POSITION-RELATED DIFFERENCES IN VOLUME AND INTENSITY OF LARGE-SCALE CYCLIC MOVEMENTS OF MALE PLAYERS IN HANDBALL

Marko Šibila[1], Dinko Vuleta[2] and Primož Pori[1]

[1]Faculty of Sport, University of Ljubljana, Slovenia
[2]Faculty of Kinesiology, University of Zagreb, Croatia

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Abstract:

The aim of this study was to identify the differences in the volume and intensity of large-scale cyclic movement activities performed by handball players in different playing positions – backcourt players, wings, pivots and goalkeepers. For this purpose six experimental model matches (2x20min), played by the Slovenian male handball teams (youth, juniors and seniors), were analysed. The sample consisted of 84 players of twelve teams (average age 20.26 ± 4.28yrs; average height 182.51 ± 6.59cm; average body mass 80.61 ± 10.37kg) and was divided into four sub-samples by playing position. The collection of data on the cyclic loading of players in a handball match was based on the computer-aided automatic tracking method with the SAGIT system, based on computer vision methods. The output data on the cyclic movements obtained by the SAGIT programme were processed by the selected descriptive statistics methods in Excel and SPSS programmes. Statistically significant differences were registered between the groups of players in different playing positions in terms of average distances walked or run during matches (volume). The greatest total distance was covered by the wings (3,855m), followed by the backcourt players (3,432m) and pivots (3,234m), whereas goalkeepers ran the least (1,753m). Differences also appeared in the intensity of large-scale cyclic movements, that is in the percentage of time spent in all the speed classes. In the first speed class statistically significant differences occurred among all the groups – the goalkeepers spent the highest percentage of time (86%) here, followed by the pivots (62%) and wings (58%). There were no statistically significant differences in the second speed class between the groups of wings (23%), backcourt players (25%) and pivots (25%); however, all three groups differed from the goalkeepers (11%). The highest percentage of time spent in the third speed class was that of the wings (14%) and backcourt players (14%). Nevertheless, there were no statistically significant differences between them. Pivots (10%) and goalkeepers (2%) did not spend much time in the third speed class, so statistically significant differences were registered for the latter two and the groups mentioned before**.** In the fourth speed class statistically significant differences occurred between all the groups of players. In this speed class the wings spent the most time (4%), followed by the backcourt players (3%) and pivots (2%), whereas the lowest percentage of time in this speed class was that of the goalkeepers (0.5%). There were statistically significant differences between all the groups of players in terms of average speed of movement – the fastest were the wings (1.60m/s), followed by the backcourt players (1.43m/s), pivots (1.34m/s), and goalkeepers (0.73m/s).

Key words: *handball, time and motion analysis, large-scale cyclic movements, play-rate, work-rate*

POSITIONSBEDINGTE UNTERSCHIEDE IM UMFANG UND IN DER INTENSITÄT DER GROßRÄUMIGEN ZYKLISCHEN BEWEGUNGEN DER HANDBALLSPIELER

Zusammenfassung:

Diese Studie hatte als Ziel, die Unterschiede im Umfang und in der Intensität bei den zyklischen Bewegungen zu bestimmen, die für die an verschiedenen Spielpositionen spielenden Handballspieler charakteristisch sind, bzw. für die Rückraumspieler, die Flügel, die Kreisspieler und die Torhüter. Zu diesem Zweck wurden sechs Testspiele (2x20Min) der slowenischen männlichen Handballmannschaften (Kadetten, Junioren und Senioren) analysiert. 84 Handballspieler aus zwölf Mannschaften nahmen an dieser Forschung

teil (das Durchschnittsalter 20,26±4,28 Jahre; die Durchschnittshöhe 182,51±6,59cm; das durchschnittliche Körpergewicht 80,61±10,37kg). Sie wurden in vier weitere Gruppen eingeteilt gemäß der Spielposition. Die Daten über die zyklische Belastungen der Spieler im Handballspiel wurden mit einer computergestützten automatischen Tracking Methode gesammelt bzw. mit SAGIT System, das auf Computer-visuellen Methoden basiert. Die mit SAGIT Programm erhaltenen Ergebnisse der zyklischen Bewegungen wurden mittels der ausgewählten Methoden der deskriptiven Statistik in Excel und SPSS Programmen verarbeitet. Statistisch bedeutende Unterschiede sind zwischen auf verschiedenen Spielpositionen spielenden Spielern bemerkbar, in Bezug auf die durchschnittliche Entfernung, über die ein Spieler während des Spiels gegangen oder gelaufen ist (Umfang). Die größte Entfernung legten die Flügel (3855m) zurück, dann die Rückraumspieler (3432m) und die Kreisspieler (3234m), während die Torhüter am wenigsten liefen (1753m). Die Unterschiede waren auch in der Intensität der zyklischen Bewegungen zu erkennen, d.h. im Prozent der verbrauchten Zeit in allen Geschwindigkeitsklassen. In der ersten Geschwindigkeitsklasse statistisch bemerkenswerte Unterschiede kamen in allen Gruppen auf - die Torhüter verbrauchten die meiste Zeit (86%), dann die Kreisspieler (62%) und die Flügel. Es gab keine statistisch bedeutenden Unterschiede in der zweiten Geschwindigkeitsklasse zwischen den Torhütern, den Kreisspielern und den Flügeln; alle drei Gruppen aber unterschieden sich von den Torhütern (11%). In der dritten Geschwindigkeitsgruppe verbrauchten prozentual die Flügel (14%) das größte Zeitquantum, dann die Rückraumspieler (14%). Trotzdem gab es keine statistisch bedeutenden Unterschiede zwischen ihnen. Die Kreisspieler (10%) und Torhüter (2%) verbrauchten nicht viel Zeit in der dritten Geschwindigkeitsklasse, so dass statistisch bedeutende Unterschiede für die letzten zwei und die oben genannten Gruppen auch hier gelten. In der vierten Gruppe sind Unterschiede zwischen allen Spielergruppen festzustellen. In dieser Geschwindigkeitsklasse verbrauchten die Flügel (4%) das größte Zeitquantum, dann die Rückraumspieler (3%), die Kreisspieler (2%) und die Torhüter (0.5%). Statistisch bedeutende Unterschiede zwischen allen Spielergruppen sind bei mittlerer Bewegungsgeschwindigkeit zu merken - die Flügel waren am schnellsten (1,60m/s), dann die Rückraumspieler (1,43m/s), die Kreisspieler (1,34m/s) und die Torhüter (0,73m/s).

Schlüsselwörter: *Handball, Zeit- und Bewegungsanalyse, großräumigen zyklische Bewegungen, Spielgeschwindigkeit, Belastungsumfang*

Introduction

Handball is a team sport in which players of two opposing teams alternately take the role of either attackers or defenders, depending on the *possession of the ball* criterion. The aim of the team on attack is to play the ball past or through the opposing team's defence wall and score a goal. The aim of the defending team is to prevent the opponents from scoring a goal and to assume the role of attackers, that is to win possession of the ball as soon as possible. Victory in handball, as in other field games, is secured by scoring more goals than the opposition.

Due to advances in information- and video-technology the analyses of various activities (loading) individual players perform in game contexts are ever more diversified and thorough. The purpose of such analyses is to improve the comprehension of factors which determine the performance capability of a team as a whole and of how much individuals contribute to team effort (Reilly, 2001). The obtained data help sport practitioners to optimise and control training activities.

The intensity and volume of work-rate or loading in handball are very heterogeneous. In a match acyclic (intermittent) activities (passing the ball, various kinds of shots, jumps, body contacts with an opponent when breaking through, falls, etc.) occur along with the player's cyclic movements (running, walking, jogging, cruising, moving sideways or backwards). In handball, loading of players is a combination of both the cyclic and acyclic activities and varies in intervals. Therefore, during the course of play, work-rate or loading, which may vary in intensity and volume, alternates continuously with periods of relative rest, i.e. standing or slow walking.

The large-scale cyclic movements are fundamental because they allow a player to move across the court area in two dimensions, in length and width. They include walking and running without a ball, as well as dribbling the ball while walking or running. Investigation of the physiological demands of sports games can be conducted by making the relevant observations during a match played or by the monitoring physiological responses in real or mock-up games. The type, intensity, and duration (or distance) of activities performed can be observed by motion analysis. Work-rate profiles of players within a team can be established according to the intensity, duration, and frequency of classified activities (cyclic or acyclic ones) (Reilly, 2001). Recently, researchers have tried to analyse the volume and intensity of large-scale cyclic activities of handball players by using

different methods and samples. In our opinion the following studies are particularly interesting:

- Cambel (1985) reported that about 80% of all run and/or walked distances during a handball match are performed with a velocity of 2m/s, 15% with a velocity of 2-4 m/s, 5% with a velocity of 4-8 m/s and only 1% with a velocity of 8-9 m/s.
- Cuesta (1988, summarized from Cardinale, 2000) analysed the cyclic activities of the players of Spanish teams who played in different positions in attack. He established that the left backcourt players cover a distance of 3,464 metres on average, the right backcourt players 2,857m, left wings 3,557m, right wings 4,083m, and pivots 2,857 metres. The above data show that wings cover a greater distance on average in attack compared to players in the other playing positions.
- Martin (1990) defined that the total of all distances run and/or walked in a handball match are between 4,700 and 5,600 metres. That is approximately 80 to 90 metres per minute. During a match players execute 70 sprints on average, or cover 470 to 560 metres. It means that an average sprint distance is 6 to 8 metres. The average time interval between two sprints was 50 seconds.
- By means of a video analysis Al – Lail (1996) established the volume and frequency of cyclic loading using a sample of eight Kuwaiti national team players. His sample of variables included five types of cyclic movements (walking, slow running, sprinting, backward running, sideways movements), as well as the share of movements with the ball and without it. The total distance covered by all the types of large-scale cyclic movements with and without the ball averaged 2,478 ± 224 metres, of which walking accounted for 620 metres, running 707, sprinting 451, running backwards 158, and sideways movements 540 metres. The analysed players spent in play 40 ± 7.2 minutes on average. The bulk of the playing time, i.e. 53.9%, the players walked – with or without the ball (21.3 ± 5.4 minutes). The author established in the continuation that the share of highly intensive activities (sprinting) was relatively low, with results ranging between 2% and 3.8% of the total playing time.
- After analysing the cyclic activities in an experimental match between two Slovenian premier-league teams, Bon (2001) established that the players ran and walked a distance of 4,790m on average. Sprint accounted for 7% of the playing time, fast running 25%, slow running 31%, and walking or standing for as much as 37% of the playing time. As regards the distance covered by the individual players during the match, there were no great deviations from the average (from –7% to +6%). This study is even more interesting, because the author measured the volume and intensity of the large-scale cyclic activities by applying the same method as used in this study.

The aim of this study was to identify the differences in volume and intensity of cyclic activities performed by the players in different playing positions – backcourt players (B), wings (W), pivots (P) and goalkeepers (G).

Methods

The **sample of subjects** consisted of 84 male players of twelve teams (average age 20.26 ± 4.28 yrs; average height 182.51 ± 6,59cm; average body mass 80.61 ± 10.37kg) and was divided into four sub-samples according to playing position – backcourt players (B; average age 20.32 ± 4.41yrs; average height 184.84 ± 5.13cm; average body mass 82.62 ± 7.41kg), wings (W; average age 20.59 ± 4.61yrs; average height 177.92 ± 6.34cm; average body mass 76.71 ± 10.52kg), pivots (P; average age 19.43 ± 3.31yrs; average height 184.52 ± 8.11cm; average body mass 85.89 ± 11.78kg), and goalkeepers (G; average age 20.82 ± 4.58yrs; average height 184.41 ± 4.72cm; average body mass 79.18 ± 11.51kg). The subjects were members of four youth teams, four junior teams, and four senior teams. The data on work-rate or loading of the male handball players during a match were collected from six model matches in the categories of senior men, junior men and youth (cadets). In each category two matches were played and analysed, i.e. four teams were observed. In each team we monitored the parameters of large-scale cyclic movements of the players who played in different positions, i.e. two wings, three backcourt players, a pivot and a goalkeeper.

In all the matches certain environment conditions were standardised: the play time for all the games was 2 times 20 minutes, all the teams played the 5-1 zone defence, the selected players had to play the entire game, and a one-minute team time--out was not allowed.

The applied statistical methods required a sufficient number of entities (players in each playing position) and matches. Due to this, we also systematically included the juniors and cadets in the sample. At the same time we were forced, for practical reasons, to shorten the playing time. Namely, obtaining and processing data with the

SAGIT system is complex and time-consuming work (Bon, 2001; Perš et al., 2002).

The **sample of variables** included the ones pertaining to the large-scale cyclic movements by definition. We established the volume (duration) of all cyclic movements, percentages of time spent in particular speed classes, and the average speed of movement. Cyclic movements were divided into four speed classes according to the speed of performance (Table 1).

The collection of data on the cyclic movements of players in a handball match was based on the computer-aided automatic tracking method with the SAGIT system (Perš et al., 2002). It is based on computer vision methods. The SAGIT system essentially consists of several modules. The basic one is a module for the preparation of recording (video-recording), further analysis and tracking. The second one is an automatic tracker. The output data of the tracker are *xy* co-ordinates in the plane of the court for each or the selected player, which are used for further calculations. The last two modules are designed for calculating and displaying the results. The images were captured by two cameras placed directly above the court so that the optical axis of the camera and the court formed a right angle. The cameras were fixed while recording the match, each of them covering one half of the court. Their fields of vision partly overlapped which enabled tracking of players while crossing the centre of the court. Once the matches had been recorded, the

Table 1. The variables used for the evaluation of volume and intensity of the cyclic activities in a handball match

VARIABLE	DESCRIPTION OF VARIABLES	UNIT
S (distance)	Total of all distances run and/or walked in a match	m
First speed class (1stSC)	Percentage of time spent in the 1stSC (standing still or distances run and/or walked at speed up to 1.4 m/s)	%
Second speed class (2ndSC)	Percentage of time spent in the 2ndSC (running at speed of 1.4 to 3.4 m/s)	%
Third speed class (3rdSC)	Percentage of time spent in the 3rdSC (running at speed of 3.4 to 5.2 m/s)	%
Fourth speed class (4thSC)	Percentage of time spent in the 4thSC (running at speed above 5.2 m/s – sprinting)	%
Va	Average speed of walking or running	m/s

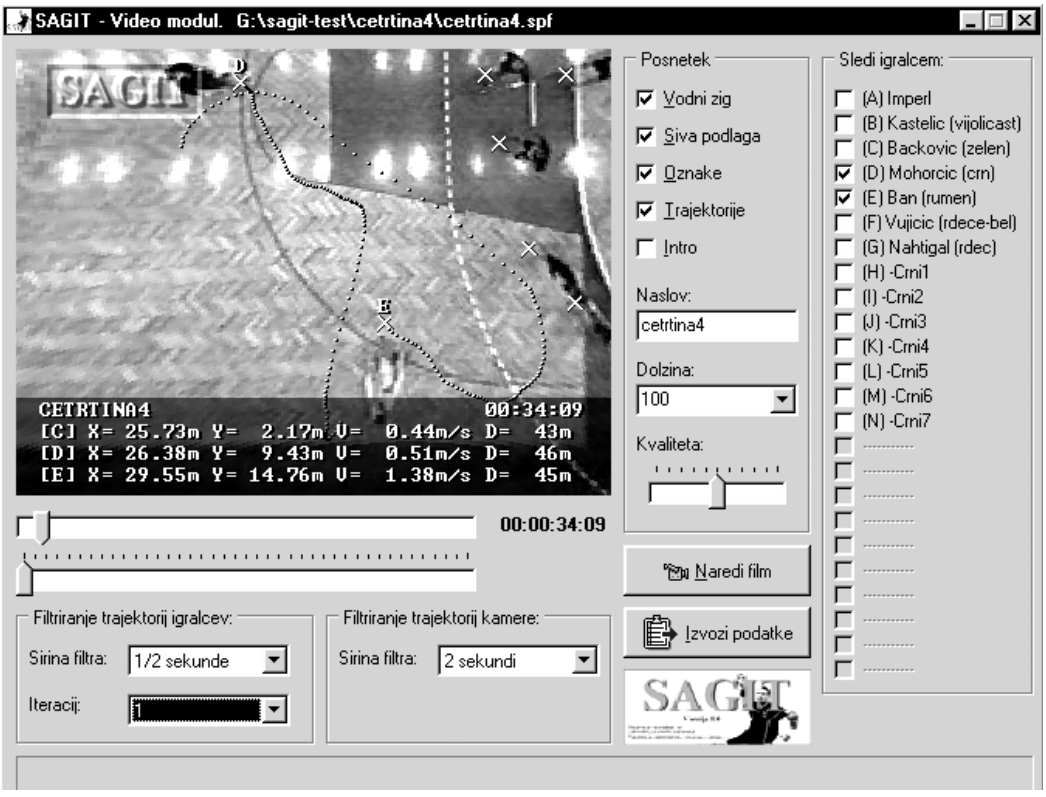


Figure 1. User interface of the module for displaying results. Player's current speed, as well as distances walked or run are shown.

video-recordings were digitized using the microVideo DC30+ video digitizer hardware with the resolution of 768 x 576 at 2 MB/s data rate. The captured images were synchronised before processing so that at any time the tracker was able to produce images recorded by both cameras at the same moment (Fig. 1).

The output data on the cyclic movements obtained from the SAGIT programme were processed by the selected descriptive statistics methods in Excel and SPSS programmes. The differences in the volume and intensity of the large-scale cyclic movements were established by multi-factor analysis of variance. When establishing these differences, absolute values were used for the total of distances run and walked, as well as for the average speed (metres and m/s), whereas for the volume of movement in individual speed classes, the percentage of time spent in a certain speed class was used.

A comparative *(post hoc)* analysis was made so as to compare additionally the playing positions and thus establish any statistically significant differences between them. Owing to the multiple comparisons, correction was necessary which is why the Bonferroni correction was applied. Statistical significance was set at $\alpha < .05$.

Results

Table 2 shows the absolute values of all the distances walked and run during the matches played, the percentages of time the players spent in individual speed classes and average speed of movement.

Table 2. Volume and intensity of cyclic loading of players as regards the initial playing positions in attack

Volume and intensity of loading	Backcourt players	Wings	Pivots	Goalkeepers
TRD	3,432 m	3,855 m	3,234 m	1,753 m
1stSC	57%	58%	62%	86%
2ndSC	25%	23%	25%	11%
3rdSC	14%	14%	10%	2%
4thSC	3%	4%	2%	0.5%
Va	1.43 m/s	1.60 m/s	1.34 m/s	0.73 m/s

Legend: TRD – total run distance; 1stSC – first speed class; 2ndSC – second speed class; 3rdSC – third speed class; 4thSC – fourth speed class; Va – average speed of movement.

The wings achieved the greatest volume of movements, as well as the highest average of speed of movement. According to these two parameters then follow the groups of backcourt players and pivots. At the very end are the goalkeepers with the lowest values of the two parameters. Nevertheless, the goalkeepers' share of movements pertaining to the first speed class is the highest.

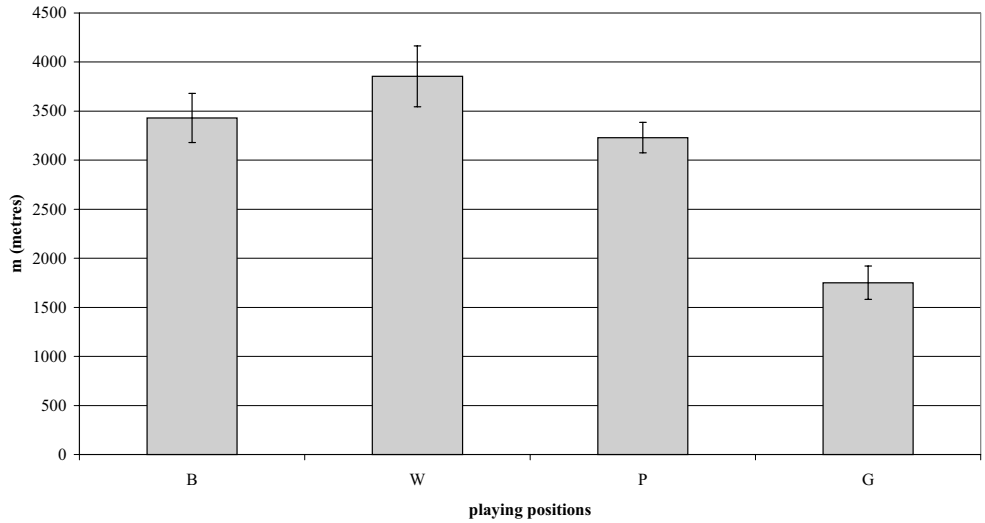
Table 3. Analysis of variance of the total distance run, percentages of time spent in individual speed classes and average speed of movement by playing positions

	DEGREES OF FREEDOM	F	p
TRD	3	268.991	.000
1stSC	3	169.028	.000
2ndSC	3	79.994	.000
3rdSC	3	89.516	.000
4thSC	3	124.030	.000
Va	3	268.991	.000

Legend: TRD – total run distance; 1stSC – first speed class; 2ndSC – second speed class; 3rdSC – third speed class; 4thSC – fourth speed class; Va – average speed of movement.

The results of the analysis of variance showed that there were statistically significant differences in terms of volume of the total distances run and/or walked ($p = .000$), percentage of time in the first, second, third and fourth speed class ($p = .000$), and total average speed of movement ($p = .000$) between the groups of players playing in positions of backcourt players, wings, pivots, and goalkeepers.

In the continuation, the nature of these differences is explained by a more detailed comparative analysis.



Legend: B – backcourt players; W – wings; P – pivots; G – goalkeepers.

Graph 1. Volumes of cyclic movements performed by players on individual playing positions.

The graph shows the average distances walked or run by players in different playing positions during the entire match. The wings covered the greatest distance as compared to other players – 3,856 m, followed by backcourt players with 3,433 m and pivots with 3,238 m. The smallest volume of movement was seen in goalkeepers (1,753 m), and it markedly deviates from the volume of movement recorded for the other playing positions.

The average distance covered by wings was by 422 m, 618 m and as much as 1,679 m greater than those of backcourt players, pivots and goalkeepers, respectively. The average difference between backcourt players and pivots was 195 m.

Table 4. Comparative analysis of variance between the players on different playing positions in terms of total distance run or walked

CATEGORIES		AVERAGE DIFFERENCES	STANDARD ERROR	p
B	W	-422.97	56.27	.000
	P	195.11	71.18	.046
	G	1679.86	71.18	.000
W	B	422.97	56.27	.000
	P	618.08	75.50	.000
	G	2102.83	75.50	.000
P	B	-195.11	71.18	.046
	W	-618.08	75.50	.000
	G	1484.75	87.18	.000
G	B	-1679.86	71.18	.000
	W	-2102.83	75.50	.000
	P	-1484.75	87.18	.000

Legend: B – backcourt players; W – wings; P – pivots; G – goalkeepers.

The analysis of variance revealed statistically significant differences between all the position-related groups of players in terms of distance walked and/or run throughout the match. The results are particularly interesting from the point of view of wings, backcourt players and pivots. It was expected that goalkeepers would differ from other groups of (field) players in terms of volume of distances walked and run. However, we did not expect that statistically significant differences would occur among all the groups of field players.

Table 5. Comparative analysis of variance between the groups of players on different playing positions shown as percentage of time spent in the first speed class

CATEGORIES		AVERAGE DIFFERENCES	STANDARD ERROR	p
B	W	-1.0743	1.0467	1.000
	P	-5.1431	1.3240	.001
	G	-28.6847	1.3240	.000
W	B	1.0743	1.0467	1.000
	P	-4.0687	1.4043	.030
	G	-27.6104	1.4043	.000
P	B	5.1431	1.3240	.001
	W	4.0687	1.4043	.030
	G	-23.5417	1.6216	.000
G	B	28.6847	1.3240	.000
	W	27.6104	1.4043	.000
	P	23.5417	1.6216	.000

Legend: B – backcourt players; W – wings; P – pivots; G – goalkeepers.

Table 5 shows the results of the comparative analysis of variance between the groups of players in different playing positions expressed as the percentage of time spent in the first speed class. The results show statistically significant differences between all four groups of players. Goalkeepers had on average the highest share in the first speed class in the entire match (86%) and they differ substantially from the field players. The lowest share in the above-mentioned speed class was that of backcourt players (57%), followed by wings (58%) and pivots (62%).

Table 6. Comparative analysis of variance between the groups of players on different playing positions shown as the percentage of time spent in the second speed class

CATEGORIES		AVERAGE DIFFERENCES	STANDARD ERROR	p
B	W	1.799	.733	.099
	P	.376	.927	1.000
	G	13.922	.927	.000
W	B	-1.799	.733	.099
	P	-1.423	.983	.913
	G	12.123	.983	.000
P	B	-.376	.927	1.000
	W	1.423	.983	.913
	G	13.546	1.135	.000
G	B	-13.922	.927	.000
	W	-12.123	.983	.000
	P	-13.546	1.135	.000

Legend: B – backcourt players; W – wings; P – pivots; G – goalkeepers.

Table 7. Comparative analysis of variance between the groups of players on different playing positions shown as the percentage of time spent in the third speed class

CATEGORIES		AVERAGE DIFFERENCES	STANDARD ERROR	p
B	W	.663	.630	1.000
	P	4.113	.797	.000
	G	12.496	.797	.000
W	B	-.663	.630	1.000
	P	3.450	.846	.001
	G	11.833	.846	.000
P	B	-4.113	.797	.000
	W	-3.450	.846	.001
	G	8.383	.976	.000
G	B	-12.496	.797	.000
	W	-11.833	.846	.000
	P	-8.383	.976	.000

Legend: B – backcourt players; W – wings; P – pivots; G – goalkeepers.

Table 6 illustrates the results of comparative analysis of variance shown as the percentage of time spent in the second speed class. Backcourt players spent 25% of the total playing time in the second speed class, wings 23%, pivots 25%, and goalkeepers 11%. There are no differences among the groups of backcourt players, wings and pivots in terms of time spent in this speed class. However, there are statistically significant differences between all the three groups and that of the goalkeepers.

Backcourt players and wings spent 14% of the total playing time in the third speed class, pivots 10%, and goalkeepers 2%. There are no statistically significant differences between the groups of wings and backcourt players, but these two groups differ from those of the pivots and goalkeepers. The group of pivots statistically significantly differed from the group of goalkeepers in this speed class. As regards the higher speed classes, it is in particular the wings and backcourt players that differ from the groups of players in other playing positions. As expected, all groups recorded a decrease in the share of distances run in this more intensive speed class.

Table 8. Comparative analysis of variance between the groups of players on different playing positions shown as the percentage of time spent in the fourth speed class

CATEGORIES		AVERAGE DIFFERENCES	STANDARD ERROR	p
B	W	-1.5715	.1446	.000
	P	.5014	.1829	.046
	G	2.0472	.1829	.000
W	B	1.5715	.1446	.000
	P	2.0729	.1940	.000
	G	3.6187	.1940	.000
P	B	-.5014	.1829	.046
	W	-2.0729	.1940	.000
	G	1.5458	.2240	.000
V	Z	-2.0472	.1829	.000
	K	-3.6187	.1940	.000
	KN	-1.5458	.2240	.000

Legend: B – backcourt players; W – wings; P – pivots; G – goalkeepers.

Backcourt players spent 3% of the total playing time in the fourth speed class, wings 4%, pivots 2%, and goalkeepers 0.5%. A comparative analysis of the different playing positions reveals statistically significant differences among all the groups of players.

Table 9. Comparative analysis of variance between the groups of players on different playing positions in terms of average speed of distances run and walked (Va)

CATEGORIES		AVERAGE DIFFERENCES	STANDARD ERROR	p
B	W	-.176	2.343E-02	.000
	P	8.126E-02	2.969E-02	.046
	G	.699	2.969E-02	.000
W	B	.176	2.343E-02	.000
	P	.257	3.148E-02	.000
	G	.876	3.148E-02	.000
P	B	-8.126E-02	2.969E-02	.046
	W	-.257	3.148E-02	.000
	G	.618	3.633E-02	.000
G	B	-.699	2.969E-02	.000
	W	-.876	3.148E-02	.000
	P	-.618	3.633E-02	.000

Legend: B – backcourt players; W – wings; P – pivots; G – goalkeepers.

On average, the wings moved at the highest speed (Va = 1.60 m/s), followed by the backcourt players (Va = 1.43 m/s), pivots (Va = 1.34 m/s), and goalkeepers (Va = 0.73 m/s). A comparative analysis among the individual playing positions reveals statistically significant differences between all the groups. The average speeds also confirm the data on the shares of distances run and walked in individual speed classes.

Discussion and conclusions

In view of the different initial playing positions of handball players and the related variety of tasks they have to execute, we expected to see some differences among them in terms of volume and intensity of large-scale cyclic movements. Our expectations have been met in almost all the observed variables.

Comparing our results with the literature data, we can find a similar share of run and/or walked intensity classes (Cambel, 1985; Al – Lail, 1996; Bon, 2001). We also establish similar differences in the total distances run and/or walked between the groups of players in different playing positions (Cuesta, 1988; Bon, 2001).

Of course, it stands to reason that cyclic activities constitute only a part of the comprehensive game loading of handball players. Besides running at various intensities and of different duration (walking, jogging, cruising, sprinting, moving sideways and backwards), handball players have also to perform many acyclic activities, such as: shots at goal, jumps, passing the ball, body checking, dribbling, falls, and standing ups. As a rule, these activities are carried out with high intensity and represent a substantial share of the player's work--rate in a match. Therefore, we can conclude that highly intensive running in the third and, particularly, the fourth speed class (sprints) is just one segment of the highly intensive loading in a handball match - another segment, i.e. the acyclic activities, complementing the former. The volume of the less intensive activities or standing still actually represents a break (rest) between the highly intensive loading of both the cyclic and acyclic types. A conclusion may be drawn that the tasks which players in different playing positions perform in a game vary substantially in terms of distances walked or run. We assumed that the volume of cyclic movements is predominantly influenced by the initial playing positions in attack and defence. The initial playing position of a wing in attack is at the junction of the free-throw line and the sideline. Most of the time in a game wings await their opportunity to shoot at goal subsequently from the corner of the court. In a flat zone defence, wings, owing to their morphological characteristics, mostly take the position of the first defence player either on the left or right. This initial position is close to the side and goal lines on the handball court. In transition, while moving from defence to attack and back, the wings run or walk a slightly greater distance than players in other positions (Pori, 2003). The cyclic activities of the third speed class intensity are primarily employed by handball players when crossing up and down the court running fast (not at maximum speed) in a counter--attack (fast-break) or when returning to defence. When the zone defence is used, backcourt players and wings perform the bulk of cyclic activities with the above intensity mostly because they execute various combinations jointly. These types of running primarily include quick running start before shooting at goal, position exchanging, dribbling, moving without the ball, as well as getting open in various group combinations. Wings spend the bulk of time in the fourth speed class, which can probably be attributed to counter-attack (fast--break) sprints. Considering the model of handball game, once a team takes possession of the ball, the commonest mission of wings is to be the first among the players to run in counter-attack at maximum speed. While accomplishing this, they try to outrun the opposing defence players. The commonest task of other players is to transfer the ball safely into the counter-attack by running at optimal speed, which often does not mean the fourth speed class velocity. On the other hand, when backcourt players are not directly involved in the closure of the attacking action (shot at goal), they have to return to defence at maximum speed

so as to mark the opposing wings "escaping" into the counter-attack. In the described game situations players run at maximum speed most of the time. That is why wings and backcourt players had the highest shares in the fourth speed class.

Based on the findings we can suggest some instructions for handball players' physical conditioning, primarily from the point of view of cyclic loading. At least 3-4% of the total time of training (with individual training sessions usually lasting for 90 to 120 minutes) of wings, backcourt players and pivots have to be allotted to exercises of running with maximum intensity and at least 10-14% to running with medium intensity. From the point of view of cyclic activities, the remaining time should be devoted to running with low intensity and walking or standing. Naturally, the broad-brush sports training doctrine dealing with that loading which results from running with maximum intensity, has to be considered within a micro cycle of various trainings. In view of the modern model of handball which has been substantially conditioned by changes of the rules, it may be concluded that the time during which players are subjected to low--intensity training load has to be reduced. The training methods have to include a large number of highly intensive activities, i.e. drills of both the cyclic and acyclic types. The volume of less intensive cyclic movements has to be reduced and the latter should only be used as a relative break. However, this doctrine has to change slightly when it comes to goalkeepers. Compared to the other groups of players, goalkeepers perform a small volume of large-scale cyclic movements in a match. Therefore, it would be more reasonable to include a large volume of acyclic activities, inherent to their technique, in the goalkeepers' training instead of a large volume of cyclic activities.

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Correspondence to:
Prof. Marko Šibila, PhD
Faculty of Sport, University of Ljubljana
Gortanova 22, SI-1000 Ljubljana, Slovenia
Phone: +386 1 520 77 57
Fax: +386 1 520 77 30
E-mail: marko.sibila@sp.uni-lj.si

IGRAČKIM MJESTIMA UVJETOVANE RAZLIKE U EKSTENZITETU I INTENZITETU CIKLIČKIH KRETNIH AKTIVNOSTI RUKOMETAŠA

Sažetak

Uvod

Zahvaljujući napretku informatičke i video tehnologije, analize raznorodnih motoričkih aktivnosti (opterećenje) koje igrači izvode tijekom rukometne utakmice, postale su raznolike i podrobnije. Svrha im je proširiti spoznaje o strukturi opterećenja pojedinih igrača i momčadi u cjelini, a te spoznaje nužne su trenerima za racionalno planiranje i kontrolu trenažnog procesa.

Opterećenja u rukometu, tj. njihov intenzitet i ekstenzitet, vrlo su heterogena zato što se ukupna kretna aktivnost rukometaša sastoji i o acikličkih struktura gibanja (dodavanja lopte, udarci na vrata, skokovi, tjelesni kontakt prilikom prodora ili obrambenih akcija, padovi) i od cikličkih struktura gibanja (trčanje, hodanje, trčkaranje, bočno kretanje, kretanje unatrag), a razne kombinacije tih kretanja pojavljuju se u intervalima. Tijekom utakmice, radno se opterećenje, obilježeno visokim ili niskim intenzitetom te velikim ili malim ekstenzitetom, kontinuirano izmjenjuje s razdobljima relativnog mirovanja, tj. s razdobljima stajanja ili vrlo polaganog hodanja. Cikličke kretne aktivnosti temeljne su za rukomet zato što igraču omogućuju da se po igralištu kreće u dvije dimenzije – u širinu i u dužinu. Uključuju hodanje i trčanje bez lopte, ali i vođenje lopte u hodanju ili trčanju.

Metode

Uzorak ispitanika sastojao se od 84 igrača iz 12 momčadi koji su bili podijeljeni u 4 poduzorka prema kriteriju igračkog mjesta – vanjski igrači, krila, kružni napadači i vratari. Svaka momčad odigrala je jednu ispitnu utakmicu (2 x 20 minuta). Promatrali smo parametre cikličkih kretnih aktivnosti igrača na različitim igračkim mjestima, dakle, u svakoj se momčadi bilježio ekstenzitet i intenzitet kretanja dva krila, tri vanjska igrača, jednoga kružnog napadača i jednog vratara. Utakmice su se igrale u relativno kontroliranim uvjetima.

Uzorak varijabli obuhvaća cikličke kretne strukture po definiciji. Utvrdili smo ekstenzitet svih cikličkih aktivnosti, postotak zastupljenosti pojedine brzinske kategorije (ukupno 4 – kriterij: brzina kretanja) u ukupnom opsegu kretanja te prosječnu brzinu kretanja.

Podaci o opterećenju igrača u rukometnoj utakmici prikupljeni su računalno podržanom metodom automatskog praćenja igrača pomoću sustava SAGIT (Perš i dr., 2002).

Izlazni podaci o cikličkim kretnim aktivnostima obrađeni su izabranim deskriptivnim statističkim metodama iz programa Excel i SPSS. Razlike u ekstenzitetu i intenzitetu cikličkih kretnih aktivnosti utvrđene su multifaktorskom analizom varijance. Koristile su se apsolutne vrijednosti za prehodane i/ili pretrčane udaljenosti (metri), kao i prosječna brzina (m/s), dok se za utvrđivanje količine kretanja određenim intenzitetom koristio postotak vremena koje je pojedini igrač proveo u određenoj brzinskoj kategoriji.

Provedena je i komparativna (post-hoc) analiza u kojoj su uspoređeni podaci o kretanju igrača na pojedinim pozicijama kako bi se ustanovilo postoje li statistički značajne razlike. Zbog višestrukih usporedaba poslužili smo se Bonferronijevom korekcijom. Statistički značajnim smatrao se svaki rezultat na razini $\alpha < .05$.

Rezultati

Statistički značajne razlike dobivene su među skupinama igračkih mjesta s obzirom na prosječnu udaljenost prevaljenu tijekom utakmice. Najveću su udaljenost na utakmici istrčavala krila, zatim vanjski igrači pa kružni napadači, dok su vratari najmanje trčali. Razlike su dobivene i za prosječno vrijeme kretanja određenom brzinom za sve brzinske kategorije. U prvoj, najsporijoj, brzinskoj kategoriji zabilježene su statistički značajne razlike između sve četiri skupine igrača. Vratari su proveli najviše vremena u toj brzinskoj kategoriji, a slijedili su ih kružni napadači i krila. Statistički značajne razlike za drugu brzinsku kategoriju nisu zabilježene između skupina vanjskih igrača, krila i kružnih napadača, ali su se sve tri skupine značajno razlikovale od skupine vratara. Najveći postotak vremena provedenoga u trećoj brzinskoj kategoriji zabilježen je za krila i vanjske igrače (nisu se međusobno značajno razlikovali). Kružni napadači i vratari pretrčavaju kraće udaljenosti –

zabilježena je statistički značajna razlika između te dvije skupine igrača i dvije ranije spomenute skupine. U četvrtoj brzinskoj kategoriji zabilježene su značajne razlike među sve četiri skupine igrača. U toj su brzinskoj kategoriji krila provela najviše vremena, slijede ih vanjski igrači i kružni napadači, dok su vratari zabilježili najniži postotak vremena kretanja tom brzinom. Statistički značajne razlike pojavile su se između sve četiri skupine igrača i s obzirom na prosječnu brzinu kretanja – najbrža su bila krila, slijede ih vanjski igrači, kružni napadači pa vratari.

Rasprava i zaključci

S obzirom na različita igračka mjesta u rukometu te poslove i zadatke koje igrači na tim mjestima moraju obaviti tijekom utakmice, očekivale su se razlike u ekstenzitetu i intenzitetu cikličkoga kretanja igrača na različitim pozicijama. Očekivanja su ispunjena u gotovo svim varijablama.

Usporedimo li rezultate ovog istraživanja s rezultatima nekih prijašnjih istraživanja, možemo reći da smo dobili sličan doprinos pojedinih brzinskih kategorija ukupno prevaljenim udaljenostima u rukometnoj utakmici (Campbel, 1985; Al-Lail, 1996; Bon, 2001). Dobivene su i slične razlike među skupinama igrača na različitim igračkim mjestima s obzirom na ukupno pretrčane i prehodane udaljenosti (Cuesta, 1988; Bon, 2001).

S aspekta cikličkih opterećenja u rukometu, a na temelju dobivenih rezultata, mogli bismo trenerima dati neke preporuke za fizičku pripremu rukometaša. Najmanje 3-4% ukupnog vremena pojedinog treninga (od 90 do 120 minuta) za vanjske igrače, kružne napadače i krila trebalo bi posvetiti vježbama trčanja maksimalnom brzinom, a najmanje 10-14% vježbama trčanja srednjim intenzitetom. S gledišta cikličkih aktivnosti, preostalo vrijeme može se provesti u vježbama trčanja niskim intenzitetom ili u hodanju i stajanju. Naravno, opći plan i program treninga poklanja naročitu pozornost opterećenjima koja proizlaze iz trčanja maksimalnim intenzitetom i povezuje ih s treninzima i vježbama i drugih usmjerenja. Međutim, čini se kako u suvremenom rukometu, koji je bitno određen promjenama pravila igre, ostaje sve manje prostora za rad niskog intenziteta. Trenažni programi moraju uključivati sve više visokointenzivnih aktivnosti i cikličkog i acikličkog tipa. Valja smanjiti opseg manje intenzivnih cikličkih aktivnosti i koristiti ih kao relativan predah. Taj pristup treningu nešto je drugačiji u treningu vratara. U usporedbi s igračima na drugim igračkim mjestima, vratari na utakmici izvode vrlo malo cikličkih aktivnosti. Stoga bi bilo racionalnije da se u trening vratara uvede više acikličkih specifičnih vježbi, svojstvenih njihovoj natjecateljskoj aktivnosti, a smanji opseg cikličkih aktivnosti.