The Effects of Maximal Aerobic Training on some Cardiovascular Factors and Maximum Oxygen Consumption while Training in Upper and Lower Extremities.

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ABSTRACT: The present study attempts to compare the effect of maximal aerobic training on some cardiovascular factors and maximum oxygen consumption with training in upper and lower extremities. The subjects of the study consisted of 18 high school students. The mean of age, weight and body mass index were 16.60±1.5 years, 175.9±4.7 cm, 67.1±8.1 kg, 21.6±1.8 kg per square meter, respectively, and also the mean heart rate and blood pressure measured at rest condition were 70.9±7 beat per minute and 10.6±0.7 mile meter/mercury, respectively. Aerobic test for upper and lower organs was based on casmed k4b2 protocol using ergometer bicycle. To compare the means obtained, the implicit correlated statistics method of paired T-test and Wilcoxon signed rank test were used. It revealed a significant difference in maximum oxygen consumption, heart rate, systolic blood pressure and myocardial oxygen cost between upper and lower organs (p<0.05). The amount of heart rate, systolic blood pressure, and myocardial oxygen cost in upper extremity is greater than those of the lower extremity while the amount of maximum oxygen consumption was greater for lower extremity compared with the upper extremity.

Key words: upper extremity exercise, lower extremity exercise, maximum oxygen consumption, heart rate, systolic blood pressure, myocardial oxygen cost.

INTRODUCTION

In aerobic activities, there is a linear relation between oxygen consumption and raising the intensity of exercise until the rate of oxygen consumption of the individual reaches the maximal level. Also, there is a direct relationship between the intensity of exercise and the rate of heart rate and this rises until the individual achieves the maximal heart rate. From the rest state until maximal exercise, the consumption of oxygen rises and reaches approximately as many as eight times of the rest state.

There are quantitative studies on the comparison of cardiac responses and metabolic ones while aerobic training in upper and lower extremities. Most studies revealed different cardiac and metabolic responses in training lower and upper extremities. Evidence shows that in training upper extremity compared to that of lower extremity, sympathetic nervous flux has increased because of muscular mass tension whose effect (outcome) is the contraction effect of this nerve on inactive muscular mass (Eston and Brodie., 1986). Along with increasing the intensity of exercise. The rate of oxygen consumption and heart rate in training in upper extremity is higher than that of lower extremity. In increasing training protocols to the limit of exhaustion which are performed to estimate the maximal oxygen consumption and maximal heart rate, these values have always shown higher rates in lower extremity. Because arms get exhausted much sooner compared to legs due to very small muscular mass (Michael Bond et al., 1986). Equal amount of oxygen consumption in upper extremity training causes a higher increase in heart rate compared with that of lower extremity training (Stenberg et al., 1967). In equal oxygen condition, in response to training in upper extremity, higher heart rate has been reported compared to that of lower extremity (Stenberg et al, and asterand et al., 1967).

The rate of oxygen consumption while training with equal intensity in upper extremity, is less than that of the lower extremity (75 percent), in contrast, the values of heart rate, systolic blood pressure and myocardial oxygen cost in training upper extremity are higher than those of lower extremity (shakerian et al., 2012).
The consumption of equal amount of oxygen for exercises using arms leads to higher heart rate and higher blood pressure and lower beat volume compared to those of exercises using legs. Lower beat volume rate and lower output has less been contributed to accumulation of blood in lower extremity and lower venous return. Moreover, while doing activities (training) in upper extremity, the effect of sympathetic nerves contraction on inactive muscles of legs and intestines produces a higher environmental resistance and higher arterial pressure during training in hands. Restriction of muscular pump resultant from inactive muscles of legs and accumulation of blood in lower extremity leads to reduction in venous return and cardiac overload and in consequence, beat volume reduces.

Higher heart rate while training in arms is probably a compensating solution in response to lower beat volume caused by reduction in venous blood return to heart (Stenberg et al., 1967).

MATERIALS AND METHODS

Present research is of semi-experimental and applied type. At first, healthy athlete male students from high-schools of Toyskeran town were recalled for the purpose of participation in the study, then the questionnaire of cooperation and personal information based on interest in participation in the test, personal specifications, lack of use of cigarette or any other drug, not suffering from cardiovascular diseases and blood pressure and having at least two years of athletic activity record on a constant basis was obtained from them.

Individual Specifications of the Subjects

The subjects of this research consisted of 18 active students with the mean age of 16.60±1.5 years, mean height of 175.9±4.7 centimeters, mean weight of 67.1±8.1 kilograms, mean heart beat at rest state of 70.9±7 and mean blood pressure at rest state of 10.6±0.7 millimeters.

Description of Method and Performing Sports

At first, the height and weight of the students were measured, and then heart rate and blood pressure at rest and sedentary state on the chair were computed (with soles on the floor and arms at heart level).

Then, the subjects were invited to come for the purpose of performing aerobic test and estimating maximum oxygen consumption values, heart rate, systolic blood pressure and myocardial oxygen consumption cost.

The protocol of cosmed k4b2 for aerobic test in upper extremity was selected to determine vo2 max. In this test, each subject at the beginning of the activity peddled on the ergo meter bicycle of 5 watt and then, 5 watt was added to the workload per 30 second, and the test continued until the subjects were not able to carry on the activity. Oxygen consumption and heart rate while conducting the test from the beginning to the end of the test were displayed on monitor and at the end of the test, maximum oxygen consumed was record through gas analyzer set, heart rate through the sensor of pulsometer and systolic blood pressure through digital manometer.

The cosmed k4b2 protocol for lower extremity aerobic test was used to determine vo2 max. In these tests, each subject peddled on ergo meter bicycle with 20 watts, then 35 watts were added to workload every 60 seconds. The test continued until the subjects were not able to continue the activity. To measure the given variables, the same procedure for aerobic test of upper extremity was used.

Analysis of Research Findings

Descriptive statistics was used to compute the mean and standard deviation (SD) of height, age, body mass index (indicator), blood pressure and heart rate at rest and implicational statistics (correlated t-test and Wilcoxon signed rank test) was used to compare the mean of maximal values of oxygen consumed, heart rate, systolic blood pressure and myocardial oxygen cost obtained while training in upper and lower extremity, and also mean and deviation criterion of data were used to draw tables and diagrams in word and Excel medium, version 2007. All statistical analysis operation was conducted at meaningful level p< 0.05 using minitab soft-ware version 15.

Research Findings

Mean values and standard deviation related to anthropometric specifications and cardiovascular indicators at rest of subjects are shown in table (1).

Table 1. Mean values and standard deviation of anthropometric specifications and cardiovascular indexes of subjects.

<table>
<thead>
<tr>
<th>Index Variable</th>
<th>Mean and standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age(in year)</td>
<td>16/6± 1/5</td>
</tr>
<tr>
<td>Height(cm)</td>
<td>175/9±4/7</td>
</tr>
<tr>
<td>Weight(kg)</td>
<td>67/1±8/1</td>
</tr>
<tr>
<td>Heart rate at rest(in minute)</td>
<td>70/9±7</td>
</tr>
<tr>
<td>Blood pressure at rest(mm hg)</td>
<td>10/6±0/7</td>
</tr>
<tr>
<td>Body mass index(kg/sq)</td>
<td>21/6±1/8</td>
</tr>
</tbody>
</table>
Results of Wilcoxon signed rank test (for variable s of heart rate, systolic blood pressure and maximum level of tests is lower than 5%. Therefore, it is concluded that in aerobic test, there is a statistically significant difference between the effects of training in upper and lower extremity on given variables in such a way that the effect of upper extremity is higher on heart rate, systolic blood pressure and myocardial oxygen cost and the effect of lower extremity on maximum oxygen consumed is higher.

Discussion and Conclusion

The study result demonstrated that heart rate, systolic blood pressure and myocardial oxygen cost at training in upper extremity in aerobic activity with maximal intensity is higher compared to those of lower extremity while as for the variable of maximum oxygen consumed while training in lower extremity, it showed higher values compared with those of upper extremity.

The results of R.G. Eston and D.A. Brodie revealed that there is a statistically significant difference between the values of oxygen consumed and heart rate at training in arms compared to that of legs and combination of both, in such a way that the rate of oxygen used and heart rate was reported higher at training in arms compared to training in legs and combination of both in equal workload. The findings of Louis R. Amundsen et. al, revealed that in equal power output the rate of heart rate during exercise in upper extremity is higher compared to that of lower extremity. The results obtained in the study by (J.A.L. calbet. et.al 2005) indicated that there is a significant difference between the rate of oxygen consumed in skiing using lower extremity compared to that of upper extremity in such a way that the rate of oxygen used in lower extremity is higher compared with that of upper extremity.

The rate of oxygen intake by muscles depends on external factors such as oxygen delivery and internal factors, that is, the transfer of oxygen from erythrocytes to mitochondria and constant intake of oxygen in mitochondria. The common imagination is that while training in small muscular mass, the internal factors are the main determinants of the rate of oxygen consumed since oxygen delivery in high intensity training is maintained at high levels. Laboratory experiences on human have shown that the rate of oxygen intake by upper extremity while training is lower compared to that of lower extremity, and this lower oxygen intake in upper extremity is correlated with lower oxygen transfer to arms, thus based on a certain amount of oxygen used, the amount of oxygen delivered to upper extremity must be higher and just this subject is the reason for higher proportion of blood flow in arms (calbet et. al 2005). Several factors may be effective in oxygen intake by muscles including, Synthetic loading of oxygen from hemoglobin, the rate of oxygen transfer by veins of muscles (wahren J. 1966), lake of proportion between metabolic requirements and blood flow distribution (piper J. and Haab p. 1991) and lake of proportion between maximal oxidation of muscles and the intensity of exercise (Hepple RT. et al., 2002). Intake of oxygen by cells along with increase in acidity state of blood, increase in temperature and pressure of dioxide carbon is facilitated (strainger et al., 1994). The rate of muscular mass of legs compared to that of arms is two fold, and this causes at least 50% increase in vein oxygen transfer in lower extremity muscles, and there is a positive correlation between oxygen consumed by upper extremity and vein oxygen transfer of arm muscles. Higher mean time of transfer probably facilitates oxygen transfer from erythrocytes to mitochondria. The mean time of vein transfer is estimated from dividing the vein blood volume into the rate of blood flow in muscle and the amount of vein blood volume is dependent on vein density. Laboratory studies have reported relatively higher vein density rate in lower extremity compared to that of upper extremity and as a result, there is lower blood distribution surface and higher blood distribution interval in upper extremity compared to those of lower extremity (calbet et al., 2005). Another factor is the rate of sympathetic nerve current produced while training in upper extremity in a way that it has revealed that its rate is higher while training in upper extremity, and this could be effective in higher stimulation of heart and increasing pulse produced (callister et. al., 1994.).

In the indicator of systolic blood pressure, the rate of blood pressure produced by upper extremity shows higher increase compared to that of lower extremity whose reason could be attributed to contraction effect of sympathetic nerves on organs and inactive muscles. While training in upper extremity, given that dilatation occurs only in small network of vessels in arms and the amount of inactive muscular mass, contracted by the
sympathetic nerves, is much greater, this causes an increase in afterload and as a result raises blood pressure. Also pumping activity of leg muscles while training will facilitate vein blood return from lower extremity to heart.

**REFERENCE**


