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Research the Anthropometric Measures and Indexes of Kinh and Khmer Ethnic Pupils from 6 to 17 Years Old at the Mekong River Delta in 2019: A Cross-Sectional Study

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ABSTRACT:

Objective: To describe and compare anthropometric indices (weight, standing height, body mass index - BMI) between Kinh and Khmer ethnic students aged 6 to 17 in the Mekong Delta in 2019.

Subjects and methods: A cross-sectional study was conducted on 3,242 students (1,983 Kinh students, including 1,051 females and 932 males; 1,259 Khmer students, including 717 females and 542 males) from grades 1 to 12 in secondary schools in 13 provinces of the Mekong Delta. Weight and standing height were measured using Martin anthropometric instruments according to standard procedures. Data were processed using SPSS 18.0 software, and independent t-tests were used to compare means between the two ethnic groups.

Results: Weight and standing height increased with age in both ethnic groups. Kinh students have higher average weight and height than Khmer students at the primary and lower secondary levels. At the upper secondary level, Khmer males are taller than Kinh males (12th grade: 169 cm vs. 165 cm). The BMI of the Kinh group is higher in the younger grades, then the difference narrows and is nearly equal in grades 11-12. There are statistically significant differences ($p < 0.05$) in weight and BMI in most grades, and height is higher in many grades.

Conclusion: The study notes significant differences in anthropometric indicators between Kinh and Khmer students according to gender and age. The results provide distinct anthropometric reference data by ethnicity, contributing to the scientific basis for developing appropriate school nutrition and health care programs in the Mekong Delta region

1. INTRODUCTION

Anthropometry plays a crucial role in evaluating physical growth, nutritional status, and health conditions in children and adolescents. Basic anthropometric measurements such as body weight, standing height, and indices derived from these measurements, especially body mass index (BMI), are widely applied in epidemiological and clinical studies to monitor child growth and development ^{1,2}. The World Health Organization (WHO) has emphasized that anthropometric assessment is an essential component of child health surveillance and public health planning worldwide ³.

Previous studies across different countries have demonstrated that anthropometric characteristics vary considerably depending on age, sex, ethnicity, socioeconomic status, and environmental conditions ⁴⁻⁶. Research conducted in the Middle East, including Bahrain and the United Arab Emirates, has provided population-specific reference values for BMI and body composition in children and adolescents, highlighting the necessity of local growth standards rather than relying solely on international references ⁷⁻⁹.

In Africa, several cross-sectional studies among school-aged children have reported wide variations in height, weight, and BMI, often reflecting differences in nutritional intake, living conditions, and access to healthcare services ¹⁰⁻¹³. Similar findings have been observed in European populations, where excess weight and obesity among school children have emerged as major public health concerns, with anthropometric indices serving as reliable indicators for early detection of nutritional disorders ^{14,15}.

Studies from Asian countries such as India, Iran, Pakistan, and China have also documented significant differences in anthropometric measures among children and adolescents, influenced by rapid socioeconomic changes, urbanization, and lifestyle transitions ¹⁶⁻¹⁹. Furthermore, long-term and cohort studies suggest that abnormal anthropometric indices during childhood may predispose individuals to metabolic disorders, cardiovascular diseases, and other chronic health problems later in life ²⁰.

Beyond physical health outcomes, anthropometric status has been linked to psychosocial and behavioral aspects, including body image perception, self-esteem, academic performance, and mental health among adolescents ²¹⁻²³. These associations underline the importance of comprehensive anthropometric evaluation not only for physical development but also for overall well-being during school age.

Vietnam is a multi-ethnic country with considerable diversity in cultural practices, dietary habits, and socioeconomic conditions. Although some studies have explored health-related issues among Vietnamese school children, including psychological well-being and lifestyle factors ²⁴, data on anthropometric characteristics stratified by ethnicity remain limited. This gap is particularly evident in the Mekong River Delta, where the Kinh ethnic majority and the Khmer ethnic minority coexist under distinct living and nutritional conditions.

Therefore, this study aimed to research anthropometric measures and indices among Kinh and Khmer ethnic pupils aged 6 to 17 years in the Mekong River Delta in 2019 using a cross-sectional design. The findings are expected to provide ethnicity-specific anthropometric data, contribute to a better understanding of growth patterns in this region, and serve as a scientific basis for developing appropriate school health and nutrition interventions.

2. MATERIALS AND METHODS

2.1 Study Design and Sampling

A cross-sectional study was conducted among Kinh and Khmer ethnic pupils aged 6 to 17 years during the 2018-2019 school year. The study population consisted of 1983 Kinh pupils (including 1051 females and 932 males) and 1259 Khmer pupils (including 717 females and 542 males) from primary, secondary, and high schools in the Mekong River Delta. All pupils were healthy at the time of measurement and voluntarily agreed to participate in the study.

The sample size is calculated using the formula:

$$n = \frac{Z_{(1-\alpha/2)}^2 \times \sigma^2}{d^2}$$

The sample size was calculated using a standard formula with a confidence coefficient $Z = 1.96$, corresponding to a 95% confidence level, a standard deviation (σ), and a desired precision $d = 1$.

For the Khmer ethnic group, samples were selected from the two provinces with the highest concentration of Khmer populations, Soc Trang and Tra Vinh, focusing on ethnic schools. For the Kinh ethnic group, sampling was carried out across 13 provinces in the Mekong River Delta. In each selected province, one primary school, one secondary school, and one high school were randomly chosen. Within each school, pupils were selected from grades 1 to 12 to achieve the required sample size and ensure age representation.

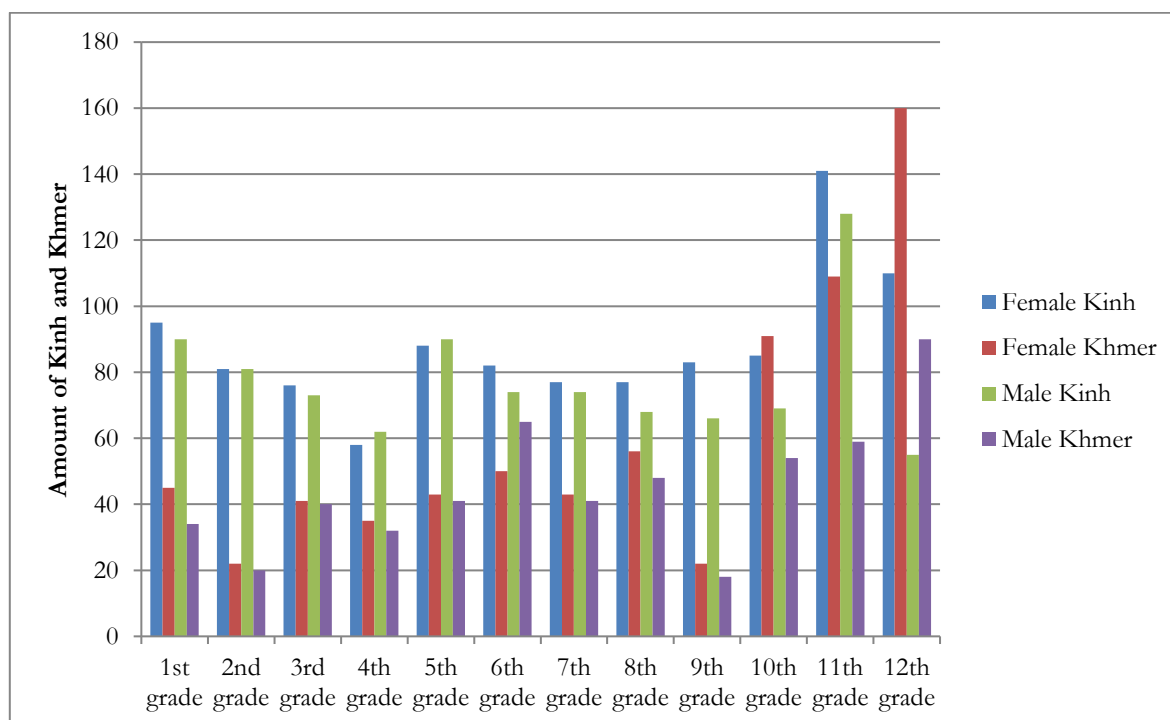
2.2 Data Collection and Analysis

Anthropometric measurements were performed using Martin anthropometric instruments manufactured in Japan, following standardized measurement procedures. Mean values of anthropometric variables were calculated, and anthropometric indices were derived accordingly. All collected data were analyzed using SPSS version 18.0, and independent t-tests were applied to compare mean values and proportions between Kinh and Khmer ethnic pupils.

3. RESULTS AND DISCUSSION

Through the study of 1983 Kinh pupils (including 1051 females and 932 males) and 1259 Khmer pupils (including 717 females and 542 males), we recorded that the following results.

3.1 Distribution of the study sample by ethnicity, sex, and grade



(Source: Author's data analysis)

Fig 1. Amount of Kinh and Khmer ethnic pupils

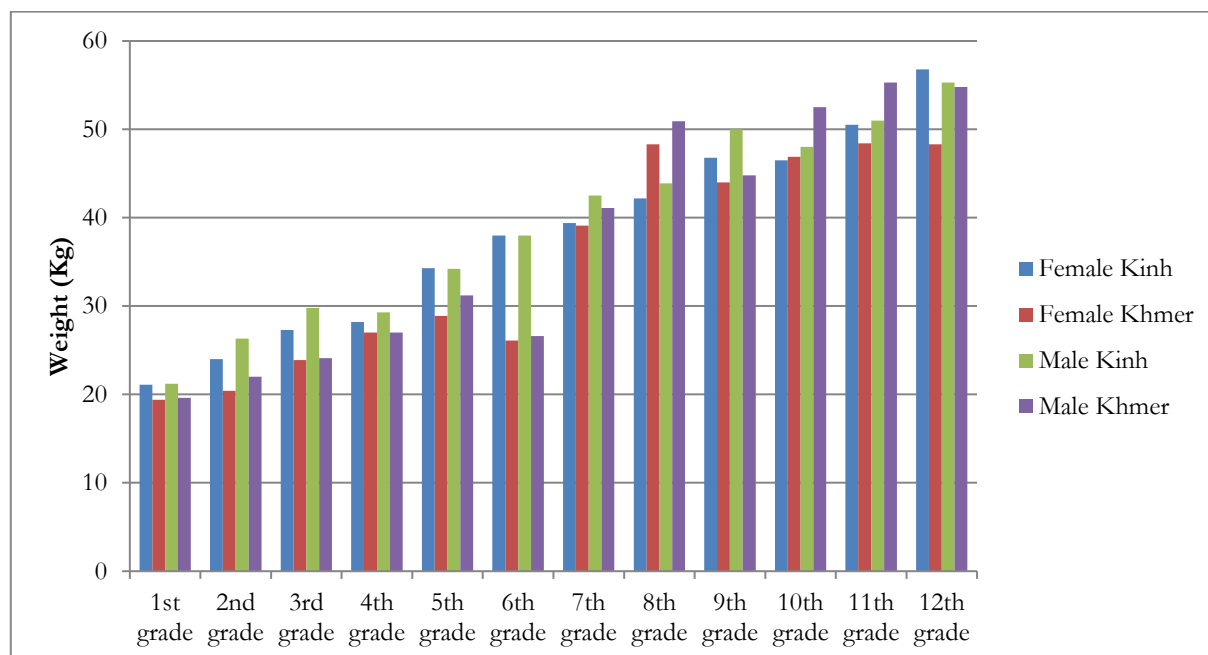
Figure 1 illustrates the distribution of Kinh and Khmer ethnic pupils by sex and grade from grade 1 to grade 12. A total of 1,983 Kinh pupils participated in the study, including 1,051 females and 932 males, while the Khmer group consisted of 1,259 pupils, comprising 717 females and 542 males.

At the primary school level (grades 1-5), the number of Kinh pupils ranged from 58 to 95 females and 62 to 90 males per grade, which was higher than that of Khmer pupils (22-45 females and 20-41 males). At the lower secondary level (grades 6-9), Kinh pupils continued to predominate, with 77-83 females and 66-74 males, whereas the number of Khmer pupils varied from 22 to 56 females and 18 to 65 males.

At the upper secondary level (grades 10-12), the sample size increased markedly in both ethnic groups. Notably, in grade 12, the number of Khmer females (160 pupils) exceeded that of Kinh females (110 pupils), while the numbers of Kinh and Khmer males were 55 and 90 pupils, respectively. Overall, females outnumbered males in both ethnic groups, particularly at the upper secondary school level.

The distribution of pupils by ethnicity, sex, and grade was relatively balanced, ensuring the representativeness and reliability of subsequent comparisons of anthropometric characteristics between Kinh and Khmer pupils.

3.2 Weight of Kinh and Khmer ethnic pupils



(Source: Author's data analysis)

Fig 2. Weight of Kinh and Khmer ethnic pupils

Figure 2 presents the mean body weight of Kinh and Khmer pupils by sex and grade. In both ethnic groups, body weight increased progressively with grade and age for males and females.

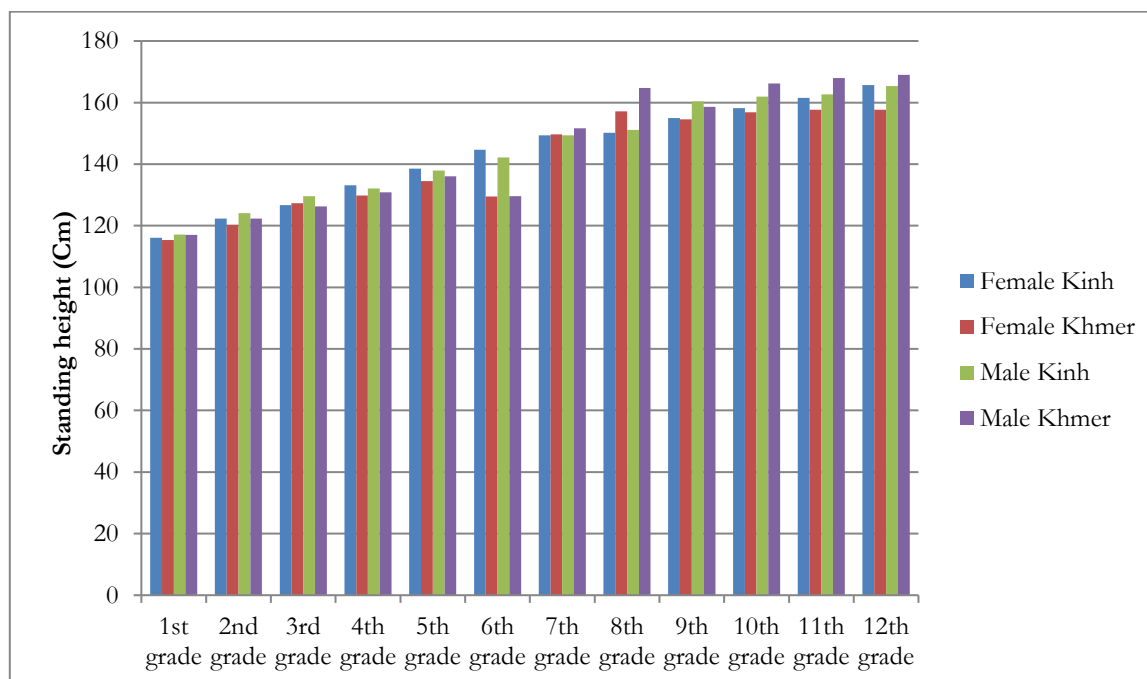
Among Kinh pupils, the mean weight of females increased from 21.1 kg in grade 1 to 56.8 kg in grade 12, while the mean weight of males rose from 21.2 kg to 55.3 kg over the same period. A similar increasing trend was observed among Khmer pupils, with female weight increasing from 19.4 kg in grade 1 to 48.3 kg in grade 12, and male weight from 19.6 kg to 54.8 kg, respectively.

At the primary school level (grades 1-5), Kinh pupils generally exhibited higher mean body weight than Khmer pupils in both sexes. For example, in grade 5, the mean weight of Kinh females and males was 34.3 kg and 34.2 kg, respectively, compared with 28.9 kg and 31.2 kg among Khmer pupils. At the lower secondary level (grades 6-9), differences in body weight between the two ethnic groups remained evident, although they tended to narrow in some grades.

At the upper secondary level (grades 10-12), the mean body weight of Khmer males was comparable to or slightly higher than that of Kinh males, reaching 55.3 kg in grade 11 and 54.8 kg in grade 12. In contrast, Kinh females maintained higher mean body weight than Khmer females in most grades, particularly in grades 11 and 12 (50.5 kg vs. 48.4 kg and 56.8 kg vs. 48.3 kg, respectively).

The results indicate sex- and ethnicity-related differences in body weight, with Kinh pupils showing higher mean values in most grades, especially at younger ages.

3.3 Standing height of Kinh and Khmer ethnic pupils



(Source: Author's data analysis)

Fig 3. Standing height of Kinh and Khmer ethnic pupils

Figure 3 shows the mean standing height of Kinh and Khmer pupils by sex and grade. In both ethnic groups, standing height increased steadily with grade and age for males and females, reflecting normal physical growth during the school years.

Among Kinh pupils, the mean standing height of females increased from 116 cm in grade 1 to 166 cm in grade 12, while that of males rose from 117 cm to 165 cm. Similarly, Khmer pupils showed a continuous increase in height, with female height rising from 115 cm in grade 1 to 158 cm in grade 12, and male height from 117 cm to 169 cm.

At the primary school level (grades 1-5), Kinh pupils were generally taller than Khmer pupils in both sexes. For example, in grade 5, the mean height of Kinh females and males was 139 cm and 138 cm, respectively, compared with 135 cm and 136 cm among Khmer pupils. At the lower secondary level (grades 6-9), the difference in standing height between the two ethnic groups varied by grade and sex, with Khmer males exceeding Kinh males in some grades, such as grade 8 (165 cm vs. 151 cm).

At the upper secondary level (grades 10-12), Khmer males exhibited the greatest mean standing height, reaching 166 cm in grade 10, 168 cm in grade 11, and 169 cm in grade 12, which was higher than that of Kinh males in the corresponding grades (162 cm, 163 cm, and 165 cm, respectively). In contrast, Kinh females remained taller than Khmer females in most upper secondary grades.

The results indicate distinct patterns of standing height according to sex and ethnicity, with Kinh pupils showing greater height at younger ages, while Khmer males tended to surpass Kinh males during late adolescence.

3.4 Body mass index (BMI) of Kinh and Khmer ethnic pupils

Table 1. BMI index

	Kinh ethnic pupils		Khmer ethnic pupils	
	Female	Male	Female	Male
1 st grade	15.6±0.2	15.4±0.3	14.5±0.3	14.3±0.6

	Kinh ethnic pupils		Khmer ethnic pupils	
	Female	Male	Female	Male
2 nd grade	15.9±0.3	16.8±0.4	14±0.4	14.7±0.3
3 rd grade	16.9±0.3	17.6±0.4	14.6±0.3	15±0.3
4 th grade	15.8±0.3	16.7±0.4	15.8±0.5	15.7±0.3
5 th grade	17.7±0.4	17.8±0.3	15.9±0.4	16.7±0.4
6 th grade	18±0.4	18.6±0.4	15.4±0.4	15.4±0.4
7 th grade	17.6±0.3	18.9±0.4	17.4±0.4	17.7±0.5
8 th grade	18.6±0.4	19.2±0.4	19.5±0.3	18.7±0.4
9 th grade	19.5±0.3	19.3±0.5	18.3±0.4	17.8±0.4
10 th grade	18.5±0.3	18.2±0.3	19.1±0.3	19±0.4
11 th grade	19.4±0.2	19.3±0.3	19.5±0.2	19.6±0.2
12 th grade	20.7±0.4	20.3±0.4	19.4±0.2	19.2±0.2

(Source: Author's data analysis)

Table 1 presents the mean body mass index (BMI) of Kinh and Khmer pupils by sex and grade. In both ethnic groups, BMI generally increased with advancing grade and age, with some fluctuations observed during early adolescence.

Among Kinh pupils, the mean BMI of females increased from $15.6 \pm 0.2 \text{ kg/m}^2$ in grade 1 to $20.7 \pm 0.4 \text{ kg/m}^2$ in grade 12, while that of males rose from $15.4 \pm 0.3 \text{ kg/m}^2$ to $20.3 \pm 0.4 \text{ kg/m}^2$. A gradual increase in BMI was observed throughout primary school, followed by a more pronounced rise during the secondary school years.

In the Khmer ethnic group, female BMI increased from $14.5 \pm 0.3 \text{ kg/m}^2$ in grade 1 to $19.4 \pm 0.2 \text{ kg/m}^2$ in grade 12, while male BMI rose from $14.3 \pm 0.6 \text{ kg/m}^2$ to $19.2 \pm 0.2 \text{ kg/m}^2$. Similar to the Kinh group, BMI values tended to increase with age, particularly from grades 7 to 12.

At the primary school level (grades 1-5), Kinh pupils exhibited higher BMI values than Khmer pupils in both sexes. For example, in grade 3, the mean BMI of Kinh females and males was 16.9 ± 0.3 and $17.6 \pm 0.4 \text{ kg/m}^2$, respectively, compared with 14.6 ± 0.3 and $15.0 \pm 0.3 \text{ kg/m}^2$ among Khmer pupils. During lower secondary school (grades 6-9), the difference in BMI between the two ethnic groups narrowed, with comparable values observed in several grades.

At the upper secondary level (grades 10-12), BMI values between the two ethnic groups became more similar, particularly among males. In grade 11, Khmer pupils showed slightly higher BMI values than Kinh pupils (19.5 ± 0.2 vs. $19.4 \pm 0.2 \text{ kg/m}^2$ in females and 19.6 ± 0.2 vs. $19.3 \pm 0.3 \text{ kg/m}^2$ in males).

The results indicate age-, sex-, and ethnicity-related variations in BMI, with Kinh pupils presenting higher BMI values at younger ages, while differences between the two ethnic groups tended to diminish during late adolescence.

3.5 Comparison of anthropometric measures and indices between Kinh and Khmer pupils

Table 2. Comparison between anthropometric measures and anthropometric indicator mean in Kinh and Khmer ethnic pupils

	Weight	Standing height	BMI
1 st grade	0.002	0.002	0.002
2 nd grade	0.001	0.051	0.000

	Weight	Standing height	BMI
3 rd grade	0.000	0.169	0.000
4 th grade	0.071	0.037	0.261
5 th grade	0.000	0.005	0.000
6 th grade	0.04	0.000	0.002
7 th grade	0.497	0.014	0.026
8 th grade	0.024	0.043	0.003
9 th grade	0.027	0.427	0.013
10 th grade	0.014	0.000	0.017
11 th grade	0.012	0.365	0.000
12 th grade	0.000	0.000	0.000

(Source: Author's data analysis)

Table 2 presents the statistical comparison of mean body weight, standing height, and BMI between Kinh and Khmer ethnic pupils by grade. Significant differences between the two ethnic groups were observed in most grades and anthropometric indicators.

For body weight, statistically significant differences were found in grades 1, 2, 3, 5, 6, 8, 9, 10, 11, and 12 ($p < 0.05$). No significant differences were observed in grades 4 and 7 ($p > 0.05$), indicating comparable mean body weight between the two ethnic groups in these grades.

Regarding standing height, significant differences between Kinh and Khmer pupils were observed in grades 1, 4, 5, 6, 7, 8, 10, and 12 ($p < 0.05$). In contrast, no statistically significant differences were found in grades 2, 3, 9, and 11 ($p > 0.05$), suggesting similar height patterns between the two ethnic groups at these ages.

For BMI, statistically significant differences were detected in all grades except grade 4 ($p < 0.05$). Particularly strong differences were observed in early grades and at the upper secondary level, with p -values below 0.01 in most grades, indicating a clear distinction in BMI between Kinh and Khmer pupils.

The findings demonstrate that ethnicity is significantly associated with variations in anthropometric measures and indices, especially for body weight and BMI. The magnitude and consistency of these differences varied by age and developmental stage, with more pronounced differences observed during early childhood and late adolescence.

3.6 Discussion

This cross-sectional study analyzed anthropometric characteristics of Kinh and Khmer ethnic pupils aged 6-17 years in the Mekong River Delta and demonstrated clear differences according to ethnicity, sex, and school grade. The results from sections 4.1 to 4.5 provide detailed evidence of variations in body weight, standing height, and BMI, reflecting differences in growth patterns and nutritional status.

Regarding the sample structure, the distribution of pupils by ethnicity, sex, and grade was relatively balanced across primary, lower secondary, and upper secondary levels, ensuring representativeness for comparisons. Female pupils outnumbered males in both ethnic groups, particularly at the upper secondary level, a pattern also reported in school-based anthropometric studies in Africa and Asia ^{10,11,16}. The adequate sample size across all grades strengthens the reliability of the observed anthropometric differences between Kinh and Khmer pupils.

Body weight results showed a progressive increase with grade and age in both ethnic groups, which is consistent with normal growth trajectories described in previous studies from Nigeria, Pakistan, India, and Iran ^{1,2,6,16}. However, Kinh pupils generally had higher mean body weight than Khmer pupils at the primary and lower secondary levels. For example, in grade 5, Kinh

females and males weighed 34.3 kg and 34.2 kg, respectively, compared with 28.9 kg and 31.2 kg among Khmer pupils. Similar disparities related to ethnicity and socioeconomic background have been reported among primary school children in Nigeria and Ghana, where children from more advantaged groups exhibited higher body weight^{5,10}. At the upper secondary level, the difference in body weight narrowed, and Khmer males showed comparable or slightly higher values than Kinh males, suggesting a catch-up growth pattern during adolescence.

Standing height findings also indicated an overall increase with age in both ethnic groups, in line with WHO growth principles and international observations^{3,4}. Kinh pupils were generally taller than Khmer pupils during early school years, such as in grade 5 (139 cm vs. 135 cm in females). However, at the upper secondary level, Khmer males surpassed Kinh males in standing height, reaching 169 cm in grade 12 compared with 165 cm among Kinh males. This late-adolescent height advantage among Khmer males may reflect delayed but prolonged pubertal growth spurts, a phenomenon reported in European and Asian adolescent growth studies^{4,20}. Similar patterns have been observed in populations experiencing early childhood nutritional constraints followed by improved adolescent growth conditions¹².

BMI results demonstrated a general increase with age in both ethnic groups, particularly from grades 7 to 12, corresponding to pubertal development and changes in body composition. At the primary school level, Kinh pupils had higher BMI values than Khmer pupils, for instance in grade 3 (16.9 vs. 14.6 kg/m² in females). These findings are consistent with studies from Bahrain, the UAE, and Greece, which reported higher BMI values among children with better nutritional access during early childhood^{7-9,14}. At the upper secondary level, BMI differences between Kinh and Khmer pupils became smaller, and in grade 11, Khmer pupils even showed slightly higher BMI values than Kinh pupils. Overall, BMI values in both ethnic groups mostly remained within normal ranges, indicating a lower prevalence of overweight and obesity compared with Middle Eastern and European populations^{9,15}.

The statistical comparisons presented in section 4.5 further confirmed the significant influence of ethnicity on anthropometric measures. Significant differences in body weight and BMI were observed in most grades ($p < 0.05$), particularly at early childhood and late adolescence. Standing height differences were significant in several grades but not consistently across all ages, suggesting that height is more strongly influenced by pubertal timing and genetic factors than by short-term nutritional status. Similar associations between ethnicity, nutritional status, and anthropometric indicators have been reported in studies from Nigeria, Uganda, and South Africa¹¹⁻¹³.

The observed anthropometric differences between Kinh and Khmer pupils may be explained by variations in socioeconomic status, dietary habits, physical activity levels, and access to healthcare services. Previous research has shown that dietary intake and physical activity significantly affect body composition and BMI in school-aged children^{18,23}. Moreover, long-term evidence suggests that childhood anthropometric status is associated with later risks of metabolic syndrome and cardiovascular diseases^{13,19}, highlighting the importance of early monitoring, especially among ethnic minority populations.

In addition to physical health implications, anthropometric status has been linked to psychosocial outcomes such as body image, self-esteem, and mental health during adolescence^{21,24}. Differences in growth patterns between Kinh and Khmer pupils may therefore have broader consequences for overall well-being and academic development, underscoring the need for comprehensive, school-based health and nutrition programs tailored to specific ethnic groups.

In summary, results demonstrate that significant ethnic differences exist in anthropometric measures and indices among school-aged children in the Mekong River Delta. These findings support the necessity of using ethnicity-specific anthropometric data and reinforce the importance of targeted nutritional and health interventions rather than relying solely on international reference standards^{3,7}.

4. CONCLUSION

This cross-sectional study provides detailed anthropometric evidence on body weight, standing height, and body mass index (BMI) among Kinh and Khmer pupils aged 6-17 years in the Mekong River Delta. The results clearly demonstrate that anthropometric characteristics differ by age, sex, and ethnicity throughout the school years. In general, Kinh pupils exhibited higher body weight, standing height, and BMI during early childhood and primary school ages. These differences were most pronounced in body weight and BMI, indicating potential disparities in early-life nutritional status between the two ethnic groups.

As age increased, the magnitude of ethnic differences in anthropometric measures gradually decreased. During late adolescence, Khmer males surpassed Kinh males in standing height, suggesting a later but more prolonged growth spurt and differences in pubertal timing. BMI values in both ethnic groups increased progressively with age and largely remained within normal ranges, although ethnic disparities persisted at certain developmental stages. Overall, the findings highlight distinct growth patterns between Kinh and Khmer pupils and underscore the importance of considering ethnicity when evaluating physical development in Vietnamese children and adolescents.

Despite its strengths, this study has several limitations that should be carefully considered. First, the cross-sectional design restricts the ability to assess individual growth trajectories, growth velocity, and causal relationships between anthropometric outcomes and influencing factors. As measurements were taken at a single time point, it is not possible to determine whether observed differences reflect long-term growth patterns or temporary developmental variations.

Second, the study did not collect data on key determinants of growth, such as dietary intake, physical activity levels, household socioeconomic status, parental education, or pubertal stage. These factors are known to substantially influence anthropometric measures and may partly explain the differences observed between Kinh and Khmer pupils. Third, the study sample included only school-attending pupils, which may limit the generalizability of the findings to all children and adolescents in the Mekong River Delta, particularly those who have dropped out of school or never attended school.

Future research should prioritize longitudinal study designs to monitor growth patterns over time and to better understand differences in growth velocity, pubertal development, and catch-up growth between ethnic groups. Such studies would allow for a more accurate assessment of how early-life nutritional status influences adolescent and adult health outcomes.

Additionally, future studies should integrate comprehensive data on dietary intake, physical activity, socioeconomic conditions, and pubertal maturation to identify the key determinants underlying ethnic disparities in anthropometric indicators. Expanding research to include other ethnic minority groups and different geographic regions of Vietnam would further enhance the representativeness of anthropometric reference data. These efforts would contribute to the development of population- and ethnicity-specific growth standards and support evidence-based public health policies and school-based health and nutrition interventions.

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AUTHOR CONTRIBUTIONS

Giao Ha Nguyen Thi and Trang Huynh Vo have made substantial contributions to conception and design, or acquisition of data, or analysis and interpretation of data. My Pham Viet and Tu Hoang Minh have been involved in drafting the manuscript or revising it critically for important intellectual content, Tho Vu Tan and Huong Tran Duc and De Tran Van have given final approval of the version to be published.

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

ETHICS STATEMENT

The topic was approved by the medical ethics committee of Can Tho University of Medicine and Pharmacy and with the consent of all pupils to participate in the study.

DATA AVAILABILITY STATEMENT

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Data supporting the findings of this study are available from the corresponding author upon reasonable request.

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