Category of Manuscript: Original Article

Peak running intensity of elite female field hockey players during competitive match play

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Running Title: Peak running demands of female hockey players

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Abstract Word Count: 260

Word Count: 3500

Number of tables and figures: 2 tables and 3 figures

ABSTRACT

In recent years backroom coaching staff have relied heavily on the global demands of competitive match-play to monitor running performance within training and match environments. Although, these figures help prepare players for the demands of match-play they do not account for the physical and physiological stress of the most intense periods of competition. The aim of the current study was to quantify the duration and position specific maximal running performance during match-play using a 1-10 min moving average epoch methodology. Twenty-six (*n* = 26) elite international female field hockey players (23 ± 3 years; 162.6 ± 13 cm; 66 ± 6 kg) participated in the current observational study. Data was collected during 22 international games, resulting in over three hundred and sixty individual samples (*n* = 368) being obtained for analysis. Players were catagorised based on their positional lines of play (defenders, midfielders and forwards). Variables of interest included relative total ($m \cdot min^{-1}$), high-speed (> 16 $km \cdot h^{-1}$; $m \cdot min^{-1}$) and sprint distance (> 20 $km \cdot h^{-1}$; $m \cdot min^{-1}$). Regardless of position varying differences were observed between 10 minute rolling average for relative total (*mod - large*), high-speed (*mod- large*), and sprint (*mod - large*), distance respectively. Furthermore, as the duration of the rolling average increased so too did the observed differences (*small*). The forwards (119.3 ± 19.7 $m \cdot min^{-1}$) were reported to have the highest peak output during minute one for relative high-speed distance when compared to the defenders (100.7 ± 19.7, ES 0.9, *large*) and the midfield (106.8 ± 23.4 $m \cdot min^{-1}$, ES 0.5, *moderate*). The results of the current study show that the running performance of field hockey players alters during match-play irrespective of moving average. Finally, the data will aid practitioners in the development of sport specific drills to adequately prepare hockey players for the maximal intensity periods of elite hockey match-play.

Key Words: Team Sport, GPS, Intermittent exercise, Peak

INTRODUCTION

Field hockey is a stick and ball invasive team sport which is comprised of both technical and tactical components completed at moderate to high levels of intensity (15,17). In recent years the International Hockey Federation (FIH) has introduced many rule changes to competitive match-play, with the major structural change being the change of the game from a halves based game to a quarters based game (18). Indeed, prior to 2015, competitive match-play comprised of two 35-minute halves which were separated by a ten-minute half-time. However, match-play now consists of four 15-minute quarters with a 2-minute break separating quarters and a 10-minute break for half-time, reducing the overall game time from 70 minutes to 60 minutes. The most recent rule change implemented by the FIH is the stopping of the match clock when a penalty corner is awarded. If a penalty corner is awarded both teams have 40 seconds to prepare for this high scoring opportunity, in turn increasing the overall game time by an additional 40 seconds every time a penalty corner is awarded.

Previous studies have shown that elite female field hockey players will cover on average 4847 ± 583 m , representative of a work-rate of 127.6 ± 15.3 $m \cdot min^{-1}$, with 580 ± 147 m or 15.3 ± 3.9 $m \cdot min^{-1}$ performed at high-speed (> 16 $km \cdot h^{-1}$) (15,17,18). McMahon and colleagues (18) were the first to report the changes to players activity profiles following the rule changes in 2015. Meanwhile, McGuinness et al., (15) reported the changes in running performance across the quarters of competitive match-play. The study reported no difference across relative total distance for players over the course of match-play however a significant difference was reported between the 1st and 2nd quarter and the again between the 2nd and 4th quarter for relative high-speed distance. In recent years coaching staff have relied heavily on the global demands of competitive match-play to monitor running performance during training and match-play (4,6,9,12,16,21). However, due to the stop–start nature of match-play and the frequent changes in running intensity, variation in players relative running demands are to be expected. Although, these figures help prepare players for the demands of match-play they do not make allowances for the stress inflicted on players during the most intense epochs of match-play (6,14).

Advancements in match-analysis software and tracking devices has allowed for the monitoring of players within specific epochs of match-play (1,4). Bradley et al., (3) were among the first to report the high intensity activity and temporal fatigue patterns within elite soccer players with respect to position. During match-play and independent of position, players were reported to cover up to 241 ± 71 m. Furthermore, results suggested that the decline in high-intensity running directly after the most intense 5-minute epoch was up to ~51% (114 ± 57 m). When the positional differences were reported, attackers were shown to have the greatest decline in high-intensity running immediately after the most intensified epoch of play (~60%). Although the current study shows the inability of athletes to maintain optimal performance during the most intensified 0 - 5 and 0–10 min epochs, it is hard to define exactly at what point athletes are faced with these “worst case scenario” epochs of play. Furthermore, these periods fail to account for the technical and tactical elements of match-play. Recently studies have shown the duration specific running intensities utilizing a rolling average methodology during match-play across numerous sports (4,7,10,17). Delaney et al., (5) quantified the duration specific running during professional rugby league competition with players running intensities quantified during competitive match-play using a 1–10 min rolling average epoch. It was reported that during match-play a significant difference was observed in players average relative distance ($m \cdot min^{-1}$) as the time of the rolling average increased. However, no difference was observed between nine and ten minutes. During match-play the forwards were reported to cover significantly less relative distance than the rest of the positions with the full-backs covering significant greater relative distance during the 1- and 2-minute rolling averages. Malone et al., (14) reported a similar trend in Gaelic football. During match-play it was reported that the middle three positions (half-back, midfield and half-forwards) had the highest relative output (241 – 255 $m \cdot min^{-1}$) due to the transitional role of these specific positions.

It has been suggested that as the duration of the moving average decreases the relative running demands of the athletes increases (5,14). Given the nature of field hockey and the use of rolling substitutions, the above studies provide a justification for the utilization of a 1-10-minute rolling average analysis. The use of multiple rolling average time epochs may allow teams the ability to decipher the appropriate time epoch to implement specific individual timings for their teams' rotational strategies. Additionally, such information can show the importance of duration during sport specific training as a change of up to 1 minute can change the relative output of players considerably. Although significant positional changes were reported in both studies (5,14) it is important to note that these changes may not justify changes to positional training prescription. Overall the identification of the “worst case scenarios” of each individual during intermittent team sport match-play can be utilised by practitioners to build sport specific drills. These specified drills can help target specific running-based outputs that are reflective of the maximal intensity epochs during match-play. Therefore, allowing coaches to ascertain not only the technical quality of drills but also the physical quality within these drills to understand if these drills are preparing athletes appropriately for competitive play. The aim of the current study therefore is to quantify the duration and position specific maximal running performance of elite female field hockey players during match-play. It was hypothesized that forwards would have the highest running performance across all durations given their tactical role within the outlet phases of play in dynamic leading running. Additionally, forwards role in counter-attack play results in increased running demands when compared to other players.

METHODS

Experimental approach to the Problem

The current observational study was designed to quantify the peak running demands of elite female field hockey players over the course of the 2017 - 2018 season encompassing the 2018 FIH World Cup. Data was collected during 22 international games, resulting in over three hundred and sixty individual samples (*n* = 368). Game data was only included if a full match was completed (60 mins). During the time of data collection, the team was exposed to various playing formations during each game. Players running performance was monitored using global positioning systems (10 Hz V4, JOHAN Sports, Noordwijk, Netherlands). During match-play players were catagorised into three positional lines of play specifically, defence (*n* = 119 data files), midfield (*n* = 123 data files) and forward (*n* = 126 data files). All competitive matches took place between 14.00 and 20.00. Temperature during match-play ranged between 12 – 21 °C. Prior to match-play the players were advised to abstain from any strenuous activity and to maintain their normal pre-match routine. Additionally, players were reminded to continue with their pre-game dietary requirements with special emphasis being placed on the intake of fluids and carbohydrates.

Subjects

Twenty-three (*n* = 23) elite international female field hockey outfield players (23 ± 3 years; 162.6 ± 13 cm; 66 ± 6 kg) participated in the current observational study. Players were selected from the current national World Cup training squad and were therefore deemed the best players within the period of testing. Prior to data collection and after ethical approval, participants were provided with information which informed them of the purpose, benefits, and procedures of the current study. Written informed consent and medical declaration were obtained from participants in line with the procedures set by the local institution's research ethics committee, The Institute of Technology Tallaght.

Activity Profiling

During match-play athletes were required to wear an individual GPS unit (V4, JOHAN Sports, Noordwijk, Netherlands) sampling at 10-Hz, containing a tri-axial accelerometer across 22 international games, resulting in over three hundred and sixty individual samples (*n* = 368). during the 2017–2018 season. The GPS unit was encased within a protective harness and worn by the athletes between the shoulder blades. Previous literature has shown the coefficient of variation (CV %) of the GPS units used within the current investigation to range between 1–3 % for several running and speed based measures (20). Post-match-play in a retrospective analysis all data was extracted from each unit and split using the unit's software (JOHAN Sports, Noordwijk, Netherlands). Variables of interest included relative total distance (RTD; m·min^{-1}), high-speed distance (RHID, m·min^{-1}; > 16 km·h^{-1}) and sprint distance (RSD, m·min^{-1}; > 20 km·h^{-1}). Once the data was uploaded to the bespoke GPS software, games were cut for each quarter and the times of the breaks between quarters were noted. Once the data was cut for quarters a segmental 1-minute analysis was conducted for all athletes across the quarters of play. The data at the end of each quarter was not included if the minute was not completed by the athlete. Once analysis was finalized it was then exported to Microsoft Excel (Microsoft, Redmond, USA) and added to customized spreadsheets to allow the calculation of players' moving averages. At this time players 1-10 min rolling average epochs were calculated for both RTD, RHID and RSD. Each players' rolling average relative distance was calculated by taking the distance covered by the athlete and dividing it by duration of the rolling average (e.g. 345=m in 2 minutes is equal to 172.5 m·min^{-1}).

Statistical Analysis

Data are presented as a mean (MN) ± standard deviation (SD) with 95% confidence intervals (95% CIs) effect size (ES) and partial Eta-squared (η^2) unless stated otherwise. Multiple repeated measures ANOVA's were used to determine the potential running performance differences across a 1 - 10 min rolling average epoch with respect to positional lines of play. When significant main effects were observed, Games-Howell post hoc test was applied to determine the significant differences across the position groups. The level of statistical significance was set at an accepted level of $p < 0.05$. Standardized effect sizes were defined as *trivial* (< 0.009), *small* (0.01 – 0.08), *moderate* (0.09 – 0.24) *large* (> 0.25). Where an effect size (Cohen's D) of ≥ 0.5 (*medium*) was observed it was flagged as a potential difference. All statistical analyses were performed using SPSS for Windows (Version 22, SPSS Inc. Chicago, USA).

RESULTS

Global activity profile based on a moving average

Selected running variables are presented in table 1 and table 2. Firstly, results showed that there was a non-significant interaction between position and the rolling average epochs for RTD (Wilks's Lambda = 0.4, F (18, 16) = 0.51, p = 0.9, η^2 = 0.37, *large*). A main effect for time (Wilks's Lambda = 0.5, F (9, 8) = 19.1, p ≤ 0.001, η^2 = 0.95, *large*) across all three positions was observed showing a reduction in RTD over the ten-minute rolling average epochs analysed (see Table 1.). Regardless of position *moderate* – *large* differences were observed between 1- and 2-minute epochs when compared to 10-minute rolling average epochs (ES 0.5 – 1.4) for RTD. There was a non-significant interaction between position and the rolling average epochs for RHID (Wilks's Lambda = 0.5, $F (18, 16) = 0.4$, $p = 1.0$, $\eta^2 = 0.29$, *large*), with a significant main effect for time reported (Wilks's Lambda = 0.02, $F (9, 8) = 29.4$, $p \leq 0.001$, $\eta^2 = 0.97$, *large*). All three positions showed a reduction in RHID over the ten-minute rolling average epochs when analysed (see Table 2.). Regardless of position *moderate – large* differences were observed across the 10 rolling average epochs (ES 0.7 – 2.1) for RHID. A *large* difference was observed between 1- and 2-minute epochs when compared to 10-minute rolling average epochs. Furthermore, a non-significant interaction between position and the rolling average epochs for RSD was observed (Wilks's Lambda = 0.26, $F (18, 16) = 0.85$, $p = 0.6$, $\eta^2 = 0.49$, *large*). There was a significant main effect for time (Wilks's Lambda = 0.03, $F (9, 8) = 30.76$, $p \leq 0.001$, $\eta^2 = 0.97$, *large*) with all three positions showing a reduction in RSD over the 10-minute rolling average epochs (Table 2.). Regardless of position *moderate – large* differences were observed across the 10-minute rolling average epochs (ES 0.5 – 2.5) for relative sprint distance.

**** INSERT TABLE ONE HERE****

Positional Activity Profile

Selected running variables are presented in table 1 and table 2. The main effect comparing the positional lines of play was non-significant for both RTD ($p = 0.06$, $F (2, 16) = 3.6$, $\eta^2 = 0.31$, *large*) and RHID ($p = 0.12$, $F (2, 16) = 2.4$, $\eta^2 = 0.22$, *moderate*) suggesting no significant difference in the positional demands across rolling average epochs. Multiple significant main effects were observed (ES 0.5 – 0.9) when RHID across the positional lines of play was considered (see Table 2.). Defenders were reported to have a lower peak output when compared to the midfield and forwards. The forwards (119.3 ± 19.7 $m \cdot min^{-1}$) were reported to have the highest peak output during one-minute epochs for RHID when compared to the defenders (100.7 ± 19.7, ES 0.9, *large*) and the midfield (106.8 ± 23.4 $m \cdot min^{-1}$, ES 0.5, *moderate*). Non-significant main effects were observed for positional lines of play ($p = 0.86$, $F (2, 16) = 0.14$, $\eta^2 = 0.02$, *small*) when RSD was considered suggesting no differences in the positional demands for RSD during hockey match-play. Multiple significant main effects were observed (ES 0.5 – 2.5) when RHID was considered with respect to positional lines of play (see Table 2.). Defenders had a higher one-minute epoch for relative sprint output (67.7 ± 8.5 $m \cdot min^{-1}$) when compared to the midfield (62,6 ± 16.7 $m \cdot min^{-1}$, ES 0.8, *large*) but a lower output when compared to the forwards (78.8 ± 16.6 $m \cdot min^{-1}$, ES 0.9, *large*).

****INSERT TABLE TWO HERE****

DISCUSSION

The aim of the current study was to quantify the duration and position specific maximal running performance of elite female field hockey players during match-play using a 10-minute rolling average epoch methodology. The results of the current study suggest that elite female field hockey players have a higher relative output ($m \cdot min^{-1}$) across all running variables than previously reported (15,16,18). Indeed, previous literature has allowed for the quantification of the overall match-play demands but failed to consider the natural peak and troughs of these demands during competitive international hockey match-play. Our findings suggest regardless of position elite female field hockey players have a maximal running performance of 196 ± 14.9 $m \cdot min^{-1}$. Furthermore, varying differences were observed over the 10-minute rolling average epochs for RTD (ES 0.5 – 1.4, moderate – large), RHID (ES 0.7 – 2.1, *moderate - large*), and RSD (ES 0.5 – 2.5 *moderate - large*), respectively. Furthermore, when positional differences were considered forwards (119.3 ± 19.7 $m \cdot min^{-1}$) were reported to have the highest peak output during 1-minute epochs for RHID (> 16 $km \cdot h^{-1}$) when compared to the defenders (100.7 ± 19.7, ES 0.9, *large*) and the midfield players (106.8 ± 23.4 $m \cdot min^{-1}$, ES 0.5, *moderate*).

Previous literature has shown that elite female field hockey players cover between 113 - 142 $m \cdot min^{-1}$ with forwards covering the highest relative total (142 $m \cdot min^{-1}$) and high-speed distance (18 $m \cdot min^{-1}$) when compared to the defenders (115 $m \cdot min^{-1}$, 14 $m \cdot min^{-1}$) and midfield (132 $m \cdot min^{-1}$, 15 $m \cdot min^{-1}$) (15,17,18). The results of the current study have shown a decrease in running performance across 1-10-min rolling epochs for peak RTD (215.2 – 186.3 $m \cdot min^{-1}$) RHID (119.4 – 77.6 $m \cdot min^{-1}$) and RSD (77.8 – 44.1 $m \cdot min^{-1}$) during competitive match-play. A major finding of the current observational study was that, as the duration of the rolling average epoch decreased, so too did the relative running performance (194.9 – 169.3 $m \cdot min^{-1}$). *Moderate - large* differences were observed between 1-minute epochs and all other epoch durations. While a *moderate* difference was reported across 3- and 4-minute epochs (ES: 0.5 – 0.7). It may be suggested that tactical decisions such as rotational strategies may be related to the observed moderate effect across the analysed running variables. During match-play teams are permitted to make “rolling” substitutions with most international teams making these substitutions within the first three to four minutes of each quarter of play. It is believed that these impact substitutions prevent the continuous drop in running performance across match-play. Our data would appear to support these coaching perceptions with a noted levelling off of across running performance variables after the first rolling epoch. Given the above findings, special consideration must be given when developing hockey specific drills to best replicate the running outputs of players during match-play with respect to rolling average epochs. However, the majority of team sports training time is spent within small-sided games (SSG). These SSG have been shown to improve the players’ technical and tactical awareness of competitive match-play (10,11). If such games are not planned correctly some critical attributes (e.g. maximal velocity exposures and high-speed running distance) that have previously been shown to protect the athlete against injury will be significantly reduced (13,19). Based on the results of the current study it may be suggested that coaches monitor athletes exposure to 'worst-case scenario' events during match-play and utlised these data to understand potential differences between match-play demands and training demands across their specific athletes. Therefore, the results of the current study can be used to customise the duration and distance requirements of field-hockey players during specific SSG or training drills to simulate the demands of match-play.

**** INSERT FIGURE 1 & 2 HERE****

The secondary aim of the current investigation was to quantify the position specific peak running performance of elite female field hockey players during match-play. Previous literature has shown positional variations during competitive match-play exist (7,15,18). A major finding of the current study was that, as the duration of the moving average epoch increased, the distance cover by players decreased. These results were consistent across all the positional lines of play. The average peak distance achieved during the 10-minute rolling average epoch ranged between 159.7 – 201.1 m·min^{-1} (Figure 2). The forwards were reported to have the highest RTD (201 ± 11.9 m·min^{-1}) when compared to the midfielders (195.1 ± 15.2 m·min^{-1}) and the defenders (188.4 ± 24.8 m·min^{-1}) for 1-minute epochs. Similar trends were reported for RHID and RSD (Figure 3). During match-play the midfield and forwards were reported to cover significantly more RHID (106.8 ± 23.4 m·min^{-1} & 119.3 ± 22.9 m·min^{-1}) when compared to other positional lines. Furthermore, the forwards had the highest RSD (20 km·h^{-1}) output (78.8 ± 16.6 m·min^{-1}). Similar trends were reported across the 10-miute rolling average epochs when position was considered. It may be suggested that the specific tactical role of both the midfielders and forwards during match-play may explain the observed positional difference. Indeed, during match-play both the midfielders and forwards are exposed to many opportunities that allow them travel at high-speed. These opportunities arise for example when a team is defending, and they turn the ball over during an opposition attacking phase in their own defensive quarter. During these counter-attacking phases of play these positions are often required to transition from defence to attack quickly covering on average 65–70 m. Additionally, due to positional spacing and the nomadic nature of the midfield position players are given the opportunity to cover vast distances allowing them to achieve high relative distances across different duration epochs. It is important to note that during match-play different phases of play or set plays may require positions to cover large distances in a condensed period of time increasing their chances of high relative outputs within specific epochs or a "worst-case scenario" event (e.g. a defensive short corner). Once the short corner has been awarded, players are required to retreat to the half way line and return to their goal quickly once the short corner has been taken. This may explain similar 1-minute epochs for RTD being completed by defenders when compared to the other positional lines of play. Furthermore, midfielders and forward lines of play are often exposed to shorter rotation periods when compared to defenders. Due to their positional nature forwards are often required to spend anywhere between 4 – 6 mins in play with 3 – 4 minutes of recovery. These durations are similar to that of the midfielders who are required to complete 6 – 8 mins in match-play with 2 – 3 minutes recovery. These durations are significantly different to that of the defenders, who may be exposed to rotations of 12 - 14 minutes during match-play. These longer recovery periods along with their positional demands may provide the reasoning as to both midfielders and forwards having higher "worst-case scenarios" across all epochs when compared to defenders.

**** INSERT FIGURE 3 HERE****

When compared to previously literature the results for the relative running demands across 1-10 minute rolling average epochs within the current study were lower than that recently reported within elite female field hockey (7). Delves et al. (7) recently quantified the mean peak running intensities in sub-elite male and female field hockey in the domestic Australian hockey league (AHL). In addition to being known as the highest domestic league in Australia the AHL is also globally recognised as a league for other international athletes to join for a 6 – 8-week period thus being recognised as one of the premier club competitions within club field hockey. While our data were lower when compared to Delves et al. (7), similar trends were observed across positional lines. Both studies reported midfielders and forwards covered the highest peak distance when compared to the defenders. Furthermore the midfielders were more likely to cover more distance than the forwards. However, the results of the current observational study need to be considered within the context of the study's limitations. Although the results of the current study include 22 international games which took place during major international tournaments, the investigation only analysed one team. Therefore, it is recommended that future research should aim to quantify the peak running performance of elite female field hockey players over multiple seasons, during each tournament and across multiple international teams. These factors will allow for a better understanding of the global running performance demands during competitive match-play across different competitive phases. By examine the effect of competition level it will allow practitioners ensure their athletes are prepared for the "worst-case scenario" of each tournament (e.g. continental championships, World cups and Olympic games). Furthermore, during the current investigation the tactical style of play during each game was not considered. Due to the fluid alteration of tactical shape during elite field hockey the authors suggest that future studies aim to examine the effect playing formation has on the global demands of elite female field hockey players both globally and with respect to duration specific epochs. The identification of how specific styles of play and the level of opposition effect the running performance of players will allow coaching staff to include plan for these contextual variables when developing SSG and training drills that aim to attain position specific "worst-case scenarios" as part of the teams overall periodised training programme.

PRACTICAL APPLICATIONS

To the authors' knowledge, the current study is the first to quantify the duration and position specific maximal running performance of elite international female field hockey players during competitive match-play using a 10-minute rolling average epoch methodology. The results of the current study suggest that regardless of playing position there are *moderate – large* differences observed between 10-minute rolling average epochs across specific running variables namely; relative total, high-speed and sprint distance during match-play. Furthermore, it was observed that as the duration of the rolling average epoch increased the relative distance reported for these epochs decreased. Our data suggests that forwards have the highest peak output during 1-minute epochs for RTD (200.7 ± 11.8 $m \cdot min^{-1}$) and RHID (119.3 ± 22.9 $m \cdot min^{-1}$) when compared to the defenders (188.4 ± 16.9, ES 0.8, *large* & 100.7 ± 19.7, ES 0.9, *large*) and the midfield playing positions (195.0 ± 15.1, ES 0.4, *small* & 106.8 ± 23.4 $m \cdot min^{-1}$, ES 0.5, *moderate*). Given the above, the current study has shown the need for the forward and midfield positional lines to be exposed to similar stress to mirror the demands they may face during match-play. Furthermore, the forwards should be exposed to additional position specific running which simulates their match-play requirements or specifically modified small side games that will allow them to achieve a great total distance in a shorter period of time when compared to other positional lines of play. It is important to note however that these figures represent the players "worst-case scenario" and should only be performed in moderation and as part of a structured and periodised training programme. Coaching staff and practitioners alike need to consider the results of the current study to pre-plan the specific duration for player rotations during match-play in order to maintain consistent peak running performances across duration specific epochs, these data in turn could impact the substitution policy of teams during match-play to allow each player to achieve their peak running demands across rolling epochs.

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TABLES AND FIGURES

Table 1. The comparison of peak relative total distance ($m \cdot min^{-1}$) outputs of elite female field hockey players for a 10-minute rolling average (M ± SD, ES)

Table 2. The maximum relative high-speed ($m \cdot min^{-1}$; > 16 $km \cdot h^{-1}$) and sprint ($m \cdot min^{-1}$; > 20 $km \cdot h^{-1}$) distances for elite female field hockey players across the positional lines of play (M ± SD)

The numbers 1 and 2 signify the variation across the rolling average minutes. The letters a, b, c signifies the positional variation between the defenders (a), midfield (b) and forwards (c).

Figure 1. The maximum relative distance ($m \cdot min^{-1}$) of elite female field hockey players across a 1 to 10 - minute rolling average. (M ± SD

The numbers 1 and 2 signify the variation across the rolling average minutes.

Figure 2. The average maximum relative distance ($m \cdot min^{-1}$) across the positional lines of play of elite female field hockey players during a 1 to 10 - minute rolling average. (M ± SD)

The letters a, b, c signifies the positional variation between the defenders (a), midfield (b) and forwards (c).

Figure 3. The maximal relative high-speed distance ($m \cdot min^{-1}$; > 16 $km \cdot h^{-1}$) of elite female field hockey players across the positional lines of play.(M ± SD)

The letters a, b, c signifies the positional variation between the defenders (a), midfield (b) and forwards (c).

Table 1.

	1 min	2 min	3 min	4 min	5 min	6 min	7 min	8 min	9 min
2 min	↓ 10.5 ± 1.3 *moderate*								
3 min	↓ 14.6 ± 1.4 *large*	↓ 4.1 ± 0.6 *small*							
4 min	↓ 16.2 ± 1.3 *large*	↓ 5.7 ± 0.5 *small*	↓ 1.6 ± 0.4 *small*						
5 min	↓ 18.2 ± 1.4 *large*	↓ 7.7 ± 0.5 *small*	↓ 3.6 ± 0.4 *small*	↓ 2.0 ± 0.3 *small*					
6 min	↓ 19.3 ± 1.4 *large*	↓ 8.8 ± 0.7 *small*	↓ 4.8 ± 0.5 *small*	↓ 3.2 ± 0.5 *small*	↓ 1.2 ± 0.3 *small*				
7 min	↓ 20.9 ± 1.6 *large*	↓ 10.4 ± 0.6 *moderate*	↓ 6.3 ± 0.5 *small*	↓ 4.7 ± 0.5 *small*	↓ 2.7 ± 0.3 *small*	↓ 1.6 ± 0.3 *small*			
8 min	↓ 21.9 ± 1.6 *large*	↓ 11.4 ± 0.7 *moderate*	↓ 7.3 ± 0.5 *small*	↓ 5.7 ± 0.5 *small*	↓ 3.7 ± 0.4 *small*	↓ 2.5 ± 0.5 *small*	↓ 1.0 ± 0.3 *small*		
9 min	↓ 22.6 ± 1.6 *large*	↓ 12.1 ± 0.7 *moderate*	↓ 8.0 ± 0.6 *small*	↓ 6.4 ± 0.5 *small*	↓ 4.4 ± 0.4 *small*	↓ 3.2 ± 0.4 *small*	↓ 1.7 ± 0.3 *small*	↓ 0.7 ± 0.2 *small*	
10 min	↓ 23.9 ± 1.6 *large*	↓ 13.3 ± 0.8 *moderate*	↓ 9.3 ± 0.6 *small*	↓ 7.7 ± 0.6 *small*	↓ 5.7 ± 0.5 *small*	↓ 4.5 ± 0.5 *small*	↓ 2.9 ± 0.4 *small*	↓ 1.9 ± 0.2 *small*	↓ 1.3 ± 0.3 *small*

Table 2.

High-Speed Distance (m.min)	Average	Defender	Midfielder	Forward
1 min	119.4 ± 24.5	100.7 ± 19.7 [c]	106.8 ± 23.4 [c]	119.3 ± 22.9
2 min	105.1 ± 17.8 [1]	83.7 ±15.3 [c]	89.7 ± 20.9	93.6 ± 20.1
3 min	88.5 ± 16.2 [1, 2]	74.9 ± 13.7 [b, c]	85.6 ± 19.5	85.6 ± 18.3
4 min	84.8 ± 15.2 [1, 2]	71.8 ± 12.6 [b, c]	84.7 ± 18.6	83.8 ± 17.1
5 min	84.2 ± 14.6 [1, 2]	71.2 ± 12.1 [b, c]	80.9 ± 17.8	84.2 ± 16.3
6 min	85.3 ± 14.2 [1, 2]	70.4 11.7 [b, c]	78.8 ± 17.3	79.2 ± 15.9
7 min	81.0 ±13.9 [1, 2]	68.1 ± 11.4 [b, c]	79.5 ± 17.0	75.8 ± 15.6
8 min	78.9 ±13.9 [1, 2]	68.7 ± 11.3 [b, c]	77.4 ± 16.8	75.7 ± 15.7
9 min	77.8 ±13.9 [1, 2]	66.9 ± 11.3 [b, c]	75.6 ± 16.7	76.8 ± 15.7
10 min	77.6 ± 13.8 [1, 2]	67.6 ± 11.2 [b, c]	74.5 ± 16.6	75.9 ± 15.6
Sprint Distance (m.min)				
1 min	78.8 ± 16.6 [2 - 10]	67.7 ± 8.5 [c]	62.6 ± 16.7 [c]	78.8 ± 16.6
2 min	67.5 ± 13.3 [3 - 10]	55.3 ± 13.7	54.3 ± 13.6	58.2 ± 13.7
3 min	59.9 ± 11.9 [4 - 10]	51.6 ± 12.3	46.6 ± 12.5 [c]	54.4 ± 12.1
4 min	54.6 ± 11.0 [5 - 10]	45.2 ± 11.4	44.8 ± 11.7 [c]	50.0 ± 11.5
5 min	48.8 ± 10.5 [10]	44.7 ± 11.0	44.2 ± 11.2	48.4 ± 10.6
6 min	50.3 ± 10.2 [9, 10]	43.4 ± 10.8	42.9 ± 10.8	45.2 ± 10.1
7 min	49.5 ± 10.0 [10]	43.0 ± 10.6	42.1 ± 10.5	43.8 ± 9.9
8 min	48.2 ± 10.0	42.0 ± 10.5	41.3 ± 10.3	42.7 ± 9.8
9 min	45.1 ± 9.9	39.7 ± 10.5	39.9 ± 10.2	42.8 ± 9.8
10 min	44.1 ± 9.9	40.1 ± 10.5	38.9 ± 10.1	41.6 ± 9.7

Figure 1.

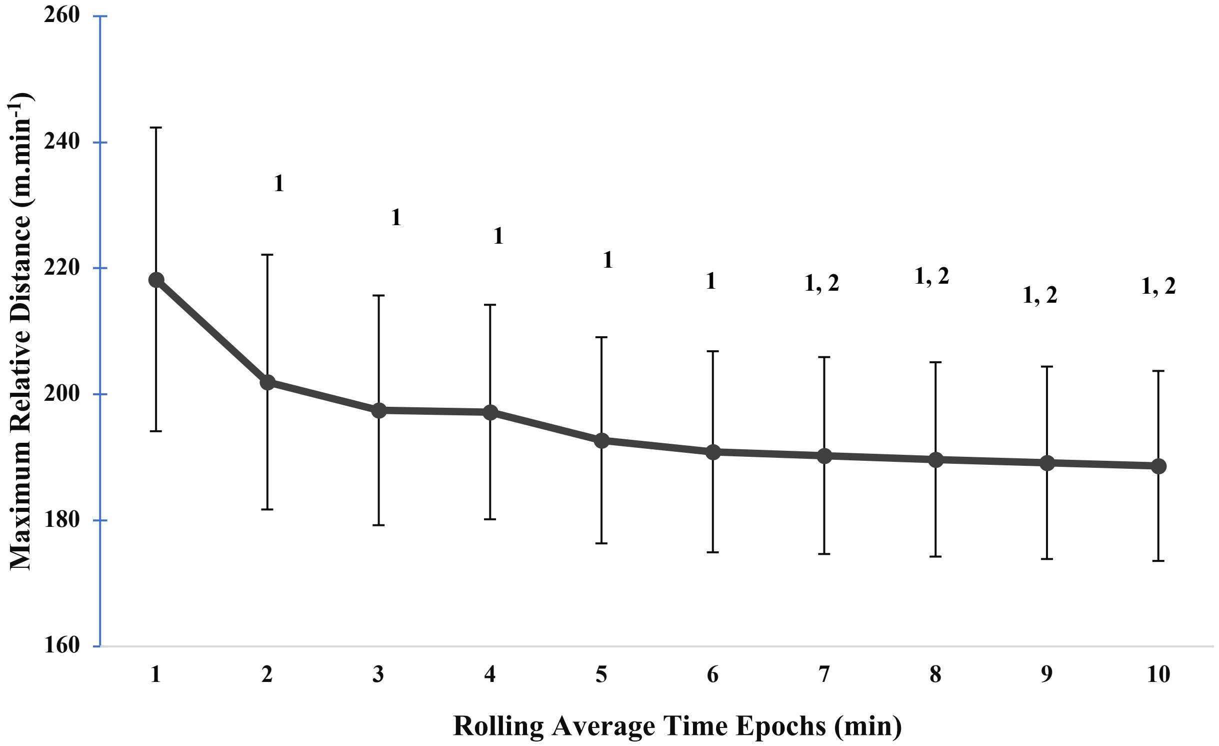


Figure 2.

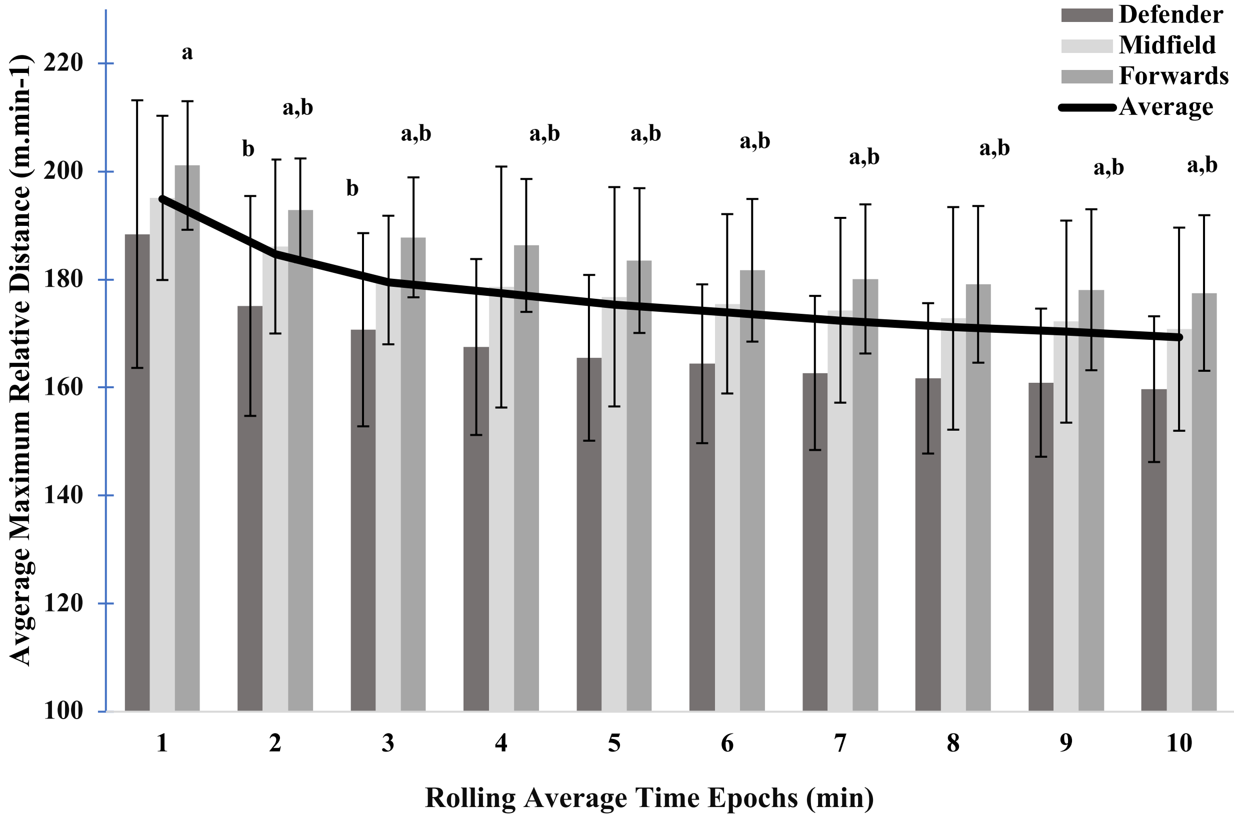
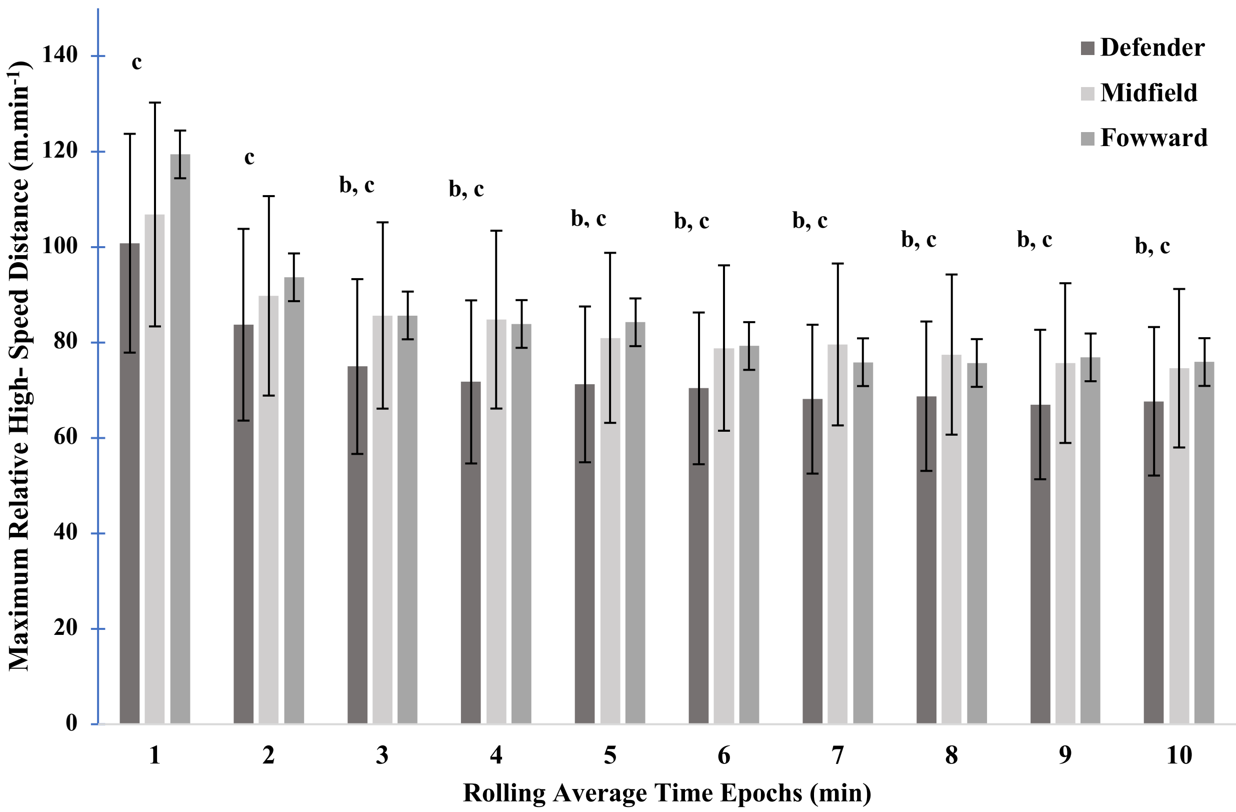


Figure 3.


Maximum Relative High- Speed Distance (m.min-1)
140
120
100
80
60
40
20
0
c
c
b, c
b, c
b, c
b, c
b, c
b, c
b, c
b, c
Defender
Midfield
Fowward
1
2
3
4
5
6
7
8
9
10
Rolling Average Time Epochs (min)