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To cite this article: Ivan Baptista, Andreas K. Winther, Dag Johansen, Morten B. Randers, Sigurd Pedersen & Svein Arne Pettersen (2022): The variability of physical match demands in elite women's football, Science and Medicine in Football, DOI: [10.1080/24733938.2022.2027999](https://doi.org/10.1080/24733938.2022.2027999)

To link to this article: <https://doi.org/10.1080/24733938.2022.2027999>



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Published online: 21 Jan 2022.



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The variability of physical match demands in elite women's football

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ABSTRACT

Peak locomotor demands are considered as key metrics for conditioning drills prescription and training monitoring. However, research in female football has focused on absolute values when reporting match demands, leading to sparse information being provided regarding the degrees of variability of such metrics. Thus, the aims of this study were to investigate the sources of variability of match physical performance parameters in female football players and to provide a framework for the interpretation of meaningful changes between matches.

54 female players from four top-level clubs were monitored during one season. GPS APEX (STATSports, Northern Ireland), with a sampling frequency of 10 Hz, were used in 60 official matches ($n = 393$) to determine the full-match and 1-min peak locomotor demands of total distance (TD), high-speed running distance (HSRD), sprint distance (SpD), accelerations and decelerations (Acc/Dec) and peak speed (Pspeed). For each variable, the between-team, between-match, between-position, between-player, and within-player variability was estimated using linear mixed-effect modelling.

With exception to SpD (29.4 vs. 31.9%), all other metrics presented a higher observed match-to-match variability in the 1-min peaks than in the full-match (6.5 vs. 4.6%; 18.7% vs. 15.9%; 12.9 vs. 11.7%; for TD, HSRD and Acc/Dec, respectively). With the exception of SpD, higher changes in 1-min peaks than in full-match values are required to identify meaningful changes in each variable.

Different sources of variability seem to impact differently the match physical performance of female football players. Furthermore, to identify meaningful changes, higher changes in 1-min peaks than in full-match values are required.

ARTICLE HISTORY

Accepted 6 January 2022

KEYWORDS

Women's football; match-to-match variability; performance analysis; high-speed running; accelerations; peak locomotor demands

Introduction

The use of technology for monitoring match physical demands has become a common practice in professional football (Carling 2013). In recent years, the assessment of external load during official matches has evolved, partly due to the increasing prevalence of Global Positioning Systems (GPS) among football clubs (Whitehead et al. 2018), and the rule change in 2015 introduced by the International Football Association Board (IFAB) allowing the use of these technologies during official matches (FIFA 2015). Despite the growing body of knowledge within the match demands domain, the majority of the studies underestimate the true physical demands of competition, since several sport-specific movements (e.g., heading, tackling, accelerations and decelerations) are often omitted, leading to an underestimation of match-load by 6–8% (Osgnach et al. 2010). The detailed performance data obtained through the analysis of match running activity and acceleration metrics can be used by practitioners to profile the player's game requirements and consequently guide decision-making throughout the microcycle, such as the adjustment of recovery sessions or to establish physical targets during the week (Al Haddad et al. 2018).

Football performance is a multifactorial construct with a dynamic and stochastic nature, where players' physical performances (e.g., high-speed activities) are affected by external factors (e.g., ball possession and period of the season) which consequently causes a fluctuation of these metrics between consecutive matches (Gregson et al. 2010). The variability in a football player's performance from match to match can provide estimates of the smallest worthwhile change, an important piece of information for sport scientists monitoring players or for scientists designing and analysing studies on factors affecting performance (Hopkins et al. 1999). This concept has been deeply studied in men's football (Bush et al. 2015; Carling et al. 2016; Gonçalves et al. 2018; Oliva-Lozano et al. 2021) and demonstrated by the coefficient of variation (CV) of a particular physical performance parameter (Novak et al. 2021). Previous studies have shown that this match-to-match variability can be caused by internal (e.g., fitness characteristics) and external factors (ball possession in match-play) (Carling et al. 2016) including the method used for match analysis (Randers et al. 2010; Pettersen et al. 2018). Previous research in men's football has been unanimous when reporting high-speed running as the most inconsistent variable from match-to-match (Bush et al. 2015; Carling et al. 2016; Trewin et al. 2017)

with Gregson et al. (Gregson et al. 2010) adding that this variability (CV~15% to 30%) is higher for central positions than for wide positions.

However, little research has been done within this field in the women's football context. Although both men and women play the same game, research in other sports, such as weightlifting (McGuigan and Kane 2004) and cycling (Paton and Hopkins 2006) has shown a tendency for greater variability in women compared to men. In a recent study of a women's national team, Trewin et al. (Trewin et al. 2018) reported a higher occurrence and lower variability of accelerations (CV = 17%), when compared to high-speed running and sprint efforts (CV = 34% and 56%, respectively). These results are in line with research in men's football (Dalen et al. 2019) where accelerations have been proposed to be a more stable and sensitive measure of physical performance than high-speed running activities. The study of female national team players (Trewin et al. 2018) also presented the high-speed running and sprint efforts of centre backs (CB) as the metrics with the greatest variation when compared to other playing positions (CV = 41–65%). Despite the novelty of the study, Trewin et al. (Trewin et al. 2018) analysed data from a single national team, across five consecutive seasons, which should be considered as a possible bias of the results, since within this time span changes in the physical condition of the players are very likely to occur (Mohr et al. 2003). Moreover, a multiple team analysis would be beneficial in order to reduce the possible bias caused by certain contextual factors (i.e., team) in the match-to-match variability observed.

Research within the match analysis domain is no longer bound to the analysis of absolute (full match) values, and the concept of peak locomotor demands has been gathering researchers' attention over the last years (Weaving et al. 2019). Previous research has suggested that match average demands are not the most informative outcomes for players preparation, since the use of such values to characterize match physical demands will most likely underestimate the most intense periods of the match (Delaney et al. 2015). Although, more common terms, such as peak period (Baptista et al. 2019a, most demanding passages of play (Martin-Garcia et al. 2018; Castellano et al. 2020) and worst-case scenarios (Cunningham et al. 2018; Fereday et al. 2020) have been used to refer to this concept. Researchers and practitioners should also be aware that only univariate locomotor measurements have been presented and that such an approach does not represent the total amount of activity (Novak et al. 2021). Therefore, to minimize such misinterpretation of the concept, this paper will use the term suggested by Weaving et al. (Weaving et al. 2019) and further supported by Novak et al. (Novak et al. 2021) – *peak locomotor demands*. Despite the growing interest in studying the training and match demands in female football (Gabbett and Mulvey 2008; Mohr et al. 2008; Andersson et al. 2010; Vescovi 2012; Gabbett et al. 2013; Hewitt et al. 2014; Vescovi and Favero 2014; Datson et al. 2017; Mara et al. 2017; Vescovi and Falenchuk 2019), this representation of external load has focused on absolute values (full-match) or long fixed-periods (i.e., 15 minutes), with sparse information provided about shorter peak locomotor demands (e.g., 1, 3 or 5 minutes) of female competitions (Trewin et al. 2018; Harkness-Armstrong

et al. 2020; Panduro et al. 2021). This can in turn lead to limited information for training prescription, since peak locomotor demands have been suggested as key-metrics for the prescription of conditioning drills and the monitoring of training intensities (Whitehead et al. 2018).

Irrespectively, the random factors (i.e., match, position, players, and team) become important to determine the different degrees of variability of key physical variables, so practitioners can make more evidence-based decisions in their daily practices. Quantifying the match-to-match variability of different physical variables may be used to determine whether a change in match demands can be considered as normal or unusual (Oliva-Lozano et al. 2021). Therefore, the aim of this study was twofold: 1) to investigate the different sources of variability of selected match physical performance parameters in elite football player cohorts, using full match values and 1-min peak locomotor demands; and 2) to provide reference values for interpreting changes in match physical performance.

Methods

Participants and match samples

With ethical institutional approval and written informed consent from the participants, 108 female football players (22.4 ± 4.0 years of age) from four elite-level (top tier division) Norwegian clubs participated in the study. Player movement data from one season (2020) including 60 official matches was collected using GPS APEX (STATSports, Northern Ireland), with a sampling frequency of 10 Hz. The validity and acceptable levels of accuracy (bias <5%) of this tracking system have previously been presented (Beato et al. 2018). During matches, each player wore a tight vest with a GPS unit on the back of their upper body between scapula as described by the manufacturer. The microsensor devices were activated 15 min before the start of each match, in accordance with the manufacturer's recommendations and previous research (Lozano et al. 2020), with this period of time excluded from analyses. To minimize inter-devices error (Beato et al. 2018), each player used the same GPS unit for the entire season. The mean number of satellites and horizontal dilution of precision was 17.5 ± 2.8 and 1.4 ± 0.6 , respectively.

Data processing

Doppler derived speed data were exported from manufacturer software (STATSport Sonra 2.1.4) into Python 3.7.6. for processing (linearly interpolating any missing raw data), and to derive metrics. Raw acceleration was then calculated over a period of 0.6 seconds. Matches were treated in which two of our teams played against each other as separate matches, and, because of positional differences in locomotor demands, the same player in a new position was treated as a new player. Goalkeepers were excluded from analysis and the selected playing positions, (central defenders, full-backs, midfielders, wide midfielders, and forwards), were chosen according to previous research (Schuth et al. 2016; Baptista et al. 2018). To get a representative sample, players were included only if: a) completed, at least, two full-time (90 min) matches; b) and played the entire match in the

same playing position. Match performance data of <90 min was treated as missing. This resulted in an initial sample of 501 observations with 108 missing values, which were subsequently removed in the complete case analysis. The final sample included 393 match observations (M_{obs}) from 54 players (central defenders, $n = 10$, $M_{obs} = 113$; full-backs, $n = 11$, $M_{obs} = 84$; central midfielders, $n = 16$, $M_{obs} = 105$; wide midfielders, $n = 9$; $M_{obs} = 57$ and central forwards, $n = 8$, $M_{obs} = 34$).

Physical performance variables

The physical parameters analysed included: total distance (TD), high-speed running distance (HSRD) ($>4.44 \text{ m}\cdot\text{s}^{-1}$), sprint distance (SpD) ($>5.55 \text{ m}\cdot\text{s}^{-1}$), number of accelerations and decelerations (Acc/Dec), and peak speed (Pspeed). In accordance with Trewin et al. (Trewin et al. 2017), accelerations and decelerations were defined as a positive or negative change in speed of more than $\pm 2.26 \text{ m}\cdot\text{s}^{-2}$, with a minimal effort duration of 0.3 seconds, finishing when the rate of acceleration/deceleration reached $0 \text{ m}\cdot\text{s}^{-2}$. The speed thresholds were chosen according to previous research (Trewin et al. 2018; Strauss et al. 2019). Except for Pspeed, all other variables were used to analyse both full match (absolute values) and peak locomotor demands (1-min rolling analysis period). The epoch length for the peak locomotor demands was chosen according to the findings of Doncaster et al. (Doncaster et al. 2020), where 1 min epochs produced the highest relative intensities when compared with 3- and 5-min epochs.

Statistical Methods

After deriving all the metrics, the data were transferred to R (R.4.0.5, R Core Team, 2021) for statistical analysis. To estimate the sources of variability (between-team, between-position, between-player, between-match, and the residual within-player variability) and to provide reference values for

interpreting changes in match physical performance, we used a similar approach as Oliva-Lozano et al. (Gonçalves et al. 2018). The design located units of analysis (individual match observations) nested within clusters of units (players), further nested within playing positions and teams. To account for this hierarchical (correlated) nesting, and to quantify the variability in match physical performance, data were analysed using linear mixed-effect modelling with the package lme4 (Bates et al. 2015). For each physical parameter, the model was specified to include a random intercept for the random effects: team, position, player ID, and match ID. All models were estimated via Restricted Estimated Maximum Likelihood (REML), and model appropriateness was verified by examining the QQ-plots of the studentized residuals. Each random effect represented a source of variability and was expressed in raw units (standard deviation – SD) by modelling the original data, and in percentage units (CV%) by first log-transforming the original data before modelling, and then back-transforming each estimate after modelling was done (Hopkins et al. 2009).

Similar to Oliva-Lozano et al. (Oliva-Lozano et al. 2021), variability estimates were used to provide a framework for practitioners to interpret individual changes in indicators of match physical performance. Here, 80% and 90% limits of agreement (LoA) were calculated by multiplying the square root of 2 with the appropriate values from the t-distribution (with infinite degrees of freedom) and the observed between-match variability expressed (e.g., the pooled between-match and within-player variability). Furthermore, practical significant changes associated with alpha levels of 0.10 and 0.05 were calculated using the formula: * observed between-match variability * t-statistic + threshold. Here, the *observed between-match variability* was the same as described above, while the *threshold* term was equivalent to the smallest worthwhile change ($0.2 * \text{the observed between-player variability} - \text{or the pooled between-player and within-player variability}$).

Table 1. Variability of full match and 1-min peak locomotor demands expressed in raw units and coefficients of variation (%).

	Metric		Variability				
			Between-match	Between-team	Between-position	Between-player	Within-player
SD (90% CI) ^a	TD (m)	Full match	335 (278–393)	37 (0–212)	456 (132–749)	473 (379–547)	259 (239–277)
		1' peak	6 (4–7)	2 (0–4)	8 (2–14)	7 (5–8)	10 (10–11)
	HSRD (m)	Full match	132 (103–154)	51 (0–137)	288 (95–446)	272 (222–323)	160 (148–171)
		1' peak	7 (5–8)	2 (0–6)	10 (2–15)	8 (6–10)	13 (12–14)
	SpD (m)	Full match	40 (29–49)	0 (0–39)	111 (31–172)	103 (84–122)	73 (68–78)
		1' peak	3 (0–4)	1 (0–3)	8 (3–12)	6 (4–7)	11 (10–12)
	Acc/Dec (#)	Full match	12 (10–15)	0 (0–11)	19 (0–32)	28 (23–33)	20 (18–21)
		1' peak	0.3 (0.0–0.4)	0.0 (0.0–0.3)	0.8 (0.2–1.2)	0.7 (0.5–0.9)	1.3 (1.2–1.3)
CV (90% CI) ^b	Peak _{speed} (m/s)	Full match	0.1 (0.0–0.1)	0.0 (0.0–0.1)	0.1 (0.0–0.9)	0.3 (0.3–0.4)	0.3 (0.3–0.3)
		1' peak	3.1 (2.3–3.8)	0.7 (0.0–2.2)	4.7 (1.5–7.3)	3.7 (2.7–4.5)	5.7 (5.3–6.1)
	TD (m)	Full match	3.6 (3.0–4.2)	0.2 (0.0–2.2)	4.9 (1.7–8.0)	4.9 (4.0–5.8)	2.8 (2.6–3.0)
		1' peak	10.2 (8.1–12.2)	1.1 (0.0–7.3)	22.8 (7.1–37.4)	18.9 (15.0–22.8)	11.7 (10.9–12.5)
	HSRD (m)	Full match	7.6 (5.5–9.7)	1.4 (0.0–5.2)	12.8 (2.6–20.9)	10.7 (7.9–13.3)	16.7 (15.5–17.9)
		1' peak	13.8 (10.0–17.5)	0.0 (0.0–13.1)	39.3 (8.8–66.9)	37.2 (28.4–46.2)	27.7 (25.6–29.7)
	SpD (m)	Full match	6.4 (0.0–9.7)	0.0 (0.0–7.2)	20.0 (6.6–32.1)	14.9 (10.0–19.0)	28.4 (26.4–30.6)
		1' peak	6.2 (4.7–7.6)	0.0 (0.0–6.0)	9.2 (0.0–15.6)	14.2 (11.0–17.0)	9.7 (9.1–10.4)
Acc/Dec (#)	Full match	0.3 (0.0–0.4)	0.0 (0.0–3.2)	7.1 (0.8–11.3)	7.3 (5.1–9.0)	12.6 (11.7–13.5)	
	1' peak	0.1 (0.0–0.1)	0.0 (0.0–1.7)	1.9 (0.0–3.7)	4.4 (3.4–5.2)	4.4 (4.0–4.7)	

SD = Standard deviation; CI = Confidence Intervals; CV = Coefficient of variation.

^aValues presented in the metric's unit of measurement;

^bValues presented as a percentage of the mean

Results

The decomposed variability of full match and 1-min peak match analysis metrics are presented in Table 1. All estimates of between-position, between-match, between-player, within-player, and between-team are expressed in raw (SD) and percentage (CV) units. CV values of full match variables ranged from 0.0% to 39.3%, with the lowest CVs associated with between-team variability of Pspeed (0.0%) and the highest with between-position variability of SpD (39.3%). With the exception of between-team variability, which presented low values for all metrics, all sources of variability of full match metrics were greater for SpD (13–39%) when compared with all other external load variables. Between-player (for TD, Acc/Dec and Pspeed) and between-position analysis (for HSRD and SpD) present higher CVs, in the full match variables analysed, relative to the other sources of variability. CV values of 1-min peak variables ranged from 0.0% to 28.4%, with the lowest CVs associated with the between-team variability of Acc/Dec (0.0%) and the highest with the within-player variability of SpD (28.4%). The within-player variability assumes the largest CVs for the 1-min peak variables.

The observed match-to-match variability (combined between-match and within-player) and reference values for interpreting individual changes are presented in Table 2. With exception to SpD (29.4 vs. 31.9%), all other metrics presented a higher observed match-to-match variability in the 1-min peaks than in the full match (6.5 vs. 4.6%; 18.7% vs. 15.9%; 12.9 vs. 11.7%; for TD, HSRD and Acc/Dec, respectively). Based on the model used to identify significant changes (see methods section), between-match individual changes of $\pm 9\%$ ($\alpha = 0.10$) and $\pm 12\%$ ($\alpha = 0.05$) in full match metrics of TD and Pspeed would be considered unusual and suggest practical significance. For HSRD (33%; 42%), SpD (68%; 84%) and Acc/Dec (25%; 31%) these thresholds ($\alpha = 0.10$; $\alpha = 0.05$; respectively) are considerably higher. Regarding 1-min peaks, and with exception to SpD, higher changes than in full-match values are required to identify meaningful difference.

Discussion

Full-match vs. 1-min peak variability

This study is novel, being the first that decomposes and compares the variability of absolute (full-match) and relative (1-min peak) match external load metrics in elite women's football. A novel finding was the higher observed match-to-match variability in 1-min peaks when compared to the full match, in TD (6.5% vs. 4.6%), HSRD (18.7% vs. 15.9%) and Acc/Dec (12.9% vs. 11.7%). This difference may be caused by external factors (e.g., match result and opponent) alongside the dynamic and stochastic nature of a football match, which in this case seasonal fluctuations appear to have had a higher influence in the most demanding periods than in the mean match values. (Gregson et al. 2010) While not having reference to female football, previous research in male football (Novak et al. 2021) presented CV values of 3-min peaks similar to our study, for TD (~7%), HSRD (~21–31%) and SpD (~35–56%). This information is particularly relevant since the study of univariate peak locomotor demands has been used by practitioners to inform training prescription (Baptista et al. 2019a), and consequently as a strategy to better prepare their players to cope with these peaks during match-play. However, as previously observed in absolute values (Carling et al. 2016), peak locomotor demands are also unstable across matches. The poor consistency of specific peak high-speed metrics presented in men's football (Novak et al. 2021), and here corroborated for women's football, may raise questions regarding its practical applicability. Although the analysis of peak locomotor demands in matches has become a common trend among practitioners, its applicability as benchmarks for training sessions may be controversial.

Sources of variability

After decomposing the variability into five different sources (between-match, between-position, between-player, within-player and between-team), we observed that all sources were greater for SpD than for the other physical metrics, both in full match (13.8–39.3%) and 1-min peaks (6.4–28.4%), with a minor exception in the between-team variability, where HSRD (~1%) presented slightly higher CV than SpD (~0%). These results are in line with previous research in male football, where the highest CV values were observed in high-speed metrics (Gregson et al. 2010;

Table 2. Reference values for interpretation of individual changes in match physical performance in full match and 1-min peak periods.

Metric	Observed match-to-match variability ^b CV (90% CI) ^a	\pm Limits of agreement (%) ^c		Change (\pm) required to be practically significant (%) ^c		
		80%	90%	$\alpha = 0.10$	$\alpha = 0.05$	
TD	Full match	4.6 (4.1–5.0)	8.3	10.6	9.4	11.8
	1' peak	6.5 (6.0–7.0)	11.8	15.1	13.2	16.5
HSRD	Full match	15.9 (14.3–17.7)	28.8	36.9	33.3	41.5
	1' peak	18.7 (17.2–20.1)	33.9	43.5	38.0	47.6
SpD	Full match	31.9 (29.1–34.5)	57.7	74.1	67.5	83.9
	1' peak	29.4 (27.1–31.6)	53.3	68.4	59.9	75.0
Acc/Dec	Full match	11.7 (10.8–12.6)	21.2	27.2	24.7	30.7
	1' peak	12.9 (12.1–13.8)	23.4	30.0	26.3	33.0
Pspeed	Full match	4.5 (4.2–4.8)	8.1	10.4	9.4	11.7

CV = Coefficient of variation.

^aValues presented as a percentage of the mean.

^bBased on the combined between-match and within-player variability.

^cBased on the observed match-to-match variability

Carling et al. 2016). For instance, Carling et al. (Carling et al. 2016) presented greater variability for distances above 7.0 m s^{-1} (37%) than for distances between 5.5 and 7.0 m s^{-1} (18.1%). These discrepancies between locomotor categories (full-match values) are somewhat similar to those presented in our study, where the observed match-to-match variability of SpD (31.9%) presented twice the magnitude of HSRD (15.9%).

Using a similar approach of previous research (Oliva-Lozano et al. 2021), we separately analysed the elements occurring at the match and player level by partitioning the observed match-to-match variability into between-match and within-player variability. Our full match results for TD (3.6% vs. 2.8%) and Pspeed (1.0% vs. 4.4%) were identical to those reported by Oliva-Lozano et al. (Oliva-Lozano et al. 2021) (4.3% vs. 3.7% and 1.5% vs. 4.9%; for TD and Pspeed, respectively), where these metrics appeared relatively stable both for between-match and within-player variability. However, regarding Acc/Dec our study presents a lower CV for between-match than for between-position variability (6.2% vs. 9.7%), while the study of Oliva-Lozano et al. (Oliva-Lozano et al. 2021) reported an opposite trend (4.9% vs. 2.6%). We conjecture that the presence of a high between-position variability could be caused by the divergent individual characteristics within the playing position. In fact, our study presented a higher sample size, and consequently more players per position than the study of Oliva-Lozano et al. (Oliva-Lozano et al. 2021), meaning the presence of a larger diversity of players within each position. Furthermore, the between-match (10.2%) and within-player (11.7%) variability of HSRD observed in our study were considerably lower than reported in men's teams (19% and 23%, respectively) (Oliva-Lozano et al. 2021). We conjecture that this discrepancy between studies is caused by the different high-speed running thresholds used in female ($>4.44 \text{ m s}^{-1}$) and male teams ($>5.8 \text{ m s}^{-1}$), which is associated with the fact that variability tends to increase with running intensity, (Carling et al. 2016) justifies such differences.

Individual changes interpretation

By partitioning the match physical performance variability into different sources, we provide valuable information that may assist football coaches to make more evidence-based decisions regarding the monitoring of between-match changes. The reference values for interpreting the individual changes presented in Table 2 were obtained by a combination of between-match and within-player variability, resulting in 80% and 90% LoA, which were then complemented with thresholds for practical significance (see Methods section). For example, according to our results, a player's positive or negative variation in the match Pspeed of $>9.4\%$ ($\alpha = 0.10$) should be considered unusual, while a change in HSRD peak period of $<47.6\%$ ($\alpha = 0.05$) could be interpreted as usual. Previous research (Stevens et al. 2017; Baptista et al. 2019a) have suggested that the interpretation of training load data is facilitated if match

load is used as a reference, allowing a more appropriate training prescription and communication between practitioners. Therefore, understanding the meaningfulness and practical significance of match physical performance variability may help coaches during the training load management process. For instance, a marked decrease in HSRD from one match to another does not necessarily mean a lower physical condition of the player. Consequently, before making hasty conclusions, practitioners may firstly confirm if such variation falls within the practical significant range.

Limitations and further research

Following the suggestion of Oliva-Lozano et al. (Oliva-Lozano et al. 2021) for the necessity to conduct a multi-club study, we included four different top-level teams. This strategy has the added benefit of likely increasing the data heterogeneity and consequently diminishing the risk of bias caused by a specific style of play and/or training periodization (Baptista et al. 2019b). However, the low values for between-team variability may suggest that our data contain too few and too homogenous clusters. Future studies should try to remedy this by including more teams from a broader range of performance level within a division. Other limitations include the fact that GPS may present lower accuracy than radio-based local positioning systems (Pettersen et al. 2018), particularly for high-speed measures like HSRD, SpD and Pspeed (Buchheit and Simpson 2017). We also recognize that positional differences will likely affect the magnitude of the variability and thus, future research should also attempt to present results by playing position. Despite the deliberate exclusion of the warm-up data, at a finer granularity, this pre-match period might influence the players' readiness and preparedness for the game. Furthermore, in this study only univariate peak locomotor demands were considered and, therefore, different conclusions could be drawn if multivariate peak periods were analysed.

Conclusion

In general, match physical performance of female football players seems to be affected differently by the different sources of variability. Moreover, the high-speed metrics presented a higher observed match-to-match variability than the other key-metrics analysed. Finally, higher changes in 1-min peaks than in full-match values are required to be considered meaningful. The outcomes of the present study may address reference values that allow coaches to better interpret the inevitable variation of match physical performance. Practitioners must consider performance variability as advantageous and keep in mind that such a phenomenon is part of the team sports nature. Therefore, training prescription should avoid using specific benchmarks to achieve, but rather promote the presence of varied training stimulus and intensities, as well as use

reference values for interpreting individual changes in match physical performances.

Acknowledgements

The authors would like to thank Astrid Grøttå Ree, Helene Davidsen Moa, Thomas Lyngbø, Mads Pettersen, Elias Koppen, and Atle Ingebrigtsen for their help in the data collection.

Author contributions

Conceptualization, IB, AKW, MBR and SAP; Data curation, AKW; Formal analysis, AKW; Investigation, IB and AKW; Methodology, IB, AKW, DJ, MBR and SAP; Project administration, SAP; Supervision, DJ and SAP; Writing—original draft, IB; Writing—review & editing, AKW, DJ, MBR, SP and SAP. All authors have read and agreed to the published version of the manuscript.

Data availability statement

The data that support the findings of this study are available upon reasonable request.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This research was funded by Tromsø Research Foundation and UiT, The Arctic University of Norway. The funding body had no role in designing the study and data collection, analysis, interpretation, and in writing of the study. There is no grant/award number to report; Tromsø Research Foundation and UiT, The Arctic University of Norway.

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