ANALYSIS OF FEMALE HANDBALL PLAYERS' EFFORT IN DIFFERENT PLAYING POSITIONS DURING OFFICIAL MATCHES

Grega Karpan, Branko Škof, Marta Bon and Marko Šibila

Faculty of Sport, University of Ljubljana, Slovenia

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Abstract:

The aim of the present study was to establish the physiological workload that female handball players are exposed to in different playing positions during official matches. The research included fifteen HC Krim Mercator female handball team players. During the 2009/10 season, six matches of the Women's Regional Handball League were analysed. The results indicated that at the lowest monitored workload in the 50–59% range of maximum heart rate (HR_{max}) there were no statistically significant differences between groups of players in particular playing positions. Workload intervals of 60 to 69% and 70 to 79% HR_{max} showed statistically significant ($p<.05$) differences between goalkeepers and all the other groups of players; on average, goalkeepers spent more time in the low-effort zones than the other groups of players. Groups of goalkeepers (25min 44s±9min 40s) and backs (25min 36s±7min 24s) did not significantly differ with regard to the time players spent in the 80 to 89% HR_{max} interval. However, the previously mentioned two groups of players had significantly higher values ($p<.05$) in this interval than groups of pivots (19min 42s±7min 45s) and wings (15min 52s±8min 11s). In the highest-effort interval (90–100%), groups of wings (27min 28s±9min 20s) and pivots (35min 55s±12min 41s) reached significantly higher values ($p<.05$) than goalkeepers (4min 57s±4min 58s) and backs (19min 04s±9min 00s). Goalkeepers, in contrast, recorded significantly lower values than the other three groups of players. We can conclude that during the analysed matches pivots and wings showed the highest levels of effort, followed by backs. Due to markedly different physiological workloads, physical preparation for different playing positions should also be quite different. Coaches should use the results of this study in practice to make timely decisions on when to substitute players in different position in order to prevent possible drop in their playing efficiency.

Key words: *handball, physiological effort, official matches*

Introduction

Playing handball imposes on players an intermittent high-intensity workload that requires a combination of high aerobic and anaerobic capacities. Apart from technical and tactical skills, the physical preparedness of handball players is also extremely important (Kuchenbecker & Zieschang, 1992). Handball workloads of interval nature are combined of cyclic and acyclic activities and alternate with recoveries of different lengths (Karcher & Buchheit, 2014). So, during a match, workloads of higher or lower intensity and shorter or longer duration alternate with relative rest (recovery) in the form of walking or standing still (Buchheit, et al., 2009; Cardinale, 2002; Manchado, Hoffman, Navarro-Valdivielso, & Platen, 2007; Manchado, et al., 2013; Sichelschmid & Klein, 1986). Loading and the related physiological effort of handball players also depend on the type of defence system applied and players' roles in the game (Pori, 2003; Karcher & Buchheit, 2014). As a rule, acyclic activities are performed at high intensities and represent a substantial part of the players' workload. High-intensity running (sprints) is only a part of handball players' extremely intensive workload. The volume of lower-intensity cyclic activities or standing in place without additional acyclic loading, however, represents recovery between periods of high-intensity cyclic and acyclic workloads (Šibila, Vuleta, & Pori, 2004).

Based on game analysis, it can be claimed that at workloads typical of handball, all three ATP re–synthesis systems that supply energy to muscles are involved (Delamarche, et al., 1987). In numerous short sprints, shots at goal and sudden changes of movement direction anaerobic alactic power and capacity are involved. Attacks that last longer, frequent physical contact with the opposing team players and frequent fast-breaks require well-developed anaerobic lactic capacity. However, the fact that a large number of sub-maximum and maxi-mum intensity bouts of exertion require also well-developed general aerobic endurance must be accounted for (Buchheit, et al., 2009; Gorostiaga, Grana-dos, Ibanez, Gonzalez-Badillo, & Izquierdo, 2006; Karpan, 2011; Pori, 1998).

In competitive sports, heart rate is a fairly common parameter for calculating the level of exertion during a match. In handball, research into levels of exertion during a match was mainly done using model matches. Thus, Bon (2001) determined that (during the model match designed with some control factors) players spent 47% of playing time in the effort zone below 70% of the maximum heart rate (HR_{max}), while the rest of the time (53%) was spent in the zone over 70% HR_{max}. Pori (2003) came to similar conclusions while studying differences in selected workload and effort variables of male wing players. Only a few studies were found in which the authors investigated HR in female top-level handball players during official tournament matches. Manchado et al. (2007) examined seven matches of the German women's national team (n=14) during the 2004 European Championship in Hungary. The study reported a mean HR of 85.8% of HR_{max} with a broad between-player variation – from 74.7 to 91.7%. In a more recent study, Manchado et al. (2013) analysed HR during a match between a female German First League team (n=11) and the Norwegian national team (n=14). The mean HR during the match was approximately 86% of HR_{max}, and for >65% of playing time it was higher than 85% of HR_{max}. With the exception of goalkeepers, who had lower values, no position-specific differences could be detected. Heart rate was also studied during six competitive matches in junior elite female handball players (U19) (Belka, Hulka, Safar, Weisser, & Samcova, 2014). The results show that, during the matches, players played at mean intensity of 89.6±3.6% of HR_{max}. They spent more than 83% of playing time per match in the high-intensity zone (>85%HRmax). Due to the lack of investigations addressing HR values during the competitive official matches of top-level female players, we decided to define the physical loads (using percentage of HR_{max}) that handball players experience during official matches. With the hypothesis that some differences exist (especially between the court players and goalkeepers), we attempted to establish the differences in exertion in different playing positions (goalkeeper, pivot, backs and wings). This information may empower coaches to plan effective training programmes and support a more rational substitution strategy of players during a match in order to limit a possible drop in physical/playing efficiency (Karcher & Buchheit, 2014).

Methods

Subjects

Our sample of subjects (N=15) were players of HC Krim Mercator, Ljubljana, Slovenia, who, during the 2009/10 season, participated in the regional league (age 22.8±5.3 years; body height 22.8±5.3; body mass 73.7±7.8 kg; VO_{2max} 46.4±2.4 ml/kg/min). On average players had 6.8±3.3 years of playing experience at the senior level. They were divided into four groups according to playing positions: two goalkeepers (age 28.5±9.2 years; body height 183.5±0.7 cm; body mass 74.8±2.1 kg; VO_{2max} 41.5±2.3 ml/kg/min), three pivots (age 23.3±6.9 years; body height 181.3±1.5 cm; body mass 84.4±9.3 kg; VO_{2max} 46.2±0.3 ml/kg/min), seven backs (age 22.4±4.8 years; body height 181.3±5.7 cm; body mass 72.3±4.3 kg; VO_{2max} 47.7±1.6 ml/kg/min), and three wings (age 19.3±1.5 years; body height 174±9.6 cm; body mass 65.8±3.3 kg; VO_{2max} 47±0.2 ml/kg/min).

Analysed matches

Data were collected from six regional league matches with elite participant teams from Austria, Slovenia, Croatia, Serbia and Montenegro. All matches were played at the beginning of the com-

Table 1. Players' basic anthropometric and physiological data

		Age (age)	BH (cm)	BW (kg)	MAV (km/h)	VO_{2max} ($mL{\cdot}min^{-1}{\cdot}kg^{-1}$)	HR_{max} (bpm)
Goalkeepers (2)	M	28.5	183.5	74.8	15.3	41.5	183.0
	SD	9.192	0.707	2.121	0.353	2.333	4.243
Pivots (3)	M	23.3	181.3	84.4	17.8	46.2	186.3
	SD	6.928	1.527	9.349	0.763	0.341	12.583
Backs (7)	M	22.4	181.3	72.3	18.3	47.7	193.1
	SD	4.760	5.677	4.295	0.556	1.619	6.362
Wings (3)	M	19.3	174.0	65.8	18.3	47.0	196.7
	SD	1.527	9.647	3.286	0.288	0.205	6.807
All Team (15)	M	22.8	180.1	73.7	17.8	46.4	191.1
	SD	5.354	6.140	7.837	1.175	2.425	8.417

Legend: body height (BH), body weight (BW), maximum aerobic velocity (MAV), estimate of maximum relative O_2 uptake (VO_{2max}), maximum heart rate (HR_{max}), mean (M); standard deviation (SD).

petitive period in September and October of the previously mentioned season. Out of the six analysed matches HC Krim won three matches and lost three. Totally, players of HC Krim scored 205 goals (on average 34.1 per match) and conceded 192 goals (on average 32 per match). At the end of the main round HC Krim won 3rd place (out of 6 teams), with a positive goal difference (344 vs 318) accomplished in six won and four lost matches. The average number of HC Krim attacks during the analysed matches was 59.5 per match. In all the analysed matches HC Krim and all the opponents applied the 6:0 zone defence system.

Table 2. Results of all the six analysed matches and number of Krim's attacks per match (in parenthesis)

	Teams and Results					
	Biseri	Budućnost	Hypo	Podravka	Biseri	Budućnost
Krim Mercator	44 : 28 (66)	27 : 28 (49)	33 : 31 (61)	41 : 43 (63)	34 : 24 (64)	26 : 37 (54)

The Ethics Committee of the Faculty of Sports, University of Ljubljana, approved this protocol in compliance with the Declaration of Helsinki, and the subjects provided informed written consent prior to participation.

Heart rate monitoring and determining the level of effort

Before the experimental period, the subjects performed 30-15_{IFT} field endurance test (Buchheit, et al., 2009; Cambel, 1985). This is an intermittent fitness test performed on the handball court: 30 seconds of running and 15 seconds of rest. The subjects ran at a pace dictated by an audible signal. The running speed increased with each repetition and the runners persevered running until volitional exhaustion or so long as they were capable of running the specific distance foreseen in the interval. The subjects wore heart rate monitors. The highest HR obtained at the end of the test was used as HR_{max} reference for further calculations. This test also helped us to determine maximum aerobic velocity (MAV), which we used to estimate maximum oxygen uptake according to the formula: VO_{2max} (ml/min/kg) = 28.3 - 2.15*G - 0.741*A - 0.0357*P + 0.0586*A*V + 1.03*V, where individual symbols stand for: gender (G) (1=male, 2=female); age (A), body mass (P) and terminal velocity (V) reached by players during the 30–15_{IFT} field endurance test (Buchheit, et al., 2009; Cambel, 1985). To monitor HR, telemetry technology was used (Polar Team System 2, Polar Electro OY, Kempele, Finland).

Individual playing time (the time span when an individual player was active on the court) was considered. The time when the game was stopped and when a player was not active on the court due to a substitution, suspension or injury (all inactive time periods) was excluded from the HR analysis. For each playing position, individual playing time (and HR recorded during these periods) of all those players who played in the particular position were summed. Absolute and relative HR values and data regarding HR zones of the subjects were monitored. Relative level of effort was determined by the percentage of HRmax (% effort = (workload HR/ HRmax)×100). On the basis of the determined effort level, following Póvoas et al. (2012), HR during a match was classified into five levels of physiological effort (50–59%, 60–69%, 70–79%, 80–89%, and 90–100% of the maximum HR). Heart rate zone below 50% HR_{max} was ignored.

Heart rate data acquisition during the matches

The matches were always played by the same team (with regard to the lineup of the players) and according to the official IHF handball rules. At the beginning of each match, the observed players performed a standardized 30-minute warm-up protocol. During the matches, the coach switched players on each playing position based on the competitive needs and tactical requirements (just like he does at every official match). According to this, time spent on the court was not equal for all players. For further statistical analysis, we took into account only the data obtained during the player's presence on the court. Therefore, we used the sum of individual HRs for each playing position. The summarized measure used was the mean HR expressed by beats per minute (bpm) and its equivalent as a percentage of HR_{max} ($\%HR_{max}$).

Statistical analysis

For data processing, we used the SPSS 18.0 (Statistical Package for the Social Sciences) program package. We calculated basic statistical characteristics of the observed variables. By means of Kolmogorov-Smirnov test, the distribution normality of data about the length of time that the players of each group spent in every zone of effort was checked. In some cases, the normality of the distribution of data could not be confirmed. Therefore, in such cases the Kruskal Wallis test was used to determine differences between more than two groups of players. To determine differences between two groups, a Tamhane's *post-hoc* test was used. The threshold for statistical significance was set at $p<.05$.

Results

Table 3 shows basic statistical data about the time players spent in a particular physiological effort zone. The results of the Kolmogorov-Smirnov test for the normality of data distribution are also displayed.

To determine whether any significant differences existed among all four playing positions (goal-keepers, pivots, backs, and wings) in the time spent in a particular HR zone, Kruskal Wallis test was applied. The results are presented in Table 4.

In order to determine individual %HR differences among all four groups of players a series of Tamhane's *post-hoc* tests was applied. Results are presented in Table 5.

Figure 1 is a graphic representation of percentages of different effort levels expressed in the HR ranges for all four playing positions in the observed handball team.

Tables 4 and 5 show that at the lowest monitored workload in the 50 to 59% range of HR_{max} there were no statistically significant differences between groups of players in particular playing positions. Workload intervals of 60 to 69% and 70 to 79% HR_{max} showed statistically significant differences between goalkeepers and all the other groups of players; on average, goalkeepers spent significantly

Table 3. Total time players at different playing positions spent in a particular effort zone

PLAYING POSITION	Effort zone % HRmax	M (min·s)	SD (min·s)	MIN (min·s)	MAX (min·s)	Kolmogorov-Smirnov test
	50%–59%	0.24	0.33	0.00	1.28	.002
	60%–69%	5.43	4.27	1.12	12.55	.043
Goalkeeper	70%–79%	17.52	8.10	7.34	29.25	.200
	80%–89%	25.44	9.40	12.50	36.10	.200
	90%–100%	4.57	4.58	0.18	14.22	.128
	50%–59%	0.33	0.48	0.00	1.53	.000
	60%–69%	1.05	1.01	0.00	2.51	.000
Pivot	70%–79%	2.52	1.31	0.03	4.07	.510
	80%–89%	19.42	7.45	9.03	32.51	.156
	90%–100%	35.55	12.41	16.09	52.02	.055
	50%–59%	0.57	1.00	0.00	2.53	.000
	60%–69%	1.42	1.37	0.01	4.25	.000
Back	70%–79%	5.30	4.02	0.55	13.04	.051
	80%–89%	25.36	7.24	11.01	31.13	.200
	90%–100%	19.04	9.00	5.34	32.30	.200
	50%–59%	0.30	0.26	0.00	1.42	.006
	60%–69%	1.00	0.51	0.22	2.35	.014
Wing	70%–79%	4.22	3.40	0.33	12.06	.200
	80%–89%	15.52	8.11	2.29	28.48	.022
	90%–100%	27.28	9.20	5.18	34.38	.143

Legend: mean (M); standard deviation (SD); minimum value (MIN); maximum value (MAX).

Table 4. Results of Kruskal Wallis test

Effort zone % HRmax.	F	Sig.
50-59%	0.375	.771
60-69%	3.173	.030*
70-79%	19.989	.000*
80-89%	3.742	.015*
90-100%	8.684	.000*

"*" Differences significant at p<.05

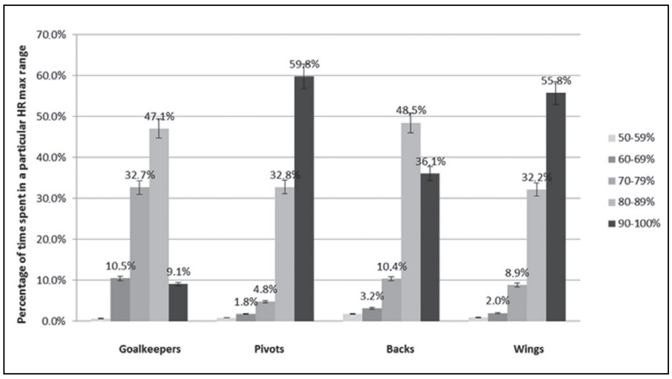

Figure 1. Graphic representation of effort levels expressed in heart rate ranges.

Table 5. Results of Tamhane's post-hoc test

Variable	Position	Position	Sig.	Position	Position	Sig.
50-59%[a]	Goalkeepers	Pivots	.978	Pivots	Goalkeepers	.987
		Backs	.948		Backs	1.000
		Wings	1.000		Wings	.978
	Backs	Goalkeepers	.948	Wings	Goalkeepers	1.000
		Pivots	1.000		Pivots	.978
		Wings	.886		Backs	.886
60-69%[b]	Goalkeepers	Pivots	.035*	Pivots	Goalkeepers	.035*
		Backs	.039*		Backs	1.000
		Wings	.020*		Wings	.998
	Backs	Goalkeepers	.039*	Wings	Goalkeepers	.020*
		Pivots	1.000		Pivots	.998
		Wings	.958		Backs	.958
70-79%[c]	Goalkeepers	Pivots	.000*	Pivots	Goalkeepers	.000*
		Backs	.000*		Backs	.592
		Wings	.000*		Wings	.998
	Backs	Goalkeepers	.000*	Wings	Goalkeepers	.000*
		Pivots	.592		Pivots	.998
		Wings	.891		Backs	.891
80-89%[d]	Goalkeepers	Pivots	.020*	Pivots	Goalkeepers	.020*
		Backs	1.000		Backs	.028*
		Wings	.023*		Wings	.996
	Backs	Goalkeepers	1.000	Wings	Goalkeepers	.023*
		Pivots	.028*		Pivots	.996
		Wings	.040*		Backs	.040*
90-100%[e]	Goalkeepers	Pivots	.000*	Pivots	Goalkeepers	.000*
		Backs	.001*		Backs	.026*
		Wings	.000*		Wings	1.000
	Backs	Goalkeepers	.001*	Wings	Goalkeepers	.000*
		Pivots	.026*		Pivots	1.000
		Wings	.030*		Backs	.030*

* Differences significant at p<.05

[a] No statistically significant differences
[b] G > P, B and W
[c] G > P, B and W
[d] G > P and W; B > W and P
[e] G < P, B and W; B < W and P

more time in the lowest effort zone than the other groups of players. Groups of goalkeepers and backs did not differ significantly as regards the time spent in the 80 to 89% HR_{max} interval. However, these two groups of players spent significantly more time in this HR interval than the groups of pivots and wings (the latter groups, however, did not differ significantly among themselves). In the highest effort interval (90–100%), groups of wings and pivots reached significantly higher time values than goalkeepers and backs (pivots reached the highest value of time spent in this interval: 35 min 55 s or 59.8%). Goalkeepers, in contrast, recorded significantly lower time values than the other three groups of players (4 min 57 s or 9.1%). Also, significant differences between backs, pivots and wings were obtained for this effort zone.

Discussion and conclusions

The results of our research allow us to conclude that during official matches there were statistically significant differences in the levels of effort between different groups of female handball players. These results were expected as similar differences have been reported by several authors who have recently analysed effort and workload in handball players (Delamarche, et al., 1987; Pori, Mohorič, & Šibila, 2009; Šibila, et al., 2004). In only one study authors were unable to confirm the differences in HR_{max} classes among different groups of players, with the exception of goalkeepers (Manchado, et al., 2013). Each particular playing position in handball requires performance of specific activities, which differ both in volume and intensity (Karcher & Buchheit, 2014). Goalkeepers perform relatively few cyclic activities

(2000±240 m walking or running) of different intensities (Pori, 2006), whereas during their team's attack phase of game they are exposed to almost no physical stress. Their defence activities are mainly acyclic, and their purpose is to prevent the opposing team from scoring (Pori, 2006). Intensity at which these activities are performed, however, is extremely high. Due to these specific features, the assessment of goalkeepers' effort should also be highly specific. They differ significantly from the other groups of players practically in all ranges determined by the percentage of HR_{max}. There were no differences only in the lowest effort range, between 50 and 59% HR_{max}. The goalkeepers spent significantly more time in the 60 to 69% and 70 to 79% ranges than the other groups of players. In the effort range between 80 and 89%, goalkeepers did not significantly differ from the group of backs, while both of the previously mentioned groups of players differed significantly from pivots and wings. The situation was radically different in the 90 to 100% workload range, where the goalkeepers achieved significantly lower time values than the remaining three groups of players. With short high-intensity workloads and sufficiently long recoveries between them, handball goalkeepers spend most of their playing time in moderate effort zones. Similar results (which were, logically, to be expected) are reported by researchers of other team games: goalkeepers show lower values of physiological parameters than players in other positions (Michalsik, 2008; Soares & Jose, 1994; Ziv & Lidor, 2011). As regards activities performed during a match, the players of the remaining three groups were much more similar. They performed many cyclic and acyclic activities. Nevertheless, they differed among themselves regarding the type, intensity and volume of these activities (Michalsik, 2011; Póvoas, et al., 2012). As a consequence, there were certain differences between them in their degrees of effort. The differences only occurred in the two highest ranges, while the differences in ranges 50–59%, 60–69% and 70–79% were not significant. The time proportion of effort in the 80–89% range was much higher in the backs than in the wings and pivots. The situation was reversed in the highest range of effort, where the wings and pivots achieved a significantly higher time proportion of effort than the backs. It must be emphasized here that the pivots had the longest duration of effort of this class (35 min 55 s, or 59.8% of playing time). We can conclude that in this playing positions the players are particularly highly taxed both in defence, where they are often marking the most prominent opposing players, and in attacks, where pivots are in constant physical contact with defenders who push them aside, hinder and hold them back (Michalsik, Aagaard, & Madsen, 2011). In this way, defenders try to cover the opposing team's pivots and prevent them from setting a screen. High-intensity acyclic activities performed by pivots in attack (screen settings, shots, falls, getting up and constant physical contact with defenders) are the activities that make them different from the other groups of players (Pori, Mohorič, et al., 2009). As they do not usually differ significantly from backs and wings in the volume and intensity of cyclic activities (Šibila, et al., 2004), we can conclude that it is acyclic activities in the phase of attack that, in fact, require a high time proportion of high effort in this playing position. As previously stated, the second longest duration of playing time (after pivots) in the 90-100% HR_{max} range per match (27 min 28 s, or 55.8%) was recorded for the wings. Apart from that, they also spent a large proportion of playing time in the 80–89% HR_{max} effort zone (15 min 52 s, or 32.2% per match. It is typical of wings that they regularly play both in attack and defence, and are not substituted on switches of game phases as often as other players (Karcher & Buchheit, 2014). It is also typical of wings that they perform the largest number of cyclic activities of all team members, i.e. they walk and run more than other players (Karcher & Buchheit, 2014). Wings also perform a large proportion of high-intensity cyclic activities, i.e. sprints (Pori, 2003). The reason for this is, above all, the primary playing position of wings in defence and attack, and their roles in fast-breaks and in retreating to the set-up zone defence. The distance they have to cover when switching from defence to attack and vice versa is the longest of all playing positions, and quite often it is pure sprinting. This means higher workloads and higher physiological effort.

Among backs, the in-match effort expressed in $\%HR_{max}$ was somewhat lower as the duration of the highest effort was only 19 min 4 s (36.1%), which was a statistically lower value than those of wings and pivots. For the backs, the longest duration of effort was recorded in the 80–89% HR_{max} range (25 min 36 s or 48.4% of playing time). We also have to take into account the fact that the backs were substituted more frequently and were thus offered more recovery time. Otherwise, backs are quite busy performing acyclic activities that are typically less intensive. We refer to a large number of passes and piston movements to the goal (Pori, Mohorič, et al., 2009). Less frequently, they also perform high-intensity acyclic activities such as dribbling and shooting at the goal. Researchers also report fewer cyclic activities and, above all, lower intensity than in the case of wings (Pori, Mohorič, et al., 2009).

However, we have to point out some limiting factors in the interpretation of our data. Our measurements were done 'in vivo', which of course narrowed the possibilities of controlling the factors that modify the players' level of effort. Player substitutions during matches, application of different defence strategies and time-outs are just a few of the most notable uncontrollable factors that influence the degree of players' effort during a match. In the case of the matches in question, the players in our analysis and all the opponents applied 6:0 zone defence strategy.

Our research showed that during official matc-hes players have to cope with a significantly higher effort than during the model handball matches studied by Bon (2001) and Pori (2003). The results are remarkably similar to other studies regard-ing women's top-level handball player's official matc-hes (Manchado, et al., 2007; Manchado, et al., 2013; Michalsik, 2008; Sahin, Hazir, Asci, & Acikada, 2010; Belka, et al., 2014). In these studies, players spent more than 70% of all playing time in the intensity zone above 85% of HR_{max}. Authors also reported broad variations among players. As the level of approximately 85% of HR_{max} could be considered as an indicator of anaerobic threshold (Helgerud, et al., 2007), we can speculate that during a match players spent most time near to this level. According to these data, a highly developed basic endurance capacity seems to be important for the female handball players in all playing positions (with the exception of goalkeepers) to optimize handball-specific performance during matches (Belka, et al., 2014). It has to be particularly emphasized that loading in handball training cannot be as precisely planned as, for example, in cyclic sports (Karcher & Buchheit, 2014). Nevertheless, for the development of handball abilities and despite different practices, the principle of individual approach (particularly by playing positions) in the process of handball training is of key importance. The authors of this paper share the opinion that interval training methods are favourably suitable from the endurance preparation aspect (Helgerud, et al., 2007; Pori, Pori, Zanoškar, & Šibila, 2009). Researchers have confirmed that short periods of high intensity loading with short rest periods in between have the greatest effect on aerobic strength (Helgerud, et al., 2007). When planning the training units focused on endurance development, it is desirable to select those exercises that include both the handball technical skills and the development of motor abilities (Pori, Pori, et al., 2009; Corvino, Tessitore, Minganti, & Šibila, 2014). Observing the individual HR during training ses-sions is highly recommended, particularly because there are research reports that indicate the lower level of effort during training sessions compared to matches (Sahin, et al., 2013). A large proportion of high-intensity work (e.g. 5% above and 5% below 85% of HR_{max}) during training sessions is recommended (Pori, 2003). With such an approach, coaches will achieve better player adaptation to the match demands. Our results do not allow full generalization. Despite these caveats, we think that the validity of data on players' effort during official matches more than compensates for these shortcomings. Specifically, the results reflect the actual state of a competitive environment and offer both theoretical starting points and practical advice. Both can be applied to further research work, planning and carrying out the training process and monitoring of handball matches.

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Correspondence to:
Grega Karpan
Ulica Koroškega bataljona 26, 1231 Ljubljana, Slovenia
Phone: + 386 31 204 719
E-mail: gkarpan@gmail.com

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