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EVALUATION OF TRENDS IN THE NUTRITIONAL STATUS OF STUDENTS AT THANH THUY SECONDARY SCHOOL, HANOI: A THREE-YEAR CONSECUTIVE CROSS-SECTIONAL STUDY

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Abstract. This study aims to assess the changes in nutritional status among students aged 11 to 14 at Thanh Thuy Secondary School, Hanoi, over three consecutive years (2021 to 2023). The study involved a total of 606 students in 2021, 638 in 2022, and 694 in 2023. Nutritional status was evaluated based on WHO 2007 guidelines using the WHO AnthroPlus software. Results showed a statistically significant decline in median height from 152 cm in 2021 to 150 cm in 2022 and 2023 ($P = 0.036$), indicating a decrease in physical stature. The percentage of students with normal nutritional status decreased from 75.4% in 2021 to 69.2% in 2023. Concurrently, moderate thinness increased from 9.6% to 13.3%, and severe thinness rose from 1.5% to 3.2%. Overweight prevalence remained stable at around 11%, while obesity slightly increased from 2.1% to 2.7%. The overall prevalence of malnutrition significantly increased from 24.6% in 2021 to 33% in 2023 ($P < 0.05$), primarily due to a significant rise in undernutrition, which rose from 11.1% in 2021 to 17.6% in 2023 ($P < 0.05$). For 11-year-olds, overweight prevalence significantly decreased ($P < 0.001$), while moderate thinness significantly increased ($P = 0.037$). Among 12- and 13-year-olds, significant increases in moderate thinness and overweight were observed. These findings underscore the growing issue of the double burden of malnutrition and highlight the need for targeted nutritional interventions among school-aged children.

Keywords: nutritional status, double burden of malnutrition, overnutrition, undernutrition.

1. Introduction

Nutritional status plays a critical role in the physical and cognitive development of adolescents, directly influencing their academic performance, overall health, and future

well-being. Adequate nutrition is a critical determinant of physical development, particularly during puberty. In recent years, there has been growing global attention on the nutritional challenges faced by school-aged children, particularly in rapidly developing regions. Vietnam, undergoing significant socioeconomic changes, has seen shifts in dietary habits and lifestyle, which may affect the health outcomes of its younger population.

Nutritional imbalances, including both underweight and overweight/obesity, have substantially adverse effects on health, growth, psychological well-being, and physiological functions. These disorders not only contribute to various health conditions in children but also impose a significant burden on the healthcare system and society at large [1].

The issue of the double burden of malnutrition, including undernutrition and overnutrition, among school-aged children is a global concern that affects both developed and developing countries. The nutritional challenges faced by adolescents vary by region, driven by factors such as socioeconomic status, food availability, and cultural dietary practices. In many low- and middle-income countries, undernutrition remains a significant challenge. According to UNICEF's report "The State of the World's Children 2021", millions of children worldwide suffer from stunting (low height-for-age) and wasting (low weight-for-height) [2]. On the other hand, developed countries like the United States and some of European face rising levels of childhood obesity. The World Health Organization (WHO) highlighted that over 340 million children and adolescents globally were overweight or obese in 2021 [3]. This trend is largely driven by high consumption of processed foods, sugary beverages, and increasingly sedentary lifestyles. Vietnam, as a rapidly developing nation, experiences both undernutrition and overnutrition among its adolescent population. This double burden of malnutrition is prevalent in both rural and urban settings [4]. Despite significant economic progress, undernutrition remains a concern in rural areas of Vietnam. According to a UNICEF report in 2020, about 24% of Vietnamese children under five were stunted, with a higher prevalence in rural and mountainous regions [5]. Stunting rates are not only higher in younger children, they can be transferred into adolescence, affecting physical and cognitive development. In contrast, urban areas like Hanoi and Ho Chi Minh City are witnessing a rapid increase in childhood obesity. A national cross-sectional study conducted on 2,788 Vietnamese children aged 11 to 14 reported the prevalence of overweight and obesity as 17.4% and 8.6%, respectively, based on WHO Z-score criteria. According to the International Obesity Task Force (IOTF) reference, the prevalence rates were 17.1% for overweight and 5.4% for obesity [6].

This study, conducted at Thanh Thuy Secondary School in Hanoi, aims to evaluate the trends in the nutritional status of students over three years, from 2021 to 2023. Through a comprehensive follow-up analysis, we seek to identify key patterns, potential risk factors, and the impact of changing nutrition on student health. By examining these trends, this research contributes valuable insights into the effectiveness of school nutrition programs and provides evidence for targeted interventions to address emerging nutritional challenges in this age group.

The findings of this study are expected to inform policymakers, educators, and health professionals about the evolving nutritional needs of students, with a focus on promoting healthier dietary practices and improving overall student well-being in secondary schools across the region.

2. Content

2.1. Methodology

2.1.1. Research subjects

A 3-year consecutive cross-sectional study focused on students aged 11 to 14 at Thanh Thuy Secondary School (Thanh Oai, Hanoi). In 2021, the study included 606 students. In 2022, the number of participants increased to 638 students. By 2023, the population expanded further to encompass 694 students. The study specifically excluded individuals with acute medical conditions, such as kyphosis and congenital scoliosis, as well as those with chronic diseases including tuberculosis, HIV/AIDS, and cardiovascular disorders.

Participants' privacy and confidentiality were ensured through informed consent from parents, anonymization of data, secure storage with restricted access and usage of only aggregated data in analyses. Ethical approval was obtained from the Department of Human and Animal Physiology, ensuring all procedures adhere to privacy and confidentiality standards.

The sample size for this cross-sectional study was calculated using the standard formula for estimating a proportion in a population [7]:

$$N = \frac{Z^2 \cdot P(1-P)}{E^2}$$

Z is the Z-value corresponding to the desired confidence level (1.96 for 95% confidence), *P* is the expected prevalence (30% based on prior studies), and *E* is the margin of error (5%). The initial sample size was calculated to be 323. The final sample sizes used in the study (606 in 2021, 638 in 2022, and 694 in 2023) exceeded the minimum requirement, ensuring adequate power to detect statistically significant differences.

2.1.2. Measurement

Height was measured using a stadiometer. The device was positioned securely on a flat, uncarpeted floor against a rigid vertical surface. Participants were instructed to remove shoes, bulky clothing, and hair accessories, and to stand with their backs against the vertical surface, feet flat on the floor, heels together, and touching the base of the stadiometer. The body was aligned in a straight line with the buttocks, shoulders, and head in contact with the vertical surface, and arms hanging down naturally at both sides. The measuring arm was gently lowered until it touched the top of the head, ensuring it was parallel to the floor. Measurements were read at eye level to avoid parallax errors and recorded to the nearest centimeter. This process was repeated twice with each record for accuracy [8].

Weight was measured using an electronic scale. The scale was placed on a flat, stable surface, ensuring it was calibrated correctly. Participants were instructed to

remove shoes, heavy clothing, and any accessories that might affect the measurement. They were then asked to stand upright and centered on the scale with their feet flat and evenly spaced, ensuring their weight was distributed evenly. The participant's posture should be relaxed with arms hanging naturally by their sides. The electronic scale was then activated, and the participant remained still until the measurement stabilized. The weight was recorded to the nearest 100 grams. To ensure accuracy, the measurement process was repeated twice [8].

2.1.3. Diagnostic criteria

The nutritional status of children was evaluated using the WHO 2007 guidelines and WHO AnthroPlus software. Data were entered into Epi Info as part of a nutritional survey, and the software calculated Body Mass Index (BMI), height-for-age Z-score (HAZ), and BMI-for-age Z-score (BAZ). Nutritional status was subsequently classified based on BAZ. Classification criteria were as follows: children with BAZ less than -3 SD were categorized as having severe thinness; those with -3 SD ≤ BAZ < -2 SD as moderate thinness; -2 SD ≤ BAZ ≤ +1 SD as normal; +1 SD < BAZ ≤ +2 SD as overweight; and BAZ > +2 SD as obese.

2.1.4. Statistical analysis

Data analysis was conducted using SPSS software. Proportions were compared using the Chi-square test to assess differences between categorical variables. Quantitative variables that were normally distributed were expressed as means with standard deviations (SD). Comparisons of these quantitative variables were performed using ANOVA analysis. Quantitative variables that were not normally distributed were expressed as medians with interquartile ranges (25^{th} to 75^{th} percentiles). Comparisons of these quantitative variables were performed using the Kruskal-Wallis test. Statistical significance was determined at a threshold of $P < 0.05$ (two-tailed).

2.2. Results and discussion

2.2.1. Characteristics of the study subjects from 2021 to 2023

Table 1 presents the characteristics of the study objects from 2021 to 2023. The proportion of male participants was consistent across the years, ranging from 52.4% to 55.3%, with no significant difference ($P = 0.580$). The mean age of the subjects slightly decreased over time, but the difference was not statistically significant ($P = 0.159$). Slight fluctuations were observed in the percentiles of weight over the three years, with a marginal decrease in the median weight from 2021 to 2022, followed by an increase in 2023 with medians of approximately 43.1 kg, 41.4 kg, and 42.2 kg, respectively. However, these changes were not statistically significant ($P = 0.084$). There was a slight but statistically significant decrease in height over the three years with medians of approximately 152 cm, 150 cm, and 150 cm, respectively, indicating the growth in stature among the students ($P = 0.036$). The BMI percentiles showed minor variations, with a general trend of decreasing lower percentiles and increasing upper percentiles. These changes were not statistically significant ($P = 0.239$). There was a statistically

significant difference in the height-for-age Z-score (P = 0.013), whereas the BMI-for-age Z-score showed no significant changes (P = 0.599).

Similar trends have been observed in other global studies on the nutritional status of adolescents. For example, a study in the United States reported fluctuations in weight and height percentiles among children and adolescents, with a general trend of increasing height over time due to improved nutrition and healthcare standards. However, weight changes were more variable, reflecting dietary habits and physical activity levels [9]. Global studies have reported varying trends in BMI among adolescents. A study by NCD Risk Factor Collaboration (2017) indicated a rising trend in BMI percentiles in many countries, correlating with increased consumption of high-calorie foods and sedentary lifestyles. The non-significant changes in BMI observed in this study might reflect balanced trends in diet and physical activity among the students [10].

Table 1. Characteristics of the study objects from 2021 to 2023

Parameter	2021 (n = 606)	2022 (n = 638)	2023 (n = 694)	P
Male (n, %)	335 (55.3%)	334 (52.4%)	371 (53.5%)	0.580
Age (years)[a]	13.0 ± 1.1	12.9 ± 1.2	12.8 ± 1.2	0.159
Weight (kg)[b]	43.1 (37.2-48.4)	41.4 (35.1-47.9)	42.2 (35.9-49.3)	0.084
Height (cm)[b]	152 (145-157)	150 (144-157)	150 (145-158)	**0.036**
BMI (kg/m^2)[b]	18.4 (16.7-20.4)	18.0 (16.4-20.4)	18.1 (16.3-20.5)	0.239
HAZ	-0.58 (-1.19-0.03	-0.64 (-1.40-0.23)	-0.53 (-1.20-0.15)	**0.013**
BAZ	-0.05 (-0.91-0.72)	-0.20 (-1.07-0.85)	-0.14 (-1.11-0.85)	0.599

BMI: body mass index; HAZ: Height-for-age Z-scores; BAZ: BMI-for-age Z-scores.
[a]Data is expressed as mean±SD. Data are expressed as median (25th - 75th percentiles). P obtained by One-way ANOVA or Kruskal-Wallis test or Chi-square test. Bold values indicate significance over the years.

Studies in Vietnam have reported similar growth patterns among adolescents. For instance, a study by Hoang et al. (2020) found significant increases in height among Vietnamese adolescents aged 11-14, consistent with improvements in nutrition and health interventions [11]. The weight fluctuations observed in this study align with the findings of Tran et al. (2021), who noted variable weight trends among adolescents in urban and rural settings in Vietnam [12]. BMI trends in Vietnamese adolescents have shown mixed results. Some studies, such as that of Nguyen et al. (2019), reported increasing BMI percentiles due to dietary shifts and reduced physical activity [13]. The non-significant changes in BMI in this study might reflect a balance between these opposing factors, potentially influenced by regional dietary habits and school-based health programs.

A comparable study conducted on a total of 124,603 children in China demonstrated that during school closures, the increase in mean height was approximately 1 cm less than in the same period in the preceding two years. However, no significant differences in weight change were observed among the three periods [14]. The slight decrease in the average height of 11-14-year-old students after the COVID-19 period can be attributed to several interconnected factors. Economic hardships led to

food insecurity and poor nutrition. Besides, lockdowns and school closures reduced physical activity and increased screen time, negatively impacting health and sleep patterns. Additionally, limited access to routine healthcare delayed the detection and treatment of growth-related issues and the psychological stress of the pandemic affected hormone levels critical for growth. Disruptions in daily routines, including irregular meal and sleep schedules, further contributed to the observed decline in average height during this period [15].

2.2.2. Changes in correlations among anthropometric measurements from 2021 to 2023

Table 2 illustrates the changes in correlations among anthropometric measurements in 11- to 14-year-old children at Thanh Thuy Secondary School from 2021 to 2023.

Table 2. Changes in the correlation among anthropometric measurements from 2021 to 2023

Year	Measurements	Weight	Height	BMI	HAZ	BAZ	Age
2021	Weight	1	0.69**	0.86**	0.55**	0.71**	0.34**
	Height		1	0.24*	0.68**	0.07	0.62**
	BMI			1	0.27*	0.93**	0.04
	HAZ				1	0.29**	-0.14*
	BAZ					1	-0.23*
	Age						1
2022	Weight	1	0.69**	0.83**	0.54**	0.68**	0.45**
	Height		1	0.18*	0.76**	0.01	0.69**
	BMI			1	0.16*	0.93**	0.09
	HAZ				1	0.15*	0.08
	BAZ					1	-0.15*
	Age						1
2023	Weight	1	0.67**	0.86**	0.47**	0.72**	0.42**
	Height		1	0.21*	0.70**	0.06	0.62**
	BMI			1	0.15*	0.93**	0.13*
	HAZ				1	0.19*	-0.10*
	BAZ					1	-0.12
	Age						1

*** Correlation is significant at the 0.01 level (2-tailed); *. Correlation is significant at the 0.05 level (2-tailed); BMI: body mass index; HAZ: Height-for-age Z-score; BAZ: BMI-for-age Z-score*

In all three years, students' weight exhibited a strong positive correlation to height, BMI, HAZ, and BAZ, with correlation coefficients ranging from 0.67 to 0.86 ($P < 0.01$), and a moderate correlation with age (ranging from 0.34 to 0.45). Height showed a consistently strong positive correlation with HAZ (ranging from 0.68 to 0.76, $P < 0.01$) and a moderate positive correlation with age (ranging from 0.62 to 0.69, $P < 0.01$). BMI consistently had a very strong correlation with BAZ (ranging from 0.93 to 0.93, $P < 0.01$), but its correlation with age was weaker, fluctuating between no correlation and to weak

positive correlation across the years. HAZ was moderately correlated with BAZ, showing significance in all three years, while age showed a weak negative correlation with BAZ. The trends observed from 2021 to 2023 reflect consistent patterns of changes in growth and body composition among adolescents, with key correlations between anthropometric measures similar to findings in other countries.

2.2.3. Changes in nutritional status from 2021 to 2023

Table 3 shows that from 2021 to 2023 the nutritional status of 11-14-year-old students at Thanh Thuy Secondary School exhibited notable trends. The percentage of students with normal nutritional status decreased from 75.4% to 69.2%, while the prevalence of moderate thinness increased from 9.6% to 13.3% and severe thinness rose from 1.5% to 3.2%. Although the percentage of overweight students remained relatively stable, fluctuating around 11%, and obesity slightly increased from 2.1% to 2.7%, the overall trend indicated a decline in normal nutritional status and a concerning rise in undernutrition. This underscores the need for targeted nutritional interventions to address both undernutrition and the emerging overweight and obesity issues among the students.

Table 3. Changes in nutritional status of 11-14-year-old students at Thanh Thuy Secondary School from 2021 to 2023

Nutritional status		**2021 (n = 606)**	**2022 (n = 638)**	**2023 (n = 649)**	***P***
Normal	n	457	461	480	0.078
	%	75.4	72.3	69.2	
Overweight	n	69	67	81	
	%	11.4	10.5	11.7	
Obese	n	13	13	19	
	%	2.1	2.0	2.7	
Moderate thinness	n	58	77	92	
	%	9.6	12.1	13.3	
Severe thinness	n	9	20	22	
	%	1.5	3.1	3.2	

P obtained from the Chi-square test

The changes in the nutritional status of 11 to 14-year-old students at Thanh Thuy Secondary School from 2021 to 2023 reflect broader trends observed in similar age groups in Vietnam and globally. The decline in the percentage of students with normal nutritional status, alongside the increase in obese, moderate, and severe thinness.

Figure 1 illustrates trends in malnutrition, overnutrition, and undernutrition among students from 2021 to 2023. Malnutrition rates significantly increased from 24.6% in 2021 to 33% in 2023 ($P < 0.05$), reflecting a concerning rise in poor nutritional status. Undernutrition prevalence increased significantly from 11.1% in 2021 to 17.6% in 2023 ($P < 0.05$). Overnutrition prevalence, however, showed no statistically significant changes over the three years, suggesting that efforts to control overnutrition have remained stable but may require further intervention.

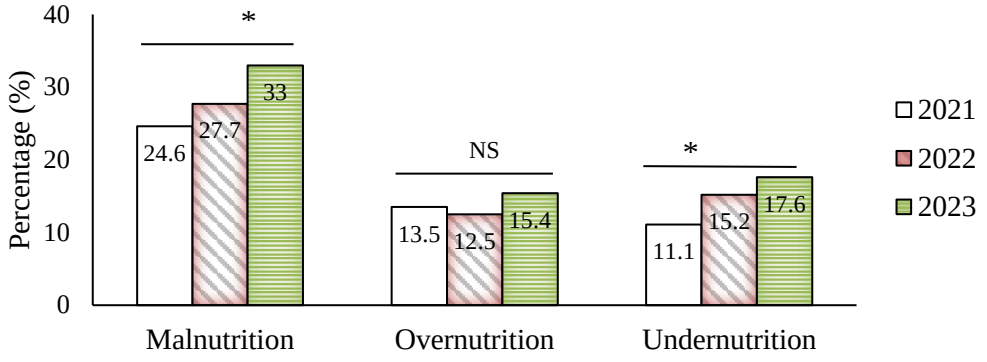

Figure 1. Trends in nutritional status among 11-14-year-old students at Thanh Thuy Secondary School from 2021 to 2023

*P values were obtained from the Chi-square test. *P < 0.05; NS. nonsignificant.*

Table 4. Prevalence of malnutrition by age group and year among 11-14-year-old students at Thanh Thuy Secondary School

Age Group	Year	Overnutrition		Undernutrition	
		Overweight	***Obese***	***Moderate thinness***	***Severe thinness***
11	2021	22.0	1.6	6.3	0.8
	2022	13.2	3.2	14.7	3.2
	2023	13.4	3.6	12.4	3.6
P		**< 0.001**	0.386	**0.037**	0.554
12	2021	14.1	4.1	13.5	1.2
	2022	10.7	1.5	5.3	5.3
	2023	11.2	2.6	12.8	3.1
P		0.480	0.614	**0.046**	0.141
13	2021	6.8	1.4	4.7	1.4
	2022	11.2	1.2	10.0	1.2
	2023	13.5	2.3	17.3	5.3
P		**< 0.001**	0.189	**< 0.001**	0.051
14	2021	4.3	1.2	12.4	2.5
	2022	6.1	2.0	17.0	3.4
	2023	8.8	2.3	11.7	1.2
P		0.177	0.448	0.099	0.617

P values were obtained from the Chi-square test. Bold values indicate significance over the years.

Table 4 presents the prevalence of overnutrition (overweight and obesity) and undernutrition (moderate and severe thinness) among students aged 11 to 14 years from 2021 to 2023. For the 11-year-old group, overweight prevalence significantly decreased ($P < 0.001$), while moderate thinness significantly increased ($P = 0.037$). For 12-year-olds, moderate thinness showed significant variation across years ($P = 0.046$). Among 13-year-olds, both overweight and moderate thinness showed significant increases ($P < 0.001$).

No significant trends were observed for 14-year-olds in either overnutrition or undernutrition. These results highlight fluctuations in nutritional status by age group, with notable increases in both undernutrition and overnutrition in certain groups over time.

The results reveal distinct trends in malnutrition among children aged 11 to 14 years from 2021 to 2023, indicating a shift in the nutritional landscape. These findings highlight the complexity of malnutrition in this population. The co-occurrence of rising overweight rates alongside persistent undernutrition is indicative of the "double burden" of malnutrition seen in many low- and middle-income countries (LMICs). As the global food environment shifts, children are exposed to both undernutrition due to food insecurity and overnutrition due to the increasing availability of cheap, energy-dense but nutrient-poor foods. This pattern has been observed in countries such as India and Mexico, where stunting, thinness, and overweight occurred within the same age groups [16], [17]. The increasing prevalence of overweight and obesity in 13-year-olds, for instance, may also reflect greater consumption of processed foods, sugary drinks, and reduced physical activity, which is the trend documented globally in urbanized and transition regions. On the other hand, the increase in thinness among younger children raises concerns about access to adequate, nutrient-dense food, suggesting that efforts to improve food security and child nutrition may need to be targeted more effectively at specific age groups. In addition, the 2021-2023 period was affected by the Covid-19 pandemic. National studies in various countries, including Vietnam, have reported similar disruptions in growth patterns during the COVID-19 period [18], [19]. Studies in LMICs reported that the disruptions to economic, food, and health systems caused by the COVID-19 pandemic were anticipated to further exacerbate the prevalence of all forms of malnutrition [20].

The data highlight complex, age-specific nutritional challenges, with both overnutrition and undernutrition becoming significant public health concerns. These trends emphasize the urgent need for comprehensive interventions addressing both aspects of malnutrition. Strategies such as school-based nutrition programs, physical activity promotion, and policies for food security and dietary quality improvement are essential. Additionally, creating environments that support healthier food choices is crucial, especially in regions undergoing economic and nutritional transitions. The decline in normal nutritional status and the rise in undernutrition reflect broader challenges in Vietnam and globally, requiring coordinated efforts to mitigate long-term health impacts in children.

The study's strengths include its longitudinal design, which allows for the observation of changes in nutritional status over three years among students at Thanh Thuy Secondary School. The application of WHO 2007 guidelines and WHO AnthroPlus software ensures that the nutritional assessments are standardized and reliable. Additionally, the increase in sample size from 606 to 694 students enhances the study's representativeness and statistical power. However, the study also has notable weaknesses. The use of a cross-sectional approach, despite its longitudinal nature, limits the ability to draw causal inferences about the factors influencing nutritional changes. Additionally, the study lacks detailed information on potential confounding variables, such as changes in dietary habits, physical activity levels, or socioeconomic factors during this stage.

3. Conclusions

Research on the nutritional status of students aged 11 to 14 at Thanh Thuy Secondary School in Hanoi from 2021 to 2023 revealed a notable decline in median height, from approximately 152 cm in 2021 to 150 cm in 2022 and 2023 ($P = 0.036$), indicating a concerning decrease in stature. The percentage of students with normal nutritional status decreased significantly from 75.4% to 69.2%, accompanied by increases in moderate thinness from 9.6% to 13.3% and severe thinness from 1.5% to 3.2%. Although overweight levels remained relatively stable at around 11% and obesity slightly increased from 2.1% to 2.7%, the overall trend underscores a troubling rise in the double burden of malnutrition. Overall malnutrition rates significantly rose from 24.6% in 2021 to 33% in 2022 ($P < 0.05$), driven by a significant increase in undernutrition, which rose from 11.1% in 2021 to 17.6% in 2023 ($P < 0.05$). For 11-year-olds, overweight prevalence significantly decreased ($P < 0.001$), while moderate thinness significantly increased ($P = 0.037$). Among 12- and 13-year-olds, significant elevation in moderate thinness and overweight were observed. These findings emphasize the urgent need for targeted nutritional interventions and support to address the increasing prevalence of undernutrition and to improve overall nutritional status among students. Continuous monitoring and targeted interventions are essential to support the healthy growth and development of adolescents.

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