

MINISTRY OF EDUCATION AND TRAINING MINISTRY OF HEALTH
NATIONAL INSTITUTE OF HYGIENE AND EPIDEMIOLOGY

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**THE STATUS OF OVERWEIGHT AND OBESITY,
RISK FACTORS, AND PROPORTIONS OF SOME
INTESTINAL MICROBIOTA IN
SECONDARY SCHOOL STUDENTS IN HANOI CITY**

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DOCTORAL THESIS SUMMARY

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Criticism 1:

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The thesis will be defended at the Institute level
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INTRODUCTION

In recent years, overweight and obesity (OWOB) have been increasing rapidly across different age groups, including children. According to the Vietnam National Nutrition Survey 2019-2020, the prevalence of OWOB in the 5-19 age group increased from 8.5% in 2010 to 19.0% in 2020, with the highest rate observed in urban areas (26.8%). Numerous factors contribute to an increased risk of OWOB, especially in the 11-14 age group. Inadequate nutrition and lack of physical activity are adverse behaviors that can lead to OWOB. Additionally, children are also influenced by their home and school environments. Recently, much evidence has revealed the important role of a factor, whose changes are related to the increased risk of OWOB, which is the gut microbiota. Numerous studies have shown that there has been a change in the proportion of certain phyla of gut microbiota in obese individuals.

Ha Noi city has been witnessing a rapid increase in childhood overweight and obesity in recent years, while prevention efforts still face many challenges. With the aim of providing evidence on the status of OWOB in children aged 11-14 years and evidence on the risk factors for obesity, including changes in the proportion of certain groups of gut microbiota, the dissertation "*The status of overweight and obesity, risk factors, and proportions of some intestinal microbiota in secondary school students in Hanoi city* " was conducted with the following three objectives:

1. Describe the status of overweight and obesity among secondary school students in Hanoi city in 2017.
2. Identify some risk factors for obesity among secondary school students in Hanoi city in 2018.
3. Compare the proportion of some groups of gut microbiota between obese secondary school students and students with normal nutritional status in Hanoi city, 2018 - 2019

Novelty and Practical Value of the Research Topic

The study has described the status of OWOB among secondary school students in Hanoi city, an age group with limited data on nutrition and physical fitness in recent years, and also a crucial age for interventions to improve physical health. The research results contribute to providing evidence for the development of intervention plans to improve the health and stature of adolescents in Hanoi city.

The study also identifies the basic risk factors for obesity in the 11-14 age group. This serves as a basis for proposing intervention activities in the prevention and control of obesity for adolescents in Hanoi city.

The research also provides initial data on the change in the proportion of certain groups of gut microbiota in obese children compared to children with normal nutritional status. This is a completely new research direction in Vietnam, and the research results are the basis for future research directions on the relationship between gut microbiota and obesity in particular, as well as non-communicable diseases in general, to serve the prevention and control of obesity and non-communicable diseases

STRUCTURE OF THESIS

The thesis consists of 139 pages excluding the list of related published articles, references and appendices, with 31 tables, 2 figures, 2 diagrams and 4 charts. Introduction 2 pages, Literature review 39 pages; Research methods 22 pages; Research results 38 pages; Discussion 31 pages; Conclusion 2 pages, Recommendation 1 page.

Chapter 1 . LITERATURE REVIEW

1.1. Concepts, assessment/classification methods, and health impacts of overweight and obesity

According to the World Health Organization (WHO), overweight is defined as abnormal or excessive fat accumulation, and obesity is a complex chronic disease defined by the excessive accumulation of fat in the body's adipose tissue, which may lead to impaired health. The National Institute of Nutrition applies the method of assessing the OWOB status of children aged 10-19 years based on the BMI-for-age and sex Z-score, according to the WHO's 2007

recommendations, with overweight defined as a BMI Z-score $> +1$ SD and obesity defined as $> +2$ SD. Overweight and obesity can lead to serious health problems in children, such as increasing the incidence and mortality of non-communicable diseases and precocious puberty

1.2. Propotion of overweight and obesity in adolescent worldwide and in Viet Nam

Currently, OWOB is becoming a pressing public health issue. In 2020, there were 175 million children aged 5-19 living with obesity, and this is estimated to increase to 383 million by 2035, with rapid increases in Africa, Southeast Asia, and the Western Pacific.

In Vietnam, OWOB is increasing rapidly in major provinces/cities, urban areas, and even in provinces/cities with average living standards, and rural areas of Vietnam. The National Nutrition Survey 2019-2020 recorded that the prevalence of OWOB in the 5-19 age group increased from 8.5% in 2010 to 19.0% in 2020, with the highest rate in urban areas (26.8%), followed by rural areas at 18.3% and mountainous areas at 6.9%. In recent years, Hanoi has shown an increasing trend of OWOB in the 11-14 age group, which is easily affected by external factors in the formation of adverse health behaviors

1.3. Risk factors for obesity in school-aged children: Research worldwide and in Viet Nam

In recent years, obesity has been placed in a broader context of impact to analyze influencing factors. According to Davison and Birch, risk factors for childhood obesity include intrinsic factors such as age, gender, genetic/hereditary factors; and factors within different environmental layers. These include behaviors related to eating habits, sedentary activity, and physical activity. Influences from the family contribute to promoting obesity in children, such as parental childcare practices, knowledge of nutrition, eating habits, food choices, or physical activity of parents, supervision of children's physical/sedentary activities, or the influence of siblings in the family. In addition, children are also affected by their living environment, including the school environment with catering services provided at the school, school health education programs,

and the social environment such as socioeconomic status, recreational activities, regulations on learning time, rest time, or ethnic and religious characteristics.

1.4. Gut microbiota and overweight and obesity

Globally, the role of gut microbiota as a risk factor for obesity in humans has only recently been researched and understood, with changes identified in numerous studies related to the proportion and, subsequently, the metabolic products of the gut microbiota. Many studies in adults show that obese individuals have a reduced proportion of the phylum *Bacteroides* and an increased proportion of the phylum *Firmicutes* compared to healthy individuals with normal nutritional status. Most studies have only focused on understanding and delving deeper into this relationship in adults, while research data in children remains very limited. Observations in children show that obese children have a reduced proportion of the genus *Bifidobacterium* belonging to the phylum *Actinobacteria*, a reduced proportion of some species of the genus *Bifidobacterium*, an increased or decreased proportion of the phylum *Bacteroidetes*, and an increased or no difference in the proportion of the phylum *Firmicutes*. In Viet Nam, studies on the role of gut microbiota in disease prevention, as well as changes in gut microbiota under certain conditions, are very limited, especially studies related to metabolic diseases such as obesity, which have not yet been conducted in Viet Nam.

Chapter 2. RESEARCH METHODOLOGY

2.1. Objective 1 – Cross-sectional descriptive study

2.1.1. Research subjects

Secondary school students (grades 6-9), aged 11-14 years old, who are permanent residents and studying at public schools in Hanoi city for 12 months or more

2.1.2. Time and location of research

The study was conducted from November to December 2017 in 30 public secondary schools across 10 inner districts, 1 town, and 16 suburban districts of Hanoi city.

2.1.3. Sample size and sampling method

Cluster, stratified, multi-stage sampling was used. The sample size for objective 1 was 9,040 students, and in reality, 8,980 eligible subjects were selected to conduct the study. Children were measured for height and weight, and given a questionnaire to collect basic information (age, sex, area).

2.2. Objective 2 - Case-control study

2.2.1. Research subjects

Secondary school students aged 11-14 years who were identified as obese or having normal nutritional status in objective 1; agreed to participate in the study; the matching ratio was 1:1.

2.2.2. Time and location of research

The study was conducted from January 2018 to December 2018 at 30 public secondary schools in Hanoi city.

2.2.3. Sample size and sampling method

The sample size consisted of 378 obese students and 378 students with normal nutritional status. Obese students were randomly selected from the obesity list in objective 1. The control group consisted of students with normal nutritional status who were the same age, gender, and grade as the obese students. Information was collected through interviews using a structured questionnaire that had been previously designed and tested.

2.3. Objective 3 – Case-control study

2.3.1. Research subjects and materials

Study subjects: Secondary school students age from 11-14 year old who were identified as obese or having normal nutritional status and selected to participate in the study in objective 2. Study material: stool samples from students meeting the selection criteria

2.3.2. Time and place of research

The study was conducted from January 2018 to December 2019 at 21 public secondary schools in Hanoi city.

2.3.3. Sample size and sampling method

A random sample of 100 obese children and 100 children with normal nutritional status (who had been selected in objective 2) was chosen to collect stool samples to test the proportion of certain groups of gut microbiota. The proportion of gut microbiota groups

was determined using qPCR for relative quantification of the 16S rRNA gene and using specific primer pairs for the phylum and order of bacteria of interest.

2.4. Data management and analysis

Data was entered using Microsoft Excel 2016 (Objectives 1 and 3) and Epi Data 3.1 software (Objective 2). Data was cleaned before analysis. IBM SPSS version 23.0 software was used for analysis. Data from objectives 1 and 2 were described in the form of frequency tables and appropriate proportions. Univariate and multivariate unconditional logistic regression analysis was applied to determine the association between obesity and some risk factors. Multicollinearity was checked before performing multivariate analysis. When performing multivariate analysis, all factors from the univariate analysis were selected into the multivariate logistic regression model. Objective 3: The Mann-Whitney U test was applied to compare the proportion of certain groups of gut microbiota between the obese group and the group with normal nutritional status.

2.5. Ethics in research

The study was reviewed and approved by the Scientific Council and the Ethics Committee in Biomedical Research of the Hanoi University of Public Health under Decision No. 390/2017/YTCC-HD3 dated December 28, 2017, for the topic "Metabolic Syndrome in Overweight and Obese Secondary School Students in Hanoi City in 2017" and Decision No. 250-2018/YTCC-HD3 dated April 17, 2018, for the topic "Some Risk Factors and Characteristics of the Gut Microbiota of Obese Secondary School Students in Hanoi, 2017." The data collection plan was disseminated to the Department of Education, the Department of Health, and the schools before data collection. Parental consent forms were collected before stool samples were taken. The information collected is for research purposes only

Chapter 3. RESULTS

3.1. The current status of overweight and obesity in secondary school students in Hanoi city in 2017

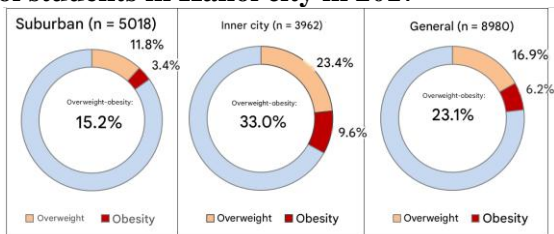


Figure 3.1. The proportion of overweight and obesity among secondary school students aged 11-14 in Hanoi city by region, 2017

The proportion of overweight and obesity among 11-14 year old students in Hanoi City was 23.1% (95%CI: 22.2-24.0). The proportion of overweight was 16.9% (95%CI: 16.1-17.1) and obesity was 6.2% (95%CI: 5.7-6.7). The inner city area had a higher prevalence of overweight and obesity compared to the suburban area ($p < 0.001$).

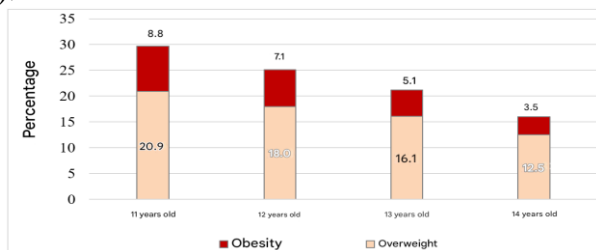


Figure 3.2. The proportion of overweight and obesity among secondary school students in Hanoi city by age, 2017 (n = 8980)

The proportion of overweight and obesity among secondary school students in Hanoi varied by age ($p < 0.001$). The highest proportion of overweight and obesity was in the 11-year-old group and tended to decrease with age. The proportion of overweight in the 11-year-old group was 20.9% (95%CI: 19.2-22.6), decreasing to 12.5% (95%CI: 11.1-14.0) in the 14-year-old group. Similarly, 8.8% (95%CI: 7.7-10.0) of 11-year-old students were obese, decreasing to 3.5% (95%CI: 2.8-4.4) in the 14-year-old group.

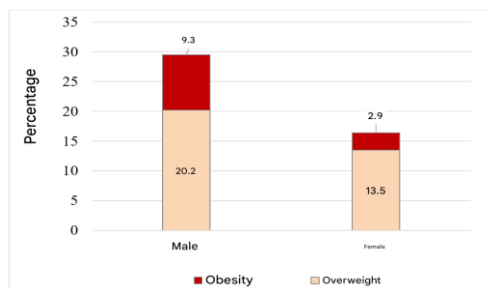


Figure 3.3. The proportion of overweight and obesity among secondary school students in Hanoi city by gender, 2017 (n = 8980)

By sex, the rate of both overweight and obesity was higher in male students than in female students. The prevalence of overweight (20.2%, 95%CI: 19.0-21.4) in male students was approximately 1.5 times higher than the prevalence in female students (13.5%, 95%CI: 12.5-14.6). Meanwhile, the rate of obesity in male students was 9.3% (95%CI: 8.5-10.1), approximately 3 times higher than that in female students (2.9%, 95%CI: 2.4-3.5) ($p < 0.001$).

Table 3.4. Rate of overweight and obesity among secondary school students in Hanoi city by age and gender in 2017 (n = 8980)

Age group	Male student (n = 4617)		Female student (n = 4363)	
	SL	% (95%CI)	SL	% (95%CI)
Overweight	932	20.2 (19.0 - 21.4)	589	13.5(12.5 - 14.6)
11 years old	284	23.8 (21.4 - 26.3)	201	17.8 (15.6 - 20.2)
12 years old	255	20.8 (18.6 - 23.2)	150	14.5 (12.5 - 16.9)
13 years old	221	19.3 (17.1 - 21.7)	140	12.7 (10.8 - 14.8)
14 years old	172	16.3 (14.2 - 18.7)	98	8.9 (7.3 - 10.6)
Obesity	428	9.3 (8.5 - 10.1)	127	2.9 (2.4 - 3.5)
11 years old	162	13.6 (11.7 - 15.6)	42	3.7 (2.7 - 5.0)
12 years old	124	10.1 (8.5 - 12.0)	36	3.5 (2.5 - 4.8)
13 years old	90	7.9 (6.4 - 9.6)	25	2.3 (1.4 - 3.2)
14 years old	52	4.9 (3.7 - 6.4)	24	2.2 (1.4 - 3.2)
No OWOB	3257	70.5 (69.2 - 71.9)	3647	83.6 (82.5 - 84.7)
11 years old	749	62.6 (59.9 - 65.4)	885	78.5 (75.9 - 80.8)
12 years old	846	69.1 (66.4 - 71.6)	845	82.0 (79.5 - 84.3)
13 years old	833	72.8 (70.1 - 75.4)	935	85.0 (82.9 - 87.1)
14 years old	829	78.8 (76.1 - 81.2)	982	88.9 (87.0 - 90.8)

By age and sex, the highest rates of overweight and obesity were in the 11-year-old male group (23.8% (21.4 - 26.3) overweight and 13.6% (11.7 - 15.6) obese), and the lowest in the 14-year-old female group (8.9% (7.3 -10.6) overweight and 2.2% (1.4 - 3.2) obese). At each age, the rate of overweight in male students was higher than in female students by approximately 1.3 (11-year-old group) - 1.8 times (14-year-old group), and the rate of obesity in male students was also higher than in female students by approximately 2.2 (14-year-old group) - 3.7 times (11-year-old group).

3.2. Some risk factors for obesity among secondary school students in Hanoi city in 2018

3.2.1. Nutritional habits and obesity risk

Table 3.8 . Number of meals, frequency, eating time and risk of obesity in 11-14 year old students in Hanoi city

Factors		Obesity (n=378)		Normal nutritional status (n=378)		OR (95%CI)	P
		SL	%	SL	%		
Eating 3 main meals a day	No	223	59.0	156	41.3	1	
	Yes	155	41.0	222	58.7	0.49 (0.37-0.65)	<0.001*
Eating breakfast every day	No	198	52.4	114	30.2	1	
	Yes	180	47.6	264	69.8	0.39 (0.29-0.53)	<0.001*
Eating ≥ 3 snacks /day	No	40	10.6	50	13.2	1	
	Yes	338	89.4	328	86.8	0.78 (0.50-1.21)	0.312
Frequently snacking	No	258	68.3	259	68.5	1	
	Yes	120	31.7	119	31.5	0.99 (0.73-1.34)	0.938
Eating after 9pm	No	155	41.0	162	42.9	1	
	Yes	223	59.0	216	57.1	0.93 (0.69-1.24)	0.606

Eating 3 meals/day and eating breakfast every day reduced the risk of obesity in 11-14 year old students, the difference was statistically significant ($p < 0.001$).

Table 3.9. Feelings, eating habits and risk of obesity in 11-14 year old students in Hanoi city

Factors		Obesity (n=378)		Normal nutritional status (n=378)		OR (95% CI)	P
		SL	%	SL	%		
Often feel hungry, eat well, want to eat more	Yes	50	13.2	51	13.5	1	1
	No	328	86.8	327	86.5	0.98 (0.64-1.49)	0.915
Eating faster	Yes	148	39.2	60	15.9	1	
	No	230	60.8	318	84.1	3.41 (2.42-4.81)	<0.001*
Eating more	Yes	108	28.6	44	11.6	1	
	No	270	71.4	334	88.4	3.04 (2.07-4.46)	<0.001*

Students who had a habit of eating faster and eating more compared to their peers of the same age and gender had a higher risk of obesity ($p < 0.001$).

Table 3.10. Eating/drinking habits and risk of obesity in 11-14 year old students in Hanoi city

Factors		Obesity (n=378)		Normal nutritional status (n=378)		OR (95% CI)	P
		SL	%	SL	%		
Eat fried food every week							
	Yes	227	60.1	199	52.6	1	
	No	151	39.9	179	47.4	1.35 (1.01-1.84)	0.040*
Eat BBQ every month							
	Yes	128	33.9	144	38.1	1	
	No	250	66.1	234	61.9	0.83 (0.52-1.12)	0.256
Eat meat without fat							
	No	68	18.0	77	20.4	1	
	Yes	310	82.0	301	79.6	1.17 (0.81-1.68)	0.460
Eat chicken without skin							
	No	169	44.7	170	45.0	1	
	Yes	209	55.3	208	55.0	1.01 (0.76-1.35)	0.942

Eat sweets often						
<i>Yes</i>	254	67.2	262	69.3	1	
<i>No</i>	124	32.8	116	30.7	0.91 (0.67-1.23)	0.584
Drink carbonated soft drinks regularly						
<i>Yes</i>	261	69.0	285	75.4	1	
<i>No</i>	117	31.0	93	24.6	0.73 (0.53-1.00)	0.051

Eating fried foods weekly was the risk of obesity (OR=1.35, 95%CI: 1.01-1.84, p= 0.04) .

3.2.2. Physical activity and risk of obesity

Table 3.12 . Association between regular school activities during recess and risk of obesity in 11-14 year old students in Hanoi city

Factors	Obesity (n=378)		Normal nutritional status (n=378)		OR (95%CI)	P
	<i>SL</i>	%	<i>SL</i>	%		
Sitting (talking, listening to music, etc.)						
<i>Yes</i>	130	34.4	116	30.7	1	
<i>No</i>	248	65.6	262	69.3	1.18 (0.87-1.61)	0.277
Play (jump rope, badminton, basketball ...)						
<i>No</i>	263	69.6	226	59.8	1	
<i>Yes</i>	115	30.4	152	40.2	0.65 (0.48-0.88)	0.005*

Children who participate in physical activities during recess such as jumping rope, badminton, basketball, etc. had a lower risk of obesity than children who did not participate in these activities (OR=0.65, 95%CI: 0.48-0.88, p= 0.005).

Table 3.15 . Association between participation in some moderate and heavy physical activities and obesity risk in 11-14 year old students in Hanoi city

Factors		Obesity (n=378)		Normal nutritional status (n=378)		OR (95%CI)	P
		SL	%	SL	%		
Participate in moderate to vigorous physical activity for at least 60 minutes/day	No	124	32.8	116	30.7	1	0.584
	Yes	254	67.2	262	69.3	0.91 (0.67-1.23)	
Some muscle and bone strengthening activities are performed at least 3 times/week.							
Basketball	No	351	92.9	343	90.7	1	0.289
	Yes	27	7.1	35	9.3	0.75 (0.45-1.27)	
Football	No	275	72.9	285	75.4	1	0.407
	Yes	103	27.2	93	24.6	1.51 (0.83-1.59)	
Jogging	No	289	76.5	263	69.6	1	0.033*
	Yes	89	23.5	115	30.4	0.70 (0.51-0.97)	
Swimming	No	333	88.1	347	91.8	1	0.090
	Yes	45	11.9	31	8.2	1.31 (0.94-2.45)	
Badminton/table tennis	No	300	79.4	315	83.3	1	0.191
	Yes	78	20.6	63	16.7	1.30 (0.90-1.88)	

Students who participated in jogging at least 3 times/week had a lower risk of obesity than the non-participating group (OR=0.70, p=0.033).

Table 3.17 . Association between sedentary activity time >120 minutes/day on weekdays and obesity risk in 11-14 year old students in Hanoi city

Factors		Obesity (n=378)		Normal nutritional status (n=378)		OR (95%CI)	P
		SL	%	SL	%		
General static activities	No	43	11.4	53	14.0	1	0.275
	Yes	335	88.6	325	86.0	1.27 (0.83-1.95)	
	No	169	44.7	202	53.4	1	

Factors		Obesity (n=378)		Normal nutritional status (n=378)		OR (95%CI)	P
		SL	%	SL	%		
Static activities using screens	Yes	209	55.3	176	46.6	1.42 (1.07-1.89)	0.016*
	No	338	89.4	359	95.0	1	
Watch TV	Yes	40	10.6	19	5.0	2.24 (1.27-3.94)	0.004*
	No	341	90.2	354	93.7	1	
Play video games	Yes	37	9.8	24	6.3	1.60 (0.94-2.73)	0.083
	No	349	92.3	364	96.3	1	
Go to internet	Yes	29	7.7	14	3.7	2.16 (1:12-4:16)	0.019*
	No	350	92.6	364	96.3	1	
Using electronic devices before bed	Yes	28	7.4	14	3.7	2.08 (1.08-4.02)	0.026*
	No	350	92.6	364	96.3	1	

Total time spent on screen-based sedentary activities exceeding 120 minutes/day, spending >120 minutes/day watching television, accessing the internet, and using electronic devices before bed all increase the risk of obesity in 11-14 year old students ($p < 0.05$).

Table 3.18 . Association between sedentary activity time >120 minutes/day on weekends and obesity risk in 11-14 year old students in Hanoi city

Factors		Obesity (n=378)		Normal nutritional status (n=378)		OR (95%CI)	P
		SL	%	SL	%		
Overall sedentary activities	Yes	264	69.8	230	60.8	1.49 (1.10-2.01)	0.009*
	No	114	30.2	148	39.2	1	
Screen-based sedentary activities	Yes	213	56.3	174	46.0	1.51 (1.14-2.02)	0.005*
	No	165	43.7	204	54.0	1	
Watching TV	Yes	39	10.3	23	6.1	1.78 (1.04-3.04)	0.034*
	No	339	89.7	355	93.9	1	

Factors	Obesity (n=378)		Normal nutritional status (n=378)		OR (95%CI)	p	
	SL	%	SL	%			
Playing video games	No	226	84.3	347	91.8	1	0.176
	Yes	42	15.7	31	8.2	1.40 (0.86-2.28)	
Accessing the internet	No	342	90.5	362	95.8	1	0.004*
	Yes	36	9.5	16	4.2	2.38 (1.30-4.37)	
Using electronic devices before sleeping	No	355	93.9	363	96.0	1	0.183
	Yes	23	6.1	15	4.0	1.57 (0.81-3.05)	

On weekends, the proportion of obese students spending >120 minutes/day on overall sedentary activities and screen-based sedentary activities increased significantly compared to weekdays and compared to the group with normal nutritional status. The difference was statistically significant with $p < 0.05$. On weekends, spending > 120 minutes/day watching TV and accessing the internet both increased the risk of obesity ($p < 0.05$). Other activities did not show any association with the risk of obesity ($p > 0.05$)

Table 3.19. Association between daytime nap duration, nighttime sleep duration, and risk of obesity in 11-14 year old students in Hanoi City.

Factors	Obesity (n=378)		Normal nutritional status (n=378)		OR (95%CI)	p
	SL	%	SL	%		
Daytime nap						
< 60 minutes/day	280	74.1	268	70.9	1	0.328
≥ 60 minutes/day	98	25.9	110	29.1	1.17 (0.85-1.61)	
Nighttime sleep duration						
< 8 hours/day	163	43.1	134	35.4	1	0.031*
≥ 8 hours/day	215	56.9	244	64.6	1.38 (1.03-1.85)	

Assessing the association between nap duration and nighttime sleep duration with the risk of obesity, the study showed that

nighttime sleep duration <8 hours/day increased the risk of obesity in 11-14 year old children ($p=0.031$). However, no association was found between nap duration and the risk of obesity

3.2.3. Parental concern and risk of obesity

Table 3.20. Parental childcare practices (as perceived by children) and the risk of obesity in 11-14 year old students in Hanoi City.

Factors		Obesity (n=378)		Normal nutritional status (n=378)		OR (95%CI)	p
		SL	%	SL	%		
Often pays attention to and guides children to eat reasonably	No	112	29.6	123	32.5	1	0.387
	Yes	266	70.4	255	67.5	1.15 (0.84-1.56)	
Often encourage children to participate in physical activities and sports.	No	96	25.4	159	42.1	1	<0.001
	Yes	282	74.6	219	57.9	2.13 (1.57-2.90)	
Often pay attention and guide children to do housework	No	140	37.0	161	42.6	1	0.119
	Yes	238	63.0	217	57.4	1.26 (0.94-1.69)	
Often pays attention to and restricts children in sedentary activities such as watching TV and playing video games	No	114	30.2	117	31.0	1	0.813
	Yes	264	69.8	261	69.0	1.04 (0.76-1.41)	

Statistically significant difference was only found in the activity of often encouraging children to participate in physical activities and sports ($p<0.001$)

3.2.4. Multivariate analysis of obesity risk factors in children aged 11-14 years

Table 1. Results of multivariate logistic model analysis of obesity risk factors in students aged 11-14 in Hanoi city

Risk factors	OR	95% CI	p
Eating faster than peers of the same age and sex	3, 09	2, 13 – 4 , 50	<0.001
Eating more than peers of the same age and gender	2, 76	1, 81 – 4, 21	<0.001
Having changes in eating habits in the past 3 years	1, 89	1, 34 – 2, 66	<0.001
Eating breakfast daily	0.4 0	0.29 – 0.56	<0.001
Playing (jump rope, badminton, basketball...) during recess at school	0.6 7	0.4 6 – 0.9 3	0.0 17
Sitting and watching TV >120 minutes/day on weekends	1, 89	1, 04 – 3 , 43	0.0 37
Parents often encourage participation in physical activities and sports	2, 16	1.5 3 – 3.03	<0.001

Including all variables (statistically significant and non-significant) into the multivariate logistic regression model, using the Forward: Wald method. The results show that the factors associated with and increasing the risk of obesity in the 11-14 age group include: the habit of eating faster; eating more than peers of the same age and gender; changes in eating habits in the past 3 years; and spending >120 minutes/day watching TV on weekends ($p < 0.05$). Meanwhile, factors such as eating breakfast daily; participating in physical activities during recess at school such as jumping rope, badminton, and basketball are considered protective factors that help children reduce the risk of obesity ($p < 0.05$). However, one factor, parental encouragement to participate in physical activities and sports, which was significant in the univariate model, no longer maintained statistical significance in the multivariate model ($p < 0.05$). This factor would be discussed in more detail in the following section.

3.3. Comparison of the proportion of some groups of gut microbiota between obese secondary school students and students with normal nutritional status in Hanoi city, 2018 - 2019

Table 3.23. Average proportion of some groups of gut microbiota between the obese group and the control group, 11-14 year old students in Hanoi city

Bacteria	Group	n	Q1	Median	Q3	p
Phylum <i>Bacteroidete</i>	Normal	99	14.91	19.69	26.20	0.905
	Obesity	100	14.06	20.66	25.62	
Genus <i>Prevotella</i>	Normal	99	0.001	3.41	15.32	0.085
	Obesity	100	0.001	7.60	22.54	
Phylum <i>Firmicutes</i>	Normal	99	0.06	0.15	0.35	0.569
	Obesity	100	0.05	0.14	0.32	
Genus <i>Bifidobacterium</i>	Normal	99	0.02	0.09	0.37	0.077
	Obesity	100	0.02	0.05	0.16	

The study did not find any statistically significant differences in the proportion of the four groups of gut microbiota between obese children and children with normal nutritional status in the 11-14 age group ($p > 0.05$).

Table 3.26-27. Average proportion of some groups of gut microbiota in male and female students, 11-14 years old in Hanoi city

Bacteria	Group	n	Q1	Median	Q3	p
Male student						
Phylum <i>Bacteroidete</i>	Normal	84	15.09	20.31	26.44	0.444
	Obesity	77	14.24	20.36	24.39	
Genus <i>Prevotella</i>	Normal	84	0.01	4.93	16.59	0.465
	Obesity	77	0.001	7.79	21.99	
Phylum <i>Firmicutes</i>	Normal	84	0.07	0.15	0.34	0.631
	Obesity	77	0.05	0.14	0.32	
Genus <i>Bifidobacterium</i>	Normal	84	0.02	0.05	0.19	0.264
	Obesity	77	0.01	0.04	0.14	
Female student						
Phylum <i>Bacteroidete</i>	Normal	15	11.22	17.39	23.56	0.332
	Obesity	23	12.78	21.62	31.36	
Genus <i>Prevotella</i>	Normal	15	0.001	0.001	2.25	0.004*

	Obesity	23	0.12	6.60	23.10	
Phylum <i>Firmicutes</i>	Normal	15	0.02	0.17	0.44	0.971
	Obesity	23	0.03	0.10	0.32	
Genus <i>Bifidobacterium</i>	Normal	15	0.13	0.46	0.84	0.009*
	Obesity	23	0.02	0.06	0.27	

In the group of male students, the study also did not find any differences in the proportion of the remaining four groups of gut microbiota between the two study groups.

In the group of 11-14 year old female students, differences in the proportion of some phyla of gut bacteria were recorded. Specifically, there was an increase in the proportion of the genus *Prevotella* ($p < 0.05$) and a trend towards an increase in the proportion of the phylum *Bacteroidetes* ($p = 0.33$) in the obese female group compared to the female group with normal nutritional status. Conversely, there was a decrease in the proportion of the genus *Bifidobacterium* (belonging to the phylum *Actinobacteria*) in obese female children compared to female children with normal nutritional status ($p = 0.009$). There was no difference in the proportion of the phylum *Firmicutes* between the two study groups ($p > 0.05$)

Table 3.28-3.31. Average proportion of some groups of gut microbiota in students in Hanoi city according to age

Bacteria	Group	n	Q1	Median	Q3	p
11 year old group						
Phylum <i>Bacteroidetes</i>	Normal	36	13.20	19.97	26.44	0.918
	Obesity	36	15.24	20.74	23.21	
Genus <i>Prevotella</i>	Normal	36	0.02	5.52	20.69	0.742
	Obesity	36	0.26	7.31	22.54	
Phylum <i>Firmicutes</i>	Normal	36	0.06	0.13	0.30	0.816
	Obesity	36	0.05	0.12	0.32	
Genus <i>Bifidobacterium</i>	Normal	36	0.02	0.06	0.33	0.296
	Obesity	36	0.01	0.05	0.13	
12 year old group						
Phylum <i>Bacteroidetes</i>	Normal	29	16.13	19.97	28.41	0.337
	Obesity	28	10.56	19.42	26.38	
Genus <i>Prevotella</i>	Normal	29	0.001	3.60	13.83	0.464
	Obesity	28	0.001	5.64	22.53	
Phylum <i>Firmicutes</i>	Normal	29	0.03	0.15	0.33	0.694
	Obesity	28	0.02	0.09	0.29	
Genus <i>Bifidobacterium</i>	Normal	29	0.04	0.12	0.20	0.274
	Obesity	28	0.02	0.06	0.26	
13 year old group						

Phylum <i>Bacteroidete</i>	Normal	21	17.41	20.39	25.38	0.283
	Obesity	21	13.87	19.08	22.70	
Genus <i>Prevotella</i>	Normal	21	0.03	1.07	14.65	0.541
	Obesity	21	0.001	7.61	19.32	
Phylum <i>Firmicutes</i>	Normal	21	0.07	0.12	0.42	0.213
	Obesity	21	0.10	0.24	0.56	
Genus <i>Bifidobacterium</i>	Normal	21	0.01	0.11	0.46	0.657
	Obesity	21	0.01	0.06	0.16	
14 year old group						
Phylum <i>Bacteroidete</i>	Normal	13	11.22	16.32	21.45	0.022*
	Obesity	15	19.51	25.86	28.58	
Genus <i>Prevotella</i>	Normal	13	0.01	0.94	5.97	0.045*
	Obesity	15	0.001	12.17	26.97	
Phylum <i>Firmicutes</i>	Normal	13	0.16	0.28	0.51	0.037*
	Obesity	15	0.03	0.06	0.47	
Genus <i>Bifidobacterium</i>	Normal	13	0.02	0.16	0.64	0.320
	Obesity	15	0.01	0.04	0.27	

The study did not find any differences in the proportion between certain groups of gut microbiota between the two groups at the ages of 11-13 years old ($p>0.05$). Specifically, in the group of 14-year-old children, there was an increase in the proportion of the phylum *Bacteroidetes* and the genus *Prevotella*, belonging to the phylum *Bacteroidetes* (median=12.17) in 14-year-old obese children compared to normal children of the same age ($p<0.05$). Conversely, there was a decrease in the proportion of the phylum *Firmicutes* in the 14-year-old obese group compared to the group of the same age with normal nutritional status ($p=0.037$). No difference was found in the proportion of the genus *Bifidobacterium* (belonging to the phylum *Actinobacteria*) between the two study groups ($p>0.05$)

Chapter 4. DISCUSSION

4.1. The current status of overweight and obesity in secondary school students in Hanoi city in 2017

The study collected nutritional status information from 8980 students aged 11-14 in 30 schools in 27 districts of Hanoi city in 2017. The results showed that the proportion of students classified as OWOB citywide was 23.1%, with 16.9% overweight and 6.2% obese. The research results are quite similar to other studies in major cities. In addition, the results also show a clear trend of higher OWOB classification in inner city areas compared to suburban areas,

especially this rate in inner city areas is higher than the general rate of the city, the difference is statistically significant with $p < 0.0001$. This result is also consistent with findings from previous studies in Ho Chi Minh City and Binh Duong. The difference in OWOB status was also seen by age, with the 11-year-old group having a higher prevalence than other age groups. The results are also similar to previous findings from the National Nutrition Survey in 2009-2010, or a study in Ho Chi Minh City in 2010. Assessing differences by gender, the study showed that male students had a higher prevalence of OWOB than female students in all age groups. Many studies in other provinces/cities such as Binh Duong province, Ho Chi Minh City, Hai Phong City, or Quang Ninh province also reported similar results showing that the rate of OWOB in male children is higher than in female children of the same age. Differences in OWOB rates by sex can be explained first of all by the fact that girls in this age group have earlier puberty, awareness of changes, and earlier anxiety about appearance, so girls will pay attention to diet, lose weight to maintain their figure, and beautify themselves according to the slim, Asian view, while boys prefer a more muscular and plump body. In addition, different eating habits between boys and girls can also explain the difference in this rate, while girls usually eat small portions with smaller portions, boys often focus on eating until they are full.

4.2. Some risk factors for obesity among secondary school students in Hanoi city in 2018

Nutrition and obesity risk

Assessing risk factors on 378 pairs of obese and normal individuals, the results showed that the proportion of students who correctly understand a reasonable meal and correctly understand the content and meaning of the food pyramid is still quite low, with no difference between the two groups. The proportion of correct understanding of the definition of OWOB and knowing the harms of OWOB was higher in the obese group compared to the group with normal nutritional status ($p < 0.05$). With a better knowledge of obesity, it can be seen that in the past 3 years, the proportion of obese children in the study has had changes in eating habits, and this rate

is higher than that of children with normal nutritional status, especially the rate of eating less fatty meat and abstaining from sweets ($p < 0.001$). However, the proportion of correct understanding of a reasonable meal or the content of the food pyramid in the study is very low (below 10%), precisely because of the lack of knowledge about reasonable meals or the meaning of the food pyramid to apply reasonably in the process of changing nutritional habits, leading to the fact that although they have changed habits for 3 years, children are still obese. Healthier eating habits in obese children were also found in studies through comparisons related to the habit of eating grilled foods, smoked foods, eating meat without fat, removing skin, or eating sweets. Paying more attention to appearance and having better knowledge about obesity may be a motivation for children to maintain dietary changes and bring eating habits closer to normal. And this also shows that there has been a change in perception, leading to a change in behavior, that is, food selection habits have improved significantly in the group of obese 11-14 year old children participating in the study in Hanoi City. In addition, statistically significant differences were found in the habit of eating 3 main meals a day and eating breakfast daily. This result is consistent with previous findings worldwide. At the same time, children who eat faster and eat more than their peers of the same age and gender have a higher risk of obesity compared to the group without this habit ($p < 0.001$). This result is quite similar to previous findings worldwide and in Viet Nam.

Physical Activity - Sedentary Activity and Obesity Risk

The rate of correctly answering all 4 questions is not high, this finding is also consistent with previous records about the obese group when they have a certain knowledge about obesity, and have become aware of their nutritional status. Physical activity during breaks is higher in the group with normal nutritional status compared to the obese group, and this is considered a protective factor, helping to reduce the risk of obesity in children (OR=0.65; 95% CI, 0.48-0.88, $p=0.005$). Mild physical activities, although no statistically significant difference has been found, should still be encouraged for children to participate in. The proportion of obese children

participating in activities using screens >120 minutes/day on both weekdays and weekends is higher than the group with normal nutritional status, and children participating in these activities increase the risk of obesity, especially the factor of sitting and watching TV >120 minutes/day on weekends is still retained in the final model (OR=1.89; 95%CI, 1.04-3.43, p=0.037). The research results are consistent with previous findings. In addition, children who sleep less than 8 hours/day have a higher risk of obesity compared to the group sleeping \geq 8 hours/day. The results are similar to previous studies in Viet Nam

Parental care, encouragement and guidance

The trend shows that the proportion of obese children who are reminded by their parents about the above issues is higher than the group of children with normal nutritional status. This concern brings some effectiveness, that is, nutritional behaviors have improved in obese children, but have not yet been able to change behaviors, habits in eating, or participation in PA of children, and especially to change habits in spending time on sedentary activities, especially screen-based sedentary activities. Parents need to create a good relationship with children, always be there to encourage, respect, understand children's problems promptly and give reasonable advice.

4.3. Comparison of the proportion of some groups of gut microbiota between obese secondary school students and students with normal nutritional status in Hanoi city, 2018 - 2019

The study focused on the phylum *Bacteroidetes*, the genus *Prevotella*, the phylum *Firmicutes*, and the genus *Bifidobacterium* belonging to the phylum *Actinobacteria*. These are groups of gut microbiota that have been identified as related to obesity through previous studies. Statistically significant differences in the proportion of gut microbiota were recorded in female students and 14-year-old students. There was an increase in the proportion of the phylum *Bacteroidetes* and the genus *Prevotella* and a decrease in the proportion of the phylum *Firmicutes* and the genus *Bifidobacterium* (belonging to the phylum *Actinobacteria*) in the obese group compared to the group with normal nutritional status (depending on

the age of 14 or female students). In Viet Nam, studies on gut microbiota related to NCD prevention are very limited, especially to date, there have been no studies on the relationship between the role of gut microbiota and metabolic diseases such as obesity. It can be said that this is the first study to compare the proportion of some common gut microbiota groups related to obesity in Viet Nam. It also creates a basis for a new research direction on the relationship between gut microbiota and overnutrition, contributing to providing new evidence for the prevention and control of OWOB in Viet Nam.

CONCLUDE

1. The current status of overweight and obesity in secondary school students in Hanoi city in 2017

The proportion of overweight and obesity among 11-14 year old students in Hanoi city was 23.1%, of which overweight was 16.9% (95%CI: 16.1 - 17.1) and obesity was 6.2% (95%CI: 5.7 - 6.7).

The rate of overweight and obesity was highest in the 11-year-old group and decreased to the 14-year-old group. Male students were more likely to be overweight and obese than female students, and the inner city area had a higher prevalence of overweight and obesity compared to the suburbs.

2. Some risk factors for obesity among secondary school students in Hanoi city in 2018

Factors that significantly increased the risk of obesity in 11-14 year old secondary school students were eating faster, eating more than peers of the same age and gender, and spending >120 minutes/day watching TV on weekends ($p < 0.001$), while factors that contribute to protection and help reduce the risk are eating a full breakfast daily and participating in sports activities during recess at school ($p < 0.05$). However, some risk factors in the univariate and multivariate analysis models still need further research to provide more appropriate explanations.

3. The proportion of some groups of gut microbiota between obese secondary school students and students with normal nutritional status in Hanoi city, 2018 - 2019

No difference was found in the proportion of the four groups of gut microbiota between the two study groups, citywide, by area, in male students, and in students aged 11-13 years.

There were statistically significant differences in the proportion of some groups of gut microbiota in the group of 14-year-old students and the group of female students, specifically: In the group of 14-year-old students: Increased proportion of the phylum *Bacteroidetes* ($p = 0.022$), the proportion of the genus *Prevotella* ($p = 0.045$) and decreased proportion of the phylum *Firmicutes* ($p = 0.037$) in obese children compared to children with normal nutritional status; In the group of female students: Increased proportion of the genus *Prevotella* ($p = 0.004$) and decreased proportion of the genus *Bifidobacterium* (belonging to the phylum *Actinobacteria*) ($p = 0.009$) in obese children compared to children with normal nutritional status.

RECOMMENDATION

Health Department and Education Department need to coordinate to assess nutritional status annually to detect overnutrition in secondary school students early, promptly respond to families and schools, and provide appropriate guidance.

The city needs to build a safe, green, clean, and beautiful school and social environment to encourage students to participate in physical activities and outdoor recreational activities. Families need to create a healthy environment, set a good example, and care for, encourage, and motivate children to have good nutritional habits, actively participate in appropriate physical activities, and limit children's time on sedentary activities, especially screen-based sedentary activities.

Further studies on the relationship between gut microbiota and obesity are needed to provide a basis for comprehensive intervention solutions in the prevention and control of overnutrition in Hanoi city in particular and Vietnam in general

**LIST OF PUBLISHED ARTICLES
RELATED TO THE THESIS**

1. **Luu Phuong Dung** , Nguyen Thi Lan Anh, Bui Thi Minh Thai, Nguyen Thi Thi Tho (2023), "The proportion of secondary school children aged 11-14 years suffering from overweight and obesity in Hanoi, 2017", *Journal of Preventive Medicine* , Vol. 33, No. 5, pp. 102-109.
2. **Luu Phuong Dung** , Nguyen Thi Lan Anh, Bui Thi Minh Thai, Nguyen Thi Thi Tho (2023), "Some behavioral risk factors associated with obesity among students aged 11-14 in Hanoi city, 2018", *Journal of Preventive Medicine* , Vol. 33, No. 5, pp. 110-119.
3. **Luu Phuong Dung** , Nguyen Thi Thi Tho, Bui Thi Minh Thai, Phan Ha My, Nguyen Thi Lan Anh (2023), "Comparison of the proportion of some phylums/genus pff intestinal microbiota between obese and normal weight children aged 11 - 14 in Hanoi city, 2018 - 2019", *Journal of Preventive Medicine* , Vol. 33, No. 6, pp. 49 - 58.