Journal of Public Health and Development
Vol.23 No.3 September-December 2025

ORIGINAL ARTICLE

Addressing the nutritional status of secondary school students in Cambodia: a cross-sectional study

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Received: 17 September 2024 **Revised:** 29 December 2024 **Accepted:** 30 December 2024 **Available online:** September 2025
DOI: 10.55131/jphd/2025/230303

ABSTRACT

This study aims to assess the nutritional status and dietary quality of secondary school students in Cambodia by analyzing factors such as gender, school type, location, socioeconomic status, and maternal education. Data on demographics, Body Mass Index (BMI), and dietary intake were collected, with dietary quality evaluated using the Dietary Quality Index-International (DQI-I). The one-way ANOVA, t-test, and chi-square were used to analyze the factors. Significant gender differences in height, weight, and BMI were observed. Boys had higher BMI scores than girls ($p<0.001$). Urban students exhibited higher dietary quality indices in variety, adequacy, and overall Dietary Quality Index (DQI) (all $p<0.01$) compared to rural students. Private school students had better BMI and DQI scores than public school students, with significant differences in height, weight, variety, adequacy, and overall DQI (all $p<0.05$). Socioeconomic status significantly affected weight, BMI, variety, moderation, and overall DQI (all $p<0.05$). Furthermore, higher maternal education levels influenced dietary variety, adequacy, and overall DQI (all $p<0.001$). These findings highlight the importance of addressing maternal education and socioeconomic factors in enhancing the nutritional status of students.

Keywords:
Secondary school students; Malnutrition; Dietary Quality Index; Cross-sectional study

Citation:
Sophealeaksmy Em, Keisuke Teramoto, Kohei Yamada. Addressing the nutritional status of secondary school students in Cambodia: a cross-sectional study. J Public Hlth Dev. 2025;23(3):33-46
(https://doi.org/10.55131/jphd/2025/230303)

INTRODUCTION

In modern developing countries, malnutrition is a severe health issue resulting from poverty. The majority of malnourished children live in developing countries such as Asia, Africa, and South Africa.[1] Malnutrition occurs when the body cannot get food of sufficient quality and quantity, signified by thin arms and legs, scanty hair, and dry skin. The person may also be mentally dull and aggressive.[2] Additionally, malnutrition can have a psychosocial effect and result in brain damage, delayed physical growth, and intellectual development of students.[3] Gender, dietary intake, physical activity, environmental factors, socioeconomic status, parents' jobs, and parents' education levels contribute to students' nutritional status.[4]

Adolescence is a critical phase of life, characterized by rapid lifestyle changes and increased nutritional needs. Health education can prevent malnutrition and encourage the consumption of nutritious food for students' well-being.[5] Regional research in Southeast Asia demonstrated that adolescents were likely to eat fewer fruits and vegetables than the minimum amount recommended by the World Health Organization (WHO).[6] However, obesity is related to inappropriate dietary intake and is considered to be an important clinical, public health problem associated with metabolic risk factors.[7] Obesity can impact the immediate health, educational attainment, mental health, and quality of life of adolescents.[8]

To ensure physical growth, cognitive development, and productivity, students must balance their daily nutritional consumption.[9] Thus, students lacking adequate nutrition tend to achieve a lower academic performance and have poorer attendance compared to those who are well-nourished.[10] A research project in Thailand aimed to implement a variety of lunch menus in schools called the Thai School Lunch program to ensure students would have a proper balance of nutrients during school hours. Students would grow up with fundamental knowledge of what constitutes a healthy diet and practice proper eating habits.[11]

Cambodia is the least developed country, ranking 146 out of 189, and faces a high malnutrition rate among Asian nations.[12] Children aged 6–17 years represented 24.4% of the total population in 2013, while the height-for-age Z-score and BMI Z-score for school-age students are below the WHO standard in all ages and genders.[13] However, the National School Health Policy was created by the Prime Minister of Cambodia with the participation of all stakeholders aiming to improve school health, with 20 ministries working together to promote healthcare services for learners and personnel, nutrition, learning environments, personal culture, family, and social care.[14] In 2022, the Ministry of Education Youth and Sports published a standard operational guideline on school health, encouraging teachers and students to cooperate in raising awareness of school health education in Cambodia.[15]

Optimizing dietary intake among students is critical for their well-being and educational outcomes. Identifying and addressing the factors influencing dietary habits within the Cambodian context is essential for stakeholders. This study aims to assess the nutritional status and dietary quality of secondary school students in Cambodia and analyze how factors such as gender, school type, school location, socioeconomic status, and maternal education influence these outcomes. By exploring the connection between these variables and key indicators such as BMI and dietary quality scores, this study aims to fill the gap in region-specific research. This research provides actionable insights to guide targeted nutritional interventions and policy recommendations, ultimately supporting the health and educational attainment of Cambodian students.

The Dietary Quality Index (DQI) was first published globally in 1996.[16] It is an economic tool for assessing the dietary food intake of children and adolescents in developing countries. The intake of fruits, vegetables, whole grains, proteins, dairy, fatty acids, and sugar was used to provide an overall score that reflects the healthiness of the diet.[17] The DQI was used to assess the nutritional intake of secondary school students (school-aged children 6–17 years). Various applications of DQI are used in the context of different countries.

METHODOLOGY

Study Design

This is a descriptive cross-sectional study conducted from March to April 2024. The study aims to describe the nutritional status and dietary intake of secondary school students in Cambodia.

Study Population

The participants included current secondary school students from both urban and rural areas attending private and public schools across Cambodia. The students ranged from grades 7 to 12 and were aged between 10 to 18 years. Participants under 10, over 18 years old, or those not currently enrolled in secondary school were excluded from the study. Purposive sampling was utilized by selecting participants from distinct demographics and accessible schools with internet connections, allowing the data to be gathered within the available timeframe.

Data Collection

The questionnaires were distributed using Google Forms, with the link sent to high school students in Cambodia and their teachers. To ensure accessibility, the questionnaire was translated into Khmer to facilitate self-administered responses to both open and closed questions. The teacher-guided students in completing the questionnaire on their smartphones, ensuring confidentiality and obtaining informed consent. In contrast, the use of Google Forms may limit participation to those students with internet access. To minimize selection bias, the data collection took place in accessible schools with reliable internet connectivity. Additionally, a paper-based survey was provided to accommodate students without smartphones.

The questionnaire consisted of two main sections. The first section included questions on demographics such as gender, age, grade, location, school type, maternal education level, maternal occupation, socioeconomic status, income source, number of siblings, and birth order. Data on weight and height were also collected for BMI (kg/m^2) calculation. The second section evaluated the dietary intake through a modified version of the DQI-I questionnaire. Due to limited data availability, several adjustments were made to the original DQI-I regarding the scoring for moderation and balance. For instance, the maximum points for total fat and cholesterol were increased from the original 6 points to a new maximum of 9 points because data on saturated fat was unavailable. Additionally, modifications were made to the overall balance score. The original DQI-I assessed the fatty acid ratio (PUFA: MUFA: SFA); however, in this study, such data were not collected, and the other overall balance score based on macronutrient ratios was adjusted accordingly. The maximum score for this component was raised from 6 to 10 points.

The students completed a validated Food Frequency Questionnaire (FFQ). The FFQ data also detailed the grams of food consumed across various groups (rice, fruits, vegetables, etc.), which were then converted into daily serving sizes using the Recommended Dietary Guidelines for school-aged children in Cambodia.[18] The data obtained from the FFQ were used to develop a modified DQI-I score, serving as a composite measure of diet quality based on nutritional intake.

The DQI-I consisted of four main aspects: variety, adequacy, moderation, and overall balance. The scoring system ranged from 0 to 100 (0 being the poorest). The higher score indicates a healthier and good food consumption.

BMI scores were categorized into four groups: underweight (≤18.5), normal weight (18.5–24.9), overweight (25.0–29.9), and obesity (≥30) based on the healthy lifestyle WHO recommended (WHO, 2010). The socioeconomic status of students was defined by the assets owned by the household and categorized as low economic, middle economic, and high economic status.[19]

Data Analysis

Data analysis was conducted using SPSS V.25. Descriptive statistics summarized the demographic background of students. Inferential statistics, including t-test and one-way ANOVA, were used to assess the mean differences in continuous variables (e.g., BMI and dietary quality) across groups such as gender, school type, and school location. Chi-square tests examined associations in the categorical data. Assumptions of normality (Shapiro-Wilk) and homogeneity of variance (Levene's test) were verified with the significance level set at 0.05. In addition, confounders like age and socioeconomic status were accounted for using multivariable analyses to isolate the effects of primary variables, minimizing confounding influences.[20]

Table 1. Diet Quality Index-International (DQI-I) components, scores, cut-off points, and baseline proportions adapted from William et al. [21]

Components	Possible Points (pts)	Scoring
Variety	0–20 pts	
Overall food group variety	15 pts	≥ 1 serving from each food group/d
(meat/poultry/fish/eggs; dairy/beans;	12	Any 1 food group missing/d
grains; fruits; vegetables)	9	Any 2 food groups missing/d
	6	Any 3 food groups missing/d
	3	≥4 food groups missing/d
	0	None from any food groups
Within-group variety for protein	0–5 pts	
sources (meat, poultry, fish, dairy,	5	From ≥3 different sources/d
beans, eggs)	3	From 2 different sources/d
	1	From 1 source/d
	0	None
Adequacy	0–40 pts	
Vegetable group	0–5pts	
	5	3–5 servings/d
	0	0 servings/d
Fruit group	0–5 pts	
	5	2–4 servings/d
	0	0 servings/d
Grain group	0–5 pts	
	5	6–11 servings/d
	0	0 servings/d

Components	Possible Points (pts)	Scoring
Fiber	0–5 pts	
	5	≥ 30 g/d
	0	0 g/d
Protein	0–5 pts	
	5	≥ 10% of total energy/d
	0	0% of total energy/d
Iron	0–5 pts	
	5	≥ 100% RDA (AI)/d (15 mg)
	0	0% RDA (AI)/d
Calcium	0–5 pts	
	5	100% RDA (AI)/d (1300 mg)
	0	0% RDA (AI)/d
Vitamin C	0–5 pts	
	5	100% RDA (RNI)/d (75 mg)
	0	0% RDA (RNI)/d
Moderation	0–30 pts	
Total fat	0–9 pts	
	9	≤ 20% of total energy/d
	6	> 20–30% of total energy/d
	0	> 30% of total energy/d
Cholesterol	0–9 pts	
	9	≤ 300 mg/d
	6	> 300–400 mg/d
	0	> 400 mg/d
Sodium	0–6 pts	
	6	≤ 2400 mg/d
	3	> 2400–3400 mg/d
	0	≥ 3400 mg/d
Empty calorie foods	0–6 pts	
	6	≤ 3% of total energy/d
	3	> 3–10% of total energy/d
	0	> 10% of total energy/d
Overall balance	0–10 pts	
Carbohydrate: protein: fat ratio	10	55–65:10–15:15–25
(% of total energy)	7	52–69:9–16:13–27
	0	50–70: 8–17: 12–30

RESULTS

The analysis of demographic results revealed that the mean age of students was 16.55 years (±1.48), 10% of participants (n=153) were in junior high school, and 90% (n=1375) were senior high school students. In terms of gender, 630 students were boys (41.20%) and 898 girls (58.80%). The majority of participants lived in moderate-sized families with three siblings (36.40%), and 61.45% came from rural areas. The socioeconomic status was distributed as follows: 41.1% high, 28.9% medium, and 30% low. In terms of maternal education, 29.27% graduated with a high school degree, while 31.21% of mothers were housewives.

Table 2. Comparison of anthropometric and DQI scores based on **gender** analyzed by independent t-test

Variables	Boys (n=630)		Girls (n=898)		Gender		95% Confidence Interval of the Difference	
	Mean	SD	Mean	SD	t-value	p-value	Lower	Upper
Age (years)	16.80	1.48	16.38	1.47	5.479	<.001	0.269	0.569
Height (cm)	167.83	8.32	158.09	6.10	26.38	<.001	8.194	10.439
Weight (kg)	57.51	12.55	49.19	8.58	15.38	<.001	7.385	9.571
BMI (kg/m^2)	20.365	4.056	19.66	3.15	3.791	<.001	0.337	1.061
Variety	13.79	2.96	13.73	2.91	0.370	0.712	-0.243	0.355
Adequacy	22.10	8.45	21.65	8.29	1.034	0.300	-0.402	1.304
Moderation	19.04	4.61	19.32	4.95	-1.082	0.279	-0.762	0.220
Overall balance	3.31	1.31	3.32	1.33	-0.153	0.879	-0.146	0.125
DQI score	58.24	10.96	58.01	11.19	0.391	0.696	-0.906	1.358

Table 2 presents a detailed comparison of dietary quality and anthropometric measurements between boys and girls in the secondary school population, using independent t-tests for statistical analysis. Significant differences were observed in physical characteristics such as age, height, weight, and BMI with p-values of less than 0.001. Specifically, boys had a higher average BMI of 20.365 kg/m^2(SD=4.056) compared to girls, whose average BMI was 19.66kg/m^2 (SD=3.15), with a t-value of 3.791 (p<0.001).

In terms of dietary quality, no significant differences were observed between boys and girls. The DQI score (p=0.696), variety (p=0.712), adequacy (p=0.300), moderation (p=0.279), and overall balance (p=0.879) all showed p-values greater than 0.05, indicating no gender-based variation in these aspects. These results suggest that while anthropometric measurements differ significantly between boys and girls, their dietary quality intake remains comparable across genders.

Table 3. Comparison of anthropometric and DQI scores based on **school location** analyzed by independent t-test

Variables	Urban (n=589)		Rural (n=939)		School Location		95% Confidence Interval of the Difference	
	Mean	SD	Mean	SD	t-value	p-value	Lower	Upper
Age (years)	16.53	1.54	16.57	1.45	0.570	0.569	-0.109	0.198
Height (cm)	162.96	8.99	161.57	8.25	3.08	0.002	0.503	2.265
Weight (kg)	53.52	12.24	52.05	10.42	2.498	0.013	-2.61	0.316
BMI (kg/m^2)	19.879	3.342	20.074	3.901	-1.041	0.298	-0.591	-0.095
Variety	14.01	2.89	13.56	2.93	3.304	0.001	0.206	0.809
Adequacy	22.86	8.73	21.20	8.06	3.777	<.001	0.795	2.512
Moderation	19.25	5.28	19.17	4.50	0.314	0.753	-0.417	0.576
Overall balance	3.31	1.31	3.32	1.33	-0.041	0.968	-0.139	0.134
DQI score	59.48	11.75	57.24	10.58	3.853	<.001	1.099	3.377

Table 3 presents a comparison of anthropometric and dietary quality between students from urban (n=589) and rural (n=939) schools, analyzed using independent t-tests. Significant differences were found in height, weight, dietary variety, adequacy, and DQI scores. Urban students were significantly taller on average (162.96 cm) than rural students (161.57 cm), with a p-value of 0.002. They also weighed more (53.52±12.24 kg vs 52.05±10.52 kg) with a p-value of 0.013.

In terms of dietary quality, urban students scored higher in variety (p=0.001), adequacy (p<0.001), and DQI (p<0.001), indicating better overall dietary intake compared to rural students. No significant differences were observed in BMI (p=0.298), moderation (p=0.753), or overall balance (p=0.968), indicating that both urban and rural areas demonstrate similar patterns in these dietary quality measures.

Table 4. Comparison of anthropometric and DQI scores based on **school type** analyzed by independent t-test

Variables	Public (n=1325)		Private (n=203)		School Type		95% Confidence Interval of the Difference	
	Mean	SD	Mean	SD	t-value	p-value	Lower	Upper
Age (years)	16.55	1.47	16.57	1.59	-0.132	0.901	-0.109	0.198
Height (cm)	161.35	12.28	163.39	9.06	-2.273	0.023	-1.727	0.732
Weight (kg)	52.45	11.31	54.23	12.64	-2.067	0.039	-2.544	-0.174
BMI (kg/m^2)	19.91	3.51	20.21	3.92	-1.089	0.276	-0.155	0.054
Variety	13.66	2.92	14.36	2.93	-3.177	0.002	-1.132	-0.268
Adequacy	21.61	8.35	23.31	8.28	-2.652	0.007	-2.930	-0.462
Moderation	19.22	4.66	19.03	5.73	0.522	0.602	-0.523	0.902
Overall balance	3.30	1.30	3.37	1.48	-0.639	0.488	-0.266	0.127
DQI score	57.80	11.00	60.08	11.51	-2.726	0.006	-3.913	-0.638

Table 4 compares the anthropometric and dietary quality of students from public and private schools. Significant differences were found in height, with private school students being taller on average (163.39 cm) compared to public school students (161.35 cm) (p=0.023). Weight also showed a significant difference, with private school students weighing more (54.23 kg) than their public school counterparts (52.45 kg) (p=0.039).

In terms of dietary quality, private school students had significantly higher dietary variety (p=0.002), adequacy (p=0.007), and overall DQI scores (p=0.006), indicating better dietary intake.

However, no significant differences were observed in BMI (p=0.276), moderation (p=0.602), and overall balance (p=0.488), suggesting that students from both public and private schools exhibit similar patterns in these aspects. The results suggest that private school students may enjoy better overall dietary quality despite similarities in BMI and dietary moderation between the two groups.

Table 5. Comparison between anthropometric and DQI scores based on **socioeconomic status** analyzed by one-way ANOVA

		Sum of Square	d.f	Mean Square	F-value	p-value
Height	Between Group	179.264	2	89.632	.630	0.533
	Within Groups	216954.820	1525	142.265		
	Total	217134.083	1527			
Weight	Between Group	1423.448	2	711.724	5.407	**0.005**
	Within Groups	200723.609	1525	131.622		
	Total	202147.057	1527			
BMI Score	Between Group	104.22	2	52.11	4.191	0.017
	Within Groups	19342.34	1525	12.68		
	Total	19446.56	1527			
Variety	Between Group	853.632	2	426.816	53.044	<.001
	Within Groups	12270.858	1525	8.046		
	Total	13124.490	1527			
Adequacy	Between Group	321.839	2	160.919	2.304	0.100
	Within Groups	106505.878	1525	69.840		
	Total	106827.717	1527			
Moderation	Between Group	139.955	2	69.978	3.023	0.049
	Within Groups	35305.563	1525	23.151		
	Total	35445.518	1527			
Overall balance	Between Group	6.473	2	3.236	1.837	0.160
	Within Groups	2686.742	1525	1.762		
	Total	2693.215	1527			
DQI	Between Group	1502.904	2	751.452	6.142	0.002
	Within Groups	186589.132	1525	122.354		
	Total	188092.036	1527			

Table 5 presents a comparison between anthropometric and dietary indicators among students categorized by socioeconomic status (SES) using one-way ANOVA. The results indicate significant differences in weight (p=0.005), BMI (p=0.017), dietary variety (p<0.01), moderation (p=0.049), and DQI score (p=0.002), suggesting that these factors were positively influenced by higher SES. Conversely, height (p=0.533), adequacy (p=0.100), and overall balance (p=0.160) demonstrated no significant differences across the SES group, implying that these aspects remained largely unaffected by socioeconomic factors. Overall, the findings highlight that while SES plays a crucial role in determining weight, BMI, dietary variety, moderation, and DQI score, it does not significantly impact height, adequacy, or overall dietary balance among students.

Table 6. Comparison of anthropometric and DQI scores based on **mother's education** analyzed by one-way ANOVA

		Sum of Square	d.f	Mean Square	F-value	p-value
Height	Between Group	817.369	4	204.342	1.439	0.219
	Within Groups	216316.714	1523	142.033		
	Total	217134.083	1527			
Weight	Between Group	578.737	4	144.684	1.093	0.358
	Within Groups	201568.320	1523	132.350		
	Total	202147.057	1527			
BMI Score	Between Group	10.546	4	2.636	0.207	0.935
	Within Groups	19436.024	1523	12.762		
	Total	19446.569	1527			
Variety	Between Group	218.756	4	54.689	6.454	<.001
	Within Groups	12905.734	1523	8.474		
	Total	13124.490	1527			
Adequacy	Between Group	3892.979	4	973.245	14.400	<.001
	Within Groups	102934.738	1523	67.587		
	Total	106827.717	1527			
Moderation	Between Group	92.675	4	23.169	.998	0.407
	Within Groups	35352.843	1523	23.213		
	Total	35445.518	1527			
Overall balance	Between Group	9.211	4	2.303	1.307	0.265
	Within Groups	2684.004	1523	1.762		
	Total	2693.215	1527			
DQI	Between Group	6324.400	4	1581.100	13.248	<.001
	Within Groups	181767.636	1523	119.348		
	Total	188092.036	1527			

Table 6 presents the results of a one-way ANOVA analysis of the differences in dietary intake and anthropometric measurements based on the mother's education level. According to the analysis, there were no significant differences in weight, height, and BMI scores among the groups categorized by maternal education, with p-values of 0.358, 0.219, and 0.935, respectively.

In contrast, significant differences were found in dietary quality indicators. Specifically, dietary variety (p<0.001), dietary adequacy (p<0.001), and the DQI score (p<0.001) all showed substantial variations across groups. These findings suggest that a mother's education level plays a crucial role in shaping the dietary intake of children, particularly in terms of the variety and nutritional adequacy of their diets. However, no significant differences were observed in the moderation (p=0.407) and overall balance scores (p=0.265), indicating that these aspects of dietary intake were not influenced by the mother's education level. Overall, the analysis highlights the importance of maternal education in influencing children's dietary behaviors in Cambodia, particularly regarding the diversity and adequacy of their nutrition.

DISCUSSION

This cross-sectional study highlights the significant influence of gender, school type, school location, SES, and maternal education on the nutritional status of secondary school students in Cambodia.

The analysis revealed that boys tended to be taller, heavier, and have higher BMI scores than girls; however, both genders generally fell within the normal weight range (18.5–24.9). This difference may be attributed to the fact that boys and girls differ in several factors, such as body composition, hormonal biology and susceptibility to certain social influences, patterns of weight gain, and ethnic, genetic, and environmental factors.[22] Moreover, girls had stricter diets and were more concerned about their body image than boys.[23] Additionally, urban students exhibited better dietary quality, reflected in higher DQI scores, compared to their rural counterparts. Urban students often have greater access to a variety of healthy foods, while rural areas face significant challenges relating to food availability and economic constraints, consistent with the findings of Mam and colleagues on the limited food options in rural Cambodia.[24] The study also revealed that students from private schools outperformed those from public schools in terms of height, weight, and dietary variety, suggesting that private school students had better access to nutritious food. Students in private schools, both boys and girls, opted for more nutrient-dense and diverse snacks, while those in public schools primarily consumed lower-quality, energy-dense options like oily snacks and sweets. This difference can be attributed to inadequate enforcement of food safety regulations, leading to unhealthy snacks in the school canteens.[25] Moreover, SES was a significant determinant of dietary habits. Families with higher incomes provided a greater variety of food sources, leading to improved protein intake and overall dietary quality. In contrast, students from low-income families, particularly in rural areas, faced challenges in accessing healthy food, often relying more on unhealthy options such as sugary drinks and fast food.[26] Similarly, Divya et al. found a significant correlation between nutritional status and SES due to lower-income households with limited education and unskilled parents influencing the dietary intake of children.[27] Furthermore, maternal education emerged as a crucial determinant of children's dietary quality. Higher levels of maternal education correlated with better DQI scores, with educated mothers being more likely to provide nutritious and diverse food to their children.[28] The results align with those of a systematic review, which indicated that lower maternal education often led to a lack of knowledge on food consumption and was found to be a major factor in malnutrition among children and adolescents.[29]

CONCLUSION

In conclusion, this study highlights the significant differences in the nutritional status and dietary quality of secondary school students in Cambodia, influenced by gender, school type, school location, SES, and maternal education. The findings indicate that boys tend to have higher BMI and better dietary quality compared to girls, while urban students exhibit superior dietary diversity and adequacy compared to their rural counterparts. Private school students also demonstrate better nutritional outcomes than those in public schools. Both SES and maternal education affect the nutritional status of students. Improving maternal education and enhancing access to diverse and nutritious food options are essential for promoting the well-being of students.

LIMITATION

This study has several limitations that should be acknowledged. First, the cross-sectional design restricts the ability to establish causal relationships between nutritional status and various socio-demographic factors. Additionally, self-reported dietary intake can be subject to recall bias since students may not accurately remember their food consumption. The use of a single method to assess dietary quality, specifically the DQI-I, may not capture the full complexity of dietary habits.

AUTHOR CONTRIBUTIONS

Sophealeaksmy Em: Conceptualization, Methodology, Data Collection, Formal Analysis, Writing-Original Draft; Keisuke Teramoto: Supervision, Writing – Review & Editing. Kohei Yamada: Data Validation, Visualization, Writing – Review & Editing.

ETHICAL CONSIDERATION

Ethical approval for this study was obtained from the Ministry of Education, Youth and Sport (MoEYS), Cambodia, as part of the Physical Health Education Joint-Research Work under the Memorandum of Cooperation signed on March 16, 2021. Data collection approval was formally granted through a support letter issued by MoEYS on March 7, 2024, in response to a request from Professor Keisuke Teramoto, Department of Health and Physical Education, Aichi University of Education, Japan. Additional ethical clearance was granted by the Aichi University of Education, Japan, under its institutional review policy.

FUNDING

None to declare. The author(s) received no financial support for the research and/or publication of this article.

ACKNOWLEDGMENT

The authors would like to thank the educational research teams at Aichi University of Education (AUE) and the National University of Education (NIE) in Cambodia for conducting and modifying questionnaires. We are also grateful to the teachers and school directors of secondary schools in Cambodia for their support in data collection.

CONFLICT OF INTEREST

None to declare.

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