

## CORRELATION OF EXERCISE CAPACITY (VO<sub>2</sub> MAX) WITH ANTHROPOMETRICS VARIABLES IN NORMAL HEALTHY SUBJECTS

Ekta Khurana<sup>1</sup><sup>1</sup>Associate Professor, Department of Physiology, Jaipur National University Institute for Medical Sciences and Research Centre, Jaipur, Rajasthan, India

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**Corresponding Author:**

**Dr. Ekta Khurana,**  
 Email: ektakhurana50@gmail.com

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**ABSTRACT**

**Background:** Exercise capacity, like some other variables of exercise stress test, is a strong predictor of cardiovascular fitness and overall mortality. Many confounding factors, including age, sex and BMI have been found to affect exercise capacity. This study evaluated whether exercise capacity differs in respect to age, sex and BMI. Our aim was to determine the cross-sectional relationship between exercise capacity and anthropometrics variables in normal healthy subjects. **Materials and Methods:** The study was conducted in “Haldiram and Moolchand Heart Centre”, PBM Hospital, S.P. Medical College, Bikaner on 323 subjects for a period of one year from 1 August 2017 to 1 August 2018. Required information according to study was gathered from the study participants’ hospital record and was categorized into young (18-35 years), middle age (36-55 years), older age (more than 55 years) and underwent maximal treadmill exercise using Bruce protocol. **Result:** This study revealed that exercise capacity was substantially negatively correlated with age, height and BSA. ( $p < 0.05$ ) whereas VO<sub>2</sub>max was not substantially correlated with weight and BMI. ( $p > 0.05$ ) in normal healthy subjects. **Conclusion:** Our results indicate that increase in age is related to a progressive decrease in VO<sub>2</sub>max. Aging is an unavoidable phenomenon as well, is related with progressive decline in VO<sub>2</sub>max. Maintaining cardiovascular fitness will not only help in increasing longevity and reducing premature death but, more significantly, it might reduce the illness period so that until near death people will be healthy. Present study also showcases that sex of individual also be a considerable factor to the performance of exercise. Male performs better than female whereas VO<sub>2</sub>max was not substantially correlated with weight and BMI in normal healthy subjects.

## INTRODUCTION

During childhood and adolescence one of the significant factor affecting the growth is aerobic or cardiopulmonary fitness. In the ageing process, it is still a significant element. Exercise capacity is a physiological indicator of your cardiovascular fitness. Exercise capacity is described by way of “the maximum oxygen uptake for a given workload” as well as thus, expressed either as VO<sub>2</sub> max (the greatest rate of oxygen uptake during exercise as well as used by the body) or METS (metabolic equivalent or oxygen consumption’s basal rate’s multiples while a person being at rest that is for an average adult 3.5 ml/kg/min).<sup>[1]</sup>

VO<sub>2</sub> max is affected by many factors, for example cardiorespiratory fitness, obesity, comorbidities (hypertension and metabolic syndrome), and advanced age.<sup>[2-5]</sup>

Identification of other factors can influence exercise capability is extremely important because its reversals can enhance the patients’ life quality and have an impact on their survival as their ability to exercise is related to prognosis in healthy people and in heart disease patients.<sup>[6-8]</sup>

Modern day sedentary lifestyle has contributed to the pandemic of obesity. Sedentary life style decreases physical activity and lead to obesity which in turn again affects exercise capacity (VO<sub>2</sub> max). The key explanation for this is that fat free body weight, composed primarily of muscle weights in the body, is specifically linked to cardiovascular fitness.

Males have a muscle mass greater than females on general. For age 16-19 years in women and 18-20 years in males, maximum oxygen consumption increases. There is a steady reduction across these ages such that 60-years-olds are around 70% VO<sub>2</sub> max of what they were at 25. Before age of 10, there stands no major difference amongst girls and boys;

thereafter the average differentiation in maximal oxygen uptake among females as well as males amounts to 25 to 35%.

While flexibility declines with age as well as is normally less in women as compared in men, exercise time duration remains the projected value after age and sex adjustment. The length of exercise is such a strong predictive predictor which is used for exercise treadmill testing's risk evaluation.<sup>[9]</sup> In people with impaired cardiopulmonary system, the requirement for full effort to reliably calculate the VO<sub>2</sub> max may be risky, therefore, sub-maximal methods have been established for measuring the VO<sub>2</sub> max.

Two types of intense fitness, the bicycle ergo meter and the treadmill, are often popular for training. Modern day sedentary lifestyle has contributed to the pandemic of obesity. Sedentary life style decreases physical activity and lead to obesity which in turn again affects ability to exercise. Hence if we can recognize major modifiable factors affecting endurance with aging, intervention can be targeted to improve endurance and thereby nullify the declining function and delay overall mortality.

## MATERIALS AND METHODS

The subjects were nominated from "Haldiram and Moolchand Heart Centre", PBM Hospital, S.P. Medical College, Bikaner after approval from S.P. Medical ethical board and research committee.

**Study population:** The study was conducted on 323 subjects from 1 August 2017 to 1 August 2018 for a period of one year and each and every patient whoever fits my inclusion and exclusion criteria was enrolled in the study after taking a consent and subjects were categories into young (18-35 years), middle age (36-55years), older age (more than 55 years).

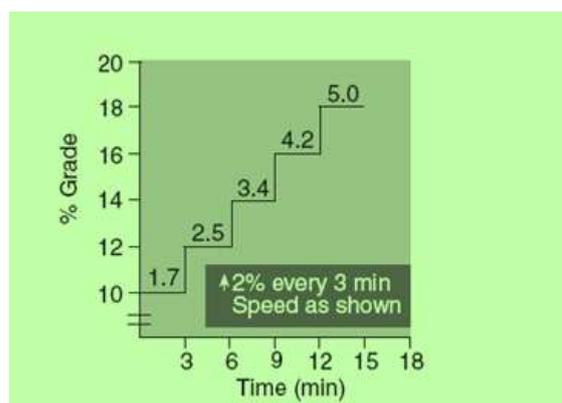
### Exclusion criteria

For excluding the situations which may affect the results, one will be requiring the given criteria: not taking any drugs which may affect the heart; any respiratory disease; atrial fibrillation/flutter; cardiac valve disease, heart failure, or any coronary artery disease.

Clinical assessment Subjects provided completely informed approval for their study participations. Information was collected on family history, age, personal habits (known pathological situations, drug ingestion, physical exercise level and type, smoking, tobacco consumption, alcohol intake). A comprehensive physical investigation was conducted to exclude endocrine and cardiac comorbidities. Anthropometric variable such as weight and height was attained as well as BSA and BMI was analyzed from them. For calculating BMI, following formula is used = "weight (kg)/ height (m)." For calculating BSA, following formula is used = "0.0001x71.84 x (weight in kg)0.425 x(height in cm)0.725." A detailed general examination in mmHg after 5 minutes of complete rest was measured. This was

followed by systemic examination to rule out any major medical or surgical illness.

**Methodology:** Treadmill Test: The CTMT 12 lead device was used for performing the treadmill exercise test. A multi-stage treadmill testing of maximum exercise was conducted using the Bruce protocol (Bruce. R, A.1972). Initially, subjects are allowed to walk slowly at a 10% grade (inclination) at 1.7miles/hour for 3 minutes, grade and speed then amplified after 3 minutes each till exhaustion. The numbers on step indicates speed in miles per hour (mph).



The subject was prepared by applying 12 disposable leads for ECG measurement and allowed to rest for 5 minutes. Blood pressure, pulse rate and resting ECG was measured. After that blood pressure and a standing ECG pulse rate was analyzed.

According to Bruce protocol speed of treadmill and inclination (grade) was increased every three minutes and ECG will be recorded in each phase of the protocol.

The test will be terminated with target heart rate achievement i.e.220-age and time taken for achieving the target rate was used to calculate VO<sub>2</sub> max by following formula.

VO<sub>2</sub> max is calculated according to the equation stated by Bruce which is as follows "In male, VO<sub>2</sub> max = 14.8 - (1.379 × T) + (0.451 × T<sup>2</sup>) - (0.012 × T<sup>3</sup>) whereas in women, VO<sub>2</sub> max =4.38 × T - 3.9 ("T" represents test's total time articulated in minutes as well as minute fractions considered for achieving target heart rate)."

Test was terminated with the appearance of any of following symptoms like chest pain, dyspnoea, fatigue, unable to walk, a fall in systolic BP by 10mmHg or more.,ST-T depression ≥ 1.0 mm.

After exercise termination and after 1 minute as well as 5 minutes of rest, Pulse rate, ECG, and blood pressure was reported automatically. Once VO<sub>2</sub> max has been obtained from the Bruce procedure as well as cardiopulmonary function that is systolic and diastolic function with echocardiography, reasonable mathematical study can demonstrate the correlation between them.

**Statistical analysis:** Data were entered in an excelsheet and analysed using the SPSS (Statistical

Package for the Social Sciences). Pearson Correlation and linear regression model was carried out to test the significant correlation between anthropometric variables (including Age, Height, Weight, BMI, BSA) and VO2 max at 95% confidence interval.

## RESULTS

[Table 1] showed the descriptive statistics of anthropometric variables. Present study includes minimum age of 15 years and maximum age of 72 years of participants under study with mean age 48 years and standard deviation 11.9 years. Male to Female Ratio was (2.05 : 1). The average body mass index was recorded as 24.8 kg/m<sup>2</sup> with  $\pm$  3.1 kg/m<sup>2</sup> of deviation. Average BSA was observed 1.71.

[Figure 1] showed that the average VO<sub>2</sub>max of male was recorded i.e.29.8 more than the of female i.e.26.58.

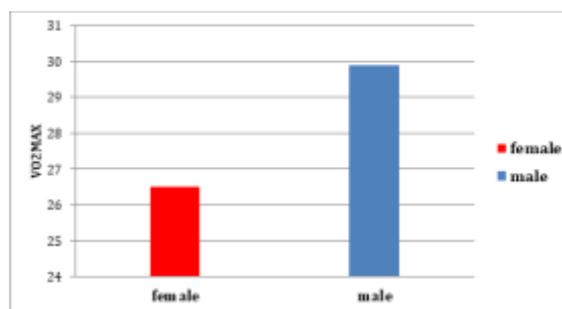


Figure 1: Bar Diagram: Sex vs. VO<sub>2</sub> max (ml/kg/min)

Table 1: Descriptive Statistics of Anthropometric Variables

Variables	Mean $\pm$ sd	Range/ratio
Age (years)	48 $\pm$ 11.9	15 – 72
Male / Female	217/106	2.05:1
Height (cm)	163.4 $\pm$ 8.20	145 - 186
Weight ( kg )	66.5 $\pm$ 10.5	35 -115
BMI (kg/m <sup>2</sup> )	24.8 $\pm$ 3.1	16.6 - 36.7
BSA	1.71 $\pm$ 0.16	1.20 - 2.30

Table 2: Descriptive Statistics of Clinical Variables

Variables	Mean $\pm$ sd	Range/ratio
Resting Pulse rate (bpm)	78.2 $\pm$ 11.03	50 – 127
Resting SBP (mmHg)	126.2 $\pm$ 10.3	100 – 160
Resting DBP (mmHg)	83.5 $\pm$ 6.4	68 – 100
Peak exercise HR achieved (bpm)	166 $\pm$ 15.7	110 – 250
Peak exercise SBP (mmHg)	167.1 $\pm$ 18.8	60 – 220
Peak exercise DBP (mm Hg)	87.3 $\pm$ 7.37	70 – 100
Peak exercise RPP (mmHg)	277.2 $\pm$ 41.1	112.2 -404

[Table 2] showed the MEAN  $\pm$  SD values of Clinical Variables.

Table 3: Correlation and regression of VO<sub>2</sub> max with anthropometric variables

VARIABLES	r	R <sup>2</sup>	F	P	B1	B2
AGE	-0.28	0.07	26.66	0*	38.46	-0.17
HEIGHT	-0.13	0.01	5.53	0.01*	49.34	-0.11
WEIGHT	-0.10	0.01	3.54	0.05	35.12	-0.07
BMI (kg/m <sup>2</sup> )	-0.03	0	0.36	0.54	32.23	-0.07
BSA(m <sup>2</sup> )	-0.13	0.07	5.56	0.02*	40.51	-5.96

p < 0.05, Significant at 5% Level Of Significance; r = Pearson Correlation Coefficient, R<sup>2</sup> = Multiple correlation Coefficient; F = One Way ANOVA F statistic value, B1 = Intercept (Slop) value of linear regression model; B2 = Coefficient of Independent Variables.

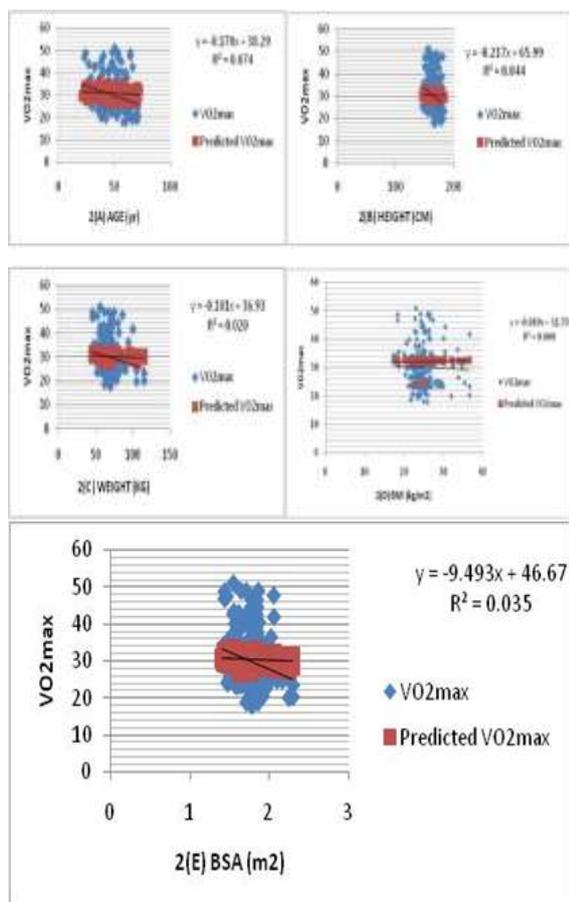


Figure 2: Scatter Diagram showing VO2 max (ml/kg/min) vs (A) Age (B) Height (C) Weight (D) BMI (E) BSA. Figure 2(A) showed that “there was highly significant negative correlation between VO2max and age ( $r = -0.28, p < 0.05$ ).” Figure 2(B) showed “that there was highly significant negative correlation between VO2max and height ( $r = -0.13, p < 0.05$ ).” Figure 2(C) showed “that there was no significant correlation between VO2max and weight ( $r = -0.10, p = 0.05 \geq 0.05$ ).” Figure 2(D) showed “that there was no significant correlation between VO2max and BMI (VO2max  $r = -0.03, p > 0.05$ ).” Figure 2(E) showed “that there was highly significant negative correlation between VO2max and BSA (VO2max  $r = -0.13, p < 0.05$ ).”

[Table 3] presented that VO2 max has been negatively correlated with age, height and BSA revealed that the potential for exercise was substantially negatively correlated with age, height and BSA. ( $p < 0.05$ ) whereas VO2max was not substantially correlated with weight and BMI. ( $p > 0.05$ ).

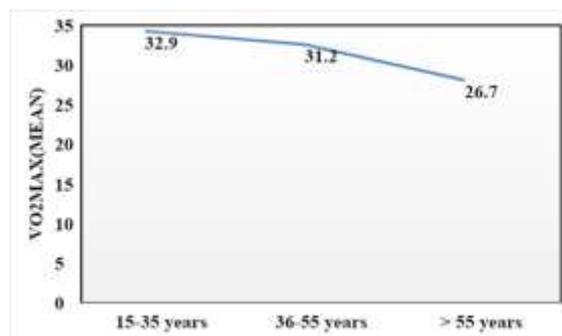


Figure 3: Scatter Diagram of Exercise Capacity (VO2 max) (ml/kg/min) VS AGE GROUPS.

## DISCUSSION

As we know physical fitness it is determined by diverse independent factors. Aging is found to be one of the major factors affecting maximum exercise capacity. Findings of present study as [Table 3, Figure 2] shows a substantial decline in VO2max ( $r = -0.28, p < 0.05$ ) with age. That interprets that as age increases endurance decreases. Similar result was recorded as decrease in VO2 max with age by Okura et al (2000) and Adam et al (1987).<sup>[10,11]</sup> Takeshi Ogawa et al (1992) found a 28-37% reduced VO2max in elders as compared to younger subject.<sup>[12]</sup> Jean Louis et al (1993) reported VO2 max with progressive decline with age.<sup>[13]</sup> Age also affected various functional dynamics of the heart. Slower peak exercise heart rate with increasing age as in our study may be a contributory factor to decrease in VO2max as also reported by Takeshi Ogawa et al.<sup>[12]</sup> According to him, for a portion of this consequence the slower mean heart rate was of greater significance, the lesser stroke volume. David Akinpelu (2006) suggested that the fastest heart rate and cardiac output in older people was partially diminished due to the decline in beta-adrenergic reactivity.<sup>[14]</sup> Older years are closely linked to lower VO2max, as is seen in our research and elsewhere. Higginbotham MB et al (1983) suggested causal pathways for this relationship include decreased maximal heart rate or a reduction of the arteriovenous oxygen content gap impacting the overall heart production, Coggan AR et al (1992) states that ageing is also related to reduced muscle skeleton mass and diminished blood supply of muscle and mitochondrial function, both of which can also contribute in reducing ability for exercise.<sup>[15]</sup>

**BMI, Height, Weight and Exercise Capacity:** In present study Body Mass Index displayed no substantial association with exercise capacities ( $r = -0.03, p = 0.54 > 0.05$ ). Which contradict to the study done by Carl J Lavie et al (2004) in African American men on fitness capacity concluded that endurance and BMI are inversely related. According to him increasing physical fitness and weight reduction is emphasized specifically required for prevention of cardiopulmonary diseases. Similar finding were reported by Grewal (2009).<sup>16</sup> However BMI and

Weight ( $r = -0.10$ ,  $p = 0.05 \geq 0.05$ ) were not found to be significantly related factor to induce endurance in present study but height individually had substantial adverse correlation with VO<sub>2</sub> max ( $r = -0.13$ ,  $p = 0.01 < 0.05$  [Table3, Figure2 A,B,C,D,E]).

**Sex and Exercise Capacity:** In present study Male to Female Ratio is 2.05 : 1. [Figure 1] showed that the average VO<sub>2</sub> max of male (29.8) recorded more than female (26.5). That clearly shows that VO<sub>2</sub> max depends on the sex of an individual.

Proctor et al (1998) and Coggan's AR et al (1992) stated disparity in VO<sub>2</sub> max between men and women was primarily due to unmodifiable variations in heart performance and skeletal muscle mass.<sup>17,18</sup> The findings of Takeshi Ogawa et al (1992) were similar to our study where VO<sub>2</sub>max normalized for weight was higher in male in comparison to female subject.<sup>[12]</sup> Jean Louis et al (1993) in their study on 66 normal healthy individuals confirmed a relation among aerobic capacity and gender.<sup>[13]</sup> Younis LT et al (1990), Higginbotham et al (1984), Adams et al (1987) suggested that the lower aerobic capacity in women is a result of gender associated modification in myocardial contractility evident in older and middle aged women in the form of increased ESVI and sometimes decreased EF at the time of exercise.<sup>[18-20]</sup> The exact mechanisms underlying the gender related difference are not clear.

## CONCLUSION

One of the most debilitating effects of aging is the decline in VO<sub>2</sub>max. Our results indicate that increase in age is related to a progressive decrease in VO<sub>2</sub>max. Present study also showcase that sex of individual also be a considerable factor to the performance of exercise. Male performs better than female. Moreover we observed that, in spite of aging a high fitness capacity comparative to that of younger fit individuals can be maintained if the person undergoes regular physical exercise (as per recommended guidelines for the particular age and associated clinical conditions). However BMI and Weight were not found to be significantly related factor to induce endurance in present study but height individually had substantial adverse correlation with VO<sub>2</sub> max. With increasing age, it is common to have the chronic conditions. Maintaining cardiovascular fitness will not only help in increasing longevity and reducing premature death but, more significantly, it might reduce the illness period so that until near death people will be healthy.

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