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Original Scientific Research Study

GPS ANALYSIS OF A TEAM COMPETING IN A NATIONAL UNDER 18 FIELD HOCKEY TOURNAMENT

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BLUF

The running demands in regional male under 18 field hockey is position specific, therefore, training schedules, substitutions and intra-match recovery should be tailored by position, taking into account the needs of the individual players.

ABSTRACT

The purpose of this study was to utilise global-positioning system (GPS) technology to quantify the running demands of national under 18 field hockey players competing in a regional tournament. Ten male players (mean ± SD; age 17.2 ± 0.4 years; stature 178.1 ± 5.2 cm; body mass 78.8 ± 8.8 kg), consisting of strikers, midfielders and defenders wore GPS units while competing in six matches over a seven-day period at an under 18 national hockey tournament. GPS enabled the measurement of total distance (TD), low-speed activity (LSA; 0 -14.9 km/hr), and high-speed running (HSR; ≥ 15 km/hr) distances in addition to distances over five velocity bands (≤ 5.9km.h^{-1}; 6 – 10km.h^{-1}; 10.1 – 14.9km.h^{-1}; 15 – 24.6km.h^{-1}; and ≥ 24.7km.h^{-1}). Data was log-transformed to reduce bias due to non-uniformity and analysed using a Hopkins spreadsheet to determine differences ($p \leq 0.05$) between playing groups. Midfielders covered significantly higher TD and the highest LSA when compared to other positional groups. Strikers covered significantly higher HSR and the lowest LSA out of all positional groups. These results suggest that these playing positions are sufficiently different to warrant specialised position-specific conditioning training leading into a hockey tournament. Therefore, training schedules, substitutions and intra-match recovery should be tailored by position, taking into account the needs of the individual players.

Key Words - Field hockey, development, GPS.

INTRODUCTION

Hockey is an international field-based sport played by both men and women at various levels, ranging from amateur to elite. It is an invasive team sport, which incorporates offensive and defensive skills with intermittent high-speed running and activity bouts during match-play, which is divided into 15-minute quarters of play (7, 18, 19). Teams are comprised of one goalkeeper and ten outfield players, categorised as strikers, midfielders and defenders.

Matches are often played in tournament format at the development, amateur and elite levels with schedules often involving intense periods of match-play during which teams may be required to play up to three matches over a four day period (9). The limited time between matches and the importance of match outcomes, leaves little time to recover and may lead to increased levels of fatigue potentially leading to decreased performance. The amount of field hockey research has increased in recent years due to the advances in global positioning systems (GPS) and motion analysis software (4, 14, 15). Limited research studies have however examined the activity profiles over field hockey tournaments (9, 21, 25).

Research outlining the running demands of male field hockey has primarily focused on the elite and international level with limited investigation into the amateur and development levels. Elite male field hockey players cover between 7000 – 8500 m total distance (TD) (2, 7, 13, 14) during match-play consisting of a combination of low speed activity (LSA), high speed running (HSR) and sport specific movement. Research has indicated there are clear differences in the running demands between international field hockey players and their national-level counterparts especially in regards to TD and HSR demands (10). Playing position was found to affect the running demands of field hockey players with generally forwards covering greater HSR and sprinting than defenders (14, 16). This information is essential as it provides greater understanding of the position-specific demands imposed on players, may be used to estimate the energy system demands, and help in the development of informed, position-specific training and recovery programs (15, 22). There is however, limited information regarding the running demands of development or under 18 male field hockey players with only one study investigating the activity profiles of youth international field hockey players (25). Therefore, the aim of the current study is to investigate the position-specific running demands of male under 18 field hockey strikers, midfielders and defenders during tournament match-play.

METHODS

Approach to the Problem

The current observational study was designed to examine the running demands of regional under 18 field hockey players using GPS technology across competitive tournament match-play. Ten male field hockey players currently within a regional under 18 program were observed over six competitive matches during the 2018 New Zealand national under 18 field hockey tournament. Tournament matches consisted of four, 15-minute quarters, adhering to the International Hockey Federation rules, which allow for the use of unlimited substitutions throughout matches. Players were categorised based on three positional lines of play (strikers, midfielders and defenders) with match data only included for analysis of the athletes who played in all four quarters, playing a minimum of seven total minutes in each. All matches were played between 12:15pm and 7pm in stable ambient temperature (5-9^{o}C) over a seven-day period with one rest day separating matches three and four.

Subjects

Ten regional male field hockey outfield players (mean ± SD; age 17.2 ± 0.4 years; stature 178.1 ± 5.2 cm; body mass 78.8 ± 8.8 kg) participated in the current observational study. Players were selected as part of a regional field hockey squad and were deemed as the best under 18 male players in region at the time of data collection. After ethical approval was granted, players were informed of the purpose, benefits and procedure of the current study prior to providing written informed consent and medical declarations adhering to the procedures set by the institutional research ethics committee.

Procedures

Time-motion analysis was conducted using GPS units (VX350b Log, Visuallex Sport International Ltd, Lower Hutt, New Zealand) sampling at 10-Hz for the duration of each match. The GPS units were enclosed in a custom pocket, situated between the scapulae in the upper thoracic-spine region, within the manufacturers GPS sports vest (VXsport SmartVest, Visuallex Sport International Ltd, Lower Hutt, New Zealand). Literature has found that 10-Hz GPS units measure movement demands with greater validity and inter-unit reliability than 15-Hz, 5-Hz and 1-hz units (11). The coefficient of variation (CV%) of GPS units has been reported as 1-8% with greater variance at high speed running which may be a limitation when assessing intermittent exercise requiring frequent bouts of high intensity acceleration and deceleration (17). To limit error, each player wore the same unit for all matches and the units were turned on 15 minutes prior to the pre-match warm up to allow for the acquisition of a stable satellite signal (7-9, 19). Post-match the GPS data was extracted from each unit and downloaded to a personal laptop from where it was trimmed using the manufacturer’s proprietary software (VXsport, Visuallex Sport International Ltd, Lower Hutt, New Zealand). GPS data was trimmed to time-on-pitch in order to optimally determine both the distance-related and time-dependent factors (24) prior to being exported to Microsoft Excel (Microsoft, Redmond, USA) for further analysis. The following parameters were determined for each match: TD, HSR (≥ 15 $km.h^{-1}$), LSA (≤ 14.9 $km.h^{-1}$). Distances covered across five velocity bands were also assessed. Band 1 (≤ 5.9$km.h^{-1}$), band 2 (6 – 10$km.h^{-1}$), band 3 (10.1 – 14.9$km.h^{-1}$), band 4 (15 – 24.6$km.h^{-1}$) and band 5 (≥ 24.7$km.h^{-1}$).

Statistical Analyses

Descriptive data is presented as mean ± SD. All other variables were log-transformed to reduce bias due to non-uniformity of error and analysed using effect size (ES) statistic with 90% confidence intervals and percent difference to determine the magnitude of effect using a custom spreadsheet (6). Effect sizes were interpreted as trivial (≤ 0.19), small (0.2 – 0.59), moderate (0.6 – 1.19), large (1.2 – 1.99) and very large (≥ 2)(3). The level of significance for between group comparisons was set as $p \leq 0.05$.

RESULTS

The mean TD covered, independent of the positional groups per match was 5852 ± 1005 m (range: 3850 – 7570 m). Individual match running performance and tournament average for TD, LSA and HSR is shown in Table 1. Midfielders covered significantly ($p \leq 0.05$) greater TD than both strikers and defenders and HSR distance when compared to defenders. Strikers covered significantly greater HSR distance and lower LSA than both midfielders and defenders. Quantitative and qualitative analyses of mean match TD, LSA and HSR (Table 2) found very large ES differences and percentage differences (%Diff) between strikers and midfielders for TD and LSA, strikers and defenders for LSA and HSR, and defenders and midfielders for HSR. A large ES difference was also found between defenders and midfielders for TD.

Table 1 - Mean match total, low- and hi-intensity distance (m) covered during a domestic under 18 field hockey tournament.

	Opponent						
	Game 1	**Game 2**	**Game 3**	**Game 4**	**Game 5**	**Game 6**	**Tournament Average**
Strikers (n= 3)							
Total distance	4801 ± 237	5269.5 ± 176	4862.5 ± 227	4980.5 ± 588	5225.5 ± 133	4630.5 ± 147	4961 ± 393*
Low-speed-activity distance	3319.5 ± 281	3810.5 ± 179	3433 ± 95	3247 ± 475	3690.5 ± 33	3517.5 ± 143	3503 ± 316*†
High-speed-running distance	1447 ± 16	1435.5 ± 2	1398 ± 129	1710.5 ± 111	1499.5 ± 97	1092.5 ± 7	1431 ± 199*†
Midfielders (n= 4)							
Total distance	7032 ± 691	6969 ± 213	7038 ± 633	6691 ± 771	5822 ± 627	6140 ± 54	6604 ± 761†
Low-speed-activity distance	5780 ± 673	5760 ± 398	5771 ± 792	5334 ± 958	4802 ± 571	4987 ± 440	5372 ± 786
High-speed-running distance	1222 ± 134	1180 ± 182	1236 ± 262	1326 ± 346	997 ± 383	1127 ± 388	1179 ± 326†
Defenders (n= 3)							
Total distance	5131 ± 904	5143 ± 693	6034 ± 69	6795 ± 114	4482 ± 894	5578 ± 474	5471 ± 895
Low-speed-activity distance	4367 ± 618	4555 ± 700	5375 ± 19	6132 ± 194	4104 ± 780	5000 ± 307	4856 ± 806
High-speed-running distance	747 ± 294	569 ± 89	641 ± 54	639 ± 76	369 ± 110	559 ± 160	597 ± 180

Data presented as mean ± SD; *Significantly different to midfielders ($p \leq 0.05$); †Significantly different to defenders ($p \leq 0.05$)

Table 2 - Quantitative and qualitative positional differences in total, low- and hi-intensity match-specific distance covered during a domestic under 18 field hockey tournament.

	%Diff	**ES (d)**	**Qual**
Strikers vs Midfield			
Total Distance	-24.3 ± 6.0	-2.71 (-4.18; -0.15)	Very large
Total Low-Intensity Speed	-34.3 ± 7.7	-3.12 (-4.62; -0.36)	Very large
Total Hi-Intensity Speed	25.8 ± 15.0	0.93 (-0.91; 2.40)	Moderate
Strikers vs Defenders			
Total Distance	-8.4 ± 9.2	-0.74 (-2.22; 1.05)	Small
Total Low-Intensity Speed	-27.2 ± 9.6	-2.21 (-3.65; 0.12)	Very large
Total Hi-Intensity Speed	147 ± 17.1	4.40 (0.96; 6.06)	Very large
Defenders vs Midfield			
Total Distance	-17.4 ± 9.3	-1.36 (-2.80; 0.63)	Large
Total Low-Intensity Speed	-9.8 ± 10.0	-0.65 (-2.14; 1.11)	Moderate
Total Hi-Intensity Speed	-49.1 ± 19.9	-2.21 (-3.65; 0.12)	Very large

%Diff, percentage difference; ES, effect size; 95% confidence intervals shown for d; Qual, qualitative outcome.

The mean running distances and percentage of TD completed in each of the five velocity bands for the different positional groups is shown in Table 3. The quantitative and qualitative analysis of this data (Table 4) found very large ES differences and %Diff between strikers and midfielders for zones 1 – 3, strikers and defenders for zones 1-2 and 4, and defenders and midfielders for zone 4. Additionally, large ES and %Diff were also found for strikers and defenders for zone 5 and defenders and midfielders for zone 3.

Table 3 - Mean distance (m) covered in discreet velocity bands during a domestic under 18 field hockey tournament.

	Striker (n= 3)		Midfielder (n= 4)		Defender (n= 3)	
Velocity (km/hr)	**Distance (m)**	**% Total distance**	**Distance (m)**	**% Total distance**	**Distance (m)**	**% Total distance**
0 to 5.9	1328 ± 200*†	26.8 ± 4.0	2026 ± 279	30.6 ± 3.8	2106 ± 411	38.7 ± 5.7
6 to 10	886 ± 90*†	17.9 ± 1.6	1602 ± 400	24.0 ± 4.3	1436 ± 274	26.2 ± 2.5
10.1 to 14.9	1289 ± 207	25.9 ± 2.8	1791 ± 271	27.1 ± 2.0	1315 ± 321	23.8 ± 3.2
15 to 24.6	1385 ± 194†	27.9 ± 3.2	1135 ± 314	17.3 ± 5.3	599 ± 182	10.9 ± 2.6
≥ 24.7	73 ± 52	1.5 ± 1.1	50 ± 45	0.8 ± 0.7	17 ± 15	0.3 ± 0.3
Total	4961 ± 393*	100 ± 0.0	6604 ± 761	100 ± 0.0	5471 ± 895	100 ± 0.0

Data presented as mean ± SD; *Significantly different to midfielders ($p \leq 0.05$); †Significantly different to defenders ($p \leq 0.05$).

Table 4 - Quantitative and qualitative positional differences in distances covered in discreet velocity bands during a domestic under 18 field hockey tournament.

	%Diff	ES (d)	Qual
Strikers vs Midfield			
0 to 5.9	-33.9 ± 9.9	-2.88 (-4.36; -0.23)	Very large
6 to 10	-42.1 ± 12	-2.47 (-3.92; -0.02)	Very large
10.1 to 14.9	-28.0 ± 10.4	-2.08 (-3.52; 0.19)	Very large
15 to 24.6	24.0 ± 14.2	0.96 (-0.89; 2.42)	Moderate
≥ 24.7	28.6 ± 72	0.47 (-1.24; 1.99)	Small
Strikers vs Defenders			
0 to 5.9	-36.5 ± 12.5	-2.41 (-3.86; 0.01)	Very large
6 to 10	-37.5 ± 11.4	-2.70 (-4.16; -0.14)	Very large
10.1 to 14.9	-0.3 ± 15.3	- 0.10 (-1.68; 1.52)	Trivial
15 to 24.6	139.3 ± 17.3	4.18 (0.86; 5.81)	Very large
≥ 24.7	380.3 ± 95.3	1.46 (-0.56; 2.90)	Large
Defenders vs Midfield			
0 to 5.9	4.0 ± 11.1	0.23 (-1.42; 1.79)	Small
6 to 10	-7.4 ± 14.4	-0.48 (-2.00; 1.23)	Small
10.1 to 14.9	-27.8 ± 13.9	-1.60 (-3.03; 0.48)	Large
15 to 24.6	-48.2 ± 19.7	-2.09 (-3.52; 0.19)	Very large
≥ 24.7	-73.2 ± 89.1	-0.98 (-2.45; 0.88)	Moderate

%Diff, percentage difference; ES, effect size; 95% confidence intervals shown for d; Qual, qualitative outcome.

DISCUSSION

The current study describes the running demands of regional under 18 male field hockey players during week-long tournament conditions. TD covered was greatest for midfielders, and HSR was greater for strikers than all other positions. Overall, both strikers and midfielders covered significantly higher HSR than defenders and midfielders and defenders significantly higher LSA when compared to strikers. To the authors knowledge the current study is the first to investigate the running demands of positional groups during regional under 18 male field hockey tournament match-play.

The current study demonstrates that the running demands placed upon field hockey players differ considerably with playing position in regard to TD, LSA, HSR (Table 1) and the distances covered in different velocity bands (Table 3). Mean TD covered during match-play was 5852 ± 1005 m across all positional groups. Mean TD from this tournament is lower than those previously reported in literature for elite male field hockey players which ranged between 7000 m and 8500 m (2, 7, 13, 14). The mean HSR demands increase from defenders to midfielders and then again to strikers, which are similar to research into the physical requirements of different positions in elite male field hockey (10, 14, 22). Strikers covered the most HSR distance and spent greater percentage of TD (29.4%) completing HSR than midfielders (18.1%) and defenders (11.2%). Due to their position-specific roles, strikers and midfielders covered more HSR distance when compared to the defenders during match-play. These findings are similar to those found by Jennings et al. (10) who investigated the running demands of international and national level Australian field hockey players during match-play which reported higher HSR distances by strikers and midfielders than defenders. Direct comparisons with previous research examining field hockey may however be problematic due to the use of different methodologies and speed zones used in literature (7, 22).

It is important to consider that positional physical demands are not exclusive to running and that positional specific movement demands which are not captured by GPS should also be accounted for in literature (7). Therefore, the lower level of HSR seen in defenders may be due to defensive tackling activities during which defenders must react to and defend against the movement patterns of opposition attacking players during match-play (5, 7, 23). Midfielders act as a link between strikers and defenders which may, in part, account for this positional group covering the greatest TD and LSA during offence, defence and repositioning during match-play (5). Strikers covered the least amount of TD during match-play which may be due to the position-specific tactical and technical demands which require strikers to undertake regular bouts of high-intensity running, both on- and off-ball, to evade defending players and create scoring opportunities (7, 23). Absolute velocity bands were used in the current study to help establish positional norms which will be used in future training interventions with similar athlete groups. The use of absolute velocity bands has however been found to not effectively cater for individual players within a team who possess different top-speed and fitness levels (25). Therefore, future research should endeavour to individualise the velocity bands for individual athletes to better quantify the player-specific loads during match-play. Qualitative analysis of the position differences between playing groups for TD, LSA, HSR (Table 2) and distances covered in different velocity bands (Table 4) serve to further illustrate the different running demands for the three positional groups in the current study. Therefore, it is advised that position-specific training be considered when preparing field hockey teams for competition (4, 7, 18, 22, 25).

Differences in tactics, technical abilities, the quality of opposition and the score line can all affect the running demands of a field hockey match (1, 10, 12, 19). Match-play running demands and intensity can be further influenced by the competitive importance placed on the match and the use of the rolling substitution rule throughout a match (9, 15). In the current study a high number of rolling substitutions were used in order to rotate players throughout each match in an attempt to maintain match intensity. This meant that players generally had periods of 5-8 minutes on the field and 2-4 minutes on the bench to recover. Field hockey coaches often use a high number of substitutions throughout match-play in order to facilitate optimal recovery from high-intensity bouts with the aim to maintain positional intensity (9). Players who are able to sustain high work rates throughout a match generally gain a competitive advantage over equally skilled players whose activity levels decrease towards the end of a match, or following periods requiring high-intensity efforts, which can result in decreased performance (20). It is therefore advised that coaches should incorporate consistent, position-specific, substitution strategies during under 18 match-play to allow for the optimisation of performance on-field and recovery off-field (9, 18, 25). Further research that investigates the relationship between the technical, tactical and running demands of different positional groups is required to quantify these differences (10, 22). Future research should also investigate the effects of technical and tactical aspects on player running demands during match-play by combining video analysis and GPS in order to better investigate the running demands as well as temporal and contextual aspects of both tournament and individual matches (14, 18).

Future research should also investigate the influence of multiple matches on both team and individual running demands and fatigue during regional under 18 field hockey tournaments as well as the differences in running demands between quarters of match-play as seen in previous research (7, 10, 18).

PRACTICAL APPLICATIONS

The results from the current study provide beneficial information for hockey coaches and strength and conditioning staff, detailing the dissimilar running demands of different positional groups during match-play for male under 18 hockey players. The information garnered from this study can be used to design and implement position-specific strength and conditioning programs.

Based on the findings from this study, strikers must be able to cover 4,900m, midfielders 6,600m and defenders 5,500m over a 60-minute match. High-speed-running demands for the different positions are 1,400m for strikers and 1,200m and 600m for midfielders and defenders respectively.

Strength and conditioning programs should focus on increasing position-specific aerobic capacity through the implementation of interval training based on maximal aerobic speed (MAS) and high intensity interval training (HIIT) training initiatives. Repeated sprint ability (RSA) training should also be incorporated to promote the high-speed-running as well as optimal recovery between bouts of activity. The utilisation of position-specific substitution strategies as well as the implementation of recovery modalities to promote intra- and inter-game recovery should also be looked at.

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