Advanced International Journal for Research (AIJFR)
E-ISSN: 3048-7641 ● Website: www.aijfr.com ● Email: editor@aijfr.com

A Cross-Sectional Study on the Association of Physical Activity Levels, Sleep Quality, and Snacking Behaviour on the Risk of Metabolic Syndrome in Young Adults aged 18 to 25 years

Ms. Sadaf Ansari[1], Dr. Rekha Battalwar[2], Ms. Krisha Shah[3]

[1]Post Graduate Student Masters in Specialized Dietetics, Sir Vithaldas Thackersey College of Home Science (Empowered Autonomous Status), S.N.D.T. Women's University, Juhu, Mumbai, India,
[2]Retd. Professor & Director - Administration and Planning, Sir Vithaldas Thackersey College of Home Science (Empowered Autonomous Status), S.N.D.T. Women's University, Juhu, Mumbai, India
[3]Consultant Statistician.

Abstract

Introduction: Metabolic syndrome (MetS) is an emerging cardiometabolic concern among young Indian adults, driven by early lifestyle transitions. Characterized by central obesity, hypertension, dyslipidemia, and impaired glucose regulation, it increases the risk of type 2 diabetes and cardiovascular disease. South Asians are particularly vulnerable due to the "thin-fat" phenotype.

Aim: To assess the association of physical activity levels, sleep quality, and snacking behaviour with MetS risk among young adults aged 18–25 years in Mumbai.

Methodology: A cross-sectional study was conducted among 100 participants using purposive sampling. Data were collected using validated tools (IPAQ-SF, PSQI, DEBQ, FINDRISC, NIM-METS), along with anthropometry, blood pressure, and dietary recall. Statistical analysis included Mann–Whitney U test, Chi-square test, and Spearman's correlation ($p < 0.05$).

Results: 69% were at low and 31% at moderate MetS risk. Male gender, family history of heart disease and hypertension, and smoking were significantly associated with higher risk ($p < 0.05$). The moderate-risk group showed significantly higher adiposity measures and blood pressure ($p \leq 0.015$). Poor sleep quality and unhealthy snacking behaviour were strongly associated with increased risk ($p < 0.001$), while physical activity was not. MetS risk correlated positively with sleep quality ($r = 0.42$) and emotional eating ($r = 0.49$), and weakly negatively with physical activity ($r = -0.18$).

Conclusion: Poor sleep and unhealthy snacking were stronger predictors of MetS risk than physical activity. Early, integrated lifestyle interventions targeting sleep and dietary behaviours are essential to reduce long-term cardiometabolic risk.

Keywords: Metabolic syndrome, Young adults, Physical activity, Sleep quality, Snacking behaviour

1. Introduction

Metabolic syndrome (MetS) is a multifactorial cardiometabolic disorder characterized by central obesity, hypertension, dyslipidemia, and impaired glucose regulation, which collectively increase the risk of type 2 diabetes mellitus and cardiovascular disease (Fahed et al., 2022; Zimmet et al., 2024). Globally, the prevalence of MetS rises sharply from adolescence to early adulthood, with South Asians disproportionately affected due to the "thin-fat" phenotype, characterized by higher visceral adiposity despite lower body mass index (Misra et al., 2020).

In the Indian context, large-scale national surveys such as the National Family Health Survey (NFHS-5) and the Comprehensive National Nutrition Survey (CNNS) indicate a rising burden of overweight and obesity among adolescents and young adults. Additionally, data from the ICMR-INDIAB study report a MetS prevalence ranging from 12% to 18% in urban young adults, with certain states such as Maharashtra reporting rates approaching 20%, highlighting a growing public health concern (ICMR et al., 2023; IIPS & MoHFW, 2021).

Lifestyle behaviours, particularly insufficient physical activity, poor sleep quality, and frequent consumption of energy-dense foods, are recognized as key modifiable determinants of MetS risk (Li et al., 2021; Radavelli et al., 2023). Physical inactivity contributes to visceral fat accumulation and insulin resistance, while poor sleep quality disrupts circadian rhythms and appetite regulation, thereby promoting central obesity and dyslipidemia (Grandner, 2024; Nunes et al., 2022).

Furthermore, increasing consumption of ultra-processed foods has been identified as a major contributor to excess caloric intake among urban youth, significantly elevating the risk of abdominal obesity and metabolic dysfunction (Monteiro et al., 2019; Chen et al., 2021). Emerging evidence suggests that these lifestyle behaviours tend to cluster, resulting in a two- to three-fold increase in the risk of metabolic syndrome among young adults (Chaput et al., 2022; Chou et al., 2023).

Given the rising prevalence of MetS in India and the synergistic clustering of lifestyle risk factors, examining the combined influence of physical activity, sleep quality, and snacking behaviour in young adults aged 18–25 years provides a critical opportunity for early intervention to reduce long-term cardiometabolic complications.

Aim :

To assess the relationship between physical activity levels, sleep quality, and Snacking behaviour, and their combined impact on the risk of metabolic syndrome among young adults aged 18 to 25 years

Material and Methodology :

A descriptive cross-sectional study was carried out among 100 young adults (both males and females) aged 18–25 years living in Mumbai. Participants were recruited through purposive sampling based on defined eligibility criteria. Only individuals within the specified age group who willingly consented to participate were included. Those with known metabolic or cardiovascular disorders, individuals taking medications that could influence metabolic parameters, pregnant women, and participants unable to complete the study assessments were excluded. Ethical clearance was obtained from the Intersystem Biomedica Ethics Committee before the commencement of the study, and written informed consent was collected from all participants to ensure voluntary participation and confidentiality.

Information was gathered using a structured questionnaire through face-to-face interviews, with each session lasting approximately 15–20 minutes. Standardized and validated instruments were used for

assessment: the IPAQ-Short Form to evaluate physical activity levels, the PSQI for sleep quality, the DEBQ to assess snacking and eating behavior, the FINDRISC for estimating diabetes risk, and the NIM-METS tool for screening metabolic syndrome risk. In addition, data on demographic characteristics, medical history, and anthropometric measurements (such as height, weight, BMI, and waist circumference) were recorded. Blood pressure readings and a three-day 24-hour dietary recall were also collected to capture dietary intake patterns.

Statistical analysis was conducted using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Continuous data were summarized using median and interquartile range, while categorical variables were presented as frequencies and percentages. Comparisons between different metabolic risk groups were performed using the Mann–Whitney U test for continuous variables and the Chi-square test for categorical variables. Associations between metabolic risk scores and lifestyle factors were evaluated using Spearman's rank correlation coefficient. A p-value of less than 0.05 was considered statistically significant.

Results :

The study included 100 participants, and their sociodemographic characteristics were assessed using frequency and percentage distributions. Anthropometric and clinical parameters were evaluated using BMI, waist circumference, waist-to-height ratio, and blood pressure. Metabolic syndrome risk was assessed using the NIM-METS score, and diabetes risk using the FINDRISC score. Physical activity and sleep quality were evaluated using the IPAQ and PSQI, respectively. Dietary intake was assessed using a three-day dietary recall, including energy and macronutrient intake. Snacking behavior was evaluated using the DEBQ, focusing on emotional and external eating. Associations between lifestyle, dietary, and behavioral factors with MetS risk were examined, along with correlation and regression analyses to identify significant predictors.

Table 1 : Sociodemographic, Anthropometric and Clinical Characteristics of the Study Population

Basic Characteristics	Overall n=100	Low MetS risk n=69	Moderate MetS risk n=31	test value	p value
Age (in years, Median (IQR)	22.0 (19.0-23.0)	21.0 (19.0-23.0)	23.0 (19.0-24.0)	-	-
Gender, n (%) Male Female	 45 (45) 55 (55)	 24 (35%) 45 (65%)	 21 (68%) 10 (32%)	9.39	0.002**
Educational Qualification n (%) Secondary Graduate Post Graduate	 39 (39)	 26 (38%)	 13 (42%)	3.29	0.193

	49 (49) 12 (12)	32 (46%) 11 (16%)	17 (55%) 1 (3%)		
Family history, n (%) - Heart diseases No Yes Hypertension No Yes Heart diseases No Yes	 51 (51) 49 (49) 60 (60) 40 (40) 87 (87) 13 (13)	 42 (61%) 27 (39%) 47 (68%) 22 (32%) 62 (90%) 7 (10%)	 9 (29%) 22 (71%) 13 (42%) 18 (58%) 25 (81%) 6 (19%)	 8.68 6.11 1.6	 0.003** 0.013** 0.205
Smoking, n (%) Never Former Current	 86 (86) 7 (7) 7 (7)	 65 (94%) 2 (3%) 2 (3%)	 21 (68%) 5 (16%) 5 (16%)	 12.44	 0.002**
Alcohol, n (%) Never Occasionally	 93 (93) 7 (7)	 66 (96%) 3 (4%)	 27 (87%) 4 (13%)	 2.4	 0.121
Height in cm, Median (IQR)	160.8 (155.4-170.0)	161.5 (155.4-167.0)	158.4 (154.2-173.4)	1037	NS
Weight in kg, Median (IQR)	58.0 (52.8-72.5)	55.0 (50.0-60.0)	78.0 (72.0-85.5)	157	< 0.001**
Waist circumference in cm, Median (IQR)	76.4 (71.0-91.4)	72.0 (70.0-78.0)	96.5 (92.7-103.0)	8	< 0.001**
WHtR, Median (IQR)	0.5 (0.4-0.6)	0.5 (0.4-0.5)	0.6 (0.6-0.6)	29.5	< 0.001**
SBP (mmHg), Median (IQR)	117.0 (110.0-126.5)	115.0 (110.0-118.0)	132.0 (128.0-135.0)	129.5	0.001**
DBP (mmHg), Median (IQR)	76.0 (70.0-79.8)	72.0 (70.0-77.0)	84.0 (82.0-88.0)	160	0.015**

Table 1 presents the median age of the overall population was 22.0 (19.0–23.0) years, with 21.0 (19.0–23.0) years in the low MetS risk group and 23.0 (19.0–24.0) years in the moderate-risk group, showing no statistical significance. A statistically significant association was observed for gender (p = 0.002), with 68% males in the moderate-risk group compared to 35% in the low-risk group. Educational qualification did not show a statistically significant association (p = 0.193). Family history of heart disease was significantly associated with MetS risk (p = 0.003), with 71% of participants in the moderate-risk group reporting a positive history compared to 39% in the low-risk group. Similarly, family history of hypertension showed a significant association (p = 0.013), with 58% in the moderate-risk group compared to 32% in the low-risk group. The second heart disease variable did not show a significant association (p = 0.205). Smoking status was significantly associated with MetS risk (p = 0.002), with higher proportions of current (16%) and former smokers (16%) in the moderate-risk group compared to 3% each in the low-risk group. Alcohol consumption did not show a statistically significant association. Among anthropometric parameters, weight, waist circumference, and waist-to-height ratio were significantly higher in the moderate-risk group compared to the low-risk group (p < 0.001 for all). Height did not show a statistically significant difference. Clinical parameters showed that systolic blood pressure (p = 0.001) and diastolic blood pressure (p = 0.015) were significantly higher in the moderate-risk group compared to the low-risk group.

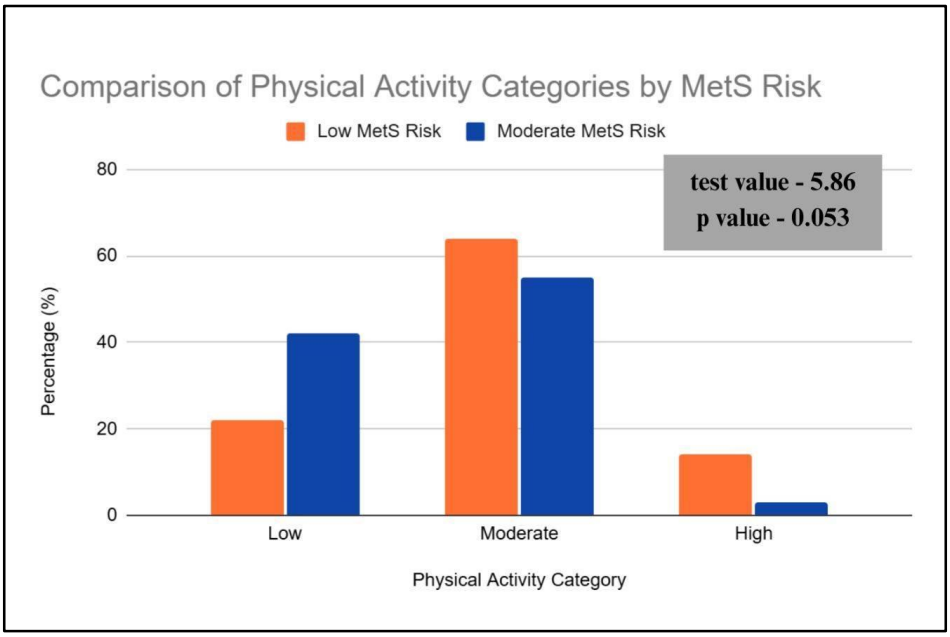

Figure 1 : Distribution of Physical Activity Levels Across Metabolic Syndrome Risk Categories

Figure 1 compares physical activity levels between low and moderate MetS risk groups using IPAQ scores. The median physical activity level (MET-min/week) was higher in the low-risk group (825.0 [495.0–1386.0]) compared to the moderate-risk group (528.0 [371.5–1287.0]), although this difference was not statistically significant. With respect to physical activity categories, the majority of participants in both groups were moderately active. However, a higher proportion of moderate-risk participants were categorized as having low physical activity (42%) compared to the low-risk group (22%). Similarly, high physical activity levels were less prevalent in the moderate-risk group (3%) compared to the low-risk

group (14%). Although the association did not reach statistical significance (p = 0.053), the observed trend suggests that lower physical activity levels may be associated with increased MetS risk.

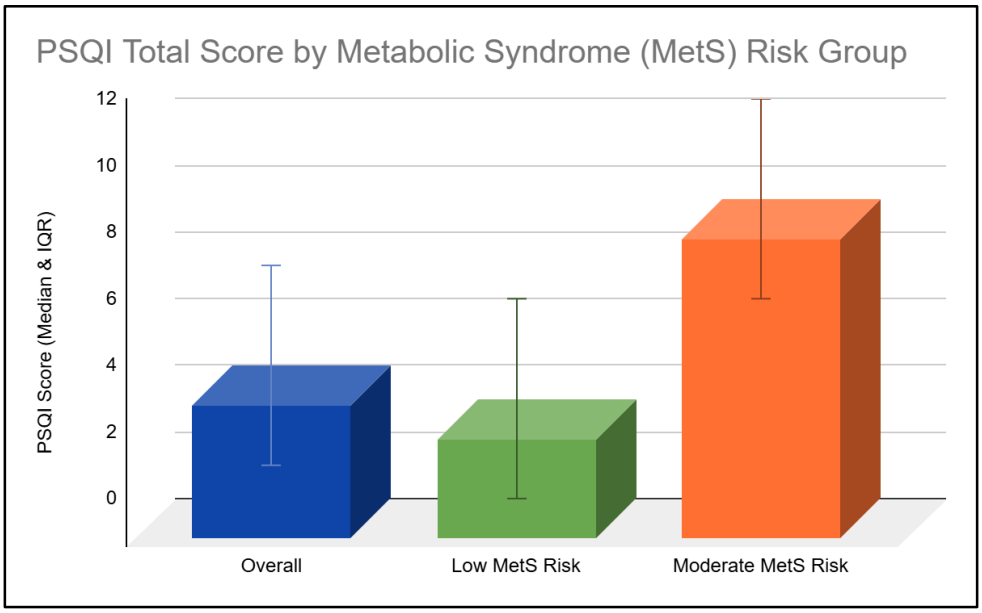

Figure 2: Comparison of Median PSQI Scores Across Metabolic Syndrome (MetS) Risk Groups

Figure 2 compares the median PSQI total scores between Metabolic Syndrome (MetS) risk groups. Low MetS Risk Group: Demonstrated the best sleep quality with a median score of (3.0 [2.0–5.0]). Moderate MetS Risk Group: Showed significantly poorer sleep, with a median score of (9.0 [4.5–12.0]), well above the clinical threshold for poor sleep (PSQI > 5). Overall Population: Maintained a median score of 4.0 (2.8–8.0). The sharp increase in scores for the moderate-risk group ($p < 0.001$) indicates a strong correlation between higher metabolic risk and increased sleep dysfunction. The larger error bars in the moderate group further reflect a wider range of sleep disturbances among these participants.

Table 2 : Comparison of Snacking Behaviors among MetS Risk Categories

Snacking Behaviors parameters	Low MetS risk n=69	Moderate MetS risk n=31	test value	p value
Emotional eating scores, median (IQR)	2.4 (1.6-3.6)	4.4 (3.3-5.0)	462.5	< 0.001**
External eating scores, median (IQR)	3.2 (2.0-4.2)	5.0 (3.7-5.0)	511	< 0.001**
Emotional eating Category,				

n (%) Low Moderate High	35 (51%) 16 (23%) 18 (26%)	5 (16%) 6 (19%) 20 (65%)	14.86	< 0.001**
External eating Category, n (%) Low Moderate High	23 (33%) 20 (29%) 26 (38%)	3 (10%) 4 (13%) 24 (77%)	13.66	0.001**

Table 2 compares emotional and external eating behaviors between low and moderate MetS risk groups. The median emotional eating score was significantly higher in the moderate-risk group (4.4 [3.3–5.0]) compared to the low-risk group (2.4 [1.6–3.6]) ($p < 0.001$). Similarly, the median external eating score was higher in the moderate-risk group (5.0 [3.7–5.0]) compared to the low-risk group (3.2 [2.0–4.2]) ($p < 0.001$). With respect to emotional eating categories, 65% of participants in the moderate-risk group were classified as high emotional eaters, compared to 26% in the low-risk group. Low emotional eating was observed in 51% of the low-risk group and 16% of the moderate-risk group, while moderate emotional eating was reported in 23% and 19%, respectively ($p < 0.001$). For external eating categories, 77% of participants in the moderate-risk group were classified as high external eaters, compared to 38% in the low-risk group. Low external eating was observed in 33% of the low-risk group and 10% of the moderate-risk group, while moderate external eating was reported in 29% and 13%, respectively ($p = 0.001$).

Table 3 : Comparison of Average Dietary Intake among MetS risk Categories

Dietary parameter	Low MetS risk n=69	Moderate MetS risk n=31	test value	p value
Energy-avg (kcal), median (IQR)	1255.0 (997.0-1424.0)	1554.0 (1288.5-1947.5)	644.5	0.002**
Protein-avg (g), median (IQR)	38.9 (29.3-50.9)	52.6 (41.8-62.0)	615.5	< 0.001**
Carbs-avg (g), median (IQR)	150.0 (114.2-187.0)	187.0 (153.1-219.0)	767.5	0.025**
Fats-avg (g), median (IQR)	45.6 (37.9-68.3)	68.1 (47.6-78.1)	726	0.011**

Table 3 presents the comparison of average dietary intake between MetS risk groups. A statistically significant difference was observed in all macronutrients: Energy intake: higher in moderate-risk (1554 kcal) vs low-risk (1255 kcal) ($p = 0.002$). Protein intake: higher (52.6 g vs 38.9 g) ($p < 0.001$). Carbohydrates: higher (187.0 g vs 150.0 g) ($p = 0.025$). Fat intake: higher (68.1 g vs 45.6 g) ($p = 0.011$). These results indicate that participants in the moderate-risk group had significantly higher caloric and macronutrient intake compared to those in the low-risk group. This suggests that excessive dietary intake may contribute to the development and progression of metabolic syndrome risk.

Table 4 :Interrelationship between NIM-METS Scores with lifestyle and Metabolic Risk Factors (Correlation matrix)

Variable 1	Variable 2	Correlation coefficient (Spearman's rho)	p value
NIM-METS Scores	IPAQ MET-mins per week	-0.18	NS
NIM-METS Scores	PSQI Total Score	0.42	< 0.001**
NIM-METS Scores	Emotional eating scores	0.49	< 0.001**
NIM-METS Scores	External eating scores	0.45	< 0.001**
NIM-METS Scores	FINDRISC Scores	0.77	< 0.001**
NIM-METS Scores	Waist circumference in cm	0.8	< 0.001**
NIM-METS Scores	WHtR	0.81	< 0.001**
NIM-METS Scores	SBP (mmHg)	0.73	< 0.001**
NIM-METS Scores	DBP (mmHg)	0.71	< 0.001**
NIM-METS Scores	Energy-avg	0.32	0.001**
NIM-METS Scores	Protein-avg	0.31	0.002**
NIM-METS Scores	Carbs-avg	0.26	0.01*
NIM-METS Scores	Fats-avg	0.24	0.014*

Table 4 showed the Spearman's correlation analysis between NIM-METS scores and selected anthropometric, clinical, and lifestyle variables. A strong positive correlation was observed between NIM-METS scores and waist circumference (r = 0.80) and waist-to-height ratio (r = 0.81). Similarly, systolic and diastolic blood pressure showed strong positive correlations (r = 0.71–0.73). A strong positive correlation was also noted with diabetes risk (r = 0.77). Moderate positive correlations were observed between NIM-METS scores and emotional eating (r = 0.49), external eating (r = 0.45), and sleep quality (r = 0.42). Dietary intake variables showed weak positive correlations with NIM-METS scores. Physical activity demonstrated a negative correlation with NIM-METS scores, which was not statistically significant.

Discussion :

Sociodemographic characteristics were analysed to assess their association with metabolic syndrome (MetS) risk. Among the 100 participants, age distribution was fairly uniform, with a median age of 22 years and no significant difference between low- and moderate-risk groups. However, gender showed a significant association ($p = 0.002$), with a higher proportion of males in the moderate-risk category. A family history of heart disease ($p = 0.003$) and hypertension ($p = 0.013$) was also significantly linked with increased risk, indicating a genetic predisposition. Smoking was significantly associated with higher MetS risk ($p = 0.002$), while alcohol intake ($p = 0.121$) and dietary pattern ($p = 0.065$) were not significantly related. These findings align with previous research highlighting the combined influence of genetic susceptibility and behavioural factors on early cardiometabolic risk (Fahed et al., 2022).

Anthropometric and clinical parameters showed strong associations with MetS risk. Participants in the moderate-risk group had significantly higher BMI (31.1 vs 21.1 kg/m², $p < 0.001$), waist circumference (96.5 vs 72.0 cm, $p < 0.001$), and waist-to-height ratio (0.6 vs 0.5, $p < 0.001$). Additionally, over 60% of individuals in the moderate-risk group were classified as obese, compared to around 10% in the low-risk group. Blood pressure was also significantly higher in the moderate-risk group, with elevated systolic (132 vs 115 mmHg, $p = 0.001$) and diastolic values (84 vs 72 mmHg, $p = 0.015$). These findings are consistent with earlier studies identifying central adiposity and hypertension as major predictors of metabolic syndrome (Ranasinghe et al., 2017).

Physical activity levels, assessed using the IPAQ-SF, did not show a statistically significant independent association with MetS risk. Although a trend toward lower activity was observed in the moderate-risk group, most participants were moderately active. This supports findings from previous research suggesting that physical activity alone may not independently predict metabolic risk without considering other lifestyle factors (Pengpid & Peltzer, 2021).

Sleep quality, measured using the PSQI, demonstrated a strong and statistically significant association with MetS risk. Participants in the moderate-risk group had poorer sleep quality, with median PSQI scores of 9.0 compared to 3.0 in the low-risk group ($p < 0.001$). A higher proportion of poor sleepers was observed in the moderate-risk group (68%) compared to the low-risk group (23%). These findings are supported by evidence linking poor sleep to hormonal imbalance, circadian disruption, and increased metabolic risk (Wang et al., 2021; Itani et al., 2017).

Snacking behaviour, assessed using the DEBQ, was also significantly associated with MetS risk. Emotional eating scores were higher in the moderate-risk group (4.4 vs 2.4, $p < 0.001$), along with external eating scores (5.0 vs 3.2, $p < 0.001$). A greater proportion of participants in the moderate-risk group were classified as high emotional eaters, whereas low emotional eating was more common in the low-risk group.

These findings are consistent with literature linking unhealthy eating behaviours and ultra-processed food intake to obesity and metabolic disturbances (Chen et al., 2021; Monteiro et al., 2019).

Correlation analysis further supported these observations. Higher NIM-METS scores were strongly correlated with central adiposity measures (waist circumference and waist-to-height ratio), blood pressure, and diabetes risk scores, reinforcing their role in metabolic dysfunction (Fahed et al., 2022). Moderate positive correlations were observed with poor sleep quality and unhealthy eating behaviours, while dietary intake showed weaker but significant associations. Physical activity demonstrated a non-significant inverse relationship with metabolic risk. Overall, these findings highlight that metabolic syndrome is influenced by a combination of physiological and lifestyle-related factors. Poor sleep quality and unhealthy snacking behaviours appeared to be stronger predictors of MetS risk than physical activity alone. The clustering of multiple lifestyle risk factors in young adults underscores the need for comprehensive prevention strategies. Interventions should focus on improving sleep hygiene, promoting healthier dietary habits, and addressing behavioural triggers to reduce long-term cardiometabolic risk (Chaput et al., 2022; Ding et al., 2015).

Conclusion :

The study revealed that most participants were moderately active; however, physical activity levels did not show a statistically significant association with metabolic syndrome risk. In contrast, poor sleep quality was significantly associated with higher metabolic risk, with participants in the moderate-risk group reporting poorer sleep patterns and shorter sleep duration. Snacking behaviour assessment showed that emotional and external eating patterns were more prevalent among participants with higher metabolic risk, indicating an association between unhealthy snacking habits and metabolic abnormalities. Overall, the study highlights that while physical activity remains important for overall health, sleep quality and snacking behaviour emerged as stronger lifestyle factors associated with metabolic syndrome risk in young adults, emphasizing the need for early lifestyle modification and preventive strategies in this population.

References :

1. Chaput, J. P., Dutil, C., & Sampasa-Kanyinga, H. (2018). Sleeping hours: what is the ideal number and how does age impact this?. Nature and science of sleep, 10, 421–430. https://doi.org/10.2147/NSS.S163071
2. Chen, X., Zhang, Z., Yang, H., Qiu, P., Wang, H., Wang, F., Zhao, Q., Fang, J., & Nie, J. (2020). Consumption of ultra-processed foods and health outcomes: a systematic review of epidemiological studies. *Nutrition journal*, *19*(1), 86.https://doi.org/10.1186/s12937-020-00604-1
3. Chomiuk, T., Niezgoda, N., Mamcarz, A., & Śliż, D. (2024). Physical activity in metabolic syndrome. Frontiers in physiology, 15, 1365761. https://doi.org/10.3389/fphys.2024.1365761
4. Ding, D., Rogers, K., van der Ploeg, H., Stamatakis, E., & Bauman, A. E. (2015). Traditional and Emerging Lifestyle Risk Behaviors and All-Cause Mortality in Middle-Aged and Older Adults: Evidence from a Large Population-Based Australian Cohort. PLoS medicine, 12(12), e1001917. https://doi.org/10.1371/journal.pmed.1001917

5. Fahed, G., Aoun, L., Bou Zerdan, M., Allam, S., Bou Zerdan, M., Bouferraa, Y., & Assi, H. I. (2022). Metabolic Syndrome: Updates on Pathophysiology and Management in 2021. International journal of molecular sciences, 23(2), 786. https://doi.org/10.3390/ijms23020786
6. Grandner M. A. (2017). Sleep, Health, and Society. Sleep medicine clinics, 12(1), 1–22. https://doi.org/10.1016/j.jsmc.2016.10.012
7. Indian Council of Medical Research (ICMR), Public Health Foundation of India (PHFI), & Institute for Health Metrics and Evaluation (IHME). (2023). ICMR-INDIAB study: National report on metabolic disorders in India. ICMR.
8. International Institute for Population Sciences (IIPS), & Ministry of Health and Family Welfare (MoHFW). (2021). National Family Health Survey (NFHS-5), 2019–21: India report. IIPS.
9. Itani, O., Jike, M., Watanabe, N., & Kaneita, Y. (2017). Short sleep duration and health outcomes: a systematic review, meta-analysis, and meta-regression. Sleep medicine, 32, 246–256. https://doi.org/10.1016/j.sleep.2016.08.006
10. Ministry of Health and Family Welfare (MoHFW), UNICEF, & Population Council. (2019). Comprehensive National Nutrition Survey (CNNS) 2016–2018. MoHFW.
11. Monteiro, C. A., Cannon, G., Levy, R. B., Moubarac, J. C., Louzada, M. L., Rauber, F., Khandpur, N., Cediel, G., Neri, D., Martinez-Steele, E., Baraldi, L. G., & Jaime, P. C. (2019). Ultra-processed foods: what they are and how to identify them. Public health nutrition, 22(5), 936–941. https://doi.org/10.1017/S1368980018003762
12. Pandit, K., Goswami, S., Ghosh, S., Mukhopadhyay, P., & Chowdhury, S. (2012). Metabolic syndrome in South Asians. Indian journal of endocrinology and metabolism, 16(1), 44–55. https://doi.org/10.4103/2230-8210.91187
13. Pengpid, S., & Peltzer, K. (2019). Sedentary Behaviour, Physical Activity and Life Satisfaction, Happiness and Perceived Health Status in University Students from 24 Countries. International journal of environmental research and public health, 16(12), 2084. https://doi.org/10.3390/ijerph16122084
14. Ranasinghe, P., Mathangasinghe, Y., Jayawardena, R., Hills, A. P., & Misra, A. (2017). Prevalence and trends of metabolic syndrome among adults in the asia-pacific region: a systematic review. BMC public health, 17(1), 101. https://doi.org/10.1186/s12889-017-4041-1
15. Xie, J., Li, Y., Zhang, Y., Vgontzas, A. N., Basta, M., Chen, B., Xu, C., & Tang, X. (2021). Sleep duration and metabolic syndrome: An updated systematic review and meta-analysis. Sleep medicine reviews, 59, 101451. https://doi.org/10.1016/j.smrv.2021.101451