Primož Pori,
Maja Pori, *Faculty of Sport, University of Ljubljana, Slovenia*
Marko Zanoškar, *Handball club Prevent Slovenj Gradec*
Marko Šibila*, Faculty of Sport, University of Ljubljana, Slovenia*

THE ANALYSIS OF SOME PHYSIOLOGICAL VARIABLES IN TWO DIFFERENT TYPES OF HANDBALL TRAINING

1. Introduction

As a result of its dynamics, pace, unpredictability and the appeal, the game of handball is becoming increasingly more popular. Game analyses revealed that the handball players are constantly active during the game; their activities include running with or without changes of direction, running with different pace – from slow jogging to explosive sprints, high jumping, various types of landing, direct physical contact and challenges by the opponent. According to its structure, the game of handball is a complex type of sport (Šibila, 2004). Movements that occur during the handball game are either of cyclical and acyclic nature or the combination of both (Bon, 2001).

In order to successfully execute all the activities, which enable handball player and the team to score at least one goal more than the opponent and consequently win, a planned and systematic preparation is required, based on learning and upgrading of skills as well as a parallel development and maintaining of all for handball important psychomotor abilities. Studying the structure of loading in handball and the optimisation of sports training is very difficult due to the complexity of the game. One of the problems presents also the interval loading during the handball match, which occurs as a result of the changes in dynamics and the types of loading (Pori, 2003). Sports science has, together with other scientific areas and the coaches in practice, in the last few years studied these problems progressively more (Coutts, Reaburn, & Abt, 2003). Researchers mainly examined the structure and dynamics of loading during the matches. In general, researchers are interested in types of loads, which sportsman endures during the match, the frequency of their occurrence, as well as the relations between them (Cardinale, 2000; Kotzamanidis, Chatzikotoluas, & Giannakos, 1999; Šibila, Vuleta & Pori, 2004).

Data about the loading in handball form a foundation for studying the degree of effort and allow easier explanation of energetic mechanisms, which participate in supplying the body during the match. In order to evaluate the effort in handball, which could be defined as a response of the human body to particular loading, the response of some physiological and biochemical processes is being used. Thus the most often used methods are heart rate frequency (FS) and the level of blood lactates (LA) (Pori, Pori, Bon, & Šibila, 2007). Certain uncertainties have to be considered when explaining the results of effort variables; namely that the data, particularly the absolute values of heart rate frequency and blood lactate in interval loading could be misleading. Data about the absolute average values of heart rate frequency in specific parts of the game can lead to wrong conclusions; furthermore, they do not provide adequate information about the actual effort of the player during the match or training (Cardinale, 2000).

The problem of planning the training is extensive in handball. When focusing on endurance training and training of energetic systems, it can be stated that coaches use various methods and means for their development. When planning the training units, it is desired for better optimisation of trainings for development of energetic systems to select those exercises, which include both technical skills of handball and development of motor abilities. Different methods (continuous, interval, repeating) can be selected within the selection of situational activities.

The goal of the present study was to compare and analyse some physiological variables in two different types (methods) of handball training. The aim of the study was to find which energetic mechanisms dominate in two different types of situational handball trainings (interval, continuous) and what kind of effort do players experience under such loading. Enhanced understanding will contribute to better and more optimal construction of exercises, trainings and consequently also to better match results.

2. Methodology

2.1 Sample of measured subjects

Sample of measured subject was represented by twelve players of highest (1A) Slovenian handball league (average height 185 ± 5 cm, average weight 87 ± 4,3 kg, average age 22,25 ± 2,5 years). Four wing players, six outside players and two pivots were analysed. The average playing experience period was seven years. All the measured subjects were healthy and uninjured during the study.

2.2 Sample of measured variables

Table 1: *Selected variables, measured in the laboratory conditions*

	Abbreviation	**Description of the variable**	**Unit**
1.	HR_rest	Heart rate frequency at rest	beats/min
2.	HR_max	Maximum heart rate frequency	beats/min
3.	La_rest	Blood lactate levels at rest	mmol/l
4.	La_max	Maximum blood lactate levels	mmol/l
5.	VO2_max	Maximum oxygen consumption	ml/min×kg
6.	An_tres	Anaerobic threshold (absolute levels)	beats/min
7.	An_tres(%)	Anaerobic threshold (relative levels)	%

Table 2: *Selected variables, measured during the training*

	Abbreviation	**Description of the variable**	**Unit**
1.	HR_abs	Absolute heart rate frequency values (HR) during the training	beats/min
2.	HR_rel5	Relative HR values under 50% of maximum effort	%
3.	HR_rel5_7	Relative HR values between 50% and 70% of maximum effort	%

4.	HR_rel7_9	Relative HR values between 70% and 90% of maximum effort	%
5.	HR_rel9	Relative HR values above 90% of maximum effort	%
6.	HR_ rel±5%AP	Relative HR values 5% above and 5% below anaerobic threshold	%
7.	LA	Blood lactate levels after the exercises	mmol/l
8.	VO_2_max	Maximum oxygen consumption	ml/ min×kg

2.3 Data collection methods

Measurements were carried out in three parts. The first part of measurements was carried out in the laboratory for sports physiology at the Institute of Sport in Ljubljana, Slovenia. The subjects were measured according to the Nowacki procedure by using the running test with the increasing speed on the running treadmill (Woodway ELG6, ZDA) and with the use of spirometer (Mijnhardt Oxyco β, Netherlands) and heart rate frequency monitor. The Nowacki procedure is based on the principle of increased intensity. The first blood sample from the earlobe of measured subjects was taken at the beginning of the test. The speed of treadmill at the test was computer controlled (IMB PC AT486) and has been increasing by 0.33 ms-1 for every finished distance of 200 metres. The incline of the treadmill has been increasing at the same time and rate by 2% upwards. Measured subjects continued to run until they reached their maximum heart rate frequency, afterwards the second blood sample was taken from their ear lobe in order to analyse the blood lactate. Subjects continued to run for another five minutes at a low intensity and the decrease of heart rate frequency was monitored. Blood samples were processed with the use of analysing machine (Eppendorf EBIO plus, Germany).

The second part of measurements was carried out by the subjects themselves, as they were required to monitor their heart rate frequency at rest (FS_mir) for ten consecutive days on the radial artery of wrist first thing in the morning and also prior to every activity. They counted heart beats in a minute and recorded the result on special forms. An average heart rate frequency at rest was calculated for every individual from daily records.

The third part of measurements was carried out in two training days; each of them was of different type. Trainings were held in Slovenj Gradec sports hall at 5 pm. The complete Prevent club senior team participated at the training and the measured subjects trained as a part of the team. Trainings were logically constructed and included warm-up exercises, main activity exercises and cool-down exercises. Measured subjects were fitted with the Polar (s750i) heart beat monitors and (Cosmed K4b2) spirometers prior to the start of the training. The heart rate monitors and spirometers were switched on at the start of the training and switched off at the end of the training with the spirometers checking the oxygen consumption every 5 seconds. Blood sample from the ear lobe was taken at the end of each exercise. Blood sample collection and analysis were carried out according to the standard procedures and with the group of experienced measurers (health personnel at the Faculty of sport). Trainings were also recorded for further analysis of loading.

2.4 Description of analysed exercises

Training 1: *Exercises with characteristics of continuous activity*

	Exercise	Intensity	Duration
1.	Crossing in two groups at the half court line	medium	6 minutes
2.	Run-ins in two groups at the half court line	medium	6 minutes
3.	Standing shooting from the left (LZ) and right (RZ) back player position after the pass from the central back player (SZ)	high	12 minutes
4.	Standing shooting from the left (LZ) and right (RZ) back player position after the wide run and pass from left (LK) and right (BK) wing players	high	12 minutes

Training 2: *Exercises with characteristics of interval activity*

	Exercise	Intensity	Duration	Repetitions	Execution	Rest
1.	Handball obstacle course	medium	6 min	8	/	30 sec
2	Short period high intensity loading in groups of three	medium	6 min	4	30 sec	60 sec
3.	Repeated short term loading in groups of three	high	2 min	2	30 sec	15 sec
4.	Continuous shooting from the central back position after executing movement around the cone	high	40 sec	2	/	2 min

2.5 Data analysis

Following procedures and statistical methods were used to analyse and present the data:

1. Data from the heart rate frequency monitors were analysed with the use of Polar Precision Performance SW computer programme. Data were transferred from the monitors to the programme with the use of interface.

2. Karvonen model was used to calculate relative heart rate frequency, which is based on the calculation of heart reserve (FS % = 100 X (FS ─ FSmir)/(FSmax ─ FSmir).

3. Simple descriptive statistics was calculated for all the used variables. Differences between the average arithmetic mean values of physiological variables of the entire training were tested with the use of t-test for pairs. Statistically significant differences were accepted at the 5% alpha error (two-way testing).

3. Results and Discussion

Table 1 shows average values of physiological variables, measured at the loaded training on the treadmill in the laboratory (Nowacki procedure). The highest recorded average heart rate frequency was 186±5 beats/min; the average heart rate frequency at rest was 49±3 beats/min. The average anaerobic threshold of analysed players at the time of testing was 167.3±4 beats/min, representing in average 86.5±4.4 % of maximum heart rate frequency of measured subjects.

Table 1: *Average values of physiological variables, measured in the laboratory*

	HR_rest (beats/min)	HR_max (beats/min)	LA (mmol/l)	LA_max (mmol/l)	VO_2_max (ml/min×kg)	An_tres (beats/min)	An_tres (%)
Average values	49±3	186±5	1,1±0,2	7,8±2,1	57,6±4,3	167,3±4	86,5±4,1

Data about the physiological indicators of effort, recorded in the laboratory conditions, represented reference values of heart rate frequency in order to calculate relative heart rate frequency in training. By using the maximum and minimum heart rate frequency, a relative heart rate frequency of every individual could be calculated in particular point in the exercise. Data about the maximum oxygen consumption was used as an indicator of aerobic capacity of a player (Wilmore, & Costill, 2004). Certain degree of caution was needed when discussing the results of effort. The authors were aware that the data of effort variables, particularly the absolute values of heart rate frequency and blood lactates in interval loading, can be misleading. Data about the average absolute values of heart rate frequency in certain parts of training could lead not only to incorrect explanation, but also would not provide information about the actual effort of the players during the match (Cardinale, 2000). Only a rough evaluation of the effort can be given when comparing sportsmen with presumably similar maximum heart beat frequencies and frequencies at rest.

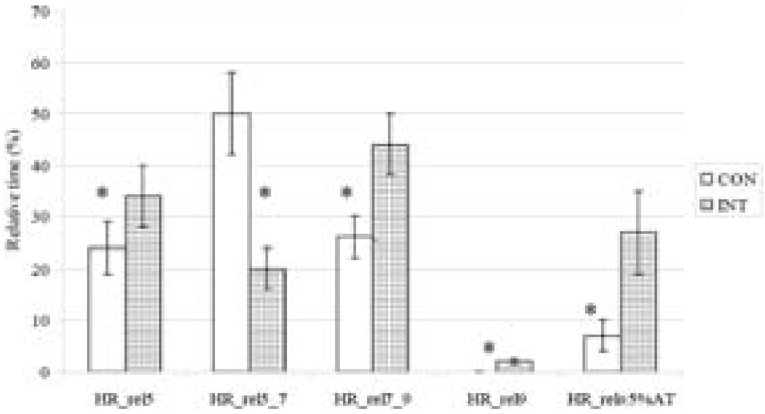
The analysis of physiological variables, measured on court in two different types of training, provided more useful information by revealing the differences in the level of effort. It revealed, that in the exercises with interval type activities (training 2), the average absolute heart frequency was 136±5,6 beats per minute, the average value of blood lactate was 2,65±0,5 mmol/l and the proportion of relative oxygen consumption was 64,7±3,7 % of the maximal oxygen consumption. All measured values of physiological variables were higher in comparison to the values for training with continuous type of activities (training 1). T-test for pairs also confirmed statistically significant differences (see Table 2).

Table 2: *Differences of average heart rate frequency values (absolute values), blood lactate values and maximum oxygen consumption for two different types of training*

	HR_abs (beats/min)	p(t)	LA (mmol/l)	p(t)	VO_2_max (ml/min×kg)	p(t)
Training 1	130±7,2	.000*	1,8±0,3	.000*	55,3±4	.000*
Training 1	136±5,6		2,56±0,5		64,7±3,7	

Key: p(t) – statistical significance of t-test coefficient

Loadings during the exercises with the continuous type of activities have in average resulted in higher response of relative effort of low (below 50% of maximum effort) and medium (between 50% and 70% of maximum effort) intensity (p = ,000) (see Graph 1).



** – statistical significance of t-test coefficient*

Graph 1: *Differences in average relative proportions of effort in two different types of training*

In contrast, the exercises with the interval type of activities revealed significantly higher average proportions of effort between 70% and 90% and above 90% of maximum effort. Average proportions of effort above 5% and below 5% of anaerobic threshold are also in average higher in the interval type of training (27±8 % of maximum effort) than in continuous type of training (7±3% of maximum effort).

A comparison of the results in the study of average proportions of effort during the handball matches (Pori, & Šibila, 2006) with the results of the present study revealed similarities in the average levels of effort between the interval type of exercises and the match game.

The review of analyses also revealed a fact that both types of training represent a relatively low level of effort for the players, compared to the research findings of the model matches (Pori, 2003). The average absolute heart rate frequency levels at the matches achieve values between 150 and 180 beats per minute and the most frequent level of relative effort is between 70% and 90% of maximum heart rate frequency, whereas the blood lactate levels do not exceed the concentration above the 5 mmol/l.

Available studies do not provide the information about the oxygen consumptions during the handball match. Values of the measured subjects in the present sample alerted that attention is required when setting the training load. It has to be particularly emphasised that loading in handball cannot be as precisely planned as for example in cyclical sports. Nevertheless, for development of handball abilities and despite different practice, the principle of individual approach in the process of handball training is of key importance. Authors share the opinion that the use of interval methods is more suitable from the endurance preparation aspect than the use of continuous methods. In order for a player to sustain the loading, good working of cardio-vascular system is required and the interval methods have a great influence on the working of this system. Researchers have confirmed that short period loading with short rest periods in between have the greatest effect on the aerobic strength. The products of anaerobic breakdown, which occur at intensive short runs, are a strong stimulator of breathing processes and result in increased oxygen consumption. If the intensity of runs is not too high, then the high oxygen consumption becomes stabilised (Wilmore, & Costill, 2004).

The research by Pori & Šibila (2006) revealed that the players execute in average 620 metres of movements with highest intensity per match. The authors have also recorded at the analysed matches in average 80 movements with the velocity above 5.2 m/s (highest intensity category), which in average were 7.7 metres long. These findings also speak in favour of interval loading when modelling suitable training loads. The selection of interval training methods also influences more suitable recruitment of muscle fibres. Due to the higher intensity achieved with interval training, higher proportion of type 2 muscle fibres participate in movement. Development of this type of muscle fibres is more suitable for handball game than the development of type 2 muscle fibres.

4. Conclusion

In summary of the results of the present study it can be said that the exercises with the continuous type of activities required less effort from handball players than exercises with the interval types of activities. In average the interval exercises are similar in effort to that established at the matches. Authors consider interval training easier in order to simulate the match conditions from the aspect of energetic demands on the players. Nevertheless, it has to be emphasised that players in the training process have different level of endurance preparation and the training stimulus needs to be adjusted to the physical preparation level of each individual with an aim of developing and upgrading desired abilities. The key importance in this is the principle of individual approach.

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THE ANALYSIS OF SOME PHYSIOLOGICAL VARIABLES IN TWO DIFFERENT TYPES OF HANDBALL TRAINING

The purpose of the research paper was to establish, which energetic mechanisms are dominant in two different types of situational handball trainings and what kind of effort the players experience under those charges. Chosen exercises in handball training were activities of interval and continuous nature. With the use of measurements both in the sports hall and in physiological laboratory, the heart frequency, values of blood lactate and oxygen consumption were monitored.The sample of measured subjects was represented by 12 senior players from different attacking playing positions in the first handball league (average age 22.25 ± 2.5 let). The results of the study revealed that in the interval type of exercises the average absolute heart frequency was 136 beats per minute, the average value of blood lactate was 2,65 mmol/l, the proportion of relative oxygen consumption was 64.7 % of maximal oxygen consumption, the biggest proportion in relative heart frequency (HR % = (HR - HRrest)/(HRmax - HRrest) was below 50 % and between 70% and 90 % of maximal strain. The players spent in average 27 % of the playing time in areas between 5 % under and 5 % above anaerobic threshold. In exercises of continual nature we established, that the average absolute heart frequency was 130 beats per minute, the average value of blood lactate was 1,8 mmol/l, the share in relative oxygen consumption was 55,25 % of maximal oxygen consumption, the biggest share in relative heart frequency takes up strain between 50 and 70 % of maximal effort. It can be concluded that in chosen situational handball exercises the dominant type of effort is aerobic – anaerobic. In average, the exercises of interval nature required more effort from handball players.