SELECTED PARAMETERS OF ANAEROBIC CAPACITY AMONG PLAYERS IN VARIOUS POSITIONS ON THE POLISH SUPERLEAGUE HANDBALL TEAM

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Key words: anaerobic capacity, interval training, handball

Abstract:

Introduction: An overview of the literature on the subject of handball indicates that today’s top-level handball is dominated by sequences of short-duration (5 – 20 seconds) intensive anaerobic physical efforts. Taking this data and the lack of scientific contribution describing the levels of the anaerobic capacity of top-level handball players into account, it seems essential to research this sphere of capacity in men’s Superleague teams.

Aim: The objective of the study is to evaluate the relative mechanical work (J/kg), peak power (W/kg), peak power production time (s) and peak power sustainment time (s) using Wingate tests performed on players in various positions.

Basic procedures: Research participants: 18 players on the Superleague handball team; average age of participants = 25.96±3.97 years old, average height = 192.76±7.21 cm, average body mass = 97.61±11.46 kg; average BMI = 25.84±1.92. The evaluation of anaerobic capacity was performed according to the 30-second Wingate test procedure, with the use of the Monark 824E cycle ergometer and MCE v5.0 computer software.

Results: The mean peak power of the research participants was 11.12±0.84 W/kg; mean work value – 254.56±16.92 J/kg; mean peak power production time – 4.82±0.82s; peak power sustainment time – 2.98±1.04s; fatigue index – 25.82±3.64%.

Conclusions: In the process of top-level handball training, it is necessary to pay more attention to the development of anaerobic endurance through the increased use of interval workloads.

Introduction

Power training is an essential factor on the road to sports championships. Taking the handball-match time into account – 60 minutes – it can be stated that the effort is based on aerobic potential, which is fundamental to shaping speed endurance [1]. Handball is a sport belonging to the group of endurance and speed sports disciplines [2]. The development of aerobic and anaerobic capacity is of particular significance in the training process. Both mechanisms to secure power for work are aimed at the continuous reproduction of adenosine triphosphate (ATP), and their activity depends on the duration and intensity of the physical effort [3].

One of the main ways of producing energy with the use of the anaerobic method is to reproduce ATP in reactions involving phosphocreatine. However, the supply of this compound in muscle cells is low, and only allows muscle work for a couple of seconds, however, the work can be performed at its peak rate [4]. The glycolysis process is another anaerobic method for producing energy, which involves glucose breakdown, and is related to the production of lactic acid. This way, muscles gain the power to work during short-duration physical efforts.
(about 1 minute) and during efforts of high and sub-maximum intensity. In the course of a game, the physical effort load is characterised by the repetition of short-duration physical effort of high intensity, such as running, jumping and throwing, which are separated by periods of low-intensity physical efforts [5]. Successful performance in handball largely depends on the progress of physical effort capacity, which can be achieved by special preparation and shaping appropriate levels of motor qualities [6]. The functioning of the skeletal muscles during intensive efforts is based on anaerobic processes, which are the main source of power [7].

In scientific research, it has been shown that the ability to perform recurring high-intensity physical efforts relies on the store of phosphocreatine in the muscles as well as its resynthesis time [8]. The phosphocreatine resynthesis time depends on aerobic metabolism, which suggests that athletes displaying higher values of the VO2max indicator are able to resynthesise this compound more effectively [9]. The ability of muscles to take up subsequent intensive efforts is partly related to the phosphocreatine resynthesis time and how fast the hydrogen ions are removed.

In today’s handball, anaerobic capacity is one of the most important parts of match workload structure [10]. Research on the match workload structure by Czerniński [11] and Norkowski [12] proved that in the case of handball, 30–35% of the match is played in anaerobic physical effort zones. Detailed planning, recording, monitoring and analysing training loads are among the key requirements of contemporary training, understood as the process of achieving the highest sports level [13]. The main task of sports training is to reach the highest levels of adaptation to physical effort of specific metabolic characteristics, which is expressed by the increase in capacity indicators and progress in sports achievements.

Applying the criterion of the metabolic nature of physical effort, training resources and methods used in handball mainly involve: workloads carried out in the range of anaerobic reactions involving lactic acid, during which the highest degree of activity is observed in the field of anaerobic effort, and workloads carried out in the range of anaerobic reactions not involving lactic acid, the intensity of which corresponds to anaerobic peak power [14]. The time for producing peak power from non-lactate, lactate and aerobic energy sources corresponds to the following work values in time intervals of 10, 60, 180 seconds [15].

The Wingate test developed by Bar-Or is a widely used method of evaluating anaerobic capacity [16]. In the view of numerous authors, the Wingate test can be a useful tool in a coach's work for the purpose of diagnosis, prognosis and selection [17]. The objective of this study is to evaluate the relative mechanical work (J/kg), peak power (W/kg), peak power production time (s) and peak power sustainment time (s) in Wingate tests performed on players in various positions. Based on the analysis of the course and results of the game, it was hypothesized that the examined team is not properly prepared for the season in terms of anaerobic capacity. There is little data in Polish literature on this topic. However, much more information on the subject of the study is provided by foreign publications referred to in the discussion.

### Material and methods

The research participants: 18 players from the Superleague handball team; average age of participants = 25.96±3.97 years, average height = 192.76±7.21 cm, average body mass = 97.61±11.46 kg. Research was conducted during the first week of November of the 2018/2019 season, in the laboratory of the Physical Culture Centre at Maria Curie-Sklodowska-University, Lublin.

The Wingate test involved 30 seconds of maximum physical effort on a cycle ergometer with the load individually calculated for each player, amounting to 7.5% of their body mass [18]. The test was carried out after a 5-minute warm-up on the cycle ergometer and following a subsequent 5-minute resting period. The tests were performed with the use of the Monark 824E (Sweden) cycle ergometer connected to an IBM PC Pentium computer with the MCE_v_5.1 software [19]. A revolution-per-minute sensor was attached to the flywheel. One pedal turn initiated 3.7 revolutions of the flywheel, which corresponds to a distance of 6 metres. The participants, having adjusted the seat and handle height, performed the test seated, starting from a still position. Their feet

<table>
<thead>
<tr>
<th>Table 1. Characteristics of the researched group</th>
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<tbody>
<tr>
<td>N = 18</td>
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were strapped to the pedals. During the physical effort, the study participants were motivated to reach the maximum speed of turning the pedals and to maintain it until the test was over. The following measurements and calculations were performed with the MCE_v_5.1 software: number of flywheel revolutions, work value (J/kg), mean power (W/kg), peak power (W/kg), peak power production time Pmax (s), power production time P border (s) and power sustainment time P border (s) [20]. Body composition was assessed with the use of the Bioelectrical Impedance Method (via the Tanita SC 330 body composition analyser, Japan), the fat free body mass was marked (FFM%), fatty tissue (FAT%) and BMI were calculated. The obtained results were statistically processed, using descriptive statistics calculating the arithmetical means (x), standard deviations (SD), minimum values (min), maximum values (max). All calculations were performed using the SPSS v. 22 software [21].

Results

As it may be seen from the data in Table 2, in the stress test, the relative mechanical work of the athletes and peak power value can be placed at the average levels according to Norkowski and Noszczał’s classification [22]. The mean value of the peak power production time in the Wingate test was classified as an average result, while the mean value of peak power sustainment time

<table>
<thead>
<tr>
<th>N = 18</th>
<th>Work [J/kg]</th>
<th>Pmax [W/kg]</th>
<th>Production time [sec.]</th>
<th>Sustainment time [sec.]</th>
<th>Fatigue index [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>254.56*****</td>
<td>11.12****</td>
<td>4.82 *****</td>
<td>2.98 ***</td>
<td>25.82***</td>
</tr>
<tr>
<td>SD</td>
<td>±16.92</td>
<td>±0.84</td>
<td>±0.82</td>
<td>±1.04</td>
<td>±3.64</td>
</tr>
<tr>
<td>Min.</td>
<td>227.44</td>
<td>9.71</td>
<td>3.55</td>
<td>1.55</td>
<td>17.79</td>
</tr>
<tr>
<td>Max.</td>
<td>277.48</td>
<td>12.63</td>
<td>5.97</td>
<td>5.87</td>
<td>32.28</td>
</tr>
</tbody>
</table>

Key: ***** poor result; **** average result; *** good result

<table>
<thead>
<tr>
<th>N = 18</th>
<th>Pmax [W/kg]</th>
<th>Work [J/kg]</th>
<th>Production time [sec.]</th>
<th>Sustainment time [sec.]</th>
<th>Fatigue index [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goalkeepers N=3</td>
<td>X</td>
<td>10.19*****</td>
<td>235.60****</td>
<td>4.91****</td>
<td>2.42**** 23.44</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0.83</td>
<td>11.85</td>
<td>0.69</td>
<td>0.13 2.18</td>
</tr>
<tr>
<td></td>
<td>Min.</td>
<td>9.70</td>
<td>228.42</td>
<td>4.13</td>
<td>2.27 22.16</td>
</tr>
<tr>
<td></td>
<td>Max.</td>
<td>11.15</td>
<td>249.27</td>
<td>5.40</td>
<td>2.51 25.96</td>
</tr>
<tr>
<td>Backs N=6</td>
<td>X</td>
<td>11.22*****</td>
<td>258.48****</td>
<td>5.10****</td>
<td>2.98*** 23.89</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0.77</td>
<td>15.04</td>
<td>0.91</td>
<td>1.62 3.68</td>
</tr>
<tr>
<td></td>
<td>Min.</td>
<td>10.88</td>
<td>250.31</td>
<td>5.14</td>
<td>2.39 23.25</td>
</tr>
<tr>
<td></td>
<td>Max.</td>
<td>10.96</td>
<td>252.36</td>
<td>5.25</td>
<td>2.34 23.04</td>
</tr>
<tr>
<td>Wingers N=6</td>
<td>X</td>
<td>11.56*****</td>
<td>261.92****</td>
<td>4.78****</td>
<td>3.32*** 25.13</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0.79</td>
<td>16.20</td>
<td>0.90</td>
<td>0.72 4.34</td>
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<tr>
<td></td>
<td>Min.</td>
<td>10.81</td>
<td>243.84</td>
<td>3.73</td>
<td>2.83 17.88</td>
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<tr>
<td></td>
<td>Max.</td>
<td>12.63</td>
<td>278.38</td>
<td>5.97</td>
<td>4.58 29.63</td>
</tr>
<tr>
<td>Pivot players N=3</td>
<td>X</td>
<td>10.59*****</td>
<td>235.02****</td>
<td>4.32****</td>
<td>2.62*** 31.71</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0.12</td>
<td>0.65</td>
<td>0.40</td>
<td>0.35 6.51</td>
</tr>
<tr>
<td></td>
<td>Min.</td>
<td>10.50</td>
<td>234.56</td>
<td>4.03</td>
<td>2.37 27.11</td>
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<tr>
<td></td>
<td>Max.</td>
<td>10.67</td>
<td>235.48</td>
<td>4.60</td>
<td>2.87 36.31</td>
</tr>
</tbody>
</table>

Key: ***** poor result; **** average result; *** good result
was considered good. The mean value of the fatigue index, calculated as the percentage difference between the peak power and the minimum power recorded after peak power production, reached average levels.

In Table 3, the mean results of the anaerobic capacity parameters are shown for players in various positions. Having analysed the data, it needs to be stated that the highest values of peak power were obtained by wingers, followed by backs, pivot players and goalkeepers. As far as peak power production time is concerned, the highest results were obtained by wingers, followed by backs, pivot players, runners and goalkeepers.

Discussion

In handball, sustaining a high intensity of performance is only possible in the case of having large anaerobic and aerobic potential [11,12]. The level of tolerance for the match workload is always higher in the case of players displaying high values of the \( \text{VO}_{2\text{max}} \) indicator and anaerobic capacity. For this reason, continuous monitoring of the levels of aerobic and anaerobic capacity is highly recommended. The reduction of these indicators below the value of 54 ml/kg/min [13] in the case of aerobic capacity and below 10.86 W/kg [22] in the case of anaerobic capacity imposes substantial limitations on handball players' professional training and their effective performance during the match.

The ability to adjust the structure of training loads to match workloads is a key issue in the training process. Czerwiński [11] proved that the intensity level of handball training is substantially lower than that observed during the sporting battle. The most frequently mentioned cause is the occurrence of errors in technical and tactical drills, which do not provide an appropriate impulse for physical effort as far as adaptation to the actual match conditions is concerned. Norkowski’s research results [12] indicate that the problem lies in the low effectiveness regarding methods of shaping anaerobic capacity through drills, as their structure and organisation methods do not correspond to the physiological criteria of maximum anaerobic physical effort.

When training the team, the coach cannot bring about asituation in which the player is not clearly and fully effective because his/her energy resources are depleting. In handball, which can be characterised by changeability of physical effort, the training process requires a well-thought-out action, which most of all, involves the coach’s knowledge of the sporting competition characteristics[1]. The test results are confirmation of the hypothesis stating that the team included in the analysis is not prepared for the season in terms of anaerobic capacity. The values obtained in the Wingate test, in which the mean value of peak power was 11.15 (W/kg), at the minimum and maximum values of 9.73 and 12.65 (W/kg), respectively, maybe classified as an average result according to the authors quoted above [22].

This is similar in the case of results relating to peak power production and peak powersustainment time. The mean values of peak power sustainment time were classified within the good-result limits, probably due to the fact that the results of peak power and peak power production time were low. Also, the mean value of the fatigue index, calculated as the percentage difference between the peak power and minimum power recorded after obtaining peak power, maybe classified as an average result [19]. Additionally, in terms of players in various positions, goalkeepers and circle runners obtained peak power values classified as low, whereas backs and wingers had average results according to Norkowski’s classification [22]. The comparison between players in the above positions is similar in the case of peak power sustainment time values, which indicates better endurance at the anaerobic glycolysis stage. Similar results of anaerobic parameters in game positions were obtained by Rannou, Prioux, Zouhal. Maximum power values were similar to those of sprinters and higher than athletes training endurance disciplines [29]. The results of other authors suggest that anaerobic metabolism seems to be important for handball players, as well as sprinters, because handball is known as sport with usually short periods of high intensity exercise alternating with rests, anaerobic metabolism then seems to be of great importance for the results [29]. Other authors have found significant differences between player positions for some anthropometric traits (body fat percentage and increase), but not in the case of physiological and endurance features [30]. Performance skills between positions in elite team handball players seem very similar [30]. There is a paucity of research on the physiological, physical, and anthropometric profiles of elite and sub-elite handball players [30, 32]. Profiling can be a valuable means of identifying talent, strengths and weaknesses, assigning player positions, and helping in the optimal design of strength and conditioning pro- grammes [30]. Other studies found that field players were faster than goalkeepers when considering the maximum running speed on a treadmill. The wingers and backs compared to goalkeepers and pivot players had the highest values of \( \text{VO}_{2\text{max}} \), oxygen consumption. Blood lactate results did not give statistically significant differences between player positions [31, 33].

The above-quoted results and the examples of research work related to shaping and controlling anaerobic capacity prove that this sphere of capacity is significant in the overall energy potential of an athlete.

According to Jensen [23], Karp [24] and Rygula [25], the basic method of shaping and retaining high levels of anaerobic capacity is interval training at maxi-
mum workload intensity, and, according to Linossier [26], repeated physical efforts of up to 10 seconds are the most effective. Systematic high-intensity physical exercise with interval workload elements have more influence on anaerobic and aerobic capacity, and also display a more-beneficial modification of anthropometric and biochemical indicators, as compared to endurance exercises of low and moderate intensities [27,15,28]. The results presented in this paper may serve the purpose of supplementing knowledge concerning the diagnostics of the training process in the case of top-level handball teams.

Summary and conclusions

The following conclusions can be drawn based on analysis of the obtained test results:
1. The levels of the selected parameters regarding anaerobic capacity obtained by the study participants in the Wingate test were classified as good and average, in the search results of other authors.
2. Backs and wingers achieved higher anaerobic capacity parameters as compared to pivot players and goalkeepers.
3. The wingers achieved the best results in the test and the goalkeepers the weakest.
4. Profiling can be a valuable means of identifying talent, strengths and weaknesses, assigning player positions, and helping in the optimal design of strength and conditioning programmes.
5. The continuous monitoring of the aerobic and anaerobic capacity levels as well as training loads, and evaluation of the player’s function changes, will facilitate planning and implementing the training process in a rational way.

References:


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