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BODY COMPOSITION ANALYSIS AND SERUM CHOLESTEROL LEVELS IN HEALTHY MEDICAL STUDENTS: A COMPARATIVE CROSS-SECTIONAL STUDY

Dr. Almahateer Alam*	Resident, Department of Physiology, MLN medical College, Prayagraj *Corresponding Author
Dr. Kavita Chawla	MD, Professor, Department of Physiology, MLN medical College, Prayagraj
Dr. Poonam Gupta	MD, Professor, Department of Physiology, Moti Lal Nehru Medical College, Prayagraj
Dr. Preeti Gupta	MD, Professor, Department of Physiology, Moti Lal Nehru Medical College, Prayagraj
Dr. Rakesh Pathak	PhD, Associate Professor, Department of Physiology, Motilal Nehru medical College, Prayagraj
Dr. Namrata Lahoty	MD, Assistant Professor, Department of Physiology, Motilal Nehru medical College, Prayagraj
Dr. Aman Gupta	MD, Assistant Professor, Department of Physiology, Madhav Prasad Tripathi Medical College and Hospital, Siddharthnagar
Dr. Pravesh Kumar	Resident, Department of Physiology, MLN medical College, Prayagraj

ABSTRACT

Background and Objectives: Obesity and dyslipidemia are significant public health issues among young adults in urbanizing countries. Medical students, despite being health-aware, often face stress, poor diets, lack of sleep, and physical inactivity. This study aimed to compare body composition and serum cholesterol in healthy medical students, explore gender differences, and assess the correlation between body composition indices and lipid profiles in this group. **Methods:** Total 100 healthy medical students (50 males, 50 females) aged 18–25 years at a tertiary care hospital. Body composition was assessed using Bioelectrical Impedance Analysis (BIA). Fasting venous blood samples were collected for serum lipid profile estimation. Lifestyle data were gathered through structured self-administered questionnaires. **Results:** Males were significantly taller (170.94 cm) and heavier (69.38 kg) than females (159.08 cm; 56.64 kg), yet mean BMI did not differ significantly between genders (23.80 vs. 22.51 kg/m², $p > 0.05$). Body fat percentage was significantly higher in females (30.72 ± 5.01%), while males showed greater muscle mass (52.06 ± 7.28 kg). HDL cholesterol was significantly higher in females (49.95 vs. 41.24 mg/dL, $p < 0.05$). Total cholesterol and LDL levels were highest in underweight students and declined with increasing BMI. A significant negative correlation was found between BMI and LDL ($r = -0.274$, $p = 0.006$). Physical inactivity, frequent fast-food consumption, inadequate sleep, and high stress were all significantly associated with overweight/obesity. **Conclusion:** Despite a predominantly normal BMI, notable gender differences exist in body composition and lipid profiles among medical students. BMI alone is insufficient for metabolic risk stratification in young adults. A combined assessment of body composition and lifestyle factors offers more comprehensive insight. Targeted health promotion programmes emphasising physical activity, balanced nutrition, adequate sleep, and stress management are urgently needed within medical education.

KEYWORDS : Body composition; serum cholesterol; BMI; medical students; dyslipidemia; lifestyle factors; bioelectrical impedance analysis

INTRODUCTION

Obesity has emerged as one of the most serious global public health challenges of the twenty-first century. Defined as an excessive accumulation of adipose tissue that imposes adverse effects on health, it has reached epidemic proportions in both developed and developing nations [1]. In recent decades, its prevalence has escalated dramatically, particularly among young adults, driven by profound shifts in dietary habits, lifestyle patterns, and reduced physical activity.

India presents a particularly compelling case, as it now bears the dual burden of malnutrition—encompassing both undernutrition and overweight/obesity [2]. Rapid industrialisation, urban migration, and economic transitions have precipitated sustained changes in food environments and occupational activity. Estimates suggest that between 50% and 70% of Indian adults may be overweight, obese, or have abdominal obesity [3,4]. These changes carry profound implications: the World Health Organization (WHO) attributes approximately 2.6 million deaths per year globally to obesity, with nearly 80% of non-communicable disease (NCD) deaths occurring in low- and middle-income countries [5].

The relationship between excess body weight and cardiovascular risk is well established. Elevated adiposity, particularly visceral fat, is metabolically active and promotes insulin resistance, chronic low-grade inflammation, and atherogenic dyslipidemia [6]. Among biochemical markers, the serum lipid profile-comprising total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), and triglycerides (TG)—provides valuable information about cardiovascular risk. Elevated LDL-C plays a central mechanistic role in atherosclerosis through foam cell formation and endothelial dysfunction [7], while HDL-C exerts a cardioprotective effect by facilitating reverse cholesterol transport [8]. Dyslipidemia, characterised by elevated LDL-C, raised TG, and reduced HDL-C, is frequently observed alongside obesity and substantially increases risk for coronary artery disease [9].

Body Mass Index (BMI), the most widely used surrogate for obesity assessment, is calculated as weight in kilograms divided by height in metres squared. Although BMI is convenient, inexpensive, and applicable at the population level, it does not differentiate between fat mass and lean mass, nor does it convey information on fat distribution [10]. Individuals with identical BMI values may harbour markedly different proportions of body fat and skeletal muscle mass, leading to potential misclassification of metabolic risk. Body composition analysis (BCA) through Bioelectrical Impedance Analysis (BIA) addresses these limitations by providing direct estimates of fat mass, fat-free mass, muscle mass, and related compartments [11].

Medical students represent an important yet inadequately studied group for assessing metabolic risk. Despite their health knowledge, they encounter significant academic pressures, irregular schedules, insufficient sleep, high stress, sedentary habits, and reliance on convenience foods. These factors may hasten metabolic decline in early adulthood, putting them at risk for diseases they aim to prevent. Identifying body composition issues and dyslipidemia early offers opportunities for intervention. Notably, gender differences in body composition and lipid metabolism exist, with females typically having higher body fat and males more lean mass. The influence of the medical student lifestyle on these physiological differences warrants further investigation.[12-14] Despite the expanding literature on obesity and metabolic health, studies specifically examining the interplay between body composition indices, serum lipid profiles, and lifestyle determinants within Indian medical student populations remain limited [15]. The present study was, therefore, designed to fill this gap by comparing body composition and serum cholesterol levels in healthy male and female medical students, and by investigating the relationship between these parameters and prevalent lifestyle behaviours.

METHODS

This prospective comparative cross-sectional study was conducted in the Department of Physiology, M.L.N. Medical College, Prayagraj, Uttar Pradesh, India, over a period of one year. Ethical approval was obtained from the Institutional Ethics Committee (IEC) prior to participant recruitment. All participants provided written informed consent, Total 100 healthy medical students aged 18–25 years were enrolled using random sampling, comprising 50 males and 50 females. The sample size was computed using the formula for comparison between two means: $n = (Z\alpha/2 + Z\beta)^2(\sigma^2 + \sigma^2)/d^2$, where $Z\alpha/2 = 1.96$ (95% confidence level) and $Z\beta = 0.84$ (80% power). Inclusion criteria were: healthy students aged 18–25 years who provided written informed consent. Exclusion criteria comprised: history of chronic illness or any metabolic disorder, use of medications known to affect lipid metabolism, pregnant or lactating females, and significant weight fluctuation (≥55 kg) within the preceding three months.

Height was measured to the nearest 0.1 cm using a calibrated stadiometer with participants standing barefoot in the Frankfurt horizontal plane. Body weight was recorded to the nearest 0.1 kg on a digital weighing scale. BMI was calculated as weight (kg)/height (m^2) and classified according to WHO Asian cut-offs: underweight (<18.5), normal (18.5–22.9), overweight (23–24.9), and obese (≥25.0 kg/m^2). Body composition analysis was performed using a validated Bioelectrical Impedance Analyser (BIA) under standardised conditions-fasting state, voided bladder, no vigorous exercise for 24 hours-yielding body fat percentage, skeletal muscle mass (kg), and bone density estimates.

Biochemical assessment: Fasting venous blood samples (5 mL) were collected after 10–12 hours of overnight fasting under aseptic conditions. Serum was separated by centrifugation at 3000 rpm for 10 minutes. Total cholesterol (TC) was estimated by the cholesterol oxidase peroxidase (CHOD-PAP) enzymatic method. HDL cholesterol was estimated following precipitation of LDL and VLDL with phosphotungstic acid and magnesium chloride. LDL cholesterol was calculated using the Friedewald equation: LDL = TC − HDL − (TG/5). Triglycerides were measured by the glycerol-3-phosphate oxidase method. All assays were performed on a calibrated semi-automated analyser using commercial kits in the Department of Biochemistry, M.L.N. Medical College, Prayagraj. Reference ranges applied were: TC <200 mg/dL, HDL ≥40 mg/dL (male), ≥50 mg/dL (female), LDL <130 mg/dL, and TG <150 mg/dL, as per National Cholesterol Education Programme (NCEP ATP-III) guidelines.

Lifestyle assessment: Lifestyle data were collected through a validated structured questionnaire. Physical inactivity was defined as fewer than 150 minutes of moderate-intensity aerobic activity per week. Frequent fast-food consumption was defined as intake three or more times per week. Inadequate sleep was defined as less than six hours per night. Stress levels were self-reported on a Likert scale (low, moderate, high), with the high-stress category considered for analysis. Questionnaire responses were validated against clinical interview to minimise recall bias.

Data were entered and analysed using SPSS version 26.0 (IBM Corp., Armonk, NY). Continuous variables are expressed as mean ± standard deviation (SD). The independent-samples t-test was used to compare parameters between male and female groups. One-way analysis of variance (ANOVA) with post-hoc Tukey's test was applied to compare parameters across BMI categories. Pearson's correlation coefficient was computed to examine associations among BMI, body composition indices, and lipid parameters. A p-value of <0.05 was considered statistically significant.

RESULTS

Table 1: Age distribution of study participants by gender

Age Group (years)	Males (n=50)	Females (n=50)	Total (n=100)
18–20	18 (36.0%)	20 (40.0%)	38 (38.0%)
21–23	27 (54.0%)	26 (52.0%)	53 (53.0%)
24–25	5 (10.0%)	4 (8.0%)	9 (9.0%)
Mean ± SD	21.44 ± 1.69	21.36 ± 1.72	21.40 ± 1.70
p-value	0.803 (NS)		

The mean age of male participants was 21.44 ± 1.69 years and of female participants was 21.36 ± 1.72 years, with no statistically significant difference between the two groups (p = 0.803). The majority of students across both genders belonged to the 21–23-year age group (53%), followed by 18–20 years (38%). This demographic homogeneity ensures that age-related confounding is unlikely to have influenced the observed differences in body composition and lipid parameters between genders (Table 1).

Table 2: Comparison of anthropometric parameters between male and female medical students

Parameter	Males (n=50) Mean ± SD	Females (n=50) Mean ± SD	t-value	p-value
Height (cm)	170.94 ± 7.34	159.08 ± 7.76	8.22	<0.001*
Weight (kg)	69.38 ± 9.36	56.64 ± 10.11	6.93	<0.001*
BMI (kg/m^2)	23.80 ± 3.14	22.51 ± 3.59	1.99	0.049 (NS)

*Statistically significant (p < 0.05); NS = not significant

Male medical students were significantly taller and heavier than their female counterparts (p < 0.001 for both). While the mean BMI was marginally higher in males (23.80 kg/m^2) compared to females (22.51 kg/m^2), this difference did not reach statistical significance after accounting for the observed height–weight differences. These findings confirm that BMI, despite its widespread use, may not adequately capture gender-based differences in body composition (Table 2).

Table 3: Distribution of BMI categories among male and female medical students

BMI Category	Males n (%)	Females n (%)	Total n (%)
Underweight (<18.5)	4 (8.0%)	5 (10.0%)	9 (9.0%)
Normal (18.5–22.9)	29 (58.0%)	32 (64.0%)	61 (61.0%)
Overweight (23–24.9)	15 (30.0%)	13 (26.0%)	28 (28.0%)
Obese (≥25.0)	2 (4.0%)	0 (0.0%)	2 (2.0%)
Total	50 (100%)	50 (100%)	100 (100%)

The majority of students (61%) had a normal BMI, while 28% were overweight and 9% were underweight. Obese participants accounted for only 2% of the cohort, both of whom were male. There was no statistically significant association between gender and BMI category distribution (p > 0.05). The fact that almost one-third of students were already overweight highlights the early onset of metabolic risk within this young, educated demographic (Table 3).

Table 4: Comparison of body composition parameters between male and female medical students

Parameter	Males (n=50) Mean ± SD	Females (n=50) Mean ± SD	t-value	p-value
Body Fat (%)	21.74 ± 3.32	30.72 ± 5.01	11.21	<0.001*
Skeletal Muscle Mass (kg)	52.06 ± 7.28	40.84 ± 6.08	8.60	<0.001*
Bone Density (g/cm^2)	2.78 ± 0.31	2.41 ± 0.28	6.60	<0.001*

*Statistically significant (p < 0.05)

Marked and statistically significant gender differences were observed in all three body composition parameters. Female students demonstrated substantially higher body fat percentage (30.72 ± 5.01% vs. 21.74 ± 3.32%; p < 0.001), while male students showed significantly greater skeletal muscle mass (52.06 ± 7.28 kg vs. 40.84 ± 6.08 kg; p< 0.001) and bone density (2.78 ± 0.31 vs. 2.41 ± 0.28 g/cm^2; p < 0.001) (Table 4).

Table 5: Comparison of serum lipid profile parameters between male and female medical students

Lipid Parameter (mg/dL)	Males (n=50) Mean ± SD	Females (n=50) Mean ± SD	t-value	p-value
Total Cholesterol	180.42±28.43	180.01 ± 26.02	0.08	0.938(NS)
HDL Cholesterol	41.24 ± 6.52	49.95 ± 7.23	6.71	<0.001*
LDL Cholesterol	113.44±20.11	117.04 ± 20.47	0.93	0.356 (NS)
Triglycerides	135.64±32.17	130.87 ± 33.97	0.76	0.451 (NS)

*Statistically significant ($p < 0.05$); NS = not significant

The only statistically significant gender difference in the lipid profile was observed for HDL cholesterol, which was markedly higher in female students (49.95 ± 7.23 mg/dL) compared to males (41.24 ± 6.52 mg/dL; $p < 0.001$). Total cholesterol, LDL cholesterol, and triglycerides did not differ significantly between genders. The higher HDL in females is in keeping with the known cardioprotective hormonal effects of oestrogen in premenopausal women. The absence of gender differences in TC, LDL, and TG in this young cohort suggests that hormonal and lifestyle-driven divergence in atherogenic lipids may not yet be fully manifest at this age (Table 5).

Table 6: Pearson correlation of BMI and body composition parameters with serum lipid profile

Variable	TC r (p)	HDL r (p)	LDL r (p)	TG r (p)
BMI	−0.159 (0.113)	−0.157 (0.118)	−0.274** (0.006)	0.068 (0.499)
Body Fat %	0.018 (0.862)	0.329** (0.001)	−0.072 (0.474)	−0.033 (0.746)
Skeletal Muscle Mass	0.085 (0.399)	−0.356** (<0.001)	0.014 (0.890)	−0.105 (0.299)

**Statistically significant ($p < 0.01$); TC = Total Cholesterol; TG = Triglycerides

BMI showed a significant negative correlation only with LDL cholesterol (r=-0.274, $p = 0.006$), meaning that as BMI increased, LDL levels declined-a paradoxical finding that merits careful interpretation in the context of a predominantly normal-weight, young sample. Body fat percentage was positively and significantly correlated with HDL cholesterol ($r = 0.329$, $p = 0.001$), while skeletal muscle mass showed a significant negative correlation with HDL ($r = -0.356$, $p < 0.001$). These reciprocal associations between fat mass, muscle mass, and HDL may reflect the gender-confounded nature of these relationships, as females have higher fat mass and HDL simultaneously. No significant correlations were found between any body composition variable and TC, TG, or LDL, apart from the BMI–LDL association (Table 6).

DISCUSSION

The present study systematically examined body composition and serum lipid profiles in 100 healthy medical students, with an equal gender distribution and a mean age of 21.40 years, ensuring comparability between groups.

Our observation that males were significantly taller and heavier than females, yet did not differ significantly in BMI, is in agreement with multiple previous studies conducted in young adult populations [16,17]. The physiologically established sex dimorphism in body composition was clearly demonstrated, with female students carrying approximately 41% more body fat than their male counterparts (30.72% vs. 21.74%), and male students displaying greater skeletal muscle mass (52.06 kg vs. 40.84 kg). This divergence—masked by comparable BMI values—underlines the well-documented limitation of BMI as a sole proxy for adiposity [18]. Messner et al. found that girls had significantly higher fat mass index and BMI-adjusted adiposity than boys, supporting the utility of BIA-derived fat mass over BMI for gender-specific risk assessment [19].

With respect to BMI distribution, the majority of students (61%) fell within the normal range, yet nearly 28% were overweight. This figure is consistent with earlier reports among Indian medical students and reflects the growing burden of excess adiposity in this demographic [20,21]. Overweight and obese students in our study were significantly more likely to report physical inactivity, frequent fast-food consumption, sleep of less than six hours per night, and high psychological stress, all of which have been independently linked to weight gain and metabolic dysfunction [22]. These findings corroborate those of Haider et al., who documented that sedentary behaviour and dietary excess were independently associated with elevated LDL and total cholesterol in medical students [23].

The serum lipid profile analysis yielded several noteworthy observations. Total cholesterol did not differ significantly between genders, which is consistent with the report by Begum et al. and Tejashwini et al., who also found no significant sex-based difference in TC among young medical students [16,24]. However, the gender difference in HDL cholesterol was marked and statistically significant (49.95 mg/dL in females vs. 41.24 mg/dL in males; $p < 0.001$). This finding aligns with the well-established oestrogen-mediated enhancement of HDL synthesis and reduced hepatic lipase activity in premenopausal females [25]. Similar observations were reported by Sahitha et al. and Vikram et al. in comparable Indian populations [26,27].

Perhaps the most intriguing finding of the present study was the paradoxical inverse relationship between BMI and both total cholesterol and LDL cholesterol, with underweight students demonstrating the highest mean values (TC = 205.84 mg/dL; LDL = 129.31 mg/dL) and overweight students showing lower values. This inverse pattern has been previously documented in certain young, healthy cohorts where dietary inadequacy, genetic predisposition, or physiological stress may drive cholesterol elevation independent of adiposity [28]. Mushtaq et al. and Eke et al. reported the expected positive association between BMI and LDL in predominantly obese adult samples; the discordance with our findings likely reflects the relative paucity of frankly obese participants in our cohort and the potential influence of dietary and genetic factors in underweight students [29,30].

The significant positive correlation between body fat percentage and HDL ($r = 0.329$, $p = 0.001$) and the significant negative correlation between skeletal muscle mass and HDL ($r = -0.356$, $p < 0.001$) are most plausibly explained as gender-confounded associations. Female students have both higher body fat percentages and higher HDL levels, while males have greater muscle mass and lower HDL, creating these apparent statistical associations. Choi et al. had similarly concluded that total body fat correlated more strongly with blood lipids than BMI, suggesting that direct body composition measurement provides superior metabolic insights [31]. Maleki et al. further demonstrated that body fat-related indices were more effective indicators of poor metabolic status than BMI alone in a large Tehran cohort, reinforcing the clinical value of BIA-based body composition assessment [32].

Lifestyle factors emerged as powerful determinants of excess body weight in our study. Students classified as overweight or obese were 2–3 times more likely to be physically inactive, consume fast food frequently, sleep insufficiently, and report high stress. This clustering of unhealthy behaviours mirrors findings from Wati et al., who demonstrated that active lifestyle maintenance is protective for BMI, body fat, and cholesterol in young cohorts [33]. The medical education environment, characterised by prolonged hours of study, minimal scheduled physical activity, easy access to canteen food, and high examination-related psychological stress, creates a fertile ground for accelerated metabolic deterioration [34]. Addressing these modifiable risk factors through institutional health promotion policies may be of greater long-term benefit than clinical intervention alone.

The study has several limitations that should be acknowledged. First, the cross-sectional design precludes causal inference, and longitudinal follow-up would be needed to track the evolution of body composition and lipid changes over the medical curriculum. Second, the sample was drawn from a single institution, which may limit generalisability to other Indian medical colleges or geographic regions. Third, lifestyle data were self-reported and may be subject to social desirability and recall bias. Fourth, advanced techniques such as dual-energy X-ray absorptiometry (DEXA) were not available, and BIA estimates may differ under conditions of altered hydration status. Future multicentric studies using DEXA and objective physical activity monitoring would strengthen the evidence base.

CONCLUSION

This study reveals substantial gender differences in body composition and HDL cholesterol levels among healthy medical students, with males showing more muscle mass and lower body fat, while females have higher adiposity and HDL cholesterol. BMI alone fails to adequately reflect these differences or predict lipid abnormalities, highlighting a paradoxical relationship between BMI and LDL cholesterol. Lifestyle factors such as physical inactivity, fast-food consumption, inadequate sleep, and psychological stress are linked to excess body weight and are crucial targets for intervention. The study advocates for integrating physical activity, nutritional counseling, sleep hygiene, and mental health support into medical training to enhance early detection of cardiometabolic risks, thereby improving overall health outcomes for future healthcare professionals and the populations they serve.

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