Published by
Saidu Medical College

OPEN ACCESS

Original Article

Association of Risk Factors of Overweight and Obesity among the Adult Population: A Case–Control Study

Mohammad Munib[1], Mohammad Khalid Khan[2], Muhammad Jibran Khan[3], Muhammad Nadeem[4], Naeem Ullah[4], Syed Jawad Hussain[3], Muhammad Ishtiaq[3] & Jaweria Ahmad Khattak[3]

[1] Swat Medical College, Swat, Pakistan
[2] Gajju Khan Medical College, Swabi, Pakistan
[3] Khyber Medical University – Institute of Medical Sciences, Kohat, Pakistan
[4] Saidu Medical College, Swat, Pakistan

https://doi.org/10.52206/jsmc.2026.16.1.1377

Abstract

Background: Overweight and obesity are emerging as major global public health challenges and are among the leading causes of morbidity and mortality worldwide. The prevalence of overweight and obesity has increased rapidly over the past four decades, affecting both developed and developing countries, including Pakistan. These conditions are strongly associated with non-communicable diseases such as diabetes mellitus, cardiovascular disorders, and metabolic syndromes.

Objective: To assess the association between selected sociodemographic, behavioral, dietary, and lifestyle risk factors and overweight/obesity among the adult population.

Methodology: A community-based case–control study was conducted from January to April 2024 in Swat and Peshawar districts of Khyber Pakhtunkhwa, Pakistan. A total of 363 adults aged ≥18 years were included using a 2:1 control-to-case ratio. Individuals with BMI ≥25 kg/m² were classified as cases, while those with BMI <25 kg/m² served as controls. Data were collected using a semi-structured questionnaire covering demographic characteristics, lifestyle behaviors, dietary practices, and family history. Statistical analysis was performed using SPSS version 26.0, and associations were assessed using odds ratios and chi-square tests.

Results: Overweight and obesity showed significant associations with advancing age, literacy status, higher monthly income, positive family history of obesity, tobacco smoking, sedentary lifestyle, lack of physical activity, high screen time, consumption of soft and energy drinks, and preference for high-caloric diets. Protective associations were observed with regular physical activity and higher intake of fruits and vegetables.

Conclusion: Overweight and obesity among adults were strongly associated with modifiable lifestyle and dietary factors, as well as selected sociodemographic determinants. These findings highlight the need for comprehensive public health interventions focusing on lifestyle modification, dietary improvement, and behavioral change to reduce the burden of obesity in the adult population.

Keywords: Adult Population, Diet, Lifestyle, Obesity, Overweight, Physical Activity, Risk Factors.

ISSN (P): 1819-4583
ISSN (E): 3007-9470

Copyright © Copyright (c) 2026 The authors retain the copyrights. Authors are permitted and encouraged to post their work online (e.g. in institutional repositories or on their website), as it can lead to productive exchanges, as well as greater citation of published work.

Citation:
Munib M, Khan MK, Khan MJ, Nadeem M, Ullah N, Hussain SJ, et al. Association of Risk Factors of Overweight and Obesity among the Adult Population: A Case–Control Study. *J Saidu Med Coll.* 2026;16(2):244–251.

Corresponding Author:
Dr. Mohammad Munib
Assistant Professor,
Department of Community Medicine,
Swat Medical College, Swat, Pakistan
peokurram5@gmail.com

Funding:
The authors received no external funding for this study.

Conflicts of Interests:
The authors have declared that no competing interests exist.

Data Sharing Statement:
The data that support the findings of this study are available on request from the corresponding author. The data is not publicly available due to privacy or ethical restrictions.

Received: August 07, 2025
1st Revision: September 18, 2025
2nd Revision: December 5, 2025
Accepted: December 12, 2025

Check for updates

Introduction

Overweight and obesity have emerged as global epidemics of major public health concern, with their prevalence nearly tripling worldwide over the past four decades [1,2]. According to the World Health Organization, obesity is among the leading contributors to preventable morbidity and mortality and is estimated to be the fifth leading cause of death globally [3]. In 2019, more than 1.9 billion adults were classified as overweight, including over 650 million individuals living with obesity, and these numbers are projected to rise substantially by 2045 [4-6].

The growing burden of overweight and obesity is strongly linked to an increased risk of non-communicable diseases, including type 2 diabetes mellitus, cardiovascular diseases, hypertension, chronic kidney disease, musculoskeletal disorders, infertility, and certain cancers [7-9]. Evidence from epidemiological studies indicates that overweight and obesity are influenced by a complex interplay of genetic predisposition, socioeconomic status, behavioral patterns, dietary practices, and environmental factors [10,11].

Lifestyle-related determinants such as physical inactivity, sedentary behavior, increased screen time, consumption of high-caloric and energy-dense foods, intake of soft and energy drinks, tobacco smoking, and reduced consumption of fruits and vegetables have been consistently associated with excess body weight across diverse populations [12-15]. Rapid urbanization, nutritional transition, occupational stress, and changes in social structure further contribute to unhealthy lifestyle behaviors, particularly in low- and middle-income countries [16,17].

In Pakistan, the prevalence of overweight and obesity has increased alarmingly in recent years. Studies have reported strong associations between excess body weight and advancing age, female gender, urban residence, higher income, lower physical activity levels, job-related stress, and sedentary lifestyles [18-21]. Despite this growing burden, there remains a scarcity of analytical case–control studies exploring the combined influence of sociodemographic, behavioral, and dietary risk factors in local contexts [22,23].

Given the rising prevalence of obesity and its associated health consequences, particularly in developing countries like Pakistan, there is a critical need for evidence-based research to identify context-specific risk factors. Therefore, this case–control study was conducted to assess the association between selected risk factors and overweight/obesity among the adult population in Swat and Peshawar districts, with the aim of informing targeted preventive and public health strategies.

Methodology

Study Design

A community-based case–control study was conducted to assess the association between selected risk factors and overweight/obesity among adults. The study was carried out from January to April 2024 in Swat and Peshawar districts of Khyber Pakhtunkhwa, Pakistan. A 2:1 ratio of controls to cases was maintained to enhance statistical efficiency and comparative analysis. Cases were defined as individuals with body mass index (BMI) ≥25 kg/m², while controls were individuals with BMI <25 kg/m².

Ethics

Ethical approval for the study was obtained from the Ethical Review Board of Saidu Medical College, Swat (Approval No. 126-ERB/024, dated 02-02-2024). Written informed consent was obtained from all participants prior to data collection. Confidentiality and anonymity of participants were ensured throughout the study, and data were used strictly for research purposes.

Setting

The study was conducted in both urban and rural settings of Swat and Peshawar districts. These districts were selected to capture socioeconomic, demographic, and lifestyle variability representative of the adult population in Khyber Pakhtunkhwa. Data collection was carried out through field visits and interviews in community settings.

Participants

The study included 363 adults aged 18 years and above. Participants were selected using a non-probability convenience sampling technique. Individuals who were pregnant, severely ill, or unable to provide informed consent were excluded. Based on predefined criteria, 121 participants were classified as cases (overweight/obese) and 241 as controls (normal weight).

Variables

The primary outcome variable was overweight/obesity, determined using BMI. Independent variables included sociodemographic factors (age, gender, marital status, education, occupation, monthly income, and locality), behavioral factors (tobacco smoking, physical activity, sedentary lifestyle, screen time), dietary factors (intake of meat, fruits, vegetables, sugar, salt, soft drinks, energy drinks, and high-caloric diets), and non-modifiable factors

such as family history of obesity/overweight and presence of chronic diseases.

Data Sources/Measurement
Data were collected using a semi-structured questionnaire, developed after an extensive literature review and adapted to the local socioeconomic and environmental context. The questionnaire was modified based on previously validated studies to assess modifiable and non-modifiable risk factors.

Anthropometric measurements were taken using standard procedures. BMI was calculated as weight (kg) divided by height squared (m^2). Dietary intake variables were assessed based on consumption at least once per week, while screen time was categorized using a cut-off of ≥2 hours per day.

Bias
To minimize information bias, data collectors were trained prior to data collection, and standardized measurement techniques were used. Recall bias was reduced by limiting dietary and behavioral questions to recent and habitual practices. Selection bias is acknowledged due to the use of convenience sampling, which is addressed in the limitations.

Study Size
The sample size was calculated using a 95% confidence interval, 80% study power, and an assumed odds ratio of 2, based on previously published studies. The calculated sample size was 341 participants, including 121 cases and 241 controls. To improve robustness, a total of 363 participants were included in the final analysis.

Quantitative Variables
Continuous variables such as age and BMI were categorized into meaningful groups for analysis. BMI was categorized into overweight/obese (≥25 kg/m^2) and normal weight (<25 kg/m^2). Income, screen time, and age were grouped into predefined categories based on epidemiological relevance.

Statistical Methods
Data were entered and analyzed using SPSS version 26.0. Descriptive statistics were used to summarize demographic and exposure variables. Associations between risk factors and overweight/obesity were assessed using odds ratios (ORs) with 95% confidence intervals, and statistical significance was determined using the chi-square test. A p-value <0.05 was considered statistically significant. Results were presented in the form of tables.

Results

Participants
A total of 363 adults aged 18 years and above participated in the study from Swat and Peshawar districts. Among these, 121 participants (33.3%) were classified as cases (overweight/obese with BMI ≥25 kg/m^2), while 241 participants (66.7%) served as controls (BMI <25 kg/m^2). The overall sample included 276 males (76.03%) and 87 females (23.97%). Most participants were married (70.80%), and a larger proportion resided in rural areas (61.71%) compared to urban settings (38.29%). The distribution of participants across sociodemographic variables is detailed in Table 1.

Descriptive Data
With respect to age distribution, a substantial proportion of participants were 55 years or older (74.93%), with a higher percentage observed among controls (52.34%) compared to cases (22.59%). Regarding education, 65.01% of participants were literate, while 34.99% were illiterate, with literacy showing a statistically significant association with overweight/obesity. In terms of employment status, 35.81% of participants were unemployed, followed by government servants (25.90%), laborers (18.18%), and housewives (14.88%). Monthly income varied across participants, with 49.04% reporting an income greater than 60,000 PKR, and income categories demonstrated a statistically significant association with overweight/obesity status (Table 1).

Lifestyle and behavioral characteristics revealed that 49.31% of participants reported current tobacco smoking, 31.96% had a positive family history of overweight/obesity, and 31.96% reported the presence of chronic diseases. Dietary habits showed that 68.87% preferred fruits, 61.43% preferred vegetables, and 32.78% preferred meat, while 64.19% reported consumption of soft or energy drinks. Additionally, 48.76% of participants reported a sedentary lifestyle, 32.51% reported no regular physical activity, and 58.13% spent more than two hours per day on television or screen-based activities, as summarized in Table 2.

Outcome Data
The outcome of interest, overweight/obesity, was significantly associated with multiple modifiable and non-modifiable risk factors. Among cases, higher proportions were observed for sedentary lifestyle (22.59%), lack of physical activity (13.50%), high screen time (28.10%), soft and energy drink consumption (26.45%), and preference for high-caloric diets (24.52%). Positive family history of overweight/obesity was present in 12.95% of cases, while

20.94% of cases reported current tobacco smoking. Chronic diseases were reported by 15.15% of cases, indicating a notable overlap between obesity and comorbid conditions.

Main Results

Statistical analysis demonstrated that advanced age, educational status, and monthly income were significantly associated with overweight/obesity. Literacy showed a strong association (OR = 2.99, p < 0.0001), while higher monthly income was inversely associated with obesity risk (OR = 0.62, p = 0.0319). Behavioral and lifestyle factors exhibited particularly strong associations; sedentary lifestyle (OR = 3.25, p < 0.0001), high screen time (OR = 6.55, p < 0.0001), high-caloric diet consumption (OR = 4.15, p < 0.0001), soft and energy drink intake (OR = 2.94, p < 0.0001), and meat preference (OR = 3.82, p < 0.0001) were all significantly linked with overweight/obesity. Conversely, physical exercise (OR = 0.59, p = 0.0222), fruit intake (OR = 0.56, p = 0.0135), and vegetable intake (OR = 0.18, p < 0.0001) showed protective associations. Additionally, tobacco smoking (OR = 2.28, p = 0.0003), positive family history of obesity (OR = 1.59, p = 0.0474), and presence of chronic disease (OR = 2.47, p = 0.0001) were significantly associated with increased odds of overweight and obesity.

Table 1: Demographics of Study Population of District Swat & Peshawar (n=363).

Variables		Cases (n=121) n (%)	Controls (n=241) n (%)	Total (n=363) n (%)	Odds Ratio	p-value
Age in years	< 35	3 (0.83)	4 (1.10)	7 (1.93)	1.73	0.026*
	35- 45	9 (2.48)	17 (4.68)	26 (7.16)		
	45-55	27 (7.44)	31 (8.54)	58 (15.98)		
	55 & above	82 (22.59)	190 (52.34)	272 (74.93)		
Gender	Male	97 (26.72)	179 (49.31)	276 (76.03)	1.42	0.193
	Female	24 (6.61)	63 (17.36)	87 (23.97)		
Occupation	Labor	21 (5.79)	45 (12.40)	66 (18.18)	0.98	0.939
	Govt servants	35 (9.64)	59 (16.25)	94 (25.90)		
	Housewife	15 (4.13)	39 (10.74)	54 (14.88)		
	Students	2 (0.55)	17 (4.68)	19 (5.23)		
	Nill	48 (13.22)	82 (22.59)	130 (35.81)		
Educational status	Literate	97 (26.72)	139 (38.29)	236 (65.01)	2.99	<0.000*
	Illiterate	24 (6.61)	103 (28.37)	127 (34.99)		
Monthly Income PKR	< 25000	4 (1.10)	27 (7.44)	31 (8.54)	0.61	0.031*
	25- 45000	11 (3.03)	45 (12.40)	56 (15.43)		
	45-60000	37 (10.19)	61 (16.80)	98 (27.00)		
	> 60000	69 (19.01)	109 (30.03)	178 (49.04)		
Marital Status	Married	92 (25.34)	165 (45.45)	257 (70.80)	1.48	0.122
	Unmarried	29 (7.99)	77 (21.21)	106 (29.20)		
Locality	Rural	79 (21.76)	145 (39.94)	224 (61.71)	1.25	0.321
	Urban	42 (11.57)	97 (26.72)	139 (38.29)		

*Significant at p<0.05.

Table 2: Modifiable & Non-Modifiable Risk Factors of Study Population of District Swat & Peshawar.

Variables		Cases (n=121) n (%)	Controls (n=241) n (%)	Total (n=363) n (%)	Odds Ratio	p-value
Tobacco Smoking	Yes	76 (20.94)	103 (28.37)	179 (49.31)	2.279	< 0.000*
	No	45 (12.40)	139 (38.29)	184 (50.69)		
Positive Family History of Obesity/ Overweight	Yes	47 (12.95)	69 (19.01)	116 (31.96)	1.592	0.047*
	No	74 (20.39)	173 (47.66)	247 (68.04)		
Any acute disease	Yes	17 (4.68)	43 (11.85)	60 (16.53)	0.756	0.3695
	No	104 (28.65)	199 (54.82)	303 (83.47)		
Any chronic disease	Yes	55 (15.15)	61 (16.80)	116 (31.96)	2.472	< 0.000*
	No	66 (18.18)	181 (49.86)	247 (68.04)		
Like salt in food	Yes	95 (26.17)	210 (57.85)	305 (84.02)	0.556	0.044*
	No	26 (7.16)	32 (8.82)	58 (15.98)		
Use too much salt	Yes	29 (7.99)	46 (12.67)	75 (20.66)	1.566	0.106
	No	66 (18.18)	164 (45.18)	230 (63.36)		
Like sugar in food/drinks	Yes	69 (19.01)	97 (26.72)	166 (45.73)	1.983	0.002*
	No	52 (14.33)	145 (39.94)	197 (54.27)		
Use too much sugar	Yes	18 (4.96)	30 (8.26)	48 (13.22)	1.524	0.2071
	No	61 (16.80)	155 (42.70)	216 (59.50)		
Like fruits	Yes	73 (20.11)	177 (48.76)	250 (68.87)	0.558	0.013*
	No	48 (13.22)	65 (17.91)	113 (31.13)		
Like vegetables	Yes	42 (11.57)	181 (49.86)	223 (61.43)	0.179	< 0.000*
	No	79 (21.76)	61 (16.80)	140 (38.57)		
Like meat	Yes	64 (17.63)	55 (15.15)	119 (32.78)	3.817	< 0.000*
	No	57 (15.70)	187 (51.52)	244 (67.22)		
Sedentary Life Style	Yes	82 (22.59)	95 (26.17)	177 (48.76)	3.253	< 0.000*
	No	39 (10.74)	147 (40.50)	186 (51.24)		
Physical Exercise	Yes	72 (19.83)	173 (47.66)	245 (67.49)	0.586	0.022*
	No	49 (13.50)	69 (19.01)	118 (32.51)		
TV/Screen Time	Yes	102(28.10)	109(30.03)	211(58.13)	6.550	< 0.000*
	No	19(5.23)	133(36.64)	152(41.87)		
Soft drinks/ Energy Drinks	Yes	96(26.45)	137(37.74)	233(64.19)	2.940	< 0.000*
	No	25(6.89)	105(28.93)	130(35.81)		
Hi Caloric Diet/ Fats Carbs etc.	Yes	89(24.52)	97(26.72)	186(51.24)	4.150	< 0.000*
	No	32(8.82)	145(39.94)	177(48.76)		

*Significant at p<0.05.

Discussion

The present case–control study examined the association between selected sociodemographic, behavioral, dietary, and lifestyle factors and overweight/obesity among adults in Swat and Peshawar districts. The findings demonstrate that advancing age, educational status, monthly income, positive family history of obesity, tobacco smoking, sedentary lifestyle, physical inactivity, high screen time, and consumption of high-caloric foods and energy drinks were significantly associated with overweight and obesity.

In this study, advancing age showed a strong positive association with overweight and obesity, particularly among individuals aged 55 years and above. This finding is consistent with previous studies reporting increased adiposity with aging due to metabolic slowdown, hormonal changes, and reduced physical activity [3,8,19]. Educational status was also significantly associated with overweight/obesity, with literate individuals showing higher odds, possibly reflecting occupational sedentary behavior

and lifestyle transitions associated with higher socioeconomic status [21].

Monthly income demonstrated a significant association with overweight and obesity, indicating that individuals with higher income may have increased access to energy-dense foods, sedentary occupations, and screen-based leisure activities. Similar findings have been reported in studies conducted in Pakistan and other developing countries, where economic growth is accompanied by nutritional transition and lifestyle changes [19,21].

A positive family history of overweight or obesity emerged as an important non-modifiable determinant, highlighting the role of genetic susceptibility and shared household behaviors. This observation aligns with earlier evidence demonstrating familial aggregation of obesity due to genetic, behavioral, and environmental influences [4,11,24]. Additionally, the presence of chronic diseases showed a strong association with overweight/obesity, reinforcing the well-established link between excess body weight and non-communicable disease burden [5,10,18].

Behavioral and lifestyle factors showed particularly strong associations with overweight and obesity. Tobacco smoking was significantly associated with increased odds of overweight/obesity in this population, which may reflect clustering of unhealthy behaviors such as poor diet and physical inactivity [19]. A sedentary lifestyle, lack of physical activity, and prolonged screen time were among the strongest predictors, consistent with evidence demonstrating reduced energy expenditure and increased caloric intake associated with sedentary behaviors [3,25].

Dietary patterns also played a critical role. Preference for high-caloric diets, frequent consumption of meat, and intake of soft and energy drinks were significantly associated with overweight and obesity, supporting findings from international studies that link energy-dense diets with excess weight gain [14,23]. Conversely, regular consumption of fruits and vegetables showed a protective association, consistent with studies highlighting the role of fiber-rich diets in weight regulation and metabolic health [12,16].

The findings of this study are consistent with existing literature from low-, middle-, and high-income countries and highlight the multifactorial nature of overweight and obesity. The results emphasize the need for integrated public health strategies targeting behavioral modification, dietary improvement, and promotion of physical activity within the local sociocultural context.

Limitations

Despite its strengths, this study has certain limitations. The case–control design limits the ability to establish causal relationships between risk factors and overweight/obesity. A prospective cohort design would provide stronger evidence of temporality. Additionally, the analysis relied primarily on odds ratios and chi-square tests, and multivariable logistic regression was not performed, which may have limited control for potential confounding factors. The study was conducted in only two districts (Swat and Peshawar), which may limit the generalizability of the findings to other regions of Pakistan. Furthermore, the use of non-probability convenience sampling may introduce selection bias. Some behavioral and dietary data were self-reported, which could lead to recall bias or social desirability bias.

Conclusion

This study concludes that overweight and obesity among adults are strongly associated with advancing age, higher monthly income, positive family history of obesity, tobacco smoking, sedentary lifestyle, physical inactivity, high screen time, and preference for high-caloric diets and energy drinks. In contrast, regular physical activity and higher intake of fruits and vegetables demonstrated protective effects against overweight and obesity. These findings underscore the urgent need for comprehensive, evidence-based public health interventions focusing on lifestyle modification, dietary improvement, and behavioral change to reduce the growing burden of overweight and obesity among adults. Community-based awareness programs, policy-driven nutritional interventions, and promotion of physical activity are essential to mitigate obesity-related health risks in the adult population.

Authors' Contributions:

All authors meet the ICMJE criteria for authorship.

Author 1: Substantial contribution to conception and design, drafting the manuscript, final approval, agreed to be accountable for all the work.
Author 2: Substantial contribution to conception and design, data acquisition, drafting the manuscript, final approval, agreed to be accountable for all the work.
Author 3: Analysis and interpretation of data, drafting the manuscript, final approval, agreed to be accountable for all the work.
Author 4: Analysis and interpretation of data, critical revision, final approval, agreed to be accountable for all the work.

Author 5&6: Substantial contribution to conception and design, drafting the manuscript, final approval, agreed to be accountable for all the work.

Author 7&8: Substantial contribution to conception and design, data acquisition, drafting the manuscript, final approval, agreed to be accountable for all the work.

References

1. Wang Y, Pan L, He H, Li Z, Cui S, Yang A, et al. Prevalence, associated factors, and gene polymorphisms of obesity in Tibetan adults in Qinghai, China. *BMC Public Health.* 2024;24(1):1–11. https://doi.org/10.1186/s12889-023-17181-7
2. Najafi F, Soltani S, Karami Matin B, Kazemi Karyani A, Rezaei S, Soofi M, et al. Socioeconomic - Related inequalities in overweight and obesity: Findings from the PERSIAN cohort study. *BMC Public Health.* 2020;20(1):1–13. https://doi.org/10.1186/s12889-020-8322-8
3. Shi J, Liang Z, Zhang X, Ren S, Cheng Y, Liu Y, et al. Association of physical activity and dietary inflammatory index with overweight/obesity in US adults: NHANES 2007–2018. *Environ Health Prev Med.* 2023;28:1–9. https://doi.org/10.1265/ehpm.23-00016
4. Keller M, Svensson SIA, Rohde-Zimmermann K, Kovacs P, Böttcher Y. Genetics and Epigenetics in Obesity: What Do We Know so Far? *Curr Obes Rep* [Internet]. 2023;12(4):482–501. https://doi.org/10.1007/s13679-023-00526-z
5. Das S, Debnath M, Das S, Sarkar S, Rumana AS. Association of overweight and obesity with hypertension, diabetes and comorbidity among adults in Bangladesh: evidence from nationwide Demographic and Health Survey 2017-2018 data. *BMJ Open.* 2022;12(7):1–11. https://doi.org/10.1136/bmjopen-2021-052822
6. Kim DH, Rajaguru V, Kim B, Jang SY, Shin J, Lee SG, et al. Association of behavior pattern with overweight and obesity in South Korean adults–A multi correspondence analysis (KNHANES-2018–2020). *PLOS Glob Public Heal.* 2023;3(9):e0002384. https://doi.org/10.1371/journal.pgph.0002384
7. Tekalegn Y. Determinants of Overweight or Obesity among Men Aged 20-59 Years: A Case-Control Study Based on the 2016 Ethiopian Demographic and Health Survey. *J Obes.* 2021. https://doi.org/10.1155/2021/6627328
8. Oluwasanu AO, Akinyemi JO, Oluwasanu MM, Oseghe OB, Oladoyinbo OL, Bello J, et al. Temporal trends in overweight and obesity and chronic disease risks among adolescents and young adults: A ten-year review at a tertiary institution in Nigeria. *PLoS One.* 2023;18:1–19. https://doi.org/10.1371/journal.pone.0283210
9. Sitaula D, Dhakal A, Lageju N, Silwal A, Basnet SK, Shrestha N, et al. Prevalence and Associated Factors of Adolescent Obesity among Rural School Adolescents in Nepal: A Cross-Sectional Study. *Glob Health Epidemiol Genom.* 2023:2957278. https://doi.org/10.1155/2023/2957278
10. Wu Q, Han R, Li Z, Huang X, Cheng D, Ni J, et al. Effect of virtual reality-based exercise and physical exercise on adolescents with overweight and obesity: study protocol for a randomised controlled trial. *BMJ Open.* 2023;13(10):e075332. https://doi.org/10.1136/bmjopen-2023-075332
11. Kedir S, Hassen K, Melaku Y, Jemal M. Determinants of overweight and/or obesity among school adolescents in Butajira Town, Southern Ethiopia. A case-control study. *PLoS One.* 2022;17(6):1–13. https://doi.org/10.1371/journal.pone.0270628
12. Ghorbani Z, Noormohammadi M, Kazemi A, Poustchi H, Pourshams A, Martami F, et al. Higher intakes of fiber, total vegetables, and fruits may attenuate the risk of all-cause and cause-specific mortality: findings from a large prospective cohort study. *Nutr J.* 2023;22(1):1–18. https://doi.org/10.1186/s12937-023-00883-4
13. Mandefro M, Shore H, Hailu S, Ayele F, Tekola A, Shawel S, et al. Overweight and obesity and associated factors among public and private secondary school adolescent students in Harar city, Eastern Ethiopia: A comparative cross-sectional study. *Medicine (Baltimore).* 2024;103(21):e38271. https://doi.org/10.1097/MD.0000000000038271
14. Aljaadi AM, Turki A, Gazzaz AZ, Al-Qahtani FS, Althumiri NA, BinDhim NF. Soft and energy drinks consumption and associated factors in Saudi adults: a national cross-sectional study. *Front Nutr.* 2023;10:1286633. https://doi.org/10.3389/fnut.2023.1286633
15. Wu E, Ni J, Zhou W, You L, Tao L, Xie T. Consumption of fruits, vegetables, and legumes are associated with overweight/obesity in the middle- and old-aged Chongqing residents: A case-control study. *Medicine (Baltimore).* 2022;101(27):e29749. https://doi.org/10.1097/MD.0000000000029749
16. Li SY, Leung JCS, Lu ZH, Kwok TCY. Quantity and Variety of Fruit and Vegetable Intake with Changes in Measures of Adiposity among Community-Dwelling Chinese Older Adults. *Nutrients.* 2023;15(19): https://doi.org/10.3390/nu15194096
17. Azanaw MM, Zewde EA, Gebremariam AD, Dagnaw FT, Asnakew DT, Chanie ES, et al. Spatiotemporal distribution and determinants of overweight or obesity among urban women in Ethiopia: a multivariate decomposition analysis. *BMC Womens Health.* 2022;22(1):1–15. https://doi.org/10.1186/s12905-022-02102-4
18. Chen JQ, Wang D, Liu B. Body mass index and carpal tunnel syndrome: A case-control study. *Medicine (Baltimore).* 2023;102(31):e34468. https://doi.org/10.1097/MD.0000000000034468
19. Nomani RM un N, Khan A, Shah STA, Naeem A, Liaquat A, Khan MJ. Risk Factors of Obesity in the Adult Population of Pakistan. *Life Sci.* 2023;4(4):8. https://doi.org/10.37185/LnS.1.1.433

20. Vahid F, Rahmani W, Davoodi SH, Bohn T. The micronutrient content of the diet is correlated with serum glucose biomarkers and lipid profile and is associated with the odds of being overweight/obese—a case-control study. *Front Nutr.* 2023;10:1–12. https://doi.org/10.3389/fnut.2023.1148183
21. Mamdouh H, Hussain HY, Ibrahim GM, Alawadi F, Hassanein M, Zarooni A Al, et al. Prevalence and associated risk factors of overweight and obesity among adult population in Dubai: A population-based cross-sectional survey in Dubai, the United Arab Emirates. *BMJ Open*. 2023;13(1):1–9. https://doi.org/10.1136/bmjopen-2022-062053
22. Shakya S, Absetz P, Neupane S. Two-decade trends and factors associated with overweight and obesity among young adults in Nepal. *PLOS Glob Public Heal.* 2023;3(10):e0002522. https://doi.org/10.1371/journal.pgph.0002522
23. Alamnia TT, Sargent GM, Kelly M. Dietary patterns and associations with metabolic risk factors for non-communicable disease. *Sci Rep.* 2023;13(1):1–10. https://doi.org/10.1038/s41598-023-47548-0
24. Bhuiyan MU, Zaman S, Ahmed T. Risk factors associated with overweight and obesity among urban school children and adolescents in Bangladesh: a case-control study. *BMC Pediatr.* 2013;13:72. https://doi.org/10.1186/1471-2431-13-72
25. Guo X, Gong S, Chen Y, Hou X, Sun T, Wen J, et al. Lifestyle behaviors and stress are risk factors for overweight and obesity in healthcare workers: a cross-sectional survey. *BMC Public Health*. 2023;23(1):1–13. https://doi.org/10.1186/s12889-023-16673-w