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Exercise capacity in young handball players

Capacitatea de efort la jucătorii tineri de handbal

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Abstract

Background. The high level of the handball game requires a carefully designed physical training program, as well as adequate technical-tactical, psychological and theoretical training.

Aims. The indicators of exercise capacity during the spe¬cific training period were studied in young handball players compared to young subjects with general sports training.

Methods. The research was performed in 6 groups (n=10 subjects/group): group C1 (18 years), group C2 (17 years), group C3 (16 years) - controls, and group E1 (18 years), group E2 (17 years), group E3 (16 years) - athletes. The measured indicators of exercise capacity were heart rate, maximal O_2 consumption, maximal aerobic power, VO_2 max depending on age and aerobic exercise capacity.

Results. Significant decreases in heart rate and significant increases in VO_2 max, aerobic exercise capacity and maximal aerobic power were found in the groups of athletes compared to the groups of non-athletes of the same age.

Conclusions. In the post-pubertal period, in young people with general physical training, an increase in VO_2 max depending on age occurs. Specific sports training determines an improvement of VO_2 max, aerobic exercise capacity and maximal aerobic power in young handball players.

Key words: VO_2 max, aerobic capacity, physical exercise, young handball players.

Rezumat

Premize. Handbalul este o specialitate sportivă care impune o pregătire fizică specifică şi o pregătire tehnică şi tactică, psihologică şi teoretică adecvată.

Obiective. S-au studiat indicatorii capacităţii de efort în cursul perioadei de pregătire specifică la handbalişti tineri şi la tineri cu pregătire fizică generală.

Metode. Cercetările au fost efectuate pe 6 loturi de tineri (n=10 subiecţi pe lot): lotul C1 (18 ani), lotul C2 (17 ani), şi lotul C3 (16 ani) - martori şi lotul E1 (16 ani), lotul E2 (17 ani) şi lotul E3 (16 ani) - sportivi. Indicatorii capacităţii de efort determinate au fost frecvenţa cardiacă, consumul maxim de O_2 în funcţie de vârstă şi capacitatea aerobă de efort.

Rezultate. Se observă scăderi semnificative ale frecvenţei cardiace, creşteri semnificative ale consumului maxim de O_2, capacităţii aerobe de efort şi puterii maxime aerobe la loturile de sportivi, faţă de martorii de aceeaşi vârstă.

Concluzii. Pregătirea fizică specifică în perioada postpubertară determină îmbunătăţirea indicatorilor capacităţii de efort la jucătorii de handbal tineri.

Cuvinte cheie: VO_2 max, capacitate aerobă, efort fizic, jucători tineri de handbal.

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Introduction

Handball is a sport characterized by a wide diversity of actions, which require specific physical training, as well as adequate technical-tactical, psychological and theoretical training. Physical effort during handball game involves a very good anaerobic capacity paralleled by a very good aerobic capacity.

Aerobic and anaerobic exercise capacity in handball players, assessed based on specific indicators, presents variations depending on:

- the playing position in the team (Schweisig et al., 2006; Nikolaidis et al., 2015; Ilić et al., 2015; Ilić et al., 2011; Zapartidis et al., 2011; Rannou et al., 2001);
- gender (Zapartidis et al., 2009b);
- anthropometric profile (Jakovljevic et al., 2015; Nikolaidis and Ingebrigtsen, 2013; Zapartidis et al., 2009a; Moncef et al., 2012);
- age and maturation of young athletes (Vieira et al., 2013; Nikolaidis et al., 2015; Rousanoglu et al., 2014);
- training (Jakovljevic et al., 2015; Wagner et al., 2014);
- the team's competitive level (Vieira et al., 2013; Rousanoglu et al., 2014).

Values are higher in athletes compared to non-athletes, in men compared to women, in adults compared to young subjects, in trained compared to untrained subjects, in teams with a high competitive level.

Hypothesis

Physical training specific to the game might contribute to improving aerobic exercise capacity.

Material and methods

The research was conducted with the approval of the Cluj County School Inspectorate, the subjects' informed consent, the consent obtained from the subjects' parents, and the approval of the sports medicine doctor at the *George Coșbuc* National College in Cluj-Napoca.

Research protocol

a) Period and place of the research

The determinations of anthropometric parameters in athletes of the experimental groups and in the control groups were performed at time T1 - October 2015.

The studies were carried out at the school medical office of the *George Coșbuc* National College in Cluj-Napoca and at the medical office of the Sports High School in Cluj.

b) Subjects and groups

The research was conducted in 6 groups of subjects, each consisting of 10 subjects.

The experimental groups (E) included professional athletes from the Sports High School Cluj and the Potaissa Handbal Club Association Turda, while the control groups (C) comprised pupils from the *George Coșbuc* National College in Cluj-Napoca, as follows:

C1 – subjects born in 1997, aged 17.77 ± 0.26 at time T1

C2 – subjects born in 1998, aged 16.57 ± 0.19 at time T1

C3 – subjects born in 1999, aged 15.88 ± 0.25 at time T1

E1 – subjects born in 1997, aged 17.72 ± 0.26 at time T1

E2 – subjects born in 1998, aged 16.24 ± 0.38 at time T1

E3 – subjects born in 1999, aged 15.47 ± 0.17 at time T1

The weekly training program of groups C consisted of general physical training for 1-2 hours/week, while the weekly training of groups E consisted of specific physical training for 2-3 hours/day, 5 days/week.

c) Tests applied

Aerobic exercise capacity (AEC) was explored indirectly using the Åstrand-Ryhming method (Drăgan, 2002); submaximal exercise for 6 minutes, performed on the Ergoline 900 cycle ergometer, at 40-80 rotations/min, with an intensity of 2.5 W/kg maintained constant throughout the test.

The indicators of aerobic exercise capacity were determined:

Directly

- heart rate in cycles/min (HR), measured immediately after exercise using the Polar F2 heart rate monitor.

Indirectly

- maximal O_2 consumption in ml (VO_2 max), determined using the Åstrand-Ryhming nomogram, based on the linear relationship between heart rate, O_2 consumption and wattage;
- maximal aerobic power (MAP) in ml/kg, calculated based on the formula: $MAP=VO_2max/G$;
- aerobic exercise capacity (AEC), expressed as percentage, in relation to ideal VO_2 max: AEC=MAP/ ideal VO_2 max.
- VO_2 max depending on age: VO_2 max (V)

d) Statistical processing

Statistical processing was performed using the StatsDirect v.2.7.2 program, with the OpenEpi 3.03 application and the Excel application (Microsoft Office 2010). The results were graphically represented using Excel (Microsoft Office 2010).

Results

a) Comparative analysis

In the groups of athletes E1, E2, E3, compared to the control groups C1, C2, C3, the following were found:

- significant decreases in heart rate (Table I)
- significant increases in VO_2 max (Table II)
- significant increases in AEC (Table V)
- significant increases in MAP (Table III)
- insignificant changes in VO_2 max depending on age (Table IV)

Depending on age, in the groups of athletes the following were found:

- significant decreases in heart rate in group E2 compared to group E1 and in group E3 compared to group E2 (Table I)
- significant increases in VO_2 max depending on age in group E2 compared to group E1, in group E3 compared to group E1 and in group E3 compared to group E2 (Table IV)
- significant increases in MAP in group E3 compared

to group E1 and in group E3 compared to group E2 (Table III)

In the control groups - C1, C2, C3, - depending on age, the following were found:

- significant decreases in VO_2 max in group C2 compared to group C1 (Table II)
- significant increases in VO_2 max depending on age in groups C2 and C3 compared to group C1 and in group C3 compared to group C2 (Table IV)
- significant decreases in AEC in group C2 compared to group C1 and in group C3 compared to group C2 (Table V)

b) Correlation analysis (Table VI)

Table I

Comparative analysis of *heart rate* values (measured in cycles/min) in the studied groups and statistical significance.

Group	Mean	SE	Median	SD	Minimum	Maximum	*Statistical significance (p)*
C1	172.20	2.2000	174	6.9570	162	180	C + E
C2	172.80	1.4967	174	4.733	168	180	< 0.0001
C3	170.40	2.2271	171	7.043	162	180	
E1	153.00	5.1575	150	16.3095	132	180	C1-C2-C3
E2	148.20	3.6932	144	11.6790	138	168	0.7214
E3	135.60	1.8330	135	5.7966	126	144	
p	C1-C2	0.9863	E1-E2	0.6178	C1-E1	0.0050	E1-E2-E3
	C1-C3	0.5724	E1-E3	0.0088	C2-E2	< 0.0001	0.0088
	C2-C3	0.5009	E2-E3	0.0096	C3-E3	9.27×10^{-10}	

Table II

Comparative analysis of *VO_2 max* values (measured in ml/min) in the studied groups and statistical significance.

Group	Mean	SE	Median	SD	Minimum	Maximum	*Statistical significance (p)*
C1	3175	98.9529	3175	312.9164	2650	3600	C + E
C2	2790	111.5049	2725	352.609	2200	3250	1.08×10^{-12}
C3	2915	99.1772	3000	313.626	2350	3250	
E1	4090	142.5560	4100	450.8018	3400	5000	C1-C2-C3
E2	4300	232.3790	4200	734.8469	3400	5400	0.0408
E3	4400	161.9328	4400	512.0764	3700	5300	
p	C1-C2	0.0188	E1-E2	0.4531	C1-E1	7.58×10^{-5}	E1-E2-E3
	C1-C3	0.0799	E1-E3	0.1679	C2-E2	5.61×10^{-5}	0.4834
	C2-C3	0.4132	E2-E3	0.7286	C3-E3	1.14×10^{-6}	

Table III

Comparative analysis of *MAP* values (measured in ml/kg) in the studied groups and statistical significance.

Group	Mean	SE	Median	SD	Minimum	Maximum	*Statistical significance (p)*
C1	40.34	2.0342	40.01	6.4327	31.18	50.00	C + E
C2	37.34	0.6911	36.65	2.186	34.67	40.83	8.44×10^{-9}
C3	40.01	1.4096	38.33	4.458	34.44	47.00	
E1	46.75	2.6760	47.32	8.4622	33.61	58.82	C1-C2-C3
E2	49.50	2.3211	51.86	7.3401	38.64	59.04	0.3076
E3	55.94	1.4309	56.78	4.5249	49.41	62.50	
p	C1-C2	0.1898	E1-E2	0.4472	C1-E1	0.0736	E1-E2-E3
	C1-C3	0.8961	E1-E3	0.0090	C2-E2	0.0004	0.0195
	C2-C3	0.1123	E2-E3	0.0322	C3-E3	2.78×10^{-7}	

Table IV

Comparative analysis of *VO_2 max* values depending on age in the studied groups and statistical significance.

Group	Mean	SE	Median	SD	Minimum	Maximum	*Statistical significance (p)*
C1	47.88	0.0324	47.88	0.1026	47.69	48.00	C + E
C2	48.32	0.0244	48.33	0.077	48.22	48.42	< 0.0001
C3	48.59	0.0314	48.58	0.099	48.47	48.76	
E1	47.89	0.0327	47.88	0.1035	47.71	48.03	C1-C2-C3
E2	48.28	0.0473	48.27	0.1495	48.10	48.47	3.21×10^{-15}
E3	48.58	0.0221	48.61	0.0698	48.48	48.65	
p	C1-C2	4.41×10^{-9}	E1-E2	4.33×10^{-6}	C1-E1	0.8783	E1-E2-E3
	C1-C3	5.86×10^{-12}	E1-E3	< 0.0001	C2-E2	0.4216	< 0.0001
	C2-C3	3.41×10^{-6}	E2-E3	< 0.0001	C3-E3	0.9557	

Table V

Comparative analysis of *AEC* values (%) in the studied groups and statistical significance.

Group	Mean	SE	Median	SD	Minimum	Maximum	*Statistical significance (p)*
C1	0.54	0.0213	0.54	0.0672	0.43	0.63	C + E
C2	0.49	0.0065	0.50	0.021	0.46	0.52	2.21×10^{-13}
C3	0.52	0.0112	0.52	0.036	0.47	0.57	
E1	0.66	0.0226	0.69	0.0715	0.56	0.75	C1-C2-C3
E2	0.70	0.0316	0.72	0.0999	0.54	0.81	0.0641
E3	0.75	0.0205	0.75	0.0649	0.67	0.84	
p	C1-C2	0.0468	E1-E2	0.4017	C1-E1	0.0011	E1-E2-E3
	C1-C3	0.4366	E1-E3	0.0096	C2-E2	8.73×10^{-5}	0.0613

Table VI
Statistical correlation analysis between the values of the studied indicators.

Indicators	\ Group	C1		E1		C2		E2		C3		E3	
	VO_2max	-0.7426	***	-0.1224	*	0.4438	**	-0.8003	****	-0.4407	**	-0.8310	****
	MAP	-0.6237	***	-0.8844	****	-0.3514	**	-0.7102	***	-0.3828	**	-0.7786	****
	VO_2max (V)	-0.5284	***	-0.2393	*	-0.3114	**	-0.2832	**	0.1782	*	0.0672	*
	AEC (%)	-0.7241	***	-0.8216	****	0.1298	*	-0.8428	****	-0.6092	***	-0.8813	****
VO_2max -	MAP	0.6099	***	0.0152	*	-0.5459	***	0.5853	***	-0.3601	**	0.6541	***
	VO_2max (V)	0.3492	**	-0.2176	*	0.1539	*	0.1413	*	-0.2418	*	-0.3727	**
	AEC (%)	0.7842	****	0.4926	**	0.6345	***	0.9057	****	0.1681	*	0.9046	****
MAP	VO_2max (V)	0.0458	*	0.4611	**	-0.0804	*	0.2071	*	0.1019	*	-0.0671	*
	AEC (%)	0.9696	****	0.8725	****	0.2989	**	0.8714	****	0.8575	****	0.9139	****
VO_2max (V) -	VO_2max/HR	0.4237	**	-0.0793	*	0.2365	*	0.2082	*	-0.2541	**	-0.3727	**
	AEC (%)	0.1542	*	0.2855	**	0.1066	*	0.2292	*	-0.0236	*	-0.2622	**
VO_2max/HR -	AEC (%)	0.8068	****	0.8511	****	0.6560	***	0.9388	****	0.3522	**	0.9337	****

The correlation analysis between the studied indicators in the groups of athletes showed for:

Group E1: - a very good negative correlation for HR-MAP, HR-AEC and a very good positive correlation for MAP-AEC;

Group E2: - a very good negative correlation for HR-VO_2 max, HR-AEC and a very good positive correlation for VO_2 max-AEC, MAP-AEC;

Group E2: - a very good negative correlation for HR-VO_2 max, HR-MAP, HR-AEC and a very good positive correlation for MAP-AEC;

Group C1: - a very good positive correlation for VO_2 max-AEC, MAP-AEC;

Group C3: - a very good positive correlation for MAP-AEC;

Discussions

Our results are in accordance with the data of other authors regarding the increase of VO_2 max, AEC and MAP in junior handball players as a result of specific training (Jakovljevic et al., 2015; Wagner et al., 2014), depending on age and maturation (Vieira et al., 2013; Nikolaidis et al., 2015; Rousanoglu et al., 2014).

Other authors found no differences regarding VO_2 max depending on the playing position (Buchheit et al., 2009).

Our results are in agreement with the data on standard anthropometric parameters presented in the article published in the Palestrica of the Third Millennium journal, no. 4/2016 (Potoră et al., 2016).

The improvement of exercise capacity parameters can be considered as an adaptive change induced by specific physical training in young handball players.

Conclusions

1. In the post-pubertal period, in young people with general physical training, an increase of VO_2 max depending on age occurs.
2. Specific physical training of young handball players during the post-pubertal period causes an improvement in VO_2 max, AEC and MAP.
3. Adaptive changes of exercise capacity indicators in young handball players should be taken into account for tertiary selection, with a view to training elite players.

Conflicts of interests

There are no conflicts of interest.

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