should be aware of the potential impact of adopting senior-derived thresholds on youth physical characteristics. These measures may facilitate interpretation of physical data, and

consequently, avoid erroneous interpretations or misconceptions of the physical demands of elite youth female soccer (Kavanagh and Carling 2019). Thus, we recommend researchers and practitioners consider the aim of the study or intended use of the data to ensure that evidence-based youth or senior velocity thresholds are adopted (Lovell et al. 2019; Vescovi 2019), which are appropriate for both the population and the intended use of the data.

When comparing youth and age-group velocity thresholds, both U14 and U16 age-groups covered similar distances in all velocity zones. These results suggest adoption of youth thresholds are appropriate for both U14 and U16 age-groups, and thus, there is no need to adopt age-group thresholds. This finding has several implications for researchers and practitioners working with this population. Firstly, the use of youth thresholds, facilitates comparisons of physical characteristics between age-groups within the talent pathway (Vescovi 2014; Ramos et al. 2019b; Harkness-Armstrong et al. 2021). This can be used to optimally prepare players transitioning from U14 to U16 age-groups, and inform talent development and identification processes. Furthermore, it is standard practice for U14 players to 'play-up' an age-group within RTC competitions. Whilst previous research has explored the effect of 'playing-up' in elite youth male soccer players (Kelly et al. 2021), this is yet to be explored within elite youth female soccer. Utilising youth velocity thresholds will facilitate comparison of physical loads during match-play to better understand potential physical implications of 'playing-up'. Practitioners may use this data to inform practices surrounding players 'playing-up', and also to prepare players for transitioning between U14 and U16 age-groups. Additionally, as practitioners are not required to change thresholds between age-groups, this reduces potential time requirements of data processing for GPS data within this population.

Exploring the influence of workload profiles on velocity thresholds was another novel aspect of this study. Firstly, playing half had no substantial effect on thresholds, as first half observations resulted in trivially higher thresholds. This supports previous research which identified insignificant reductions in higher-speed distances between the first and second half of elite youth female soccer (Vescovi 2014). Whilst age-group had a non-significant small effect on thresholds, this resulted in higher thresholds for U16s than U14s. This finding is reflective of the increasing physical demands observed across age-groups in elite female soccer match-play (Vescovi 2014; Ramos et al. 2019b; Harkness-Armstrong et al. 2021). However, similar distances were covered in all velocity zones when youth and age-group thresholds were adopted. Finally, the effect of playing position was position-dependent, which supports previous findings that playing position influences the workload of elite youth female soccer players (Vescovi 2014; Ramos et al. 2019b; Harkness-Armstrong et al. 2021), CM thresholds were notably lower than all other positions, which is reflective of the workload of CMs (Harkness-Armstrong et al. 2021).

Importantly, these findings confirm that workload profiles of the sample influence velocity thresholds (Park et al. 2019). Future research should carefully consider the sample used to determine velocity thresholds for their respective sport and/

or population (e.g. a sample which involves predominantly CMs would result in lower thresholds). Furthermore, practitioners attempting to utilise this approach to derive individualised player velocity thresholds should consider playing position within match observations. Additionally, future research should ensure adequate information regarding the sample is provided to allow researchers and practitioners to make informed decisions regarding implementing the proposed velocity thresholds. For example, Park et al. (2019) established velocity thresholds via a Spectral Clustering approach yet provided limited sample characteristics, including no positional information, which we found to influence velocity thresholds.

The current study contributes to the ongoing narrative surrounding appropriate velocity thresholds within female soccer populations, providing age-appropriate thresholds for youth players. The current study attempted to address some of the key limitations acknowledged by Park et al. (2019) when establishing the senior velocity thresholds via Spectral Clustering, including; data from competitive match-play and the involvement of multiple RTCs. However, limitations of the current study should be acknowledged. Firstly, we only included U14 and U16 RTC age-groups. However, including match-play data of younger RTC age-groups (U10 and U12) would have been inappropriate for computing elite youth female soccer velocity thresholds (Harkness-Armstrong et al. 2021), as these younger age-groups compete in mixed-gender competitions. Additionally, whilst the study explored the effect of age-group, playing position and match-play half to understand how workload profiles of the sample may influence thresholds, situational factors of match-play data were not explored. For example, match status or match outcome (Moalla et al. 2018), team and opposition formation (Bradley et al. 2011), or environmental factors (Trewin et al. 2018b), may have influenced the workload profile of the sample, and thus, the derived youth velocity thresholds.

Practical applications

The youth velocity thresholds established in the current study provide age-appropriate thresholds for the quantification of the physical characteristics of youth female soccer populations. For example, quantification of distances covered in respective velocity zones, or repeated HSR and SPR characteristics within youth female soccer match-play. However, researchers and practitioners should carefully consider their study aim or intended use of the data, to identify whether youth or senior-derived velocity thresholds are the most appropriate to adopt. Furthermore, researchers and practitioners should understand how different thresholds will impact the quantification and interpretation of physical characteristics. When adopting senior-derived thresholds, we recommend the removal of qualitative descriptors (e.g. HSR, SPR), and to simply refer to distances covered above a specific velocity to facilitate interpretation. For example, utilising non-descriptive velocity zones across youth and senior levels may provide insight into the physical capabilities of youth players and exposure to distances at higher velocities within youth

match-play compared to senior match-play, to inform practices to optimally prepare youth players progressing to senior environments.

Conclusions

The current study has proposed youth velocity thresholds for HSR, VHSR, and SPR of 3.00 m·s^{-1}, 4.83 m·s^{-1}, and 5.76 m·s^{-1}, respectively, for U14 and U16 elite youth female soccer. The results found velocity thresholds differ between youth and senior levels and are similar between U14 and U16 age-groups. Additionally, findings suggest that playing half does not influence youth velocity thresholds but playing position may. Furthermore, elite youth female soccer match-play physical characteristics will differ depending upon whether youth or senior thresholds are adopted. Therefore, practitioners should carefully consider the intended use of the physical data and make an informed decision regarding the most appropriate thresholds to adopt. Finally, the current study has identified the need for youth velocity thresholds in female soccer, however future research should aim to determine age-adjusted velocity thresholds for the quantification of physical characteristics in other youth sport populations.

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