

VARIOUS AGE CATEGORY – RELATED DIFFERENCES IN THE VOLUME AND INTENSITY OF THE LARGE-SCALE CYCLIC MOVEMENTS OF MALE PLAYERS IN TEAM HANDBALL

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The aim of this study was to identify differences in the volume and intensity of large-scale cyclic movement activities performed by handball players of three age categories – cadet men (aged between 15 and 17 years), junior men (aged between 17 and 20 years) and senior men (aged 20 years or over). For this purpose six experimental model matches (2×20 min), played by the Slovenian male handball teams, were analyzed. The sample consisted of 84 players of twelve teams (average age 20.26 ± 4.28 yrs; average height 182.51 ± 6.59 cm; average body mass 80.61 ± 10.37 kg) and was divided into three sub-samples by age (cadet men, junior men and senior men). The collection of large-scale cyclic movement data in a handball match was based on the computer-aided automatic tracking method SAGIT (Ljubljana, Slovenia) based on computer vision. The data output on large-scale cyclic movements obtained by the SAGIT program were processed by selected descriptive statistical methods. There were statistically significant differences between different age categories in terms of the volume of the total distances walked and run during the matches. The greatest distance was achieved by senior men, followed by junior men and cadet men. In all analyzed age categories the volume of total distances was greater in the first than in the second half of the match. Statistically significant differences also appeared in the average share of time recorded in all speed classes (SC – speed class), except for the second one (2nd SC). In the 1st SC some statistically significant differences were seen between cadet men and senior men as well as between cadet men and junior men, while there were none between junior men and senior men. In the 3rd SC statistically significant differences appeared between all of the analyzed age categories. Similarly to the 1st SC there were statistically significant differences between cadet men and senior men as well as cadet men and junior men in the 4th SC, while no differences were seen between senior men and junior men. In view of the different age categories of handball players, we expected some differences in the analyzed variables, as the athletes belonging to older categories are biologically more mature and are subjected to functional training for a longer time. That reason enables them to perform more large-scale cyclic activities during a match and spend a higher percentage of time in higher speed classes.

Keywords: Team handball, time and motion analysis, large-scale cyclic movements, age categories.

INTRODUCTION

Handball is a team sport in which the players of the two opposing teams alternately take the role of either attackers or defenders, depending on the criterion of possession of the ball. The aim of the team during the attack is to play the ball past or through the opposing team (Šibila, 2004). Due to advances in information and video technology the analyses of various activities and the loading of individual players, performing in game contexts, are ever more diversified and thorough. The purpose of such analyses is to improve the comprehension of factors determining the performance capability of a whole team or also individual contribution to team effort (Reilly, 2001).

The intensity and volume of work-rate or loading in handball are very heterogeneous. In a handball match

acyclic (intermittent) activities (passing the ball, various kinds of shots, jumps, etc.) occur along with the player's cyclic movements (running, walking, moving sideways, etc.). In handball the loading of players is a combination of both, cyclic movements and acyclic activities. Therefore, during the course of play, the work-rate of loading, which may vary in intensity and volume, alternates continuously with periods of relative rest, i.e. standing or slow walking. Large-scale cyclic movements are fundamental because they allow the player to move across the court area in two dimensions. They include walking and running without a ball as well as dribbling the ball when walking or running (Bon, 2001).

The type, intensity and duration (or distance) of movements and activities performed can be observed by time-motion analysis. Numerous studies have used

time-motion analysis to access the demands of soccer players and referees (Ali & Farraly, 1991; Krunstrup & Bangsbo, 2001; Krunstrup, Mohr, & Bangsbo, 2002; Reilly & Thomas, 1976), rugby players (Coutts, Reaburn, & Abt, 2003; Deutsch, Maw, Jenkins, & Reaburn, 1998) and other sports. Also in team handball in recent years the researchers have tried to analyze the volume and intensity of the large-scale cyclic movements of handball players by using different methods and samples. Cuesta (1988, in Cardinale, 2000) analyzed cyclic movements of the players of the Spanish teams who played different positions in the attack. The author did not describe the methodology he used in collecting data. He established that the left outside players on average ran a distance of 3464 ± 256 meters, the right outside players 2857 ± 189 , left wings 3557 ± 311 , right wings 4083 ± 286 and pivots 2857 ± 145 meters. The above data shows that the wings on average cover a greater distance in the attack compared to other playing positions. By means of a video analysis Al-Lail (1996) established the volume and frequency of large-scale cyclic movements by using a sample of eight Kuwaiti national team players. His sample of variables included five types of movements (walking, slow running, sprint, backward running, sideway movements) as well as the share of movements with the ball and without it. The total distance covered by all types of cyclic movements with and without the ball averaged 2478 ± 224 meters, of which walking accounted for 620 ± 88 meters, running 707 ± 134 meters, sprint 451 ± 162 meters, running backwards 158 ± 73 meters and sideways movements for 540 ± 123 meters. The analyzed players on average played for 40 ± 7.2 minutes in a match. The bulk of the playing time, i.e. 54%, the players walked – with or without the ball (21.3 ± 5.4 minutes). On the basis of the results the author established, in the continuation, that the share of highly intensive activities (sprint) was relatively low, with results ranging between 2% and 4% of total playing time. After analyzing large-scale cyclic movements in an experimental match between two Slovenian premier-league teams, Bon (2001) established that players on average ran and walked a distance of 4790 m. Sprinting accounted for 7% of the playing time, fast running for 25%, slow running for 31% and walking or standing for as much as 37% of the playing time. As regards the distance covered by 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 cyclic activities by applying the same method as we used in our study.

The aim of our study was to identify differences in the volume and intensity of large-scale cyclic movements performed by the players of three age categories – cadet men (aged between 15 and 17 years), junior men (aged

between 17 and 20 years) and senior men (aged 20 years or over).

MATERIALS AND METHODS

The sample of subjects consisted of 84 male handball players of twelve teams (average age 20.26 ± 4.28 yrs; average height 182.51 ± 6.59 cm; average body mass 80.61 ± 10.37 kg) and was divided into three sub-samples by age – cadet men (average age 16.14 ± 0.76 yrs; average height 178.82 ± 6.74 cm; average body weight 73.86 ± 12.99 kg), junior men (average age $19.29 \pm .98$ yrs; average height 181.93 ± 5.90 cm; average weight 81.07 ± 7.11 kg) and senior men (average age 25.36 ± 3.03 yrs; average height 186.79 ± 4.45 cm; average weight 86.89 ± 4.78 kg). The subjects were members of four cadet teams, four junior teams, and four senior teams. The data on the work-rate of the loading of male handball players during a match were collected from six model matches in the categories of cadet men, junior men and senior men. In each category two matches were played and analyzed, 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 environmental conditions were standardized: the playing time for all the games was 2 times 20 minutes, all the teams played a 5-1 zone defense, 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 and matches. Due to the fact that obtaining and processing data with the SAGIT system is complex and time-consuming (Bon, 2001; Perš, Bon, Kovačič, Šibila, & Dežman, 2002), we were forced for practical reasons to shorten the playing time.

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

The collection of data on the large-scale cyclic movements of players in handball matches was based on a computer-aided automatic tracking method with the SAGIT (Ljubljana, Slovenia) system (made by Perš et al., 2002). It is based on the computer vision methods. 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 the tracking of players while

crossing the center of the court. Once the matches had been recorded, the video-recordings were digitized using the MiroVideo DC30 + video digitizer hardware with a resolution of 768×576 at a 2 MB/sec data rate. The captured images were synchronized 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 large-scale cyclic movements obtained from the SAGIT program were processed by selected descriptive statistical methods. The differences in the volume and intensity of large-scale cyclic movements were established by a multi-factor analysis of variance. When establishing these differences, absolute values were used for the total of distances run and walked, whereas for the volume of movement in the individual speed class the average share of time spent in a certain speed class was used. The data of total distances run and walked during the matches were rounded off by five metres accurately, while the system SAGIT performances had certain error (Perš, Bon, & Kovačič, 2001).

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

TABLE 1

The variables used for the evaluation of the volume and intensity of the cyclic movements in a handball match

VARIABLE	DESCRIPTION OF VARIABLE	UNIT
S (distance)	Total of all distances run/or walked in a match	m
First speed class (1 st SC)	Percentage of time spent in the 1 st SC (standing still or distances run/or walked at speed up to 1.4 m/s)	%
Second speed class (2 nd SC)	Percentage of time spent in the 2 nd SC (running at a speed of 1.4 to 3.4 m/s)	%
Third speed class (3 rd SC)	Percentage of time spent in the 3 rd SC (running at a speed of 3.4 to 5.2 m/s)	%
Fourth speed class (4 th SC)	Percentage of time spent in the 4 th SC (running at a speed above 5.2 m/s)	%

Fig. 1

User interface of the module for analysing and tracking



RESULTS

TABLE 2 shows the absolute values of all the distances walked and run during the matches played and the percentages of time the players of different age categories spent in individual speed classes. The senior men achieved the greatest volume of movements, as well as the highest intensity of movements in the 3rd and the 4th speed classes. According to the volume of movements, then follow the groups of junior men and cadet men. Cadet men achieved the highest average percentage of movement in the 1st speed class.

TABLE 2

Volume and intensity of the large-scale cyclic loading of players as regards the different age categories

	CADET MEN	JUNIOR MEN	SENIOR MEN
TRD	3055 ± 465	3300 ± 275	3505 ± 285
1 st SC	67%	62%	60%
2 nd SC	23%	23%	21%
3 rd SC	8%	12%	15%
4 th SC	2%	3%	4%

Legend: TRD – total run distance; 1st SC – first speed class; 2nd SC – second speed class; 3rd SC – third speed class; 4th SC – fourth speed class

The results of analysis of variance in the TABLE 3 showed that there were statistically significant differences between the cadet men, junior men and senior men in terms of volume of the total distances run ($p = .000$) and the percentage of time in the first, third and fourth speed class ($p = .000$). It was only in percentage of time in the second speed class, that there were no statistically significant differences ($p = .673$).

TABLE 3

Analysis of the variance of total run distance, the percentage of distances run in individual speed classes (SC) and average speed of movement by category

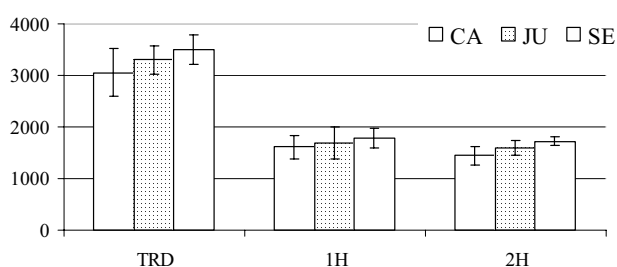
	F	p
TRD	20.268	.000
1 st SC	11.669	.000
2 nd SC	.399	.673
3 rd SC	23.832	.000
4 th SC	41.495	.000

Legend: TRD – total run distance; 1st SC – first speed class; 2nd SC – second speed class; 3rd SC – third speed class; 4th SC – fourth speed class; F – coefficient F; p – statistical significance of coefficient F

In the continuation, the nature of these differences is explained by a more detailed comparative analysis. Fig. 2 shows the average total distances run or walked by players of different age categories during the entire match and both of the half times.

Fig. 2

Volume of large-scale cyclic movements performed by players of different age categories



Legend: CA – cadet men; JU – junior men; SE – senior men; TRD – total run distance, 1H – 1st half time; 2H – 2nd half time

The average of all the distances walked and run were as follows, by age category: 3055 ± 465 m (CA), 3300 ± 275 m (JU) and 3505 ± 285 m (SE). The difference between the highest and the lowest value was 445 m. In all three categories the average distance covered in the first half (CA – 1615 ± 225 m, JU – 1700 ± 310 m and SE – 1780 ± 185 m) was higher than in the second half (CA – 1445 ± 180 m, JU – 1595 ± 135 m and SE – 1725 ± 90 m).

TABLE 4

Comparative analysis of variance between the group of players of different age categories in terms of volume of total distance walked or run

CATEGORIES		AV. DIFF.	S. E.	p
CA	JU	-238.32	57.07	.000
	SE	-443.89	57.07	.000
JU	CA	238.32	57.07	.000
	SE	-205.57	57.07	.002
SE	CA	443.89	57.07	.000
	JU	205.57	57.07	.002

Legend: CA – cadet men; JU – junior men; SE – senior men; AV. DIFF. – average differences; S. E. – standard error

The average distance covered by senior men was by 443 m and as much as 205 m greater than those of junior men and cadet men (TABLE 4). The average difference between junior men and cadet men was 238 m. The comparative analysis of variance revealed statistically significant differences between all age – related groups in terms of total distances walked or run throughout the match.

TABLE 5

Comparative analysis of variance between the group of players of different age categories shown as the percentage of time spent in the first speed class (1st SC)

CATEGORIES		AV. DIFF.	S. E.	p
CA	JU	5.0143	1.0616	.000
	SE	6.6054	1.0616	.000
JU	CA	-5.0143	1.0616	.000
	SE	1.5911	1.0616	.415
SE	CA	-6.6054	1.0616	.000
	JU	-1.5911	1.0616	.415

Legend: CA – cadet men; JU – junior men; SE – senior men; AV. DIFF. – average differences; S. E. – standard error

TABLE 5 shows the results of the comparative analysis of variance between the groups of players in different age categories expressed as the percentage of time spent in the first speed class. The results show statistically significant differences between the cadet men and the senior men as well as between the cadet men and junior men. The cadet men on an average recorded a 5% higher share of the first speed class than the junior men ($p = .000$) and a 7% higher share than the senior men ($p = .000$). The analysis of variance in which junior men and senior men were compared does not confirm any statistically significant differences in the share of the first speed class throughout the match ($p = .415$).

In the first speed class the achieved average values in the first and the second halves and in the entire match in all categories ranged between 60% (senior men) and 67% (cadets) (TABLE 2). Differences between the first

and the second halves also occurred. In the second half the share of the run or walked distance in the 1st SC was higher in all categories. The greatest differences were seen with junior men.

TABLE 6

Comparative analysis of variance between the group of players of different age categories shown as the percentage of time spent in the second speed class (2nd SC)

CATEGORIES		AV. DIFF.	S. E.	p
CA	JU	.127	.743	1.000
	SE	1.580	.743	.111
JU	CA	-.127	.743	1.000
	SE	1.454	.743	.163
SE	CA	-1.580	.743	.111
	JU	-1.454	.743	.163

Legend: CA – cadet men; JU – junior men; SE – senior men; AV. DIFF. – average differences; S. E. – standard error

There are no substantial deviations between the age categories in the average shares of the second speed class. The highest average shared in the entire match was achieved by the cadet men and junior men – 23%, followed by senior men – 21% (TABLE 2). A higher share in the second speed class was recorded with junior men and senior men in the second half of the match, while cadets saw a decrease in the above mentioned values in the second half.

The comparative analysis of variance show that there were no statistically significant differences in the average shares of the second speed class in the entire match between individual categories (TABLE 6). On average the cadet men achieved only a 0.1% higher share of the second speed class compared to junior men ($p = 1.000$) and a 1.6% higher share than senior men ($p = .111$). The analysis of variance does not confirm any statistically significant differences between the junior men and senior men in the share of the second speed class in the entire match ($p = .163$).

TABLE 7

Comparative analysis of variance between the group of players of different age categories shown as the percentage of time spent in the third speed class (3rd SC)

CATEGORIES		AV. DIFF.	S. E.	p
CA	JU	-3.709	.639	.000
	SE	-6.655	.639	.000
JU	CA	3.709	.639	.000
	SE	-2.946	.639	.000
SE	CA	6.655	.639	.000
	JU	2.946	.639	.000

Legend: CA – cadet men; JU – junior men; SE – senior men; AV. DIFF. – average differences; S. E. – standard error

The age-related differences between all analyzed groups of players in shares of the time spent in the third speed class in the entire match were statistically significant ($p = .000$) (TABLE 7). On average the above mentioned shares are lower by 3.7% ($p = .000$), if cadet men are compared to junior men and by 6.6% ($p = .000$) if they are compared to senior men. The average differences between junior and senior men was 2.9% ($p = .000$).

Senior men achieved the highest shares of average values in the time spent in the third speed class, which was not the case in the first or second speed class. On average the third speed class accounted for 15% of the entire match. In the categories of both junior men and cadets the above stated shares in the entire match were substantially lower (junior men – 12%, cadet men – 8%).

TABLE 8

Comparative analysis of variance between the groups of players of different age categories shown as the percentage of time spent in the fourth speed class (4th SC)

CATEGORIES		AV. DIFF.	S. E.	p
CA	JU	-1.4125	.1466	.000
	SE	-1.6964	.1466	.000
JU	CA	1.4125	.1466	.000
	SE	-.2839	.1466	.170
SE	CA	1.6964	.1466	.000
	JU	.2839	.1466	.170

Legend: CA – cadet men; JU – junior men; SE – senior men; AV. DIFF. – average differences; S. E. – standard error

A comparative analysis of the variance of the three analyzed groups of players show some statistically significant differences between cadets and senior men ($p = .000$) as well as between cadets and junior men ($p = .000$) (TABLE 8). However, there were no differences between junior and senior men ($p = .170$). In all of the age categories the shares in this speed class are the lowest compared to other speed classes. The values range between 2% (CA) and 4% (SE).

DISCUSSION AND CONCLUSION

After analyzing the volume and intensity of large-scale cyclic movements we can establish that there exist differences between these three age groups of players during handball matches. The senior men achieved the greatest volume of movements, as well as the highest intensity of movements in the 3rd and the 4th speed classes. According to the volume of movements, then follow the groups of junior men and cadet men.

In view of the fact that the defense model was standardized (5-1 zone defense) and that the players in the phase of attack or defense were on specified playing positions, the possibility that these differences resulted from tactical characteristics of both teams playing was excluded. We presume that the principal reason for these differences lies in the player's capability of preserving a certain level of intensity. This is also proven by the fact that the difference between the distances run and walked by the senior-men teams in both halves was only 55 meters, while the relevant difference in the cadet category was 170 m.

The range of distance (2800-4800 m) reported previously (Al-Lail, 1996; Cuesta, 1988 in Cardinale, 2000), make comparison difficult, as the methods, playing level and duration of the matches in these previous studies were not reported. Comparing our result with that of Bon (2001), we can find similar share of the total work-rate as well as intensity speed classes during games, especially if we take under consideration that we used in our study the same methodology (SAGIT system) for collection and analyzing as Bon.

In view of the different age categories of the handball players, we expected some differences in the analyzed variables, as the athletes belonging to older categories are biologically more mature and are subjected to functional training for a longer time (Malina & Bouchard, 2004). That reason enables them to perform more large-scale cyclic activities during a match and spend a higher percentage of time in higher speed classes. Cadet men, being the youngest, differed from junior men and senior men in all of the discussed variables, except in the 2nd SC. The results of junior and senior men were slightly closer and did not differ in all variables. It is particularly interesting that junior men do not differ statistically significantly from senior men in terms of percentage of time spent in 4th SC. Biological development of most junior men (aged between 17 and 20) is nearly completed and, with an adequate training, the level of fitness of these athletes may be quite close to that of senior men (Šibila, 2004). Many junior men already take part in the training sessions of senior men and are modeling themselves on the absolute category from the individual and the team points of view. Smaller differences are probably the consequence of a shorter period of playing (2 × 20 minutes) compared to the official playing time of the category of senior men (2 × 30 minutes). Perhaps we expected to see somewhat different ratios between the cyclic movements of high and low intensity in the handball match owing to this shorter playing time, particularly with senior men. In all three categories 1st SC was predominant.

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 in-

tensities and of different duration (walking, jogging, cruising, sprinting, moving side-ways), handball players also have to perform many acyclic activities such as: shots at a goal, jumps, passing the ball, dribbling, falls and standing up. As a rule, these activities are carried out with high intensity and represent a substantial share of the player's work-rate in the match. Therefore, highly intensive running in the 3rd speed class (SC), and particularly the 4th (SC) is just one segment of the highly intensive loading in a handball match (Šibila, Vuleta, & Pori, 2004). The volume of less intensive activities or standing without additional acyclic loading actually represents a break between the highly intensive loading of the cyclic and acyclic types. Based on our findings we may prepare some instructions for handball players' conditioning, primarily from the point of view of cyclic loading.

In view of the modern model of handball, which has been substantially conditioned by a change of rules, it may be concluded that the time during which the players are subject to low- intensity loading has to be reduced. Already with cadets (or particularly with them) the training methods have to include a large number of highly intensive activities of both large-scale cyclic and acyclic types. The volume of less intensive cyclic movements has to be reduced and these should only be used as a relative break.

An effective training plan must be based upon intermittent drills in which handball players have to perform different motions with different paths/movements at the highest intensity possible, followed by lower intensity periods. General drills can be easily developed using cones, circles, small obstacles and small circuits, but, what is most important, game-like drills need to be used in training.

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- kadeti (chlapci ve věku mezi 15 a 17 lety), junioři (muži ve věku 17 až 20 let) a senioři (ve věku 20 let a více).
- Pro tento účel bylo analyzováno šest experimentálních modelových zápasů (2 × 20 minut), odehraných slovinskými mužskými házenkářskými družstvy. Vzorek sestával z 84 hráčů ve dvanácti týmech (průměrný věk 20,26 let ± 4,28 let; průměrná výška 182,51 cm ± 6,59 cm; průměrná tělesná hmotnost 80,61 kg ± 10,37 kg) a byl rozdělen do tří dalších podskupin podle věku (kadet, junior a senior).
- Soubor údajů širokého spektra cyklických pohybů v zápase házené byl získán metodou SAGIT (Ljubljana, Slovinsko), založenou na počítačovém zobrazování. Takto získané údaje byly zpracovány vybranými deskriptivními statistickými metodami. Zjistili jsme statisticky významné rozdíly mezi různými věkovými kategoriemi v objemu celkové vzdálenosti, kterou ušli a uběhli během zápasů. Největší vzdálenost byla dosažena skupinou seniorů, následně juniory a poslední byli kadeti. Ve všech analyzovaných kategoriích byly celkové vzdálenosti větší v první polovině zápasu než ve druhé polovině.
- Statisticky významné rozdíly se rovněž objevily v průměrném podílu času zaznamenaném ve všech rychlostních třídách, kromě druhé rychlostní třídy. V první rychlostní třídě byly některé statisticky významné rozdíly spatřeny mezi kadety a seniory a rovněž mezi kadety a juniory, zatímco mezi juniory a seniory nebyly zaznamenány žádné rozdíly. Ve třetí rychlostní třídě se objevily statisticky významné rozdíly mezi všemi analyzovanými věkovými kategoriemi.
- Podobně jako v první rychlostní třídě byly i ve čtvrté rychlostní třídě zaznamenány statisticky významné rozdíly mezi kadety a seniory a také mezi kadety a juniory, zatímco mezi seniory a juniory nebyly spatřeny žádné rozdíly.
- Se zřetelem k rozdílným věkovým kategoriím u hráčů házené jsme očekávali rozdíly v analyzovaných proměnných, protože sportovci patřící do starších věkových kategorií jsou biologicky více vyzrálí a jsou již delší dobu vystaveni funkčnímu tréninku. Z tohoto důvodu mají možnost vykonávat více cyklických aktivit ve velkém měřítku během zápasu a strávit větší procento času ve vyšší rychlostní třídě.

Klíčová slova: týmová házená, analýza času a pohybu, cyklické pohyby ve velkém měřítku, věkové kategorie.

**RŮZNÉ VĚKOVÉ KATEGORIE VE VZTAHU
K OBJEMU A INTENZITĚ ŠIROKÉHO SPEKTRA
CYKlickÝCH POHYBŮ HRÁČŮ
MUŽSKÉ HÁZENÉ
(Souhrn anglického textu)**

Cílem této studie bylo identifikovat rozdíly v síle a intenzitě cyklických pohybů ve velkém měřítku vykonávaných hráči házené ve třech věkových kategoriích –

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