International Journal of Medical and Pharmaceutical Research

Online ISSN-2958-3683 | Print ISSN-2958-3675
Frequency: Bi-Monthly
Available online on: https://ijmpr.in/

Original Article

A Cross - Sectional Study to Assess the Burden of Metabolic Syndrome Among Young Adults and its Association with Cardiorespiratory Fitness

Dr Shivani Sharma[1], Dr Ankita Juyal[2], Dr Anant Narayan Sinha[3]
[1]MD PG 3rd year (Physiology) Government Doon Medical College Dehradun
[2]Associate Professor, (Physiology) Government Doon Medical College Dehradun
[3]Professor and Head, (Physiology) Soban Singh Jeena Government Institute of Medical Science & Research, Almora.

OPEN ACCESS

Corresponding Author:

Dr. Ankita Juyal
Associate Professor, Physiology
Government Doon Medical College Dehradun.
Email:
ankitajuyalmbbs2005@gmail.com

Received: 15-04-2026
Accepted: 25-05-2026
Available online: 31-05-2026

ABSTRACT

Background: Metabolic syndrome recently emerged as a significant and growing public health challenge worldwide, resulting from rapid urbanization, excessive energy intake, developing obesity, and sedentary lifestyle habits. The prevalence of metabolic syndrome has been increasing in India. Hence, it is important to identify patients at high risk of developing the condition as early as possible to prevent future complications.
Aim and objective: The study aimed to assess the burden of metabolic syndrome in young adults and to identify its association with cardiorespiratory fitness.
Methods: A cross-sectional study was conducted among 55 young adults aged 18-25years.In this study CRF was measured by treadmill exercise test. For evaluation of CRF target heart rate, maximal oxygen uptake (VO2max), metabolic equivalent were assessed. Metabolic syndrome was identified using laboratory measures included high – density lipoprotein cholesterol, triglycerides, total cholesterol. Fasting blood glucose was measured using the GOD-POD method to determine the prevalence of metabolic syndrome.
Results: The results of this study show the existence of association between CRF and metabolic syndrome. Physical inactivity and sedentary lifestyle are key factors in the development of the metabolic syndrome .
Conclusion: The findings of the present study indicate that metabolic syndrome is relatively uncommon among healthy young adults, with a low prevalence of 1.96% in the study population. Overall, the participants demonstrated satisfactory cardiorespiratory fitness (CRF), as none were classified in the low CRF category.

Keywords*: Metabolic Syndrome , Cardiorespiratory fitness ,VO2max.*

INTRODUCTION

Metabolic syndrome (MetS) is a cluster of interrelated metabolic abnormalities, including central obesity, dyslipidemia, hypertension, and impaired glucose regulation, that collectively increase the risk of cardiovascular disease and type 2 diabetes mellitus. Due to its strong association with morbidity and mortality, MetS has become a major global public health concern [1,2].

In India and other South Asian countries, this rising trend is increasingly observed among younger populations. Early identification of MetS is therefore essential for timely intervention and prevention of future cardiovascular disease and diabetes [3].

Early definitions of metabolic syndrome, such as those by the World Health Organization (WHO), required evidence of insulin resistance. However, because direct measurement is impractical in routine clinical and epidemiological settings, later definitions focused on easily measurable clinical parameters[4].

The concept of metabolic syndrome has evolved over time, with its early description as "Syndrome X" highlighting insulin resistance as the key underlying mechanism linking metabolic abnormalities [5,6].

The International Diabetes Federation (IDF) defines metabolic syndrome with central obesity as a mandatory component, along with any two of the following: elevated triglycerides, reduced HDL cholesterol, raised blood pressure, or increased fasting plasma glucose [7].

In India and neighboring countries, the prevalence of metabolic syndrome varies with urbanization, lifestyle, and socioeconomic status, with higher rates seen in urban populations due to physical inactivity, unhealthy diet, and stress [8]. Cardiorespiratory fitness (CRF) is the ability of the circulatory and respiratory systems to deliver oxygen to skeletal muscles during sustained physical activity, reflecting the efficiency of oxygen uptake, transport, and utilization. It is commonly assessed by maximal oxygen uptake (VO_2 max), the gold standard for aerobic fitness. Higher CRF is associated with improved metabolic health, including better insulin sensitivity, lipid profile, and blood pressure, and is recognized as an independent predictor of lower cardiovascular and all-cause mortality risk [9,10].

VO_2max and its relation to CRF

VO_2max is the maximum rate of oxygen consumption attained during intense or exhaustive exercise and is considered the gold standard measure of cardiorespiratory fitness (CRF). It is expressed as either an absolute value (L/min) or relative to body weight (mL/kg/min) for individual comparison [11].

VO_2max varies widely, exceeding 90 mL/kg/min in elite endurance athletes and ranging from 25–40 mL/kg/min in healthy sedentary adults. Men generally have higher VO_2max values than women. Lower VO_2max is associated with metabolic syndrome, insulin resistance, and increased cardiometabolic risk [10]. In this study, VO_2max will be estimated indirectly using the Modified Bruce Protocol treadmill test, a valid and practical alternative to direct measurement.

The relationship between cardiorespiratory fitness (CRF) and metabolic syndrome is complex and multifactorial, with substantial evidence demonstrating an inverse association between them. Moreover, higher CRF can lessen the harmful effects of obesity, thereby reducing cardiometabolic risk irrespective of body composition [11].

Cardiorespiratory fitness itself is an independent protective factor against metabolic syndrome and related disorders. However, its interaction with fat distribution is critical. High CRF can partially mitigate the adverse metabolic effects of excess adiposity, yet central obesity remains a strong independent predictor of poor metabolic outcomes regardless of fitness level [12,13].

Objectives: To assess the burden of metabolic syndrome in young adults and to identify its association with cardiorespiratory fitness.

METHODOLOGY:

Study Design & Ethical Considerations

A cross-sectional study was conducted in research laboratory of the Department of Physiology, Government Doon Medical college Dehradun, Uttarakhand. The study was approved by the Institutional Ethical Committee (IEC) of Government Doon Medical College, Dehradun. Written informed consent was obtained from all participants prior to enrolment.

Sample Size

The sample size was calculated using the following formula:

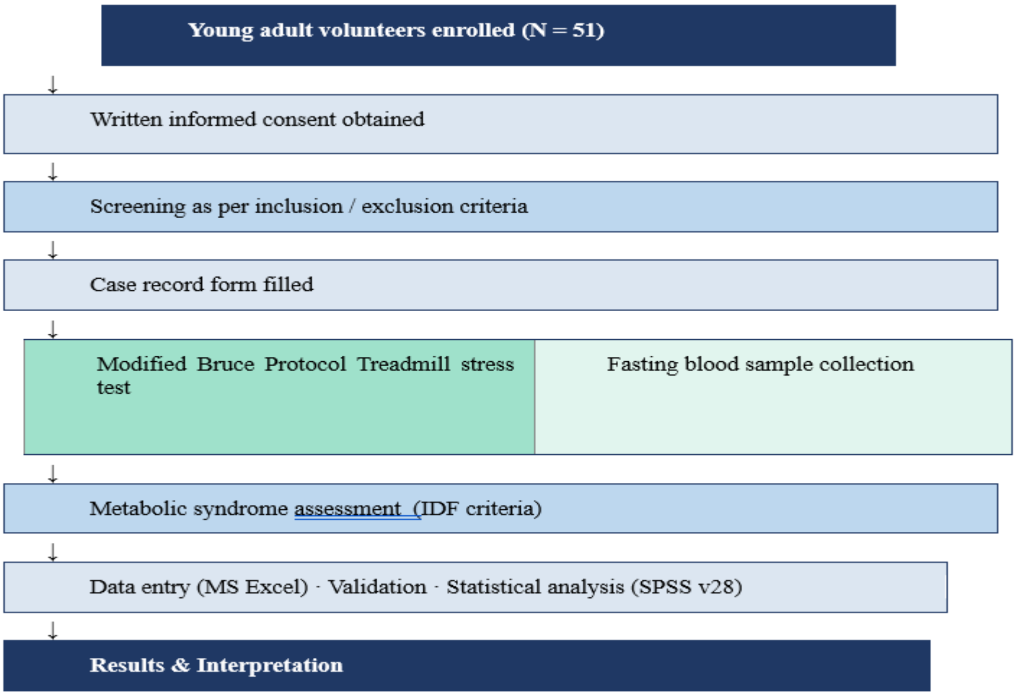
$n = Z\alpha^2 \times S^2 / d^2$

Where $Z\alpha = 1.96$ (standard normal deviate at 95% confidence level), $S^2 = 0.7$ (expected population standard deviation), and $d^2 = 0.2$ (margin of error). The sample size was estimated using Statulator software, targeting a precision of 0.2 with 95% confidence interval. The total sample size was 51 .

Young adults aged between 18 years and 25 years and with a BMI between 18.5 to 29.9 kg/m², including both values, were eligible for inclusion criteria.

Individuals were excluded if there were any history of cardiorespiratory disease and Diabetes or any other chronic disease, any history of smoking, alcohol consumption, or any other substance abuse, recent use of lipid-lowering agents and BMI < 18.5 kg/m² or > 29.9 kg/m².

Study Algorithm



Study Tools

a) Allengers Treadmill Test Machine

b) ECG electrodes

c) Body measuring tape

d) Weighing machine

e) Stadiometer

f) Digital Sphygmomanometer

g) Stethoscope

h) Stop Watch

Data were collected using a pre-designed Case Record Form (CRF) developed for the study. All observations including heart rate, blood pressure values, treadmill parameters, fasting blood sugar, and lipid profile results were recorded systematically in the observations table. The collected data were then entered into MS Excel (Microsoft Office) for tabulation and further analysis .

RESULTS:

Table 1: Comparison of Selected Metabolic Parameters According to Gender (N = 51)

Parameter	Female (n=29) Mean ± SD	Male (n=22) Mean ± SD	t-value	p-value
Waist Circumference (cm)	75.4 ± 4.71	83.5 ± 5.33	-5.719	<0.001
Fasting Blood Sugar (mg/dL)	84.4 ± 6.41	84.0 ± 7.90	0.207	0.837
HDL Cholesterol (mg/dL)	55.0 ± 10.83	59.7 ± 9.87	-1.615	0.113
Triglycerides (mg/dL)	129.1 ± 10.55	150.9 ± 35.23	-3.149	0.003

Parameter	Female (n=29) Mean ± SD	Male (n=22) Mean ± SD	t-value	p-value
Systolic BP (mmHg)	123.4 ± 8.62	124.6 ± 6.69	-0.566	0.574
Diastolic BP (mmHg)	78.8 ± 4.49	80.0 ± 4.81	-0.914	0.365

The above table compares metabolic parameters between male and female participants. Males had significantly higher waist circumference (83.5 ± 5.33 cm vs. 75.4 ± 4.71 cm, $p < 0.001$), indicating greater central adiposity. Triglyceride levels were also significantly elevated in males (150.9 ± 35.23 mg/dL vs. 129.1 ± 10.55 mg/dL, $p = 0.003$). Fasting blood sugar, HDL cholesterol, and blood pressure values were comparable between both groups and did not differ significantly.

Table 2: Comparison of Cardiorespiratory Fitness Parameters According to Gender (N = 51)

Parameter	Female (n=29) Mean ± SD	Male (n=22) Mean ± SD	t-value	p-value
VO_2 Max (mL/kg/min)	32.93 ± 6.05	39.0 ± 6.96	-3.324	0.002
METs	9.40 ± 1.73	11.1 ± 1.99	-3.327	0.002
Duke Treadmill Score	13.05 ± 1.66	13.4 ± 2.81	-0.501	0.619

As presented in the above table, male participants had significantly higher VO_2 Max (39.0 ± 6.96 vs. 32.93 ± 6.05 mL/kg/min, $p = 0.002$) and METs (11.1 ± 1.99 vs. 9.40 ± 1.73, $p = 0.002$) compared to females. The Duke Treadmill Score, however, was comparable between the two groups (13.4 ± 2.81 in males vs. 13.05 ± 1.66 in females, $p = 0.619$), indicating similar cardiovascular risk stratification across genders.

Statistical test: Independent samples t-test. For Duke Treadmill Score, Welch's t-test was used due to unequal variance. $p < 0.05$ is considered statistically significant.

Table 3: Comparison of Metabolic Syndrome Risk Factors Across Different CRF Levels (N = 51)

CRF Level	Waist Circumference (cm)	Systolic BP (mmHg)	Fasting Blood Sugar (mg/dL)	HDL Cholesterol (mg/dL)	Triglycerides (mg/dL)	Total Cholesterol (mg/dL)
Low CRF (< 18)	—	—	—	—	—	—
Moderate CRF (18–35)	79.20 ± 7.75	125.09 ± 7.80	84.36 ± 6.90	57.55 ± 9.96	130.95 ± 18.44	160.64 ± 28.56
High CRF (> 35)	78.65 ± 5.24	123.03 ± 7.82	84.14 ± 7.23	56.62 ± 11.21	144.24 ± 30.32	177.07 ± 21.36

The above table compares metabolic syndrome risk factors across CRF levels. Participants in the High CRF group showed marginally lower waist circumference (78.65 ± 5.24 cm vs. 79.20 ± 7.75 cm) and systolic blood pressure (123.03 ± 7.82 vs. 125.09 ± 7.80 mmHg) than those in the Moderate CRF group. Fasting blood sugar and HDL cholesterol values were comparable across both groups. Interestingly, triglyceride and total cholesterol levels were higher in the High CRF group, a finding that may warrant further exploration. No participant was recorded under the Low CRF category.

Note: Values are expressed as Mean ± SD. CRF = Cardiorespiratory Fitness; SBP = Systolic Blood Pressure; HDL = High-Density Lipoprotein. Low CRF row is empty as no participant had VO_2 Max < 18 mL/kg/min.

DISCUSSION

The study comprised 51 participants with a mean age of 20.0 ± 1.52 years, with 56.86% females (n = 29) and 43.14% males (n = 22). Cardiovascular disease risk factors in young adults have been assessed in many studies. Most studies have looked at a single or a combination of risk factors[14,15].In the present study we also assessed the cardio respiratory fitness of the young adults by measuring their VO2 max using TMT machine. Mean VO_2 Max was 35.6 ± 7.07 mL/kg/min, mean METs 10.2 ± 2.02, and mean Duke Treadmill Score (DTS) 13.2 ± 2.21.

All 51 participants (100%) scored ≥5 on the Duke Treadmill Score, placing them in the Low Risk cardiovascular category. The DTS, originally validated by Mark et al., classifies scores ≥5 as low cardiovascular risk with a predicted 4-year survival of 99%[16]. All participants falling in this category reflects the expected cardiovascular profile of a healthy young adult sample without known cardiac disease. By MET score category, 47.06% were in the Good category (9–11 METs), 39.22% in the Fair category (5–8 METs), and 13.73% in the Excellent category (≥12 METs). A meta-analysis by Kodama et al. across 33 studies demonstrated that each 1-MET increment in maximal aerobic capacity was associated with a 13% reduction in all- cause mortality and a 15% reduction in cardiovascular events[17]. In the published literature, an inverse association between CRF and metabolic syndrome has been consistently reported in larger studies. Kim et al. in a cross-sectional study of 168 Japanese adult males demonstrated that cardiorespiratory fitness was the physical fitness component most strongly linked to metabolic syndrome risk[18].

Hong et al. similarly reported that lower CRF was significantly associated with higher prevalence of metabolic syndrome among Korean adults[19]. Mäestu et al. in a longitudinal study tracking CRF from adolescence to young adulthood found that subjects with persistently low CRF had substantially higher risk of metabolic syndrome at ages 25 and 33 years compared to those with persistently high CRF[20].

Gupta et al. reported significant positive correlations of BMI and WHR with blood pressure and triglycerides in urban Indian subjects [21]. The mean METs of 10.2 observed in the present study places the majority of participants within a moderate- to-good fitness range.

In the present study, Pearson's correlation analysis between CRF parameters (VO_2 Max, METs, Duke Treadmill Score) and individual metabolic risk factors (waist circumference, fasting blood sugar, HDL cholesterol, triglycerides, systolic and diastolic BP) was analysed. In contrast to other studies, due to the extremely low prevalence of metabolic syndrome (n = 1), no formal comparison between participants with and without metabolic syndrome was performed and no inferences are drawn from individual case data. Also due to the relatively small study population and inclusion of only young adult population may have resulted in a narrower distribution of cardiometabolic risk outcomes .

The findings of the present study indicate that metabolic syndrome is relatively uncommon among healthy young adults, with a low prevalence of 1.96% in the study population. Overall, the participants demonstrated satisfactory cardiorespiratory fitness (CRF), as none were classified in the low CRF category. In addition, all individuals were categorized as having low cardiovascular risk according to the Duke Treadmill Score, further reflecting a generally favourable cardiovascular profile. A gender-based comparison in the present study demonstrated that male participants exhibited significantly higher levels of cardiorespiratory fitness (CRF) compared to females, as reflected by superior performance in aerobic capacity measures. This finding is consistent with established physiological differences between sexes, including greater lean body mass, larger stroke volume, higher hemoglobin concentration, and enhanced oxygen-carrying capacity in males, all of which contribute to improved aerobic performance. However, despite this apparent fitness advantage, males also showed relatively higher central adiposity and elevated triglyceride levels, indicating that superior CRF does not necessarily equate to an entirely favorable metabolic profile. Increased central fat distribution, particularly abdominal adiposity, is known to be closely linked with insulin resistance, dyslipidemia, and future cardiovascular risk. Thus, the coexistence of better fitness with less favorable anthropometric and lipid parameters in males suggests a complex and mixed cardiometabolic pattern. Among the individual components of metabolic syndrome, elevated blood pressure emerged as the most prevalent abnormality, affecting more than one-fourth of the study population. This observation is noteworthy considering the relatively young and apparently healthy nature of the participants. The presence of raised blood pressure at an early age may reflect the influence of modern lifestyle factors such as increased psychological stress, sedentary behavior, irregular sleep patterns, excessive dietary sodium intake, and reduced physical activity. Since elevated blood pressure is often asymptomatic in its early stages, its high prevalence in young adults underscores the importance of regular screening and early lifestyle modification to prevent progression toward hypertension and future cardiovascular disease.

Although the overall cardiometabolic health status of the study population appears generally satisfactory, the identification of certain metabolic risk factors, particularly elevated blood pressure along with gender-specific differences in body composition and lipid profile, highlights the need for continuous monitoring even in individuals who are considered clinically healthy. These findings reinforce the concept that metabolic risk factors may begin developing silently during early adulthood, long before overt clinical disease becomes evident.

CONCLUSION

No statistically significant associations were observed between CRF parameters and individual metabolic risk factors in the present study. However, a consistent trend toward lower CRF was noted among participants with metabolic syndrome, suggesting that reduced aerobic fitness may still have a subtle relationship with metabolic abnormalities. The absence of statistical significance may be explained by the relatively small sample size, low prevalence of full metabolic syndrome in this young population, and the generally healthy baseline characteristics of participants, which may limit the ability to detect stronger correlations.

Taken together, these findings suggest that even in the absence of strong statistical relationships between CRF and metabolic variables, subtle underlying patterns linking reduced fitness with adverse metabolic outcomes may still exist. Early identification would facilitate timely implementation of preventive strategies such as lifestyle counselling , dietary modifications, regular physical activity, and weight management, thereby reducing the likelihood of progression to overt metabolic syndrome, type 2 diabetes mellitus, and cardiovascular disease later in life.

REFERENCES

1. Alberti KGMM, Zimmet P, Shaw J. The metabolic syndrome—a new worldwide definition. Lancet. 2005;366(9491):1059–62. PMID: 16247509.
2. Reaven GM. Banting lecture 1988. Role of insulin resistance in human disease. Diabetes. 1988 Dec;37(12):1595-607. doi: 10.2337/diab.37.12.1595. PMID: 3056758.
3. Prasad DS, Kabir Z, Dash AK, Das BC. Prevalence and risk factors for metabolic syndrome in Asian Indians: a community study. Diabetes Metab Syndr. 2012;6(4):181–6. PMID: 33075086
4. Tobi E.W., Goeman J.J., Monajemi R., Gu H., Putter H., Zhang Y., Slieker R.C., Stok A.P., Thijssen P.E., Müller F., et al. DNA Methylation Signatures Link Prenatal Famine Exposure to Growth and Metabolism. Nat. Commu. 2014;5:5592. doi: 10.1038/ncomms6592.
5. Lee DC, Artero EG, Sui X, Blair SN. Mortality trends in the general population: the importance of cardiorespiratory fitness. Prog Cardiovasc Dis. 2010;52(5):377–84. PMID: 19776211.
6. Rothwell J.A., Jenab M., Karimi M., Truong T., Mahamat-Saleh Y., Ferrari P., Dashti S.G., Kühn T., Cross A.J., Severi G., et al. Metabolic Syndrome and Risk of Gastrointestinal Cancers: An Investigation Using Large-Scale Molecular Data. Clin. Gastroenterol. Hepatol. 2021;20:E1338–E1352. doi: 10.1016/j.cgh.2021.10.016.
7. Bener A, Yousafzai MT, Darwish S, Al-Hamaq AOAA, Nasralla EA, Abdul-Ghani M. Obesity index that better predict metabolic syndrome: body mass index, waist circumference, waist hip ratio, or waist height ratio. J Obes. 2013;2013:269038. doi:10.1155/2013/269038. PMID: 24000310.
8. Raghuveer G, Hartz J, Lubans DR, Takken T, Wiltz JL, Mietus-Snyder M, et al. Cardiorespiratory fitness in youth: an important marker of health: a scientific statement from the American Heart Association. Circulation. 2020;142(7):e101–18. doi:10.1161/CIR.0000000000000866. PMID: 32686500.
9. Ross R, Blair SN, Arena R, et al. Importance of assessing cardiorespiratory fitness. Circulation. 2016;134(24):e653–99. PMID: 38444247
10. Janssen I, LeBlanc AG. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. Int J Behav Nutr Phys Act. 2010;7:40. doi:10.1186/1479-5868-7-40. PMID: 20459784.
11. Ross R, Janssen I. Physical activity, total and regional obesity. Int J Obes. 2003;27(2):204–10. PMID: 14747219.
12. Lee DC, Artero EG, Sui X, Blair SN. Mortality trends in the general population: the importance of cardiorespiratory fitness. Prog Cardiovasc Dis. 2010;52(5):377–84. PMID: 19776211.
13. Earnest CP, Artero EG, Sui X, Lee DC, Church TS, Blair SN. Maximal estimated cardiorespiratory fitness, cardiometabolic risk factors, and metabolic syndrome in the Aerobics Center Longitudinal Study. Mayo Clin Proc. 2013;88(3):259–70.
14. Guerra S, Duarte JA, Mota J, Physical activity and cardiovascular disease risk factors in school children In Eur Physical Educ Rev,2001,7:269-281.
15. Ribeiro JC, Guerra S, Oliveira J, Teixeira-Pinto A, Twisk JWR, Duarte JA, Mota J, Physical activity and biological risk factors clustering in pediatric population In Prev Med,2004,39:596-601.
16. Mark DB, Hlatky MA, Harrell FE Jr, Lee KL, Califf RM, Pryor DB. Exercise treadmill score for predicting prognosis in coronary artery disease. Ann Intern Med. 1987;106(6):793–800.
17. 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(19):2024–2035.
18. Kim B, Kim S, Park J, Ahn H, Jung H, Jee SH, et al. Cardiorespiratory fitness is strongly linked to metabolic syndrome among physical fitness components: a retrospective cross-sectional study. J Physiol Anthropol. 2020;39(1):30.
19. Hong S, Baik I, Kim SW, Kim D, Lim SC. Association between cardiorespiratory fitness and the prevalence of metabolic syndrome among Korean adults: a cross-sectional study. BMC Public Health. 2014;14:481.
20. Mäestu E, Harro J, Veidebaum T, Kurrikoff T, Jürimäe J, Mäestu J. Changes in cardiorespiratory fitness through adolescence predict metabolic syndrome in young adults. Nutr Metab Cardiovasc Dis. 2020;30(4):701–708.
21. Gupta R, Bhatt K, Gupta VP, Sharma KK. Body-mass index, waist-size, waist-hip ratio and cardiovascular risk factors in urban subjects. J Assoc Physicians India. 2007;55:621–627.