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ORIGINAL RESEARCH

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Nutritional status and associations of anthropometric indicators with socioeconomic and demographic factors among adult males in three provinces in Vietnam: a cross-sectional study

Ngan TD Hoang[1,2,*], Nghien TT Hoang[3,*], Hoa A Le[1], Tuyen D Le[1,4], Duong T Tran[1,2], Hiep N Le[2], Yen TT Bui[1], Dung V Nguyen[1], Ha HP Truong[5], Hai Phung[2], Ewa A. Szymlek-Gay[6]

[1]National Institute of Nutrition, 100000 Hanoi, Vietnam
[2]School of Medicine and Dentistry, Griffith University, 4215 Gold Coast, QLD, Australia
[3]Department of Clinical Nutrition and Family Medicine, Faculty of Medicine, VNU University of Medicine and Pharmacy, 100000 Hanoi, Vietnam
[4]Vietnam Dietetics Association, 100000 Hanoi, Vietnam
[5]Vietnam Institute of Applied Medicine, 100000 Hanoi, Vietnam
[6]Institute for Physical Activity and Nutrition (IPAN), School of Exercise and Nutrition Sciences, Deakin University, Melbourne Burwood Campus, 3125 Burwood, VIC, Australia

***Correspondence**
hoangthiducngan@dinhduong.org.vn (Ngan TD Hoang);
nghienhtt.ump@vnu.edu.vn (Nghien TT Hoang)

Abstract

Background: Males exhibit higher health-related risk behaviours compared to females but they have not been a prioritized group for nutritional research and interventions in Vietnam. This study aimed to determine the nutritional status of adult males and associations of the anthropometric indicators with demographic and socioeconomic factors. **Methods**: This was a cross-sectional study of 453 Vietnamese males aged ≥18 years. Weight, height, and waist circumference (WC) measurements were collected, and Body Mass Index (BMI) and Waist to Height Ratio (WtHR) calculated. Demographic and socioeconomic data included age, ethnicity, marital status, education level, employment status, monthly household income, monthly personal income, monthly household food expenditure, and the total number of household possessions. **Results**: The prevalence of overweight and obesity was 29.5% and 3.7%, respectively; abdominal adiposity, defined by WC >90 cm, and abdominal obesity, defined by WtHR ≥0.56 were 20.0% and 15.0%, respectively; and overweight/obesity and abdominal obesity was 16.7%. BMI was negatively associated with education level, while WtHR was positively associated with age and negatively associated with monthly household income. **Conclusions**: The findings highlight a high prevalence of overweight and obesity among adult males and the complex relationship between anthropometric measurements and demographic and socioeconomic factors. The results underscore the importance of considering these variables in public health strategies for improving nutritional status in males in Vietnam.

Keywords

Anthropometry; BMI; WtHR; Nutritional status; Males; Obesity; Central adiposity

1. Introduction

Vietnam is undergoing a nutrition transition, characterised by a rising incidence of non-communicable diseases across all regions and population groups. Males exhibit higher-risk behaviours compared to females, such as tobacco smoking (41.1% of males) and alcohol consumption (64.2%), while these figures are around 1% and 10% for females, respectively [1]. The same pattern is observed for behaviours such as skipping meals, impulsive eating, and taste preferences for salty or sweet foods [2]. The STEPwise approach to non-communicable disease (NCD) risk factor surveillance (STEPS) in Vietnam (2020) found a higher proportion of NCD risk factors in males compared to females [3]. For instance, the prevalence of inadequate consumption of vegetables and fruits was 61.5% in males (51.6% in females), hypertension was 33.3% in males (19.1% in females), males consumed 8.7 g/d of salt (6.9 g/d for females), and the prevalence of overweight-obesity among Vietnamese males was 19.3% in 2020 (19.7% in females) [3]. Consequently, males have a higher prevalence of chronic diseases compared to females, such as hypertension and diabetes [4]. The risk of premature death from non-communicable diseases is also higher in males than in females [5]. This disparity underscores the need for further investigations to propose effective solutions for controlling risk behaviours and improving the health status of Vietnamese males.

Currently, BMI is the most common anthropometric indicator used to assess the nutritional status of adults [6]. However, there is controversy about whether BMI can distinguish adiposity in body segments such as the abdomen, thighs, hips, or limbs. Waist-to-height ratio (WtHR) was subsequently proposed as an indicator of abdominal obesity [7]. This has been

identified as a predictor of metabolic-dysfunction-associated fatty liver disease [8], diabetes, hypertension, and dyslipidemia [9–11].

BMI and WtHR have been found to be associated with sex [12], place of residence [13, 14], education level, and age. These factors reflect the lifestyle, socio-economic, and environmental influences on nutritional and health outcomes. For instance, residents in urban and rural areas exhibit different dietary behaviours, such as watching cooking programs on TV in higher socioeconomic families and home-cooked meals in low- and middle-income households [15], which may result in differential nutritional status. Food insecurity is prevalent among families with limited resources, which may increase the risk of malnutrition, either in the form of undernutrition or overnutrition, thereby affecting anthropometric indices.

Public health nutrition policies in Vietnam have focused on maternal health and children, as they are more vulnerable to malnutrition and micronutrient deficiencies than males [16]. Research typically has not differentiated data on males' nutrition status, even in the general national nutrition survey [17]. Therefore, there are limited data on the nutritional status of males in Vietnam, which may pose challenges for policymakers when targeting this sub-group in future nutrition policies.

This study, therefore, aimed to determine the nutritional status of adult males and explore the associations between anthropometric indicators and demographic and socioeconomic factors.

2. Materials and methods

2.1 Study design

A cross-sectional study was conducted from December 2020 to June 2021 on 453 adult males in Ha Giang and Ninh Thuan provinces, and Can Tho City, in Vietnam.

2.2 Sample size

The sample size was calculated for a proportion study, based on a 14.9% prevalence of overweight and obesity among males [18], with a 95% confidence interval, a 5% error margin, and a design effect of 2. Accounting for a 15% refusal rate, the desired sample size was 449 males. Ultimately, 453 males participated in the study.

2.3 Location selection and recruitment

A multistage random sampling strategy was employed. One province/city was randomly selected from the list of provinces in each of Vietnam's three main unique ecological regions (Northern, Central, and Southern). In each selected province/city, three districts were randomly chosen from the list of districts. District Health Centers were invited to participate through written invitations, phone calls, and emails. Communes were selected until the sample size was met, resulting in 18 participating communes. A community-based recruitment approach was used to recruit males. Commune health stations distributed the plain language statement and recruitment flyers to the community through a network of village health collaborators. Village health collaborators then contacted males in villages to explain the study procedure, objectives, and tasks. Those who agreed to take part in the study signed the consent form and returned it to village health collaborators. The population was heterogeneous in terms of both physical build and demographic and socioeconomic factors.

2.4 Participant recruitment

Village health workers distributed study information flyers to all households in the participating communes. Males aged ≥18 years were invited. Exclusions included individuals under 18 years of age; those with anthropometric abnormalities (*e.g.*, kyphosis, chest deformities due to childhood whooping cough, scoliosis); individuals with intellectual impairments that could prevent them from understanding and responding to interviewers; and those with chronic diseases to avoid confounding factors and minimize disease-related measurement errors.

2.5 Anthropometric measures

Participants were weighed, in light clothing without shoes, with calibrated electronic body scales (SECA Robusta 813, SECA GmbH & Co. KG, Hamburg, HH, Germany). Each participant was weighed twice to the nearest 0.1 kg; if the two measurements differed by more than 0.1 kg, a third measurement was taken. Height was measured twice to the nearest 0.1 cm with a SECA stadiometer (SECA 222, SECA GmbH & Co. KG, Hamburg, HH, Germany). Participants were measured without a hat, shoes or socks. If the duplicate measurements differed by more than 0.1 cm, a third measurement was taken. Waist circumference (WC) was measured twice horizontally to the nearest 0.1 cm with a non-stretchable tape (Lufkin W606PM, Apex Tool Group, MD, USA) at a point halfway between the lowest rib and the top of a participant's hipbone [19]. Measurements were taken twice, with a third measurement taken if discrepancies exceeded 0.1 cm. Final values were the mean of the two or three measurements, as appropriate. All anthropometric measurements were conducted by trained staff from the National Institute of Nutrition in Vietnam following standardised procedures [19].

The following indices were calculated:

• BMI was calculated by dividing weight in kg by the square of height in meters [6]. BMI categories were defined as follows: BMI <18.5: underweight; BMI ≥25 to <30: overweight; and BMI ≥30: obesity [6].

• WtHR was calculated by dividing waist circumference in cm by height in cm. The WtHR cutoff used to define abdominal obesity was >0.56 [20].

• Waist circumference >90 cm was used to define abdominal adiposity [21].

2.6 Demographic and socioeconomic data

Data were collected using a pretested, researcher-administered questionnaire. The following data were collected: age, ethnicity, marital status, education level, employment status, monthly household income, monthly personal income, monthly household food expenditure, and the total number

of household possessions from a standardised list including: computer, video compact disc player, digital video disc player, fridge, washing machine, air conditioner, motorbike, car, bicycle, and telephone.

Participants' ethnicity was categorised as Kinh or other groups. Marital status was classified as married or not married. Education level was dived into four categories: primary school (grades 1–5), secondary school (grades 6–9), high school (grades 10–12), or university degree and above [22].

2.7 Data analysis

Generalised linear mixed models (LMMs) were fitted to estimate the prevalence of underweight, overweight, obesity, abdominal adiposity, and overweight/obesity and abdominal adiposity, with commune as a random effect. For each outcome, we report a measure of similarity of outcomes among males in the same commune, the intracluster correlation coefficient (ICC), estimated under a model with commune as a random effect.

LMMs, with commune as a random effect, were used to estimate the association between continuous outcomes (BMI and WtHR) and demographic and socioeconomic variables. Both univariate associations (considering only one demographic or socioeconomic factor at a time) and adjusted associations (including all demographic and socioeconomic factors (*i.e.*, age, ethnicity, marital status, education level, employment status, and income related variables) were reported. The factors included in the covariate model were selected based on the literature review and the statistical significance in univariate analyses. However, if a variable was not statistically significant in the univariate analysis but had been shown to be associated with the dependent variable (BMI or WtHR) in the literature, it was still included in the covariate model.

All prevalence and LMMs coefficient estimates are reported with 95% confidence intervals (CIs). Analyses were performed with Stata (version 14.0; Stata Corp LP, College Station, TX, USA).

3. Results

3.1 Characteristics of adult males who took part in the research

Out of 650 men approached for participation, 453 agreed to participate and were included in the analysis. The participants had a mean age of 37.8 years (standard deviation (SD) 11.2). Among them, 80.4% were Kinh, 51.4% held a university degree, 70.0% were employed, and 73.5% were married (Table 1, Ref. [6]).

3.2 Nutritional status of adult males

The prevalence of underweight was 2.1%; overweight and obesity was >30%; abdominal adiposity was 20.0% as defined by WC >90 cm and 15.0% as defined by WtHR ≥0.56; and overweight/obesity and abdominal obesity was 16.7% (Table 2, Ref. [6, 20, 21]).

The estimated ICC for underweight, overweight, obesity and abdominal obesity defined by WC and WtHR are reported in Table 3 (Ref. [6, 20, 21]). This information may inform sample size calculations in future studies aiming to estimate similar indicators of nutritional status among male adults in Vietnam.

3.3 Associations between anthropometric indicators and demographic and socioeconomic factors among males

3.3.1 Body mass index

BMI showed a significant association with education level in both univariate and multivariate analyses (Table 4). The overall coefficient for the association between education and BMI was −0.41 (95% CI: −0.78, −0.03) (results not shown in Table 2). Analysis showed that males who completed high school tended to have a higher BMI compared to those who completed primary school (Table 4).

3.3.2 Waist-to-height ratio

In the univariate analyses, WtHR was significantly associated with age, marital status, and monthly household income. However, in the multivariate analysis, only age and monthly household income remained statistically significant (Table 5). Higher age was associated with higher WtHR, while higher household income was associated with a lower WtHR.

4. Discussion

The results of this study showed that, among participating men, the prevalence of overweight and obesity was 33.2%, and abdominal adiposity was between 15–20% as defined by WC or WtHR. BMI was significantly negatively associated with education, and WtHR was positively correlated with age and negatively correlated with monthly household income.

The findings also indicated significant variations in anthropometric indices reflecting the nutritional status among males, influenced by various demographic and socioeconomic factors. Further research is needed to explore the underlying mechanisms driving these associations and to evaluate the effectiveness of interventions targeting healthy anthropometric outcomes or nutritional status. Longitudinal studies could provide deeper insights into how sociodemographic factors influence changes in anthropometric indices over time, which may help Vietnam make significant strides in improving the health and well-being of its male population.

4.1 The prevalence of overweight and obesity among adult males

Findings from our research showed that the participants had a higher prevalence of overweight and obesity compared to the national data (19.3% in 2020) [3]. The prevalence of abdominal adiposity in the present study was consistent with the national level (25% in men in 2015) [23]. Although it is challenging to compare these proportions due to differences in sampling procedures, this prevalence highlights the rising issue of overnutrition in Vietnamese males, particularly since our study was conducted in two of the poorest provinces in Vietnam, with the other location being an urban area. Meanwhile, these two provinces are still facing a high prevalence

TABLE 1. Characteristics of study participants.

	N	%
Age (yr) (N = 453)		
Mean (SD)	37.8 (11.2)	
Median (min–max)	36.9 (18.6–70.4)	
Height (cm) (N = 453)		
Mean (SD)	164.1 (5.5)	
Median (min–max)	164.5 (150.0–179.0)	
Weight (kg) (N = 453)		
Mean (SD)	65.7 (9.0)	
Median (min–max)	66.0 (45.4–87.3)	
Waist circumference (cm) (n = 449)		
Mean (SD)	81.7 (9.2)	
Median (min–max)	80.0 (60.0–104.0)	
BMI (N = 453)*		
Mean (SD)	24.3 (3.0)	
Median (min–max)	24.5 (17.9–31.7)	
Waist to Height Ratio (N = 449)**		
Mean (SD)	0.50 (0.06)	
Median (min–max)	0.49 (0.36–0.63)	
Ethnicity (N = 453)		
Kinh	364	80.4
Other	89	19.6
Education (N = 426)		
Primary school (grades 1–5)	61	14.3
Secondary school (grades 6–9)	84	19.7
High school (grades 10–12)	62	14.6
University and above	219	51.4
Employment (N = 390)		
Unemployed	117	30.0
Employed	273	70.0
Marital status (N = 438)		
Married	322	70.9
Not married	116	29.1
Number of household possession (N = 438)		
Mean (SD)	6.5 (2.1)	
Median (min–max)	7.0 (0.0–10.0)	
Monthly personal income (million VND) (N = 401)		
Mean (SD)	5.9 (3.2)	
Median (min–max)	5.0 (1.0–16.0)	
Monthly household income (million VND) (N = 377)		
Mean (SD)	11.9 (5.9)	
Median (min–max)	12.0 (1.0–30.0)	
Monthly household food expenditure (million VND) (N = 366)		
Mean (SD)	5.1 (3.2)	
Median (min–max)	4.0 (1.0–15.0)	

**BMI was calculated by dividing weight in kg by the square of height in meters [6].*
***Waist to Height Ratio was calculated by dividing waist in cm by height in cm.*
SD: standard deviation; BMI: Body mass index; min: minimum; max: maximum; VND: Vietnamese Dong.

TABLE 2. Nutritional status among participating males (N = 453)*.

	N	%	95% CI
Underweight**	11	2.1	0.8, 5.1
Overweight**	166	29.5	22.0, 38.2
Obesity**	16	3.7	2.3, 5.9
Abdominal obesity by WC***	82	20.0	13.6, 28.7
Abdominal obesity by WtHR****	66	15.0	9.9, 22.0
Overweight/obesity and abdominal obesity^{+}	69	16.7	12.2, 22.5

**Generalised linear mixed models including commune as a random effect. The prevalences were calculated over the total number of participants (N = 453);*
***BMI <18.5: underweight, BMI ≥25 to <30: overweight, and BMI ≥30: obesity [6];*
****WC (waist circumference) >90 cm [21];*
*****WtHR (waist to height ratio) >0.56 [20];*
$^{+}$BMI ≥25 and WtHR ≥0.56.
CI: confidence interval.

TABLE 3. ICC estimates for underweight, overweight, obesity and abdominal obesity*.

	ICC	95% CI
Underweight**	0.125	0.005, 0.813
Overweight**	0.098	0.039, 0.225
Obesity**	0.000	0.000, 0.000
Abdominal obesity by WC***	0.156	0.063, 0.338
Abdominal obesity by WtHR****	0.135	0.048, 0.326
Overweight/obesity and abdominal adiposity	0.148	0.052, 0.352

**ICC (intracluster correlation coefficient) was estimated under a model with commune as a random effect;*
***BMI <18.5: underweight, BMI ≥25 to <30: overweight, and BMI ≥30: obesity [6];*
****WC (waist circumference) >90 cm [21];*
*****WtHR (waist to height ratio) >0.56 [20].*
CI: confidence interval.

TABLE 4. Associations between BMI and demographic and socioeconomic factors.

	Raw estimates		Univariate analysis*			Multivariate analysis**		
	Total	BMI Mean (SE)	Coef (95% CI)	*p*-value	Overall *p*-value***	Coef (95% CI)	*p*-value	Overall *p*-value***
Age (yr)	453	25.2 (0.59)	−0.04 (−0.15, 0.06)	0.415		−0.11 (−0.32, 0.10)	0.305	
Ethnicity								
Kinh (reference)	364	24.4 (0.16)	0			0		
Other	89	24.4 (0.32)	−0.22 (−3.20, 2.77)	0.888		−0.47 (−5.40, 4.45)	0.850	
Education level								
Primary school (grades 1–5) (reference)	61	23.3 (0.41)	0			0		
Secondary school (grades 6–9)	84	24.7 (0.38)	0.83 (−3.26, 4.92)	0.691	0.007	−0.27 (−6.87, 6.33)	0.936	0.014
High school (grades 10–12)	62	30.4 (4.01)	6.58 (2.17, 10.99)	0.003		6.84 (−0.63, 14.3)	0.073	
University and above	219	24.5 (0.19)	0.87 (−2.70, 4.43)	0.633		−1.42 (−8.54, 5.70)	0.696	

TABLE 4. Continued.

	Raw estimates		Univariate analysis*			Multivariate analysis**		
	Total	BMI Mean (SE)	Coef (95% CI)	*p*-value	Overall *p*-value***	Coef (95% CI)	*p*-value	Overall *p*-value***
Employment								
Unemployed (reference)	117	26.2 (0.93)	0			0		
Employed	273	23.6 (0.29)	2.25 (−0.60, 5.11)	0.122		4.29 (−0.64, 9.21)	0.088	
Marital status								
Married (reference)	322	24.4 (0.17)	0			0		
Not married	116	24.4 (0.30)	1.58 (−1.16, 4.32)	0.258		1.54 (−3.96, 7.04)	0.583	
Number of household possessions	438		0.39 (−0.19, 0.96)	0.187		0.51 (−0.48, 1.50)	0.316	
Monthly personal income (million VND)	400		−0.13 (−0.53, 0.28)	0.535		0.03 (−0.75, 0.81)	0.936	
Monthly household income (million VND)	376		−0.09 (0.33, 0.15)	0.472		−0.24 (−0.64, 0.17)	0.254	
Monthly household food expenditure (million VND)	365		−0.20 (−0.64, 0.24)	0.382		−0.23 (−0.87, 0.41)	0.488	

**Linear mixed model including the covariate as a fixed effect and commune as a random effect. **Linear mixed model including all nine demographic and socioeconomic factors as fixed effects and commune as a random effect. ***Overall p-value for the association between the outcome and the demographic or socioeconomic factor.*
BMI: Body mass index; VND: Vietnamese Dong; CI: confidence interval; Coef: Coefficient; SE: standard error.

TABLE 5. Associations between WtHR and demographic and socioeconomic factors.

	Raw estimates		Univariate analysis*			Multivariate analysis**		
	Total	WtHR Mean (SE)	Coef (95% CI)	*p*-value	Overall *p*-value***	Coef (95% CI)	*p*-value	Overall *p*-value***
Age (yr)	449	0.50 (0.003)	0.001 (0.000, 0.001)	0.002		0.001 (0.000, 0.002)	0.007	
Ethnicity								
Kinh (reference)	362	0.50 (0.004)	0			0		
Other	87	0.51 (0.006)	0.005 (−0.015, 0.024)	0.636		−0.002 (−0.032, 0.027)	0.891	
Education level								
Primary school (grades 1–5) (reference)	61	0.50 (0.007)	0			0		
Secondary school (grades 6–9)	83	0.50 (0.006)	0.006 (−0.021, 0.032)	0.683	0.188	0.018 (−0.021, 0.579)	0.363	0.115
High school (grades 10–12)	62	0.52 (0.020)	0.026 (−0.003, 0.054)	0.078		0.049 (0.005, 0.093)	0.03	

TABLE 5. Continued.

	Raw estimates		Univariate analysis*			Multivariate analysis**		
	Total	WtHR Mean (SE)	Coef (95% CI)	*p*-value	Overall *p*-value***	Coef (95% CI)	*p*-value	Overall *p*-value***
University and above	216	0.50 (0.004)	0.002 (−0.022, 0.254)	0.879		0.020 (−0.022, 0.062)	0.348	
Employment								
Unemployed (reference)	117	0.49 (0.006)	0			0		
Employed	269	0.50 (0.005)	0.016 (−0.001, 0.034)	0.080		0.009 (−0.020, 0.039)	0.528	
Marital status								
Married (reference)	318	0.51 (0.005)	0			0		
Not married	107	0.48 (0.005)	0.024 (0.007, 0.042)	0.007		−0.000 (−0.033, 0.033)	0.995	
Number of household possessions			0.001 (−0.003, 0.005)	0.734		0.004 (−0.001, 0.010)	0.156	
Monthly personal income (million VND)			−0.001 (−0.003, 0.001)	0.575		0.002 (−0.003, 0.007)	0.412	
Monthly household income (million VND)			−0.002 (−0.003, −0.000)	0.028		−0.003 (−0.005, −0.001)	0.018	
Monthly household food expenditure (million VND)			0.000 (−0.002, 0.003)	0.790		0.001 (−0.002, 0.005)	0.498	

**Linear mixed model including the covariate as a fixed effect and commune as a random effect. **Linear mixed model including all nine demographic and socioeconomic factors as fixed effects and commune as a random effect. ***Overall p-value for the association between the outcome and the demographic or socioeconomic factor.*
WtHR: waist to height ratio; VND: Vietnamese Dong; CI: confidence interval; Coef: Coefficient; SE: standard error.

of childhood stunting (between 20.8% and 30.1%, compared to the national data of 18.2% in 2023) [24]. Findings from our study provide additional insights into the concerns of the double burden of malnutrition during the nutrition transition in Vietnam. The increased prevalence of overweight and obesity among Vietnamese adults has been reported since the early 2000s, with a clear shift towards higher BMI levels. This trend continued through 2015 and 2020 [23], similar to trends in other nations. For example, the World Health Organisation (WHO) European Region reported that, in the ten years leading up to 2016, obesity increased by 21% [25]. In Vietnam, although the overall prevalence of overweight and obesity remains lower than in many Western countries, the relative increase has been substantial, rising by an estimated 550% between 1993 and 2015 [26]. This trend is particularly noteworthy given the country's historical context of widespread undernutrition in the post-war era, and reflects a rapid nutritional transition. Among the provinces where this research was conducted, we could not retrieve data on adult obesity in Ha Giang and Ninh Thuan provinces. In Can Tho, a study conducted on 8227 students at Can Tho University in 2016 found that 4.5% of them were overweight or obese [27]. Later, in 2022, a figure of 20% was reported among 440 students at the same university [28]. Due to the differences in sample sizes, we performed a proportion test for these prevalence estimates and obtained $p < 0.001$. Therefore, we can conclude that obesity is steadily increasing in the country. This also projects higher risks of adiposity-related diseases, such as cardiovascular disease, diabetes, fatty liver diseases, and other related disorders among males in Vietnam [29].

Vietnam has experienced steady economic growth, which has been linked to the rising prevalence of obesity in the population [30]. Globalization and trade liberalization have led to the availability of fast and processed foods, as well as the Westernization of eating behaviours and sedentary lifestyle. These factors contribute to weight gain and excess. Males, who typically work outside the home, consume fewer home-cooked meals and less fruits and vegetables than females. In fact, Vietnamese people only meet 65% of the recommended daily fruit and vegetable intake [17]. Meanwhile, males consume more fast-foods [31], alcohol [32], salt [3], and tobacco than females. If these eating patterns are not addressed through public health, education, and communication interventions, the population may face an increased burden of obesity-related health issues, such as hypertension, cardiovascular disease, cancer, and metabolic syndrome. Awareness-raising campaigns should be implemented to promote healthy food choices and control poor dietary habits.

4.2 Associations between anthropometric indicators and demographic and socioeconomic factors among males

Findings from the current research revealed a U-shaped association between education level and BMI, indicating that educational attainment may influence body weight. This result is inconsistent with findings from other studies conducted in Vietnam and other low- and middle-income countries. Studies in Malaysia, and Indonesia have shown that higher education correlates with increased BMI and central obesity [33, 34]. These populations are undergoing a nutrition transition and experiencing rapid economic growth and urbanization, leading to lifestyle changes such as higher consumption of processed foods and reduced physical activity among the educated. In contrast, in high-income countries such as the US and EU nations, a negative association is commonly found between education levels and obesity [35, 36]. Higher education is typically linked to lower BMI, particularly among women. This trend is thought to be related to greater health awareness, better access to healthier food options, and more opportunities for physical activity in higher socioeconomic groups. These associations could be attributed to lifestyle and dietary habits that vary with education. It is challenging to explain why the findings from our study are inconsistent with those from other studies in low- and middle-income countries. One possible explanation could be differences in sample size, sampling methods, participant characteristics, and behaviours specific to the Vietnamese context. For example, the moderate sample size may not be representative of the broader male population in Vietnam. Additionally, more than 50% of participants in this study held a university degree or higher, which may reflect higher health literacy and better management of body weight and shape or age-related confounding may also play a role. However, additional analyses adjusting for age in the regression models showed that the association between education and BMI remained significant even after controlling for age. The limitations of a cross-sectional study design restrict our ability to draw causal inferences, highlighting the need for further research to explore this association more comprehensively.

Age and abdominal obesity have been found to be positively associated, particularly among males in Asian communities. South Asian men are more likely to develop abdominal obesity at younger ages [37], while East Asian men tend to accumulate abdominal fat more noticeably in older ages [38]. Previous research has concluded that, as males age, reduced testosterone concentrations increase the risk of obesity [39]. A lower metabolic rate [40] may also contribute to increased adiposity in aging individuals. Moreover, the longer people live, the more obesity risks they accumulate, such as physical inactivity and unhealthy eating behaviours. Therefore, the positive relationship between age and abdominal obesity observed in our research is consistent with the literature. Given the diversity of genetic factors, culture, and diet, targeted interventions for preventing and managing abdominal obesity should be tailored to the specific needs and characteristics of each population.

In addition, WtHR was significantly associated with income and employment status, two indicators of wealth. Higher-income and employment were linked to lower WtHR, suggesting that socioeconomic status plays a crucial role in determining body composition. This finding also emphasizes the importance of addressing socioeconomic disparities in health and nutrition interventions. In the US, higher-income individuals are generally more likely to have a lower WtHR, reflecting better abdominal fat distribution and overall health [37]. Access to health education, healthier food options, and gym facilities are more common among wealthier populations, resulting in lower levels of central obesity. Similar patterns are observed across developing countries, where higher-income individuals tend to have lower WtHR [41, 42]. In many low- and middle-income Asian countries, higher income is also associated with lower WtHR, particularly in urban areas, where wealthier individuals have better access to healthcare, healthier food, and more opportunities for physical activity [43, 44]. However, it should be noted that wealth is not the sole determinant of central obesity, and its influence on abdominal adiposity can vary. A study of the US National Health and Nutrition Examination Survey from 1988 to 2015 found that educated adults had a higher prevalence of obesity-associated mortality risk and excess deaths compared to those with lower education levels [45]. In another study, educational level was found to be linearly associated with adiposity, either inverse or direct [46]. These observations suggest the need for further research to better control for confounders related to socioeconomic determinants of obesity and to provide a more nuanced understanding of how these factors interact.

4.3 Strengths and limitations

To the authors' knowledge, this study is unique in focusing on anthropometric measures among adult males in Vietnam. Although the sample size was moderate, participants were randomly selected from three provinces in Vietnam with no refusal cases. The majority of participants had a higher level of educational attainment, which may have contributed to improved communication between researchers and participants, as well as to participants' recall ability. In addition, these data, collected between December 2020 and June 2021, are the most

recent available on the nutritional status of men in Vietnam.

One limitation of this study is its cross-sectional design, which prevents the establishment of causality. Future studies should consider using longitudinal designs to better understand causal relationships and changes over time. Males with anthropometric abnormalities were excluded; therefore, the results reflect only those with healthy anthropometric profiles. Furthermore, this study did not have the resources to assess lifestyle factors, such as smoking, alcohol use, and dietary intake, which should be considered in future research.

In the context of Vietnam, conducting community-based surveys presents unique challenges. The diverse geographical and cultural aspects of Vietnam mean that data collection methods must be carefully tailored to ensure representativeness and accuracy. For instance, rural and remote areas may have limited access to communication infrastructure, making it difficult to reach all potential participants. Moreover, varying levels of literacy and understanding of health-related concepts can affect the quality of self-reported data. Developing educational materials for these areas is further complicated by the diversity of ethnic groups and traditional behaviors.

Community-based surveys often rely on local health workers and volunteers for data collection, which can introduce variability in how data are collected and recorded. Training and standardization of procedures are crucial to minimize these inconsistencies. Despite these efforts, some degree of variability is inevitable, which can affect the reliability of the findings.

5. Conclusions

This study highlights a high prevalence of overweight and obesity, as well as the significant associations between anthropometric indices and demographic and socioeconomic factors among adult males in three provinces of Vietnam. Men with lower educational attainment and those from lower-income households were more likely to have elevated BMI or indicators of central obesity. Addressing these factors through targeted public health interventions could help mitigate the observed high prevalence of overweight and obesity, ultimately improving health outcomes for this population.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available upon request from the corresponding author, in accordance with the privacy and legal regulations of the Ministry of Science and Technology (funder) and the National Institute of Nutrition—Ministry of Health, Vietnam (organization in charge of the research).

AUTHOR CONTRIBUTIONS

NTDH and TDL—Conceptualization; funding acquisition. NTDH, TDL, HP and NTTH—methodology. HP and DVN—software. DTT, HNL, YTTB and DVN—validation. NTDH, EASG, HP, TDL and DTT—formal analysis; writing–review and editing. NTTH and HAL—investigation. NTDH, TDL and DTT—resources. NTTH and HNL—data curation. NTDH and NTTH—writing–original draft preparation. HP and EASG—visualization. TDL and HP—supervision. YTTB, DVN, HAL and HHPT—project administration. All authors have read and agreed to the published version of the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of the National Institute of the National Institute of Nutrition—Ministry of Health, Vietnam (Decision No 637/VDD-QLKH; dated 21 October 2020) for studies involving humans. Informed consent was obtained from all subjects involved in the study.

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CONFLICT OF INTEREST

The funders had no role in the design of the study; in the collection, analysis, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results. The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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