Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Changing Trends of Obesity and Lipid Profiles Among Bangkok School Children After Comprehensive Management of the Bright and Healthy Thai Kid Project.

Chutima Sirikulchayanonta (chutima.sir@rsu.ac.th)
Rangsit University
Vorachai Sirikulchayanonta
Rangsit University
Kanjana Suriyaprom
Rangsit University
Rachanee Namjuntra
Rangsit University

Research Article

Keywords: Atherogenic index, Hypercholesterolemia, Hyperlipidemia, Obesity, Schoolchildren

Posted Date: September 14th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-668467/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Abstract

Background: Cardiovascular diseases are the world's leading cause of death. Children in Thailand are currently facing obesity, hyperlipidemia, and high atherogenic indices. This study aimed to assess the success of the Bright and Healthy Thai Kid project in reducing obesity and high lipid profiles among Bangkok school children.

Methods: A cross-sectional study in five randomly selected Bangkok primary schools was conducted. A participatory action involving teachers, students, and parents was initiated. Data collection on anthropometric measurements, dietary intake, physical activity, and fasting blood samples of three generations of students was carried out during July-August (midterm months in Thailand) in the years 2004, 2017, and 2019. SPSS for Windows, version 16 was used for data analysis.

Results: Comparing the data from 2004, 2017, and 2019, obesity rates of 19.3 in 2004 gradually declined to 16.9 and 15.6 in 2017 and 2019 ($P< 0.001$). High serum total cholesterol, triglyceride, LDL-C, and atherogenic indices decreased significantly ($p < 0.001$).

Conclusions: We believe that the great time and effort expended for a campaign to reduce rates of obesity and hyperlipidemia in school children does work to prevent future cardiovascular diseases. Long-term investment in national programs is required to achieve whole societal involvement in improving knowledge and skills related to health, nutrition, and healthy food choices.

Introduction

Cardiovascular diseases (CVDs) are a leading cause of mortality worldwide, taking an estimated 17.9 million people each year [1]. Four-fifths of CVD end of lives are caused by coronary heart disease and cerebrovascular accidents, and one third of them develop in people under the age of 70, including Thailand. [1, 2]. Individual risks for CVD are high blood pressure, high blood sugar and lipids, smoking, poor diet, low physical activity, and overnutrition [3]. Rates of overweight and obesity in adults and children continue to grow. From 1975 to 2016, the global prevalence of overnutrition among children and adolescents aged 5–19 years had more than quadrupled, from 4–18% [4]. Now, childhood obesity rates in low- and middle-income countries, including Thailand, are rising dramatically. This is a critical problem, and much of its adverse effects on health and society usually last into adulthood. Early detection of the CVD risk factors and appropriate early management from childhood can prevent premature deaths [5]. Our preliminary survey report in 2004 indicated that 40% of the target school-age children had high blood cholesterol [6]. We concluded that their eating habits (high calorie intake, but less fruits and vegetables) and low physical activity were the main factors leading to obesity and dyslipidemia. As we all know, obesity and hyperlipidemia are the main risk factors that lead to atherosclerosis and CVD [7, 8]. A high proportion of Thai children exhibited obesity, hyperlipidemia and high atherogenic indices [6]. Our project “The Bright and Healthy Thai Kid (BAHT) project began in 2004. It aims to improve the nutrition and activities of public-school children by strengthening specific activities with the participation of teachers and families, thus reducing childhood obesity. The purpose of this investigation was to assess the changing trends of obesity and lipid profiles among Bangkok school children after participatory action of the BAHT project.

Materials & Methods

Research design

This was a cross-sectional study. The preliminary, intermediate, and post-intervention survey was conducted in five Bangkok public primary schools that have participated in the BAHT project since 2004. A participatory action involving teachers, students, and parents had been initiated after the pre-test survey. Data collection on anthropometric measurements, dietary intake and physical activity were done annually during July-August (midterm months in Thailand). Lipid profiles of school children were taken in the years 2004, 2017, and 2019. The project was divided into 2 phases; Phase 1: Initial project implementation (2004–2006); Lag period: School self-management (2006–2012); Phase 2: Re-initiation of project (2014–2019). The new data presented in this study was collected from 2006 to 2019. However, some data from 2004, during the first phase of the BAHT is also included here for convenient comparison in tables and figures even though it was already published in 2006 [6]. Permission to include this information was obtained from the journal on Aug 5, 2021.

School Selection

According to regional distribution, 5 public schools in Bangkok under the Ministry of Education were randomly chosen from 38 schools. A total of 3 schools were selected in the inner area, 1 from the middle area and 1 from the outer area. They voluntarily joined in the BAHT Project from May 2004 to March 2020. These 5 schools were coeducational and similar in socio-demographics. Students were from low to middle income families.

Participants

All our research related to human subjects, human material or human data is handled in accordance with the Declaration of Helsinki. A written informed consent was obtained from both the participants and their parents. Due to ethical problems in humans, we were unable to randomize those who had been tested for blood lipid levels. Participant selection was based on their willingness to participate, and those who declined to participate were respected. However, the school policy was to promote participation. The participating students were in grades 1–6 and 6–12 years old, whereas those who had blood tests were from grades 3 to 6. All study protocols were assessed and endorsed by the Ethics Review Board, Institute of Research, Rangsit University (Certificate of Approval: COA No. RSUERB 2019-028).

Data collection

Preliminary, intermediate and post-intervention surveys of student nutritional status were done as outlined under the following headings.

Anthropometric measurements of weight, height, and waist circumference
All measurements were conducted by two research assistants who had been trained in exact techniques before data collection.

A calibrated digital weighing scale (Seca, Germany) and a calibrated stadiometer (Microtoise) were used to measure weight and height. We used standard methods to determine physical parameters [9]. The nutritional status of children was assessed annually as weight for height (WFH) that categorized them into 3 weight groups according to the standards itemized in the Institute of Nutrition Research, Mahidol University (INMU) Thai Growth Program [10]. This program has been used to analyze the nutritional status of Thai children.

Waist circumference was determined during the post-intervention survey in centimeters, 1 decimal point, by using non-elastic tape. It was collected at the navel level as participants stood up and read while exhaling [11]. From the measurements, a waist-to-height ratio (WHtR) was determined. In recent years, WHtR has been recognized as a measure that allows correction for individual stature. Therefore, a single and unified standard can be identified for all ethnic groups in different populations and in both sexes. A WHtR cutoff value of 0.5 is generally accepted as the international cutoff for pediatric ($\geq$ 6 years of age) and adult central obesity [12, 13].

Dietary Intake & Physical Activity

Interview questionnaires on dietary intake, food frequency questionnaires (FFQ) and physical activity were collected from parents and students. Scores of food consumption and physical activity between different nutritional statuses were determined.

Biochemical Assessment

Voluntary subjects were informed to fast after 8 PM (10–12 hours) except for small amounts of water. In the morning, collection of 3–5 milliliters of a fasting venous blood sample from each participant was done by skilled nurses and medical technicians before having breakfast. After blood collection, breakfast was offered to the children. Blood samples were sent to a standard, accredited laboratory at the Faculty of Public Health, Mahidol University. We used standard methods to determine the blood lipid parameter [14, 15]. The atherogenic index (AI) was analyzed [6].

Statistical analysis

SPSS (Statistical Package for the Social Sciences) for Windows, version 16 was used for data analysis. Kolmogorov-Smirnov was applied to test normality of the data. Descriptive statistics were utilized to describe the background features of study groups. To determine the relationship between variables, the Chi-square test and Pearson’s correlation analysis were used. One-way ANOVA was applied to examine the association between lipid profiles and different age groups including atherogenic indices and years of blood test. Differences were considered to be statistically significant, if the p-value was less than 0.05.

Results

The nutritional status of all school children grades 1–6 was assessed yearly for growth, and percentages of obesity were assessed and recorded. There were 3 generations of students who studied from grades 1 to 6 during the past 15 years (2004–2019). In other words, those who finished grade 6 had to leave for a secondary school. An initial survey was conducted in 2004 with a total of 5,126 students and the post-intervention was carried out in the first phase in 2006. After launching the BAHT project (a participatory action project) in 2004–2006, these schools established school policies for healthy school lunches and supportive environments for exercise according to the project concepts. It was demonstrated that the percent obesity gradually declined from 19.3 to 18.0%. In the following tables and graphs, data from the BAHT project from the year 2004 are shown with permission from a previous publication [6] to allow easy comparison with succeeding years.

We had presented the problems of obesity and dyslipidemia among primary school children to the Secretary General of the Office of Basic Education who responded by supporting the National school policy for healthy school lunches and physical activity. There was a lag period from 2006–2012 during which we allowed our networked schools to take action in health promotion by themselves, according to their school context, while awaiting the national school policy. We started another nutritional survey in the year 2012 with a total of 4,233 students from 5 schools, and it was shown that the obesity rates had risen to 21%. After comprehensive intervention of our project, the percent obesity in our school children gradually decreased to 20.5, 16.9, 15.9, and 15.6% in the years 2014, 2016, 2018, and 2019, respectively with statistical significance ($P < 0.001$) (Fig. 1).

Regarding blood tests for lipid profiles in the 2019 postintervention survey, there was a total of 725 volunteers of which 47.7% were male, and mean ages were 10.8 ± 0.9 years. The nutritional status was: normal 69.2%, over-weight 28.7%, and underweight 2.1%. The background characteristics of the study groups in 2004, 2017, and 2019 are shown in Table 1.

Table 1. Background characteristics of the study groups in 2004, 2017, and 2019.

Characteristics	2004*		2017		2019	
	N	%	n	%	n	%
Gender						
Male	535	52.3	344	45.8	346	47.7
female	493	47.7	407	54.2	379	52.3
Age (year)						
Mean $\pm$ SD	9.4$\pm$1.3		10.1$\pm$1.2		10.8$\pm$0.9	
6-Aug	255	24.8	81	10.8	-	-
9-Dec	773	75.2	670	89.2	725	100
Nutritional status						
Under	31	3.1	27	3.6	15	2.1
Normal	576	56	523	69.6	504	69.2
Over	421	40.9	201	26.8	209	28.7
Total number	1028	100	751	100	725	100

The mean values of lipid levels are indicated in Table 2. In 2019, the mean TC was 185.1 ± 29.9 mg/dl, while TG was 78.1 ± 36.5, LDL-C was 118.0 ± 27.8 and HDL-C was 52.2 ± 11.2 mg/dl. It was deduced that 38.2% and 29.1%, of the participants had borderline high levels of TC and LDL-C and while 30.5% and 29.1%, of them had high TC and LDL-C. Compared to the preliminary (2004) [6] and intermediate (2017) surveys, it was revealed that the percentages of children with high serum TC, TG, and LDL-C significantly diminished ($p < 0.001$) whereas the percentages with low HDL-C increased in 2017 and gradually decreased in 2019 (p < 0.001). The changing trends of lipid profiles are shown in Figs. 2–5.

Table 2 Lipid levels in 3 generations of students in primary schools that participated in the BAHT project, 2004, 2017, and 2019.

Lipid levels (mg/dl)		preliminary 2004* (n =1028) n (%)	intermediate 2017 (n = 718) n (%)	Post-intervention 2019 (n = 725) n%	χ^2 p-value
TC Mean ±SD		194.8±27.7	188.4 ± 31.6	185.1± 29.9	
Desirable	(<170)	234 (22.8)	196 (27.3)	227 (31.3)	< 0.001
Borderline	(170-199)	391 (38.0)	280 (39.0)	277 (38.2)	
High	(≥200)	403 (39.2)	242 (33.7)	221 (30.5)	
TG Mean ±SD		86.5±31.5	98.0 ± 50.5	78.1 ± 36.5	
Desirable	(<130)	916 (89.1)	579 (80.6)	663 (91.4)	< 0.001
Borderline	(130-149)	57 (5.5)	56 (7.8)	21 (2.9)	
High	(≥150)	55 (5.4)	83 (11.6)	41 (5.7)	
LDL-C Mean ±SD		125±26.3	116.9 ± 28.0	118.0 ± 27.8	
Desirable	(<110)	297 (28.9)	295 (41.1)	303 (41.8)	< 0.001
Borderline	(110-129)	315 (30.6)	216 (30.1)	211 (29.1)	
High	(≥130)	416 (40.5)	207 (28.8)	211 (29.1)	
HDL-C Mean ±SD		51.6±8.4	51.9 ± 12.2	52.2 ±11.2	
Desirable	(≥35)	1017 (98.9)	665 (92.6)	690 (95.2)	< 0.001
Low	(<35)	11(1.1)	53 (7.4)	35 (4.8)	

WHtR and lipid levels were significantly correlated, except for LDL-C levels. High TC and HDL-C levels were reported in those with normal WHtR but elevated TG levels were reported more commonly in participants with high WHtR (obesity). There was no relationship between gender and blood lipid levels (Table 3).

Table 3. The association between WHtR, gender, and lipid levels in the 2019 study group.

Lipid levels (mg/dl)		WHtR n (%)		χ^2 P value	Gender n (%)		χ^2 P value
		≤ 0.5	> 0.5		Male	Female	
TC	Mean±SD	187.2 ±29.6	180.8±30.4		184.2±29.7	180.8±30.4	
	<170	140 (27.8)	87 (39.2)	0.01	116 (33.5)	111 (29.3)	0.442
	170-199	203 (40.4)	74 (33.3)		126 (36.4)	151 (39.8)	
	≥200	160 (31.8)	61 (27.5)		104 (30.1)	117 (30.9)	
TG	Mean±SD	71.1±31.5	94.2±43.2		76.4±36.8	79.82±37.2	
	<130	477 (94.8)	186 (83.8)	< 0.001	323 (92.8)	342 (90.2)	0.084
	130-149	12 (2.4)	9 (4.1)		5 (1.4)	16 (4.2)	
	≥150	14 (2.8)	27 (12.2)		20 (5.8)	21 (5.5)	
LDL-C	Mean±SD	118.2±27.4	115.9±29.9		117.8±28.1	117.2±27.8	
	<110	204 (40.6)	99 (44.6)	0.454	144 (41.8)	159 (42.0)	0.393
	110-129	153 (30.4)	58 (26.1)		108 (31.2)	103 (27.2)	
	≥130	146 (29.0)	65 (29.3)		94 (27.2)	117 (30.9)	
HDL-C	Mean±SD	55.3±10.9	47.1±10.0		52.2±11.8	53.4±10.9	
	<35	13 (2.6)	22 (9.9)	< 0.001	22 (6.1)	13 (3.4)	0.082
	≥35	490 (97.4)	200 (90.1)		324 (93.9)	366 (96.6)	

It was revealed that TC had a high correlation with LDL-C (r = 0.894). TC and HDL-C had very low degrees of negative correlation with age; in other words, the more the age, the less the levels of TC and HDL-C (Table 4).

Table 4
Correlation coefficients of age and lipid profile of school children, 2019.

Variables	TC	TG	HDL-C	LDL-C
Age	− .087*	0.025	− .149**	-0.024
TC		.109**	.387**	.894**
TG			− .399**	0.038
HDL-C				.111**
* p < .05, ** p < .01				

Mean lipid levels among different age groups in 2019 are shown in Table 5. Atherogenic indices (AI) in the year 2004, 2017, and 2019 significantly decreased as indicated in Table 6.

Table 5. Mean lipid levels among 725 students and age groups in 2019.

Lipid profile (mg/dl)	Age (years)				F	P-value
	9 (n = 41)	10 (n = 225)	11 (n = 268)	12 (n = 191)		
TC	196.7 ± 26.0	186.8 ± 31.5	183.5 ± 29.4	183.3 ± 29.5	2.794	0.039
TG	76.6 ± 28.7	77.2 ± 32.7	78.3 ± 39.3	79.6 ± 40.2	0.171	0.916
LDL-C	122.3 ± 23.9	117.6 ± 28.5	116.8 ± 27.6	117.4 ± 29.5	0.451	0.717
HDL-C	59.1 ± 13.3	54.2 ± 11.1	51.6 ± 10.8	51.5 ± 11.4	7.325	< 0.001

Table 6. Atherogenic indices of primary school children in 2004, 2017, and 2019.

Atherogenic indices	2004 * (n = 997)	2017 (n = 751)	2019 (n = 725)	F	p-value
	Mean ± SD	Mean ± SD	Mean ± SD		
TC / HDL-C	3.8 ± 0.7	3.8 ± 1.0	3.6 ± 0.8	14.879	< 0.001
LDL-C / HDL-C	2.5 ± 0.7	2.4 ± 0.8	2.3 ± 0.7	15.798	< 0.001
(TC - HDL-C) / HDL-C	2.8 ± 0.7	2,8 ± 1.0	2.6 ± 0.8	14.879	< 0.001

According to food frequency questionnaires (FFQ) completed by the parents in 2004, the most popular dish was fried chicken, followed by sausages, and cakes, respectively. More than two-thirds of them favored sweet food. Regarding snacks, the most preference was for potato crisps while fruits and vegetables were often disliked by most children. It was shown that normal-weight children consumed fried chicken less often than obese children ($p < 0.05$) [6]. After the intervention from 2014 to 2019, the new-generation students have consumed more vegetables and fruits due to healthy school lunches with daily vegetables and with fruits 3 times / week, including reduction of fried food. They have also been trained in healthy food choices with more support from parents.

Regarding physical activity, the lower elementary school children spent more time playing, exercising and participating in the program and spent less time with phones or tablets compared to upper-level students. The results of this study are quite similar to those of the preliminary study published in 2006 [6].

Discussion

In 2004, our preliminary study reported a high prevalence of dyslipidemia [6]. The situation may have been due to the influential effect of popular, western, fast-food advertising, availability, and accessibility from either outlets or home delivery services. In addition, television advertisements and online mass media use very attractive presentations or offer special promotions to enhance consumer use. We believe these were the reasons why children had high intakes of fried chicken, sausages and cakes that are high in cholesterol and saturated fatty acids that cause hyperlipidemia. The TC and LDL-C levels in our study group were relatively high when compared to those in other countries [16, 17, 18].

We believe that the significant ($p < 0.001$) decrease in percentage of high serum TC, TG and LDL-C (including elevated HDL-C) together with a decline in percent of obesity of our school children, was due to the school-based multicomponent intervention effect of our BAHT project. It motivated students to make healthier food choices and practice more regular exercise [19, 20]. However, compared with younger children, older children had lower HDLC levels. This could be explained by the fact that the younger group was more active in playing and exercising. The older students, particularly those in grade 6 rarely had time to join our program activities because they spent more time in tutorial hours for the competitive Ordinary National Education Test and the entrance examinations for secondary schools. Moreover, they appeared to be disproportionally devoted to screen time with electronic devices. This behavior correlated with our survey which reported more obesity in them than in younger students [19]. Our findings were supported by other studies that found a positive association between screen time and overweight and obese children [21,22.23].

In this report, gender and lipid levels in the study group showed no significant association, and this was similar to our previous report [6]. This report reveals that WHtR and lipid levels were significantly correlated except for LDL-C levels. High TC levels were reported in the normal WHtR children, but this might be counteracted by their higher levels of HDL-C, which might be protective. On the other hand, elevated TG levels were reported more commonly in participants with high WHtR (> 0.5) or in abdominally obese participants who might be more at risk of cardiovascular disease in the future. These results were also supported by other studies [24, 25, 26]. In addition, our previous study reported that a child's nutritional status was positively correlated with blood pressure. In other words, the more the weight, the higher the blood pressure (Odds Ratio = 10.60, 95% CI: 3.75-30.00 for HT) [27].

Regarding atherogenic indices (AI) in the years 2004, 2017, and 2019, there were significant decreases in TC and LDL, and an increase in HDL-C as a result of behavior modification. This consisted of improving lifestyles that included healthy eating and regular exercise among school children that joined the program. If they continue with these healthy lifestyles, their CVD risk factors, i.e., obesity, hyperlipidemia, hypertension, and high AI will be very much reduced.

We became concerned during the situation of the COVID – 19 pandemic that students would have to study online at home and that this would lead to less physical activity and more screen time. Parents would need to pay more attention in providing their children with a healthy diet and in acting as good role models for doing regular exercise. It was reported in our previous study [23] that self-discipline among obese children was statistically lower than in normal children in terms of consumption behavior, spending money and time control ($p < 0.05$). Moreover, by adjusted odds ratio (AOR) the ranking of factors related to childhood obesity were money management, poor home surroundings, poor time control, and long screen time, (AOR, 95% CI; 3.1, 1.1–8.2; 3.0, 1.2–7.5; 2.9,1.6–5.4; 2.6, 1.5–4.6), respectively.

It was recommended that parents and teachers cooperate in self-discipline training for children, particularly with regard to consumption behavior, spending money and time control. This should be done in supportive surroundings that would be beneficial for preventing child obesity while simultaneously promoting the development of self-discipline. This has to be a consistent effort lest obesity rates increase during the COVID – 19 pandemic.

We believe that the great time and effort needed for a campaign to reduce rates of obesity in school children does work and that it is worthwhile as an effort to prevent future cardiovascular diseases and to increase the quality of life of children who will be our future adults. Moreover, it will be of significant economic benefit through reduced future national costs for medical care. The lesson learned from the success of our project were: first, to create awareness and instill a cooperative spirit in all stakeholders (parents, teachers and students); second, to promote school advocacy policies for healthy school lunches and for supportive surroundings for doing exercise; third, to activate teachers / working groups to successfully integrate project concepts into daily programs; fourth, to carry out public relations and communication campaigns. Finally, we elicited cooperation from other heath networks (Sweet enough project; Less salt project; Vegan & Fruit 400 g) to promote personal skill development in healthy eating and healthy food choices.

Conclusions

Childhood obesity diminishes physical, social and mental health. It is generally recognized as one of the risk factors leading to obesity and non-communicable diseases in adults. National policies and extensive response measures are required to generate a healthy environment that can support people in making healthy selections that are dependent on knowledge and skills associated with health, nutrition and healthy food choices. Long-term investment and participation of an entire society to protect children’s rights to good health and well-being are required for sustainability.

Abbreviations

AOR:	Adjusted Odds Ratio
ANOVA:	Analysis of variance, or ANOVA
BAHT:	Bright and Healthy Thai Kid
COVID-19:	Coronavirus Disease 2019
CVDs:	Cardiovascular diseases
FFQ:	Food frequency questionnaires
g:	Gram
h:	Hour
HDL-C:	High density lipoprotein- cholesterol
HT:	Hypertension
INMU:	Institute of Nutrition Research, Mahidol University
LDL-C:	Low density lipoprotein- cholesterol
OR:	Odds ratio
SPSS:	Statistical Package for the Social Sciences
TC:	Total Cholesterol
TG:	Triglyceride
WFH:	Weight for height
WHtR:	Waist-to-height ratio

Declarations

Ethics approval and consent to participate

Our research involving human participants, human material, or human data, is performed in accordance with the Declaration of Helsinki (https://www.wma.net/policies-post/wma-declaration-of-helsinki-ethical-principles-for-medical-research-involving-human-subjects/), All protocols for the study were reviewed and approved by the Institutional Review Board, Institute of Research, Rangsit University(Certificate of Approval: COA No. RSUERB 2019-028). Written informed consent was obtained from both the participants and their parents.

Consent for publication:

"Not applicable"

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that we have no competing interests.

Funding

This study was supported by the Thai Health Promotion Foundation Grant Number 62-00-0050 for administration, intervention, monitoring, supervision, and evaluation of the project with the support of Rangsit Universityfor technical issues andpublic relations, and partially for supportof the publication cost.

Authors' contributions

C.S. was the principal investigator of the project and responsible for administration, coordination, and funding acquisition. C.S. and V.S. were involved in conceptualization. C.S., V.S., and K.S. contributed to the study design. C.S. and K.S. carried out the investigation. C.S., V.S., and R.N. were involved in formal analysis and data curation. C.S.wrote the main manuscript text. V.S. reviewed and edited the manuscript. All authors reviewed the manuscript.

Acknowledgements

The authors would like to thank all school children, teachers and parents for their participation and cooperation in the study, Somchai Leelittam for assistance with instruction material and multimedia design, SasivimolRattanasiri for graphic presentation and T.W. Flegel for assistance with editing the manuscript.

References

1. World Health Organization. Cardiovascular Diseases. [Cited Nov 12, 2020]. Available from: https://www.who.int/health-topics/cardiovascular-diseases/#tab=tab_1.
2. Strategy and Planning Division, Office of the Permanent Secretary, Ministry of Public Health. Public Health Statistics A.D.2018. [Cited Dec 12, 2020]. Available from: moph.go.th/new_bps/sites/default/files/statistic 61.pdf.
3. American Heart Association. Coronary Heart Disease. [Cited Dec 24, 2020] Available from: https://www.heart.org/en/health-topics/consumer-healthcare/what-is-cardiovascular-disease/coronary-artery-disease.
4. World Health Organization. Obesity. [Cited Nov 12, 2020]. Available from: https://www.who.int/health-topics/obesity#tab=tab_1.
5. de Ferranti SD, Steinberger J, Ameduri R, Baker A, Gooding H, Kelly AS, et al. Cardiovascular Risk Reduction in High-Risk Pediatric Patients: A Scientific Statement from the American Heart

Association. 2019; 139: e603-e634. doi: 10.1161/CIR.0000000000000618.

6. Sirikulchayanonta C, Pavadhgul P, Chongsuwat R, Srisorrachata S. A preliminary study of hyperlipidemia in Bangkok school children. Asia-Pacific J Public Health. 2006; 18: 15 -19.
7. Libby P, Buring JE, Badimon L, Hansson GK, Deanfield J, Bittencourt MS, et al. Atherosclerosis. Nat Rev Dis Primers. 2019; 5: 56. doi: 10.1038/s41572-019-0106-z.
8. Mauricio D, Castelblanco E, AlonsoCholesterol and Inflammation in Atherosclerosis: An Immune-Metabolic Hypothesis. Nutrients. 2020; 12: 2444. doi: 10.3390/nu12082444.
9. Gibson Anthropometric assessment of body size. In: Gibson RS (ed). Principles of Nutritional Assessment. 2nd ed. Oxford University Press, New York; 2005: 247-253.
10. Institute of Nutrition, Mahidol University. INMU Thai Growth Program for Nutritional Assessment (using weight for height references from national survey, Department of Health, Ministry of Public Health), 2002.
11. McCarthy HD, Jarret KV, Crawley HF. The development of waist circumference percentiles in British children aged 5.0–16.9 y. Eur J Clin Nutr. 2001; 55: 902-907.
12. Ahmed AY.Comparing Measures of Obesity: Waist Circumference, Waist-Hip, and Waist-Height Ratios. In: WatsonRR (ed). Nutrition in the Prevention and Treatment of Abdominal Obesity. 2nd Elsevier Inc,Arizona, 2019. [Cited October 23, 2020] Available from: https://www.sciencedirect.com/topics/nursing-and-health-professions/waist-to-height-ratio.
13. Yoo EG. Waist-to-height ratio as a screening tool for obesity and cardiometabolic risk. Korean J Pediatr. 2016; 59: 425-431. doi: 10.3345/kjp.2016.59.11.425.
14. American Academy of Pediatrics. Committee on Nutrition. Cholesterol in childhood. Pediatrics.1998; 101:141-7.
15. The *American Academy*of Cholesterol Levels in Children and Adolescents. [Cited October 23, 2020]. Available from: https://www.healthychildren.org/English/healthy-living/nutrition/Pages/Cholesterol-Levels-in-Children-and-Adolescents.aspx.
16. Taheri F, Kazemi T, Bijari B, Namakin K, Zardast M. Chahkandi T. Prevalence of Dyslipidemia among Elementary School Children in Birjand, East of Iran, 2012**.** J Tehran Heart Cent. 2016; 11: 15-20.
17. Lartey A, Marquis GS, Aryeetey R, Nti H. Lipid profile and dyslipidemia among school-age children in urban Ghana. BMC Public Health. 2018; 18: 320. https://doi.org/10.1186/s12889-018-5196-0.
18. Ford ES, Li C, Zhao G, Mokdad AH. Concentrations of low-density lipoprotein cholesterol and total cholesterol among children and adolescents in the United States. 2009; 119: 1108 -1115.
19. Chawla N, Panza A, Sirikulchayanonta C, Kumar R, Taneepanichskul S. Effectiveness of a school-based multicomponent intervention on nutritional status among primary school children in Bangkok, Thailand. J Ayub Med Coll Abbottabad. 2017; 29: 13-20.
20. Sirikulchayanonta C**,** Pavadhgul P, ChongsuwatR, Klaewkla J. Participatory action project in reducing childhood obesity in Thai primary school. Asia Pac J Public Health. 2011; 23: 917-927.

21. MuM, Liu K, He Screen time and childhood overweight/obesity: A systematic review and meta-analysis. Child Care Health Dev. 2019; 45: 744-753. Epub 2019 Jul 24; doi: 10.1111/cch.12701.
22. Laurson KR, Lee JA, Gentile DA, Walsh DA,Eisenmann JC. Concurrent Associations between Physical Activity, Screen Time, and Sleep Duration with Childhood Obesity. Obes. 2014; 204540. eCollection 2014; doi: 10.1155/2014/204540.
23. Sirikulchayanonta C, Ratanopas W, Temcharoen P, Srisorrachatr S.Self-discipline and obesity in Bangkok school children. BMC Public Health. 2011; 11: 158. doi:10.1186/1471-2458-11-158.
24. Jung M K,Yoo Hypertriglyceridemia in Obese Children and Adolescents.J ObesMetabSyndr. 2018; 27: 143-149. doi: 10.7570/jomes.2018.27.3.143.
25. Elmaoğulları S, Tepe D, Uçaktürk SA, Karaca Kara F, Demirel F. Prevalence of dyslipidemia and associated factors in obese children and adolescents. J Clin Res Pediatr Endocrinol. 2015; 7:228-2 doi: 10.4274/jcrpe.1867.
26. Casavalle PL, Lifshitz F, Romano LS, Pandolfo M, Caamaño A, Boyer PM, et al. Prevalence of dyslipidemia and metabolic syndrome risk factor in overweight and obese children. Pediatr Endocrinol Rev. 2014; 12: 213-223.
27. **Sukhonthachit P, AekplakornW, HudthagosolC,Sirikulchayanonta C.**The association between obesity and blood pressure in Thai public-school children. BMC Public Health. 2014; 14: 729. doi: 10.1186/1471-2458-14-729.

Figures

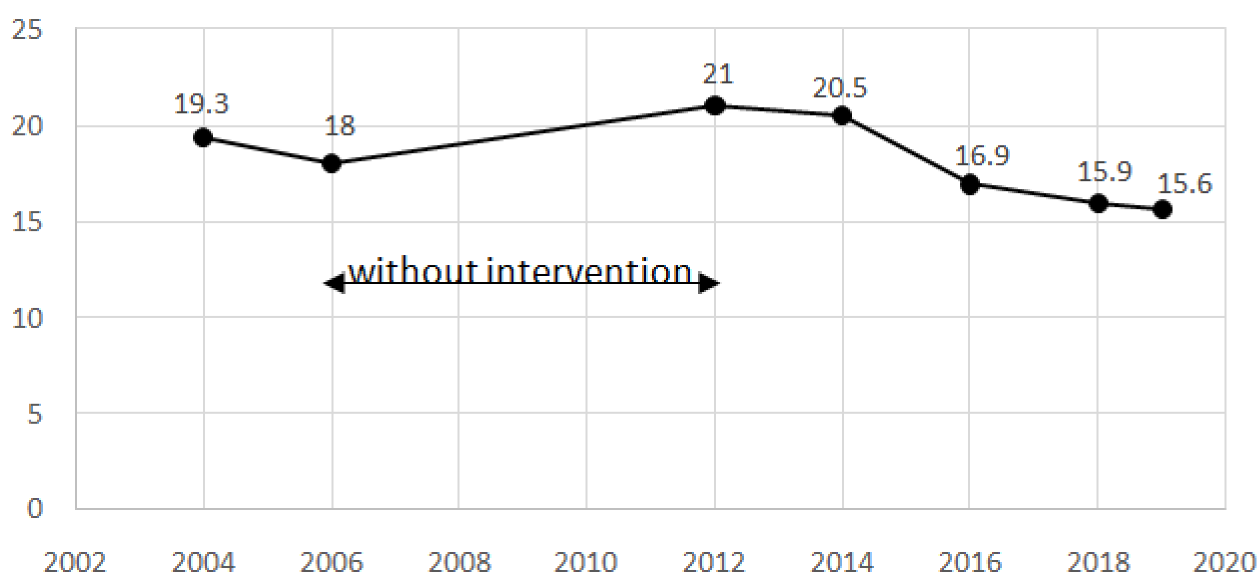

Figure 1

Trends of obesity rates among Bangkok primary school children in the BAHT project network duringan intervention in the years 2004 -2006 and 2012- 2019.

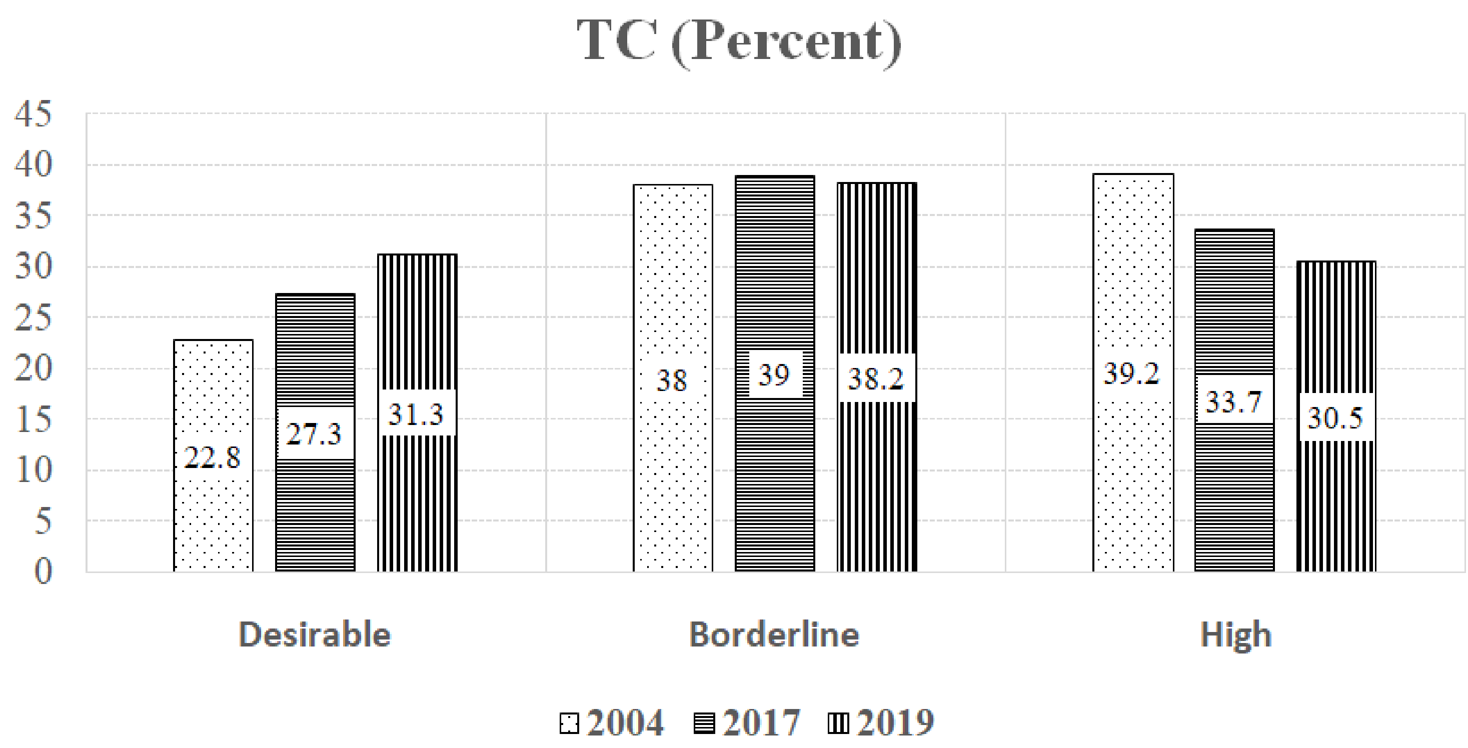

Figure 2

TC levels of primary school children in the years 2004, 2017, and 2019.

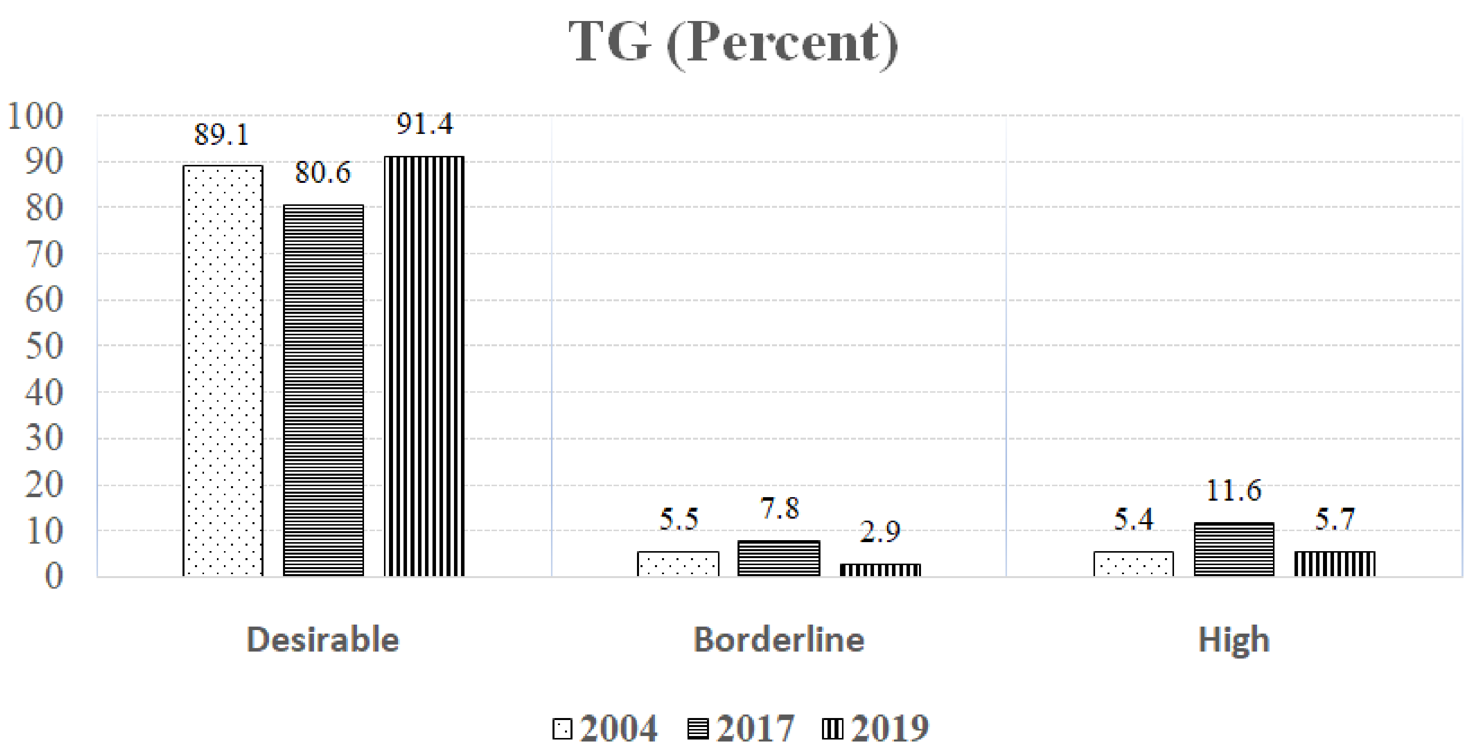

Figure 3

TG levels of primary school children in the years 2004, 2017, and 2019.

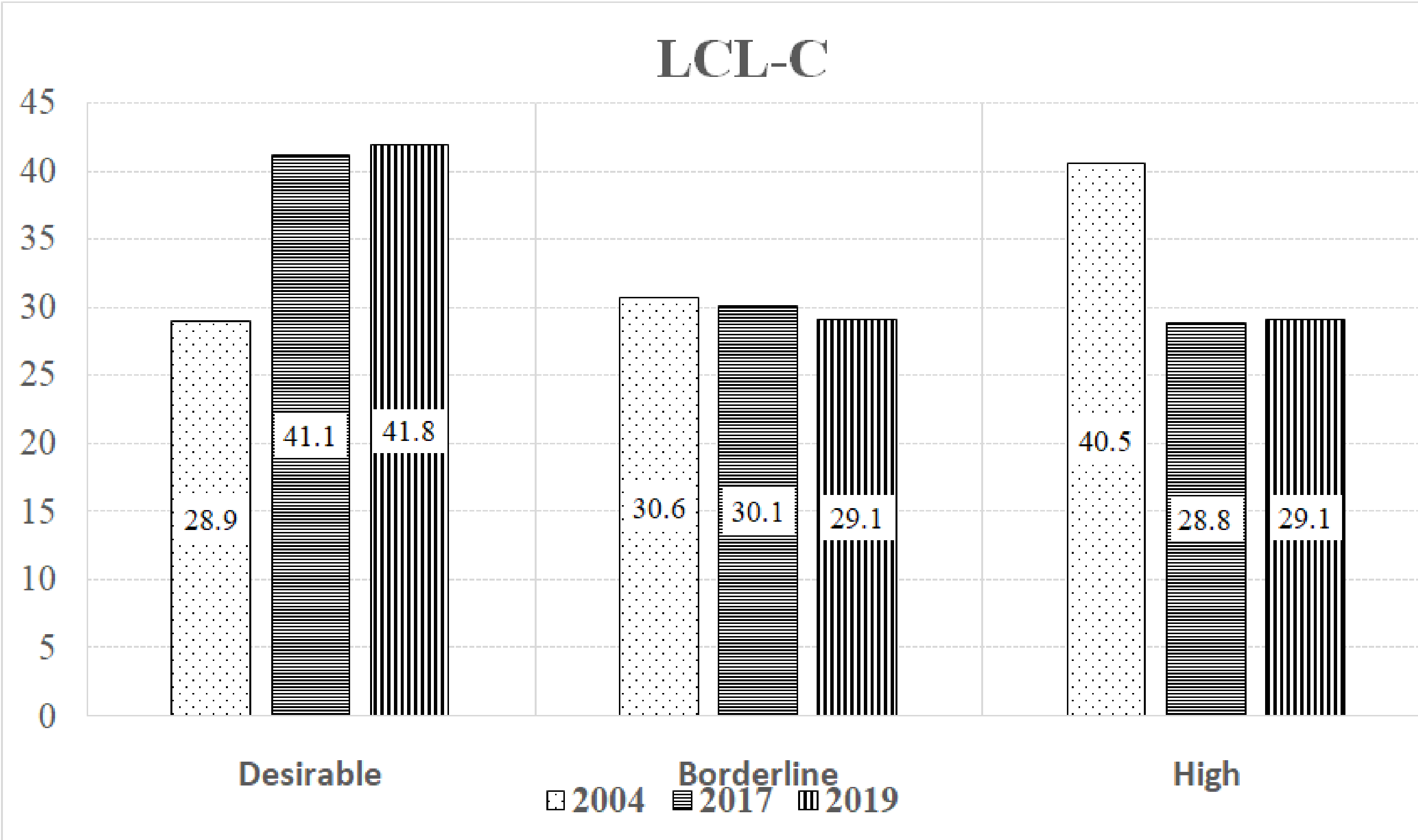

Figure 4

LDL- C levels of primary school children in the years 2004, 2017, and 2019.

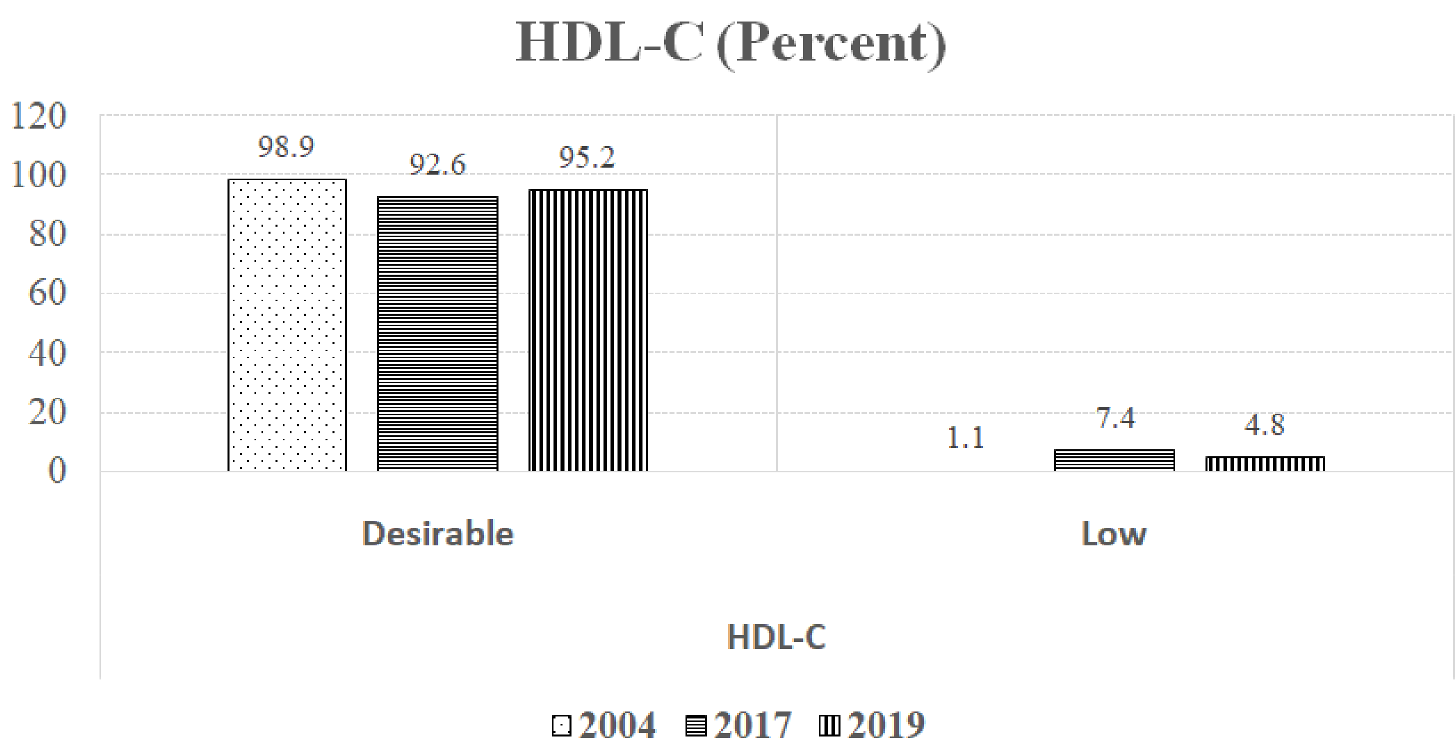

Figure 5

HDL- C levels of primary school children in the years 2004, 2017, and 2019.