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Changes in power output under the influence of sprint training in handball players

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The purpose of this paper was to study the power output using the Wingate test applied in an eight-week training programme realized by handball players, aided by repeated maximal-intensity exercise on a cycle ergometer. The study was conducted on 13 handball players divided into two groups. Group GS (n = 5) done the training in a gym and an additional sprint training on a cycle ergometer, wile group GG (n = 8) performed only the training in a gym. Both training programmes lasted 8 weeks, 5 times a week (Monday to Friday). On Saturday preceding the start of the experiment and Saturday at the end of each week during the 8-week training programmes, the participants of the experiment came through the Wingate test on a cycle ergometer. The sprint training on the cycle ergometer caused a significant improvement in alactic anaerobic output (the power increase and maintenance phase – IMP) in the Wingate test (8.3% P_{aIMP}) and in lactic anaerobic output (the power decrease phase – DP) (13.3% P_{aDP}) in group GS. No significant changes in these values were found in these participants of the Wingate test who belonged to the group GG. The changes in the parameters measured in both groups examined varied significantly.

Key words: cycle ergometer, handball, sprint training, the Wingate test

1. Introduction

Changes in muscles under the influence of training can depend on their type and structure (ABERNETHY et al. [1]). Endurance training not only develops the muscle capacity for adaptation to aerobic metabolism (activity of oxygen enzymes, consumption of oxygen), but it also improves the results of endurance tests (HENRIKSSON [12]). By contrast, sprint training increases the activity of enzymes responsible for anaerobic metabolism (COSTILL et al. [8], LINOSSIER et al. [17], ROBERTS et al. [21]) and the content of energy-bearing substrates in muscles (CADEFAU et al. [6], ROBERTS et al. [21], THORSTENSSON et al. [26]). Intermittent exercises at maximal intensity characterise the type of exercise based on multiple sprints, which are typical of certain sports disciplines such as football, handball, basketball and ice hockey. In these disciplines, the energy needed for individual spurts lasting up to 10 seconds comes from anaerobic sources (HIRVONEN et al. [13]), while the energy for recovery comes from aerobic metabolic processes (BOGDANIS et al. [4], [5], TRUMP et al. [27]). According to LINOSSIER et al. [17], exercises lasting less than 10 seconds are better for developing anaerobic capacity than longer exercises lasting. e.g., 30 seconds, during which power diminishes by the end of the exercise. The effect of sprint training on the development of anaerobic power is not clear-cut. In the studies by LINOSSIER et al. [17], SIMONEAU et al. [23], [24], STATHIS et al. [25], sprint training on a cycle ergometer caused an increase in maximal power and amount of work done in the Wingate test and in 10-second and 90-second maximal exercises. JACOBS et al. [16], ESBJÖRNSSON et al. [10], ESBJÖRNSSON LILJEDAHL et al. [11], RODAS et al. [22] did not find any significant changes in maximal power and amount of work done in the Wingate test and in the 10-second and 90-second maximal exercises following sprint training on a cycle ergometer. In the literature, there are no studies describing the effect of training using repeated, high-intensity exercise on cycle ergometers on the changes in anaerobic power in handball players.

The purpose of this work was to study the effect of an eight-week training programme realized by handball players, aided by repeated maximal-intensity exercise on a cycle ergometer, on the power output measured in Wingate test.

2. Material and methods

The study was conducted on 13 handball players from University Sport Association of Poland, the Physical Education Academy of Warsaw, a club that plays in the I B league during the beginning of the season. The subjects were divided into two groups: GS and GG. Group GS done specialised training in a gym and additional sprint training on a cycle ergometer; group GG done only the specialised training in a gym. The subjects had the following physical characteristics (mean ± SD): group GS (n = 5) – age, 23.1 ± 1.1 years; height, 186.8 ± 3.3 cm; body mass, 86.6 ± 6.7 kg; length of competitive play, 8.6 ± 7.6 years; group GS (n = 8) – age 22.3 ± 1.2 years; height, 185.9 ± 4.0 cm; body mass, 82.4 ± 7.6 kg; length of competitive play, 9.2 ± 2.4 years. In terms of age and weight, the groups differed significantly.

The study was approved of by the Senate Commission on Scientific Research of the Physical Education Academy of Warsaw. The participants were informed of the purpose of the research and its methodology and given the option to withdraw from the experiment at any phase. The subjects expressed their written consent to participate in the experiment. All measurements were taken in the morning.

2.1. Methods for measuring the power output (the Wingate test)

For the purpose of measuring the power output, the Wingate test was used. In every instance, it was carried out after a standard warm-up on a cycle ergometer and 5 minutes of rest. The test consisted in performing a maximal 30-second exercise using an individually selected weight resistance amounting to 7.5% of body weight (BAR-OR [3]). For the study, a Monark 824 E (Sweden) cycle ergometer was used, which was hooked up to an IBM class PC Pentium computer running on the program MCE v. 4.0 (JBA, Zb. Staniak, Poland). Sensors were affixed to a flywheel. The flywheel covered a distance of 6 m during one revolution of pedals. The subjects, after selecting an appropriate height for the seat and handlebars, performed the test in a sitting position without standing on the pedals, commencing pedalling from a motionless position. Their feet were strapped to the pedals. The subjects were energetically encouraged to attain the highest possible pedalling velocity and to maintain it to the end of the test. Using the MCE v. 4.0 program, the following measurements and calculations were made: average power (P_a), maximal power (P_{max}) defined as the average value of maximal power in the P_{peak} – 2.3% P_{peak} interval, amount of the work performed (W) and fatigue index (FI). The progression of power as a function of time was divided into two phases:

1. The phase of power increase and maintenance (PIM) – from the beginning of the test to the maintenance of the boundary value in the P_{peak} – 2.3% P_{peak} interval.

2. The phase of power decline (PD) – from the moment the maximal power falls below P_{max} to the power reading at the moment of the completion of the test.

2.2. Protocol of the experiment

The handball players in both groups realized a specialised 8-week training programme typical of the start of the season. The week-long cycle consisted of 5 training sessions held once a day (from Monday to Friday). The structure of the training sessions varied depending on the day of the week, and was as follows: Monday – practising motor skills with an emphasis on strength endurance in the form of a circuit consisting of 12 exercises (number of exercise repetitions – 15; length of breaks between exercises – 2 min; number of circuits – 3). Tuesday – technical-tactical training, with an emphasis on improving movement and co-ordinating defence and positional attack. Wednesday – technical-tactical training, with an emphasis on fast-break offence and shooting at goal in an organised form. Thursday – practising offensive and defensive tactics. Friday – practising tactics and throws in the form of game fragments.

Furthermore, the subjects in group GS done training consisting of maximal sprints on the cycle ergometer (17 pedal revolutions, which was the equivalent of 76.28 J/kg of an average work performed). On Monday, Wednesday and Friday, the cycle training consisted of 3 series of 17 pedal revolutions, each with breaks between sprints lasting 45 seconds; on Tuesday and Thursday, it consisted of 6 series of sprints with breaks between them, each lasting 15 seconds. The equipment used in this training was a MONARK 824E (Sweden) cycle ergometer connected to a computer running the program MCE v. 4.0 (JBA, Zb. Staniak, Poland), which made it possible to set, control and register the weight resistance variants used. Weight resistance on the cycle ergometer was selected individually (7.5% of body weight).

On every Saturday at the end of each week (1–8), starting prior to the beginning of the experiment (0), the Wingate test was conducted on the MONARK 824E cycle ergometer.

A non-parametric Wilcoxon test was used to compare the results obtained in successive measurements with the starting-point values within the same group. The significance of differences between the groups was analysed using a non-parametric Mann–Whitney test. The significance $p < 0.05$ was assumed to be significant. All calculations were done using the STATISTICA™ program (v. 5.5, Stat Soft, U.S.A.). Prior to the experiment, neither of the groups differed one from another significantly in terms of the results obtained in the Wingate test.

3. Results

The phase of a power increase and maintenance (PIM) lengthened from 6.76 ± 0.90 to 6.92 ± 0.62 seconds in the group GS, and shortened from 7.51 ± 1.08 to 7.45 ± 0.80 seconds in the group GG after 7 weeks of training. The duration of the decline phase (DP) in power did not change significantly in either group. No differences were found between the groups.

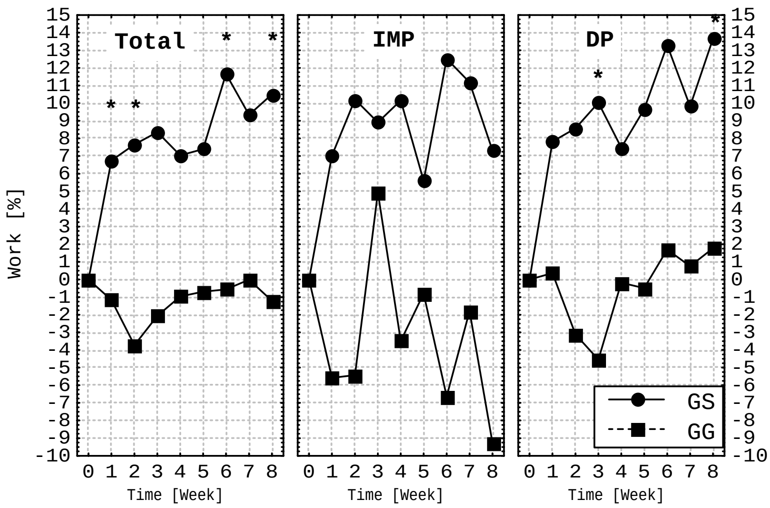

Fig. 1. Average values of the changes (expressed in percentages) of the work done

in the phase of power increase and maintenance (PIM) and in the phase of power decline (DP) in the Wingate test measured by comparing the test results recorded before the study (0) with the test results at successive week intervals (1–8) during the 8-week training programme, and significance of average differences between the group GS (trained in the gym and on the cycle ergometer) and the group GG (trained only in a gym); * – $p < 0.05$

In the phase of power increase and maintenance, the subjects in the group GS done insignificantly more work, increasing output from 66.03 ± 13.29 J/kg to 71.52 ± 5.20 J/kg after 6 weeks of training. In the group GG, an insignificant increase in the work done was observed. It ranged from 68.44 ± 8.82 J/kg to 71.82 ± 10.60 J/kg after 3 weeks of training and was followed by a significant decline to 63.75 ± 8.22 J/kg (–6.6%, $p < 0.05$) after 6 weeks of training. In the

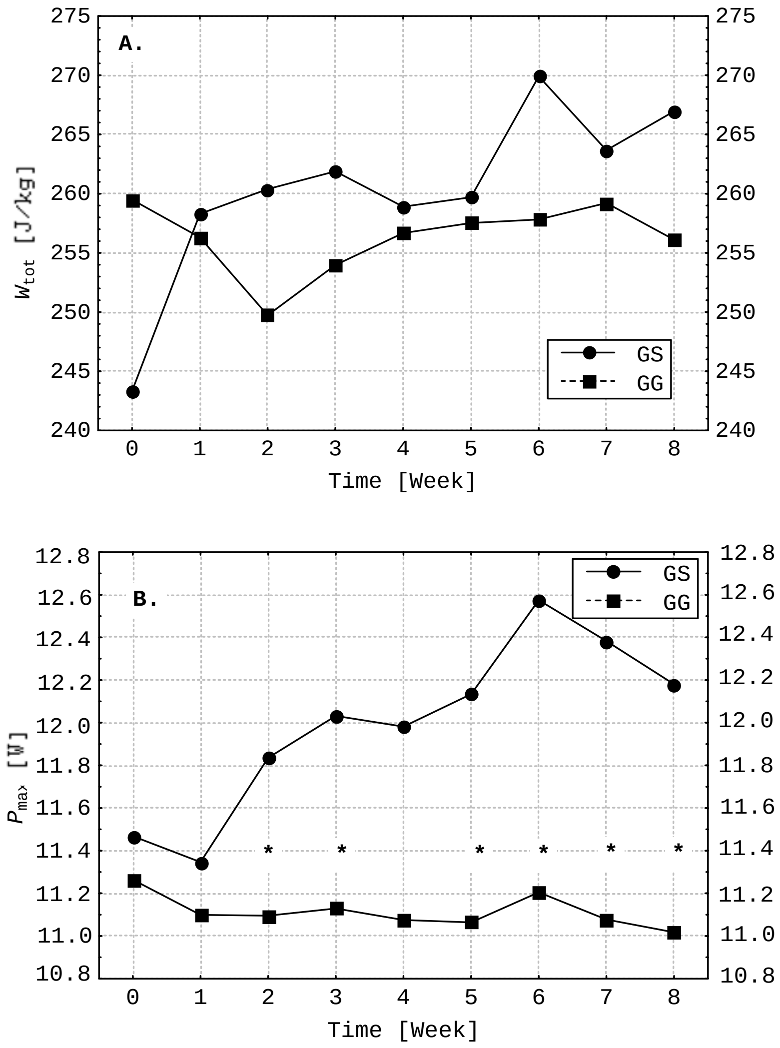

Fig. 2. Average values of the total work (W_{tot}) (A) and maximal power (P_{max}) (B) obtained in the Wingate test prior to the study (0) and at successive week intervals (1–8) during the 8-week training programme and the significance of average differences between the group GS (trained in a gym and on a cycle ergometer) and the group GG (trained only in a gym); * – $p < 0.05$

phase of power decline, the subjects in group GS done significantly greater work after 8 weeks of training (an increase from 177.30 ± 24.65 J/kg to 199.03 ± 14.44 J/kg) (+13.7%, $p < 0.05$). In the control group, a significant reduction (from 191.06 ± 8.86 J/kg to 182.15 ± 10.52 J/kg) in the amount of the work done was observed after 3 weeks of training, followed by its insignificant increase (to 194.13 ± 7.43 J/kg) after 8 weeks of training. Significant differences between the groups in terms of changes in the work done expressed in percentages were revealed after the 3rd and the 8th weeks of training (figure 1).

The subjects in the group GS done significantly greater total work increasing from 243.33 ± 29.48 J/kg to 269.90 ± 17.63 J/kg (11.7%, $p < 0.05$) after 6 weeks of training. In the group GG, a significant decline (from 259.50 ± 13.47 J/kg to 249.73 ± 12.04 J/kg) in total work was observed after two weeks, while an insignificant decline (from 259.50 ± 13.47 J/kg to 256.11 ± 11.22 J/kg) occurred after
8 weeks of training. Significant differences between the groups in terms of the total work expressed in percentages were noted after the 2nd, 3rd, 6th and 8th weeks of training (figure 2).

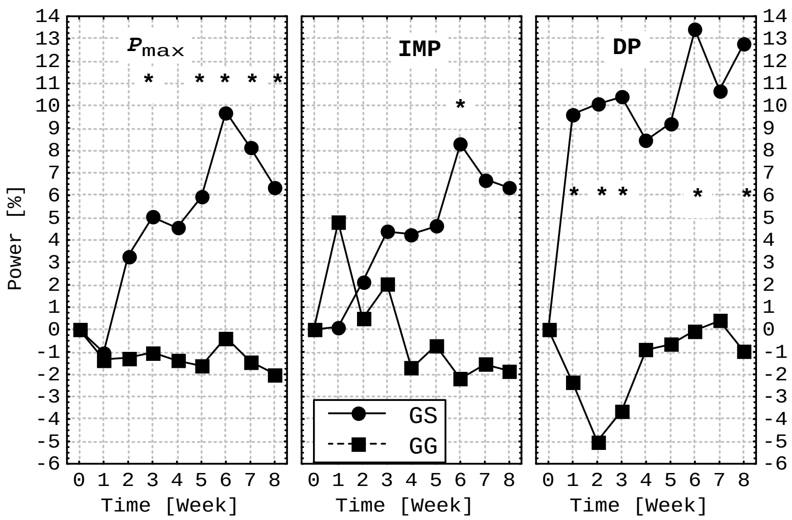

Fig. 3. Average values of the changes in power (expressed in percentages) developed in the phase of power increase and maintenance phase (PIM) and in the phase of power decline (PD) in the Wingate test measured by comparing the test results recorded

before the study (0) with the test results at successive week intervals (1–8) during the 8-week training programme and significance of average differences between the group GS (trained in a gym and on a cycle ergometer) and the group GG (trained only in a gym); * – $p < 0.05$

The power developed in the phase of power increase and maintenance by the subjects from the group GS increased significantly, i.e., from 9.70 ± 0.66 W/kg to 10.50 ± 0.60 W/kg (8.3%, $p < 0.05$), after 6 weeks of training; in the control group, only an insignificant decline in power from 9.16 ± 0.91 W/kg to 8.95 ± 0.67 W/kg was noted. Significant differences between the groups were observed in terms of the changes expressed in percentages after the 2nd, 3rd, 4th, 5th, 6th, 7th and 8th weeks of training (figure 3). In the phase of power decline, a significant increase from 7.64 ± 1.16 W/kg to 8.55 ± 0.70 W/kg (13.3%, $p < 0.05$) in the power in the group GS was observed after 6 weeks of training; no changes were noted in the control group (8.51 ± 0.44 W/kg). Significant differences between groups were revealed in terms of the changes expressed in percentages after the 1st, 2nd, 3rd and 8th weeks of training.

Maximal power improved significantly from 11.47 ± 0.68 W/kg to 12.58 ± 0.64 W/kg (9.7%, $p < 0.05$) after 6 weeks of training in the group GS. In the group GG, insignificant changes, from 11.26 ± 0.68 W/kg to 11.02 ± 0.41 W/kg, in the maximal power were observed. Significant differences between groups were recognized after the 2nd, 3rd, 5th, 6th, 7th and 8th weeks of training.

4. Discussion

Anaerobic output can be improved by repeated exercises (LINOSSIER et al. [17]), while continual exercises will not improve it (HOLLOSZY [14]). The effects produced by training depend on the intensity of the exercises done and rest breaks being made between them (DUDLEY et al. [9]). ALLEMEIER et al. [2], ESBJÖRNSSON et al. [10], ESBJÖRNSSON LILJEDAHL et al. [11], JACOBS et al. [16] and RODAS et al. [22] reported that sprint training on cycle ergometers did not cause any changes in their power. In the study by PARRA et al. [20], the subjects divided into two groups done similar training in 14 training sessions. The first group trained without breaks, day after day, for two weeks, while the second group had two-day rest after each training session. Each group trained for a total of 6 weeks. Peak power and average power in the 30-second test increased by 20% and 14%, respectively, in the group training every third day; these two values did not change significantly (3%) in the group that trained every day. In the participants of the experiment conducted by LINOSSIER et al. [17], the maximal power and the work done increased in the Wingate test by 26% and 16%, respectively, after 7-week sprint training. Analysing the changes in power in 2-second intervals, they found a significant difference in power, up to 18 seconds, compared to the test results prior to the start of sprint training. In a study by STATHIS et al. [25], 16.8% and 11.8% increases in the maximal power and in average power, respectively, were observed after 7 weeks in the subjects of the Wingate test. The progression in power calculated at 5-second intervals changed significantly in the first 25 seconds of the test compared to the power generated by the subjects prior to training, with the largest changes occurring in the first 10 seconds of the test. In our specialised study of the discipline of handball, training in a gym aided by maximal sprint exercises on a cycle ergometer caused significant increases in the values measured in the Wingate test – 9.7% for maximal power and 11.7% for the work done. These changes in power and work (expressed in percentages) are consistent with the changes reported by the authors cited. The slighter increases in the values measured in the case of the handball players compared to those found by the aforementioned authors could stem from the fact that our subjects were already in the top physical form and had many-year competitive experience. No changes in the values measured in the control group clearly indicates that the improvement in anaerobic output in the group GS was caused by the additional exercises they performed on the cycle ergometer.

In the Wingate test, the energy being expended comes from both anaerobic and aerobic sources (BAR-OR [3]). In the opinions of BAR-OR [3], CALBET et al. [7] as well as MEDBØ and TABATA [19], 13–28%, 22.9% and up to 40% of total energy, respectively, produced during the Wingate test come from aerobic sources. JACOBS et al. [15] have found that the highest power developed in the Wingate test in the course of 5 seconds is generated from intramuscular sources of phosphates (alactic component), and a 30-second average power measured in the Wingate test represents anaerobic output which primarily stems from glycolysis (lactic component). In the study conducted by SIMONEAU et al. [23], an anaerobic alatic capacity was defined as the amount of work done in a 10-second test, and an anaerobic lactic capacity – as the amount of work done in a 90-second test on a Monark ergometer. In a the study conducted by BOGDANIS et al. [4], average power values P_{a10} measured in the first 10 second of the exercise was 920 W, and in the last 20 second, P_{a20} was 600 W. An average power generated in the test was 707 ± 25 W. The ratio of P_{a20} to P_{a10} was equal to 1.53. In our study, this ratio for the power developed over the phase of power increase and maintenance in the Wingate test approached 1.3 in the group GS and 1.1 in the group GG. The division into phases in our study does not precisely correspond to the division made by SIMONEAU et al. [23], [24] and BOGDANIS et al. [4], who assumed a 10-second period for alactic anaerobic output and 30 second or longer (90 second) for lactic anaerobic output. In our study, the phase of the power increase and maintenance lasted for 6.62–7.11 seconds in the group GS, and for 6.90–7.51 seconds in the group GG – thus, this phase is shorter than 10 seconds. We can therefore assume that the amount of work done in the phase of power increase and maintenance corresponds to anaerobic alactic capacity, and in the phase of power decline, to lactic anaerobic capacity. Hence, specialised handball training aided by maximal repeated exercises done on a cycle ergometer improved alactic anaerobic output (in the phase of power increase and maintenance (PIM) by 12.5% of W_{IMP} and

8.3% of P_{aIMP} as well as lactic anaerobic output (in the phase of power decline (DP)) by 13.7% of W_{DP} and 13.4% of P_{aDP} in group GS. These results are partially consistent with these of LINOSSIER et al. [18], who have reported that sprint training on a cycle ergometer causes a substantial increase in maximal power, mainly stemming from an increase in strength. However, the ability to develop speed in sprint training appears to be difficult, which could be connected with the transformation of ST and FTb fibres into FTa fibres.

To sum up, the sprint training done on a cycle ergometer caused an increase in the values measured in the Wingate test in the phase of power decline and a similar increase in the phase of power increase and maintenance. The greatest changes were registered after 6 weeks of training. The specialised handball training in a gym did not cause any improvement in anaerobic output. The changes in the parameters measured varied significantly between the subjects belonging to both groups.

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