
AEROBIC AND CARDIAC PERFORMANCE OF ELITE WEIGHT LIFTERS AND SOCCER PLAYERS

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Abstract: Endurance training sessions and maximal strength training are different in general. That makes training sessions and aerobic, and pulmonary performance completely different in weight lifters and soccer players. Weight lifting requires maximal power and concentration, while football requires endurance, combinability and speed. Cardiopulmonary exercise testing is a basic method for evaluation of the functions of cardiovascular system in sportsmen, healthy people and in different diseases. Spiroergometry tests give additional information about the adaptation of the body to physical loadings, aerobic performance and oxygen pulse. Oxygen pulse estimates left ventricular stroke volume changes during exercise, and it is the ratio of VO_2 extracted per heartbeat.

The aim of the study was to investigate aerobic and cardiac performance, and the oxygen pulse of elite weight lifters and soccer players.

Two groups of 12 weight lifters and 17 soccer players, men, members of elite sport teams, voluntary underwent spiroergometry test on system AT-104 (Schiller, Switzerland). There was no difference in the age between weight lifters (group WL, n=12, 19.33±1.67 years) and soccer players (group S, n=17, 20.47±1.66 years), (P>0.05). The body mass index of WL (26.4±1.47 kg/m²) and S (24.99±3.58) was also similar (P>0.05).

Before the beginning of the tests we have obtained informed consent. The sportsmen denied diseases, usage of drugs and doping. Medical examinations were performed. The day before the test was without heavy physical activity. Veloergometer stepwise incremental protocol was applied.

Physical working capacity, represented as peak loading was lower in group WL as compared with group S (120±13.43 vs. 160±14.62 W, P<0.0001). Maximal heart rate was higher in S as compared with WL (172.59±14.51 vs. 137.18±12.8 b.p.m., P<0.0001). Maximal level of the systolic blood pressure was higher in S as compared with WL (179.12±24.70 vs. 137.50±15.88 mmHg, P<0.0001). Maximal level of the diastolic blood pressure was higher in S as compared with WL (93.24±12.37 vs. 79.08±10.10 mmHg, P<0.0001). Not surprising aerobic performance was better in the group of the soccer players. Oxygen pulse at the level of the anaerobic threshold was higher in soccer players' group as compared with WL (12.07±3.60 vs. 7.95±2.09, ml per beat, P=0.002), but maximal VO_2 pulse was similar for WL (15.15±5.40, ml per beat) and S (17.29±3.20, ml per beat), (P>0.05). There were no differences between the groups in the values of VO_2 pulse during the levels of loading from 30 to 120. The heart rate recovery after physical loading was determined in three grade scale (1-poor; 2-normal; 3-good) and there were no significant differences between the groups, WL (2.45±0.52), S (2.38±0.50), (P>0.05).

Despite the differences in aerobic and cardiac performance between the weight lifters and soccer players there were no differences in the values of the peak VO_2 pulse. The values of the VO_2 pulse during the levels of physical loading from 30 to 120 W was similar in both groups. Further investigations are need to evaluate the importance of VO_2 pulse values as an index for determining the physical condition in different diseases, healthy people, and sportsmen.

Keywords: soccer, weight lifting, oxygen pulse, cardiopulmonary exercise testing

INTRODUCTION

Endurance training sessions and maximal strength training are different in general. That makes training sessions and aerobic, and pulmonary performance completely different in weight lifters and soccer players. Weight lifting requires maximal power and concentration, while football requires endurance, combinability and speed.

Soccer is the most popular sport in the world and is played regardless of age, gender and physical capacity. The physical aspects of soccer have been studied most intensively in adult male players and a substantial body of information is available for this population (Mohr et al., 2003; Bangsbo et al., 2006). In a typical soccer match, elite

players cover a total distance of 9–12 km with an average aerobic loading of 75% of maximum oxygen uptake (VO_{2max}) and at about 80–90% of maximum heart rate (HR) (Krustrup et al., 2005; Stølen et al., 2005; Bangsbo et al., 2006). From published studies, it is clear that soccer performance, and thus match outcome, may be determined by the ability to perform repeated short bursts of high intensity work against an endurance background.

In weightlifting sport power, strength and explosiveness of the skeletal muscles are vital domains. This sport does not require much ventilatory efforts during training as well as competition (Snehunsu et al., 2017). So physiological adaptation (improvement) of the pulmonary function depends on the type of sport being engaged by the athletes (Snehunsu et al., 2017).

When healthy young subjects perform weight-lifting exercises the mechanical compression of blood vessels combines with a potent pressor response to produce extreme elevations in blood pressure even when exercise is performed with a relatively small muscle mass (MacDougall et al., 1985).

The left ventricular structural changes in competitive athletes represent adaptation to hemodynamic overload induced by training and are consistent with different kinds of sport activity. Work capacity during exercise is positively influenced by preload increase in endurance athletes, while increased afterload due to isometric training in strength-trained athletes determines higher systemic resistance during physical effort (D'Andrea et al., 2002).

Cardiopulmonary exercise testing (CPET) is a basic method for evaluation of the functions of cardiovascular system in sportsmen, healthy people and in different diseases (Личев и Кичуков, 2018, Wegman et al., 2015; Malhotra et al., 2016). CPET is a valuable clinical assessment and has a number of indications (Guazzi et al., 2016). CPET can be used to support sportsmen reaching their training goals and evaluate subject's ability to work (Hansen et al., 2015).

Spiroergometry tests give additional information about the adaptation of the body to physical loadings, aerobic performance and oxygen pulse (VO_{2pulse} , ml per beat), (Seminar Manual of Human Physiology, 2018; Практически упражнения по Физиология, ръководство за студенти по Фармация, 2018).

Oxygen pulse estimates left ventricular stroke volume changes during exercise, and it is the ratio of VO_2 extracted per heartbeat (Bhambhani et al., 1994; Oliviera et al., 2009). Maximal VO_{2pulse} is a significant predictor of mortality in patients with and without cardiopulmonary disease (Oliviera et al., 2009). Flattering of VO_{2pulse} during exercise may detect extensive myocardial ischemia (Munhoz et al., 2007). Oxygen pulse is investigated in sportsman as well (Hossein., et al. 2017; Seminar Manual of Human Physiology, 2019).

AIM

The aim of the study was to investigate aerobic and cardiac performance, and the oxygen pulse of elite weight lifters and soccer players.

MATERIAL AND METHODS

Two groups of 12 weight lifters and 17 soccer players, men, members of elite sport teams, voluntary underwent spiroergometry test on system AT-104 (Schiller, Switzerland). There was no difference in the age between weight lifters (group WL, $n=12$, 19.33 ± 1.67 years) and soccer players (group S, $n=17$, 20.47 ± 1.66 years), ($P>0.05$). The body mass index of WL (26.4 ± 1.47 kg/m²) and S (24.99 ± 3.58) was also similar ($P>0.05$).

Before the beginning of the tests we have obtained informed consent. The sportsmen denied diseases, usage of drugs and doping. Medical examinations were performed. The day before the test was without heavy physical activity. Veloergometer stepwise incremental protocol was applied with 30 W beginning, and increasing the loading of cycling with 30W in every two minutes. During investigation the heart rate (b. p. m.), levels of the systolic and the diastolic arterial blood pressure (mmHg), oxygen consumption (VO_2 , l/min), the volume of exhaled carbon dioxide (VCO_2 , l/min), oxygen pulse (VO_{2pulse} , ml per beat) and other functional indices were monitored. Each test was terminated at subjects' request. After the end of each test the subject continued cycling for five minutes with 10% of the peak loading in order to recover the heart rate, levels of the arterial blood pressure, breathing rate etc. The anaerobic threshold (AT) was calculated by VE/VCO_2 slope method (Стефанов, 2004). The heart rate recovery after physical loading was determined in three grade scale (1-poor; 2-normal; 3-good) using software.

Results were presented as $X\pm SD$. An independent samples t test was used (SPSS, v. 13). $P<0.05$ was accepted as significant.

RESULTS AND DISCUSSION

Physical working capacity, represented as peak loading was lower in group WL as compared with group S (120 ± 13.43 vs. 160 ± 14.62 W, $P<0.0001$).

Not surprising aerobic performance was better in the group of soccer players. Absolute peak VO₂ and relative peak VO₂ (VO₂peak/kg, ml/min/kg) were lower in group WL (Table 1). The anaerobic threshold was lower in weight lifters' group. Loading at AT, absolute and relative oxygen consumption at AT were higher in S. Loading at AT, absolute and relative oxygen consumption at AT, presented as present of the peak levels were lower in soccer players' group (Table 1).

Table 1. Indices of aerobic performance in elite weight lifters and soccer players. X±SD.

	weight lifters (n=12)	soccer players (n=17)	P
VO ₂ peak (l/min)	1.38±0.32	2.99±0.65	<0001
VO ₂ peak/kg (ml/min/kg)	22.28±6.06	35.32±9.69	<0.001
VE/VCO ₂ slope	27.35±2.99	20.67±4.06	<0001
Load AT (wat)	77.5±15.45	116.41±41.15	=0.002
Load at AT as % of Load peak (%)	64.92±10.59	52.18±10.98	=0.004
VO ₂ at AT (l/min)	0.956±0.26	1.70±0.34	<000.1
VO ₂ at AT as % of VO ₂ peak (%)	64.00±20.85	51.19±10.53	=0.004
VO ₂ /kg at AT	14.57±5.13	20.59±5.23	=0.006
VO ₂ /kg at AT as % of VO ₂ peak (%)	69.09±8.46	52.18±10.98	<0.0001

Maximal heart rate was higher in S as compared with WL (172.59±14.51 vs. 137.18±12.8 b.p.m., P<0.0001).

Maximal level of the systolic blood pressure was higher in S as compared with WL (179.12±24.70 vs. 137.50±15.88 mmHg, P<0.0001).

Maximal level of the diastolic blood pressure was higher in S as compared with WL (93.24±12.37 vs. 79.08±10.10 mmHg, P<0.0001).

At first step of the test (30 W) and at the second one (60 W) levels of the systolic and the diastolic blood pressure were lower in weight lifters group. During the third level (90 W) the heart rate was higher in WL, and the diastolic blood pressure level was again lower in the WL. The hearth rate, the levels of the systolic and the diastolic blood pressure were similar for both groups in fourth step of loading (120 W), (Table 2).

Table 2. Indices of cardiac performance in elite weight lifters and soccer players at different levels of physical loading and HR recovery after physical loading. X±SD.

Level		weight lifters (n=12)	soccer players (n=17)	P
30 W	HR	99.18±12.91	97.29±15.04	>0.05
	Sys	97.27±7.86	118.82±6.91	=0.001
	Dia	64.09±4.37	77.12±13.04	=0.004
60 W	HR	112.73±9.57	106.24±14.19	>0.05
	Sys	103.64±9.51	123.24±18.79	=0.004
	Dia	67.09±4.4	78.24±13.1	=0.002
90 W	HR	131.64±17.04	118.76±14.03	<0.05
	Sys	122.73±12.12	131.47±21.63	>0.05
	Dia	70.91±8.89	80.76±15.08	<0.05
120 W	HR	134.82±18.65	132.25±15.86	>0.05
	Sys	144.55±19.42	141.56±23.92	>0.05
	Dia	78.89±11.04	80.94±12.68	>0.05

Heart rate (HR, b.p.m.), levels of systolic blood pressure (Sys, mmHg), levels of diastolic blood pressure (Dia, mmHg).

The heart rate recovery after physical loading was determined in three grade scale (1-poor; 2-normal; 3-good) and there were no significant differences between the groups, WL (2.45±0.52), S (2.38±0.50), (P>0.05).

Oxygen pulse at the level of the AT was higher in soccer players' group as compared with WL (12.07±3.60 vs. 7.95±2.09, ml per beat, P=0.002), but maximal VO₂pulse was similar for WL (15.15±5.40, ml per beat) and S (17.29±3.20, ml per beat), (P>0.05).

There were no differences between the groups in the values of VO₂pulse during the levels of loading from one to four (Table 3).

Table 3. VO₂pulse (ml per beat) in elite weight lifters and soccer players at different levels of physical loading. X±SD.

Level	weight lifters (n=12)	soccer players (n=17)	P
30 W	10.60±3.19	9.12±2.62	>0.05
60 W	10.14±3.08	11.95±2.96	>0.05
90 W	12.85±2.99	12.42±1.21	>0.05
120 W	13.51±2.62	13.56±1.47	>0.05

Further investigations are need to evaluate the importance of VO₂pulse values as an index for determining the physical condition in different diseases, healthy people, and sportsmen.

CONCLUSION

Despite the differences in aerobic and cardiac performance between the weight lifters and soccer players there were no differences in the values of the peak VO₂pulse. The values of the VO₂pulse during the levels of physical loading from 30 to 120 W was similar in both groups. Further investigations are need to evaluate the importance of VO₂pulse values as an index for determining the physical condition in different diseases, healthy people, and sportsmen.

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