

Level of cardiovascular fitness and its relationship with physical activity and body mass index in young adults of Islamabad

Zainab Khatoon¹, Muhammad Afzaal Afridi², Taqdees-e-Maryam³, Afifa Gull⁴, Hania Farheen⁵

Abstract

Objective: To determine the level of cardiovascular fitness in young adults, and to find the relationship of maximum oxygen uptake with body mass index and physical activity.

Methods: The cross-sectional study was conducted at two private universities in Islamabad, Pakistan, from January to June 2019, and comprised subjects of both genders aged 18-25 years with normal cardiopulmonary system. Physical activity was measured using the short form of International Physical Activity Questionnaire, while maximum oxygen uptake was measured using the Bruce protocol. Data was analysed using SPSS 24.

Results: Of the 321 subjects, 59(18.4%) were males and 262(81.6%) were females. The overall mean age was 21.15 ± 1.73 years. Overall, 152 (47.3%) subjects had normal body mass index, 86(26.8%) had high level of physical activity, and 85(26.5%) had moderate level. With respect to maximum oxygen uptake, 28(47.5%) of the males were in the superior category, while 72(27.5%) women were in the good category. All the vitals along with dyspnoea and fatigue showed significant difference ($p \leq 0.05$) except oxygen saturation ($p = 0.062$). Maximum oxygen uptake showed negative weak ($p = 0.40$) correlation with body mass index and weak, positive and significant correlation ($p = 0.007$) with physical activity.

Conclusion: Majority of the young adults were found to be active as indicated by the levels of their maximum oxygen uptake and physical activity. Significant correlation was found between cardiovascular fitness and physical activity.

Keywords: Exercise test, Pakistan, Quality of life, Young adult. (JPMA 71: 1950; 2021)

DOI: <https://doi.org/10.47391/JPMA.09-1104>

Introduction

In today's world, cardiovascular fitness has become a rising concern with the sudden but significant fall in physical activity.¹ Heart diseases have been found to be the leading cause of mortality, according to Centres for Disease Control and Prevention (CDC) and the World Health Organization, accounting for 17 million deaths worldwide annually.^{2,3} Low cardiovascular fitness accounts for an estimated 12% of all deaths in the United States.¹ Lifestyle modification and risk factor reduction can reduce this increasing death rate due to cardiovascular diseases.¹

The WHO has also reported that around 3.2 billion deaths each year are attributed to lack of physical activity.⁴ The level of maximal oxygen uptake (VO_{2max}) serves as a suitable measurement of the level of physical exercise and cardiovascular endurance in an individual. VO_{2max} is defined as the maximum level of oxygen delivered and utilised during intense exercise.³

Cardiovascular fitness is a unit of measure of a person's

physical fitness. Since physical fitness is the ultimate metric in the measurement of most, if not all, of body's functional systems,⁵ therefore cardiorespiratory fitness can be passed on as a measure of body's functional system's condition.¹

Childhood and adolescence, which serve as a crucial base towards the development of a young adult as in these phases not only significant psychological and physiological developments take place, but baseline determinants of lifestyle and behaviour are also established. It has also been reported that approximately 32% Americans are obese, and a vast majority of US adults do not engage in regular physical activity.⁶ This is due to the fact that lack of physical activity induces obesity, and obesity further discourages activity. This never-ending relationship between obesity and physical activity may lead to worsened cardiorespiratory endurance.

Adults who were overweight when they were children have higher levels of lipoproteins, blood pressure and fasting insulin levels and, thus, are at increased risk for cardiovascular disease compared to adults who were slim as children.⁷

Several studies have listed top five risk factors leading to death as high blood pressure (BP), smoking, high blood glucose and obesity, and all these are connected with physical inactivity.^{1,4} Alongside the increase in these risk factors, there is decline in many physiological systems owing to ageing, in addition to loss of muscle mass, decline

¹Department of Physical Therapy, Armed forces Institute of Rehabilitation Medicine, Islamabad, Pakistan; ²Department of Physical Therapy, Capital Development Authority Hospital, Islamabad, Pakistan; ³Department of Physical Therapy, Islamabad Physiotherapy, Physiotherapy and Rehabilitation Center, Islamabad, Pakistan; ⁴Absolute Fitness Gym, Islamabad, Pakistan; ⁵Shifa College of Rehabilitation Sciences, Islamabad, Pakistan.

Correspondence: Zainab Khatoon. e-mail: zainabqureshi15@gmail.com

in balance ability, reduction in muscle strength and endurance and decline in cognitive performance. All these have a significant impact on one's functional independence.⁶

The current study was planned to determine the level of cardiovascular fitness and physical activity in young adults, and to find the relationship of VO_{2max} with body mass index (BMI) and physical activity.

Subjects and Methods

The cross-sectional study was conducted from January to June 2019 at two private universities in Islamabad, Pakistan. After approval from the ethics review board of Shifa International Hospital, Islamabad, the sample size was calculated using Rao software while assuming the young adult population to be 864,099 with a confidence interval (CI) of 95% and 5% margin of error.⁸ The sample was raised using non-probability convenience sampling technique. Those included were young healthy adults aged 18-25 years. Those excluded were individuals with anaemia, pulmonary and cardiovascular diseases, history of thoracic surgery, active/passive/retired smokers and those with any active pathology. All the parameters were excluded by detailed history, general physical assessment and cardiopulmonary system assessment.

Data was collected after taking written informed consent from each subject.

The data-collection tool was a self-designed questionnaire, covering demographic data, past medical history, BMI, assessment of cardiovascular fitness with maximal heart rate (MHR), target heart rate (THR), Bruce protocol outcomes, like VO_{2max}, total run time (TRT), total metabolic equivalent of tasks (METs), VO_{2max} categories and pre- and post- monitoring chart of the vitals, including HR, oxygen saturation, fatigue, Borg scale and BP readings, accompanied by the short form of the International Physical Activity Questionnaire (IPAQ-SF).⁹

Weight and height were measured by weight machine and stadiometer respectively BMI was calculated using standard formula of weight (kg) ÷ height (m²). Participants were classified as Underweight (<18.5kg/m²), normal (18.5-22.9 kg/m²), overweight (≥23kg/m²), at risk (23- 24.9 kg/m²), obese class 1 (25- 29.9 kg/m²) and obese class 2 (>30kg/m²) categories using standard WHO criteria for Asia Pacific Region.¹⁰ Vitals, including oxygen saturation and rather, were measured by digital pulse oximeter (Believia Electronics). BP was measured using standard mercury sphygmomanometer. Respiratory rate was calculated manually by a physical therapist, whereas dyspnoea and fatigue were measured using the modified Borg scale¹¹ and the fatigue rating scale.¹²

Bruce protocol was used to measure VO_{2max}. Pre-test vitals were noted. The subjects were given guidance over how they can stop the test process in case they felt over-exhausted or started to get symptoms of calf pain and shortness of breath. Other reasons of termination were participant's denial and THR achieved. At the completion of Bruce protocol, participant's post-test vitals were noted. The outcome measures in all the participants were assessed by a professional physical therapist to ensure uniformity. In the end, total runtime and gender was used to calculate VO_{2max} using the formulas, VO_{2 max} = 14.8 – (1.379 * T) + (0.451 * T₂) – (0.012 * T₃) for men, and VO_{2max} = 4.38 * T – 3.9 for women.¹³

The participants were classified into superior, excellent, good, fair, poor, and very poor categories of VO_{2max}.¹³

Data was analysed using SPSS 24. Mean and standard deviation was calculated for quantitative variables, like age, MHR, THR, total time on treadmill, VO_{2max} and IPAQ score. Frequencies and percentages were calculated for qualitative variables, like gender, BMI, reason for termination, level of physical activity, VO_{2max} categories according to age and norms for males and females. Shapiro Wilks normality test was applied on all baseline variables and *p*<0.05 for all the variable indicated that the data was not normally distributed. The test of choice was Wilcoxon signed rank test for inter-group comparisons. Spearman correlation was used to assess the relationship of VO_{2max} with physical activity and BMI.¹⁴

Results

Of the 351 subjects approached, 321(91.5%) participated. Of them, 59(18.4%) were males and 262(81.6%) were females. The overall mean age was 21.15±1.73 years. Overall 152 (47.3%) subjects had normal BMI, 56 (17.4%) were underweight, 32 (9.96%) were at risk, 16 (4.98%) in obese class 1 and 65 (20.2%) were found to be in obese class 2 category. The reason of termination of the Bruce protocol was calf pain for 120(37.4%) subjects, followed by shortness of breath 107(33.4%), exhaustion 87(27.1%), participant's denial 4(1.2%) and THR achieved 3(0.9%). Mean MHR, THR, total time on treadmill, VO_{2max} and IPAQ score were noted (Table 1).

Table-1: General characteristics.

Variables	Mean±SD	Minimum	Maximum
Maximum Heart Rate (B/M)	193.89±1.90	191	198
Target Heart Rate (B/M)	164.14±1.15	155	166
Time (Seconds)	12.77±52.29	0	945
VO _{2max} (Volume of Oxygen) ml\kg\min	38.32±12.67	5	88
IPAQ Score	1335.21±1638.35	0	14238

SD: Standard deviation, B/M: Beats per minute, IPAQ: International physical activity questionnaire.

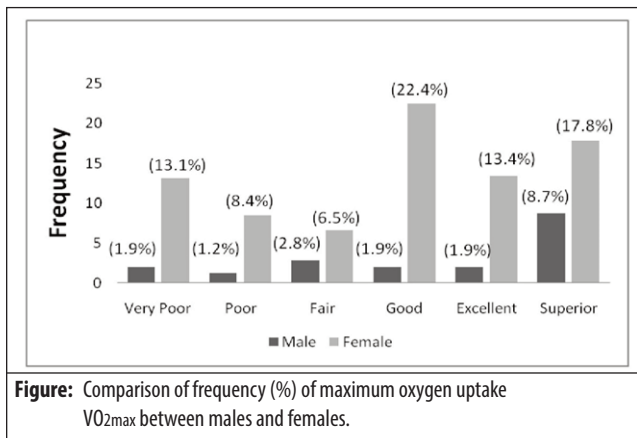


Figure: Comparison of frequency (%) of maximum oxygen uptake VO₂max between males and females.

Table-2: Comparison of pre- and post-exercise vitals, dyspnoea and fatigue within a group.

Variables	Mean±SD		p-value
	Pre-test	Post-test	
Heart Rate(B\M)	94.74 ± 14.33	150.74 ± 28.14	0.000
Systolic BP(mmHg)	111.18 ± 14.49	129.21 ± 14.82	0.000
Diastolic BP(mmHg)	74.76 ± 10.53	79.74 ± 10.79	0.000
Respiratory Rate (b\m)	16.45 ± 8.14	24.19 ± 9.99	0.000
Oxygen Saturation (%)	97.95 ± 1.90	98.15 ± 1.83	0.062
Dyspnoea	0.015 ± 1.240	1.51 ± 0.95	0.000
Fatigue	0.02±0.176	0.98±0.76	0.000

SD: Standard deviation, B\M: Beats per minute, BP: Blood pressure, b\m: breaths per minute, mmHg: Millimetre of mercury.

Lowest category of IPAQ score was found in 150(46.7%) subjects, followed by highest 86(26.8%) and moderate 85(26.5%) categories. Age wise categories of VO₂max for men aged 13-19 years and 20-29 years were 9(15.3%), and 50(84.7%), while the corresponding values for women were 57(21.8%) and 205(78.2%). According to VO₂max norms, 28(47.5%) men were in the superior category, while 72(27.5%) women were in the good category (Figure).

In terms of vitals, systolic blood pressure (SBP and diastolic BP (DBP), respiratory rate and HR showed significant difference between pre- and post-Bruce protocol readings ($p < 0.05$) except oxygen saturation ($p = 0.062$). Other variables, including dyspnoea and fatigue, also showed significant difference ($p < 0.05$) (Table 2). VO₂max and physical activity showed a weak positive but significant correlation ($r = 0.15$, $p = 0.007$), while VO₂max and BMI showed a weak negative and non-significant correlation ($r = -0.046$, $p = 0.409$).

Discussion

The study determined the level of cardiovascular fitness in young adults, and found that 47% subjects had low physical activity levels, while 53% were sufficiently active in moderate and high categories of physical activity. Similar results were reported in another study.¹⁵ Contrary to the current results, a study reported that majority of young

adults had low physical activity levels, with only 17% falling in moderate to vigorous physical activity levels.¹⁶ This difference in physical activity levels might be due to the different culture, target population and testing protocol. Changes in testing protocols and characteristics of target population can affect the results. The current findings showed that mean value of VO₂max was in the good category. However, categorical distribution of VO₂max showed that males had better values than females. Similar findings were reported earlier,¹¹ while contrasting findings have also been reported.¹⁷

Greater VO₂max in males might be due to the reason that they are taller, having greater muscle mass and lower BMI.

In present study, the findings of pre-test and post-test HR, SBP and DBP showed high significance. Similar results were reported by two studies.^{18,19}

SBP was found increased because afferent signals are sent from the exercising muscles to the brain, stimulating the sympathetic centre and causing a rise in HR and cardiac output and resulting in SBP increase.²⁰

However, conflicting results were found in the studies mentioned above for DBP.^{14,15} This conflict might be due to the differences in testing protocols.

The findings of oxygen saturation in the current study showed a very small change, where means for pre-test and post-test showed a 0.2% increase. On the contrary, studies showed a mean change in oxygen saturation before and after test as 0.5% and 0.86%, but as a decrease, as opposed to increase in the current study.^{18,19} This contradiction may be attributed to human error, such as delay in the measurement of oxygen saturation can show an increase in the readings.

The present study showed weak positive and significant correlation between VO₂max and physical activity levels, showing that increase in physical activity increases VO₂max. The correlation between physical activity and VO₂max was also observed in different studies.¹⁷ One of the possible explanations for this correlation might be that during any physical activity or exercise, adaptations occur in human body to increase the metabolic rate, resulting in most of the adaptations in cardiopulmonary system.²¹ Researchers have proven that one of the most important factors affected during physical activity is VO₂max that is the predictor of aerobic power, so the conclusion is that regular physical activity may enhance aerobic power.²¹

Furthermore, weak negative and non-significant correlation was found between VO₂max and BMI in the current study. Similar correlation was found earlier.²²

Contrary to the results, negative but significant relationship was found in a study.²³ This difference in results might be

due to the different protocols used in the studies. Further, correlation of VO_{2max} and BMI was seen at different categories of BMI and at different stages of exercise.²⁰ VO_{2max} , which indicates total body oxygen consumption, depends on ventilation and cardiac output. In obesity, due to accumulation of fats, lungs' capacity to increase the ventilation is impaired which affects VO_{2max} . Obesity also limits cardiovascular endurance with increase in workload. So increase in obesity can lead to decrease in cardiovascular fitness, which might be one of the possible reasons for the negative relationship of BMI with VO_{2max} . Therefore, daily physical activity in early age of life should be promoted for better performance, and to increase muscle endurance.²³

The current study has a few limitations, like male-female ratio being not equal in the sample. Also, VO_{2max} and IPAQ were not assessed by gold standard tools, like VO_{2max} machine and accelerometer respectively.

Conclusion

The majority of the young adults were found to be active, as indicated by their VO_{2max} values and physical activity levels. Cardiovascular fitness was found to be related to physical activity, and physical activity was an important stimulus of aerobic capacity improvement. However, the correlation between cardiovascular fitness and BMI was not of any statistical significance.

Disclaimer: The institutional review board (IRB) was the same for two studies, conducted by two different groups of medical students. The current study is Phase 1, while phase 2 of the project relates to "effect of -intensity interval training versus continuous moderate training on peak VO_{2max} in young adults of Islamabad". The inclusion criteria of the second phase is young adults falling in very poor, poor and average category of VO_{2max} from phase 1, and that is why the study was divided into two phases. The second phase will be conducted in future by other medical students under the supervision of the same supervisor.

Conflict of interest: None.

Source of Funding: None.

References

- Kodama S, Saito K, Tanaka S, Maki M, Yachi Y, Asumi M, et al. Cardiorespiratory Fitness as a Quantitative Predictor of All-Cause Mortality and Cardiovascular Events in Healthy Men and Women: A Meta-analysis. *JAMA* 2009; 301: 2024-35.
- Farheen H, Khalid Z, Tariq MI, Sadiq T, Amjad I, Ramzan T. Combined Effect of Aerobic and Resistance Interval Training on Ejection Fraction in Myocardial Infarction. *J Coll Physicians Surg Pak* 2019; 29: 290-2.
- Khalid Z, Farheen H, Tariq MI, Amjad I. Effectiveness of resistance interval training versus aerobic interval training on peak oxygen uptake in patients with myocardial infarction. *J Pak Med Assoc* 2019; 69: 1194-8.
- Taylor D. Physical activity is medicine for older adults. *Postgrad Med J* 2014; 90: 26-32.
- Ortega FB, Ruiz JR, Castillo MJ, Sjöström M. Physical fitness in childhood and adolescence: a powerful marker of health. *Int J Obes (Lond)* 2008; 32: 1-11.
- Sui X, LaMonte MJ, Laditka JN, Hardin JW, Chase N, Hooker SP, et al. Cardiorespiratory fitness and adiposity as mortality predictors in older adults. *JAMA* 2007; 298: 2507-16.
- Padilla-Moledo C, Castro-Pinero J, Ortega FB, Mora J, Márquez S, Sjöström M, et al. Positive health, cardiorespiratory fitness and fatness in children and adolescents. *Eur J Public Health* 2011; 22: 52-6.
- Review WP. Islamabad Population. 2019.
- Kurtze N, Rangul V, Hustvedt B-EJBmm. Reliability and validity of the international physical activity questionnaire in the Nord-Trøndelag health study (HUNT) population of men. *BMC Med Res Methodol* 2008; 8: 1-9.
- WHO, Regional office for the Western Pacific. The Asia-Pacific perspective: redefining obesity and its treatment. Available at <https://apps.who.int/iris/handle/10665/206936>. Cited on 23, May, 2021
- Hareendran A, Leidy NK, Monz BU, Winnette R, Becker K, Mahler DA. Proposing a standardized method for evaluating patient report of the intensity of dyspnea during exercise testing in COPD. *Int J Chron Obstruct Pulmon Dis* 2012; 7: 345-55.
- Kim E, Lovera J, Schaben L, Melara J, Bourdette D, Whitham R. Novel method for measurement of fatigue in multiple sclerosis: Real-Time Digital Fatigue Score. *J Rehabil Res Dev* 2010; 47: 477-84.
- Quinn F. The Bruce Protocol Treadmill Test for Athletes. [Online] [Cite 2020 May 20]. Available from: URL: <https://www.verywellfit.com/the-bruce-treadmill-test-protocol-3120269>
- Fogelholm M. Physical activity, fitness and fatness: relations to mortality, morbidity and disease risk factors. A systematic review. *Obes Rev* 2010; 11: 202-21.
- Prioreschi A, Brage S, Westgate K, Norris S, Micklesfield L. Cardiorespiratory fitness levels and associations with physical activity and body composition in young South African adults from Soweto. *BMC Public Health* 2017; 17: 301.
- Uddin R, Khan A, Burton NW. Prevalence and sociodemographic patterns of physical activity among Bangladeshi young adults. *J Health Popul Nutr* 2017; 36: 31.
- Kelley GA, Lowing L, Kelley K. Gender differences in the aerobic fitness levels of young African-American adults. *J Natl Med Assoc* 1999; 91: 384-8.
- Priesnitz CV, Rodrigues GH, da Silva Stumpf C, Viapiana G, Cabral CP, Stein RT, et al. Reference values for the 6-min walk test in healthy children aged 6–12 years. *Pediatr Pulmonol* 2009; 44: 1174-9.
- D'silva C, Vaishali K, Venkatesan P. Six-minute walk test-normal values of school children aged 7–12 y in India: a cross-sectional study. *Indian J Pediatr* 2012; 79: 597-601.
- Sheps DS, Ernst JC, Briesse FW, Myerburg RJ. Exercise-induced increase in diastolic pressure: Indicator of severe coronary artery disease. *Am J Cardiol* 1979; 43: 708-12.
- Mynarski W, Rozpara M, Czapla K, Garbaciak W. Aerobic capacity of students with different levels of physical activity as assessed by IPAQ. *J Human Kinetics* 2009; 21: 89-96.
- Mondal H, Mishra SP. Effect of BMI, body fat percentage and fat free mass on maximal oxygen consumption in healthy young adults. *J Clin Diagn Res* 2017; 11: CC17-20.
- Ghosh DA, Jahan DW. A Study of VO_{2max} in Relation to Body Mass Index before and After Exercise in Healthy Young Adults. *J Med Sci Clin Res* 2017; 5: 20290-3.