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Research Article

CHARACTERISTICS OF CHOSEN PARAMETERS OF EXTERNAL AND INTERNAL LOADS IN EASTERN EUROPEAN HIGH LEVEL FIELD HOCKEY PLAYERS

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ABSTRACT

The analysis of literature showed that while football (soccer) has many articles about different match analysis, field hockey has little such publications. Mainly West European Country teams or teams from other continents are studied. Still, there is no such information in reference to eastern hockey, particularly about high level competitors in Poland. Hence, the main aim of this study was to work out the characteristics of external and internal loads on Polish National Team field hockey players, representing a eastern European country. In field hockey, important information about competitive efforts must be taken into consideration to ensure correct design of the training process. For kinematics analysis (distance and velocity) Erdman's method was used, to analyze EE and HR Polar Vantage with software Polar Precision Performance were used. The results were worked out in a basic statistical way and to software Statictica 8.0, was used. It was stated that average distance covered by a player in a match is about 10,080 m (between 9,700 and 10,500 m), mean and instantaneous velocity were 2.40 m/s (between 2.29 and 2.50 m/s) and 8.92 m/s (between 8.49 and 9.22 m/s), EE average value was 947 kcal (between 874 and 1051 kcal), average value of HR and maximal value of HR were 135 bmp (between 126 and 142 bmp) and 187 bmp (between 184 and 189 bmp) respectively. The individual differences in results and playing position were noted. The results of this research bring important and necessary data for preparing precise training programs in field hockey. It can be assumed that using the information provided will allow for optimal preparation of the players to take part in competitions.

Key words: *distance, velocity, heart rate, energy expenditure, Erdman's method, match, kinematics.*

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INTRODUCTION

Field hockey is one of the oldest sports games which underwent very dynamic changes during history and especial in the last years (rules, equipment, quality of field). One of the most important changes was the swap from natural to artificial grass. In Poland the first pitch with an artificial surface was noted in the early nineties, whereas, in many places in Europe those changes were started in the 1970s. This transformation demanded changes in training process which must taking into consideration competitive loads of players as a specific model of target preparation. Contemporary field hockey requires competitors to be very fit. The effective time of a match is two times approximately 35 minutes with consecutive attacks and defenses performed with high and very high intensity. The optimal physical preparation of elite field hockey players has become an indispensable part of the professional game, especially due to the increased physical demands of match-play, we can observe this during e.g. Olympic games or European Division. To assess the level of player preparation a battery of different tests (laboratory or field) are used, which show actual possibilities of single player or whole team to realize training and competitive loads, e.g. on the basis of hypothetical model of changes the main abilities in macrocycle (Strzelczyk et al., 2001; Konarski et al., 2009). We can research energy expenditure and heart rate during training and competitive efforts (Konarski et al., 2006), however there exist many others tools utilized in professional sport (e.g. observation sheets, notation systems, etc). On the other hand, an equally important part of design for training programs is knowledge about competitive loads which are the basis and the main aim of the training process during its preparatory period for main competition. Without such information as distance, velocity, energy expenditure, heart rate level, etc., and systematically monitoring of them trainers work the only using "coaches nose" or estimate "on eye" training program and/or training loads.

The analysis of available literature showed that while football (soccer) or other team games have articles about different analysis of matches (Ohashi et al., 1988; Dufour, 1993; Bangsbo, 1994; Hughes, 1996; Chmura, 1997, 1998; Kruisinskiene et al., 2002), field hockey has little such publications. Articles present mainly West European or Australian studies (Reilly et al., 1992; Specnecr et al., 2004). Still, there is no such information in reference to eastern European hockey, particularly about the Polish highest level competitors. Most publications about hockey are involve physiological observation (Podgórski et al., 2006, 2008), anthropological (Krzykała et al., 2008a, 2008b), or assessment of other parameters (Strzelczyk et al., 2001; Straburzyńska-Lupa, 2007; Konarski et al., 2009).

Equipment monitoring players' work rate profiles during competition is now more and more easy to use and brings trainers and researchers many important parameters. Methods of motion or kinematics analysis are sometimes laborious but allow the analysis of every part of training or match in detail. One of these methods is the Erdmann's method. This method was carried out by Erdmann (1993, 2000) on the example of football, handball, athletics; Czerwiński (1996) - hand ball, Dargiewicz (1998, 2004) and Andrzejewski (2004) – football (soccer), and after specific adaptation it was possible to use it for field hockey (Strzelczyk et al., 2000; Konarski, 2002, 2003a, 2003b), too. Information about field hockey analysis by Erdman's method was not yet presented in comprehensive way.

The main aim of this study was to work out the characteristics of external and internal loads of the Polish National Team in field hockey in order to provide important information about competitive efforts which must be taken into consideration during the correct design of the training process.

MATERIALS AND METHODOLOGY

The subjects in the study were eight members of the Polish National Field Hockey Team who met the basic requirements and were analyzed in detail. They took part in the analyzed matches and were in the main line-up (two attackers, three defenders and three midfielders). The main criteria were the playing time of a competitor on the pitch in the analyzed matches. It was assumed that a player should remain on the field for the whole match (2 x 35 min) or at least for more than 90% of it. The detailed analysis were made on the example of three matches with different opponents, played as preparation to main competition in training cycle (M1- match 1, M2 - match 2 and M3 – match 3). Collected data were analyzed for separate matches and compared with each other to find specific trends during matches. Unique tactical position characteristics (attack, defense, and midfield) were calculated. Movements of players during matches were divided for walk, jog, stride and sprint. The movement's kinds were defined in references to Dargiewicz (2007) and Spencer et al. (2004). Individual characteristics of players are presented in Table 1.

Table 1. *Individual characteristics of competitors (mean value of observed cycle)*

	Age (years)	Body high (m)	Body mass (kg)	FM (%)	Training experience (years)	In National Team (years)
M±SD (n=8)	24.6±2.20	1.78±0.06	72.9±6.56	20.1±2.47	14.6±1.30	6.0±1.5
Attackers	23.0±0.00	1.70±0.01	65.0±5.66	20.0±5.66	15.0±1.41	5.5±0.71
Midfielders	25.3±2.52	1.80±0.04	75.0±3.00	21.0±1.00	15.3±1.53	7.0±1.73
Defenders	25.0±2.65	1.79±0.07	76.2±6.31	19.3±1.53	13.7±0.58	5.3±1.53

Kinematical parameters of the players, like distance and velocity, were measured using the Erdmann's method (1993, 2000). The idea of this method is the continuous and discreet record of the whole pitch and all players throughout the match or training in a given time and space together with specific individual, group and whole team analysis. To record research material, a fixed video camera with a wide-angle lens and trapezoidal view was used. The camera must be situated in an elevated position fixed high and far away enough. The location of the camera is presented on the Figure 1.

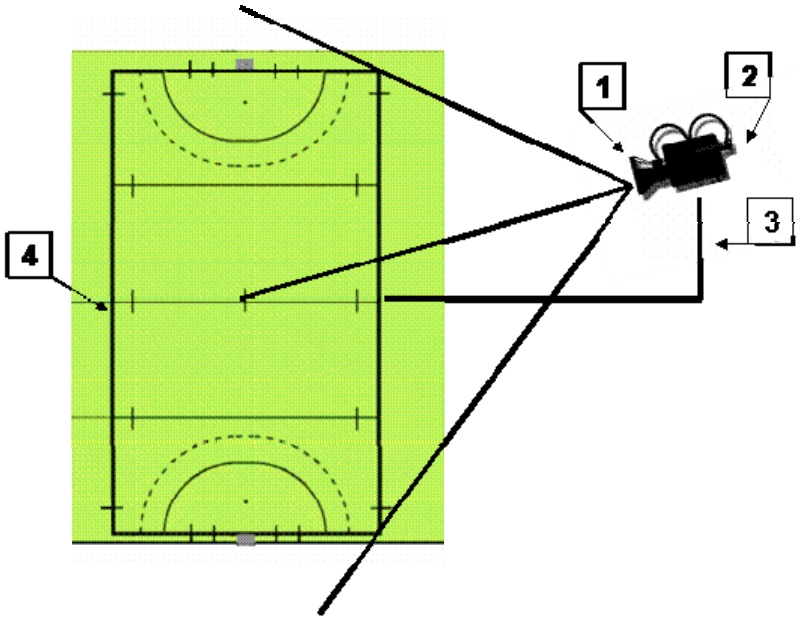

Figure 1. *Location of the camera under the pitch during recording match or training. 1 = Wide-angle lens; 2 = Digital camera; 3 = Camera's location; 4 = Middle line of pitch.*

The computer implementation of the Erdmann method is the "Banal" program by Kuzora (Kuzora and Erdmann, 1998). The program operates within the MS Windows system in cooperation with the graphics card which makes it possible to copy the video recording to the computer or use films in *.avi" format from hard drive. The program automatically displays a field with calibrated gridlines that are located in specific points of the field. The specific points for a field hockey pitch are: the four corners of the field, the points located on the middle line and 22.90 meter line, and the points located on the striking circle (Figure 2).

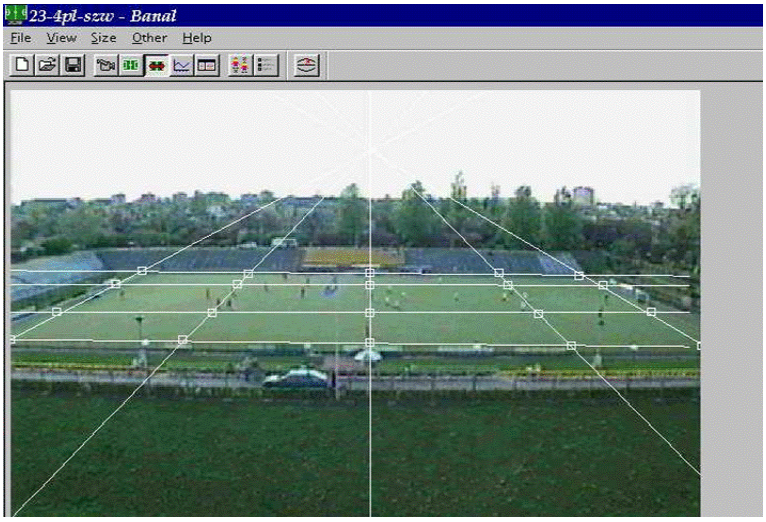

Figure 2. *Calibration's window of "Banal" software*

After the calibration, the "Banal" program automatically converts trapezoidal coordinates of a point seen at the video picture onto rectangular coordinates of a point seen at the computer picture. Moreover, the scale of the field remains the same, which enables one to determine mechanical quantities, i.e. distance (m), velocity ($m \cdot s^{-1}$). The software makes it possible to draw the trajectory of a player's movements during the game and describe the characteristics of competitors' movements, such as 1) distance - covered by a player at a particular fragment or in the whole recorded sequence, 2) velocity – instantaneous and mean data are obtained (Kuzora and Erdmann, 1998) (Figure 3 and 4).

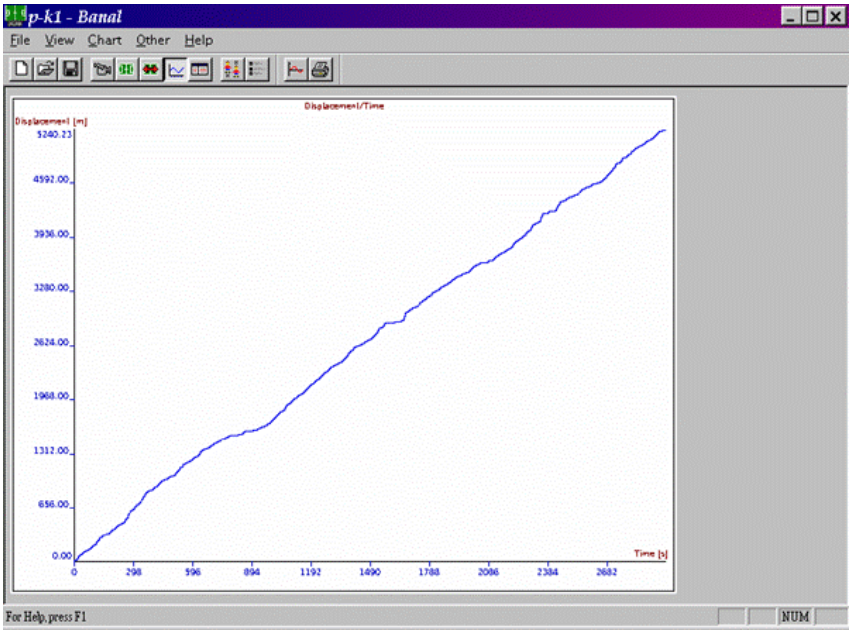

Figure 3. *Illustration of distance covered in time function by player on "Banal" software's window*

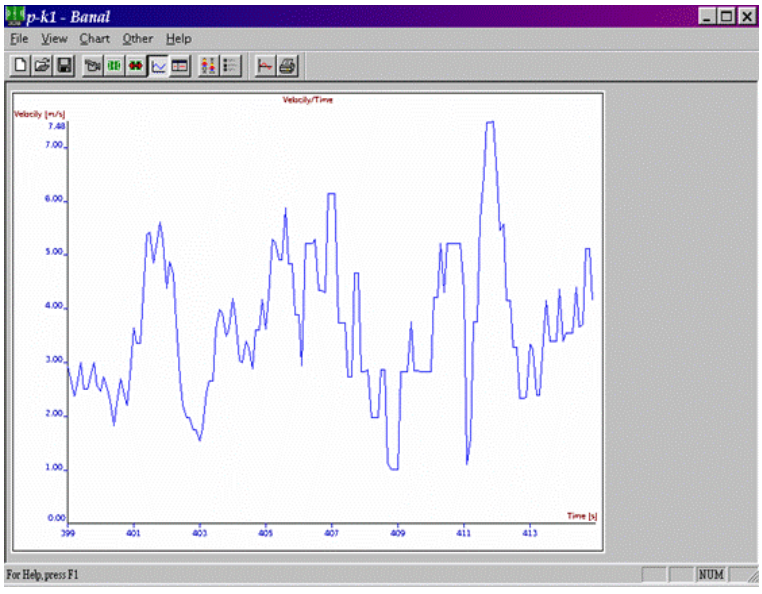

Figure 4. *Illustration of chosen fragment of player's velocity in time function on "Banal" window*

In the study, the matches were recorded with a SONY 8 DCR-TRV510E digital video camera with Hi8 cassette. On top of the standard camera lens, a wide-angle lens was fitted (SONY VCL-0637A, x 0.6 focal length). Using this apparatus it was possible to view the whole pitch from a high vantage point on a "basket elevator" or from the roof of a nearby building. The computers were fully compatible with the peripheral apparatus (such as video and camera) and met the requirements of the "Banal" program and the method (Kuzora et al., 1998).

Based on the publications of Erdmann and Grubecki (1994), Erdmann (2000) and Dargiewicz (2004) when analyzing the accuracy of the measurements, it was established that the dimensions of a football field are similar to a hockey pitch as far as size is concerned (+/- 0.1 m for the line closer to the camera and +/- 0.15 m for the further line).

Heart rate and energy expenditure of competitors were recorded at 5 second intervals using the sport-testers Polar Vantage^{TM} (Polar Electro, Finland). This equipment consists of an electrode belt which transmit ECG signals to a wristwatch, which were attached in special "small pockets" it what was important to protect electronic elements from damage during play. The belt with a pocket was strapped around the chest at the lower end of the sternum. The data stored in the belt was transferred to a computer and worked out using Polar Precision Performance ^{TM} 4 SW after matches. On the basis of individual data taken from players, the program showed a heart rate trace (HR) (beats/min) and automatically estimated energy expenditure (EE) (kcal) with reference to individual data. The collected data was divided depending on a playing position, into the backs, the midfielders and forwards.

The results were worked out in a basic statistical way. All data were analyzed using Statistica 8 (data analysis software system by StatSoft, Inc., 2007) package for MS Windows. Results are expressed as means (M) and standard deviations (SD). To check normality distribution Shapiro-Wilk Test was used. To establish significant differences between means *t*-test for a multiple dependent sample was used. The level of significance was set at $p \leq 0.05$.

RESULTS

Table 2-7 show mean scores (M) and standard deviations (SD) of the results.

Distance and velocity in matches

Analyses of the matches showed that the longest distance (10,405±1,305 m) was covered by players in M 3, similarly (10,133±844 m) in match 2 and match 1 (9,697±718 m). These differences turned out to be statistically not significant. In relation to first and second half of matches it was stated that players covered longer distance in every first part of meetings then in the second one (Table 1).

In all matches competitors covered the longest distance in jog, walk, stride and sprint (4,634±462 m; 4,464±420.1 m; 728±98.9 m; 253±55.5 m, respectively) (Table 2).

Table 2. *Distance covered by players in subsequent matches with division of movement kinds and separate part of competitions (m).*

		Walk	Jog	Stride	Sprint	Total
Match 1 n=8	I half	2425±153.1	2490±157.2	367±23.2	119±7,5	5402±341.1
	II half	1998±189.0	1929±182.4	288±27.2	82±7,7	4296±406.3
	Overall	4423±328.5	4419±326.1	655±48.4	200±14,6	9697±717.6
Match 2 n=8	I half	2464±336.8	2735±373.8	409±55.9	150±20.5	5758±786.9
	II half	1943±166.0	2039±174.2	302±25.8	92±7.9	4376±373.9
	Overall	4407±363.7	4774±399.9	711±59.7	242±21.3	10134±844.5
Match 3 n=8	I half	2566±396.6	2918±449.9	501±77.2	198±30.5	6183±953.3
	II half	1997±292.6	1790±262.3	317±46.4	118±17.3	4222±618.6
	Overall	4563±568.2	4708±594.6	817±103.0	316±40.0	10405±1304.9
Total (M 1-3) n=24	I half	2485±304.9	2715±379.2	426±78.6	155±39.1	5781±779.0
	II half	1979±214.5	1919±226.2	302±35.0	97±19.4	4298±461.9
	Overall	4464±420.1	4634±462	728±98.9	253±55.5	10079±990.3

The results of the players' velocity showed that the highest average and instantaneous velocity was achieved in match III (2.50±0.35 $m \cdot s^{-1}$ and 9.2±0.06 $m \cdot s^{-1}$, respectively). The lower value of presented velocity was achieved in match II (2.41±0.20 $m \cdot s^{-1}$ and 9.05±0.20 $m \cdot s^{-1}$, respectively) and the lowest in match I (2.29±0.17 $m \cdot s^{-1}$ and 8.49±0.63 $m \cdot s^{-1}$ respectively). The only statistically significant difference between the first and second part of the game was observed in match 3. The analysis showed that players reached a higher value of velocity in every first half of the match than in the second (Table 3).

Table 3. *Average and instantaneous velocity of players in subsequent matches with division of competition's parts ($m \cdot s^{-1}$)*

	Match 1 (n=8)	Match 2 (n=8)	Match 3 (n=8)	Total (n=24)
I half	2.57±0.16	2.74±0.37	2.89±0.37	2.73±0.33
II half	2.05±0.19	2.08±0.18	2.14±0.37	2.09±0.25
Overall	2.29±0.17	2.41±0.20	2.50±0.35	2.40±0.26
Instantaneous	8.49±0.63	9.05±0.20	9.22±0.06	8.92±0.49

Playing position - distance and velocity

On the basis of kinematical analysis of the matches it was established that, the attacking players were the most active as far as covered velocity is concerned. In each of the matches they were covering the longest distance (10,870±492.1 m). A slightly shorter distance was covered by midfielders (10,305±1,014.3 m), and the shortest distance was covered by defenders (9,325±687.7 m) (Table 4).

Table 4. *Distance covered by players in according to tactical position on the pitch (m).*

		Walk	Jog	Stride	Sprint	Total
Attackers n=6	I half	2807±281.8	3069±396.9	481±87.0	176±45.5	6533±787.5
	II half	1998±210.3	1938±225.8	304±22.2	97±13.3	4337±432.0
	Overall	4805±201.7	5007±263.8	785±74.5	273±53.6	10870±492.1
Midfielders n=9	I half	2513±250.2	2747±348.8	431±81.1	158±41.7	5849±704.5
	II half	2051±187.3	1989±206.8	314±36.3	101±22.2	4455±413.3
	Overall	4564±408.2	4735±466.9	745±112.2	259±63.4	10305±1014.3
Defenders n=9	I half	2243±100.4	2446±128.8	383±45.2	139±27.5	5211±255.2
	II half	1894±235.3	1837±243.0	289±39.6	93±21.0	4114±508.9
	Overall	4137±310.6	4283±312.6	672±75.8	233±47.2	9325±687.7

Like in the case of distance, it was shown that in all cases the attackers were the fastest with the average and instantaneous velocity for three matches 2.59 $m \cdot s^{-1}$ and 9.27 $m \cdot s^{-1}$. The midfielders and defenders were slower, with average velocities of 2.45 $m \cdot s^{-1}$ and 2.22 $m \cdot s^{-1}$ and instantaneous velocity 9.33 $m \cdot s^{-1}$ and 9.04 $m \cdot s^{-1}$, respectively. Players reached higher values of velocity and covered longer distances in every first half, than in the second halves (Table 5).

Table 5. *Average and instantaneous velocity of players in according to tactical position on the pitch ($m \cdot s^{-1}$)*

	Attackers n=6	Midfielders n=9	Defenders n=9
I half	3.04±0.27	2.79±0.34	2.48±0.12
II half	2,24±0.29	2.12±0.20	1.96±0.24
Overall	2.64±0.20	2.45±0.24	2.22±0.16
Instantaneous	8.99±0.36	9.02±0.33	8.78±0.67

Energy expenditure (EE) and heart rate HR

The energy expenditure amounted by players during matches were 874.0±82.19 (kcal) in M1, 916.6±49.29 (kcal) in M2 and 1051.25±151.46 (kcal) in M3, respectively.

The mean value of the heart rate in the first match was 126.6±5.24 (beats/min), in second 137.4±7.63 (beats/min) and 142.6±4.96 (beats/min) in the third. The mean value of HR in the matches was 135.5±8.93 (beats/min). The differences between M1 and M3 matches were statistically significant.

The average maximal value of heart rate were 184.8±6.14 (M1), 189.4±2.97 (M2) and 189.4±5.49 (beats/min) (M3), respectively. The differences between matches M1 - M2, and M1-M3 were statistically significant. Detailed results are shown in Table 6.

Table 6. *Internal reaction on competition loads during matches.*

		Energy Expenditure (kcal)	Average HR (bmp)	Maximal HR (bmp)
Match 1 n=8	I half	298.1±55.31	145.4±11.62	180.6±4.10
	II half	315,5±47.80	140.1±8.20	183.6±7.54
	Overall	874.0±82.19	126.6±5.24	184.8±6.14
Match 2 n=8	I half	355.9±31.98	148.1±7.88	184.1±5.33
	II half	350.1±13.14	145.6±7.76	188.6±3.78
	Overall	916.75±49.29	137.4±7.63	189.4±2.97
Match 3 n=8	I half	392.6±50.06	155.4±7.29	187.9±5.28
	II half	368.4±17.46	148.1±9.79	186.9±4.02
	Overall	1051,25±151.46	142.6±4.96	189.5±5.04
Total (M 1-3) n=24	I half	348.9±59.86	149.6±9.73	184.2±5.60
	II half	344.7±36.64	144.6±8.92	186.4±5.49
	Overall	947.3±125.41	135.5±8.93	187.9±5.19

The analysis of data, which takes into consideration the position of a player on the pitch has shown that mean value of HR and EE in all cases were similar and differences among them not statistically significant. The highest value of energy expenditure was observed by defenders attackers and midfielders. In the case of HR the highest values were noted in midfields, attackers and defenders, respectively. The average maximal value of heart rate was observed in defenders, attackers and defenders. Differences among positions were not statistically significant. Detailed results are presented in the Table 7.

Table 7. *Internal reaction of field hockey players dependence on playing position*

		Energy Expenditure (kcal)	Average HR (bmp)	Maximal HR (bmp)
Attackers n=6	I half	325.5±60.70	150.8±15.51	186.5±7.77
	II half	333.8±49.60	146.2±12.75	185,5±7.23
	Overall	927.8±186.81	135.2±13.42	187.8±7.73
Midfielders n=9	I half	330.2±57.28	147.6±8.73	182.3±4.58
	II half	340.0±29.64	144.4±9.88	186.3±4.12
	Overall	920.4±76.92	137.9±8.27	187.1±4.68
Defenders n=9	I half	383.1±50.98	150.9±6,17	184.6±4.85
	II half	356.6±34.24	143.8±5.21	187.0±6.00
	Overall	987.2±120.85	133.4±6.11	188.7±4.12

DISCUSSION AND CONCLUSIONS

The main aim of the study was to characterize competitive (external and internal) loads in eastern European field hockey players on the example of Polish National Team.

Comparative analysis of the matches shows that the distance covered by the Polish players in the observed matches were different (Table 1) but differences among them were not statistically significant. It could indicate specific tendencies in field hockey matches. This means that specificity and requirements of hockey should be based on the players ability to cover distance in a given time (in a match 2 x 35 min) about 10,000 m. Only then, the hockey players will appropriately adapt to the conditions of a real game. On the other hand the distance covered by a hockey player depends on many factors that include the importance of a match (friendly, league or championship matches, etc.), how demanding an opponent is, his motivation, the position on the field, tactical assumption, the psychophysical preparation, etc. While studying the literature on the kinematical analysis, no similar studies on hockey by other authors have been found. However, Spencer et al. (2004, 2005) stated that field hockey players spend the most time of match in motion as follow: walking (46.5 % of time), jogging

(40.5 %) and standing (7.4 %) and sprint take 1.5 % of global time. No information in relation to indoor hockey is currently available. After converting the presented results of distance in meters into percentages it was possible to compare both results. Average value of individual movement kinds in every observed matches were walk 44 %, jog 46 %, stride 7 % and sprint 3 %, respectively. The time spent in static (standing) was not taken into consideration during analysis in the presented research and differences between teams in analyzed kinds of movement seem to be slight, however the highest results were noted in Polish team. One of the reasons for this state could be another way of analysis and methods which were used or other tactical standards play in observed players.

Since it was stated that so called "big" team games in some elements have similarity (field size, the number of players, the character of a game, the main tactical rules, main condition skills, etc.) the results of football in this research were used for comparisons.

Reilly (1994, 1996) on the basis of his own studies but also citing other authors dealing with similar issues (Ohashi et al., 1988) showed that football players should be ready to cover a distance of 8-12 km during a match. These measures are relative and the total distance covered by players in a match is given, irrespective of the method, in approximation.

On the Polish example, Dargiewicz and Jastrzębski (1998) stated in their research, using Erdman's kinematical method that the players of the Polish Olympic Team in the match against Norway, covered an average distance of 10,098 m and their opponents covered a shorter distance of 9,180 m. In this case there was no division into formations.

Similar data is presented by Whiters et al. (1982) when testing Australian footballers (n=20). The results show that the players covered an average distance of 11,500 m: in the first part 5,800 m and in the second a slightly shorter 5,700 m. Individual differences "depending on" the formation allowed the conclusion that the longest distance was covered by midfielders (12,200 m), then attackers (11,800 m) and defenders (10,200 m).

In presented research, one can state that the attacking players were the most active as far as the covered distance goes (10,870 m). In every match they were covering longer distances then midfielders (10,305 m) and defenders (9,325 m).

On the basis of the above mentioned examples it was stated that the distance covered by players of hockey and of football during a match is similar. What is significant, though, it is the fact that in field hockey the greatest activity was on the part of the attackers, whereas in football it was the midfielders. This is connected with the different character of both games, tactical assumptions, etc. The lack of comparative data makes it impossible to point with certainty at the reasons for those differences. Further observations and analyses will be carried out to allow for a deeper understanding of this issue.

Ohashi et al. (1993) claim that the estimation of the physiological intensity of movements in real game conditions is one of the most important factors to think about when planning training. The distance covered in a match may more or less determine physiological intensity. Ekbom (1986), on the other hand, claims that the main difference between players at different levels of training does not depend on the distance covered in a match but on the total distance covered at high velocity during the game. Under the circumstances, it is very important to characterize both average and instantaneous velocity.

It was stated that the highest average and instantaneous velocity was achieved by hockey players in match III (2.50 and 9.22 $m \cdot s^{-1}$). Lower values of velocity was registered in analysis of matches: II (2.41 and 9.05 $m \cdot s^{-1}$) and I (2.29 and 8.49 $m \cdot s^{-1}$), respectively (Table 3). Taking into consideration the differences between the parts of the matches (I and II), one can observe that each first part of a match was played at a higher velocity than the second one. The statistically significant difference was observed in the match III (0.80 $m \cdot s^{-1}$), and also the highest instantaneous velocity was observed there (Table 3). When position on pitch was compared average velocity is similar, as in the case of distance (Table 2) it was also observed that in instantaneous velocity the highest results were achieved by midfielder players before attacker and defenders (Table 3)

On the basis of the literature on the subject it was stated that only the data presented by Dargiewicz and Jastrzębski (1998) is relatively accurate research material. The authors presented the results of the analysis of the international football match between Poland and Norway in 1998, using a similar method to the one used in this research.

They confirmed that, in the whole match, in the Polish team the highest velocity was achieved by the midfielders (2.1 $m \cdot s^{-1}$), then the attackers (2.0 $m \cdot s^{-1}$) and the defenders (1.5 $m \cdot s^{-1}$). The average velocity of the team was 1.87 $m \cdot s^{-1}$. In the Norwegian team, the footballers' velocity was lower and the differences between different "positions of the game" were smaller. The average velocity of the midfielders was 1.8 $m \cdot s^{-1}$, the attackers 1.7 $m \cdot s^{-1}$ and the defenders 1.6 $m \cdot s^{-1}$; the average velocity of the whole team was 1.7 $m \cdot s^{-1}$.

This comparison suggests, that hockey is faster and needs a higher level of speed and speed-endurance considering the size of the play area than e.g. football (soccer) where pitch area is similar but time of play is longer in every half about 10 minutes and results of motion analysis are close.

On the other hand, the analysis of inner-competitive loads of players showed that their exercise (play) should be classified as extremely heavy because heart rate values were greater than 150 beats/min (Astrand et al., 1987). The maximal average value of heart rate in this study (187.9±5.19 bmp) and average HR (135.5±8.93 bmp) indicate therefore high physiological requirements in the observed games. Aforementioned author and others (Reilly et al., 1992; Boyle et al., 1994) emphasize that specific training of maximal aerobic power must be one of the fundamental components in physical training programmes. The heart rate gives some information about the energy system being used. Moreover, the trainer has to remember about competitive loads which characterize specific side of preparation. In the case of hockey the main accent falls on speed which basis is in anaerobic system. However, the coach must remember also about aerobic components of physical training because it takes 60 % of competitor effort (Sharkey, 1986) and requirements of the game (Konarski et al., 2006). Field hockey became a swift and skill-based game (Anders et al., 1999), numerous changes of action require a very good preparation of endurance, speed endurance and velocity.

CONCLUSIONS

1. The field hockey players were covering a distance of approximately 10,000 m in one match with individual differences between 8,781-11,867 m resulting from tactical tasks and playing position.

2. The average velocity of the players during the matches was 2.40 $m \cdot s^{-1}$ with individual differences between 2.09 and 2.83 $m \cdot s^{-1}$ and instantaneous velocity amounted to 9.21 $m \cdot s^{-1}$.

3. It was stated that field hockey matches represent in their internal loads an extremely heavy kind of exercise what was confirmed by heart rate and energy expenditure level.

4. The players were covering a longer distance and their average velocity was higher in each first part of match than in the second.

5. As far as velocity and distance is concerned, the players were not equally active; the most active were the attackers, then the midfielders and then the defenders.

6. The results of this research bring important and necessary data for preparing precise training programs in field hockey. It can be assumed that using the information provided will allow for optimal preparation of the players to take part in competitions.

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