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Aerobic exercise capacity in young rugby players
Capacitatea aerobă de efort la sportivii tineri care practică rugby

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Abstract

Background. The high level of modern rugby requires carefully designed physical training, adapted to the particularities of this sport, in a direct correlation with age and the training level of the players.

Aims. The indicators of aerobic exercise capacity during the training period were studied in young rugby players with specific training and in pupils and students with general sports training.

Methods. The research was performed in 6 groups (n=10 subjects/group): group M I (18 years), group M II (19 years), group M III (20 years) – controls, and group S IV (18 years), group S V (19 years), group S VI (20 years) – athletes. The measured indicators of aerobic exercise capacity were heart rate and indirectly, maximal O_2 consumption, maximal aerobic power, VO_2 max depending on heart rate, VO_2 max depending on age, and aerobic exercise capacity.

Results. Significant decreases of heart rate and significant increases of 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 of 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 rugby players.

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

Rezumat

Premize. Nivelul înalt la care se practică rugby-ul modern impune o pregătire fizică atent elaborată, adaptată specificităţii acestui sport, precum şi în directă corelaţie cu vârsta şi nivelul de pregătire al sportivilor.

Obiective. S-au studiat indicatorii capacităţii aerobe de efort în perioada de pregătire la jucătorii de rugby tineri, cu pregătire specifică şi la elevi şi studenţi cu pregătire sportivă generală.

Metode. Cercetările au fost efectuate pe 6 loturi (n=10 subiecţi/lot), lotul M I (18 ani), lotul M II (19 ani), lotul M III (20 ani) - martori şi lotul S IV (18 ani), lotul S V (19 ani), lotul S VI (20 ani) – sportivi. Indicatorii capacităţii aerobe de efort determinaţi au fost frecvenţa cardiacă şi indirect, consumul maxim de O_2, puterea maximă aerobă, VO_2 max în funcţie de frecvenţa cardiacă, VO_2 max în funcţie de vârstă şi capacitatea aerobă de efort.

Rezultate. Se observă scăderi semnificative ale frecvenţei cardiace, creşteri semnificative ale VO_2 max, ale capacităţii aerobe de efort şi ale puterii maxime aerobe la loturile de sportivi, faţă de loturile de nesportivi de aceeaşi vârstă.

Concluzii. În perioada postpubertală, la tinerii cu pregătire fizică generală se constată creşterea VO_2 max în funcţie de vârstă. Pregătirea sportivă specifică determină îmbunătăţirea VO_2 max, a capacităţii aerobe de efort şi a puterii maxime aerobe de efort la jucătorii de rugby tineri.

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

Introduction

Rugby is a team sport involving fight, full commitment and direct contact with the opponent. Having a rich motor content, it belongs to the category of mixed sport games, which are played with both hand and foot. An essential feature of current rugby is full physical commitment; the game has a strong characteristic of contact fight conducted based on individual and collective confrontation during attack and defense, physical training being crucial. Tough fight without sparing the opponent is continued until exhaustion of the opponents' physical resources.

According to Drăgan (2002), from an energogenetic point of view, rugby is part of mixed sports, in which the anaerobic element, both alactacid and lactacid, is predominant. Effort alternates with static and dynamic phases.

This sport is included in the category of intermittent sprint sports due to the specificity and rapid succession of the game phases, which comprise easy running, sprinting, full contact fight with the direct opponent, scrummage, etc.

The game moments characteristic of the rugby game, during which the players attempt to move forward with the

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ball, meeting the direct opponent's resistance, as well as fast running or sprinting phases are high intensity actions. The energy required for this type of effort is provided by anaerobic pathways, while for low intensity game phases, energy is supplied by aerobic pathways.

Aerobic exercise capacity is particularly important in rugby because it can ensure the energy needed for movement on the ground, as well as restoration of phosphocreatine reserves during low intensity game phases.

Some studies have demonstrated that players with a higher aerobic exercise capacity can better cope with high intensity efforts during the game due to the influence of aerobic capacity on recovery after maximal anaerobic exercise and support of the anaerobic glycolytic system (Tomlin et al., 2001).

Hypothesis

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

Material and methods

Research protocol

The research took place at the Ambulatory Sports Medicine Clinic and was approved by its manager, by the Ethics Board of the "Iuliu Hatieganu" University of Medicine and Pharmacy Cluj-Napoca, and the informed consent of the subjects was obtained.

a) Period and place of the research

The determinations were performed in April 2013.

b) Subjects and groups

Determinations were performed in 6 groups (n=10 subjects/group):

- 3 control groups: M I (18 years), M II (19 years), M III (20 years), with general physical training (one hour of physical education/week)
- 3 groups of athletes: S IV (18 years), S V (19 years), S VI (20 years), with specific physical training (2 hours/day for 5 days weekly)

The groups of athletes included members of the rugby teams of the "Cluj-Napoca University" club, and the control groups were formed by pupils of the "Avram Iancu" Theoretical High School and students of the "Babes Bolyai" University in Cluj-Napoca. The measurements were carried out in the Ambulatory Sports Medicine Clinic in Cluj-Napoca, under medical supervision.

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_2 max/G;
- ideal VO_2 max, calculated based on the formula: ideal VO_2 max =104.4-(0.38 X G);
- aerobic exercise capacity, expressed as percentage, in relation to ideal VO_2 max: AEC=MAP/ ideal VO_2 max.

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

Comparative analysis

In the groups of athletes S_{18}, S_{19}, S_{20}, compared to the control groups M_{18}, M_{19}, M_{20}, the following were found:

- Significant decreases of heart rate (Tables I, IV)
- Significant increases of VO_2 max (Table II) and VO_2 max/HR (Table III)
- Significant increases of AEC (Table V) and MAP (Table VI)

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

- Significant increases of heart rate in group S_{19} compared to S_{10} (Table IV)
- Significant increases of MAP in group S_{18} compared to S_{19} (Table V)
- Decreases of VO_2 max depending on age in S_{19} compared to S_{18}, in S_{20} compared to S_{19} (Table IV)
- Significant decreases of AEC in S_{19} compared to S_{18} (Table VI)

In the control groups - M_{18}, M_{19}, M_{20} – depending on age, the following were found:

- Increases of VO_2 max depending on age in M_{19} compared to M_{18}, in M_{20} compared to M_{18} and M_{19} (Table IV).

The correlation analysis between the studied indicators in the groups of athletes (Table VII) showed for:

a) Group S_{18}: - a very good negative correlation for HR-MAP and HR-AEC;

- a very good positive correlation for VO_2 max-VO_2 max/HR
- a good positive correlation for VO_2-AEC
- a very good positive correlation for MAP-AEC

b) Group S_{19}: - a good negative correlation for HR-VO_2 max

- a very good negative correlation for HR-VO_2 max/HR and HR-AEC
- a good positive correlation for VO_2 max-MAP
- a very good positive correlation for VO_2 max-VO_2 max/HR and

VO_2 max-AEC

c) Group S_{20}: - a good negative correlation for HR-VO_2 max

- a very good negative correlation for HR-MAP, HR-VO_2 max/HR, HR-AEC
- a very good positive correlation for VO_2 max-MAP
- a very good positive correlation for VO_2 max-VO_2 max/HR, VO_2 max-AEC
- a very good positive correlation for MAP-VO_2 max and MAP-AEC.

The correlation analysis between the studied indicators

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)*
M18	169.8	4.0050	171	12.6649	150	192	M + S
M19	169.2	2.4980	168	7.899	156	180	< 0.001
M20	163.8	2.8355	162	8.967	150	180	
S18	137.4	4.1425	132	13.0996	120	168	M18-M19-M20
S19	146.4	3.3705	144	10.6583	132	162	NS
S20	142.8	4.3635	144	13.7986	120	168	
p	M18-S18	< 0.001	M18-M19	NS	S18-S19	< 0.05	S18-S19-S20
	M19-S19	< 0.001	M18-M20	NS	S18-S20	NS	NS

Table II

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

Group	Mean	SE	Median	SD	Minimum	Maximum	*Statistical significance (p)*
M18	2815	144.1546	2750	455.8569	2350	3600	M + S
M19	3030	125.4326	3100	396.6527	2450	3800	< 0.001
M20	2965	183.7949	2775	581.2104	2350	4100	
S18	5180	183.6664	5300	580.8040	4400	6100	M18-M19-M20
S19	4580	309.1386	4300	977.5821	3350	6100	NS
S20	5160	345.1892	5350	1091.5840	3800	6800	
	M18-S18	< 0.001	M18-M19	NS	S18-S19	NS	S18-S19-S20
p	M19-S19	< 0.001	M18-M20	NS	S18-S20	NS	NS
	M20-S20	< 0.001	M19-M20	NS	S19-S20	NS	

Table III

Comparative analysis of VO_2 max/HR values in the studied groups and statistical significance.

Group	Mean	SE	Median	SD	Minimum	Maximum	*Statistical significance (p)*
M18	16.74	1.0855	16.35	3.4327	12.24	22.22	M + S
M19	17.99	0.9212	17.54	2.9131	14.08	24.36	< 0.001
M20	18.23	1.2936	17.03	4.0907	14.08	25.31	
S18	38.03	1.7481	39.57	5.5278	26.19	45.45	M18-M19-M20
S19	31.71	2.6663	29.17	8.4315	21.47	44.20	NS
S20	36.84	3.1826	37.23	10.0642	23.21	49.28	
	M18-S18	NS	M18-M19	NS	S18-S19	< 0.001	S18-S19-S20
p	M19-S19	NS	M18-M20	NS	S18-S20	< 0.001	NS
	M20-S20	NS	M19-M20	NS	S19-S20	< 0.001	

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)*
M18	47.79	0.0276	47.78	0.0872	47.69	47.97	M + S
M19	47.42	0.0264	47.43	0.0835	47.26	47.56	< 0.001
M20	47.03	0.0270	47.03	0.0854	46.90	47.15	
S18	47.79	0.0357	47.80	0.1128	47.64	47.996	M18-M19-M20
S19	47.46	0.0377	47.47	0.1191	47.27	47.63	< 0.001
S20	47.05	0.0305	47.06	0.0964	46.89	47.17	
	M18-S18	NS	M18-M19	< 0.001	S18-S19	< 0.001	S18-S19-S20
p	M19-S19	NS	M18-M20	< 0.001	S18-S20	< 0.001	< 0.001
	M20-S20	NS	M19-M20	< 0.001	S19-S20	< 0.001	

Table V

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)*
M18	46.002	1.6404	47.058	5.1873	36.905	52.459	M + S
M19	43.105	0.9593	41.908	3.0337	40	50	< 0.001
M20	44.913	1.6281	45.973	5.1486	38.406	53.333	
S18	64.118	3.0050	66.681	9.5027	45.833	77.419	M18-M19-M20
S19	55.035	2.6226	55.929	8.2935	44.086	67.647	NS
S20	57.690	3.0033	55.155	9.4972	41.489	75.342	
	M18-S18	< 0.001	M18-M19	NS	S18-S19	< 0.05	S18-S19-S20
p	M19-S19	< 0.001	M18-M20	NS	S18-S20	NS	NS
	M20-S20	< 0.01	M19-M20	NS	S19-S20	NS	

Table VI

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

Group	Mean	SE	Median	SD	Minimum	Maximum	*Statistical significance (p)*
M18	0.569	0.0170	0.568	0.0538	0.472	0.646	M + S
M19	0.555	0.0151	0.549	0.0479	0.502	0.662	< 0.001
M20	0.567	0.0230	0.560	0.0726	0.481	0.661	
S18	0.874	0.0286	0.894	0.0903	0.675	0.967	M18-M19-M20
S19	0.759	0.0401	0.737	0.1267	0.593	0.927	NS
S20	0.823	0.0450	0.817	0.1423	0.604	0.991	
p	M18-S18	< 0.001	M18-M19	NS	S18-S19	< 0.05	S18-S19-S20
	M19-S19	< 0.001	M18-M20	NS	S18-S20	NS	NS

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

Indicator \	Group	M18	S18	M19	S19	M20	S20
Age	HR	-0.2655 **	0.0389 *	-0.2837 **	0.2103 *	0.2625 **	-0.3451 **
	VO_2 max	-0.0144 *	0.1197 *	0.0621 *	-0.0036 *	0.2219 *	0.7175 ***
	MAP	-0.3493 **	0.1036 *	-0.0545 *	-0.2432 *	-0.1083 *	0.2976 **
	VO_2 max acc. to age	-1.0000 ****	-1.0000 ****	-1.0000 ****	-1.0000 ****	-1.0000 ****	-1.0000 ****
	VO_2 max/HR	0.0585 *	0.1525 *	0.1208 *	-0.0573 *	0.0545 *	0.6265 ***
	AEC	-0.3138 **	0.1325 *	0.0845 *	-0.1290 *	0.0379 *	0.5668 ***
HR -	VO_2 max	-0.4382 **	0.0593 *	-0.4170 **	-0.6507 ***	-0.4663 **	-0.6188 ***
	MAP	-0.3618 **	-0.9342 ****	-0.4645 **	-0.9715 ****	-0.9515 ****	-0.9604 ****
	VO_2 max acc. to age	0.2655 **	-0.0389 *	0.2837 **	-0.2103 *	-0.2625 **	0.3451 **
	VO_2 max/HR	-0.7032 ***	-0.3329 **	-0.6534 ***	-0.7786 ****	-0.5742 ***	-0.8102 ****
	AEC	-0.5030 ***	-0.8044 ****	-0.5968 ***	-0.8653 ****	-0.8116 ****	-0.8427 ****
VO2 max -	MAP	0.0690 *	0.1511 *	0.7646 ****	0.7305 ***	0.6183 ***	0.6765 ***
	VO_2 max acc. to age	0.0144 *	-0.1197 *	-0.0621 *	0.0036 *	-0.2219 *	-0.7175 ***
	VO_2 max/HR	0.9441 ****	0.8434 ****	0.9598 ****	0.9828 ****	0.9666 ****	0.9573 ****
	AEC	0.5532 ***	0.5739 ***	0.9463 ****	0.9355 ****	0.8803 ****	0.9303 ****
MAP -	VO_2 max acc. to age	0.3493 **	-0.1036 *	0.0545 *	0.2432 *	0.1083 *	-0.2976 **
	VO_2 max/HR	0.2213 *	0.6429 ***	0.8013 ****	0.8378 ****	0.6848 ***	0.8484 ****
	AEC	0.8687 ****	0.8956 ****	0.9030 ****	0.9245 ****	0.9168 ****	0.8989 ****
VO_2 max HR V. -	VO_2 max/HR	-0.0585 *	-0.1525 *	-0.1208 *	0.0573 *	-0.0545 *	-0.6265 ***
	AEC	0.3138 **	-0.1325 *	-0.0845 *	0.1290 *	-0.0379 *	-0.5668 ***
VO_2 max/HR -	AEC	0.6467 ***	0.9122 ****	0.9763 ****	0.9816 ****	0.8667 ****	0.9892 ****

Correlations: **** very good, *** good, ** acceptable, * weak

in the control groups (Table VII) showed for:

a) Group M_{18}: - a good negative correlation for HR-AEC

- a very good positive correlation for VO_2 max-VO_2 max/HR
- a good positive correlation for VO_2 max-AEC
- a very good positive correlation for MAP-AEC

b) Group M_{19}: - a good negative correlation for HR-AEC

- a very good positive correlation for VO_2 max-MAP, VO_2 max-AEC and MAP-AEC

c) Group M_{20}: - a good negative correlation for HR-AEC

- a very good positive correlation for VO_2 max-MAP, VO_2 max-AEC and MAP-AEC

Discussions

Many authors have studied in young rugby players (aged 11-22 years) the factors that influence their activity profile:

- age (Galvin et al., 2013; Waldron et al., 2014; Kobal et al., 2016; Darrall-Jones et al., 2015; Till et al., 2014)
- individual physiological characteristics, physical abilities and longitudinal evolution (Till et al., 2014; Barr et al., 2014; Waldron et al., 2014; Hausler et al., 2016)
- maturation (Gabbett et al., 2008)
- the position in the game (La Monica et al., 2016; Swaby et al., 2016)
- aerobic exercise capacity (Gabbett et al., 2008; La Monica et al., 2016; Sampson et al., 2015; Woldron et al., 2014)
- training - type of training, type of movements, duration and frequency of movements (continuous or repeated) (Sampson et al., 2015; Waldron et al., 2014; Twist & Highton, 2013; Robineau et al., 2016)
- intensity and frequent collisions (Johnston et al., 2014; Mullen et al., 2015; Gabbett et al., 2013; Hausler et al., 2016)
- fatigue (Gabbett, 2008; Johnston et al., 2014)
- biochemical changes post-training (Johnston et al., 2014; Mullen et al., 2015; Galvin et al., 2013)

Our results are in accordance with the data of other authors regarding the increase of VO_2 max, AEC and MAP in junior rugby players as a result of specific training (Gabbett, 2008; La Monica et al., 2016; Twist & Highton, 2013; Kobal et al., 2016; Swaby et al., 2016).

In the studied groups, whose standard anthropometric indices were presented in the article published in no. 1/2016, the body mass index (BMI) evidenced:

- a good positive correlation with VO_2 max in all subjects of the control groups - M_{18}, M_{19}, M_{20}
- a very good positive correlation with VO_2 in group S_{19}
- a good positive correlation with VO_2 in group S_{20}
- a good positive correlation with AEC in group S_{19}

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 rugby players during the post-pubertal period causes an improvement of VO_2 max, AEC and MAP.
3. The improvement of exercise capacity indicators can be considered as an adaptive change induced by specific physical training in young rugby players.
4. Adaptive changes of exercise capacity indicators in young rugby players should be taken into account for tertiary selection with a view to training elite players.

Conflicts of interest
Nothing to declare.

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References

Barr MJ, Sheppard JM, Gabbett TJ, Newton RU. Long-term training-induced changes in sprinting speed and sprint momentum in elite rugby union players. J Strength Cond Res. 2014;28(10):2724-2731.

Darrall-Jones JD, Jones B, Till K. Anthropometric and Physical Profiles of English Academy Rugby Union Players. J Strength Cond Res. 2015;29(8):2086-2096.

Drăgan I. Medicină sportivă. Ed. Med. București 2002, 17-21.

Gabbett TJ, Johns J, Riemann M. Performance changes following training in junior rugby league players. J Strength Cond Res. 2008;22(3):910-917.

Gabbett TJ, Stein JG, Kemp JG, Lorenzen C. Relationship between tests of physical qualities and physical match performance in elite rugby league players. J Strength Cond Res. 2013;27(6):1539-1545.

Galvin HM, Cooke K, Sumners DP, Mileva KN, Bowtell JL. Repeated sprint training in normobaric hypoxia. Br J Sports Med. 2013;47 Suppl 1:i74-79.

Hausler J, Halaki M, Orr R. Application of Global Positioning System and Microsensor Technology in Competitive Rugby League Match-Play: A Systematic Review and Meta-analysis. Sports Med. 2016;46(4):559-588.

Johnston RD, Gabbett TJ, Jenkins DG. Applied sport science of rugby league. Sports Med. 2014;44(8):1087-1100.

Kobal R, Nakamura FY, Moraes JE, Coelho M, Kitamura K, Cal Abad CC, Pereira LA, Loturco I. Physical performance of brazilian rugby players from different age-categories and competitive levels. J Strength Cond Res. 2016 Jan 22 [Epub ahead of print].

La Monica MB, Fukuda DH, Miramonti AA, Beyer KS, Hoffman MW, Boone CH, Tanigawa S, Wang R, Church DD, Stout JR, Hoffman JR. Physical Differences between Forwards and Backs in American Collegiate Rugby Players. J Strength Cond Res. 2016 Mar 1[Epub ahead of print].

Mullen T, Highton J, Twist C. The Internal and External Responses to a Forward-Specific Rugby League Simulation Protocol Performed With and Without Physical Contact. Int J Sports Physiol Perform. 2015;10(6):746-753.

Robineau J, Babault N, Piscione J, Lacome M, Bigard AX. Specific Training Effects of Concurrent Aerobic and Strength Exercises Depend on Recovery Duration. J Strength Cond Res. 2016;30(3):672-683.

Sampson JA, Fullagar HH, Gabbett T. Knowledge of bout duration influences pacing strategies during small-sided games. J Sports Sci. 2015;33(1):85-98.

Swaby R, Jones PA, Comfort PJ.Relationship between Maximum Aerobic Speed Performance and Distance Covered in Rugby Union Games.Strength Cond Res. 2016 Feb 12 [Epub ahead of print].

Till K, Jones B, Emmonds S, Tester E, Fahey J, Cooke C. Seasonal changes in anthropometric and physical characteristics within English academy rugby league players. J Strength Cond Res. 2014;28(9):2689-2696.

Tomlin DL, Wenger HA. The relationship between aerobic fitness and recovery from high intensity intermittent exercise. Sports Med. 2001;31(1):1-11

Twist C, Highton J. Monitoring fatigue and recovery in rugby league players. Int J Sports Physiol Perform. 2013;8(5):467-474.

Waldron M, Worsfold PR, Twist C, Lamb K. The relationship between physical abilities, ball-carrying and tackling among elite youth rugby league players. J Sports Sci. 2014;32(6):542-549.