

Prevalence of Overweight and Obesity among Selected Bangladeshi Young Adults and Evaluation of the Associated Factors after COVID-19 Pandemic: A Cross-Sectional Study

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Abstract

Overweight and obesity have emerged as alarming public health concerns. Many contributing factors for body weight gain are present among young-aged populations. The purpose of this study was to determine the prevalence of overweight and obesity in young adults after the COVID-19 pandemic and the risk factors linked with it. This research was carried out from September 2023 to January 2024, focusing on young adults in Dhaka city. A standard questionnaire was designed for collecting data. Body weight and height were measured by an electronic weighing machine and measuring tape, respectively, to calculate the BMI of the participants. The association between factors and obesity and overweight was evaluated using the chi square test and the Fisher test of exactness. Three hundred seventeen (317) young adults were enrolled in the study. 13.9% (n = 44) and 3.2% (n = 10) of the study population were found to be overweight and obese, respectively. A family history of obesity was found to be significantly associated with being obese-overweight (p = 0.002) and identified as a high-risk factor for overweight-obesity (OR = 2.596, CI = 1.481–5.900). Overweight-obesity had a significant association with the concentration problem while working (p = 0.015), and overweight-obesity was found to be a risk factor in this regard (OR = 2.754, CI = 1.182–6.419). Inadequate sleep duration and late-night sleeping habits were found to be risk factors for overweight and obesity (OR = 1.665, CI: 0.853–3.253; OR = 1.276, CI: 0.703–2.313, respectively). Appropriate measures should be followed to reduce the burden caused by overweight and obesity among young adults.

Key words: Overweight, obesity, associated factors, COVID-19, young adults.

Introduction

In recent decades, overweight and obesity have emerged as alarming public health issues and provide considerable challenges to the overall health care system worldwide (Chu *et al.*, 2018). Overweight and obesity are complicated, multidimensional disorders that lead to long-term suffering. In an initial evaluation, the World Health Organization (WHO) identified obesity as abnormal or excessive fat

accumulation in the body, but later made a clarification on the previous statement that obesity and overweight are the result of an energy imbalance between calories consumed and calories expended (Obesity and Overweight, 2024). To classify obesity in physical health and nutrition-related studies, body mass index (BMI) is a widely used tool; a BMI of ≥ 25 – 30 kg/m^2 would be categorized as overweight, and a BMI of $>30 \text{ kg/m}^2$ as obese (Body Mass Index

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(BMI) Nomogram - Canada, 2003). Because of its increasing prevalence as a chronic illness, obesity is currently recognized as a global health crisis. The prevalence of obesity rose by over 50% compared to previous estimations within the last five decades globally (Ng *et al.*, 2014). It is also predicted that by 2030, 38% of adults worldwide will be overweight and 20% will be obese (Kelly *et al.*, 2008). At the same time, one in five women and one in seven men will be obese. Thus, nearly one billion people are at risk of becoming obese. Additionally, due to the accumulative effect of the COVID-19 pandemic, the overweight and obesity rate increased significantly worldwide (Lange *et al.*, 2021). Once, it was believed that obesity was a problem in high-income countries, but obesity is now also prevalent in low- and middle-income countries (LMICs). In fact, the majority of obese individuals nowadays reside in LMICs, although those are facing problems from the double burden of malnutrition (Ford *et al.*, 2017). Bangladesh, as a developing country with a flourishing economy, is not excluded from this scenario. Bangladesh, with its dense population, is going through a rapid demographic transformation as well as an economic revolution. This nation currently has a population of about 170 million, and by 2050, it will have close to 218 million residents (Streatfield and Karar, 2008). Among these large populations, nearly 29.4% and 10.8% are overweight and obese, respectively (Gupta and Al Kibria, 2021). With the population, the obesity rate has increased in both males and females in Bangladesh (Nguyen *et al.*, 2022).

Obesity and related disorders have become so dangerous that obesity stands as the fifth most common cause of death worldwide (Safaei *et al.*, 2021). Nowadays, obesity is one of the foremost causes of many chronic illnesses, including diabetes, hypertension, heart attacks, strokes, and other non-communicable diseases (Hall *et al.*, 2015; Strazzullo *et al.*, 2010; Taylor, 2019). Many serious health issues, like insulin resistance and dyslipidemia, are strongly correlated with being overweight or obese, and these conditions are widely acknowledged as comorbidities. This persistent issue is also connected to

a number of degenerative illnesses, such as osteoarthritis and several kinds of cancer (Kinlen *et al.*, 2018). Besides, the positive association between obesity and mental disorders was supported by the study reported in a previous study (Zhao *et al.*, 2019). Different types of multipronged and inter-related reasons are responsible for the development of overweight and obesity. Dietary factors play a crucial role in developing overweight and obesity. People are now consuming food outside their homes frequently. Lower intake of fiber, overconsumption of red meat, skipping breakfast regularly, and a higher number of daily meals are directly associated with overweight and obesity. Another major contributing component triggering weight-gaining pathways is the consumption of fast food (Jebeile *et al.*, 2022; Mahumud *et al.*, 2021). Besides, several health-risk behaviors are also responsible for weight gain. Among them, a sedentary lifestyle or inadequate physical activity, alcohol consumption, and smoking are major contributing factors (Poorolajal *et al.*, 2020). Shorter duration of sleep along with poor sleep quality is also a contributing factor for weight gain (Anam *et al.*, 2022).

Emerging adulthood is usually a time when young adults start going to college or university and become more independent. During this period, they start gaining body weight, as they are usually habituated to various practices related to obesity, like poor eating habits and decreased levels of physical activity (Nelson *et al.*, 2008). Dietary behaviors like skipping meals, eating junk food, and other related factors causing overweight and obesity, like social, physical, and socio-demographic factors, also exist among young adults (Zamsad *et al.*, 2019). Previous study has reported that young adults keep gaining body mass throughout this time period (Finlayson *et al.*, 2012; Peltzer *et al.*, 2014). Another important point is that the COVID-19 pandemic period had an influence on youth by increasing their BMI significantly (Yang *et al.*, 2020). Because young adults' eating habits and level of physical activity have all been significantly impacted by the COVID-19 period (Hossain *et al.*, 2022). A large number of Bangladeshi populations are young adults, but studies

focusing on overweight or obesity among these populations after the COVID-19 pandemic are merely found. The aim of the study is to determine the prevalence of overweight and obesity among Bangladeshi young adults and to evaluate the risk factors working behind this problem.

Materials and Methods

Study design: This descriptive cross-sectional study was conducted to find out the prevalence and associated influencing factors of overweight and obesity among Bangladeshi young adults. The study was carried out between September 2023 and January 2024 in Dhaka, the capital of Bangladesh. Both male and female individuals were enrolled. The following formula was used to calculate the sample size (Naing et al., 2022): $n = Z^2P(1 - P)/d^2$

Where n is the required sample size, Z indicates the Z statistic for a level of confidence (1.96 for a 95% confidence level), P is the prevalence (previously reported), and d indicates precision. By taking the prevalence value among Bangladeshi young populations from a reported work (Zamsad et al., 2019), along with the precision of 4%, the calculated sample number was 304. To make the data more reliable, responses from more than the calculated number of participants were collected. A random sampling technique was used to select the study participants.

Inclusion and exclusion criteria: The survey was conducted on young-aged (19-26) populations during the survey period. Individuals with any diseases or disabilities that make them vulnerable to obesity and overweight, such as using wheelchairs due to physical disabilities, being confined to bed for a long time, and so on, were excluded from the study. Besides, those who were randomly selected but refused to participate were also excluded from the study.

Ethical approval: The research team submitted all the necessary documents, including the consent form format, the questionnaire, and the research protocol, to the ethical review committee of the Faculty of Pharmacy, University of Dhaka. After

assessment, the committee approved the research proposal (Ref. No. Fa. Ph. E/027/23). The research ensures the confidentiality of the personal information of the participants. For this purpose, consent forms stating the purpose and procedure were provided to the participants, and signed forms were collected before confirming their participation. The noninvasive techniques used in this study were conducted with full adherence to ethical guidelines at all times.

Anthropometric measurements: Anthropometric measurements were reported according to the standard criteria and procedures (Li et al., 2016). The body weight was recorded using the calibrated electronic weighing machine, keeping the respondent barefooted with minimal clothing. The body height was recorded using measuring tape, keeping the respondent stranded on a platform, barefooted, with their head upright and looking straight forward. Body mass index (BMI) was calculated by using the formula $BMI = (kg/m^2) = \text{body weight (kg)} / \text{body height (m}^2\text{)}$, and the body mass index (BMI) was used to categorize the weight status of the individuals. According to the National Institutes of Health, adults were classified based on their BMI as normal ($BMI = 18.5-24.9$), overweight ($BMI = 25-29.9$), and obese ($BMI = \geq 30$) (*Body Mass Index (BMI) Nomogram - Canada*, 2003).

Data collection procedure: To conduct this study, a questionnaire was developed as a data collection tool by reviewing previously published articles related to obesity and overweight. A preset set of answers based on pertinent findings were provided with each question in this questionnaire. Prior to the study, a team was formed to gather data, and they were fully briefed on the goals and methodology of the investigation. A printed copy of the survey was distributed, and the team members gathered the information. The individuals were informed of what would be done and were given instructions on how to fill out the questionnaire. The questionnaire includes individuals' socio-demographic information (age, gender, educational level, financial condition, and so on), eating, drinking, smoking habits, exercise, and

other information related to the disease. All of the questions on the questionnaire had to be answered. If any participant refused to answer any of the questions, their participation in the study was terminated without any penalties. Finally, all the collected responses were individually checked by the principal and co-investigators of the study.

Data analysis: The team checked data completeness, and analysis was done using the Statistical Package for the Social Sciences (SPSS) version 25 (IBM Corp., Armonk, NY). Descriptive statistics were presented in frequency tables. Chi-square test and Fisher's exact test were performed between the outcome variable (overweight/obesity) and selected independent variables for measuring association. $P < 0.05$ was considered the significance level. The calculation of the odds ratio was done to identify probable risk factors associated with obesity and overweight.

Results

Distribution of study participants based on the study variables: Among the 317 study participants, 75.7% ($n = 240$) were male and 24.3% ($n = 77$) were female (Table 1). The mean age of the participants was found to be 21.8 years (± 1.87), which actually ranged between 19 and 26. Individuals aged 19-21 accounted for the largest proportion of the population (48.6%, $n = 154$). Nearly three-fourths of the participants (73.5%, $n = 233$) were unemployed (Table 1). Only 9.1% ($n = 29$) of the individuals were involved in exercise every day. 43.5% ($n = 138$) of the individuals had the late-night sleeping habit. 19.6% ($n = 62$) of the individuals consumed vegetables regularly. 29.7% ($n = 94$) of the individuals skipped their breakfast regularly. The majority of the participants were non-smokers (69.4%, $n = 220$). Family history of obesity was present among 15.1% ($n = 48$) of the study populations.

Table 1. Distribution of study participants based on the study variables.

Variable	Category	Frequency	Percentage (%)
Gender	Male	240	75.7
	Female	77	24.3
Age (years)	19-21	154	48.6
	22-23	111	35.0
	24-26	52	16.4
Employment status	Employed	84	26.5
	Unemployed	233	73.5
Involvement in physical exercise	Never	102	32.2
	Sometimes	186	58.7
	Everyday	29	9.1
Skipping breakfast regularly	No	223	70.3
	Yes	94	29.7
Vegetables consumption	Daily	62	19.6
	Once or twice per week	62	19.6
	Three or four times per week	143	45.1
	Rarely	50	15.8
Late-night sleeping habit	Yes	138	43.5
	No	179	56.5
Smoking status	Current smoker	85	26.8
	Ex-smoker	12	3.8
	Non smoker	220	69.4
Family history of obesity	Yes	48	15.1
	No	269	64.9

BMI status of the study participants: From the height-to-weight ratio of the participants, BMI was calculated, and it was identified that 70.3% (n = 223) out of 317 study participants fall under the normal category (Figure 1). 12.6% (n = 40) of the study population was underweight. 13.9% (n = 44) and

3.2% (n = 10) of the study population were identified as overweight and obese, respectively. As the current study focuses on overweight and obesity, further statistical analysis was drawn between the normal (223) and obese-overweight populations (54).

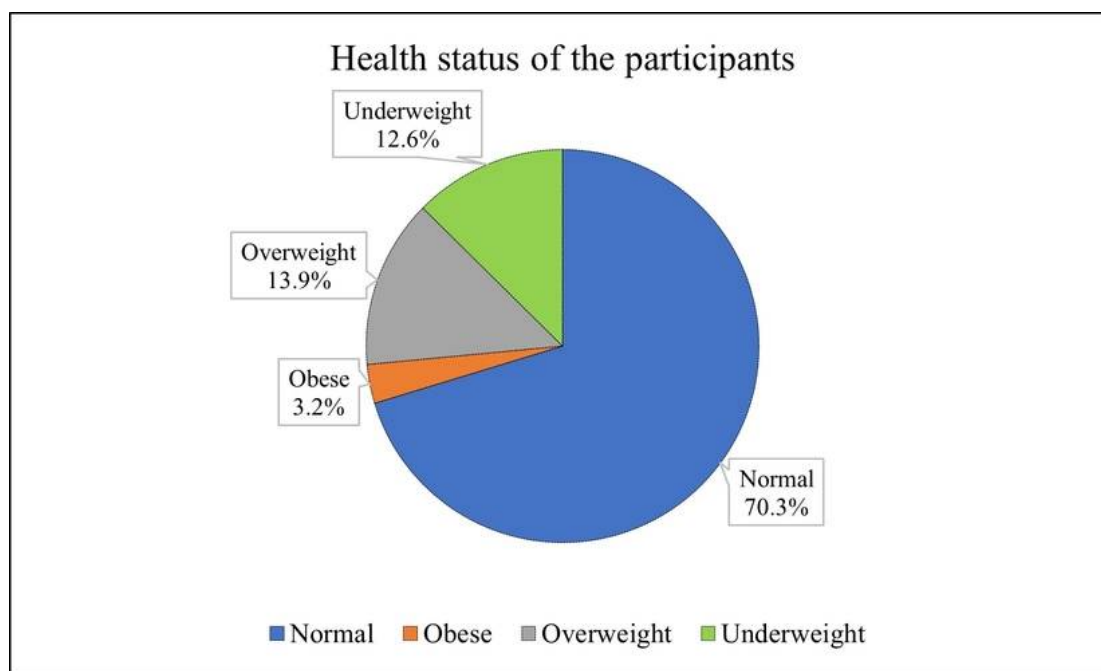


Figure 1. BMI status of the study participants.

Evaluation of the association between overweight-obesity and variables: The association between overweight-obesity and various contributing factors was evaluated in the study (Table 2). 31.5% (n = 17) of the overweight-obese individuals had a prior family history of obesity. The statistical association between these two has been found to be significant according to the Chi square test of association ($\chi^2 = 10.029$, $p = 0.002$). In 68.5% (n = 37) of cases, it was found that obese and overweight participants did not have the habit of skipping breakfast regularly, and 79.6% (n = 43) reported timely having their meals. 46.3% (n = 25) of the study population consumed vegetables three to four times a week. Only 5.6% (n = 3) of the overweight-obese participants in the study reported eating fast food on a regular basis ($\chi^2 =$

1.538, $p = 0.585$). The participants with a normal BMI were less inclined towards late-night sleeping habits (56.1%, n = 125). It was observed that 29.6% (n = 16) of the overweight-obese participants had inadequate sleep duration (< 6 hours), and in the case of participants with a normal BMI, the rate was 20.2% (n = 45). In terms of participation in sports, the results were similar in both the normal and overweight-obese groups. Among the overweight-obese participants, 37.0% (n = 20) had the habit of regular walking. In the case of both overweight-obese and normal participants, the majority reported being non-smokers.

Risk factors associated with overweight and obesity: The relative risks of the contributing factors were also evaluated in terms of the odds ratio values

(Table 3). A family history of obesity was also identified as a high-risk factor for overweight and obesity (OR = 2.956, CI = 1.481–5.900). Inadequate sleep duration (< 6 hours) and late-night sleeping habits were two factors that were found to be risk factors for overweight and obesity (OR = 1.665, CI: 0.853–3.253; OR = 1.276, CI: 0.703–2.313, respectively).

Table 2. Association between overweight-obesity and its factors.

Characteristics	Normal N (%)	Obese-overweight N (%)	P value
Family history of obesity			0.002
Yes	30 (13.5)	17 (31.5)	
No	193 (86.5)	37 (68.5)	
Dietary habits			0.736
Skipping breakfast regularly			
Yes	65 (29.1)	17 (31.5)	
No	158 (70.9)	37 (68.5)	
Having meals on time			0.216
Yes	159 (71.3)	43 (79.6)	
No	64 (28.7)	11 (20.4)	
Vegetables consumption			0.162
Daily	41 (18.4)	15 (27.8)	
Once or twice per week	46 (20.6)	10 (18.5)	
Three or four times per week	96 (43.1)	25 (46.3)	
Rarely	40 (17.9)	4 (7.4)	
Regular consumption of fast food †			0.585
Yes	20 (9.0)	3 (5.6)	
No	203 (91.0)	51 (94.4)	
Consumption of nutritional supplements			0.958
Yes	42 (18.8)	10 (18.5)	
No	181 (81.2)	44 (81.5)	
Sleep pattern			0.133
Inadequate sleep duration (< 6 hours)			
Yes	45 (20.2)	16 (29.6)	
No	178 (79.8)	38 (70.4)	
Late-night sleeping habit			0.422
Yes	98 (43.9)	27 (50.0)	
No	125 (56.1)	27 (50.0)	
Physical activity			0.902
Sports participation			
Yes	167 (74.9)	40 (74.1)	
No	56 (25.1)	14 (25.9)	
Habit of regular walking			0.729
Yes	77 (34.5)	20 (37.0)	
No	146 (65.5)	34 (63.0)	
Cigarette smoking history			0.463
Current smoker	62 (27.8)	11 (20.4)	
Ex-smoker	8 (3.6)	3 (5.5)	
Non smoker	153 (68.6)	40 (74.1)	

†Indicates p value for Fisher's test of exactness.

Distribution of study participants based on the overweight or obesity's impact: It was found that 18.5% (n = 10) of participants felt concentration problems while working due to their increased BMI value (Table 4). The analysis of this result using the Chi square test showed a significant association

between overweight-obesity and concentration problems while doing their activities ($\chi^2 = 5.866$, $p = 0.015$). More than half of the overweight-obese participants (51.9%, n = 28) reported that they were not able to perform physical activity for at least thirty minutes without getting tired.

Table 3. Risk factors associated with overweight-obesity among study participants.

Factors	OR	95% Confidence interval	
		Lower	Upper
Habit of regular walking (no vs yes)	0.897	0.484	1.662
Inadequate sleep duration (< 6 hours) (yes vs no)	1.665	0.853	3.253
Late-night sleep (yes vs no)	1.276	0.703	2.313
Having meals on time (no vs yes)	0.636	0.308	1.310
Family history of obesity or overweight (yes vs no)	2.956	1.481	5.900

Table 4. Distribution of study participants based on the overweight or obesity's impact.

Impacts	Normal (n=223)	Obese-overweight (n=54)	P value
Concentration problems while working			0.015
Yes	17 (7.6)	10 (18.5)	
No	206 (92.4)	40 (81.5)	
Ability to perform physical activity (> 30 minutes) without getting tired			0.893
Yes	116 (52.0)	26 (48.1)	
No	107 (48.0)	28 (51.9)	

Table 5. Impact of obesity-overweight as a risk factor on the participants.

Variable	OR	95% Confidence interval	
		Lower	Upper
Concentration problems while working (obesity-overweight vs normal-underweight)	2.754	1.182	6.419
Ability to perform physical activity (> 30 minutes) without getting tired (obesity-overweight vs normal-underweight)	0.993	0.548	1.801

Impact of obesity-overweight on the study participants: Table 5 represents that overweight or obese participants were 2.754 times more susceptible to concentration problems while doing their work (OR = 2.754, CI = 1.182–6.419).

Discussion

The study aimed at identifying the prevalence of overweight and obesity among Bangladeshi young adults. This study found a higher overweight-obesity prevalence value than the value found in the study

conducted before the COVID-19 period. After the pandemic, there were notable changes in physical activity, dietary habits, and emotional stress levels. Pathophysiologically, all of these factors affected the body's metabolic rate, hormonal activity, and other physiological profiles in such a way that they led to weight gain (Karmakar *et al.*, 2016; Zamsad *et al.*, 2019). Besides, commonly reported factors that could possibly be associated with obesity were evaluated in the study. The association between several lifestyle and dietary factors and overweight-obesity was assessed. In the study, genetic components or family history were significantly associated with the prevalence of overweight and obesity. The association of overweight-obesity with family history has been identified in several previous works, and the current study has also found a similar association (Makkawy *et al.*, 2021; Tayem *et al.*, 2012). A family history of overweight or obesity was also found to be a high-risk factor in terms of the odds ratio. Those who have a family history of obesity were 2.956 times more likely to be obese than those who did not have any family history of being obese. It is suggestive from the finding that individuals who have a family history of obesity have to control their health status by following a proper dietary plan and engaging in physical activities.

Although previously reported work revealed a significant association between fast food consumption and overweight or obesity, we did not find any such association (Goon, 2014). This might result from other dietary plans and lifestyle-related parameters, but the habit of consuming fast food should be controlled for a healthy lifestyle. The physical activity patterns of individuals were analyzed. From the study, it was found that participants who had inadequate sleep duration (< 6 hours) and who had a late-night sleeping habit were 1.665 and 1.276 times more likely to develop obesity or overweight, respectively. This result suggests that young adults should properly maintain the sleeping habits. This result is consistent with the works of Ha and Song, in which this condition was more prevalent among individuals with poor sleeping patterns (Ha & Song, 2019).

The calculated odds ratio cannot conclude that lack of exercise is a risk factor for overweight and obesity, and this result is anomalous to that of previously reported works (Wang, 2019). The results might be due to the contribution of other protective factors like proper dietary habits, sleeping patterns, family history, etc.

A previous study carried out among Bangladeshi individuals in 2015 found cigarette smoking to be associated with BMI, and it also indicated that smoking was more prevalent among overweight and obese individuals. On the contrary, the current work did not find any association between overweight-obesity and smoking habits (Siddiquee *et al.*, 2015). Moreover, considering the other negative effects of cigarette smoking, appropriate measures should be taken to prevent young adults from smoking.

The evaluation of overweight-obesity's impact on the participants revealed that increased body weight was associated with concentration problems while working. The same finding was found when the odds ratio was calculated. It was found that overweight or obese participants were 2.754% more likely to feel some problems due to their body weight while concentrating on their regular activities, which indirectly revealed body weight's effects on their mental health condition. Although a previous study carried out on Bangladeshi adolescents has shown no significant association between overweight-obesity and mental health (Moonajilin *et al.*, 2020). This outcome suggests that the individual's BMI should be controlled within the normal range for their mental wellbeing.

This study did not find any influence of obesity on the ability to perform physical activity for a definite period of time without getting tired. This result does not comply with the findings of the work of Stenholm *et al.*, which was carried out on elderly participants and found an association between physical activity level and BMI status (Stenholm *et al.*, 2007). However, the work of Dufek *et al.* (2012) had similar findings as the current work. Previous reports of the impact of obesity on walking ability among the Bangladeshi population were unavailable.

The study strengthens several hypotheses, notably the effect of family history and sleeping patterns on the BMI status of young adults. Although the influences of some other variables are not established due to the lower number of study participants, the study provides some valuable insight regarding this growing public health problem. However, this study proposes that young adults should follow all the recommendations from respective health-related organizations to keep their health status within the normal BMI range.

Conclusions

More than seventeen young adults out of one hundred were found to be either overweight or obese in the study, indicating an increased prevalence of overweight and obesity after the COVID pandemic period. The underlying causes of overweight and obesity were family history and irregular sleep habits. However, respective authorities should conduct this type of survey work for continuous assessment that may further help in making decisions, promoting a favorable environment for young adults as well as other aged populations, and adopting health guidelines provided by the WHO and related organizations.

Conflict of interest

The authors declare no conflict of interest.

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References

- Anam, M.R., Akter, S., Hossain, F., Bonny, S.Q., Akter, J., Zhang, C., Rahman, M.M. and Mian, M.A.B. 2022. Association of sleep duration and sleep quality with overweight, obesity among adolescents of Bangladesh: a multilevel analysis. *BMC Public Health* **22**, 374.
- Body Mass Index (BMI) Nomogram - Canada. 2003. Report no.: H49-179/2003-1E. Retrieved from <https://www.canada.ca/en/health-anada/services/food-nutrition/healthy-eating/healthy-weights/canadian-guidelines-body-weight-classification-adults/body-mass-index-nomogram.html>
- Chu, D.T., Minh Nguyet, N.T., Dinh, T.C., Thai Lien, N.V., Nguyen, K.-H., Nhu Ngoc, V.T., Tao, Y., Son, L.H., Le, D.-H., Nga, V.B., Jurgoński, A., Tran, Q.-H., Van Tu, P. and Pham, V. H. 2018. An update on physical health and economic consequences of overweight and obesity. *Diabetes Metab. Syndr.: Clin. Res. Rev.* **12**, 1095-1100.
- Dufek, J.S., Currie, R.L., Gouws, P.L., Candela, L., Gutierrez, A.P., Mercer, J.A. and Putney, L.G. 2012. Effects of overweight and obesity on walking characteristics in adolescents. *Hum. Mov. Sci.* **31**, 897-906.
- Finlayson, G., Cecil, J., Higgs, S., Hill, A. and Hetherington, M. 2012. Susceptibility to weight gain. Eating behaviour traits and physical activity as predictors of weight gain during the first year of university. *Appetite* **58**, 1091-1098.
- Ford, N. D., Patel, S. A. and Narayan, K. M. V. 2017. Obesity in low- and middle-income countries: Burden, drivers, and emerging challenges. *Annu. Rev. Public Health* **38**, 145-164.
- Goon, S. 2014. Fast food consumption and obesity risk among University students of Bangladesh. *European J. prev. med.* **2**, 99-104.
- Gupta, R.D. and Al Kibria, G.M. 2021. Prevalence and associated factors of underweight, overweight, and obesity among Bangladeshi adults: An analysis of demographic and health survey 2017-18. *Obes. Med.* **23**, 100342.
- Ha, K. and Song, Y. 2019. Associations of meal timing and frequency with obesity and metabolic syndrome among Korean adults. *Nutrients* **11**, 2437.
- Hall, J. E., Do Carmo, J. M., Da Silva, A. A., Wang, Z. and Hall, M.E. 2015. Obesity-induced hypertension: Interaction of neurohumoral and renal mechanisms. *Circ. Res.* **116**, 991-1006.

- Hossain, M.J., Ahmmed, F., Khan, M.R., Rashid, P.T., Hossain, S., Rafi, M.O., Islam, M.R., Mitra, S., Emran, T. Bin, Islam, F., Alam, M., Sarker, Md. M.R. and Naina M.I. 2022. Impact of prolonged COVID-19 lockdown on body mass index, eating habits, and physical activity of university students in Bangladesh: A web-based cross-sectional study. *Front. Nutr.* **9**, 873105.
- Jebeile, H., Kelly, A.S., O'Malley, G. and Baur, L.A. 2022. Obesity in children and adolescents: epidemiology, causes, assessment, and management. *Lancet Diabetes Endocrinol.* **10**, 351-365.
- Karmakar, P., Jahan, N., Banik, S., Das, A. and Rahman, K. A. 2016. Food habits, obesity and nutritional knowledge among the university students in Noakhali region of Bangladesh: a cross-sectional study. *J. Food Nutr. Disord.* **5**, 2.
- Kelly, T., Yang, W., Chen, C.S., Reynolds, K. and He, J. 2008. Global burden of obesity in 2005 and projections to 2030. *Int. J. Obes.* **32**, 1431-1437.
- Kinlen, D., Cody, D. and O'Shea, D. 2018. Complications of obesity. *QJM: Int. J. Med.* **111**, 437-443.
- Lange, S. J., Kompaniyets, L., Freedman, D. S., Kraus, E. M., Porter, R., Blanck, H. M. and Goodman, A. B. 2021. Longitudinal trends in body mass index before and during the COVID-19 pandemic among persons aged 2–19 Years—United States, 2018–2020. *MMWR. Morb. Mortal. Wkly. Rep.* **70**, 1278-1283.
- Li, F., Wilkens, L.R., Novotny, R., Fialkowski, M.K., Paulino, Y.C., Nelson, R., Bersamin, A., Martin, U., Deenik, J. and Boushey, C. J. 2016. Anthropometric measurement standardization in the US-affiliated pacific: Report from the children's healthy living program. *Am. J. Hum. Biol.* **28**, 364-371.
- Mahumud, R.A., Sahle, B.W., Owusu-Addo, E., Chen, W., Morton, R.L. and Renzaho, A. M.N. 2021. Association of dietary intake, physical activity, and sedentary behaviours with overweight and obesity among 282,213 adolescents in 89 low and middle income to high-income countries. *Int. J. Obes.* **45**, 2404-2418.
- Makkawy, E., Alrakha, A., Al-Mubarak, A., Alotaibi, H., Alotaibi, N., Alasmari, A. and Altamimi, T. 2021. Prevalence of overweight and obesity and their associated factors among health sciences college students, Saudi Arabia. *J. Fam. Med. Prim. Care* **10**, 961-967.
- Moonajilin, M.S., Rahman, M.E. and Islam, M. S. 2020. Relationship between overweight/obesity and mental health disorders among Bangladeshi adolescents: A cross-sectional survey. *Obes. Med.* **18**, 100216.
- Naing, L., Nordin, R.B., Abdul R.H. and Naing, Y.T. 2022. Sample size calculation for prevalence studies using Scalex and ScalaR calculators. *BMC Med. Res. Methodol.* **22**, 209.
- Nelson, M.C., Story, M., Larson, N.I., Neumark-Sztainer, D. and Lytle, L. A. 2008. Emerging adulthood and college-aged youth: An overlooked age for weight-related behavior change. *Obesity* **16**, 2205–2211.
- Ng, M., Fleming, T., Robinson, M., Thomson, B., Graetz, N., Margono, C., Mullany, E.C., Biryukov, S., Abbafati, C., Abera, S.F., Abraham, J.P., Abu-Rmeileh, N. M. E., Achoki, T., Albuhairan, F.S., Alemu, Z.A., Alfonso, R., Ali, M.K., Ali, R., Guzman, N.A. and Gakidou, E. 2014. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: A systematic analysis for the Global Burden of Disease Study 2013. *The Lancet* **384**, 766-781.
- Nguyen, P.H., Tauseef, S., Khuong, L.Q., Das Gupta, R., Billah, S.M., Menon, P. and Scott, S. 2022. Underweight, overweight or obesity, diabetes, and hypertension in Bangladesh, 2004 to 2018. *PloS One* **17**, e0275151.
- Obesity and overweight.* 2024. Retrieved from <https://www.who.int/news-room/factsheets/detail/obesity-and-overweight>
- Peltzer, K., Pengpid, S., Samuels, T., Özcan, N., Mantilla, C., Rahamefy, O., Wong, M. and Gasparishvili, A. 2014. Prevalence of overweight/obesity and its associated factors among university students from 22 Countries. *Int. J. Environ. Res. Public Health* **11**, 7425-7441.
- Poorolajal, J., Sahraei, F., Mohamdadi, Y., Doosti-Irani, A. and Moradi, L. 2020. Behavioral factors influencing childhood obesity: a systematic review and meta-analysis. *Obes. Res. Clin. Pract.* **14**, 109-118.
- Safaei, M., Sundararajan, E. A., Driss, M., Boulila, W. and Shapi'i, A. 2021. A systematic literature review on obesity: Understanding the causes & consequences of obesity and reviewing various machine learning approaches used to predict obesity. *Comput. Biol. Med.* **136**, 104754.
- Siddiquee, T., Bhowmik, B., Da Vale Moreira, N.C., Mujumder, A., Mahtab, H., Khan, A.K.A. and Hussain, A. 2015. Prevalence of obesity in a rural Asian Indian (Bangladeshi) population and its determinants. *BMC Public Health* **15**, 1-9.
- Stenholm, S., Sainio, P., Rantanen, T., Alanen, E. and Koskinen, S. 2007. Effect of co-morbidity on the association of high body mass index with walking limitation among men and women aged 55 years and older. *Aging Clin. Exp. Res.* **19**, 277-283.

- Strazzullo, P., D'Elia, L., Cairella, G., Garbagnati, F., Cappuccio, F.P. and Scalfi, L. 2010. Excess body weight and incidence of Stroke. *Stroke* **41**, e418- e426.
- Streatfield, P.K. and Karar, Z.A. 2008. Population challenges for Bangladesh in the coming decades. *J. Health Popul. Nutr.* **26**, 261-272.
- Tayem, Y.I., Yaseen, N.A., Khader, W.T., Abu Rajab, L.O., Ramahi, A.B. and Saleh, M.H. 2012. Prevalence and risk factors of obesity and hypertension among students at a central university in the West Bank. *Libyan J. Med.* **7**, 19222.
- Taylor, R. 2019. Calorie restriction for long-term remission of type 2 diabetes. *Clin. Med.* **19**, 37- 42.
- Wang, J. 2019. The association between physical fitness and physical activity among Chinese college students. *J. Am. Coll. Health* **67**, 602-609.
- Yang, S., Guo, B., Ao, L., Yang, C., Zhang, L., Zhou, J. and Jia, P. 2020. Obesity and activity patterns before and during COVID-19 lockdown among youths in China. *Clin. Obes.* **10**, e12416.
- Zamsad, M., Banik, S. and Ghosh, L. 2019. Prevalence of overweight, obesity and abdominal obesity in Bangladeshi university students: A cross-sectional study. *Diabetes Metab. Syndr.: Clin. Res. Rev.* **13**, 480-483.
- Zhao, Z., Ding, N., Song, S., Liu, Y. and Wen, D. 2019. Association between depression and overweight in Chinese adolescents: a cross-sectional study. *BMJ Open* **9**, e024177.