HEART RATE IN MAXIMUM AEROBIC EFFORT AND ANAEROBIC LACTACID CAPACITY IN FEMALE HANDBALL PLAYERS

Florin TROFIN[1*], Beatrice ABALAȘEI[1]

[1] "Alexandru Ioan Cuza" University, Faculty of Physical Education and Sport, Iași, Romania
*Corresponding author: florintrofin@gmail.com

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Abstract. *Physical training ensures the "dialogue" of the athlete with his or her body, with objects, partners, opponents or nature in the difficult conditions of performance. The athlete's will is a sine qua non attribute of training, the very high demands affecting sport performance. This quality must be seen in both its active aspect, of unleashing of energies and supporting the level of commitment, as well as passive, of abstinence, restraint, patience, bearing pain. The aim of the paper is to address the relationships established between the maximum heart rate achieved during an aerobic exercise test and anaerobic lactacid capacity in female handball players through efforts of will. The research analyses the results recorded on 15 female handball players from the first league of Romania (28.06 ± 3.99 years, 175.9 ± 6.58 cm, 71.11 ± 8.27 kg, 29.21 ± 2.45% body fat) following the VamEval test, in which heart rate was monitored, and the 8 x 10 + 10 m test. The monitored heart rate reached a percent of 98.33 ± 5.58 of the maximum, being assessed by the system used (Polar Team). There was a moderate correlation between maximum heart rate reached by the study subjects and lactate anaerobic capacity (r = 0.42), a closer relationship existing between heart rate and maximum oxygen consumption (r = 0.66). Therefore, a female handball player needs more aerobic than anaerobic endurance to be able to make intense efforts that are largely determined by will.*

Keywords: *heart rate, aerobic power, anaerobic lactacid capacity, handball.*

Introduction

The handball game is spectacular and popular by what it offers to the public: fast action, a relatively high number of goals, intense action between players, etc. In order to successfully play the game, specific skills are needed that involve optimal effort and proper technical skills to effectively perform the game tasks (Vărzaru, 2015).

The road to great performance is long. The training of children requires a careful approach to the components of sports training, taking into account the age and gender specificities, as well as the set goals (Mihăilă, 2015). At this level, the psychological approach to athlete development is important, and improving exercise capacity is an major factor in increasing self-esteem (Trofin, Abalașei, Drosescu, & Cojocaru, 2013), which will lead to a higher level of performance.

Throughout the world, women's handball is played by amateur and professional athletes, since 1976 (Montreal) being included in the Olympics programme (Clanton & Dwight, 1997).

The training of professional female handball players requires an advanced knowledge of the gameplay characteristics related to factors such as the physical and physiological ones, throwing speed, precision in execution, physical performance achieved during competitions, etc. (Lidor & Ziv, 2011). Knowing these aspects is beneficial for the technical staff to create the necessary advantage so as to approach the competition scientifically, an issue of great importance in professional competitions.

The performance of athletes is regularly assessed to see the progress they have made. Physical assessment can be done using test batteries specific to each type of effort, but taking into account possible limitations of the assessment tools (Michalsik & Aagaard, 2015). Physical tests can be conducted in the laboratory or the field, and their combination can be beneficial to show the competitive demands in relation to athletes. Meeting these demands is linked to the energy substrate used, which is determined by the combined means of testing.

The findings made after analysing the test results are likely to outline and guide the training of athletes for competitive games. Some studies have addressed the issue of physical training by implementing programmes to improve the physical factor (Jensen, Jacobsen, Hetland, & Tveit, 1997; Gorostiaga, Granados, Ibanez, Gonzalez-Badillo, & Izquierdo, 2006; Marques & Gonzalez-Badillo, 2006). The effort during the game is in a continuous dynamic determined by the new handball trends that lead to increasing anaerobic demands. The actual playing time is 40 minutes, containing sequential attack and defence actions carried out with great intensity. Game actions are around 50 during a game and, according to Boraczyński and Urniaż (2008) can last:

- up to 20 seconds in proportion of 17%;
- between 21 and 35 s, 60%;

- over 35 s, 20%.

Thus, the handball game involves the two major components: aerobic and anaerobic. Anaerobic effort is predominantly lactacid, which results in increased lactic acid production in the muscles. Anaerobic lactacid capacity is the potential of the athlete to sustain an exhausting effort under the conditions of using the energy substrate specific to anaerobic lactacid metabolism (Honceriu & Trofin, 2017).

The assessment of maximum oxygen consumption, which reflects the aerobic exercise capacity, can be done through various field and laboratory tests. Field tests follow the principle of progressively increasing exercise intensity, especially in the 20-m multistage shuttle run test (Aadland, Andersen, Lerum, & Resaland, 2018).

A precise indicator of aerobic exercise capacity is heart rate (HR). During a test for determining aerobic power, the maximum heart rate can be reached, which is induced by factors such as body mass index, smoking, or daily exercise effort (Miller, Wallace, & Eggert, 1993; Zavorsky, 2000).

Our study aims to determine the existence of a possible link between the maximum heart rate (HRmax) achieved during an aerobic power test and the anaerobic lactacid capacity of 15 professional female handball players. This connection can be due to the fact that the end of a test to determine maximum oxygen consumption is characterised by the transition to anaerobic effort for a short period of time (Nilsson & Cardinale, 2015). We believe that this aspect is related to the volitional capacity of the athlete.

Material and Methods

In our study, 15 female handball players aged between 20 and 33 were involved. Their experience in performance sport is 16.1 ± 4.03 years. All the subjects were part of a professional handball team from the first league of Romania.

Testing the research hypothesis required the assessment of the aerobic power and anaerobic lactacid capacity of the players. Physical tests were applied once, the data series being sufficient for statistical analysis. The assessment was made before the start of the competitive season.

Table 1 presents the morphofunctional characteristics of the group, including: age, height, body mass, body mass index (BMI), body fat, muscle mass and visceral fat.

These parameters were determined using a metal square and a Bosch GLM80 device – for height (Trofin, Honceriu, & Cojocaru, 2013), as well as an Omron BF511 body analyser for the other parameters.

Given that the players were to perform maximum tests and sports activity, they had the medical endorsement for physical effort. At the same time, they were informed of the purpose of the research.

Table 1. *Morphofunctional characteristics of the research group (mean ± standard deviation)*

Parameter	Value
age (years)	28.06 ± 3.99
height (cm)	175.9 ± 6.58
body mass (kg)	71.11 ± 8.27
BMI (kg/m2)	22,91 ± 1,49
body fat (%)	29.21 ± 2.45
muscle mass (%)	30.94 ± 1.31
visceral fat	3.93 ± 0.70

Anaerobic lactacid capacity

The anaerobic lactacid capacity was assessed indoors, on a wooden surface, in the sports hall where the team performed both the training and official games. During this test, all players were able to perform it.

For the test, we used a Tracktronix electronic timing system with 0.001-second resolution and 0.0001-second accuracy. The running distance was measured with a wheel ruler, and the chalk marks were used for the athletes to have precise landmarks. The results were recorded on individual sheets.

There are two lines (A and B) on the ground at a distance of 20 m from each other. Between them, a gate of the electronic timing system is placed in the middle of the distance. When ready, the athlete sprints from the starting line (A) to line B, passing through the photocell gateway. The Tracktronix system is set to “split” mode to record intermediate times. When reaching line B, the athlete steps on or crosses it and returns to line A continuing without interruption until they cover 8 times the distance between the two lines. The running speed will be maximal throughout the test, the athlete going to exhaustion after the assessment. At each passage through the photocell gateway, an intermediate time will be provided, which will be written on a result sheet.

The recorded results were processed to obtain the synthetic test parameters: T7 and (TMD/Tmin) x 100-100 (D%). T7 is the total travel time for the 140 m (distance monitored with Tracktronix) of the 20-m distance per round-trip. Running this distance in the shortest time possible reflects good agility and good anaerobic endurance of the athlete. D% is the percentage difference between the average times obtained for each run between the two lines (A and B) (TMD) and the shortest travel time for the seven sectors (Tmin). The higher the anaerobic lactate capacity of the athlete, the lower the D% value (Trofin, Honceriu, & Abalaşei, 2018).

The test can be performed once, and it can be resumed only when the energy substrate is restored and the metabolic waste is metabolised.

Maximum oxygen consumption

The test was performed in the same sports hall as the previous one. Two parallel lines were drawn on the ground at a distance of 20 meters. Prior to the start of the test, the players received Polar Team heart rate monitoring belts and began to warm up for the test. Heart rate monitoring is of high importance, providing the level of demand on the cardiorespiratory system.

The field test used to determine the maximum oxygen consumption (VO_2max) was the VamEval test, designed by researchers from the universities of Montreal and Bordeaux (Cazorla, Léger, & Marini, 1993). The method involves that the running speed of the athlete between two lines placed 20 m apart is dictated by sound signals. Initial running speed is 8.5 km/h, then progressively increases every minute by 0.5 km/h. When the athlete fails to maintain the required running speed, the level reached and implicitly the maximum aerobic speed (MAS) is recorded. Knowing the maximum aerobic speed, VO_2max can be determined by multiplying MAS by 3.5 (Trofin, Honceriu, & Cojocaru, 2013).

Polar Team records real-time heart rate, which has made it easier for us to determine the maximum heart rate achieved during the test.

Both assessments were performed on the same day, with a 30-minute break between them.

Results and Discussion

The individual data sheets subsequently formed the database of our study. The analysis software is GraphPad Prism 6, with which we calculated the statistical parameters needed to test the research hypothesis.

Our group of athletes obtained a maximum oxygen consumption of 50.18 ± 4.43 ml/kg/min, a result obtained by extrapolation from the VamEval test. Within the same test, heart rate reached 98.33 ± 5.58%. This demonstrates that the test used exerts maximum demands, but our players have resisted to the end.

The maximum oxygen consumption of female handball players was determined in other studies. A group of 181 juniors (14.12 ± 1.09 years; 3.41 ± 1.67 years of experience) developed a VO_2max of 45.47 ± 5.92 ml/kg/min (Zapartidis et al., 2009). Another study revealed a VO_2max of 49.6 ± 4.8 ml/kg/min in 83 handball players (25.4 ± 3.7 years, 175.4 ± 6.1 cm, 69.5 ± 6.5 kg and 7.2 ± 3.9 years of experience) from the first league of Denmark (Michalsik, Madsen, & Aagaard, 2015).

During the handball game, heart rate is maintained at about 85% of the maximum (Manchado & Platen, 2008).

In the result analysis, we applied a data-series correlation test (age, body mass, BMI, body fat, muscle mass, running time for the 140-m distance from the test 8 x 10 + 10 m (T_{140m}), D%, VO_2max and the percentage achieved in HRmax), resulting in the Pearson coefficients for paired data. The results are presented in Table 2. Evans (1996) presented the degree of significance of the correlation, according on the obtained coefficient (r): 0-0.19 – very poor correlation; 0.20-0.39 – poor correlation, 0.40-0.59 – moderate correlation, 0.60-0.79 – strong correlation, and 0.80-1 – very strong correlation.

Table 2. *Correlation between the research variables*

	Age (years)	Body mass (kg)	BMI (kg/m2)	Body fat (%)	Muscle mass (%)	T_{140m} (s)	D%	VO_2max (ml/kg/min)	% HRmax (%)
Age (years)		-0.019	0.032	-0.179	0.189	0.565	-0.268	-0.585	0.391
Body mass (kg)	-0.019		0.810	0.442	0.070	0.442	-0.124	-0.109	-0.309

	Age (years)	Body mass (kg)	BMI (kg/m2)	Body fat (%)	Muscle mass (%)	T_{140m} (s)	D%	VO_2max (ml/kg/min)	% HRmax (%)
BMI (kg/m2)	0.032	0.810		0.566	0.014	0.347	-0.227	-0.165	-0.050
Body fat (%)	-0.179	0.442	0.566		-0.806	-0.147	0.272	0.319	-0.243
Muscle mass (%)	0.189	0.070	0.014	-0.806		0.440	-0.479	-0.480	0.226
T_{140m} (s)	0.565	0.442	0.347	-0.147	0.440		-0.524	-0.719	0.291
D%	-0.268	-0.124	-0.227	0.272	-0.479	-0.524		0.393	**-0.422**
VO2max (ml/kg/min)	-0.585	-0.109	-0.165	0.319	-0.480	-0.719	0.393		-0.662
% HRmax (%)	0.391	-0.309	-0.050	-0.243	0.226	0.291	-0.422	-0.662	

Analysis of age-related results shows a moderate positive correlation with T_{140m} (r = 0.565); the correlation with maximum oxygen consumption (r = -0.585) has the same power, but it is negative. We note that both r values are close to the threshold of the strong correlation segment. Thus, it appears that with age, up to 33 years, the running speed decreases over long distances in the anaerobic lactate regime. The same happens with aerobic endurance, and reaching the maximum heart rate within a maximum test is an individual feature.

Body mass has a very close relationship with BMI (r = 0.810), which is normal given its inclusion in the index calculation formula. Connections are also established, at a moderately positive level, with body fat (r = 0.442), as well as with T_{140m} (r = 0.442). It seems that body mass can be increased in value by body fat and at the same time can reduce the speed of running over long distances.

As for BMI, besides the muscle mass, it is in a moderately positive relation to body fat (r = 0.566).

Body fat establishes a very strong negative relation with muscle mass (r = -0.806). A female athlete with high body fat will have low performance during exercise because her muscle mass will be low.

The muscle mass moderately positively correlated with the total running time for the 8 x 10 + 10 m test (r = 0.440), the running speed during the test being slowed down by a well-developed musculature. Negative moderate correlations show the anaerobic lactate capacity (r = -479), respectively the maximum oxygen consumption (r = -0.480). The specifics of the handball game have led to an improvement in the muscular potential under anaerobic lactacid working conditions. Instead, muscle mass can have adverse effects on aerobic endurance, lowering the capacity of players' aerobic glycolysis system.

T_{140m} moderately negatively correlated with D% (r = -0.524), both values being taken from the same test. A strong link is created with VO_2 max (r = -0.719), in the negative sense, a high peak oxygen consumption resulting in a good running speed under high acidosis conditions.

Our hypothesis has assumed that there is a connection between D% and % HRmax. The value of r = -0.422 indicates a moderately negative link, which means that female professional handball players can reach a maximum of 42% of the heart rate (Figure 1). This is not generally true, given the diversity of variables that cause to reach maximum physical demands. We consider one of them to be the will, which can be trained by the competitive character of the sports game.

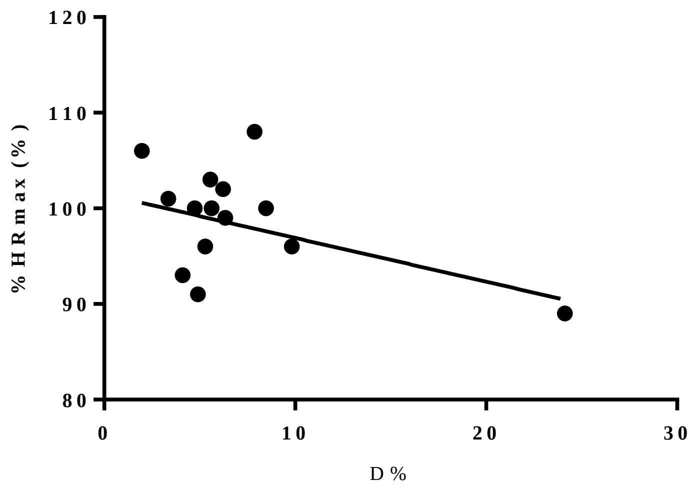

Figure 1. Linear regression of the data series

Conclusion

Body fat is a parameter that can negatively impact sport performance, directly influencing body mass and muscle mass, and indirectly affecting long-distance running speed, but also aerobic endurance.

Muscle mass has a positive effect on mechanical efficiency, sustained running being possible under anaerobic lactacid conditions, but it affects aerobic endurance.

High aerobic endurance may favour anaerobic lactacid capacity, especially running speed under the same conditions.

The research hypothesis has been partially confirmed by the analysis of the obtained results; perhaps the volitional peculiarities of the athletes have led to these results.

The topic can be developed and focused on male professional handball players or other sports to bring valuable information for those who seek it in the daily practice of sports training.

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