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Comparison between VO2 max and serum lactate levels of male bodybuilders and non-bodybuilders in Pakistan

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ABSTRACT

BACKGROUND & OBJECTIVE: Volume oxygen maximum (VO2 max) is a measure of physical fitness and athletic performance. Lactate accumulation during exercise occurs when anaerobic metabolism predominates. There is a difference of opinion among researchers on the intensity of exercise needed to cause this release and whether lactate levels play a role in it. The study aims to determine the effect of VO2 max on the circulatory lactate levels and assess the comparison between the two parameters in male bodybuilders steroid non-users.

METHODOLOGY: This study was conducted at the exercise physiology laboratory at the Postgraduate Medical Institute (PGMI) in Lahore, Pakistan. The study involved 20 healthy male subjects within the age range of 20 to 35 years recruited through convenient non-probability sampling. Group I: non-bodybuilders, Group II: bodybuilders not using anabolic steroids. All participants underwent a graded exercise test on cardiopulmonary exercise testing (CPET) equipment up till exhaustion for VO2 max assessment. Blood sampling was done pre and post-exercise (80% of VO2max) to measure blood lactate levels. Data was analyzed by SPSS version 23. Mean ± SD was calculated for quantitative variables. Paired t-test was used for the comparison of pre-and post-exercise test variables. P-value <0.05 is taken as statistically significant.

RESULTS: Bodybuilders achieved a significantly higher VO2max as compared to non-bodybuilders (p <0.001). Blood lactate levels increased significantly in all the study groups at an exercise intensity of 80% of VO2max (p <0.001).

CONCLUSION: Exercise intensity of 80% of VO2max is sufficient for the significant increase in blood lactate levels.

KEYWORDS: VO2 Max, Body Builders, Serum Lactate.

INTRODUCTION

A healthy lifestyle enhances lifelong health and decreases morbidity and mortality. All this is possible with balanced nutrition and physical activity [1]. Physical exercise (PE) is defined as a subset of Physical Activity that involves structured, planned, and repetitive body movements done to enhance or sustain components of physical fitness [2].

According to the World Health Organization (WHO), it is advised that adults should undertake moderate-intensity physical exercise for a minimum of 150 minutes [3]. Adaptations at the physiological level include improvements to cardiac and pulmonary function and myofibril biomechanical efficiency [4].

An increasing number of clinical studies demonstrate that health promotion benefits of physical exercise are associated with higher cardiorespiratory fitness (CRF) [5].

The volume of Oxygen maximum is dependent on determinants including the heart, the lungs, peripheral circulation, and skeletal muscle bioenergetics [6]. Oxygen uptake from the lungs involves pulmonary ventilation and diffusion. The role of the cardiac system encompasses the ventricular function (cardiac output and heart rate) and the ventricular-arterial coupling. A subcomponent of circulation includes the red blood cells and the blood hemoglobin concentration to efficiently transport oxygen from the heart to the exercising muscles. Numerous factors are known to affect VO2max. These include genetics, age, gender, body composition, and the type and mode of exercise training [7].

Exercise training (ET) is defined as physical activity that is planned and occurs regularly over a certain duration of time lasting from weeks to years [8]. Athletes have greater VO2max than untrained people [9].

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Graded exercise test (GXT), a direct method of VO2max measurement, is valued as the gold standard for quantitatively assessing VO2max during an incremental exercise test [10].

These secondary criteria include: 1)Volitional exhaustion.2) ±10b/m age-matched maximum heart rate achieved i.e. 220-age.3)Post-exercise respiratory exchange ratio (RER) >1.15.4) Post-exercise blood lactate concentration >8mmol/L.5) Rate of Perceived Exertion (RPE) > 17 [11].

Lactate is being extensively used in sports for predicting sports performance and training programs for athletes [12].

The present study was done to explore the relationship between VO2max, and blood lactate among the study groups to develop a better understanding of physiological processes occurring in these male subjects in response to exercise. This study may provide a basis for further medical research, especially in Pakistan, in the field of Exercise Physiology.

METHODOLOGY

This was a cross-sectional comparative study, conducted at the Physiology Research Lab, Post Graduate Medical Institute, Lahore from Jan 2021 till June 2021. The subjects were selected using Non-Probability Convenience sampling and snowball sampling. Sample Size was calculated using WHO calculator version 12.2.6.

$$n=\frac{(z_{1}-\alpha/2+z_{1}-\beta)^{2}(\sigma^{2}_{1}+\sigma^{2}_{2})}{(u_{1}-\mu_{2})^{2}}=5$$

For better statistical results the sample size was increased to 10 subjects per group (as recommended by the advanced review board panel - UHS)

The study population consisted of Th (20) healthy male subjects in the age range of 20 – 35 years divided into two groups. Group I (n = 10): Non-bodybuilders (Controls) that have not performed any type of indoor/outdoor resistance or endurance exercise for the past at least 2 years while Group II : (n=10) were Bodybuilders not using anabolic steroids (Physically Active). Bodybuilders carrying out resistance and endurance exercises for ≥ 5 hours a week for the past 6 months to 2 years that have never used anabolic steroids.

All subjects who met the inclusion criteria underwent exercise preparticipation health screening via the PAR-Q+ questionnaire Physical activity readiness questionnaire (PAR-Q).

Track master 2500 Treadmill (3.0 horsepower) with a max speed of 20 km/hr. A max incline (% grade) of 14% was used as the exercise test equipment (InnoMed China). The treadmill was equipped with a long belt 50 inches long and 20 inches wide, supporting handles on each side, and an emergency stop plug. Cardio-Pulmonary Exercise Testing (CPET) equipment (Cortex Biomedical, Germany) and its accessories.

Blood lactate concentration was measured using a portable lactate analyzer (Lactate Plus meter, Nova Biomedical, Waltham, MA).On the first contact session (Day I), weight in kilograms (kg) was measured with minimal clothing using an analog weighing machine. Height in centimeters (cm) was measured.

The Body Mass Index of each subject was determined using the formula.

BMI = body weight (kg) / height2 (m2).

The Bluetooth HR sensing Polar belt was clipped around the chest of the participant with the detector pressing firmly over the apex beat area of the chest (5th intercostal space midclavicular line). The resting HR rate is sensed and displayed on the screen.

Age predicted maximum HR = 220 – age.

This value was entered into the system so that the software shows an alert sign and alarm when the subject crosses his maximum predicted HR.

The polar belt remained attached to the participant for the entire course of the test as HR was continuously being recorded throughout the exercise testing session till exhaustion.Determination of VO2max was done by using the modified Bruce protocol for VO2max testing.Modified Bruce protocol is a staged exercise protocol.

The Exercise Test was immediately discontinued in case: the participant requests to stop the test, has a feeling of nausea, dyspnea, chest pain, leg cramps, or dizziness, signs of pallor, cyanosis, or ataxia, the inability of HR to rise with an increase in exercise intensity or physical or verbal manifestation of severe fatigue.

Upon exhaustion, the subject was put into recovery/cool-down phase for 2 minutes in which the treadmill speed was brought back to the initial warmup speed (1.5 kph) and 0O incline through which the subject walked slowly till the complete stop.The Second Contact Session was assigned as Day II. It was scheduled 3 days after the first contact session of the participant.

Pre-exercise (Baseline) test blood sampling was done by the participant by asking to sit on the chair comfortably for blood sampling for lactate.Calculation of 80% of VO2max was done by using the formula: VO2 = VO2max x 80/100. Where VO2max was the value previously achieved by the participant on 1st contact session (Day I).

Data was analyzed using IBM SPSS Version 23. Data was checked for normality by the Shapiro-Wilk Test. Normally distributed quantitative variables were presented as Mean ± SD. Non-normal data was represented as median and standard deviation. Paired t-test was applied to analyze the differences of means between pre- and post-exercise quantitative variables. Student t-test was applied for comparison among the study groups. P-value < 0.05 was considered statistically significant.

RESULTS

In group, I (non-bodybuilders) the data of all the variables were normally distributed except age. In group II (bodybuilders non-users) all the data was normally distributed except height.

Table II: Data distribution of anthropometric and biochemical variables in the study groups.

Table-I : Group I: Non-bodybuilders (Controls)

Variables	Mean±SD	Shapiro-Wilk Test		Distribution of Data
		Statistic	P-value	
Age (years)	24.8 ± 4.0	0.804	0.016	Non-normal
Height (cm)	172.2± 4.3	0.848	0.056	Normal
Weight (kg)	68.7 ± 13.3	0.975	0.936	Normal
BMI (kg/m2)	23.1 ± 4.0	0.908	0.268	Normal
VO2 at Rest (ml/kg/min)	6.9 ± 1.1	0.920	0.359	Normal
VO2max (ml/kg/min)	35.4 ± 4.8	0.920	0.356	Normal
VCO2 at Rest (L/min)	0.54 ± 0.1	0.907	0.260	Normal
VCO2 max (L/min)	2.7 ± 0.9	0.976	0.939	Normal
RER at Rest	0.9 ± 0.1	0.864	0.085	Normal
RER max	1.2 ± 0.1	0.938	0.527	Normal
Baseline Blood Lactate (mmol/L)	1.42 ±0.4	0.923	0.386	Normal
Post-exercise Blood Lactate (mmol/L)	4.86 ± 0.9	0.947	0.639	Normal

Table-II : Group II: Bodybuilders.

Variables	Mean±SD	Shapiro-Wilk Test		Distribution of Data
		Statistic	P-value	
Age (years)	24.8 ± 4.0	0.923	0.386	Normal
Height (cm)	175.7 ± 8.4	0.708	0.008	Non-Normal
Weight (kg)	74.5 ± 11.8	0.945	0.608	Normal
BMI (kg/m2)	24.0 ± 2.9	0.979	0.959	Normal
VO2 at Rest (ml/kg/min)	6.8 ± 1.6	0.869	0.098	Normal
VO2max (ml/kg/min)	43.4 ± 4.2	0.845	0.058	Normal
VCO2 at Rest (L/min)	0.54 ± 0.1	0.885	0.149	Normal
VCO2 max (L/min)	3.9 ± 0.5	0.966	0.853	Normal
RER at Rest	0.8 ± 0.1	0.925	0.401	Normal
RER max	1.1 ± 0.1	0.915	0.318	Normal
Baseline Blood Lactate (mmol/L)	1.52 ± 0.3	0.891	0.172	Normal
Post-exercise Blood Lactate (mmol/L)	4.00 ± 0.6	0.895	0.191	Normal

Table-III: Comparison of VO2max and VCO2max within the study groups using student t-test.

Variables	Group I (Non-bodybuilders) Mean ± S.D n=10	Groups II (Bodybuilders) Mean ± S.D n=10	P-value
VO2max (ml/min/kg)	35.4 ± 4.8	43.4 ± 4.2	≤0.001*
VCO2max (L/min)	2.7 ± 0.9	3.9 ± 0.5	0.002*

***p-value statistically significant**

Table-IV: Comparison of baseline and post-exercise (80% VO2max) blood lactate levels among the study groups using paired-sample t-test.

Variables	Study Group	Exercise Test		P-value
		Baseline (Pre-exercise	Post-exercise (80%VO2max)	
		Mean ± S.D	Mean ± S.D	
Blood Lactate (mmol/L)	Group I (Non-bodybuilders) n=10	1.42 ± 0.4	4.86 ± 0.9	<0.001*
	Group II (Bodybuilders) n=10	1.52 ± 0.3	4.00 ± 0.6	<0.001*

*p-value statistically significant

Table-V: Comparison of post-exercise (80% VO2 max) blood lactate within the study groups using student t-test.

Variables	Study Group	Mean ± S.D	P-value
Post-exercise Blood Lactate (mmol/L)	Group I (Non-bodybuilders) n=10	4.86 ± 0.9	0.018*
	Group II (Bodybuilders) n=10	4.00 ± 0.6	

*p-value statistically significant

DISCUSSION

To the best of our knowledge, this is the pioneer study in Pakistan that determined the VO2max using Cardio-Pulmonary Exercise Testing System (direct method) and compared the effect of VO2max on baseline lactate levels in young male bodybuilders and non-bodybuilders.

The results of the present study showed that bodybuilders not using anabolic steroids achieved much higher VO2max values as compared to non-bodybuilders. The blood lactate levels significantly increased post-exercise at 80% of VO2max in both the study groups.

Oxygen consumption (VO2) is a reliable indicator of the energy supplied by aerobic energy systems. Volume oxygen maximum (VO2 max) is regarded as the peak of oxygen consumption and is a measure of cardiorespiratory fitness. In the current study, the mean VO2max was found to be significantly ($p = 0.016$) higher in bodybuilders (43.4 ml/min/kg). Globally, several studies that investigated VO2max in the adult population have shown comparable results [13].

Several international studies done in the past have highlighted the importance of physical training leading to an improvement in VO2 max [14]. The present study substantiates the point that exercise training leads to an increase in VO2max as a significant difference in VO2max was found between the trained (bodybuilders) and the untrained (non-bodybuilders) with trained subjects having a greater VO2max (43.4 ml/min/kg) as compared to the untrained (35.4 ml/min/kg).

Interestingly, the results of the present study showed a lower VO2max magnitude in untrained and trained individuals when compared with large age-matched international studies. Aspenes et al. conducted VO2max testing on a total of 2368 healthy Norwegian men of various age groups and physical activity status. In the age range of 20-29 years, they reported a VO2max of 42 ml/min/kg in inactive healthy men and 56 ml/min/kg in inactive men [15].

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In the present study, an additional parameter that was recorded during the VO2max assessment called respiratory exchange ratio (RER). The results of our study showed no

significant difference between the maximum respiratory exchange ratio (RER max) between the study groups. A similar study was conducted in which respired gas analysis was done in 22 trained and untrained young male adults while performing a maximal exercise test on a motor-driven treadmill to determine VO2 max. A non-significant difference was observed in the resting and maximum RER between the study groups [16].

Lactate is one of the metabolic parameters that affects aerobic performance. An exponential rise in blood lactate levels during incremental exercise marks the transition from aerobic to anaerobic phase and is a sign of impending fatigue. This transition is dependent on the intensity of exercise and the activity of the enzyme lactate dehydrogenase. Our results showed that there was a significant rise in blood lactate levels at an exercise intensity of 80% of VO2max in study groups ($p < 0.001$).

The intergroup post-exercise (80% of VO2max) variation in blood lactate was evaluated in the present study using Post Hoc analysis. A significant difference was found between the bodybuilders and non-bodybuilders ($p = 0.002$). Physically trained subjects (bodybuilders) showed lower post-exercise blood lactate levels as compared to untrained (non-bodybuilders). This result agrees with [17] that long-term physical training decreases blood lactate buildup in the exercising muscles and leads to an improvement in the athletes' functional status and their ability to continue their physical performance.

In summary, this study is one of its kind in Pakistan in terms of the population chosen as well as the equipment used. The results of the present study reinforce the idea that physical exercise (bodybuilding) enhances cardiorespiratory fitness and muscle metabolic capacity as shown by VO2max values and blood lactate levels.

LIMITATIONS:

We could not induct a separate group of females due to the limited budget as well as the difficulty in finding female bodybuilders in Pakistan.

RECOMMENDATIONS:

Conducting further research studies using different exercise equipment (treadmill vs. cycle ergometer) and different exercise protocols would be insightful to see how these factors can influence the outcomes.

CONCLUSION

Bodybuilders reached a higher VO2max and VCO2max as compared to non-bodybuilders. There was a significant rise in blood lactate levels at an exercise intensity of 80% of VO2max.

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Authors' Contribution:

Saqib Javed: Substantial contributions to the conception and design of the work.
Muniza Saeed : Analysis and interpretation of data for the work
Hifza Noor Lodhi: Drafting the work and reviewing it critically for important intellectual content.