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Skinfold Thickness Measurements: A Cross-Sectional Study of Nutritional Status in Undergraduate Pharmacy Student

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Abstract: Accurate assessment of body composition is crucial for monitoring health, evaluating nutritional status, and understanding the impact of nutrition-related diseases and interventions. This study investigates the relationship between body mass index (BMI) and skinfold thickness, particularly focusing on limb site measurements (biceps, triceps, quadriceps, calf). While BMI offers a readily accessible screening tool for weight categories associated with health risks, skinfold thickness, measured using calibrated calipers, provides a more direct estimate of body fat. Given the global epidemic of overweight and obesity, as highlighted by the WHO's 2017 report of over four million related deaths, and the persistent problem of malnutrition in regions like India, where it contributes to stunting and growth deficits, effective and reliable body composition assessment methods are essential. This research leverages skinfold thickness measurements as a primary metric to explore the efficacy of limb site assessments in estimating body fat, acknowledging the need for context-specific approaches to address both over- and undernutrition.

Keywords: Nutritional assessment, Skinfold Thickness, Pharmacy Students, Cross-sectional Study, Assessment

Introduction

Accurate assessment of body composition is crucial for evaluating nutritional status, predicting disease progression, and monitoring the efficacy of dietary interventions. This study investigated the relationship between anthropometric measurements, specifically skinfold thickness, body mass index (BMI), height, and weight, in estimating body fat. Skinfold thickness, considered a reliable indicator of subcutaneous fat, served as the primary variable for statistical analysis. The selection of appropriate anthropometric methods depends on the specific objective, such as assessing weight gain or identifying malnutrition [1].

The global prevalence of obesity has reached epidemic proportions, with the World Health Organization (WHO) reporting over 4 million annual deaths attributable to overweight and obesity in 2017, reflecting a significant public health burden [2]. In India, malnutrition remains a critical concern, particularly among adolescent girls, pregnant women, and children, leading to stunting and growth deficits. Contributing factors include inadequate maternal nutrition, insufficient breastfeeding practices, limited access to education, and poor sanitation. While progress has been made, sustained and effective interventions are essential to address undernutrition and promote national development [3].

Methods and Measurements

Body mass index (BMI) provides a readily accessible and cost-effective screening tool for identifying potential weight-related health risks. However, it serves as an indirect estimate of body fat and does not replace more precise techniques such as skinfold thickness measurements or bioelectrical impedance analysis [4].

Skinfold thickness measurements were performed using calibrated calipers applying a consistent pressure of 10 g/mm². Measurements were collected at standardized anatomical sites, including central locations (subscapular, supra-iliac, abdominal) and limb sites (biceps, triceps, quadriceps, calf). To ensure consistency, measurements were taken on a single side of the body. This study focused primarily on limb site measurements [5].

Specifically, skinfold thickness was measured at four key sites: triceps, biceps, subscapular, and supra-iliac. Caliper measurements were recorded in millimeters. For each site, three consecutive measurements were taken, and the mean value was calculated to minimize measurement error. The total skinfold thickness was then calculated by summing the mean values from these four sites [6].

The formula for the calculation of body density is as follows: Age (years) 20-29

Equations for men D = 1.1631 - (0.0632 * L)

Equations for women D = 1.1599 - (0.0717 * L)

Where D = Predicted density of the body (g/ml), L = log of the total of the four skinfolds (mm). After obtaining the body density, using the Siri formula, we get the body fat percentage.

The equation may include: Siri = % body fat = (495/body density) – 450

A pharmacy student's nutritional status is critical to their decision-making abilities and overall performance. Furthermore, the development of expert clinical reasoning, involving evidence evaluation and informed patient care decisions, requires diligent practice to become an automatic skill [7].

Regarding Anthropometric Assessment:

"While upper arm edema is a relatively infrequent occurrence, the triceps skinfold measurement is generally considered the most reliable skinfold assessment for body composition. However, it's crucial to acknowledge that age-related physiological changes, such as decreased muscle mass and skin elasticity, can diminish the accuracy of skinfold measurements in older adults. In this population, it's not uncommon to inadvertently include muscle tissue within the skinfold, leading to potential overestimation of subcutaneous fat. Furthermore, conditions like dehydration, edema, and chronic neuromuscular disorders can significantly compromise the validity of skinfold measurements, yielding inaccurate results."

Regarding the Role of Pharmacy Students and Pharmacists:

"In developed healthcare systems, there's a growing demand for specialized pharmaceutical services tailored to complex patient needs. This includes, but is not limited to, deprescribing, comprehensive home medication reviews, proactive chronic disease management, and expert geriatric pharmacotherapy. Consequently, pharmacy students and practicing pharmacists are increasingly vital in delivering these essential services, ensuring optimal medication management and patient safety." [8].

Diet and Cognitive/Emotional Well-being: "A diet rich in fats and sugars can negatively impact cognitive function and emotional well-being, potentially leading to symptoms such as fatigue, impaired concentration, diminished academic performance, apathy, reduced motivation, low self-esteem, mood fluctuations, and sleep disturbances. To mitigate these effects, a diet emphasizing fiber-rich foods is recommended. This includes fruits, vegetables, legumes (peas, beans), whole grains (whole grain bread, cereals, brown rice), nuts, seeds, and potatoes with the skins intact." [9].

Physical Activity and Stress Reduction: "Engaging in regular physical activity is a recognized strategy for stress reduction among college students, as supported by the Anxiety and Depression Association of America. Prioritizing exercise, such as running or other forms of physical training, should be viewed as an essential component of self-care, rather than a dispensable activity." [10].

Body Composition and Athletic Performance: "In male athletes, low skinfold thicknesses did not significantly influence improved bike split performance. Furthermore, the impact of skinfold thickness on subsequent running performance was minimal, likely due to accumulated fatigue from the cycling component." [11].

Muscle Tissue Assessment: "MyotonPRO®, a non-invasive portable device, enables the measurement of mechanical properties in muscle tissue. Research indicates that the relationship between skinfold thickness and plyometric parameters in the rectus femoris, tibialis anterior, and biceps brachii muscles varies between male and female individuals." [12].

Body Composition and Mortality in Hemodialysis Patients: "In patients undergoing hemodialysis (HD), a correlation has been observed between lower peripheral fat content, reduced muscle mass, and increased all-cause mortality.

Further research is warranted to validate these findings and to inform clinical recommendations regarding weight management strategies for dialysis patients, both pre- and post-kidney transplantation." [13].

According to Edwards et al. (1955) Body composition assessment is crucial for evaluating metabolic disease risks and overall health. While traditional methods like skinfold thickness measurements using Harpenden calipers are readily available, they present challenges. Studies have shown significant observer differences due to inconsistent skinfold site location and technique, highlighting the need for standardized procedures [14]. To improve accuracy in specific populations, gender-specific formulas have been developed for estimating body fat percentage in Asian-Chinese individuals.

Modern techniques like Dual-energy X-ray absorptiometry (DEXA) are gaining preference over cumbersome methods like hydrostatic weighing due to their user-friendly nature and increased accuracy [15]. However, regardless of the method, it is essential that assessment tools are devoid of bias when evaluating group differences. For instance, academic support scales have shown inconsistent predictive power for GPA across different demographic groups and over time, indicating a need for further validation and investigation of their relationship with external variables [16].

The importance of population-specific validation is further emphasized by research on Sri Lankan children aged 5-15. Studies validating skinfold thickness equations for assessing fat mass and percentage fat mass have been conducted, but a lack of comparable data for other South Asian populations hinders comparative analysis. Multi-component assessments are needed to confirm these findings and provide a more comprehensive understanding of body composition in this region [17].

Beyond general population health, nutritional status evaluation is particularly important for healthcare professionals, including pharmacy students. Assessing factors like weight, BMI, and dietary intake allows these students to understand their own nutritional needs and maintain optimal health. This knowledge is crucial for them to serve as effective role models and promote healthy lifestyles within their communities.

Methodology:

This cross-sectional, prospective observational study investigated the nutritional status of pharmacy students (n=70, 40 males, 30 females, aged 18-28) at a Institute of Pharmacy, Dosut,Dhamauli,Nalanda, Bihar, India. Skinfold thickness, measured using standardized calipers, and BMI were used to estimate body fat percentage. Participants completed a lifestyle and dietary questionnaire to provide context for their nutritional status. The study aimed to identify correlations between lifestyle factors and nutritional health, and to determine the nutritional needs of malnourished students. Ethical approval was obtained from the Institute of Pharmacy Ethics Committee (1001/IOP/2024). Participants were recruited from Institute of Pharmacy, Dosut,Dhamauli,Nalanda, and data collection took place over 14 days. Students with medical conditions (eating disorders, peptic/duodenal ulcers, viral infections, neurological, metabolic, or genetic illnesses) were excluded.

Procedure:

"We're going to estimate body's overall fat composition by measuring the thickness of skinfolds at specific points on your body. These measurements, when combined, offer a reliable indicator of total body fat."

Measurement Sites (and Why They Matter):

a) Triceps (Back of Upper Arm): "This area, located on the back of upper arm, halfway between shoulder and elbow, consistently reflects subcutaneous fat storage. It's a readily accessible and reliable point for measurement."
b) Biceps (Front of Upper Arm): "Measuring the front of the upper arm, at the same midpoint, provides a comparative reading to the triceps, offering a more complete picture of upper arm fat distribution."
c) Subscapular (Below the Shoulder Blade): "The area beneath shoulder blade, the subscapular region, is another key site. It's known to store a significant amount of fat, making it a valuable indicator of overall body fat levels."
d) Supra-iliac (Above the Hip Bone): "The diagonal fold above your hip bone, the supra-iliac, is particularly sensitive to changes in body fat. This measurement helps us understand fat distribution around the abdominal area."

Measurement Technique (Step-by-Step):

a) Skinfold Isolation:
   - Using left hand, gently pinch and lift a fold of skin at the designated location. The goal is to isolate the subcutaneous fat layer, separating it from the underlying muscle.
   - For the arm, the fold will be vertical. For the hip and the subscapular area, the fold will be diagonal."

b) Caliper Application:
   - Position the jaws of the skinfold caliper approximately half an inch away from my fingers, while maintaining the skinfold.
   - Upon releasing the caliper's trigger, it will apply a standardized pressure to the skinfold, ensuring consistent measurements.
   - Left hand will continue to hold the skinfold throughout the entire measurement.

Data Collection:
- Take multiple readings at each site to minimize error and ensure accuracy.
- From those readings, select the four most consistent values for each location.

Data Interpretation:
- The collected skinfold measurements will be combined using established formulas and charts. These tools translate skinfold thickness into an estimated body fat percentage.
- By analyzing these measurements, we gain a valuable understanding of your body's fat composition, which can be useful for tracking changes over time and assessing overall health.

Results:

Age and gender distribution:

This study involved 70 participants, with a near-equal gender distribution: 40 males (57.14%) and 30 females (42.85%). The age distribution was as follows: 10 participants (14.29%) aged 19-20 years (2 males, 8 females), 26 participants (37.14%) aged 20-21 years (12 males, 14 females), 26 participants (37.14%) aged 21-22 years (19 males, 7 female), and 7 males (11.43%) aged 22-23 years. Body Mass Index (BMI) was calculated for all 40 male participants, with results categorized as underweight, normal, overweight, pre-obese, and obese type 1. Detailed BMI distribution for both males and females is presented in Table 1.

Table 1: BMI wise distribution of subject

Bmi range	Male	Female	Total	Percentage (%)
Underweight	05	10	15	21.4%
Normal	13	12	25	35.7%
Overweight	05	04	09	12.8%
Pre-obese	07	04	11	15.8%
Obese type 1	10	00	10	14.3%
Total	**40**	**30**	**70**	**100%**

Questionnaire:

Analysis of Breakfast Skipping:

Data indicates a widespread pattern of breakfast skipping within the subject group.
A significant portion of the subjects frequently skip breakfast:

- 19.8% "very often"
- 41.9% "often"
- 16.3% "always"

This adds up to a total of 78% of the subjects skipping breakfast on a regular basis. Only 22% of the subjects "never" skip breakfast.
Analysis of Dietary Habits shows the majority of the subjects (78.6%) are non-vegetarians. whereas A smaller portion (21.4%) are vegetarians.

Analysis of Junk Food Consumption:

A significant portion (52.5%) of the surveyed individuals reported frequent consumption of junk food. A smaller, but notable, percentage (8.2%) indicated very frequent consumption.12.5% reported consistent, habitual consumption of junk food.28.8% reported infrequent consumption.

Sleep Patterns:

Sleep Quality:
The majority (65.8%) of participants reported experiencing regular and satisfactory sleep. A substantial minority (34.2%) reported disrupted or fragmented sleep patterns.

Physical Activity Levels:

Engagement in Physical Activity:
A predominant proportion (72.4%) of the surveyed population indicated infrequent engagement in structured physical activity, such as Farming, gym workouts or exercise routines. A small percentage (8.6%) reported very frequent exercise.15.6% do Farming two or three times a week.3.4% exercise one time a week.

Prevalence of Adverse Habits:

The overwhelming majority (95.7%) reported abstaining from smoking and alcohol consumption. A small minority (4.3%) reported occasional engagement in smoking and alcohol consumption.

Mental Health Status:

Frequency of Depressive Episodes: More than half (52%) of the surveyed population reported experiencing occasional depressive episodes.
A significant amount of people (19.2%) report always feeling depressed due to workload and family financial condition, 26.8% rarely feel depressed. 6 % never feel depressed.

Appetite during the Depressive States:

A significant majority (65.2%) reported a tendency to Lesseat during periods of depression. Whereas 34.8% also reported overeating.

Skin Fold Thickness and Nutritional Status in Pharmacy Students (n=70)

This study examined skin fold thickness and nutritional status in 70 pharmacy students (40 males, 30 females). Skin fold measurements were taken at four sites: biceps, triceps, subscapular, and supra-iliac. Mean and standard deviation were calculated for each site, stratified by age and gender.

- Skin Fold Thickness Differences by Gender:

Males exhibited significantly higher mean skin fold thicknesses than females across all four measured sites (biceps, triceps, subscapular, and supra-iliac).
This difference was statistically significant, with a two-tailed P-value of 0.0002.

Skin Fold Thickness by Age (Females):

- Specific mean skin fold thicknesses for females at ages 20, 21, and 22 were reported.
- Age 20 (mm): Biceps: 6.7, Triceps: 8.8, Subscapular: 11.3, Supra-iliac: 12.46.
- Age 21 (mm): Biceps: 6.8, Triceps: 8.2, Subscapular: 9.5, Supra-iliac: 10.2.
- Age 22 (mm): Biceps: 5.3, Triceps: 6.3, Subscapular: 7.3, Supra-iliac: 9.3.
- Standard deviations were not provided for the age 22 measurements.

Nutritional Status Assessment:

- Nutritional status was categorized based on skin fold thickness measurements.

Results:

- High Nutritional Status: 18.42% of males, 5.40% of females.
- Average Nutritional Status: 26.31% of males, 35.15% of females.
- Good Nutritional Status: 23.68% of males, 37.83% of females.
- Overweight: 21.05% of males, 8.1% of females.
- Underweight: 10.25% of males, 13.51% of females.

Data Presentation:

- Detailed data, including mean and standard deviation for skin fold thickness measurements by age and gender, and the distribution of nutritional status, were presented in Table 2 and 3 with fig 1 and 2 respectively.

Table 2: Measurement of Skin Fold thickness for Male & Female

Age	Bicep		Triceps		Subcapsular		Supra-iliac	
	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd
20	4.2	2.87	5.4	3.45	6.3	5.67	7.9	5.82
21	7.67	2.85	9.2	3.44	12.77	5.78	13.82	5.89
22	6.7	3.02	9.3	3.78	11.9	6.16	11.8	6.11
23	10.72	3.09	12.2	3.98	20.2	6.08	20.7	6.45

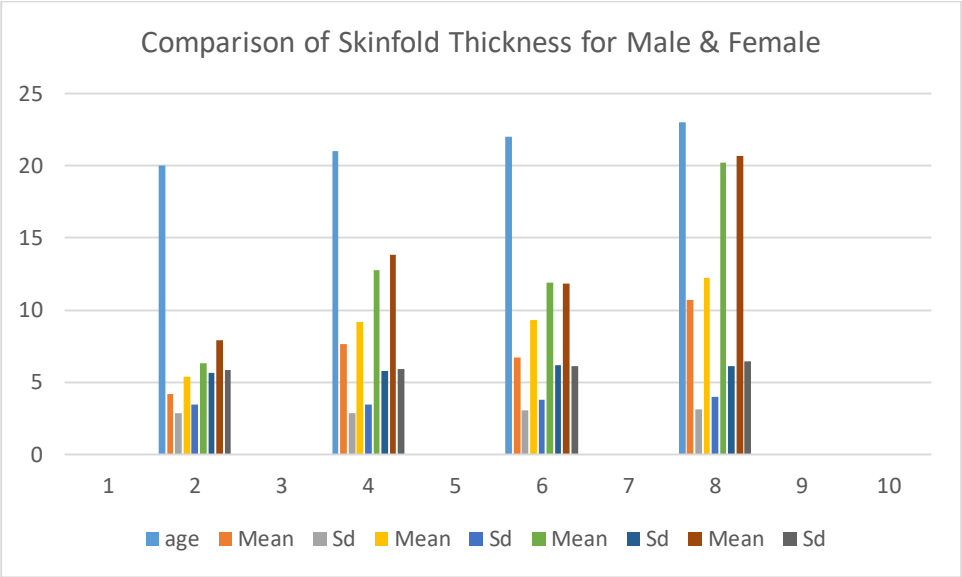

Fig 1: Graph explaining comparison of skinfold thickness for Male and Female

Table 2: Nutrition status of the Young Pharmacy Students

Nutrition status	male	Percentage	Female	Percentage
Excellent	10	25%	04	13.34%
Good	04	10%	10	33.34%
Average	06	15%	08	26.66%
Overweight	16	40%	06	20%
Competition	04	10%	02	6.66%
Total	40	100%	30	100%

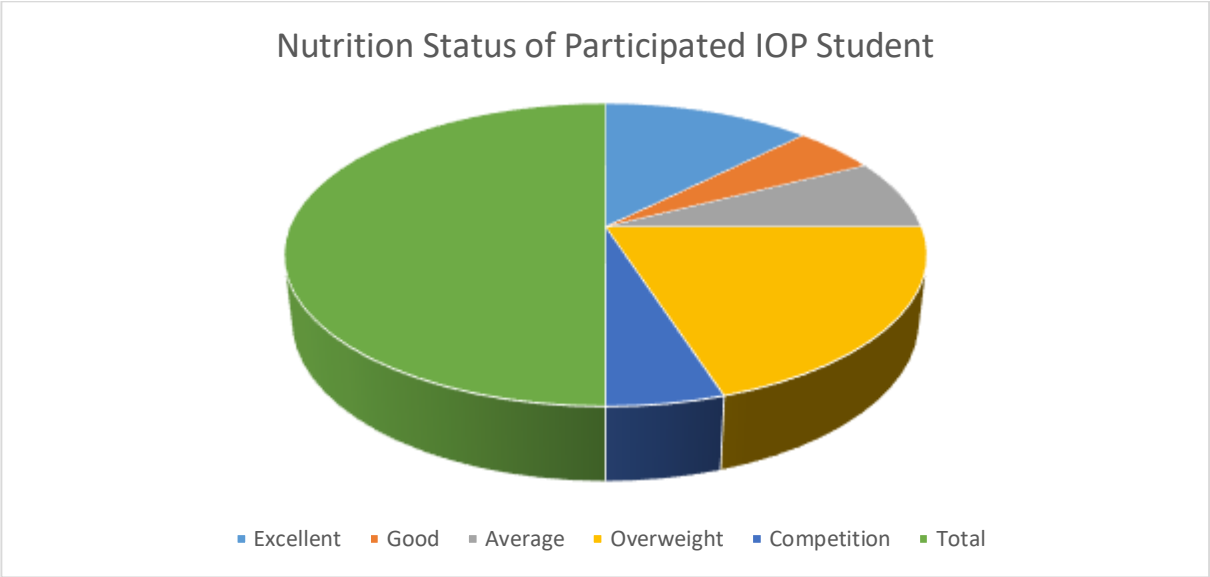

Fig 2: Graph explaining Nutrition Status of Participated IOP Student

Discussion:

The study sample comprised 70 undergraduate students, exhibiting a near-balanced gender distribution (53.33% male, 42.85% female). The majority of participants (37.14%) were aged 20-21 and 22-23 years, aligning with the typical age range for university undergraduate populations, suggesting reasonable demographic representativeness. Body composition was assessed using skinfold thickness measurements and Body Mass Index (BMI). Based on these metrics, 64.3% of the student cohort were classified as exhibiting unhealthy body composition. Specifically, 12.8% were categorized as overweight (BMI exceeding optimal values for height), while 21.4% were classified as underweight (BMI below optimal values for height).

Male students demonstrated a significantly higher mean BMI compared to their female counterparts. This observation is consistent with established physiological differences, where males often exhibit higher BMIs due to increased muscle mass or total body fat. Conversely, female students presented a higher mean body fat percentage, aligning with typical gender-specific variations in adiposity. These findings suggest that while males may exhibit greater overall body mass, potentially reflecting higher muscle or fat accumulation, females demonstrate a higher proportion of adipose tissue. This underscores the importance of considering gender-specific body composition differences in nutritional status and health assessments.

Analysis of skinfold thickness revealed significant regional variations. Specifically, male students exhibited greater supra-iliac skinfold thickness compared to females, consistent with findings reported by Kaur and Singh (2018) [18]. Conversely, female students demonstrated higher subscapular skinfold thickness, indicating greater subcutaneous adiposity, corroborating results from Soylu et al. (2021) [19].
Furthermore, the study found a non-linear relationship between body density and skinfold thickness in both sexes. In individuals with higher adiposity, substantial increases in skinfold thickness were associated with relatively minor changes in body density, a finding consistent with observations by Durnin and Womersley (1972) [20].

Lifestyle factors significantly influenced obesity prevalence within the study population. Notably, a substantial proportion of participants reported unhealthy dietary habits. Specifically, 78% frequently skipped breakfast, a practice known to disrupt metabolic homeostasis and appetite regulation. Additionally, 52.5% reported regular consumption of junk food, with 12.5% reporting frequent consumption. This pattern of dietary behavior is associated with poor nutritional choices and excessive caloric intake.

Moreover, sleep fragmentation was reported by 34.2% of the participants. By disrupting endogenous circadian oscillators, this kind of nocturnal sleep disruption can influence metabolic homeostasis by affecting energy expenditure and appetite regulation. When taken as a whole, skipping breakfast, increased intake of ultra-processed foods, and sleep fragmentation are strongly linked to adiposity. They affect general health and behavioral patterns, which indirectly contribute to weight gain, as well as directly through poor dietary choices and metabolic dysregulation. The interaction of these behaviors demonstrates the complexity of obesity and emphasizes the necessity of comprehensive lifestyle modifications to successfully address these causative factors.

Conclusion:

A concerning subgroup within our study exhibited several unhealthy behaviors. They reported inconsistent or inadequate sleep, frequent consumption of junk food, and minimal exercise. Specifically, the pattern of either severely limited sleep or frequent sleep disruptions exacerbated their pre-existing feelings of depression. We strongly recommend a comprehensive health improvement strategy to address these issues. For those showing signs of general ill-health, dietary changes are crucial, focusing on protein-rich foods, vitamins, and other essential nutrients. For individuals classified as having excess body fat, we advise eliminating junk food, adopting healthier dietary choices, engaging in regular exercise, and establishing a consistent sleep routine. These steps are vital for promoting better health and mitigating the adverse effects of their current lifestyle.

However, this study has limitations. The relatively small sample size may hinder the generalizability of our findings. Future research would benefit from a larger sample to obtain more precise and representative results. Additionally, skinfold thickness measurements only assess subcutaneous fat, potentially overlooking other forms of body fat distribution. Furthermore, measurement errors due to human factors are possible, potentially impacting data accuracy. Future studies that account for these limitations could offer a more comprehensive understanding of the health and body composition of this population.

Our analysis revealed that 26.66% of the pharmacy students in our sample were classified as unhealthy based on skinfold thickness measurements. Within this unhealthy group, 12.8% were categorized as overweight, and 21.4% as underweight. Interestingly, female participants displayed a higher average body fat percentage compared to their male counterparts. Conversely, males exhibited a higher average Body Mass Index (BMI) than females, despite the females' higher body fat percentage. This discrepancy suggests that while women may have a greater proportion of body fat, men possess a higher overall body mass, which significantly influences their BMI.

We advocate for consistent and sufficient sleep, avoidance of junk food, and the adoption of a balanced nutritional diet for individuals identified as unhealthy in this study. These lifestyle modifications are essential for addressing the observed issues and improving the overall health and well-being of the students.

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