Abstract

Introduction: India is facing a dual burden of malnutrition with high prevalence of underweight and increasing prevalence of overweight/obesity. Methodology: This study reports anthropometric findings (body mass index, waist circumference [WC], and waist–hip ratio [WHR]) from the screening of 3296 students admitted during 2018–2019. Results: Majority of the students were male (70%), with a mean age of 18.57 years. About 31% and 19% of students were underweight and overweight, respectively. Given sex-specific cutoffs for WC and WHR, about 5% and 21% of students were at substantially increased risk of metabolic complications. About 14.5% of normal and underweight students were also found to be at substantially increased risk of metabolic complications. Multivariate analysis found increasing age (odds ratio [OR] = 0.92; 95% confidence interval [CI]: 0.88–0.98) and being male (OR = 0.74; 95% CI: 0.62–0.88) to be protective factors against underweight. We did not find any statistically significant correlation for overweight, for WHR among males, and WC and WHR among females. Conclusion: It has been noted that the college environment increases the risk of weight gain. Hence, it makes a case to periodically study changes in anthropometric measures through a longitudinal study, and accordingly develop life cycle-based interventions for prevention/management of undernutrition, obesity, and related complications.

Keywords: Anthropometric measures, body mass index, college students, waist–hip ratio, young adults

Introduction

India is facing a dual burden of malnutrition with high prevalence of underweight (body mass index [BMI] <18.5 kg/m²) and increasing prevalence of overweight/obesity (BMI ≥25.0 kg/m²), as well as variations by sexes and area of residence as indicated by the National Family Health Survey (NFHS)-4 (2015–16) and NFHS-5 (2019–20) factsheets.[1-3] For instance, NFHS-4 data reported a higher prevalence of underweight among rural women (34.3% vs. 18.1%) and higher prevalence of overweight among urban women (34.5% vs. 15.4%) in Gujarat.[1] The total prevalence for underweight (27.2% vs. 22.9%) and overweight (23.7% vs. 20.6%) among women was higher in Gujarat compared to the national average.[1,2] NFHS-5 further suggested increasing burden of abdominal obesity with respect to waist–hip ratio (WHR) cutoffs for women (WHR ≥0.85; 43.7%) and men (WHR ≥0.90; 40.9%) in Gujarat.[3]

A study assessing hypertension prevalence in Maharashtra reported that people with obesity (BMI ≥25.0 kg/m²) have a high prevalence of hypertension (38% vs. 25%) compared to normal/underweight population. Further analysis suggested that the obese persons are at four-time higher risk of hypertension.[4] Another study analyzing NFHS-4 data reported higher average blood glucose levels, and also higher likelihood of being prediabetic and diabetic among the overweight/obese as compared to their counterpart. This study further reported...
that the probability of being diabetic increases with a unit increase in BMI among overweight and obese individuals as compared to normal/underweight individuals (1.5% vs 0.5%). A study, assessing anthropometric measures and blood pressure indices among the young adult female students in a college setup in Tripura, reported higher average systolic, diastolic, and mean blood pressures in overweight/obese compared to nonoverweight students. BMI, WHR, and waist circumference (WC) were positively correlated with blood pressure indices, and could potentially help identify at-risk individuals, including apparently healthy young adults.

BMI and WHR are widely studied in epidemiology, including longitudinal studies, as measures of underweight/overweight/obesity and predictors of cardiovascular, and other health conditions. Understanding the prevalence and patterns of BMI, WC, and WHR could be of public health significance in local context, given the fact that death rate in Gujarat due to coronary heart disease (160/100,000) is the leading cause of death. Hence, proposed research attempts to understand the prevalence of underweight and overweight using anthropometric measures such as BMI, WC, and WHR among college students.

**Methodology**

A university-level screening program is being carried every year as part of the routine health assessment of newly admitted college students. This study reports findings from the screening of students admitted during the academic year 2018–2019, and their screening conducted between August 2018 and April 2019, at the University situated in western India. Permission was taken from the institutional human research ethics committee before commencing the health screening program. Students were debriefed about the study and voluntary written consent was sought. About 3300 students were screened, of whom 3296 were included for statistical analysis after data cleaning.

The study instrument included sociodemographic details of the students such as age, gender, name of college and course, state/country of residence, and religion. A questionnaire also included inquiry about dietary preferences such as being pure vegetarian, average consumption of eggs, nonvegetarian food, or soft drinks per week. Anthropometric measures included height, weight, and waist and hip circumferences of the students. Height was measured using portable stadiometer and weight was measured using portable scale. Measurements were taken near to the 0.1 cm for height and 0.1 kg for weight. WC was measured at the level of the umbilicus or navel and hip circumference was measured around the widest portion of the buttocks using stretch-resistant tapes.

Study data were entered in the Excel sheet and analyzed using IBM SPSS Statistics for Windows (version 26.0, IBM Corp., New York, USA). Students were classified into underweight, overweight, and normal categories according to the WHO classification for BMI, and at increased or substantially increased risk for metabolic complication as per the classification for WC and WHR. Descriptive statistics were used to report sociodemographic variables and prevalence of underweight and overweight/obesity. Univariate analysis was performed to explore the correlates of underweight and overweight among all male and female students. Chi-square test was performed for categorical variables and t-test was performed for continuous variables (age). P < 0.05 was considered statistically significant. Multivariate analysis using multiple logistic regression was performed where appropriate and findings were reported as odds ratio (OR) and 95% confidence interval (CI). We also plotted a matrix of WC and WHR with BMI, separately for males and females, to understand the risk of metabolic complications among underweight, normal weight, and overweight students.

**Results**

The mean age of students was 18.57 (1.83) years, with majority being male (70%) and studying undergraduate courses (76%). About 48% of students reported to be pure vegetarian, whereas 21%, 15%, and 32% reported consuming eggs, nonvegetarian diet, and soft drinks at least three times a week, respectively. Of all the students screened, 31% and 19% were underweight and overweight, respectively. Among overweight, 72% were obese (BMI = 25.00–29.99 kg/m²), while 21%, 6%, and 1% were obese Classes I, II, and III as per the WHO classification, respectively. Given sex-specific cutoffs for WC and WHR, about 5% and 21% of students were at substantially increased risk of metabolic complications. Given WC cutoffs, about 7% of males and 14% of females were at increased risk, whereas 4% of males and 8% of females were at substantially increased risk of metabolic complications.

Univariate analysis to explore the correlates of underweight showed age (18.6 ± 1.7 vs. 18.3 ± 1.6; P < 0.001), sex (P < 0.001), being pure vegetarian (P = 0.01), egg consumption (P = 0.003), and nonvegetarian diet (P = 0.005) as key determinants [Table 1]. Multivariate analysis found increasing age (OR = 0.92; 95% CI: 0.88–0.98) and being male (OR = 0.74; 95% CI: 0.62–0.88) to be protective factors against underweight. Univariate analysis among males found the similar correlates as for all students, whereas among females, age (P < 0.02) was the only statistically significant

**Table 1: Determinants of underweight**

| Variables          | Normal (BMI = 18.50–24.99) | Underweight (BMI < 18.50) | P      |
|--------------------|-----------------------------|---------------------------|--------|
| Gender             |                             |                           |        |
| Male               | 1186 (71.6)                 | 668 (65.2)                | 0.000  |
| Female             | 471 (28.4)                  | 357 (34.8)                |        |
| Dietary practices   |                             |                           |        |
| Pure vegetarian    | 754 (45.5)                  | 519 (50.6)                | 0.010  |
| Egg consumption*   | 373 (22.5)                  | 181 (17.7)                | 0.003  |
| Nonvegetarian meals| 277 (16.7)                  | 130 (12.7)                | 0.005  |

*At least thrice a week. BMI: Body mass index
correlate for underweight. Univariate analysis to explore the correlates of overweight, among all, male and female students, did not find any statistically significant determinant. However, the mean age (18.85 ± 2.36 vs. 18.60 ± 1.73) was higher among overweight students compared to students having normal BMI. Univariate analysis to explore the sex-specific correlates of WC found higher age (18.62 ± 2.47 vs. 18.41 ± 1.53; \( P = 0.03 \)) associated with increased risk of metabolic complication among male students. We did not find any statistically significant correlation for WHR among males, and WC and WHR among females.

The plotting of WC and WHR with BMI revealed that 3.6% and 9% of normal weight male and female students were at increased risk of metabolic complications according to the WC cutoffs. It also categorized 5.4% and 4.6% underweight, and 8.9% and 10.2% normal weight – male and female students, respectively – at substantially increased risk of metabolic complications according to the WHR cutoffs [Table 2]. The analysis revealed a statistically significant relationship between the BMI categories and the risk of metabolic complications based on sex-specific cutoffs for WC and WHR \( (P < 0.001) \).

Table 2: Waist circumference, waist-hip ratio, and body mass index matrix by sexes

| BMI | WC (cm) | WHR (cm) |
|-----|---------|----------|
|     | ≤ 90 | > 90 | < 0.90 | ≥ 0.90 |
| Males (n=2308) | | |
| <18.50 | 286 (7.3) | 7 (0.3) | 543 (23.5) | 125 (5.4) |
| 18.50-24.99 | 1102 (47.7) | 84 (3.6) | 980 (42.5) | 206 (8.9) |
| ≥ 25.00 | 145 (6.3) | 309 (13.4) | 265 (12.0) | 178 (7.7) |
| Females (n=988) | | |
| <18.50 | 350 (35.4) | 7 (0.7) | 311 (31.5) | 46 (4.6) |
| 18.50-24.99 | 382 (38.7) | 89 (9.0) | 570 (37.5) | 101 (10.2) |
| ≥ 25.00 | 41 (4.1) | 119 (12.0) | 108 (10.9) | 52 (5.3) |

BMI: Body mass index, WC: Waist circumference, WHR: Waist-hip ratio

As these students were screened during their admission year, follow-up studies, at annual or biannual interval, on their anthropometric measures and potential correlates could provide meaningful insights in planning and testing evidence-based interventions for college students. It has been noted that college environment increases the risk of weight gain, with one study reporting a mean weight gain of 4.38 kg and increase from 23% to 41% in the proportion of overweight/obese students over the 4-year college period.\(^{14}\) A systematic review has found that about 70% of obese adolescents will still be obese over the age of 30 years and increase in BMI increases the risk of metabolic complications among college students.\(^{15,16}\) An attempt to plot WC and WHR against BMI in our study has also highlighted that normal/underweight individuals could still be at risk of metabolic complications given their WHR cutoffs.

**Discussion**

Our study found a higher prevalence of both underweight and overweight, with about 70% of overweight students being preobese. Measures of central obesity revealed about 5% and 21% of students at substantially increased risk of metabolic complications, given the cutoffs for WC and WHR, respectively. This study found age, sex, being pure vegetarian, egg consumption, and nonvegetarian diet having correlation with underweight. Higher age among male students was associated with increased risk of metabolic complication given the sex-specific cutoff for WC. However, we did not find any statistically significant correlation for overweight, for WHR among males, and WC and WHR among females. The matrix of WC and WHR with BMI highlighted about 14.5% of normal and underweight students being at substantially increased risk of metabolic complications given the sex-specific cutoff for WHR.

**Conflict of interest**

There are no conflicts of interest.

**Conclusions**

This study was aimed at understanding the patterns of anthropometric measures among newly admitted college students, and a natural expansion of this study should be to research changes in anthropometric measures through a longitudinal study, and accordingly develop life cycle-based interventions for the prevention of adult obesity.

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**References**

1. National Family Health Survey – 4 (2015-16). Ministry of Health and Family Welfare, Government of India. Available from: http://www.rchiips.org/nfhs. [Last accessed on 2021 Jul 15].

2. National Family Health Survey – 4 (2015-16). Ministry of Health and Family Welfare, Government of India. India Fact Sheet. Available from: http://www.rchiips.org/nfhs. [Last accessed on 2021 Jul 15].

NFHS-5 has reported WHR, as a measure of central obesity, with almost double the proportion of males (40.9% vs. 22.1%) and females (43.7% vs. 20.1%) aged 15–49 years in Gujarat, compared to our student population, at substantially increased risk of metabolic complications. NFHS-5 factsheet for Gujarat has reported 25.2% and 22.6% of women to be underweight and overweight/obese, which compares with 36.1% and 16.2% of females in our sample.\(^{31}\) Our population also had 75% of students from Gujarat and hence it makes a rationale comparison. In our sample, the mean age was 18.70 ± 1.48, 18.98 ± 1.74, and 19.15 ± 1.77 years for overweight, normal weight, and overweight/obese females, respectively. Younger age could be a plausible explanation for the difference as ~65% of our sample were young adults (18–24 years). The factsheet has also reported 20.9% and 19.9% of men to be overweight and overweight/obese, which compares with 28.9% and 19.7% of males in our sample.\(^{33}\) Younger age was a statistically significant correlate of underweight, among both sexes, in our population.
3. National Family Health Survey – 5 (2019-20). Ministry of Health and Family Welfare, Government of India. State Fact Sheet Gujarat. Available from: http://www.rchiips.org/nfhs. [Last accessed on 2021 Jul 15].

4. Bhise MD, Patra S. Prevalence and correlates of hypertension in Maharashtra, India: A multilevel analysis. PLoS One 2018;13:e0191948.

5. Gupta S, Bansal S. Does a rise in BMI cause an increased risk of diabetes?: Evidence from India. PLoS One 2020;15:e0229716.

6. Debnath S. BMI is a better indicator of cardiac risk factors, as against elevated blood pressure in apparently healthy female adolescents and young adult students: Results from a cross-sectional study in Tripura. Indian J Community Med 2016;41:292-8.

7. Cazzola M, Calzetta L, Lauro D, Bettoncelli G, Cricelli C, Di Daniele N, et al. Asthma and COPD in an Italian adult population: Role of BMI considering the smoking habit. Respir Med 2013;107:1417-22.

8. Li C, Engström G, Hedblad B, Calling S, Berglund G, Janzon L. Sex differences in the relationships between BMI, WHR and incidence of cardiovascular disease: A population-based cohort study. Int J Obes (Lond) 2006;30:1775-81.

9. Sabo RT, Lu Z, Daniels S, Sun SS. Serial childhood BMI and associations with adult hypertension and obesity: The Fels longitudinal study. Obesity (Silver Spring) 2012;20:1741-3.

10. Indian Council of Medical Research; Public Health Foundation of India; Institute for Health Metrics and Evaluation. India: Health of the Nation’s States – The India State-Level Disease Burden Initiative. New Delhi: ICMR, PHFI, and IHME; 2017.

11. World Health Organization. Waist Circumference and Waist-Hip Ratio – Report of a WHO Expert Consultation. Geneva: World Health Organization; 2008.

12. World Health Organization. Body Mass Index – BMI. Available from: http://www.euro.who.int/en/health-topics/disease-prevention/nutrition/a-healthy-lifestyle/body-mass-index-bmi. [Last accessed on 2021 May 05].

13. Patel G, Zalavadiya D, Parmar A. An epidemiological study for assessment of selected lifestyle disorders among University students at Central Gujarat, India. Healthline 2021;12:21-7.

14. Pope L, Hansen D, Harvey J. Examining the weight trajectory of college students. J Nutr Educ Behav 2017;49:137-41.e1.

15. Simmonds M, Llewellyn A, Owen CG, Woolacott N. Predicting adult obesity from childhood obesity: A systematic review and meta-analysis. Obes Rev 2016;17:95-107.

16. Jang I, Kim JS. Risk of cardiovascular disease related to metabolic syndrome in college students: A cross-sectional secondary data analysis. Int J Environ Res Public Health 2019;16:3708.