平和 4 年度　学位論文

ベトナムにおける小児肥満の要因

FACTORS OF CHILDHOOD OBESITY IN VIETNAM

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SUMMARY

Background and purpose:

In recent years, the increase in childhood obesity has been remarkable in Vietnam. According to the results of the National Nutrition Survey, in the decade from 2010 to 2020, the prevalence of overweight and obesity among 5-19 year old children almost doubled from 15.4% to 26.8% in urban areas and from 8.5% to 19% in whole country. Meanwhile, the prevalence of overweight and obesity in Japanese children was about 10%, one of the lowest in the world.

In simple terms, obesity is the result of an energy imbalance. Diet and physical activity, the risk factors most strongly related to obesity, have changed markedly since the onset of the obesity epidemic. In Vietnam, population-level studies on the relationship between lifestyles and childhood obesity typically focus on either physical activity or diet but seldom on both. Therefore, we conducted studies on dietary intake and physical activity in Vietnam. To define the obesity factors in Vietnam more clearly, we conducted nutrition survey and physical activity assessment in Japanese children and compared the results with Vietnamese.

Methods:

Study 1) Study on dietary intake and physical activity in Vietnamese children: A cross-sectional study was conducted on 134 children (73 boys and 61 girls) aged 10 years old at a public primary school in a Hanoi suburban. Height and weight were measured. Dietary intake was assessed by a 24-h dietary recall method for 7 days. Children were interviewed about daily activities for 7 days by questionnaire to estimate physical activity level.

Study 2) Comparison of dietary intake and physical activity between Vietnamese and Japanese children

2-1) Study on dietary intake in Japanese children: A nutrition survey was conducted on 60 children (31 boys and 29 girls) aged 10 years old in Okazaki city, Japan. Height and weight were measured. Dietary intake was assessed by a 24-h dietary recall method for a weekday and a weekend.

2-2) Study on physical activity in Japanese children in Tokyo suburban areas (35 boys and 43 girls).

Results:

Study 1) The prevalence of obesity in Vietnamese subjects was 30.6%. The average energy intake for seven days in non-obese and obese groups was similar, being 1895 ± 298 and 1881 ± 296 kcal/d, respectively ($p>0.05$). The physical activity level (PAL: Average metabolic equivalents: METs) was 1.48 in the non-obese group and 1.39 in the obese group ($p<0.001$).

Study 2-1) The prevalence of overweight and obesity in Okazaki city, Japan, was 11.6% and about 2.5 times lower than in Hanoi. There was no significant difference in energy intake of boys and girls between Hanoi and Okazaki at 1809±234 vs 1876±260 kcal/d and 1959±327 vs 2017±360 kcal/d, respectively ($p>0.05$).

Study 2-2) The PAL was higher for Japanese children (1.54) than for Vietnamese children (1.42) ($p<0.001$). Time spent in moderate to vigorous physical activity in Japanese children was about 2 times longer than for Vietnamese children.

Conclusion: The results of studies in Vietnam and Japan suggest that a high prevalence of obesity in Vietnamese children is not based on high energy intake but rather low physical activity. However, the obese children were already obese by the time of this study, and we cannot rule out the possibility that their intake was restricted or underreported. Further investigation is required in the future.

要旨

背景と目的:

近年、ベトナムでは小児肥満の増加が著しい。国民栄養調査の結果によると、2010 年から 2020 年までの 10 年間で、5 歳から 19 歳の子供の過体重と肥満の割合は、都市部では 15.4% から 26.8% に、全国では 8.5% から 19% にほぼ倍増した。一方、日本人の子供の過体重と肥満の割合は約 10% で、世界で最も低い国の 1 つである。肥満はエネルギー出納の不均衡の結果である。

ベトナムでは社会、経済などの変化により、エネルギーの摂取と消費が著しく変化した。多くの研究が行われてきたが、主にエネルギー摂取について調べられ、エネルギーの消費について少ない。さらに両方を同時に見た研究はほとんどない。　そこで、本研究では両者に焦点を与えて実施した。さらに、ベトナム小児の肥満要因をより明確に定義するために、日本人の子供たちとの比較検討も実施した。

方法:

研究 1）ベトナムの子供たちの食事摂取と身体活動に関する研究

ハノイ近郊の公立小学校に通う 10 歳の子供 134 名（男児 73 名、女児 61 名）を対象に横断研究を行った。身長と体重を測定した。食事摂取量は、24 時間食事想起法によって 7 日間調査した。身体活動レベルは、活動強度（METｓ）を用いて計算した。

研究 2）　ベトナムと日本の子供たちの食事摂取量と身体活動の比較

2-1）日本人小児の食事摂取に関する研究: 岡崎市の 10 歳児 60 名（男子 31 名、女子 29 名）を対象に栄養調査を実施した。身長と体重を測定した。食事摂取量は、平日と週末の 24 時間食事想起法によって 3 日間測定した。

2-2) 東京近郊の日本人児童(男児 35 名、女児 43 名)の身体活動レベルの研究：活動強度（METｓ）について時間調査を 3 日間行い、1 日当たりの平均活動強度を計算した。

結果：

研究 1）ベトナム人被験者の肥満率は 30.6% であった。非肥満群と肥満群

の 7 日間の平均エネルギー摂取量は類似しており、それぞれ 1895 ± 298 および 1881 ± 296 kcal/日であった(p>0.05)。平均身体活動レベル（PAL: 一日の平均 METs）は、非肥満群で 1.48、肥満群で 1.39 であった（p<0.001)。

研究 2-1） 日本の岡崎市における過体重・肥満の割合は 11.6% で、ハノイの約 2.5 分の 1 であった。男子と女子のエネルギー摂取量は、ハノイと岡崎でそれぞれ 1809±234 と 1876±260 kcal/日、1959±327 と 2017±360 kcal/日で有意差はなかった（p>0.05)。

研究 2-2） PAL は、ベトナムの子供（1.42）よりも日本人の子供（1.54）の方が高かった（p<0.001)。日本人の子供が中程度から激しい身体活動に費やした時間は、ベトナムの子供の約 2 倍であった。

結論: 以上の結果から、ベトナムの子供たちで肥満率が高いのは、エネルギー摂取量が多いことよりも、身体活動が少ないためであることが示唆された。しかしながら、肥満している子供達は、今回の研究までにすでに肥満しており、摂取量を抑制した可能性や過小報告があった可能性などを排除できない。今後さらなる検討が必要である。

STUDY 1

STUDY ON DIETARY INTAKE AND PHYSICAL ACTIVIY

IN VIETNAMESE CHILDREN

INTRODUCTION

Childhood obesity is one of the most serious global public health challenges of the 21st century, affecting every country in the world. In just 40 years the number of school-age children and adolescents with obesity has risen more than 10-fold, from 11 million to 124 million (2016 estimates) [1]. In Vietnam, childhood obesity has been on a rapid rise and become a public health concern, especially in big cities. In Hanoi, the capital city of Vietnam, the prevalence of overweight and obesity among 8–11 year-olds in 2003 was 7.5%, increasing to 12.9% in 2009 and 33.3% in 2018[2]. In Ho Chi Minh City, the largest city in Vietnam, the prevalence of overweight and obesity in children aged 7-9 and 10-11 years old in 2016 was 48.2%[3] and 53.5%[4], respectively.

Previous studies reporting on the prevalence of childhood obesity have shown continued increases in obesity during the past decade, with plateauing of obesity prevalence among some age groups. This is a concern as obese children have a higher risk of developing diseases including asthma and type 2 diabetes mellitus and are reported to have low self-esteem[5]. Once established, obesity tracks into adulthood and is associated with increased risk of cardiovascular disease and certain cancers[5]. Studies in Vietnam have suggested that obesity increased the risk for hypertriglyceridemia[6]. Addressing overweight and obesity will contribute to reducing deaths and increasing years of life lived[7].

In simple terms, obesity is the result of an energy imbalance. Diet and physical activity, the risk factors most strongly related to obesity, have changed markedly since the onset of the obesity epidemic[5]. Interventions that are successful in the prevention and management of childhood obesity are urgently needed. Understanding the relative importance of overconsumption and physical inactivity to excess weight gain among children can contribute to the development and evaluation of interventions and polices to reduce childhood obesity[8]. However, whether energy intake or expenditure is the dominant contributor to childhood obesity is a subject of debate. In the United States, the country with the highest rate of overweight and obese children in the world, there has been no consensus on the main driver of secular trends on weight gain among children[8]. In addition, population-level studies on the relationship between lifestyles and childhood obesity typically focus on either physical activity or diet but seldom on both[9]. Therefore, this study examined physical activity and dietary intake in relation to overweight and obesity in primary school children in a suburb of Hanoi, Vietnam.

1.1. METHODS

Participants

A total of 134 children (73 boys and 61 girls) in grade 5 (9-10 years old) at a public primary school in suburban Hanoi participated in this study. The school was selected by convenience sampling. All data were collected in October of 2020. Informed consent was obtained from the children, their guardians and teachers according to the Declaration of Helsinki, and the study protocol was approved by the Biomedical Research Ethics Committee of Hanoi Medical University (no. 355/HMUIRB).

Figure 1. Administrative map of Hanoi city and study location

Figure 2. The study protocol was explained to principals and teachers

Anthropometric characteristics

Height and weight were measured to the nearest 0.1 cm and 0.1 kg using a stadiometer (Seca 213) and a digital scale (OMRON HBF354IT). Children were measured with light clothing without shoes or hair ties. All measurements were conducted three times and the mean was calculated. Child's age was calculated by month based on the date of birth and survey date. The nutritional status of the children was determined based on the WHO growth reference for those aged 5-19 years old. Height-for-age z-score and BMI-for-age z-score were determined using the software WHO AnthroPlus version 1.0.4 for children above five years of age. Interpretation of cut-offs of BMI-for-age z-score is >+1SD for overweight, >+2SD for obesity, and <-2SD for thinness. Weight-for-age reference data are not available beyond age 10 because this indicator does not distinguish between height and body mass in an age period where many children are experiencing the pubertal growth spurt and may appear as having excess weight (by weight-for-age) when in fact they are just tall. Therefore, in the present study, weight-for-age z-score was not calculated.

Figure 3. Measurement children's height and weight

Dietary assessments

Dietary intake was assessed by a 24-hour dietary recall questionnaire for seven days using standard food measures and a food photobook published by Vietnamese National Institute of Nutrition during interviews to estimate portion size. When children couldn't remember exactly what they had eaten, we contacted the caregiver to reconfirm. The nutritional value of food was calculated based on the Vietnam Food Composition Table published by the Ministry of Health and Vietnam National Nutrition Institute[10]. Sugar intake was estimated from reports of various food sugar concentrations [11].

Figure 4. Interviewing children about dietary intake

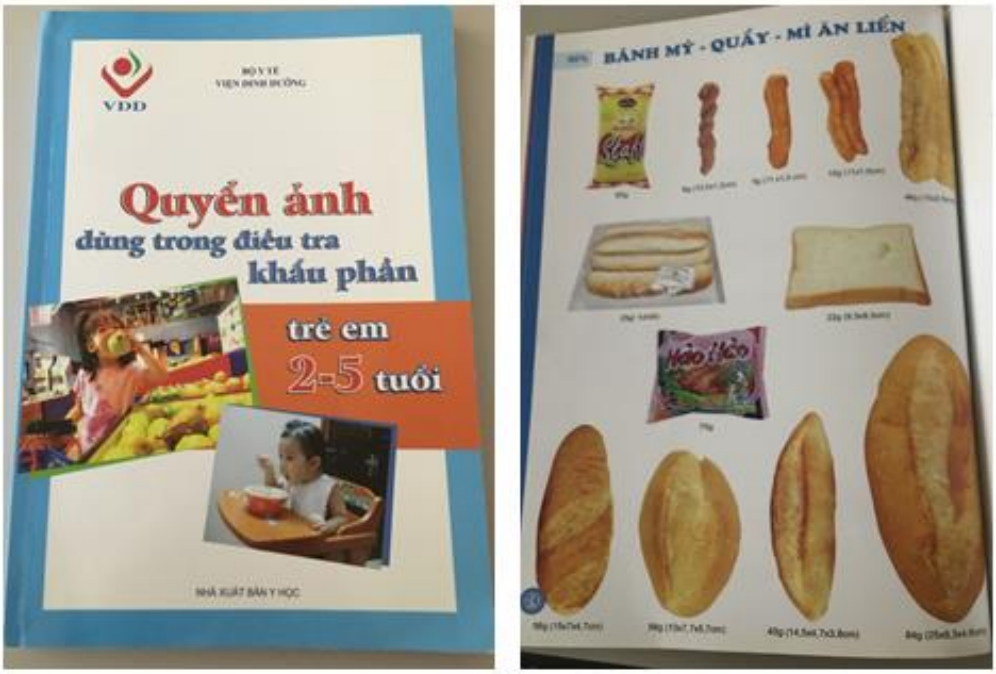


Figure 5. Food photobook published by Vietnamese National Institute of Nutrition

Physical activity assessments

The 7-day minute-by-minute activity record was used to assess the physical activity level. The activity record form is designed based on the template developed by Koebnick et.al[12]. Children were instructed to name the activity and the intensity of the activity with 3 levels of light, moderate and vigorous, and mark the start and end times for each activity. The recording method was explained to teachers, children and their guardians with an example of a completed physical activity form. We asked teachers and guardians to help the children to complete the activity record. When collecting the activity record form, we interviewed children to improve the accuracy of the activity record by adding and correcting the content regarding omissions and unclear points.

Figure 6. Interviewing children about physical activity

PHYSICAL ACTIVITY RECORD

Date:____________________ Gender: ______________ Class:_______

	0	1	2	3	4	5	6	7	8	9	10	11
AM												
	12	1	2	3	4	5	6	7	8	9	10	11
PM												

① Sleep

② Read (reading), writing, TV, listening to music (including radio), resting, listening to stories,

Talking (including phone calls), classes (including cram schools), homework, personal computers, games

③ Meals

④Chat

⑤ Getting dressed (washing up, changing clothes), Playing a musical instrument (both standing and sitting), sewing

⑥ Cleaning

⑧ Walk slowly

⑯Sit down and ride (car, bus, train, etc.)

⑰Ride while standing (bus or train)

⑲ Playing in the sand, playing house, dancing, playing in the schoolyard/park (horizontal bar, swing, jungle gym, tree climbing, swing

⑨Walk at normal speed

⑩Walk while carrying something (bag, luggage)

⑪Walk fast

⑫ Run slowly and lazily

⑮ Normal speed bicycle

⑳ Ball Throw, Dodgeball, Baseball, Softball

⑬ Run normally to fast

㉒ Tennis, Volleyball, Badminton, Judo, Kendo

㉓ Soccer, Rugby, Basketball

㉔ Swimming, strength training

㉕Other:..................................

㉖ Other:..................................

㉗ Other:..................................

㉘ Other:..................................

Figure 7. Physical activity recording form

Table 1. METs value of physical activities

	Sedentary and Light (< 3 METs)		Moderate (3-6 METs)		Vigorous (>6 METs)	
	Activity	METs	Activity	METs	Activity	METs
	② Read (reading),	1.2	⑨Walk at normal	3.3	⑬ Run normally	7.2
	writing, TV, listening to		speed		~ fast	
	music (including radio),		⑩Walk while	3.6	㉒ Tennis,	7.2
	resting, listening to		carrying something		Volleyball,	
	stories,		(bag, luggage)		Badminton, Judo,	
	Talking (including		⑪Walk fast	4.7	Kendo	
	phone calls), classes		⑫ Run slowly and	4.7	㉓ Soccer,	8.2
	(including cram schools),		lazily		Rugby, Basketball	
	homework, personal		⑮ Normal speed	3.8	㉔ Swimming,	
	computers, games		bicycle		strength training	11.0
	③ Meals		⑳ Ball Throw,	3.2		
	④Chat	1.3	Dodgeball, Baseball,			
	⑤ Getting dressed	1.6	Softball			
① Sleep:	(washing up, changing	1.4				
0.9	clothes)					
	Playing a musical					
	instrument (both standing					
	and sitting)					
	sewing					
	⑥ Cleaning					
	⑧ Walk slowly	1.7				
	⑯Sit down and ride (car,	2.7				
	bus, train, etc.)	1.7				
	⑰Ride while standing					
	(bus or train)	2.2				
	⑲ Playing in the sand,					
	playing house, dancing,	2.9				
	playing in the					
	schoolyard/park					
	(horizontal bar, swing,					
	jungle gym, tree climbing,					
	swing)					

Statistical analysis

The physical activity level (PAL) was calculated based on the following formula:

PAL = $\sum$24h {MET value of physical activity x time (min) } /1440

In which the MET value of physical activity was referenced from the compendium of physical activities of Ainsworth et al.[13]

The time spent in each physical activity intensity each day was calculated using METs for each participant: average minutes spent in sedentary and light physical activity (METs< 3), moderate to vigorous physical activity (METs ≥3.0).

All statistical analyses were performed using SPSS software (version 26; IBM Corporation, Armonk, New York). The data were expressed as mean±SD or %. The study analyses involved comparisons between the non-obese and obese groups. Differences between groups were assessed using independent *t*-tests for continuous data and chi-squared tests for categorical data. A multiple linear regression was used to predict BMI-for-age z-score based on gender (coded as 1=girl and 2=boy), physical activity level (PAL) and energy intake (kcal).Formula of multiple linear regression is $y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + ... + \beta_p x_{ip} + \epsilon$ where, for $i=n$ observations: y_i=dependent variable, x_i = explanatory variable, β_0=y-intercept (constant term), β_p=slope coefficients for each explanatory variable, ϵ=the model's error term (also known as the residuals). P values less than 0.05 were defined as a statistical difference.

1.2. RESULTS

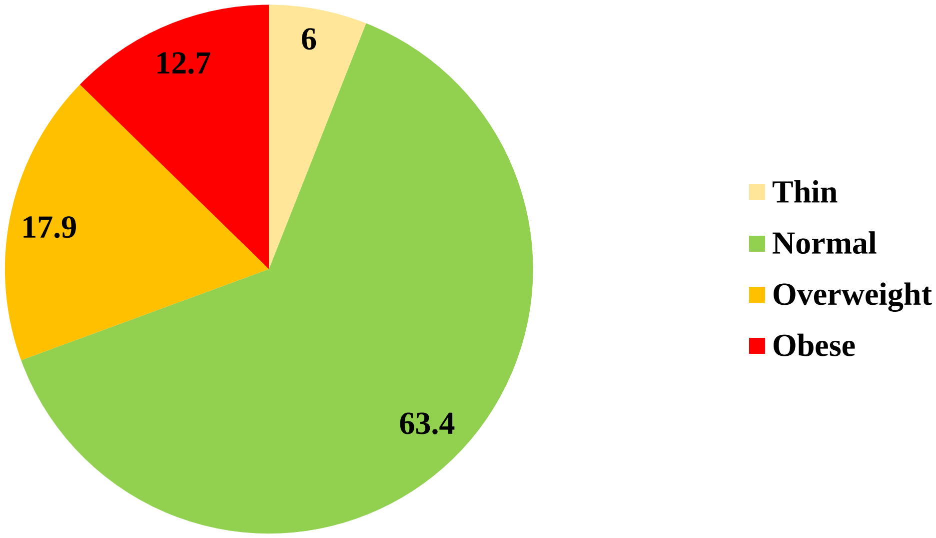


Figure 8. Weight status of children assessed by BMI-for-age z-score (n=134)

Figure 8 shows the weight status of all the children. The prevalence of overweight and obesity in children aged 10 years old was very high, about 30.6%. There prevalence of thinness in children was low at 6% and their average of BMI for age z-score was -2.12 SD near the cut-off point of normal level. Therefore, the following results were presented in non-obese group consisting of thin and normal children and obese group including overweight and obese children.

Table 2. Characteristics of child subjects (n=134)

	Girls (n=61)	Boys (n=73)	*p*-value†
Age (months)	123.3±3.5	123.0±3.1	0.723
Height-for-age z-score	-0.36±0.81	-0.19±1.06	0.305
Weight (kg)	32.4±5.7	36.0±8.3	**0.006**
BMI-for-age z-score	-0.1±1.2	0.7±1.3	**0.000**
Weight status (%)			
Non-obese	78.7	61.6	**0.008**
Obese	21.3	38.4	

Abbreviation: BMI, body mass index

Values are mean±SD and %. †Independent *t*-test except Chi-squared test for weight status (%). Significant difference: $p<0.05$.

Characteristics of children are summarized in **Table 2**. No statistically significant differences were observed between the boys and girls with regard to age, height-for-age z-score and BMI-for-age z-score. However, the prevalence of overweight and obesity in boys was significantly higher than in girls at 38.4% and 21.3%, respectively (p=0.008).

Table 3. Energy and nutrient intakes by genders and groups (n=134)

	Girls			Boys		
	Non-obese (n=48)	**Obese (n=13)**	***p*-value†**	**Non-obese (n=45)**	**Obese (n=28)**	***p*-value†**
Energy intake (kcal/d)	1798±241	1850±209	0.482	1998±321	1896±331	0.197
Protein intake (g/d)	74±23	73±14	0.876	82±24	81±28	0.886
Protein intake (% EI)	16.6±6.0	15.6±1.5	0.596	16.4±3.6	17.2±6.0	0.472
Lipid (g/d)	59±13	62±15	0.544	64±17	64±14	0.996
Lipid intake (% EI)	29.7±4.8	30.1±5.6	0.801	28.6±4.9	30.3±3.9	0.137
Carbohydrate (g/d)	252±38	260±34	0.459	280±45	253±50	**0.021**
Carbohydrate intake (% EI)	56.0±4.6	56.4±5.5	0.794	56.3±5.0	53.5±5.0	**0.023**
PFC ratio	16.6:29.7:56.0	15.6:30.1:56.4	0.983	16.4:28.6:56.3	17.2:30.3:53.5	0.933
Fiber intake (g/d)	3.9±1.4	3.6±1.0	0.583	4.3±1.7	4.2±2.0	0.736
Sugar intake (g/d)	28±16	29±8	0.945	29±17	26±12	0.398

Abbreviation: EI, energy intake, PFC ratio, a ratio of energy from Protein, Fat, and Carbohydrates
Values are mean±SD and %. *P*-values were computed using an Independent *t*-test with significant difference at $p<0.05$.

Average energy and nutrients intakes in the 7-day nutritional survey are shown in **Table 3.** There were no significant differences between non-obese and obese children in the intakes of energy, protein, lipid intake, PFC ratio, fiber and sugar in both genders. However, carbohydrate intake or boys was significantly higher in thin and normal children than in overweight and obese children ($p<0.05$).

Table 4. Physical activity of children with non-obese and obese girls and boys

	Girls			Boys		
	Non-obese (n=48)	**Obese (n=13)**	***p*-value†**	**Obese (n=13)**	**Non-obese (n=48)**	***p*-value†**
Physical activity level (PAL)	1.44±0.11	1.34±0.12	**0.002**	1.48±0.12	1.41±0.13	**0.018**
Sleeping time (min/d)	622±38	616±40	0.684	618±49	599±46	0.111
Sedentary to light physical activity (min/d)	730±49	763±55	**0.038**	717±67	765±62	**0.003**
Moderate to vigorous physical activity (min/d)	90±38	66±28	**0.044**	108±45	80±31	**0.005**
Percentage of children walking or biking to school (%)	47.9	61.5	0.093	46.7	60.7	0.046
Minutes spent walking or biking to school a day	7±9	9±9	0.513	7±9	6±7	0.743

Values are mean±SD and %. †Independent *t*-test except Chi-squared test for walking or biking to school (%). Significant difference: $p<0.05$.
PAL was calculated by ∑24h｛MET value of physical activity x time (min) ｝/1440 min. It is the same as the average METs.

Table 4 shows the physical activity of children. The physical activity level in the obesity group was significantly lower than in the non-obese group. Obesity children spent more time in sedentary to light activities than non-obese children. Time spent on moderate to vigorous physical activity in obese children was less than in non-obese children. There were no significant differences in sleeping time, the number of children walking or cycling to school, or the time spent walking or cycling between obese children and non-obese children.

Table 5: Multiple linear regression predicting BMI-for-age z-score of children (N=134)

Predictor	Estimate	Standard Error	t-statistic	*p*-value
Constant	1.7688	1.2906	1.3705	0.1729
Gender	0.8885	0.2225	3.9935	0.0001
PAL	-1.8491	0.8943	-2.0676	0.0407
Energy intake	-0.0001	0.0004	-0.1878	0.8513
Adjust R^2 =0.11, R^2 = 0.13, F(3, 120) = 6.33, p <0.001				

Abbreviation: PAL, physical activity level
Significant difference: p<0.05
PAL was calculated by ∑24h｛MET value of physical activity x time (min) ｝/1440 min. It is the same as the average METs.

A multiple linear regression was used to predict BMI-for-age z-score based on gender, PAL and energy intake (**Table 5**). The regression was statistically significant and the three predictors explained 11% of the variance (R^2 = 0.13, F (3, 120) = 6.33, p <0.001). Participants' predicted BMI-for-age z-score is equal to 1.7688 + 0.8885(GENDER) – 1.8491(PHYSICAL ACTIVITY LEVEL) – 0.0001(ENERGY INTAKE), where gender is coded as 1=girl and 2=boy, physical activity level is measured in PAL and energy intake is measured in kcal. Children's BMI-for-age z-score increased 0.0001 for each kcal of energy intake and decreased 1.85 for each PAL of physical activity and BMI-for-age z-score in boys was higher than in girls at 0.89. Gender and physical activity level were significant predictors BMI-for-age z-score at p=0.0001 and p<0.05, respectively. It was found that energy intake did not significantly predict BMI-for-age z-score (p= 0.8513)

1.3. DISCUSSION

The purpose of the present study was to examine physical activity and dietary intake in relation to overweight and obesity in children aged 10 years old in Hanoi, Vietnam. We found that in Vietnamese children the high prevalence of obesity was based on low physical activity rather than high energy intake. Most of the previous trials to control obesity were focused mainly on energy intake such as prevention by reducing/limiting junk foods and sweet foods and beverages[14, 15]. However, the results of the present study suggest that the strategy of obesity control in Vietnamese children should be focused on increasing physical activity levels.

Obesity rate:

The mixed obesity rate for girls and boys was about 31%. These results were similar to data from the National Nutrition Survey in Hanoi in 2018[2], which showed an obesity rate of 33.3% for 8-10 years old, indicating that our subjects were generally representative of children in Hanoi. The obesity rate is quite high but it is similar to that of most of East Asian countries and other parts of the world (26%) [16], with the exception of Japan[17]. For Japanese children of a similar age group, the obesity rate was 8% (11%) in 2020[18], which was perhaps the lowest in the world for this age.

Accuracy of the results

Results of 24-h dietary recall nutrition surveys are often underestimated because subjects forget some foods that they have eaten, especially with children. Such underestimated problems can be improved with the help of parents[19]. Surveys for a full week show more accurate results than surveys for 3 days, which are often used. In the present study, the survey was 7 days and children's parents cooperated. Through these efforts we believe that the reliability of this nutrition survey was greatly improved.

Concerning the accuracy of estimations of physical activity, there may be some limitations. Most of the previous studies in Vietnam were measurements of steps or described activity levels such as low, moderate and high[4, 20]. However such methods do not indicate the PAL. To define PAL more accurately, we used a time-study method. Subjects and their parents wrote down the time in minutes spent in various activities for 7 days. PAL was calculated using the measured time of various activities and metabolic equivalents (METs) [13].

Energy, nutrient and sugar intakes:

The average energy intakes for seven days in the non-obese and obese groups were 1895 ± 298 and 1881 ± 296 kcal/d, respectively (p>0.05). Major energy source (carbohydrate, lipids, and protein) intakes were similar in all the groups except carbohydrate intake in boys. The energy ratio for these nutrients (percentages from protein, lipid and carbohydrate) was 16: 30:54, which was similar as that of Japanese[21]. This ratio is consistent with WHO recommendations[22]. In the present study, there was no difference between the energy intake of obese and non-obese children. However, previous studies showed that obese children and their parents often underreport food intake[23, 24]. Moreover, Nakano et al. indicated that the highest percentages of obese boys were found when they were 8-9 years old and the girls' highest percentage of obesity was observed at 6 years old, and then it decreased[25]. The subjects in the present study were 10-year-old children, so the possibility that the energy intake of obese children could not be excluded was controlled. Usually, to reduce energy intake, Asians tend to cut down on rice intake. This was also observed during the dietary intake interviews of obese children in Vietnam. In the present study, the carbohydrate intake of obese children was approximately 27g per day less than that of non-obese children ($p<0.05$).

In many countries, high intake of sugar is an important factor for obesity. Some countries fine products with high sugar concentrations[26]. In North and South American and European countries, the intake is nearly 100g a day[27, 28]. WHO recommends energy from sugar at less than 10% and further suggests 5%, which are about 50g or 25g sugar a day[22]. Nowadays, sugar includes not only sucrose but isomerized sugars (fructose and glucose) made from starch is common because it is cheap and tasty at lower temperatures. Luckily, in Vietnam, there is a sugar composition table that includes sucrose, fructose, glucose and lactose[11]. In this study we used the composition table and calculated sugar intake. It was similar in all groups, being less than 30g/day, which meets the WHO recommendation.

Physical activity:

In the present study the clearest differences between obese and non-obese children were physical activity level (PAL). The multiple linear regression showed the most relevant factor for body weight was PAL with a *p*-value less than 0.05 (**Table 5**).

Differences in average PAL per day between the non-obese and obese groups were 0. 1 in girls and 0.07 in boys. Since the average basic metabolic rates per day for 10 year girls and boys are 1200 kcal and 1330 kcal, respectively[29], a difference in energy expenditure was 120 kcal/day (1200 kcal x 0.1) in girls and in boys about 90 kcal/day (1330 kcal x 0.07) in boys. Since they are daily differences, it is not small. Such differences were caused by the different amount of time spent in activities.

Time spent in sedentary to light activities in obese children was about 30 minutes and 50 minutes longer in girls and boys, respectively, than in non-obese children. On the contrary, time spend in moderate to vigorous activity was 25 minutes longer for non-obese girls and boys than obese ones (**Table 4**). In Vietnam, parents take children to school by car or motorcycle because traffic makes walking unsafe. It is easy to think that such a life-style is one of the major factors in obesity; however, between non-obese and obese children in both genders he time spent commuting to school on foot or bicycle was short and not different (**Table 4**), indicating that the travel method to and from school is not a major factor in obesity.

Many previous studies have shown that sleep duration is negatively correlated with BMI[30, 31]. However, in the present study, there was no difference in sleep duration between the non-obese and obese children.

Gender difference:

Consistent with findings from several previous studies assessing the weight status of Vietnamese children, the prevalence of overweight and obesity in boys was significant higher than in girls[4, 32-34]. The higher prevalence of overweight and obesity in boys could be explained by the different social expectations about weight and body shape for boys and girls[33, 35]. In Vietnam, society typically places more importance on males compared with females, resulting in boys being fed and taken care of very well[33].

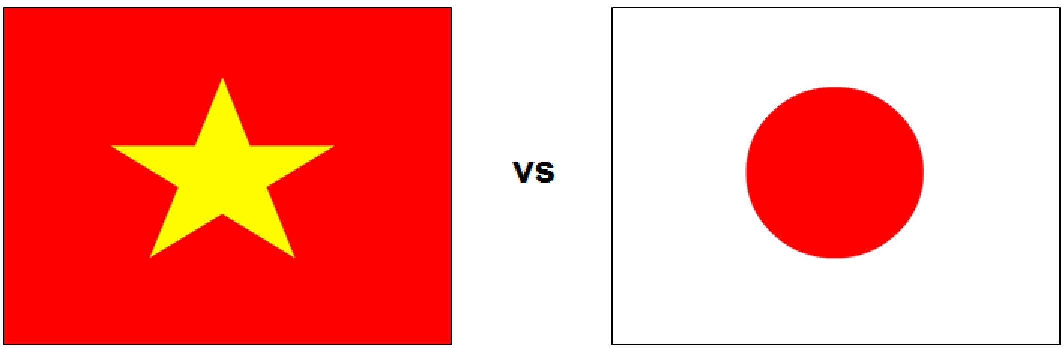
Multiple linear regression predicting BMI-for-age z-score of children

In present study, the multiple linear regression was used to predict BMI-for-age z-score based on gender, PAL and energy intake (**Table 5**). A regression was statistically significant and the three predictors explained 11% of the variance. It proves that some independent factors were not included in the BMI-for-age z-score prediction model. The previous studies indicated that parents' BMI, parents' perception of their child's body shape, duration of breast feeding, stunted growth, and socioeconomic condition as independent factors of BMI-for-age z-score[3, 33-40]. There is a need for a more comprehensive evaluation of the factors affecting BMI-for-age z-score in the future. However, the present study results indicated that energy intake was not an independent factor affecting BMI-for-age z-score while physical activity and gender were predictors.

The results of studies in Vietnam and Japan suggest that a high prevalence of obesity in Vietnamese children is not based on high energy intake but rather low physical activity. However, the obese children were already obese by the time of this study, and we cannot rule out the possibility that their intake was restricted or underreported. Further investigation is required in the future.

STUDY 2

COMPARISON OF DIETARY INTAKE AND PHYSICAL ACTIVITY BETWEEN VIETNAMESE AND JAPANESE CHILDREN



INTRODUCTION

In recent years, the increase in childhood obesity has been remarkable in Vietnam. According to the results of the National Nutrition Survey, Vietnam, in the decade from 2010 to 2020, the prevalence of overweight and obesity among 5-19 year olds almost doubled from 15.4% to 26.8% in urban areas and from 8.5% to 19% in rural areas[41]. Meanwhile, the prevalence of overweight and obesity in Japanese children was about 11%, one of the lowest in the developed countries[17]. Therefore, many countries have taken Japan as a model to compare and find solutions to overcome overweight and obesity. The low prevalence of obesity in Japan can be explained through healthy lifestyle habits that the Japanese population have continued over time[42]. The nation-wide school lunch program in Japan is noteworthy not only for its nutritional accomplishments, but also for its educational, social, and cultural aspects[43]. Japanese school lunch program is believed to contribute to the formation of healthy eating habits as well as control the rate of overweight and obesity in children[43]. In addition, the Japan Sports Association published a guideline entitled "Active Child 60 min"[44]. The main target were pre-school and primary school children (Japan Sports Association 2010). Moreover, Japan has high rates (98.3%) of active transport to school among children in public school compared with other similar-income countries[45]. Japan has a highly established "walking to school practice"[45]. The average person in Japan is thought to consume approximately 200 kcal fewer calories of energy intake than an average American person daily and the Japanese are also far more physically active than Americans[42]. A previous study showed that average height, weight, BMI, prevalence of overweight and obesity of Chinese children were greater compared with those of Japanese children[45]. The differences were predicted with respect to physical activity status socioeconomic status and dietary habit [45]. However, physical activity and dietary habits of children in the two countries were not investigated. Vietnam is a developing country, so the difference in nutritional status of Vietnamese and Japanese children may be due to other reasons compared to developed countries. In addition, the prevalence of overweight and obesity in children is increasing in many other developing countries in Asia[47-50]. A comparison of the nutritional status, dietary intake and physical activity between Vietnamese and Japanese children could be a reference for other developing countries in Asia.

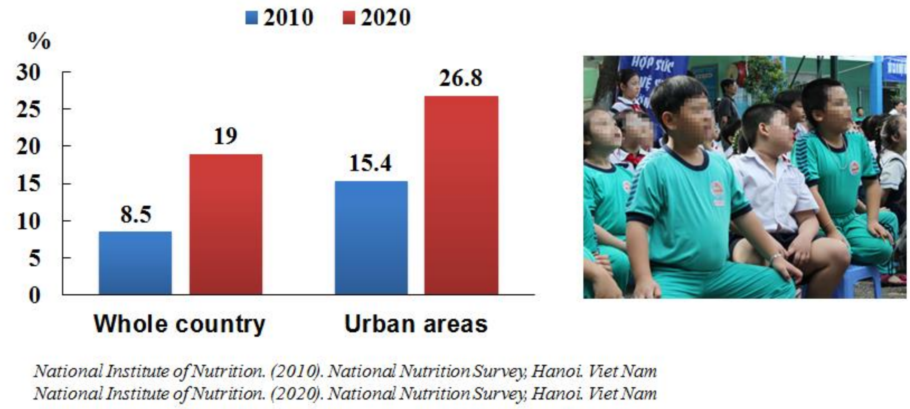


Figure 9. Prevalence of overweight and obesity in children aged 5-19 years old in Vietnam

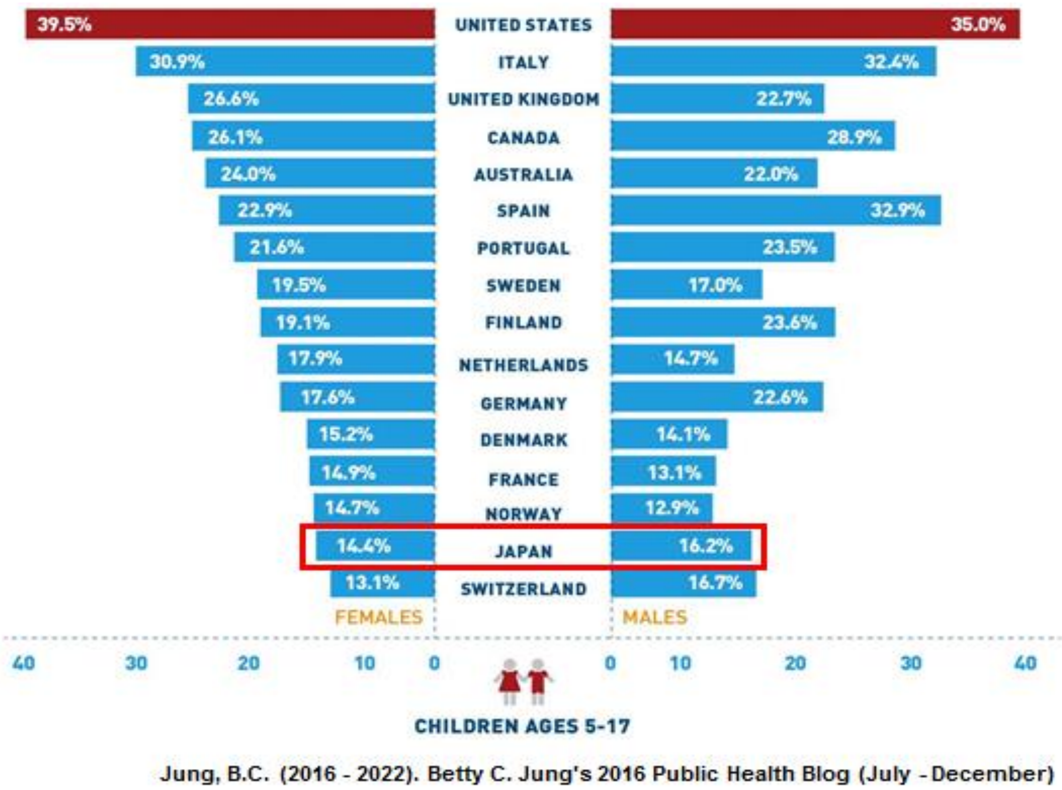


Figure 10. Prevalence of overweight and obesity in children in some countries around the world

2.1. STUDY ON DIETARY INTAKE IN JAPANESE CHILDREN

2.1.1. METHODS

Purposes

Assessment of energy intake of 10-year-old children at an elementary school in Okazaki city and comparison with data of children in Hanoi city.

Participants

A total of 60 children (31 boys and 29 girls) aged 10 years old at all elementary school in Okazaki city (core city in central Japan) participated in this study. All data were collected in November of 2018. Informed consent was obtained from the children, their guardians and teachers according to the Declaration of Helsinki, and the study protocol was approved by the City Board of Education.

Anthropometric characteristics

Height and weight were measured to the nearest 0.1 cm and 0.1 kg using a stadiometer (Seca 213) and a digital scale (OMRON HBF354IT). Children were measured with light clothing without shoes or hair ties. All measurements were conducted three times and the mean was calculated. Child's age was calculated by month based on the date of birth and survey date. The nutritional status of the children was determined based on the WHO growth reference for those aged 5-19 years old. Height-for-age z-score and BMI-for-age z-score were determined using the software WHO AnthroPlus version 1.0.4 for children above five years of age. Interpretation of cut-offs of BMI-for-age z-score is >+1SD for overweight, >+2SD for obesity, and <-2SD for thinness. Weight-for-age reference data are not available beyond age 10 because this indicator does not distinguish between height and body mass in an age period where many children are experiencing the pubertal growth spurt and may appear as having excess weight (by weight-for-age) when in fact they are just tall. Therefore, in the present study, weight-for-age z-score was not calculated.

Dietary assessments

Dietary intake was assessed by a 24-hour dietary recall questionnaire for a weekday and a weekend using standard food measures and food models to estimate portion size. When children couldn't remember exactly what they had eaten, we contacted the caregiver to reconfirm. The nutritional value of food was calculated based on the Japanese Food Composition Table.

Statistical analysis

All statistical analyses were performed using SPSS software (version 26; IBM Corporation, Armonk, New York). The data were expressed as mean±SD or %. The study analyses involved comparisons between Okazaki city and Hanoi suburban (Study 1). Differences between groups were assessed using independent *t*-tests for continuous data and chi-squared tests for categorical data. P values less than 0.05 were defined as a statistical difference.

2.1.2. RESULTS

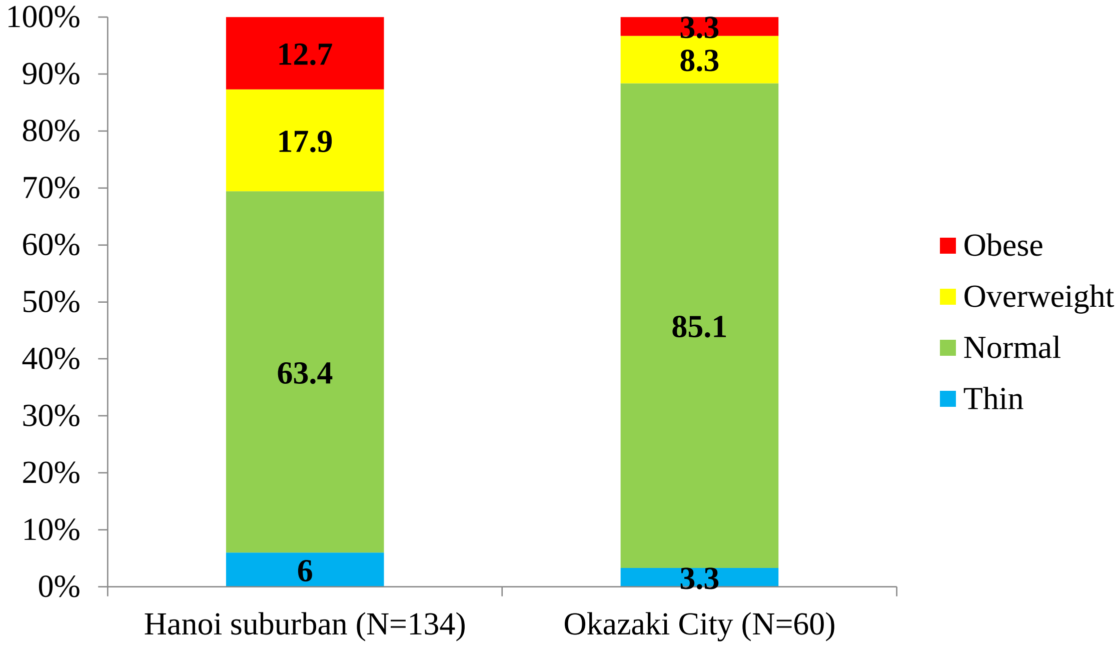


Figure 11. BMI status in children aged 10 years old in Hanoi suburban and Okazaki city

Figure 11 shows BMI status in children aged 10 years old on Hanoi suburban and Okazaki city. The prevalence of thinness in Hanoi suburban and Okazaki city were low at 6% and 3%, respectively. The prevalence of normal children in Okazaki city was higher than the figure for Hanoi suburban at 85.1 and 63.4%, respectively. The prevalence of overweight and obesity in Hanoi suburban was 2.5 times higher than that of Okazaki city at 30.6 and 11.6%, respectively.

Table 6. Characteristics of child subjects in Hanoi suburban (N=134) and Okazaki city (N=60)

	Girls			Boys		
	Hanoi (n=61)	**Okazaki (n=29)**	***p*-value†**	**Hanoi (n=73)**	**Okazaki (n=31)**	***p*-value†**
Age (months)	123.3±3.5	129.6±4.8	**<0.001**	123.0±3.1	129.6±4.8	**<0.001**
Height-for-age z-score	-0.36±0.81	-0.01±1.17	0.102	-0.19±1.06	0.18±0.99	0.100
Weight (kg)	32.4±5.7	35.3±6.6	**0.039**	36.0±8.3	36.6±7.2	0.717
BMI-for-age z-score	-0.1±1.2	-0.3±1.0	0.478	0.7±1.3	0.2±1.1	0.058
Weight status (%)						
Non-obese	78.7	96.6	**<0.001**	61.6	80.6 [a]	**0.003**
Obese	21.3	3.4		38.4	19.4	

Abbreviation: BMI, body mass index

Values are mean±SD and %. †Independent *t*-test except Chi-squared test for weight status (%). Significant difference: $p<0.05$.

[a] : There was no thin children.

Non-obese: thin and normal; Obese: overweight and obese

Characteristics of child subjects are summarized in **Table 6**. The age in months of children in Okazaki city was about 6 months higher than that of children in Hanoi (p<0.001). The weight of girls in Okazaki city was higher than that of Hanoi suburban at 35.3±6.6 vs 32.4±5.7 kg ($p<0.05$), respectively. Meanwhile, there was no significant differences in weight between Okazaki city and Hanoi suburban at 36.6±7.2 and 36.0±8.3 kg ($p>0.05$), respectively. There was no significant differences in height-for-age z-score and BMI-for-age z-score between Hanoi suburban and Okazaki city for both gender. However, the prevalence of non-obese and obese in Hanoi suburban was significantly higher than those in Okazaki city for both gender.

Table 7. Comparison of energy and nutrient intakes between Hanoi suburban (N=134) and Okazaki city (N=60) by gender

	Girls			Boys		
	Hanoi (n=61)	**Okazaki (n=29)**	***p*-value†**	**Hanoi (n=73)**	**Okazaki (n=31)**	***p*-value†**
Energy intake (kcal/d)	1809±234	1876±260	0.223	1959±327	2017±360	0.426
Protein (g)	73±21	69±10	0.318	82±25	74±13	0.093
Protein (% EI)	16.4±5.4	14.8±1.4	0.128	16.7±4.7	14.7±1.7	**0.018**
Lipid (g)	60±14	62±14	0.430	64±16	69±17	0.112
Lipid (% EI)	29.8±4.9	29.9±4.6	0.884	29.3±4.6	30.7±4.1	0.126
Carbohydrate (g)	253±37	259±44	0.519	270±49	274±48	0.694
Carbohydrate(% EI)	56.1±4.8	55.3±5.1	0.445	55.2±5.1	54.6±4.3	0.576
PFC ratio (%)	16.4:29.8:56.1	14.8:29.9:55.3	0.970	16.7:29.3:55.2	14.7:30.7:54.6	0.925

Abbreviation: EI, energy intake; PFC ratio, a ratio of energy from Protein, Fat, and Carbohydrates

Values are mean±SD and %. †Independent *t*-test except Chi-squared test for PFC ratio (%). Significant difference: $p<0.05$.

Table 7 shows the comparison of energy and nutrient intakes between of children aged 10 years old between Hanoi suburban and Okazaki city by gender. There was no significant differences in energy intake between Hanoi suburban and Okazaki city for both gender at 1809±234 vs 1876±260 kcal/d in girls and 1959±327 vs 2017±360 kcal/d in boys, respectively. PFC ratios of children in Hanoi suburban and Okazaki city was similar and met the WHO recommendation. Protein intake of boys in Hanoi suburban was significant higher than that of boys in Okazaki city at 16.7±4.7 and 14.7±1.7 g ($p<0.05$), respectively.

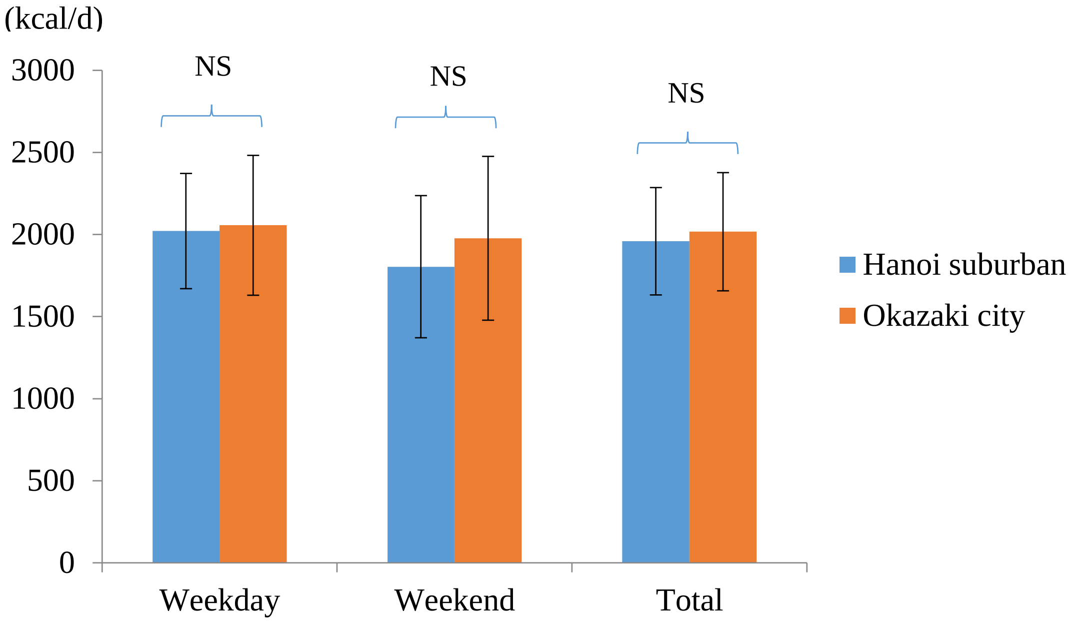


Figure 12. Comparison of energy intake of weekday and weekend in boys between Hanoi suburban (n=73) and Okazaki city (n=31)

Abbreviation: NS, non-significant differences.

All values are mean±SD. *P*-values were computed using an Independent *t*-test. All the data were similar between the groups.

Figure 12 shows comparison of energy intake of weekday and weekend in boys between Hanoi suburban and Okazaki city. There was no significant diffrences in boys' energy intake on weekday between Hanoi suburban and Okazaki city at 2021±351 and 2056±426 kcal/d, respectively. Similarly, the energy intake of boys at weekend in Hanoi suburban did not differ with that of Okazaki city at 1804±433 and 1977±499 kcal/d, respectively.

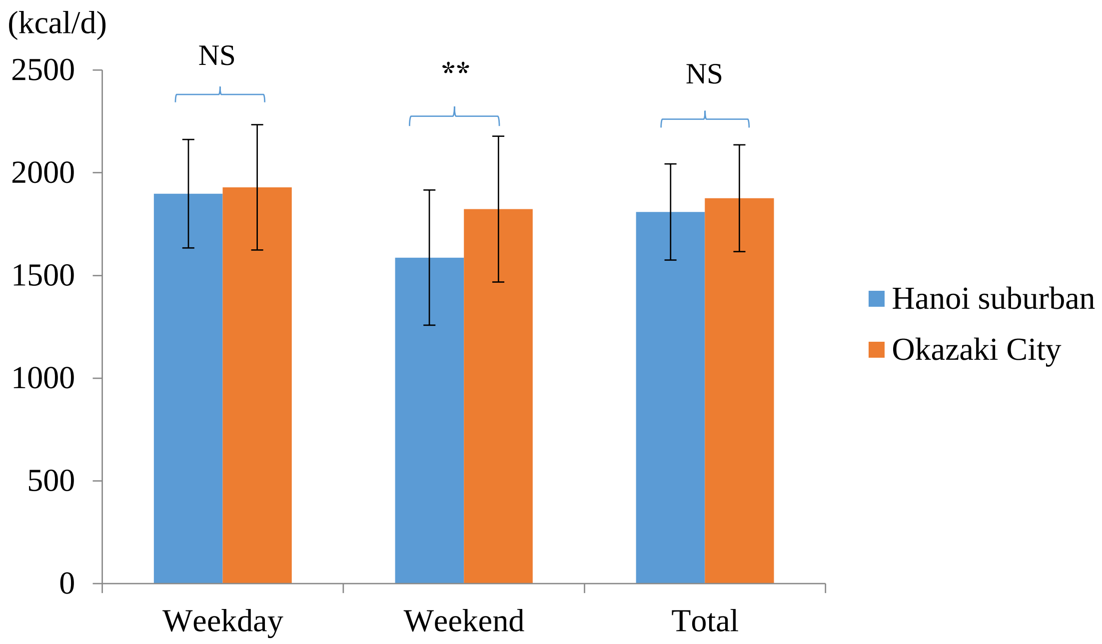


Figure 13. Comparison of energy intake of weekday and weekend in girls between Hanoi suburban (n=61) and Okazaki city (n=29)

All values are mean±SD. *P*-values were computed using an Independent *t*-test. All the data were similar between the groups.

NS: non-significant differences and **: significant differences at $p<0.01$.

Figure 13 shows comparison of energy intake of weekday and weekend in girls between Hanoi suburban and Okazaki city. There was no significant diffrences in girls' energy intake on weekday between Hanoi suburban and Okazaki city at 1898±264 and 1929±305 kcal/d, respectively. In constract, energy intake of girls in Okazaki city at weekend was significant higher than in Hanoi suburban at 1823±355 and 1587±329 kcal/d, respectively. However, there was no significant differences in average energy intake of weekday and weekend between Hanoi suburban and Okazaki city.

2.2. STUDY ON PHYSICAL ACTIVITY IN JAPANESE CHILDREN

2.2.1. METHODS

Purposes

Assessment of physical activity of 10-year-old children at an elementary school in Tokyo suburban and comparison with data of children in Hanoi suburban.

Participants

A total of 78 children (35 boys and 43 girls) aged 10 years old at an elementary school in Tokyo suburban participated in this study. All data were collected in November of 2022. Informed consent was obtained from the children, their guardians and teachers according to the Declaration of Helsinki.

Physical activity assessments

The 3-day minute-by-minute activity record was used to assess the physical activity level. The activity record form (**Figure 7**) is designed based on the template developed by Koebnick et.al[12]. Children were instructed to name the activity by number shown in **Table 1**. The recording method was explained to teachers, children and their guardians with an example of a completed physical activity form. We asked teachers and guardians to help the children to complete the activity record. When collecting the activity record form, we interviewed children to improve the accuracy of the activity record by adding and correcting the content regarding omissions and unclear points.

Statistical analysis

The physical activity level (PAL) was calculated based on the following formula:
PAL = ∑24h {MET value of physical activity x time (min)} /1440 (minutes of 24 hours)
In which the MET value of physical activity was referenced from the compendium of physical activities of Ainsworth et al.[13]

The time spent in each physical acitivity intensity each day was calculated using METs for each participant: average minutes spent in sedentary and light physical activity (METs< 3), moderate to vigorous physical activity (METs ≥3.0).

All statistical analyses were performed using SPSS software (version 26; IBM Corporation, Armonk, New York). The data were expressed as mean±SD or %. The study analyses involved comparisons between Tokyo suburban and Hanoi suburban (Study 1). Differences between groups were assessed using independent *t*-tests and dependent *t*-tests for continuous data and chi-squared tests for categorical data. P values less than 0.05 were defined as a statistical difference.

2.2.2. RESULTS

Table 8. Comparison of physical activity in children aged 10 years old between Hanoi suburban (N=134) and Tokyo suburban (N=78) by gender

	Girls			Boys		
	Hanoi (n=61)	Tokyo (n=43)	*p*-value†	Hanoi (n=73)	Tokyo (n=35)	*p*-value†
Physical activity level (PAL)	1.40±0.12	1.45±0.10	**0.027**	1.45±0.13	1.69±0.15	**<0.001**
Sleeping time (min/d)	621±38	554±37	**<0.001**	611±49	572±56	**<0.001**
Sedentary to light physical activity (min/d)	737±52	733±66	0.719	736±69	693±108	**0.020**
Moderate to vigorous physical activity (min/d)	85±37	153±59	**<0.001**	97±43	175±93	**<0.001**
No. of children walking or biking to school (%)	50.8	100	**<0.001**	52.1	100	**<0.001**
Walking or biking to school (min/d)	7±9	26±11	**<0.001**	7±8	24±9	**<0.001**

Values are mean±SD and %.

†Independent *t*-test except Chi-squared test for walking or biking to school (%). Significant difference: $p<0.05$.

PAL was calculated by ∑24h ｛MET value of physical activity x time (min)｝/1440 min. It is the same as the average METs.

Table 8 shows the comparison of physical activity in children aged 10 years old between Hanoi suburban and Tokyo suburban. The PAL of girls and boys in Tokyo suburban were significantly higher than those of Hanoi suburban at 1.45±0.10 vs 1.40±0.12 ($p<0.05$) and 1.69±0.15 vs 1.45±0.13 ($p<0.001$), respectively. Sleeping time of girls and boys in Hanoi suburban were significantly longer than those of Tokyo suburban at 67 and 39 min ($p<0.001$), respectively. Time spent for moderate to vigorous physical activity of girls and boys in Tokyo suburban was significantly higher than those of Hanoi suburban at 153±59 vs 85±37 min/d ($p<0.001$) and 175±93 vs 97±43 min/d ($p<0.001$), respectively. 100% children in Tokyo suburban walked to school while there was about 50% children in Hanoi suburban walked or biked to school. The commute time from school for children in Tokyo was about 3 times longer than that of Hanoi suburban ($p<0.001$).

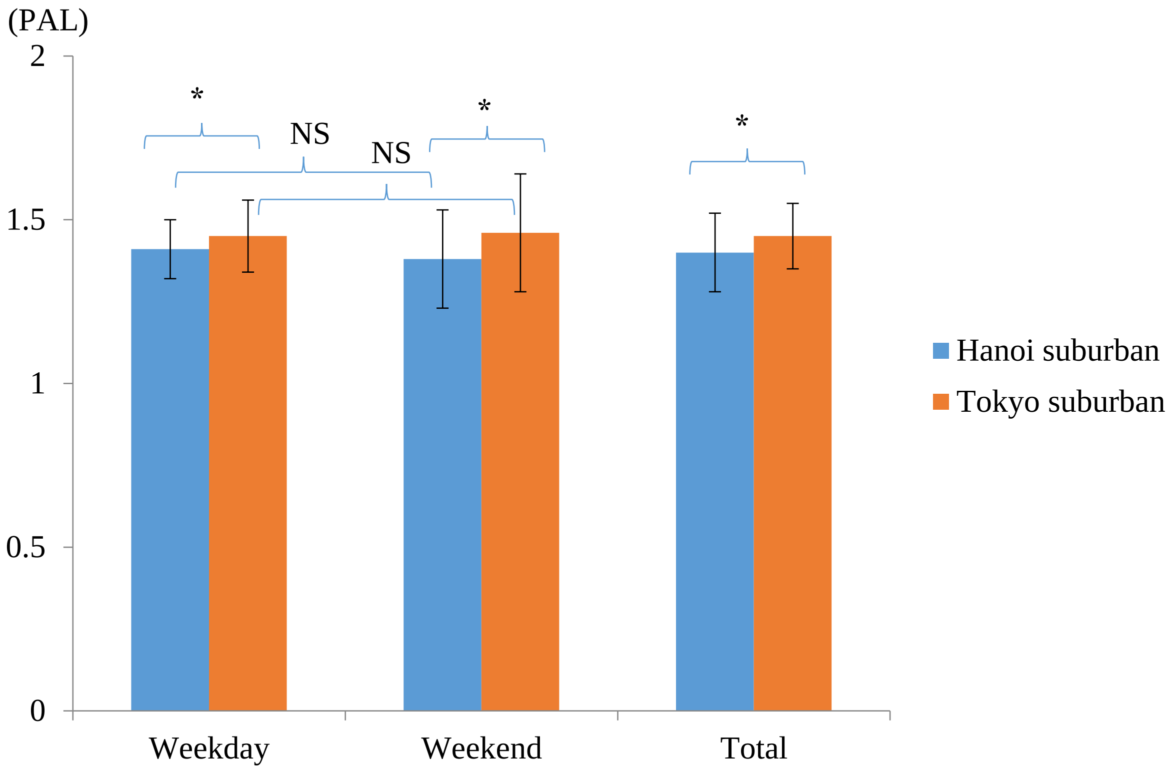


Figure 14. Comparison of PAL on weekdays and weekends between Vietnamese (n=61) and Japanese girls (n=43)

All values are mean±SD. *P*-values were computed using an independent *t*-test between groups and a dependent *t*-test within group.

NS: non-significant differences and *: significant differences at $p<0.05$.

Figure 14 shows the comparison of PAL on weekdays and weekends between Vietnamese and Japanese girls. The PAL of girls on weekdays and weekends in Tokyo suburban was significantly higher than those of Hanoi suburban were 1.45±0.11 vs 1.41±0.09 ($p<0.05$) and 1.46±0.18 vs 1.38 ±0.15 ($p<0.05$), respectively. In overall, there was no significant differences between PAL on weekdays and weekends in both Tokyo and Hanoi suburban ($p>0.05$).

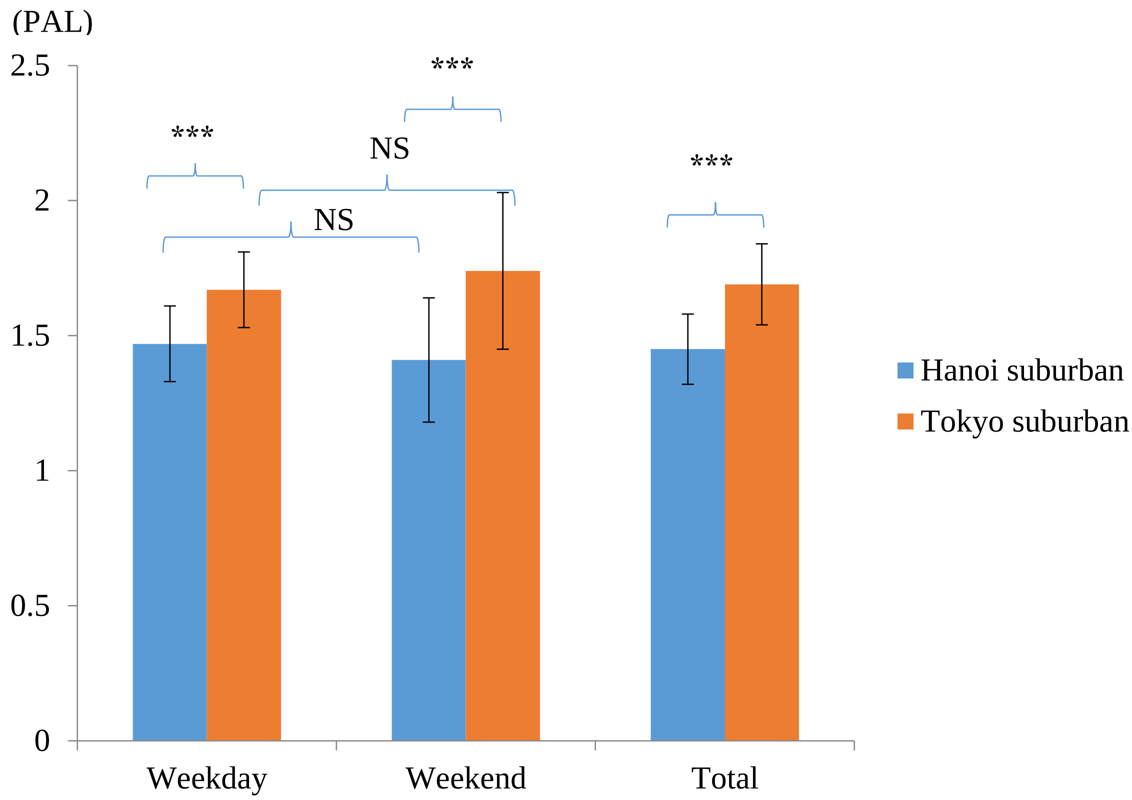


Figure 15. Comparison of PAL on weekdays and weekends between Vietnamese (n=73) and Japanese boys (n=35)

All values are mean±SD. *P*-values were computed using an independent *t*-test between groups and a dependent *t*-test within group.

NS: non-significant differences and ***: significant differences at $p<0.001$.

Figure 15 shows the comparison of PAL on weekdays and weekends between Vietnamese and Japanese boys. The PAL of boys on weekdays and weekends in Tokyo suburban was significantly higher than those of Hanoi suburban were 1.67±0.14 vs 1.47±0.14 ($p<0.001$) and 1.74±0.29 vs 1.41±0.23 ($p<0.001$), respectively. In overall, there was no significant differences between PAL on weekdays and weekends in both Tokyo and Hanoi suburban ($p>0.05$).

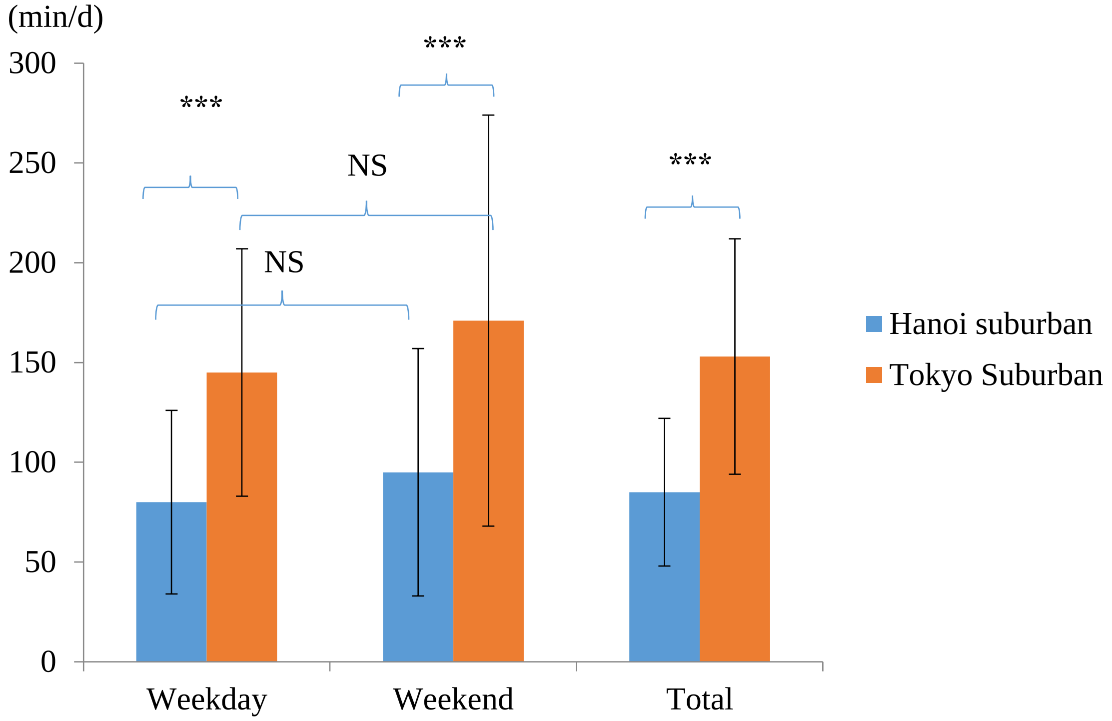


Figure 16. Comparison of time spent on moderate to vigorous physical activity on weekdays and weekends between Vietnamese (n=61) and Japanese girls (n=43)

All values are mean±SD. *P*-values were computed using an independent *t*-test between groups and a dependent *t*-test within group.

NS: non-significant differences and ***: significant differences at $p<0.001$.

Figure 16 shows the comparison of time spent on moderate and vigorous physical activity on weekdays and weekends between Vietnamese and Japanese girls. Average time spent on moderate to vigorous physical activity of girls on weekdays and weekends in Tokyo suburban was significantly higher than those of Hanoi suburban were 145±62 vs 80±46 min/d ($p<0.001$) and 171±103 vs 95±62 min/d ($p<0.001$), respectively. In overall, there was no significant differences between average time spent on moderate to vigorous physical activity on weekdays and weekends in both Tokyo and Hanoi suburban ($p>0.05$).

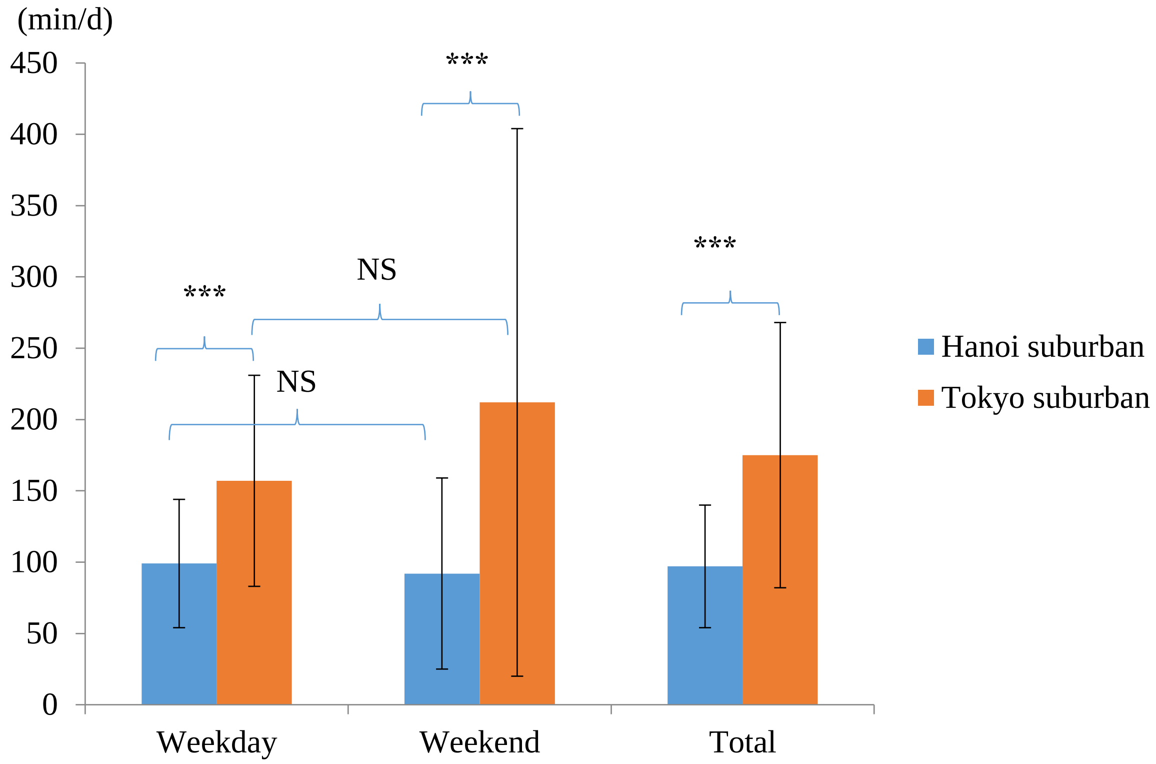


Figure 17. Comparison of time spent on moderate and vigorous physical activity on weekdays and weekends between Vietnamese (n=73) and Japanese boys (n=35)

All values are mean±SD. *P*-values were computed using an independent *t*-test between groups and a dependent *t*-test within group.

NS: non-significant differences and ***: significant differences at $p<0.001$.

Figure 17 shows the comparison of time spent on moderate and vigorous physical activity on weekdays and weekends between Vietnamese and Japanese boys. Average time spent on moderate to vigorous physical activity of boys on weekdays and weekends in Tokyo suburban was significantly higher than those of Hanoi suburban were 157±74 vs 99±45 min/d ($p<0.001$) and 212±192 vs 92±67 min/d ($p<0.001$), respectively. In overall, there was no significant differences in average time spent on moderate to vigorous physical activity between weekdays and weekends in both Hanoi and Tokyo suburban ($p>0.05$).

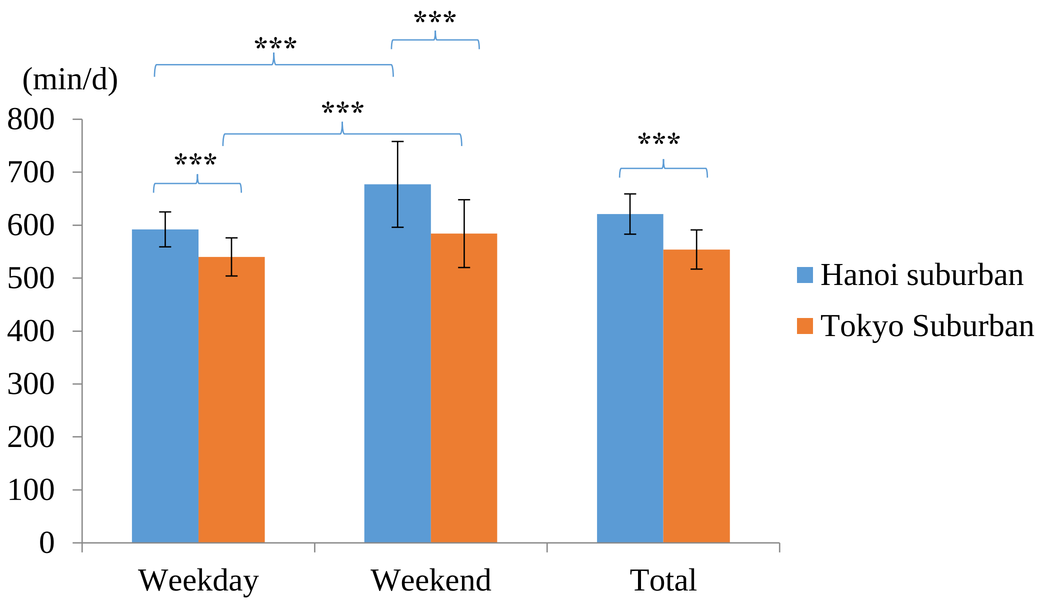


Figure 18. Comparison of sleeping time on weekdays and weekends between Vietnamese (n=61) and Japanese girls (n=43)

All values are mean±SD. *P*-values were computed using an independent *t*-test between groups and a dependent *t*-test within group.

NS: non-significant differences and ***: significant differences at $p<0.001$.

Figure 18 shows the comparison of sleeping time on weekdays and weekends between Vietnamese and Japanese girls. Average sleeping time of girls on weekdays and weekends in Tokyo suburban was significantly shorter than those of Hanoi suburban were 540±36 vs 592±33 min/d ($p<0.001$) and 584±64 vs 677±81 min/d ($p<0.001$), respectively. In addition, sleeping time on weekends in Hanoi and Tokyo suburban were 85 and 44 min higher than on weekdays, respectively ($p<0.001$).

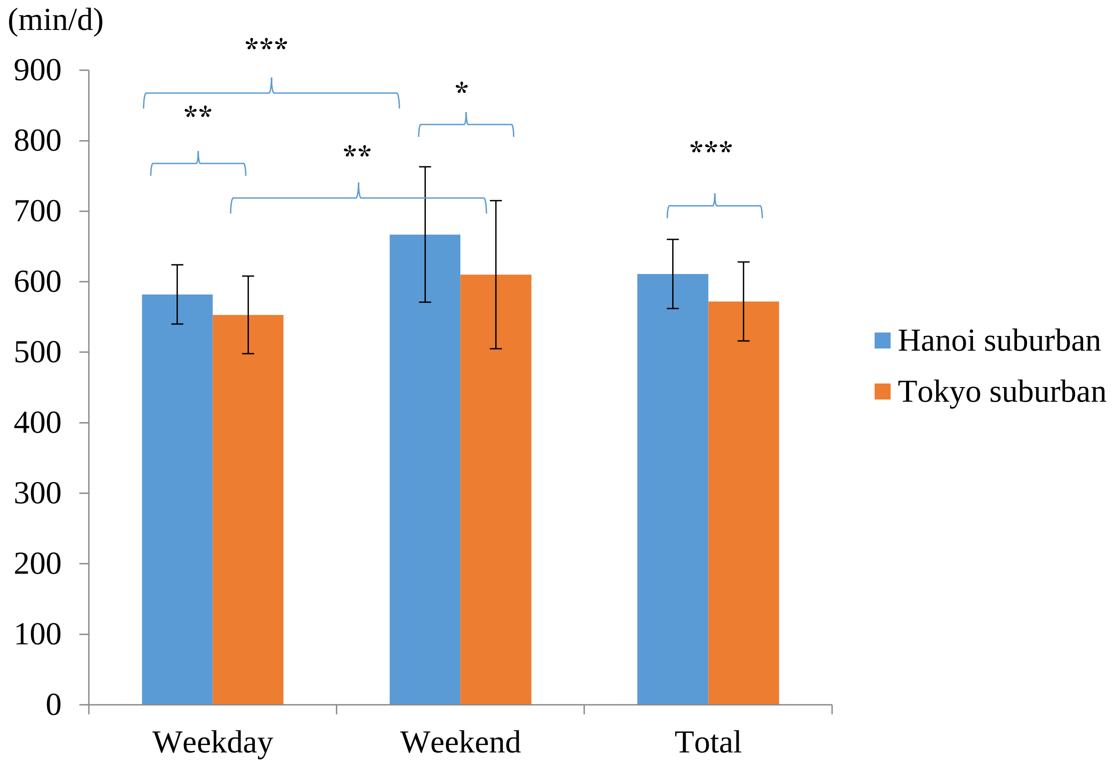


Figure 19. Comparison of sleeping time on weekdays and weekends between Vietnamese (n=73) and Japanese boys (n=35)

All values are mean±SD. *P*-values were computed using an independent *t*-test between groups and a dependent *t*-test within group.

NS: non-significant differences and *, **, ***: significant differences at $p<0.05$, $p<0.01$ and $p<0.001$, respectively.

Figure 19 shows the comparison of sleeping time on weekdays and weekends between Vietnamese and Japanese boys. Average sleeping time of boys on weekdays and weekends in Tokyo suburban was significantly shorter than those of Hanoi suburban were 553±55 vs 582±42 min/d ($p<0.01$) and 610±105 vs 667±96 min/d ($p<0.05$), respectively. In addition, sleeping time on weekends in Hanoi and Tokyo suburban were 85 min ($p<0.001$) and 44 min ($p<0.01$) higher than on weekdays, respectively.

DISCUSSION

The purposes of the present study was to compare the dietary intake and physical activity in children aged 10 years old between Hanoi and Japan. Despite being a developing country, the overweight and obesity rate of Vietnamese children was nearly 2.5 times higher than that of a developed country, Japan. There was no difference in average energy intake between Vietnamese and Japanese children constant physical activity level of Japanese children was higher than that of Vietnamese children. This result is consistent with the study 1 that the strategy of childhood obesity control in Vietnam may focus on improving physical activity than controlling energy intake.

Regarding the dietary intake assessment method, with the same 24-hour dietary recall method, the study in Vietnam was conducted for seven days but the study in Japan was conducted on a weekday and a weekend. The reason is that previous research has shown that to assess the dietary intake of primary school children that two days was the number of necessary days[51]. The energy intake Japanese children were assessed at two different locations and years. However, the energy intake of Japanese children had almost no difference between regions and has not changed in recent years[52-54]. In terms of physical activity assessment, the Japanese Ministry of Education applied the physical activity record method for three non-consecutive days[55]. The studies were all conducted around October-November of the year and in suburban area to reduce spatial and temporal errors.

In the present study, the height of Japanese children was higher than that of Vietnamese children, which is similar to youth as well. However, after puberty, this difference is reduced in both sexes. The data from the Vietnam National Nutrition Survey in 2020 showed that the average height of young Vietnamese men and women was 168.1 and 156.2 cm, respectively[56]. According to the world population review in 2006, the average height of young Japanese men and women was 172.0 and 158.0 cm, respectively[57]. However, the difference in height and age in months was not the cause of the difference in overweight and obesity rates among Vietnamese and Japanese children because there was no significant difference in BMI-for-age z-score in both gender. In other words, taller children often weigh more than other children. The prevalence of overweight and obesity among boys is higher than that of girls in Vietnam and Japan. Differences in obesity prevalence may be driven by gender-related influences, such as societal ideals about body weight and parental feeding practices, as well as sex-related influences, such as body composition and hormones[55, 56].

The present study found that there was no difference between the energy intake of Vietnamese and Japanese children in both sexes. The average energy intake of girls in Hanoi suburban and Okazaki city was 1809±234 and 1876±260 kcal/d, respectively, Compared with the results from the 2007 Japanese Ministry of Education's nutritional survey, the average energy intake of 10-year-old girls was 1868±285 kcal/d. Thus, the energy intake of girls in Okazaki city has no difference from the average energy intake of the whole of Japan and no difference from the average energy intake of girls in Hanoi suburban. In addition, the PFC ratio of children's dietary intake in the two countries did not differ and meet the WHO recommendation[22]. According to Japanese Ministry of Health, Labor and Welfare report in 2022, since 1970, energy intake of Japanese has been on a downward trend from 2026 to 1849 kcal/d[60]. In contrast, energy intake among US children increased +179 kcal/day from 1977-2006[3]. In Japan, school meal programs play an active role in controlling children's energy intake. According to the Japanese Ministry of Health, Labor and Welfare reported in 2022, 97.4% of primary school children eat lunch at school[60]. Providing balanced nutrition lunch helps parents feel secure to let their children eat lunch at school without having to let their children bring more food from home to school or give them extra pocket money to buy other food. Vietnam is in the phase of nutritional transmission[61], so appropriate strategies are needed to control the increase in energy intake.

Regarding physical activity, the present study indicates that the level of physical activity of Tokyo children is higher than that of Hanoi children of both sexes, with a big difference especially among boys. The sleep duration of Japanese children was about 554 min/d in girls and about 572 min/d in boys. Sleeping time of girls and boys in Tokyo suburban were significantly shorter than those of Hanoi suburban at 67 and 39 min, respectively. This difference may be due to the nap habits of Vietnamese. In Vietnam, after lunch, children have about 45-60 minutes to take a nap before the afternoon class starts. In the present study, 100% of children in Tokyo suburban walked to school while the percentage of children in Hanoi suburban walked or cycled to school only about 50%. A cross-sectional study in 2020 reported that 53% of school children (aged 5-15 years) used active transport to and from school in Hanoi city[62]. Promotion of active school travel (e.g., walking and cycling to/from school) may be a way to improve children's health due to its association with levels of physical activity[63]. In Japan, more than 90% of children travel to school on foot, which may partly contribute to the relatively low prevalence of childhood obesity and being overweight[64]. According to the 2018 Report Cards on Physical Activity for Children and Youth from 49 countries (also known as the Global Matrix 3.0)[65], Japan was highly rated as “A-” (i.e., 80–86% prevalence) for active transportation[66]. Previous research has shown that active school travel was positively associated with neighborhood physical and social environments, safety, walkability, and neighborhood social interactions, and negatively associated with travel distance and car ownership[67, 68]. In particular, safety has been identified as the core concept of school travel policies[69, 70] most studies have focused on traffic safety[71, 72]. In the present study, the average time children walked to school about 30 minutes was an appropriate time because normally, the walking distance to school ranges between 2 and 4 kilometers for elementary school[42]. In Vietnam, to increase the rate of children walking to school, it is necessary to improve the level of traffic safety as well as social security.

Figure 20. Japanese children walking to school (left) and Vietnamese children being transported to school by their parents (right)

The difference in physical activity levels between children in Tokyo and Hanoi is mainly due to the difference in time spent on moderate to vigorous physical activities. A survey conducted in 2021 in Japan revealed that almost 55% of girls and close to 62% of boys aged between 4 and 11 years participated in sports teams and clubs[73]. Besides sports clubs, schools often also offer clubs for cultural activities, such as playing music instruments[73]. In Vietnam, percentage of students who were physically active for a total of at least 60 minutes per day on all seven days during the past seven days was 13.6%[74]. Another study showed that female students aged 10-11 years old showed that in 2012 only 11.9% of the grade 5 students in Ho Chi Minh City participated in active play after school[74]. Time spent for moderate to vigorous physical activity of girls and boys in Tokyo suburban was significantly higher than those of Hanoi suburban at 68 min/d and 78 min/d, respectively. Consistently, the previous studies indicated that more than half of the children participated in organized sports for at least 60 minutes per day[44].

Figure 21. Japanese children (left) and Vietnamese children (right) playing soccer

The evidence suggests that Vietnamese children had low levels of physical activity. Physical activity initiatives in Vietnamese children are largely focused on enhancing physical education in schools[75]. Public health policy initiatives should focus more on community-based programs and promoting physical activity environments for children outside school settings[74]. As recommended by the WHO ACTIVE toolkit, countries should focus on four policy action areas: changing the population's perception of the importance of physical activity; providing safe and well-maintained facilities and green areas for physical activity; encouraging people of all age groups to engage in regular physical activity, and to build a strong leadership and governance system to support successful policy implementation[74].

The present study has several limitations to note. In terms of physical activity, the present study was conducted in suburban areas of two big cities in Vietnam and Japan at the same time of year. However, the effects of the covid-19 pandemic may affect children's physical activity in both countries. A study to be conducted after the covid-19 pandemic is needed. In addition, the cross-sectional design used in the present study could not determine causality. Therefore, cohort studies should be conducted among Vietnamese and Japanese children in the future.

In conclusion, in comparison with Japanese children, the results showed that a high prevalence of obesity in Vietnamese children was based on low physical activity rather than high energy intake.

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ACKNOWLEDGMENTS

First and foremost, I would like to thank the Boards of Graduate School of Human Life Sciences, Jumonji University as well as the staffs in the Department of Food Nutrition for supporting me to do this graduation thesis in the most convenient conditions.

I would like to express my respectful gratitude to my supervisors, Prof. Shigeru Yamamoto, Prof. Noriko Kato and Prof. Tamami Iwamoto, for giving me an opportunity working with them, for many valuable lessons, not only in professional knowledge but also in life skills.

I am grateful to the teachers, the children and their parents or guardians of the primary schools in Vietnam and Japan for their consent to participate in my study and their enthusiasm in answering the interview.

I would like to extend my thanks to the staffs of Nutrition and Food Culture Research Center, Jumonji University who helped me to collect the data for my study. I would also like to thank Andrew Durkin, Prof. Emeritus of Indiana University, for editing my English.

Finally, I would also like to give many thanks to my family and my friends, the greatest encouragement to me in the study process as well as support me to overcome many obstacles in my life.

Thank you so much!

NGUYEN MAI PHUONG