

Original Research Article

Normative study of VO₂ max in healthy young adults upon exercise on treadmill and cycle ergometer

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ABSTRACT

Background: As there is a linear relationship between the level of physical activity and health status therefore it is quintessential that an individual's fitness levels be regularly assessed. Cardio-respiratory fitness (CRF), is quantifiable as VO₂ max which is maximal oxygen uptake and is generally considered by exercise physiologists as one of the best indicators of physical fitness. This study aimed to establish baseline normative values of VO₂ max in healthy central Indian population upon exercise on treadmill and cycle ergometer as assessed in sports physiology laboratory of a rural medical college.

Methods: A total of 150 healthy young subjects were included in the study within the age group of 17-28 years. The VO₂ max score was evaluated by using metabolic module of lab chart software investigated through power lab data acquisition system, AD instruments.

Results: Out of 150 subjects, there were a total of 89 (59.33%) male subjects and 61 (40.66%) female subjects. The mean age of males was 21.20±2.62 years and of females was 20.36±2.69 years. The mean and SD value of VO₂ max on treadmill for males was 34.09±4.34 ml/kg/min and for females was 25.09±6.99 ml/kg/min, and on cycle ergometer for males was 32.79±1.85 ml/kg/min and for females was 24.15±5.45 ml/kg/min.

Conclusions: The baseline normative data for CRF parameter, VO₂ max was established in the current study to lay the foundation for risk assessment to improve patient management.

Keywords: VO₂ max, Physical fitness, Normative data, Healthy adults

INTRODUCTION

Rapid changes in the physical, economic, and social contexts in which we sit or walk during the day have led to a general decline in physical activity. It is crucial to constantly evaluate a person's fitness levels because the amount of physical activity directly affects one's health status.

Maximal oxygen consumption (VO₂ max) from an exercise test can be used to directly evaluate CRF, and the exercise capacity (maximal work rate) from an

exercise test is frequently used to estimate CRF. The term VO₂ max refers to the oxygen consumption threshold beyond which an increase in exercise intensity does not result in an increase in oxygen consumption.

The American Heart Association claims that VO₂ max can be regularly measured as a clinically important sign and is a very effective indicator of cardiorespiratory fitness.

A growing corpus of research has shown that CRF is an effective predictor of outcomes across the gamut of

health and disease.¹⁻⁴ Since CRF is ranked as the fourth most crucial factor in relation to coronary artery disease, it is crucial to monitor it.⁵

Given the significance of CRF in determining health risk, having precise reference values is necessary to understand what counts as a normal number. An individual's CRF should initially be taken into consideration when analysing the results of an activity test in terms of what would be typical for that person if they were healthy.

Given that CRF declines with age, this is crucial. Knowing a person's exercise capacity in comparison to their peers will not only aid in risk stratification but also make it easier for patients and healthcare professionals to discuss potential health risks, provide a starting point for bettering CRF, and support recommendations for physical activity.

Our physical health is deteriorating as a result of the sedentary nature of our everyday activities and the lethargy-inducing culture that the current generation has adopted. This way of living only causes fat, which in turn causes chronic cardio-respiratory illness, the main cause of death today. As a result, VO₂ measurement is essential. It will aid society in recognising the hidden difficulty we face.

Owing to its neoteric nature, VO₂ max demands a more extensive global data collection. It is only reasonable that the baseline value of this parameter has not been determined, particularly in Central India, given the lack of measurement of this quantity. Thus, the goal of this study was to examine the effects of exercise on VO₂ max in a healthy central Indian population as measured in a sports physiology lab using a treadmill and a cycle ergometer.

METHODS

A total of 150 subjects in 17-28 years were recruited for the study using the convenient sampling technique. They were divided into four age groups for the purpose of analysis.

Study setting

It was a cross sectional study conducted in the sports physiology laboratory of department of physiology of a rural medical institute of central India. This lab was well established indicating valid and reliable calibration and testing procedure and using experienced personnel qualified to conduct exercise test. Although there were some variations in laboratory equipment, protocols, and procedures followed in the laboratory were consistent with recommendations provided in recently published guidelines.

Study period

The study duration was from 1st May 2019 to 30th November 2019.

Ethical consideration

The permission to conduct the study had been obtained from Institute Ethics Committee before starting the research.

We obtained a signed written informed consent from all study participants prior to the beginning of the study. We ensured that the consent was given voluntarily, fully informed, and was obtained from the persons who are competent to do so.

Each subject was notified of commitment, benefits, risks and possible discomforts of the study.

Inclusion criteria

All healthy subjects who were not having any medical or psychiatric illness and gave written informed consent were recruited for the study.

Exclusion criteria

Subjects suffering from chronic debilitating diseases such as hypertension, diabetes, ischemic heart disease, cardiac arrhythmias, retinopathy, nephropathy, respiratory diseases; psychiatric illness, smokers; those with family history of metabolic diseases including diabetes and hypertension; persons receiving any drug that may affect the autonomic reflexes, persons not giving consent and not willing to participate were excluded.

Procedure

The subject was explained the procedure and all related aspects in great detail and written voluntary consent was taken. History was recorded followed by anthropometry and clinical examination of the subject. On recording height, weight and waist circumference as per set standards of the subject, body mass index (BMI) and body surface area (BSA) were calculated as per standard formulae.

$$\text{BMI} = \frac{\text{weight in kilograms}}{\text{height in m}^2}$$

$$\text{BSA (m}^2\text{)} = 0.20247 \times \text{Height (m)}^{0.725} \times \text{Weight (kg)}^{0.425}$$

Resting pulse rate, BP, and resting respiratory rate were also measured. The equipments used were power lab data acquisition system with LabChart Pro software, a metabolic module which included: Bio Amp, spirometer and flow head, gas analyzer, gas mixing chamber, pneumotach, thermistor pod and accessories. After familiarization with the laboratory and procedures the

subjects initially performed an incremental ramp exercise test to the limit of tolerance on a motorized treadmill and then on a bicycle ergometer. The blood pressure, heart rate was measured after the exercise as well. The highest value of VO₂ achieved during the course of the exercise was considered to be the VO₂ max.

Data analysis

After complete collection the data was arranged for analysis. Descriptive statistics has been used to classify and arrange data. The data has been represented as mean±standard deviation. The data was separated by gender and mode of exercise. The data was further stratified according to age into four groups. The VO₂ max has represented in two units liters/minute and milliliters/kilogram/minutes (takes into account weight of subject as well.) The Kolmogorov-Smirnov (KS) statistic was used for testing the normality of distribution of scores for each fitness test within each age group. For comparison of groups, analysis of variance (ANOVA) and a multiple comparison test of Tukey HSD test (as a post hoc test) were used. Pearson correlation test was used to evaluate the correlation between variables. Differences were considered significant at the level of $\alpha < 0.05$. SPSS for windows version 15 was used for statistical analysis.

RESULTS

The study subjects comprised of males and females of the study population in the age range of 17-28 years. Out of 150, there were a total of 89 (59.33%) male subjects and 40.67 (%) female subjects. The mean age of males was 21.20±2.62 years. The mean age of females was 20.41±1.50 years. The baseline demographic parameters of the study subjects have been enumerated in Table 1.

Their age and gender distribution has been tabulated in Table 2.

Table 1: Anthropometric parameters of study subjects.

S. No.	Parameters	Males (n=89) mean±SD	Females (n=61) mean±SD
1.	Age (years)	21.20±2.62	20.41±1.50
2.	Height (cm)	171.30±5.54	161.95±4.24
3.	Weight (kg)	66.30±8.06	59.64±8.05
4.	BMI (kg/m ²)	20.97±3.94	21.00±4.14
5.	BSA (m ²)	47.36±4.07	44.97±4.71

The VO₂ maximal data of males for treadmill exercise are depicted in Table 3 and for ergometer exercise are shown in Table 4.

The values of VO₂ max of females on treadmill exercise are indicated in Table 5 and on ergometer exercise are illustrated in Table 6.

Table 2: Distribution of study subjects.

Age groups (years)	Males (n=89)	Females (n=61)
	N (%)	N (%)
17-19	14 (35)	18 (22.5)
20-22	12 (30)	53 (66.25)
23-25	11 (27.5)	7 (8.75)
26-28	3 (7.5)	2 (2.5)

Table 3: VO₂ maximal data of males for treadmill exercise.

Age groups (years)	Treadmill	
	VO ₂ max (ml/kg/min)	VO ₂ max (l/min)
17-19	32.55±4.96	2.52±0.70
20-22	34.82±5.72	1.98±0.44
23-25	34.87±4.09	2.26±0.24
26-28	35.68±4.33	2.35±0.37

Table 4: VO₂ maximal data of males for ergometer exercise.

Age groups (years)	Cycle ergometer	
	VO ₂ max (ml/kg/min)	VO ₂ max (l/min)
17-19	32.89±2.31	1.93±0.34
20-22	32.66±2.22	2.49±0.39
23-25	32.49±1.88	2.24±0.45
26-28	33.75±1.93	2.75±0.41

Table 5: VO₂ maximal data of females for treadmill exercise.

Age groups (years)	Treadmill	
	VO ₂ max (ml/kg/min)	VO ₂ max (l/min)
17-19	28.71±5.74	1.76±0.51
20-22	26.75±3.38	1.52±0.18
23-25	25.57±2.45	1.63±0.95
26-28	24.68±3.41	1.60±0.88

Table 6: VO₂ maximal data of females for ergometer exercise.

Age groups (years)	Cycle ergometer	
	VO ₂ max (ml/kg/min)	VO ₂ max (l/min)
17-19	22.53±5.87	1.62±0.48
20-22	25.37±4.74	1.56±0.43
23-25	25.40±2.18	1.49±0.87
26-28	24.10±2.65	1.46±0.92

DISCUSSION

The current analysis represents the first reference data for VO₂ max in young healthy adults of Central India using measures obtained from exercise testing on treadmill and ergometer. The findings of the current study indicated a decrease in VO₂ max across the age range irrespective of sex. Even so, the sex-based differences in VO₂ max seemed to be greater earlier in life and began to narrow in individuals of higher age groups. This had obvious implications for interpreting the exercise test; specifically, an individual's sex and age had primary bearing on what defined a normal CRF response. Although there were discordant observations in Western literature which may be due to known limitations with self-reported physical activity measurements and possible sampling differences, our study indicated normative CRF values were region and country specific. Thus, given the clear importance of CRF as it related to health trajectory and prognosis, efforts should be undertaken to quantify reference values on a global scale to provide a region- and county-specific data. There were alarming statistics on the lack of physical fitness and activity in the developing countries along with the strong evidence of the many benefits of physical activity on health.

Normative data about cardiovascular fitness in Indian population is scarce. Therefore the purpose of this study was to evaluate physical fitness parameters and normative data in healthy young population aged 17-28 year old.

A record of the CRF of an individual helped the individual become better aware of the risks he may or may not have to various cardiovascular diseases.

The range of the baseline values was found to lie between 22-36 ml/kg/min. A general trend that can be noted was that the VO₂ max achieved in treadmill exercise is greater than that on the ergometer. This may be due to the nature of the respective exercise. Another important point to take note of is that the normative values of the males appear to be higher than that of the females. This may show that males tend to be more physically active than females of the study. It was in accordance with the fact that higher values were generally observed in men as reported by others as well.

The exact reasons for the observed differences between the current findings and the western data were difficult to elucidate; however, there were some factors that could serve as plausible hypotheses for observed differences. One was that the fixed speed (3.3 mph) of the Balke protocol requires individuals with higher CRF to perform at very high treadmill grades (>20%), which can cause local fatigue of calf muscles and potentially an early test termination. Another was that the equations used to estimate VO₂ max from treadmill speed and grade were only validated for submaximal steady-state exercise; thus, these equations were known to overpredict VO₂ at higher

levels of exercise. Regardless of the reason for these differences, it was clear that the reference CRF values derived from cardiopulmonary assessment results in notably different values compared with those derived from an actual estimation of CRF from treadmill speed and grade.

The strength of this study was that it provided the first reference data for VO₂ max measured from exercise testing using treadmill and ergometer for the central Indian population. In the past, Paap et al had noted that most studies had small sample sizes and used cycling for the mode of assessment of CRF.⁶

The laboratory contributing data was experienced in exercise testing administration, and the test effort was objectively determined by RER. The sample size was relatively large, with a good age distribution for both males and females and provides improved geographic distribution of the country because it included data from 6 different states. It was important to recognize the differences that exist between VO₂ max measured from cardiopulmonary assessment in lab and those estimated from exercise test data. Thus, this study provided more appropriate reference values for laboratories that included cardiopulmonary assessment as part of the maximal exercise test measurements. The underlying intention of this study was that the incorporation of CRF for risk classification presents health professionals with unique opportunities to improve patient management and to encourage lifestyle-based strategies designed to reduce cardiovascular risk.

Nevertheless, there were some limitations that should be considered. The term apparently healthy was not suitable for the entire study population because some had diseases (e.g., obesity), musculoskeletal concerns (e.g., back pain, osteoarthritis). Although all tests were performed for functional capacity measurement, the individual referral for the tests varied (clinical assessment, fitness screening, and research evaluation), and the choice of treadmill protocols, measurement equipment, and data collection procedures, although consistent with recommendations provided in recently published guidelines were specific to the laboratory.⁷⁻⁹ In addition, the geographic distribution of 6 states was good, although not truly representative of the entire country. The geographic distribution of future studies will improve with continued recruitment efforts.

Finally, the sample size varies among the age groups, with the most representation between the age groups of the 20s and the least in those older than 25 years. Primary limitation of currently available equations using this approach was the relatively small cohorts assessed with limited diversity. In addition, all were specific to the population from which they were drawn.

Although this was similar to the other published data sets compared it suggested that future reports should seek more representation in the younger and older age

groups.^{10,11} Finally, because we had no access to the individual subject data from the other published cohorts from the region concerned, thus limiting to only be able to make observational comparisons.

Limitations

The sample size was small due to time constraints as it was a short-term research. The age range had to be restricted as per the accessible target population.

CONCLUSION

The conduct of this study was in response to a need to establish the baseline normative values of VO₂ max and develop reference values derived from treadmill and ergometer exercise for the Indian subcontinent in the age group 17-28 years. This study will lay the foundation for future studies and the values should provide for a more accurate interpretation of measured VO₂ max from treadmill tests for the Indian population compared with previous standards on the basis of workload-derived estimations of VO₂ max. The development of the further data is ongoing because additional data are constantly being added. Subsequent reports will be released providing more reference values for a variety of measures obtained from cardiopulmonary assessment with expansion planned to include data from clinical populations and children, as well as data from other regions of the country.

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