

Changes in Aerobic and Anaerobic Power Indices in Elite Handball Players Following a 4-Week General Fitness Mesocycle

by

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The aim of this study was to evaluate the effects of a 4-week training programme during the first phase of the preparation period on selected indices of somatic structure as well as aerobic and anaerobic power in elite handball players. Nine handball players from a first league team took part in the study; their average age was 25.5±3.7 years, body mass 86.5±7.6 kg (I session) and 87.9±7.3 kg (II session) ($p<0.01$), lean body mass – 74.4±6.6 kg (I) and 76.2± 6.2 kg (II) ($p<0.01$), body fat mass 12.1±3.1 kg (I) and 11.7±3.1 kg (II) respectively. Two evaluations were conducted – the first at the end of the season, the second at the initial phase of the preparation period. The second phase was preceded by a 4-week period of general endurance and strength training. Aerobic fitness was assessed indirectly, taking into account the results of the PWC₁₇₀ test. The absolute and relative values of the PWC₁₇₀ index increased significantly from 236.6 W to 269 W ($p<0.01$) and from 2.73 W/kg to 3.06 W/kg ($p<0.01$). The values of maximum oxygen uptake – VO_{2max} were significantly improved from 3.65 l/min to 3.98 l/min ($p<0.01$) and from 42.3 ml/kg/min to 45.4 ml/kg/min ($p<0.05$). Anaerobic fitness was assessed using the 30-second Wingate test. A statistically significant improvement of the basic indices of aerobic fitness following the 4-week training programme proved its high effectiveness. Maintaining the level of the basic indices of anaerobic power despite the absence of specific training loads, seems to corroborate the strong effect of genetic factors on the level of anaerobic fitness and the effectiveness of strength training programs.

Key words: aerobic fitness, anaerobic fitness, handball

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Introduction

Contemporary handball requires a high level of general and specific fitness. The effective length of a match is about 40 minutes, with consecutive attacks and defences played with high intensity. Defensive and offensive plays (about 50 in a match) last on the average 21-35 s (about 60% of such plays), 22% last over 35 s, and 17% of them are short attacks or defences, not longer than 20 s). During a game, direct action with opponents takes place, and players perform a lot of accelerations, turns and jumps. The diversity of efforts requires a comprehensive preparation in terms of endurance, speed and strength. The energy necessary for handball competition is derived both from aerobic and anaerobic processes. The heart rate during competition ranges from 168 to 198 beats per minute, and the oxygen debt may exceed 6 l/min. A good level of general fitness, as well as a high aerobic and anaerobic capacity, form the foundation for success in handball (Delamarche et al. 1987, Loftin et al. 1996).

A systematic assessment of fitness, somatic and functional changes creates the basis of rational planning and executing training loads in team sports. The basic role in the assessment of adaptive changes caused by training is played by metabolic indices (Willmore, Costill 1999).

Regular physical training in handball brings about functional changes – an increase in aerobic and anaerobic fitness (Zajac et al. 1999, Norkowski, Huciński 2007, Wrześniewski, Norkowski 2006). There are, however, few reports on changes in the somatic structure of handball players caused by strength training.

This has encouraged the authors to take up studies aimed at the assessment of selected indices of the somatic structure, aerobic and anaerobic fitness of professional handball players after a 4-week training cycle at the initial phase of the general preparation period.

The following study questions were addressed:

- What was the level of aerobic fitness of the handball players subjected to testing?
- What was the level of anaerobic fitness of the handball players subjected testing?
- How did the endurance and general strength training program influence the changes of selected indices of somatic structure, aerobic and anaerobic fitness ?

Material and Methods

Nine handball players from a first league participated in the study.

The examination was conducted twice, after the competitive season and after the 4-week training cycle, conducted at the initial phase of the general preparation period. During the 4-week training program, the players performed 44 training sessions. The main training objectives during this period included improvement of endurance (20 training units) and strength (12 training sessions). In the last week before the second phase of the study, the players performed 3 training units of specific endurance.

Testing procedures

Before the physical fitness tests were performed in the group of handball players, the values of basic somatic indices were determined. The body composition assessment was performed with a body composition analyser manufactured by Tanita - BC 418 MA (Tanita Corporation, Japan), according to the BIA (Bioelectric Impedance Analysis) method. The following somatic indices were measured: body mass (BM), lean body mass (LBM), body fat content (%) and body fat mass (BF).

Aerobic fitness was assessed by an indirect method, using the PWC₁₇₀ (Physical Working Capacity) test (Wahlund 1948). The PWC₁₇₀ test was based on the performance of two five-minute standard efforts on a Monark cycloergometer 828 E (Monark Exercise AB, Sweden), with an individual load. The intensity of the efforts was selected in such a manner that the heart rate (HR) was close to 130 per minute during the first bout and close to 150 per minute during the second effort. The heart rate was measured with a Polar Sport Tester (Polar Electro Oy, Finland). The PWC₁₇₀ index was calculated from the mean HR values recorded at the end of each 5-minute effort.

The PWC₁₇₀ index was used to calculate maximum oxygen uptake (VO_{2max}) from the Karpman formula (1969):

$$VO_{2max} = 1,7 \cdot PWC_{170} + 1240,$$

where: 1,7; 1240 – constant values,

PWC₁₇₀ – test results expressed in kGm/min.

VO_{2max} is expressed in ml/min.

Anaerobic fitness was determined by applying the 30 s Wingate test on a Monark 874-E ergocycle (Monark Exercise AB, Sweden), (load 74 N/kg body mass), according to standard methodology (Inbar et al. 1996) and on-line MCE v. 5.1 software (JBA, Poland). The following variables were recorded:

- maximal power output - P_{\max} (W , W/kg),
- total work - W_{tot} (J, J/kg),
- time of maximal power attainment - T_{at} (s),
- time of maximal power maintenance - T_{ma} (s),
- fatigue index – FI (%)

Before the Wingate test, the players performed a 5-minute warm-up on a cycloergometer with the load set between of 100 – 150 W.

Statistical methods

The obtained results were analyzed using ANOVA with repeated measurements, to compare the two stages of preparation. The significance of average differences was analysed with the Student's t-test for paired values. All calculations were performed with the use of STATISTICA (v. 7.0, Stat Soft Inc., USA).

Results

The age and basic somatic characteristics of the tested handball players are presented in table 1. It is noteworthy that body mass and lean body mass significantly increased, while at the same time a tendency was observed towards a reduction in fat mass and fat content (statistically insignificant differences).

Table 1
Somatic characteristics of the tested handball players ($M \pm SD$), ($n=9$).

		Age (yrs)	BM (kg)	Ht (cm)	BF (%)	BF (kg)	LBM (kg)
I session	$M \pm SD$	25,5 \pm 3,7	86,5 \pm 7,6	184,8 \pm 4,6	14 \pm 3,1	12,1 \pm 3,1	74,4 \pm 6,6
II session	$M \pm SD$	25,7 \pm 3,7	87,9 \pm 7,3	185,2 \pm 4,6	13,3 \pm 3,1	11,7 \pm 3,1	76,2 \pm 6,2
			t=4,79		t=1,35	t=0,95	t=3,74
			p<0,01		NS	NS	p<0,01

Table 2 shows the values of selected indices of aerobic fitness achieved by the players in the PWC₁₇₀. The absolute values of the PWC₁₇₀ index (W) and its relative values (W/kg), as well as the maximum oxygen uptake (VO_{2max}) expressed as absolute (l/min) and relative values (ml/kg/min) significantly increased ($p < 0.05$ and $p < 0.01$).

The research results indicate that the applied training protocol, caused a significant improvement in total and relative VO_{2max} and the PWC₁₇₀ index.

Table 2

Aerobic fitness indices of the tested handball players obtained in the PWC₁₇₀ test ($M \pm SD$), ($n=9$).

		BM (kg)	VO _{2max} (L/min)	VO _{2max} (mL/kg/min)	PWC ₁₇₀ (W)	PWC ₁₇₀ (W/kg)
I session	M±SD	86,5±7,6	3,65±0,52	42,3±5,2	236,6±50,7	2,73±0,51
II session	M±SD	87,9±7,3	3,98±0,46	45,4±4,4	269,0±45,0	3,06±0,42
			t=3,67	t=3,16	t=3,73	t=3,4
			p<0,01	p<0,05	p<0,01	p<0,01

Table 3 shows the values of selected mechanical indices, achieved by the players in the Wingate test. The test revealed no statistically significant changes in all of the recorded indices. The amount of work performed in both test sessions was similar. Absolute power was slightly higher in the second session. The time of maximal power attainment - T_{at} was also reduced (by 0.31 s) in the second session, but due to a high variance of results, the difference was statistically insignificant. The time of maximal power maintenance - T_{ma} also rose by the same value (0.31 s). The difference was also statistically insignificant due to a high variance of results.

Table 3

Anaerobic fitness indices of tested handball players obtained in the 30 s Wingate test ($M \pm SD$), ($n=9$).

		W _{tot} (kJ)	W _{tot} (J/kg)	P _{max} (W)	P _{max} (W/kg)	T _{at} (s)	T _{ma} (s)
I session	M	23,23	267,9	1020,5	11,77	4,46	2,72
	SD	2,98	14,7	132,2	0,80	0,77	0,46
II session	M	23,54	267,2	1033,5	11,72	4,15	3,03
	SD	2,87	14,5	137,0	0,83	0,67	0,37
		t=1,72	t=0,29	t=1,74	t=0,44	t=1,28	t=1,58
		NS	NS	NS	NS	NS	NS

Discussion

The statistically significant increase in body mass and lean body mass was most likely caused by the large volume of strength training. This claim is substantiated by the results of many tests in which the positive effect of strength training on development of muscle mass was confirmed (Baechle 1994, Komi

1992). An increase in body mass and lean body mass may also have been caused by earlier mass loss due to participation in league matches. The first test session in this experiment was carried out immediately after the end of the competitive period. A high level of physical and mental strain due to frequent matches may have resulted in intensified catabolic processes and, in consequence, in body mass loss. During the competitive period, players were observed to have very high base concentrations of cortisol, a hormone which is an important marker of intensified catabolic processes (Fellmann et al. 1992). Several research projects confirmed that maximal, exhausting efforts may lead to hypercortisolemia (Daly and Hackney 2005).

The PWC₁₇₀ (Physical Working Capacity) test is commonly applied on handball players to assess aerobic fitness (Jastrzębski 2003).

The research results indicate that the applied training protocol, caused a significant improvement in VO_{2max} and the PWC₁₇₀ index. The improvement in aerobic power found in the second test session seems to stem logically from the training work performed. During the 4-week training before the second study session, the players performed twenty endurance training sessions. Other training units, performed during that time (general strength training, strength endurance, sporting games), may have positively affected the level of aerobic fitness. A significant increase in the aerobic fitness was also a result of a low initial value of the PWC₁₇₀ index and VO_{2max}. Despite a statistically significant increase in the PWC₁₇₀ index, the value, according to the standards developed for handball players (Jastrzębski 2003) was rather low.

The 30s test Wingate (WAnT) is regarded as highly reliable in the assessment of anaerobic fitness (Inbar et al. 1996). Wrześniewski and Norkowski (2006) showed a significant increase in the anaerobic fitness in handball players caused by interval training with maximum intensity. No significant improvement in the basic mechanical variables – total work (W_{tot}) and maximal power (P_{max}) – were achieved in the Wingate test in this study, which may have been the result of a training break after the season and the absence of specific training loads during the 4-week training cycle. On the other hand, it could be expected that strength training would positively affect the values of basic anaerobic fitness indices. Thorstensson and Karlsson (1976) showed that strength training with submaximal loads increased anaerobic power significantly. Reduction of time in which maximum power was achieved and extending the time for which maximum power was maintained seems to have been caused by an increase in muscle mass.

The P_{max} value of the tested players – 11.77 W/kg and 11,72 W/kg – was similar to the results achieved by junior and senior national team handball

players (Norkowski 2002). Consequently, the level of maximum power in the players can be regarded as high.

Conclusions

1. A 4-week mesocycle of general fitness resulted in a statistically significant increase in the PWC₁₇₀ index and VO_{2max}.
2. The level of aerobic power in the group of tested handball players (assessed by PWC₁₇₀ test) was low.
3. The 4-week mesocycle of general fitness did not result in an increase in the main anaerobic fitness indices: maximum power (P_{max}) and the amount of work performed (W_{tot}).
4. The level of anaerobic power in the tested group of elite handball players was high. The relative values of P_{max} and W_{tot} in these players were similar to those measured in the senior and junior national team players.
5. A significant increase in body mass and lean body mass was most likely caused by strength training.

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