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The match-to-match variation of match-running in elite female soccer

Joshua Trewin[a,b,c,*], César Meylan[a,b,c], Matthew C. Varley[d], John Cronin[a,e]

[a] Sports Performance Research Institute New Zealand, Auckland University of Technology, New Zealand
[b] Canadian Soccer Association, Canada
[c] Canadian Sport Institute—Pacific, Canada
[d] Institute of Sport, Exercise and Active Living, College of Sport and Exercise Science, Victoria University, Australia
[e] School of Exercise, Biomedical and Health Sciences, Edith Cowan University, Australia

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ABSTRACT

Objectives: The purpose of this study was to examine the match-to-match variation of match-running in elite female soccer players utilising GPS, using full-match and rolling period analyses.
Design: Longitudinal study.
Methods: Elite female soccer players (n = 45) from the same national team were observed during 55 international fixtures across 5 years (2012–2016). Data was analysed using a custom built MS Excel spreadsheet as full-matches and using a rolling 5-min analysis period, for all players who played 90-min matches (files = 172). Variation was examined using co-efficient of variation and 90% confidence limits, calculated following log transformation.
Results: Total distance per minute exhibited the smallest variation when both the full-match and peak 5-min running periods were examined (CV = 6.8–7.2%). Sprint-efforts were the most variable during a full-match (CV = 53%), whilst high-speed running per minute exhibited the greatest variation in the post-peak 5-min period (CV = 143%). Peak running periods were observed as slightly more variable than full-match analyses, with the post-peak period very-highly variable. Variability of accelerations (CV = 17%) and Player Load (CV = 14%) was lower than that of high-speed actions. Positional differences were also present, with centre backs exhibiting the greatest variation in high-speed movements (CV = 41–65%).
Conclusions: Practitioners and researchers should account for within player variability when examining match performances. Identification of peak running periods should be used to assist worst case scenarios. Whilst micro-sensor technology should be further examined as to its viable use within match-analyses.

1. Introduction

The use of technology is now commonplace in the examination of match-running performance in team sports.[1] Both global positioning system (GPS) and semi-automated multi-camera systems (SAMCS) have been used, with each having advantages and disadvantages.[1] Recent law changes introduced by FIFA have allowed the use of GPS in official matches,[2] allowing practitioners to utilise one system in both training and matches. This data has however been limited in the elite women's game with literature sparse.[3,4] It is important to therefore understand the match-running occurring within women's matches. These law changes also bring in to question the match-to-match variation using this technology and if subsequent inferences are meaningful or not, such as a change in match-running in response to an external factor (e.g. altitude or temperature). Biological variation occurs due to a number of factors, with differences in match situations and environments a likely cause.[5] Further, the reliability of devices to detect similar movement accurately can also affect the match-to-match variation observed. This is particularly problematic when movements with a high-rate of change are examined, where variation is known to increase.[6] Therefore, identification of the match-to-match variation must be taken into account when analysing match-running performances.

Previous studies in men's soccer have examined match-to-match variation,[5,7] with researchers reporting high-speed running to be the most inconsistent outcome variable of interest when measured with SAMCS (Co-efficient of variation, CV = 18–20%). When the team is in ball possession, variation further increased (CV = 31–32%), with authors questioning the use of high-speed running as a performance indicator for soccer match performances. However, CV using GPS in women's soccer is relatively unknown, it is therefore essential to understand the match-to-match variation of GPS metrics when attempting to justify with certainty changes

* Corresponding author. Tel.: +64 27 862 9816.
E-mail address: jtrewin@aut.ac.nz (J. Trewin).

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in match-running in relation to match-factors, such as the environment or score-line.

Although this inherent variability exists, research has attempted to identify transient fatigue, the temporary reduction in match-running in response to a period of high-intensity.[8] Researchers examine peak-periods of match running utilising a pre-set time period (e.g. 5-min), to identify where match-running is at its greatest.[4] The fatigue profile of an athlete can help inform conditioning protocols and tactical decisions made by coaches within a match or matches. French Ligue 1 players performed 71–121 m of high-speed running during a peak period, using a pre-set 5-min period (e.g. 0–5, 5–10 min), analysed using SAMCS,[5] with high variation from match-to-match (CV = 24%). The ability to quantify a change in high-speed running from peak- to post-periods indicated greater variation (CV = 134%), suggesting identification of transient fatigue is challenging. The assumption that a decline in match-running from peak to post periods is fatigue does not account for changes in tactical instructions or stoppages in play. Further, the use of pre-set time periods (e.g. 0–5, 5–10 min, etc.) has also been questioned, with rolling periods shown to more accurately identify the peak-period of running by as much as 25% compared to pre-set periods.[9] However, to date match-to-match variation of this technique has not been examined and requires further research.

Lastly, with the ability to utilise GPS within official matches, this opens up the collection of data previously not possible, such as accelerations and manufacturer micro-sensor metrics. It has been suggested that examination of total distance alone, without accounting for accelerations or decelerations, may underestimate energy expenditure by 6–8%.[10,11] Further, maximal accelerations have been observed to occur up to eight fold more in matches than sprinting.[12] Micro-sensors can also be used when GPS satellites are not present, such as in enclosed stadia. This technology samples at a much greater rate and therefore may be more sensitive to changes in performance but also interference from noise.[13] Understanding the magnitude of variation with respect to these metrics is important when utilising them in match analyses.

As match-running is of particular interest to practitioners, the quantification of match-to-match variation in an elite female population is of importance, particularly with respect to GPS systems. Researchers have suggested the use of a single reference team in the examination of match-to-match variation.[5] Therefore, the purpose of this study is to examine the match-to-match variation of elite female soccer players from a single national team during full international matches utilising both a full match and a rolling 5-min analysis.

2. Methods

Elite female soccer players (n = 45) from the same senior national team ranked top 10 in the world, provided informed consent to participate in longitudinal tracking and data analysis which was approved by the University of Victoria Human Research Ethics Board. Player movement data was tracked across five years (2012–2016) and 55 International fixtures (Files = 606). Only outfield players were included in the current study, with players belonging to the following positional groups, forward (FWD, n = 18); midfield (MF, n = 9); full back (FB, n = 11); and centre back (CB, n = 7). Where a player played in multiple positions, data in each position were analysed separately as two different players, due to the known positional differences in match-running.[14] Displacement and velocity data was collected from outfield players via GPS technology sampling at 10-Hz (Minimax S4, Catapult Innovations, Australia). Raw files were exported from manufacturer software (Sprint 5.1, Catapult Innovations, Australia) and analysed using a custom built MS Excel spreadsheet (2013, Microsoft, United States of America).[12] Speed was calculated using the Doppler shift method, as opposed to the differentiation of positional data as the Doppler shift method is associated with a higher level of precision.[15] The average number of satellites and horizontal dilution of precision for games was 12.1 ± 0.4 and 0.94 ± 0.04 respectively.

Players were required to play a minimum of two 90-min match performances, with the analysed files ranging from of 2 to 21 games played per player (Mean ± SD = 7.0 ± 6.2. Data were only included from games played in "normative" conditions, considered as near sea-level (0–383 m) and in cold/mild temperature (5–19 °C) (Files = 154). These criteria were used to mitigate the possible effects that some environmental factors may have on match running performance.[16,17] Two analyses were performed: a full match analysis; and a 5-min rolling analysis period, which was observed as a match maximum of both the peak ($Peak_5$) and the subsequent period after the peak ($Post_5$). The rolling analysis calculated movement in 5-min increments from each GPS time point, of which there were 10 per second.[9]

Player movement categories were defined following locomotor analysis guidelines developed using elite male youth players, with thresholds set using pilot data of women's players, which resulted in thresholds similar to that recommended in previous research.[18,19] High-speed running was defined as an effort greater than 4.58 m s^{-1}, which represented the mean maximal aerobic speed (MAS) of the team observed during piloting. Sprinting (Sprint) was defined as an effort exceeding 5.55 m s^{-1}, a threshold representing the team average in the 30–15 intermittent fitness test[20] and is also close to the MAS plus 30% of the aerobic speed reserve (e.g. maximal sprinting speed minus MAS). This latter method has been used in previous literature to individualise maximal speed bands.[18] Maximal accelerations were defined as an effort greater than 2.26 m s^{-2}, which represented 80% of a players acceleration over 10 m during a 40 m sprint test and was established during piloting. As a player may continue to accelerate at a sub-maximal rate following a maximal acceleration, an acceleration effort was defined as beginning when the acceleration exceeded the threshold of 2.26 m s^{-2}, and finishing when the rate of acceleration dropped below 0 m s^{-2}.[12] Acceleration was calculated from speed data over a 0.3 s time interval. Lastly, GPS were coupled with a 100 Hz accelerometer and used to estimate Player Load™, an arbitrary value developed by the manufacturer to estimate total load experienced by the athlete.[21] Total distance, high-speed running distance and Player Load™ were presented relative to total match time, or rolling period time (/min). The number of high-speed running-efforts, Sprint-efforts and accelerations were presented as a count per minute of match-play. A minimum effort duration of 0.30 s (i.e. dwell time) was applied to speed data (high-speed running and Sprints).

Data are presented as means ± SD where appropriate. Coefficient of variation (CV) and 90% confidence intervals were calculated after logarithmic transformation in MS Excel. Raw values were log transformed using a natural logarithm, allowing uniformity of error.[22] Further, as players did not play the same number of games, a weighted CV was calculated to account for player contribution to the variance.[13] The smallest worthwhile change (SWC) was calculated as 0.20 of the raw between-player SD, prior to log transformation. The SWC can be used to assess true differences in performance, observed as a change greater than the SWC.[23]

3. Results

The match-to-match variation and SWC of full match analysis metrics are presented in Tables 1 and 2. CV values ranged from 6.1% to 53%, the lowest CVs associated with the total distance