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Differences in food intake, body composition, and physical activity between university students with normal - weight obesity and normal - weight lean

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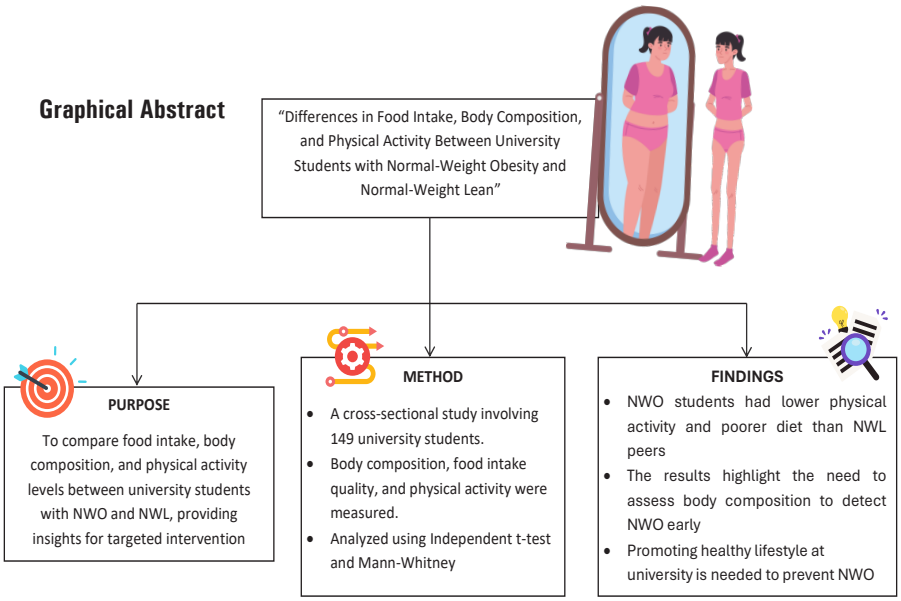
Graphical Abstract



Highlights

- *NWO is a condition marked by normal BMI but high percent body fat.*
- *People with NWO may not realize their condition despite its serious health risk.*
- *NWO students had lower physical activity and poorer diet than NWL peers.*
- *The results highlight the need to assess. body composition to detect NWO early.*

Abstract

Normal-weight obesity (NWO) is a prevalent health issue characterized by a normal Body Mass Index (BMI) alongside a high body fat percentage (BF%). An unhealthy lifestyle, characterized by poor quality of food intake and lack of physical activity, is a contributing factor to NWO. This study aims to investigate the differences in healthy food intake, physical activity, and body composition parameters between students identified as NWO and normal-weight lean (NWL). This was a cross-sectional study involving 149 university students. Body composition measurements were carried out using the InBody 370s. Physical activity data were measured using the General Physical Activity Questionnaire, and food intake quality was collected using the Food Frequency and Recommended Food Score (RFS). Comparative tests were applied to assess differences in measured variables between groups. Among the participants, 31.5% were classified as NWO, 49.7% engaged in moderate physical activity, and only 27.52% adhered to a healthy diet. Furthermore, we found lower physical activity (PA) scores and healthy food intake in NWO students compared to NWL group. Significant differences were also observed in body composition parameters, where BMI, PBF, fat-mass, fat-free mass, and BMR were higher in students with normal weight ($p<0.05$). This study highlights the urgent need for interventions aimed at promoting healthy lifestyles, which can help students achieve and maintain a balanced body composition. By focusing on enhancing physical activity levels and improving dietary intake, it is possible to mitigate the risks associated with NWO and achieve better health outcomes. Thus, the findings suggest that universities should implement targeted wellness programs, such as nutrition education, campus fitness initiatives, and accessible wellness resources, to encourage sustainable lifestyle changes. These measures can help prevent obesity-related health problems and improve students' overall well-being and academic performance.

Keywords: Body Composition. Food Intake. Lifestyle. Normal Weight Obesity. Normal-weight lean. Recommended Food Score.

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INTRODUCTION

Obesity is a chronic metabolic disorder characterized by increased adipose tissue[1,2]. Over the past three decades, numerous countries have experienced a two- to threefold increase in obesity prevalence[3]. Globally, over 2.5 billion adults aged 18 years and older were classified as overweight in 2022, and nearly 890 million were obese[4]. According to the WHO, this number represents an alarming rate, with the United States having the highest prevalence of obesity worldwide[5]. Furthermore, obesity and overweight cause more than three million deaths annually, which is higher than the deaths due to underweight[6]. Formerly considered as an issue primarily affecting high-income countries, overweight and obesity are now common in low and middle-income (LMIC) countries[7,8], resulting in the increase in obesity-related Disability-Adjusted Life Years (DALYs) since 1990[9]. Over the next 40 years, the incidence of non-communicable diseases (NCDs) related to obesity is projected to double or more in low- and middle-income countries (LMICs)[10].

Obesity is commonly assessed using the body mass index (BMI) because of its simplicity, low cost, and speed[1,11]. However, research has indicated that about 25% of people with excess body fat percentage were misclassified based solely on their BMI[12]. This misclassification occurs because BMI does not differentiate between fat and lean tissue[13,14], particularly in individuals with a BMI of 30 kg/m² or lower who may still have high levels of body fat. This has led to the emergence of te term called normal-weight obesity (NWO), which refers to individual with a normal BMI but elevated body fat percentage[15-17]. There is still no clear consensus on the body fat cutoff used to define NWO. However, many studies suggest that the body fat percentages exceeding 20% in men and 30% in women meet the criteria for NWO[18,19].

The worldwide prevalence of NWO in the adult population is quite high, ranging from 4.5% to 22%[20]. Sharing some similarities with obesity, people with normal-weight obesity (NWO) have a higher risk of developing nutrition-related non-communicable diseases (N-NCDs)[15]. Women with NWO tend to have a 2.2-fold higher risk of developing cardiovascular disease and mortality compared to their peers with normal-weight lean (NWL)[19]. This issue is particularly relevant for university students, who often experience lifestyle changes during the transition to adulthood[21]. During this time, students experience various changes such as academic demands, increased independence, and the social influences of the new environment that may contribute to unhealthy habits such as poor dietary choices and decreased physical activity[22–24], making them more vulnerable to NWO without realizing it. Furthermore, a study found that NWO negatively impacts physical function and overall quality of life[25]. However, because they are frequently classified as "normal weight," most people with NWO and healthcare practitioners are probably unaware of these risks[19].

Epidemiological studies have emphasized the critical role of dietary intake in influencing body composition, which, along with physical activity and genetic predispositions, constitute the modifiable factors contributing to normal-weight obesity[26,27]. These studies suggest that poor dietary intake, characterized by high caloric intake and low nutrient density, can lead to an accumulation of body fat even in individuals who appear to be of normal weight. Although the exact cause of NWO is not clear, an unhealthy lifestyle – including prolonged sedentary behavior and lack of physical activity – is also considered a significant cause of excessive body fat accumulation among university students[28]. A previous study in Brazilian young adults revealed that the prevalence of NWO was higher among sedentary people than active ones (10.8% vs. 5.3%)[27].

Gaining a deeper understanding of the risk factors associated with normal weight obesity (NWO) is crucial for developing interventions and policies that encourage healthy lifestyles among young adults[11]. Given the significant impact of unhealthy lifestyles on body composition and its potential risks, it is important to assess lifestyle factors, including dietary intake, body composition, and physical activity in students with NWO and NWL. Our study is among the first in Indonesia to examine NWO in university students, addressing a critical research gap in this population. This is supported by the scarcity of research on NWO in Indonesia. Therefore, this study aims to compare dietary intake, body composition, and physical activity levels between university students with NWO and NWL, providing insights for targeted interventions.

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METHODS

Study Design

This was a quantitative, cross-sectional study in which independent and dependent variables were measured simultaneously.

Participants

The population of this study comprised students from various departments and faculties. Participants were selected using a purposive sampling technique based on the following inclusion criteria: (1) age between 18 and 24 years; (2) registered as active university students; (3) willingness to participate, as demonstrated by signing an informed consent form; and (4) absence of ongoing drug therapy involving steroids, diet medications, or similar substances. Exclusion criteria included participants following specific dietary patterns (e.g., vegan or ketogenic diets) and those engaging in activities that might affect metabolism, appetite, or body composition (e.g., extreme exercise). A total of 149 students met these criteria and were included in the study. This study was conducted in accordance with the guidelines of the Declaration of Helsinki. All procedures involving human subjects/patients were conducted following the research protocol of Universitas Negeri Surabaya.

Data Collection

Data on food intake were collected using a validated food frequency questionnaire (FFQ) specifically designed for adolescents, developed by Slater *et al.*[29]. The FFQ included additional items that are commonly consumed in the local context. It consisted of 50 items, with consumption frequencies categorized as never, less than once a month, 1-3 times a month, once a week, 2-4 times a week, once a day, and twice or more per day. The information gathered was assessed using the Recommended Foods Score (RFS), an index of healthy diet quality. The RFS, developed by Kant[30], is an instrument used to evaluate overall diet quality through the FFQ, focusing on the intake of lean meats, fruits, and vegetables, and low-fat dairy products (see Table 1). In this study, we adapted the RFS to the Indonesian dietary context. Respondents received one point for each item consumed at least once a week, resulting in a maximum possible score of 50 points. A higher RFS score indicates better diet quality.

Table 1 - List of Healthy Food Items Based on Recommended Food Score (RFS), Indonesia 2025.

Group	Food	Total Item
Vegetables	Cabbage, spinach, broccoli, tomatoes, lettuce, carrot, peas or corn, beansprout, cucumber, potatoes, basil, radish, celery, cauliflower, eggplant, kale, watercress, ferns	18
Fruits	Oranges, pears or apples, watermelon, banana, lemon, melon, strawberry, pineapple, mango, guava, papaya, avocado, star fruit, dragon fruit, grapes,	15
Nuts	Soybean, mungbean, almond, peanut	4
Cereals	Oat, rice, barley	3
Dairy products	Skimmed milk, yoghurt, cheese, soymilk	4
Meat/fish	Grilled chicken/beef/fish, roasted chicken/beef/fish	6
Total		**50**

Source: List of food items classified by authors, consisting of ingredients commonly consumed by local Indonesian.

Data on physical activity were collected using the General Physical Activity Questionnaire – Short Form (GPAQ-SF). The GPAQ is a globally recognized tool developed by the World Health Organization to assess physical activity. It has been validated against accelerometer-based studies, showing a moderate to strong correlation with objective physical activity measurements. The GPAQ-SF has also demonstrated good test-retest reliability, ensuring consistent classification of physical activity levels. The selection of this tool ensures accurate, reliable, and reproducible data collection for evaluating body composition and physical activity levels in the study population[31,32].

The physical activity score was calculated using MET-minutes per week, which is derived from the total duration (in minutes) and frequency (in days) of walking, moderate, and vigorous activities, each multiplied by its respective MET value. Final scores were categorized into three levels: mild (< 600 MET-minutes/week), moderate (600-3000 METs-minutes/week), and severe (> 3000 MET-minutes/week).

Body composition measurements included anthropometry (body weight and body mass index), body fat percentage (PBF), fat mass (FM), fat-free mass (FFM), and basal metabolic rate (BMR). Measurements were obtained using InBody 370s (InBody370s; Biospace, Seoul, South Korea). The InBody 370 was chosen for body composition analysis because of its well-established validity and reliability. This bioelectrical impedance analysis (BIA) device has been validated against gold-standard methods such as dual-energy X-ray absorptiometry (DXA)[33], showing strong correlations for PBF, FM, FFM, and BMR measurements. Its reliability is demonstrated by consistent readings across repeated measurements, making it a suitable tool for assessing nutritional status[34]. Nutritional status was determined using BMI-for-age z-scores for respondents aged 13-19 years and BMI (kg/m²) for those aged ≥ 20 years and above (for Indonesian population). The interpretation of BMI measurement results is as follows:

Table 2 - BMI Classification, Indonesia 2024.

z-score BMI-for-age[35]	BMI[36]	Category
< -3SD	< 17.0 kg/m²	Severe underweight
< -2 SD until -3 SD	17.0 – 18.4 kg/m²	Underweight
-2 SD until 1 SD	18.5 – 25.0 kg/m²	Normal
> 1 SD until 2 SD	25.1 – 27.0 kg/m²	Overweight
> 2 SD	> 27.0 kg/m²	Obese

Source: WHO and Ministry of Health of Indonesia.

NWO was defined according to Parfenteva's criteria as a BMI of 18.5–25.0 kg/m² combined with a body fat percentage greater than 25% for males and greater than 30% for females[16].

Data Analysis

Data were analyzed using SPSS 29 and GraphPad Prism for Mac. Data were presented descriptively in a frequency distribution table by displaying the mean and standard deviation. Group differences in RFS score, physical activity, and body composition parameters were assessed using independent t-tests and Mann–Whitney U tests, as appropriate. The significant level was set at a = 0.05.

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RESULTS

The basic characteristics and sociodemographics of the study subjects are presented in Table 3. A total of 149 students participated in this study. Most of the participants were male (97; 65.1%) and aged 19 years (55%). A total of 100 students (67.1%) were in their second semester, and the remaining 34.9% were students in their fourth semester. The majority of them came from rural areas (70.5%) and resided in boarding houses or rented accommodation (59%). Descriptive analysis of baseline BMI showed that 27 students (18.1%) were underweight, 107 students (71.8%) were normal weight, and 15 students (10.1%) were overweight. Of the 149 students, 31.5% had NWO, and almost half of the total respondents had a moderate level of physical activity (49.7%). Regarding dietary intake, the results showed that only a quarter of students (27.52%) had RFS score above the 80th percentile, indicating that most students had low intake of healthy foods.

Table 3 - Baseline Characteristics of Participants (N=149), Indonesia 2024.

Variables	f	%
Gender		
Male	97	65.1%
Female	52	34.9%
Age		
18 years	45	30.2%
19 years	82	55%
20 years	22	14.8%
Body mass index		
Underweight (<18.5 kg/m2)	27	18.1%
Normal (18.5-25.0 kg/m2)	107	71.8%
Overweight (>25.0 kg/m2)	15	14.1%
PBF status		
NWO	47	31.5%
NWL	102	68.5%
Semester		
Second semester	49	32.9%
Fourth semester	100	67.1%
Origins		
Urban area	44	29.5%
Rural area	105	70.5%
Living arrangement		
With parent	40	26.9%
Rented house	88	59%
University dormitory	21	14.1%
Food intake (RFS score)		
> 80th percentile	41	27.52%
< 80th percentile	108	72.48%
Physical activity level		
Low (<600 MET)	59	39.6%
Moderate (600-3000 MET)	74	49.7%
High (>3000 MET)	16	10.7%

Source: Data collection analyzed by authors, 2024.

Body composition variables analyzed in this study included body weight, height, BMI, percent body fat (PBF), fat-mass, fat-free mass (FFM), and basal metabolic rate (BMR). The results of descriptive analysis of these variables showed that the average body weight was 57.57 ± 11.34 kg, the average height was 164.32 ± 8.21 cm, and the body mass index was 21.23 ± 3.27 kg/m^2. The average percentage of body fat, fat mass, fat-free body mass, and BMR were 20.06 ± 8.93%, 11.49 ± 6.22 kg, 46.08 ± 9.16 kg, and 1365.38 ± 197.87, respectively. Meanwhile, the mean score of healthy food intake that was measured using Recommended Food Score was 32.87 ± 2.45 and the mean MET score was 1827.5 ± 119.03 (Table 4).

Table 4 - Descriptive Analysis of Body Composition, Physical Activity, and Healthy Food Intake among Students (n=149), Indonesia 2024.

Variables	Mean	SD
Healthy food intake		
RFS (Recommended Food Score)	32.87	2.45
Body composition		
Body weight (kg)	57.57	11.34
Height (cm)	164.32	8.21
Body mass index (kg/m2)	21.23	3.27
Percent body fat (PBF) (%)	20.06	8.93
Fat-mass (FM) (kg)	11.49	6.22
Fat-free mas (FFM) (kg)	46.08	9.16
Basal metabolism rate (BMR)	1365.38	197.87
Physical activity		
MET score	1827.5	119.03

Source: Data collection analyzed by authors, 2024.

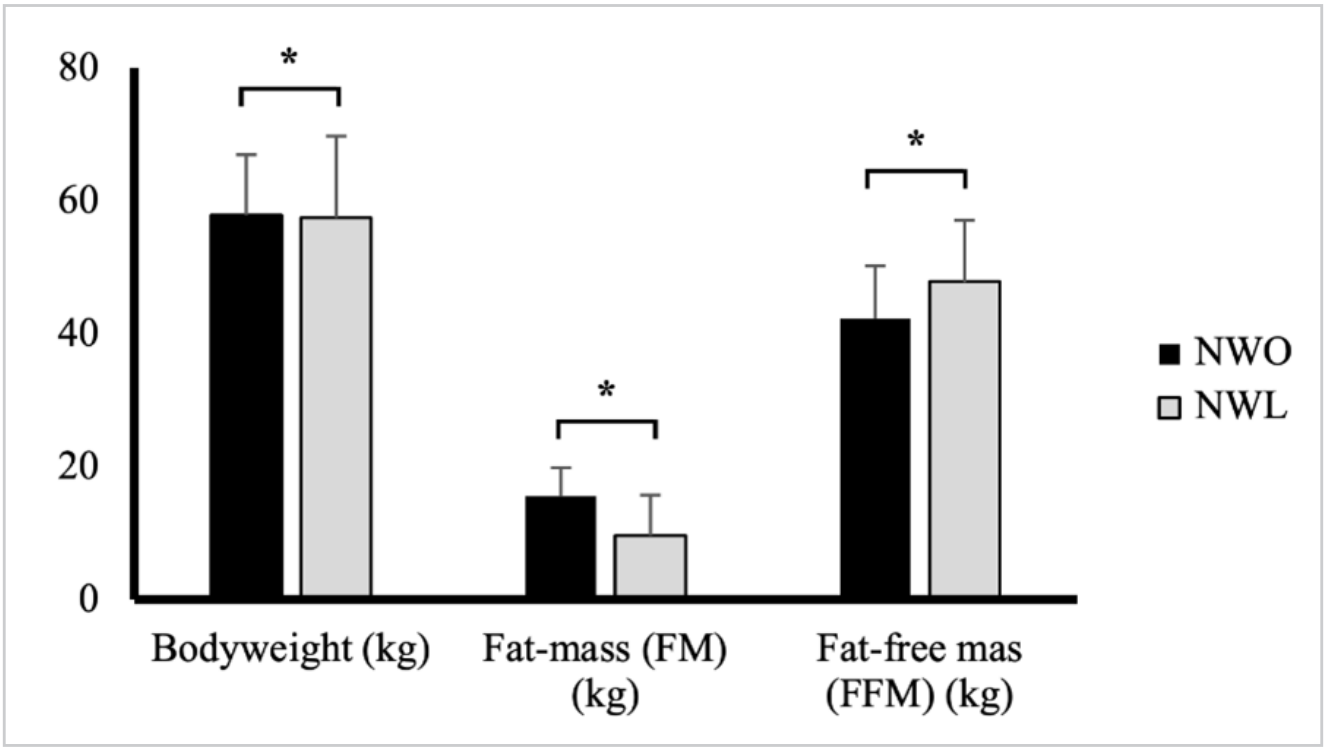

Figure 1 - The comparison of bodyweight, fat-mass, and fat-free mas between NWO and NWL students, Indonesia 2024.

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Table 5 - Comparison of Body Composition, Physical Activity Score, and Quality of Dietary Intake in NWO and Non-NWO Groups, Indonesia 2024.

Variable	Mean ± SD		
	NWO	NWL	p-value
Body composition			
Body weight (kg)	57.84 ± 9.08	57.44 ± 12.28	0.256
Height (cm)	160.53 ± 6.76	166.06 ± 8.26	0.049*
Body mass index (kg/m2)	22.35 ± 2.39	20.72 ± 3.46	0.017*
Percent body fat (PBF) (%)	28.39 ± 5.34	16.23 ± 7.54	0,000*
Fat-mass (FM) (kg)	15.57 ± 4.26	9.60 ± 6.10	0,000*
Fat-free mas (FFM) (kg)	42.27 ± 7.91	47.84 ± 9.19	0.000*
Basal metabolism rate (BMR)	1282.85 ± 170.87	1403.41 ± 198.60	0.002*
Physical activity			
MET score	1061.45 ± 99.20	1680.55 ± 100.85	0.020*
Healthy food intake			
RFS (Recommended Food Score)	31.26 ± 7.51	33.94 ± 8.22	0.045*

Source: Data collection analyzed by authors, 2024.

The analysis of dietary habits also revealed a significant difference in healthy food intake between the NWO and NWL groups, with a p-value of 0.045. These findings underscore the differences in physical characteristics, activity levels, and dietary practices between the NWO and NWL groups, highlighting the importance of addressing these factors in health-promotion efforts among young adults.

DISCUSSION

The present study shows that 31.5% of students had body-fat percentages consistent with normal-weight obesity. These findings align with research from India (24.6% in males and 13.5% in females)[37], Brazil (70.7%)[38], and China (25.5% in males and 40.1% in females)[39], where significant yet variable prevalences of NWO have been reported in young adults, including university students. These variations may be due to differences in assessment methods or other factors contributing to dietary pattern and physical activity levels. The use of InBody370, a bioelectrical impedance analysis device, may produce results that differ slightly from those obtained using DXA or simple anthropometric measurements, which could partially explain the discrepancies in reported prevalence.

The present study found that only 27.52% of students achieved high RFS scores, indicating low intake of healthy foods. Furthermore, students with NWO appeared to have lower RFS scores than their NWL counterparts. The findings align with a previous study that observed university students with NWO had lower intakes of micronutrient- and antioxidant-rich foods[40], a dietary pattern similar to that of overweight or obese people[41]. These findings clarify why individuals with normal-weight obesity (NWO) can maintain a normal weight while exhibiting a high body fat percentage. Supporting this observation, various studies have indicated that traditional and Mediterranean dietary patterns - characterized by high consumption of fresh vegetables, fruits, whole grains, and fish - are linked to a reduced risk of obesity and related health issues[42,43]. Conversely, Western diets – high in calories and rich in sweetened-foods, refined grains, processed or fried items, and alcoholic beverages – are associated with an increased risk of obesity and metabolic syndrome[44]. Previous studies have also shown that consumption of high-calorie foods, especially from fat and sugar sources, contributes to body fat accumulation even when body weight remains within normal limits[45]. For instance, a study by Santos *et al.*[46] found that consumption of high-calorie ultra-processed foods was significantly associated with increased body fat percentage in adolescents, indicating that, despite normal BMI, they remain at risk of obesity-related health problems.

Although the exact risk factors of NWO are not yet fully understood, physical inactivity appears to be a significant contributing factor. The present study found that the average physical activity (PA) score of students with NWO was significantly

lower than those of their normal-weight lean peers. This finding aligns with previous researches that highlight the influence of physical activity on body composition[47–49]. Increased fat mass is often linked to lower levels of physical activity, emphasizing the importance of an active lifestyle in maintaining healthy body composition[50]. The results of this study build on previous research by demonstrating that young adults with a normal BMI but high levels of body fat performed worse on three different measures of physical fitness[11]. Since reduced physical activity is a known predictor of chronic disease[51], these findings have significant clinical implications. Therefore, students identified as having normal-weight obesity (NWO) should not only adhere to standard physical activity guidelines but also focus on progressive endurance exercise to lower body fat and mitigate potential health risks[52]. Moreover, studies have shown that alterations in body composition - particularly increases in fat mass and decreases in muscle mass - can lead to significant health concerns, including obesity and metabolic disorders[53,54]. These changes are particularly relevant, as they may contribute to the development of normal-weight obesity.

Importantly, while this study concentrated on NWO in young adults, it does not imply that the health risks associated with being overweight or obesity can be overlooked. Given the potential impact of physical activity in preventing NWO[55], our findings underscore the necessity of incorporating body composition analysis in future preventive studies and practices, rather than relying solely on BMI measurements. This finding highlights the critical need for regular body composition assessments as part of nutritional status and physical fitness evaluations[40]. Holmes and Racette[56] emphasized the necessity of measuring body composition to accurately assess health outcomes, indicating that individuals with lower body fat percentages generally exhibit better fitness levels. This relationship suggests that maintaining an optimal balance of fat mass and lean mass is essential for overall health and fitness[57]. Thus, this study provides valuable insights into the intricate relationship between body composition and overall health. It highlights the urgent need for interventions aimed at promoting healthy lifestyles, which can help individuals achieve and maintain a balanced body composition. Focusing on enhancing physical activity levels and improving dietary habits, it is possible to mitigate the risks associated with NWO and foster better health outcomes across populations.

Additionally, the findings emphasize the importance of incorporating body composition analysis into health assessments rather than relying solely on BMI, as previously recommended in the literature. This study employed bioelectrical impedance analysis (BIA), a widely used method to estimate body fat percentage. However, it is important to acknowledge that anthropometric techniques - such as skinfold thickness measurements and body circumference assessments - are recognized as valid and reliable indirect methods for evaluating body composition, especially when performed by trained personnel. These techniques can complement the BIA and may yield different results due to variations in the measurement principles. Therefore, combining anthropometry with BIA can provide a more comprehensive understanding of a person's body composition, especially in populations where access to more advanced methods such as DXA is limited. Future research should incorporate both anthropometry and BIA measurements to estimate body fat. Moreover, longitudinal studies can be done to assess the progression of NWO and the impact of physical activity and dietary interventions over time.

CONCLUSION

In conclusion, we found lower score of physical activity and healthy food intake on NWO students compared to NWL group. Significant differences were also observed in body composition parameters: BMI, PBF, fat-mass, fat-free mas, and BMR were higher in students with normal weight. These findings highlight the importance of assessing body composition to identify potential risks of non-communicable diseases (NCDs) and to improve overall health. Despite moderate levels of physical activity, there remains room for improvement, particularly by encouraging more consistent exercise. Similarly, improving diet quality - especially by increasing fruit and vegetable intake - is essential for long-term health.

To address these issues, universities should promote structured physical-activity programs, increase access to recreational facilities, and incorporate nutrition education into student health initiatives. Promoting regular exercise and a balanced diet through awareness campaigns and professional support can help university students adopt healthier lifestyles. Future research should focus on longitudinal studies to

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monitor the progression of NWO and assess the impact of targeted interventions. Additionally, exploring psychosocial factors such as stress and sleep can provide further insight into the behavioral factors influencing physical activity and nutrition among college students.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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