Overweight and Obesity in Adolescents in Ho Chi Minh City: From qualitative and quantitative evidence to peer-led intervention

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Thesis by published works

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Statement of Authentication

This thesis is submitted to the University of Sydney, Australia, in fulfillment of the requirement for the degree of Doctor of Philosophy.

The work presented in this thesis is, to the best of my knowledge and belief, original except otherwise stated in the text. I hereby declare that I have not submitted this material, either in full or part, for a degree at this or any other institution.

Signature:  Date: 31 August 2019

Author's Contribution

The work presented in this thesis was conducted by the candidate under the supervision of Professor Michael John Dibley, Sydney School of Public Health, The University of Sydney; Dr Ashraful Alam, Sydney School of Public Health, The University of Sydney; Associate Professor Tang Kim Hong, Faculty of Public Health, Pham Ngoc Thach University of Medicine.

For all the analyses presented in this thesis, the candidate participated in planning the research, designed the studies, analysed the data interpreted the results as well as edited and revised the manuscripts for submission to peer-reviewed journals.

The candidate wrote and compiled this thesis.

Ethical Clearance

The original data from the cross-sectional and cohort research work were approved by the Human Research Ethics Committee, University of Newcastle (Ethics Reference: H-879-0904). The pilot intervention research proposal was approved by the Research Ethics Committee of Pham Ngoc Thach University of Medicine, Ho Chi Minh City. Written informed consent was obtained from the principals of the schools participating in the study. Consent from both the adolescents and their parents were acquired prior to their participation in the study.

Abstract

The aim of this body of research is to provide scientific evidence of nutritional factors and context related to overweight and obesity in adolescents in HCMC and to design a locally feasible and effective intervention to help tackle adolescent overweight and obesity. Specific objectives are: 1/ Identify factors influencing children' dietary and physical practices and the perceptions guiding these practices to prevent obesity through qualitative interviews with children, their parents and teachers in HCMC. 2/ Identify the patterns of consumptions of sugar-sweetened beverages (including soft drink) and their relationship with overweight and obesity in adolescents in HCMC. 3/ Identify the tracking of nutrient intakes and dietary behaviours and their association with overweight and obesity in adolescents in HCMC. 4/ Evaluate the effectiveness of peer-led program to prevent/reduce overweight and obesity in children and adolescents in the literature. 5/ Design a peer-led health program to prevent/reduce overweight and obesity in adolescents in HCMC.

Chapter 3 revealed that the consumption of Sugar Sweetened Beverages (SSB) is popular in adolescents in Ho Chi Minh City, however, the total energy from SSB accounted about 10% of daily energy intake. Among these SSB, fresh milk plus sugar and condensed milk both demonstrated a protective effect against overweight and obesity. Specifically, every kcal of fresh milk plus sugar reduced the odd ratio of 0.995 (95%CI [0.992-0.998]), p<0.001. Every kcal of condensed milk reduced the odd of 0.996 (95%CI [0.992-1.000]), p=0.044. We did not find the relationship between other non-milk SSB with overweight and obesity.

Chapter 4 assessed the Changes of nutrient intakes and dietary behaviours among adolescents. We found a significant increase in BMI and median energy, macronutrient intakes with increasing age, higher in boys than in girls (p <0.001). Tracking of energy and macronutrient nutrient intakes at the individual level was only poor to fair, lowest for the percentage energy from carbohydrate or percentage energy from protein and highest for fat intakes. The linear multilevel models showed two modest but significant positive associations with BMI. Specifically, every 100g higher of daily carbohydrate intake led to an increase of 0.61 unit of BMI in 5 years (p=0.001) and an increase of 100 minutes/week of screen time led to 0.14 unit of BMI increase in 5 years.

Chapter 5 revealed diversified perceptions of obesity, diet and physical activity and the relationship of these factors with adolescent obesity. Findings indicated a low practice of physical activity among participants. The major barriers to obesity prevention included knowledge gaps, food environment in schools, devaluation of physical activity and academic burden. These invaluable inputs were collected using explorative detailed interviews with students, their parents, school PE teachers and a representative of the Department of Education of Ho Chi Minh City. All of the data was

purposefully analyzed to find programmatic implications for a culturally appropriate and feasible intervention to tackle child and adolescent obesity.

Chapter 6 is a systematic review and meta-analysis of peer-led interventions versus childhood obesity. A number of findings have been revealed. The review included 15 studies of moderate to high quality from high-income countries. The age of the participants ranged from 3 years to 17 years. The duration of the intervention ranged from 5 weeks to 28 months. The peer-led content targeted physical activity alone, or a mixture of healthy lifestyle modifications. The meta-analysis of BMI involved 2506 children from 9 studies and demonstrated that programs were effective with a mean difference in BMI of -0.15kg/m^2 (95% confidence interval (CI) [-0.26, -0.03]), p=0.01. Heterogeneity was low (I^2=28%, p=0.19) for the children in the intervention group. The mean difference varied with subgroups with significantly greater effects from interventions focused on physical activity and with longer duration of implementation of the intervention. Sensitivity analysis revealed similar significant findings to the primary meta-analysis.

Chapter 7 is a proposal of the Peer Education and Peer Support Pilot (PEPS) study to evaluate to possibility and further specific requirement for full scale intervention. The pilot is still ongoing and planned to finish in late 2019. This chapter proposed a pilot school-setting programme of four weekly education sessions about healthy choices of food and drinks and usefulness of physical activities. The programme also included a school and online support system to help maintain the effect of education sessions. Both of the education and support stages would be led by students (as peer-leaders) to take advantage of peer influence among junior high school students.

Chapter 8 is for Conclusion. A few appendices were also attached for further details.

Acknowledgments

I would like to deeply acknowledge the substantial support of my three supervisors, Prof Michael John Dibley for his excellent guidance, extensive knowledge and expertise, encouragement and patience that have helped me from the beginning of my PhD candidature; Dr Ashraful Alam for his continuous support, exceptional writing guidance and his never-ending humour; Assoc Prof Tang Kim Hong for her long-term support and extensive knowledge and expertise.

I would also like to express my gratefulness to The University of Sydney (The Sydney Medical School Scholarship) and Australia Awards for co-awarding me through the process from Master of Philosophy and Doctor of Philosophy. If that acknowledgment seems too administrative, then I would like to personally thank the following people (in the hierarchy of time): Ms Annie Dinh, Ms Amy Wan (Australia Award Office); A/Prof Kirsty Foster, Ms Danielle Somers (Sydney Medical School Scholarship); Mr Esmond Esguerra (Hoc Mai Scholarship); Ms Susan Martinez, A/Prof James Gillespie, Prof Joel Negin (Sydney School of Public Health). Without them I would not be able to continue my research.

I would like to acknowledge the time, efforts and patience of all my team research staff, interviewers, research assistants. I also thank to all school students, parents and school principals for their participation in the study.

Of course, I cannot forget, and I would like to thank my home institution, Pham Ngoc Thach University and Faculty of Public Health, and all the senior and junior colleagues for their continuation of support for my training.

My deepest thanks to my family members, my beloved parents, my brother, my wife and my little princess, and also my grandparents, my aunties, my uncles. Without them I could not be the man of today.

Above all, thank you for your blessings, Buddhas of all worlds!

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Publications arising from the thesis

The thesis work is presented for examination as a thesis containing published and unpublished works. The candidate is the first author of each paper/submitted manuscript.

Chapter 5 (published): Ngoc-Minh Nguyen, Michael Dibley, Tang Kim Hong, Ashraful Alam. Perceptions and Practices Related to Obesity in Adolescent Students and Their Programmatic Implications: Qualitative Evidence from Ho Chi Minh City, Vietnam. Matern Child Health J (2017) 21:2199–2208. DOI 10.1007/s10995-017-2340-x

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Submitted manuscripts for publication

Chapter 3: Ngoc-Minh Nguyen, Tang Kim Hong, Ashraful Alam, Michael J. Dibley. Sugar Sweetened Beverage consumption and Overweight and obesity in adolescents in Ho Chi Minh City, Viet Nam: a population-based analysis.

Chapter 4: Ngoc-Minh Nguyen, Tang Kim Hong, Ashraful Alam, Michael J Dibley. Energy intake, macronutrient intakes and the percentages of energy from macronutrients with adolescent BMI: a 5-year cohort data from Ho Chi Minh City, Vietnam.

Chapter 6: Ngoc-Minh Nguyen, Ashraful Alam, Tang Kim Hong, Michael J Dibley. Effectiveness of Peer-led Programs vs Overweight and Obesity in Children: Systematic Review and Meta-analysis of Randomized Controlled Trials.

Additional relevant to the thesis

Chapter 7: Peer Education and Peer Support Pilot study (funded by Medical Research Council, The UK, 2017 – 2019)

Appendix 1: GRANT PROPOSAL - NHMRC/NAFOSTED Joint Call for Collaborative Research Projects. Application ID: APP1157954 (result outcome in October 2018)

Abbreviation

AOR	Adjusted Odd Ratio
APARQ	Adolescent Physical Activity Recall Questionnaire
ASQ	Adolescent Sedentary Questionnaire
BMI	Body Mass Index
BP	Blood Pressure
CDC	Centre for Disease Control and Prevention
CI	Confidence Interval
CVD	Cardiovascular Disease
FFQ	Food Frequency Questionnaire
GDP	Gross Domestic Product
GLLAMM	Generalized Linear Latent and Mixed Models
GPS	Global Positioning System
HCMC	Ho Chi Minh City
ICC	Intraclass Correlation Coefficients
IDF	International Diabetes Federation
IOTF	International Obesity Task Force
IQR	Interquartile Range
MET	Metabolic Equivalent
MVPA	Moderate to Vigorous Physical Activity
NCD	Non-Communicable Disease
OR	Odd Ratio
PA	Physical Activity
PEPS	Peer Education and Peer Support
SD	Standard Deviations
WC	Waist circumference
WHO	World Health Organization

SECTION I:

Overview and Background

Chapter 1:

Overview

1.1. Rationale

Adolescent obesity is one of the public health issues that not only happened in high-income countries but also in low- and middle-income nations, including Viet Nam(1, 2). Adolescent obesity is linked with serious health consequences including those of cardiovascular diseases, diabetes (type II), pulmonary, liver, renal complications and some cancers in later life. It also affects psychological health by raising unnecessary stigmas and overall it lowers health-related quality of life of the adolescents.

The situation of overweight and obesity in urban areas of Viet Nam has changed recently following the rise of the economy. Specifically in Ho Chi Minh City, one of the largest urban areas of the country, within the past two decade, the prevalence of overweight and obesity has increased dramatically, from merely 5.0% and 0.6% in 2002, to 11.7% and 2.0% in 2004,(3) and then continue to rise fifty per cent more to 17.8% and 3.2% in 2010.(4)

It is estimated that by 2030, based on current data of trend (1), that if nothing changes in the obesity prevention, the situation of overweight and obesity in many countries in Asia (including Viet Nam) will be much more serious than that of high-income now, or at least serious enough to cause a setback in total income of the countries. Not only the cost of millions of dollars,(5) thousands of unexpected and early deaths can happen.(6, 7) Thus, it is very urgent to research and find out the appropriate and effective approach to tackle this problem.

However, childhood obesity is a complicated issue which is not only limited to nutritional behaviours nor low physical activeness but also involves economic, cultural and social contributors (8, 9). Indeed, robust and reliable systematic reviews pointed out that obesity intervention, especially in children, can only succeed if researchers find a design both scientifically correct and culturally appropriate (10-15). Thus, this research work is purposefully to seek scientific evidence to build a realistic framework for intervention to

tackle obesity in the adolescent population by using a pioneer trial in a series of junior high schools in Ho Chi Minh City.

The Hypotheses/Questions of the Research Thesis:

1/ What are the nutritional and physical activity perceptions and practices which can influence the adolescent overweight and obesity in Ho Chi Minh City? Which parts of perceptions and practices can be modified?

2/ How strong are the relationships of sugar-sweetened beverage consumption and the tracking of nutrient intakes versus adolescent overweight and obesity in Ho Chi Minh City?

3/ Given the need of a prevention intervention, what kind of intervention may work? What can be drawn from the literature currently?

4/ What step(s) can be taken to implement an obesity prevention intervention in adolescents in Ho Chi Minh City?

1.2. Research Aims and Objectives

Aim of this Thesis

The aim of this Thesis is to provide scientific evidence of nutritional factors and context related to overweight and obesity in adolescents in HCMC and to design a locally feasible and effective intervention to help tackle adolescent overweight and obesity.

Objectives:

1/ Identify factors influencing children' dietary and physical practices and the perceptions guiding these practices to prevent obesity through qualitative interviews with children, their parents and teachers in HCMC.

2/ Identify the patterns of consumptions of sugar-sweetened beverages (including soft drink) and their relationship with overweight and obesity in adolescents in HCMC.

3/ Identify the tracking of nutrient intakes and dietary behaviours and their association with overweight and obesity in adolescents in HCMC.

4/ Evaluate the effectiveness of peer-led program to prevent/reduce overweight and obesity in children and adolescents in the literature.

5/ Design a peer-led health program to prevent/reduce overweight and obesity in adolescents in HCMC.

1.3. Main Objectives

The ultimate aim of this thesis is to find scientific evidence to design an intervention to prevent or reduce overweight and obesity in adolescents in HCMC, and this requires different and mixed method approach. Accordingly, as the evidence are both qualitative and quantitative, a list of objectives (above) was raised to fulfil the aim. The methods vary with each objective from the list.

Specifically, to identify the practices and the perceptions of people in objective 1 we need to apply qualitative techniques for collecting thoughts, beliefs and behaviours from varied subjects and then to apply appropriate analytic skills in qualitative research to obtain meaningful understanding and interpretations to use later.

The second objective suggests a cross-sectional analytical approach to reveal the meaningful patterns of sugar-sweetened beverage consumption and their relationship with the problem of overweight and obesity. Meanwhile the third objective may need the longitudinal data analysis approach to extract, compare, and compile data in a meaningful way to deduce the trends of targeted patterns.

The fourth objective would need the systematic review skills to find, extract, and synthesis of data from the scientific databases to answer the research question of effectiveness of the intervention. Finally, the last aim requests a specific and culturally appropriate intervention which need all of the previous information to complete.

1.4. Thesis outline

The thesis consists of eight chapters and three appendices. **Section I** is an overview of the research and includes the introduction, aims of the study (**Chapter 1**) and the background of the overweight and obesity in adolescents in Ho Chi Minh City was explored to identify the situations and context of the thesis (**Chapter 2**).

In **Section II**, nutritional patterns of adolescents in Ho Chi Minh City were explored based on previous data. **Chapter 3** (submitted) documents data from cross-sectional population-based study was used to assess the consumption of sugar sweetened beverages among adolescents and their relationships with overweight and obesity. **Chapter 4** (submitted) focuses on the tracking of nutrient intakes and some dietary behaviours using a 5-year longitudinal study profile.

Section III consists of intervention related content. **Chapter 5** (published) is a formative research with qualitative approach to find evidence and answers for an appropriate method and elements of intervention. **Chapter 6** (submitted) is a systematic review and meta-analysis to assess the effectiveness of peer-led interventions to prevent/reduce overweight and obesity in children. **Chapter 7**(Grant received by Medical Research Council, the UK) summarizes a pilot study using peer-led intervention approach.

Section IV contains the final **Chapter 8** to conclude the thesis by summarising the main findings, limitations of the research, implications of the research and recommendations for future research.

In the **Appendices**, **Appendix 1** is the submitted Protocol for another Research Grant with the larger scale intervention to prevent adolescent obesity, also using peer-led approach.
Appendix 2 is the Reviewers' comments and responses for publications.

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Chapter 2:

Background

2.1. Childhood overweight and obesity

Obesity is an abnormal accumulation of body fat (usually 20% above the normal ideal body weight) to the extent that it may have an adverse effect on health (Figure 1 below, source: CDC, 2011). It is a chronic disorder, officially classified as a disease (ICD-10 E66.0) in 1990 and defined as a body mass index (BMI) of 30 kg/m^2 or more.

Figure 1. Body mass index definitions (kg/m^2). Source: Centres for Disease Control and Prevention, 2011.

Body obesity is ideally defined as abnormal accumulation of body fat, to the extent that health may be impaired(1). Longitudinal research revealed that obesity in children dramatically increased the risk of cardiovascular diseases, type 2 diabetes, pulmonary, renal, musculoskeletal and other complications, and some cancers in adulthood.(2-7)

The cost of overweight and obesity on a global scale is enormous. A recent systematic review(8) of cost across middle- and high-income countries revealed that direct cost of obesity ranged from several thousands to tens of thousands of dollars per year per capita. Indirect and lifespan cost are many times higher.

There are several methods to precisely diagnose childhood obesity using body fat-mass measurement which includes underwater weight, Dual-energy X-ray Absorptiometry (DXA), Computerized Tomography (CT), and Magnetic Resonance Imaging (MRI)(9-11). These methods, although precise and reliable(12), are complicated and expensive. They require experience and skills in measurement, making them difficult to apply to a large number of samples. In contrast, measuring obesity based on anthropometry (Body Mass Index, Obesity Index, Skinfold thickness, Waist circumference and the Waist Hip Ratio) is far more applicable and frequently used in studies around the world (13-15). Due to its high simplicity, non-invasiveness, low cost and strongly correlated with body fat, Body Mass Index (BMI), which is calculated by dividing a person's weight in kilograms by the square of height in meters, is widely used and recognised in practice worldwide. Also using BMI in measurement can be beneficial as the results is comparable with many hundreds other studies. However, one of the major difficulties using BMI is choosing the cut-off points for categorizing the under-, normal, overweight and obesity.

For child populations, the two most recognised BMI classification systems are utilized to assess obesity: the first from the International Obesity Task Force (IOTF) and the second from the World Health Organization (WHO). Both systems were proposed based on representative samples of different national populations. The IOFT criteria are based on six large datasets from Brazil, Hong Kong (China), Holland, Great Britain, the United States and Singapore (16, 17). Table 1 below lists the cut-off points for overweight and obesity, separated by genders, for children from 2 to 18 years old. Although very easy to use in the field with clear numbers, the IOTF cut-off is an extrapolation of the adult BMI cut-off points for obesity (17). It thus may lack a strong foundation of real values for some age groups (no data for Singaporean children below six years old) and the age range is restricted to 2-18 rather than all childhood.

Meanwhile, the WHO criteria were proposed based on the data from the 1977 United States' National Centre for Health Statistics (NCHS)/WHO growth reference (1–24 years) merged with data from the under-fives growth standards' cross-sectional sample (18–71 months) to smooth the transition between the two samples (18). The WHO classifications for overweight and obesity differed greatly by age groups. For the younger children (0-5 years), WHO classifies children above +1 standard deviation (SD) as "at risk of overweight", above +2 SD as "overweight", and above +3 SD as "obese"

Table 1. International cut off points for body mass index for overweight and obesity by sex between 2 and 18 years, defined to pass through body mass index of 25 and 30 kg/m^2 at age 18, obtained by averaging data from Brazil, Great Britain, Hong Kong, Netherlands, Singapore, and United States(16)

	Body mass index 25 kg/m^2		Body mass index 30 kg/m^2	
Age (years)	Males	Females	Males	Females
2	18.41	18.02	20.09	19.81
2.5	18.13	17.76	19.80	19.55
3	17.89	17.56	19.57	19.36
3.5	17.69	17.40	19.39	19.23
4	17.55	17.28	19.29	19.15
4.5	17.47	17.19	19.26	19.12
5	17.42	17.15	19.30	19.17
5.5	17.45	17.20	19.47	19.34
6	17.55	17.34	19.78	19.65
6.5	17.71	17.53	20.23	20.08
7	17.92	17.75	20.63	20.51
7.5	18.16	18.03	21.09	21.01
8	18.44	18.35	21.60	21.57
8.5	18.76	18.69	22.17	22.18
9	19.10	19.07	22.77	22.81
9.5	19.46	19.45	23.39	23.46
10	19.84	19.86	24.00	24.11
10.5	20.20	20.29	24.57	24.77
11	20.55	20.74	25.10	25.42
11.5	20.89	21.20	25.58	26.05
12	21.22	21.68	26.02	26.67
12.5	21.56	22.14	26.43	27.24
13	21.91	22.58	26.84	27.76
13.5	22.27	22.98	27.25	28.20
14	22.62	23.34	27.63	28.57
14.5	22.96	23.66	27.98	28.87
15	23.29	23.94	28.30	29.11
15.5	23.60	24.17	28.60	29.29
16	23.90	24.37	28.88	29.43
16.5	24.19	24.54	29.14	29.56
17	24.46	24.70	29.41	29.69
17.5	24.73	24.85	29.70	29.84
18	25	25	30	30

However, for older children (>5 years), the WHO adolescence BMI for-age curves at 19 years closely coincide with adult overweight (BMI 25) at + 1 SD and adult obesity (BMI 30) at + 2 SD. As a result, these SD classifications are extended down to 5 years. Figure 2a and 2b below showed the WHO cut-offs at the 85th and the 95th centiles to categorise as overweight and obesity respectively in boys and girls. There is certainly some confusion to think about the difference that WHO criteria imposed on the borderline of 5 years old but it was understandable because the WHO standards sample was prescriptive and unhealthy weights for length/height were excluded prior

to constructing the curves(19). Furthermore, it is necessary to be cautious to classify younger children as overweight or obese to avoid the risk of placing them on restrictive diets while they are still growing.

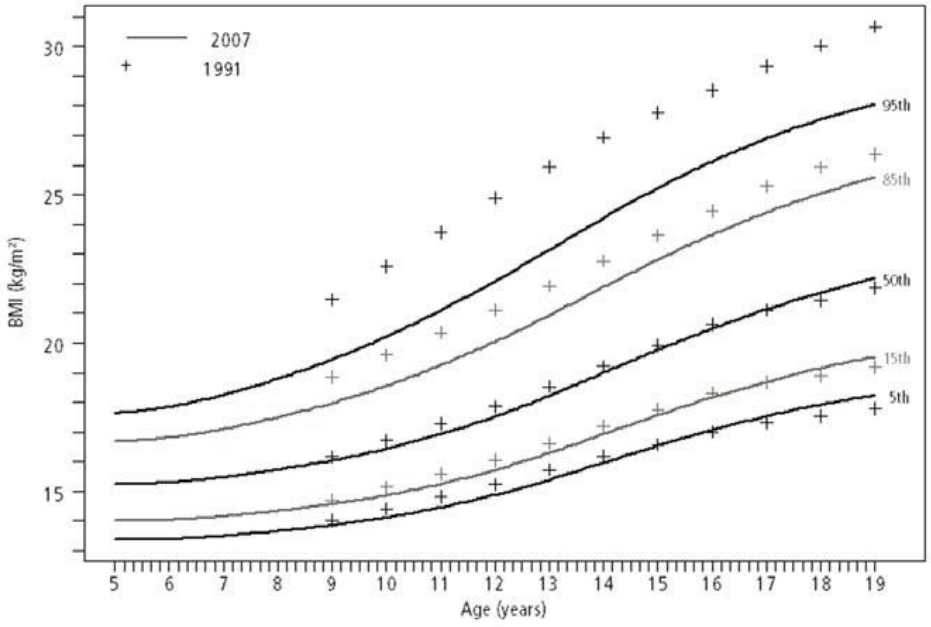

Figure 2a. Comparison between the 1991 and 2007 BMI-for-age percentile curves – boys

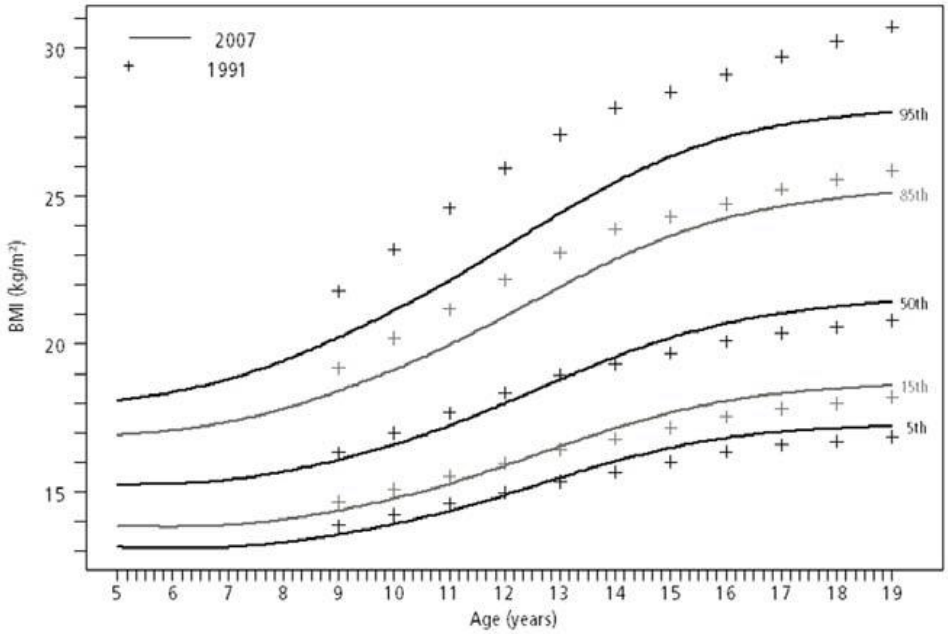

Figure 2b. Comparison between the 1991 and 2007 BMI-for-age percentile curves – girls

Nevertheless, when comparing these two classification systems, the WHO system seems to have higher sensitivity but the IOTF more specificity (20, 21). To capture the highest sensitivity (highest number of cases) to maximize the prevention effect in our project and to make comparisons with many low- to middle-income countries easier, we chose the WHO classification of overweight and obesity as our criteria for childhood obesity. In this document, we use the category of overweight when BMI is from or higher than 85th centile and lower than 95th centile, and the category of obese when BMI is from or higher than 95th centile of the WHO reference population."

2.2. Overweight and obesity situation and causation:

Overweight and obesity in children and adolescents are currently very important issues in all countries across all levels of income (22). Recent data revealed that the prevalence of overweight and obesity in many countries continues to rise (22, 23). For some countries like the United States of America (24, 25), Australia (26), the United Kingdom and some other Western European nations (22, 27), the prevalence seems to be stable or slowed down, but remains at a high level. The situation is now reaching further than a few high-income countries in the past to many other nations of all levels of income (22). Some countries which were known for undernutrition are now having to face double burdens of both under and over-nutrition.(28)

Countries from Asia, where the population is often larger than in America and Europe, will need to overcome this challenge with a number of difficulties as each increase in prevalence percentage point results in a much higher number of overweight and obese children or adults. In addition, Asian nations generally have fewer resources and expertise to deal with the situation. Indeed, a systematic review (29) of childhood prevention interventions in Asia revealed that a fewer number of trials has been conducted in the whole continents of more than half of the global population. As it has been noticed from the landmark research of NCD Risk Factor Collaboration (NCD-RisC) (22) recently published on The Lancet, the countries of Southeast Asia, including Vietnam, were likely to face with accelerated increase of obesity in children and that childhood obesity in the region were no longer correlated with the prevalence of obesity in adults.

With the above facts, the need for interventions to prevent overweight and obesity in children and adolescents is urgent and should be one of the top priorities of

countries, including Vietnam. To effectively prevent childhood obesity, it is crucial to understand its causation. As shown by previous research, the development of childhood overweight and obesity involves a complex set of factors from multiple contexts that interact with each other to place a child at risk of overweight. This multifaceted system can be conceptualized using Ecological Systems Theory (EST). EST conceptualizes human development from an interactive contextual perspective (30, 31). According to EST, development, or change in individual characteristics, cannot be effectively explained without consideration of the context, or ecological niche, in which the person is embedded. An ecological niche includes not only the immediate context in which a person is embedded but also the contexts in which that context is situated. In the case of a child, the ecological niche includes the family and the school, which are in turn embedded in larger social contexts, including the community and society in general. In addition to these larger contexts, characteristics particular to the child, such as gender and age, interact with familial and societal characteristics to influence development. To summarise, according to EST, development occurs as a result of interactions within and among these contexts; that is, characteristics of the child interact with processes in the family and the school, which themselves are influenced by characteristics of the community and society at large. The application of EST to predictors of childhood overweight is illustrated in figure 3 below.

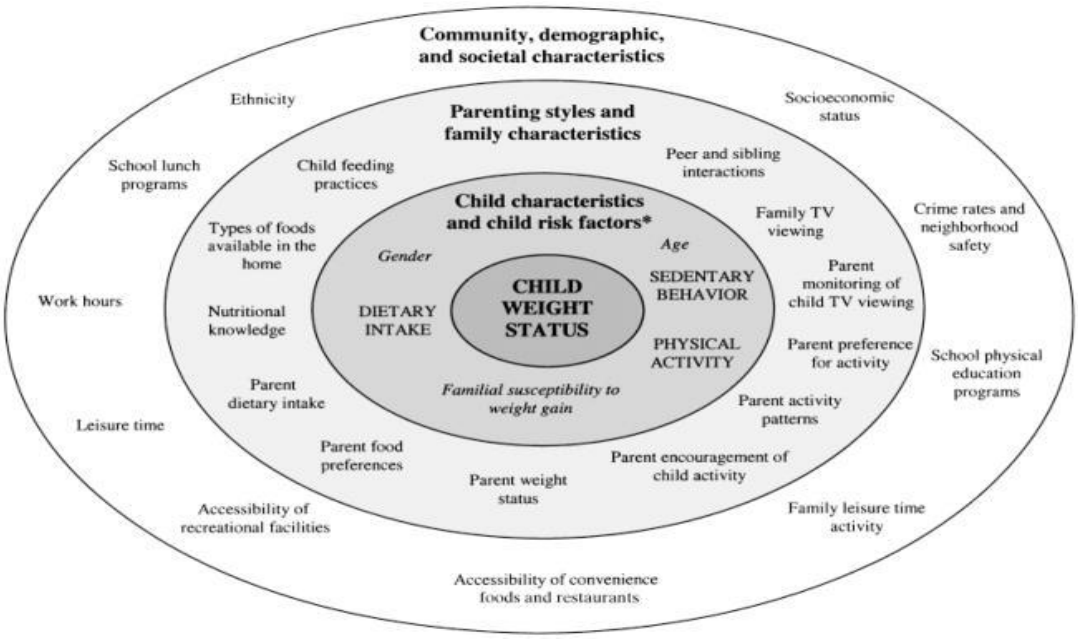

Figure 3. Ecological model of predictors of childhood overweight. ✻=Child risk factors (reproduced from original text, with permission) (32)

Figure 3 above mentioned multiple risk factors for children overweight/obesity including groups of non-modifiable and modifiable risk factors. The first groups, in summary, includes genetics and medical conditions which have been widely studies previously. For latter group comprises multiple characteristics ranging from community and society factors to family and to personal/child risk including dietary intake and physical activity.

Although challenging, there are still opportunities to control overweight and obesity in children and adolescents for several reasons. First childhood obesity is not merely an excess of energy gaining but a combination of political, social, environmental, lifestyles and personal practices and habits (33). Though it may sound complicated, each of these components has a chain of modifiable factors that allows the control over the entire component. For example, from the social and political aspects, a new policy can tackle the risk of obesity or promote anti-obesity factors. Meanwhile in a community context, a novel engaging approach or a promotion of a new beneficial culture can help reduce the obesity trend. The opportunities of change can go even further to personal level if we could apply and combine the factors that interact with children, such as peer influence, school practices and self-control over nutrition and physical activity (as seen in figure 4 below). Indeed, peer-led interventions have been proved to be effective and low cost in multiple healthcare programs including in adolescent asthma program in Australia recently (34) and in other countries previously, e.g. in reducing adolescent smoking (35) and youth-focused sexual health intervention(36). In another systematic review of interventions, authors also identified five studies comparing the effectiveness of peer-leaders to teachers in delivering the same intervention, of which two found peer-leaders to be more effective than teachers.(37)

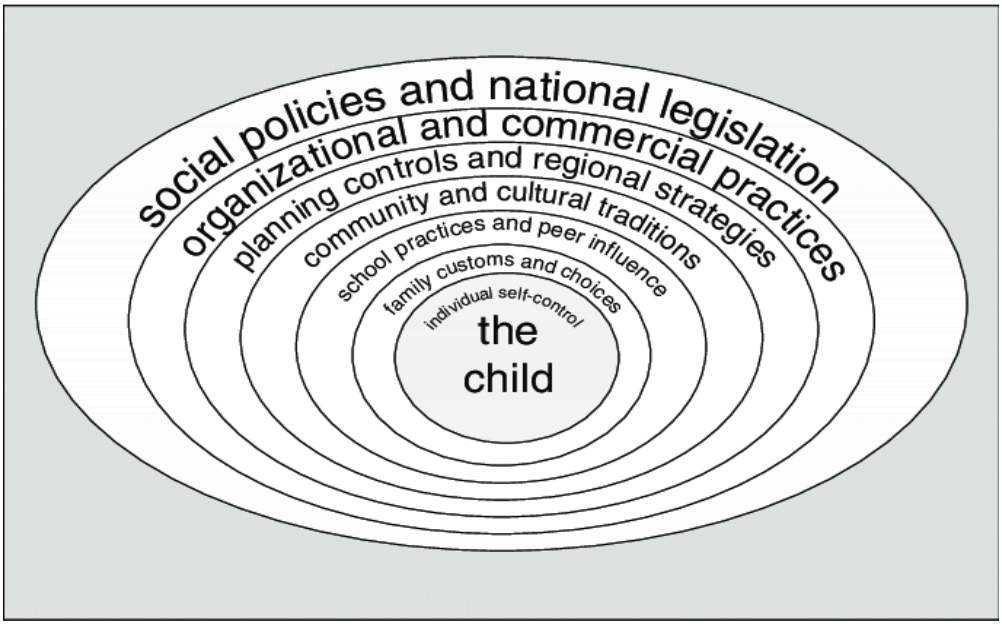

Figure 4. Opportunities for influencing a child's environment (reproduced from original text, with permission)(38)

2.3. Overweight and obesity in Ho Chi Minh City, Viet Nam

Viet Nam, in recent years, has seen economic and social changes with great speed and has recently jumped from low- to middle-income countries (39). Indeed, with a population of over 95 million people (2017), Viet Nam has become one of the world's 50 largest economies based on the total GDP (IMF 2016). Ho Chi Minh City (HCMC), one of the most populous cities and a hub for eco and social change of the country, is also recognised as the top 50 largest and most populated cities based on the World's Cities data booklet published by the United Nations in 2016. Located in between the Mekong Delta and the central highlands with ideal conditions of weather, land and logistic, it has become the ideal destination of immigrants of the whole country. However, the speed of economic development seems to coincide with an increase in childhood obesity in this city, especially in adolescents. In preventing childhood obesity, it is important to pay attention to obesity in adolescents. First, obese adolescents are more likely (than younger children) to become obese adults and have a higher risk of non-communicable diseases. Second, the prevalence of overweight and obesity in this age group is higher than other child age groups (40). Third, adolescents will soon become the young working adults of the city and thus growing up with obesity will result in a huge burden of earlier medical expenses. Fourth, the adolescents are those who are embracing changes, especially new yet modifiable and social behaviours and habits, including the nutritional ones. Thus any

interventions targeting social and behavioural changes in the adolescent context may be helpful for them against obesity and cardiovascular risks. And lastly, the adolescent population is an ideal age group for multiple intervention approaches, including peer-education and support, school-based and combining of both theoretical and practical strategies.

Unfortunately, since 1990s, the citizens of this soon-to-be megacity have witnessed a four-fold increase in prevalence of overweight and obesity in adolescents, particularly from merely 5.0% and 0.6% in 2002, to 11.7% and 2.0% in 2004,(41) and then continue to rise to 17.8% and 3.2% in 2010.(42) Particularly, the prevalence is much more serious for boys than girls with specific prevalence in each age group presented in figure 5 below.

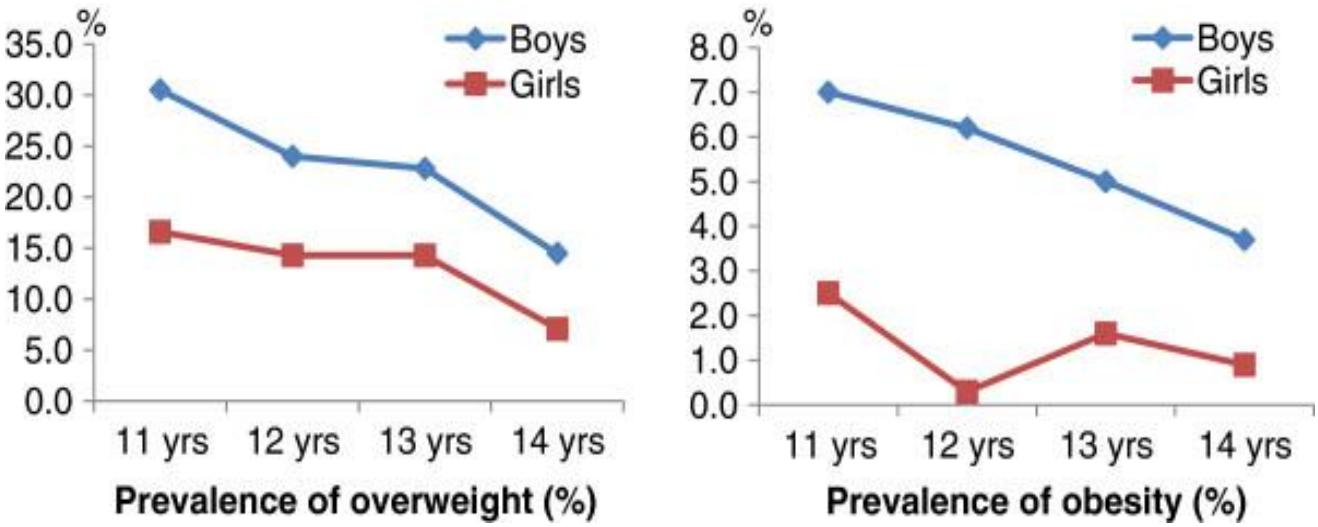

Figure 5. Prevalence of overweight and obesity by age and sex of teenagers from HCMC in 2010 (reproduced with permission)(42)

The overweight and obesity of children and adolescents in HCMC has been a burning topic for local research. Several articles have been published in the past decade that aimed to identify the risk factors (43), the relationship of risk factors with overweight and obesity of adolescents (44, 45), including male gender, younger age group (44) and the modifiable behaviours such as physical activity (46) and screen time (47). Previous work has also identified the clear risks of low physical activity and increased sedentary time (46) among local adolescents. Nonetheless, there is still a huge gap that can help transform the research results into effective obesity prevention

programs. Although some risk factors have been identified, nutritional and dietary issues are yet to be fully understood. While fast foods have been studied previously without any strong link to childhood obesity (46), there are currently speculations about the role of soft drinks. There are reports of soft drinks as a likely risk factor for childhood obesity (44), Still, questions remain, such as what kind of soft drinks or other sugar-sweetened beverages are mostly consumed by adolescents and which of them are associated with childhood obesity? Sugar-sweetened beverages are also accessible in HCMC through many new beverage shops, and through the availability of multiple types of drinks including traditional leaf juice drinks with sugar, to milk-based beverages, and canned drinks. Thus there is a need for a thorough investigation of sugar-sweetened beverages and their association with child and adolescent obesity.

Besides, there are few investigations of the pattern of nutritional consumption among adolescents in urban areas in Vietnam. Among the nutrients of fat, protein and carbohydrate, which one is more (or less) likely to track among adolescents? Furthermore, in this young population context, we need to understand which dietary patterns can be modified and which approach is more likely to be effective? Those issues have never been investigated, thus making any intended interventions very hard to design and succeed. Consequently, in this PhD dissertation, I intend to conduct a series of studies to examine the evidence about sugar-sweetened beverages, nutritional tracking and appropriate approaches to create an intervention framework for future childhood obesity prevention programs. Thus in this thesis I will use a coordinated structure to answer these objectives from Chapter 3 to Chapter 7 (as discussed at the beginning of the thesis) and Chapter 8 to summarize all the evidence found and suggest possible applications.

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SECTION II:

Finding Evidence

Chapter 3:

Cross-sectional study

Sugar sweetened beverage consumption and overweight and obesity in adolescents in Ho Chi Minh City, Vietnam: a population-based analysis

Ngoc-Minh Nguyen, Tang Kim Hong, Ashraful Alam, Michael John Dibley

(SUBMITTED)

This chapter presents and summarizes the consumption of sugar-sweetened beverages and the relationship of this consumption with overweight and obesity among adolescents in Ho Chi Minh City (HCMC). The data from this chapter came from a large, population and school-based cross-sectional study. The results of this study directly answered Objective number 2 of the Thesis (Identify the patterns of consumptions of sugar-sweetened beverages (including soft drinks) and their relationship with overweight and obesity in adolescents in HCMC).

Sugar sweetened beverage consumption and overweight and obesity in adolescents in Ho Chi Minh City, Vietnam: a population-based analysis

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SUMMARY

Objective: to describe the patterns of sugar sweetened beverage consumption among adolescents in Ho Chi Minh City and to identify a possible relationship between this consumption and overweight and obesity and with other main factors

Method: A secondary analysis from a cross-sectional study of 11 to 15-year-old students from 31 junior high schools across Ho Chi Minh City. We measured the students' anthropometric status and assessed beverage consumption using a validated FFQ. Multivariate logistic regression models were used to identify the association between the consumption of sugar-sweetened beverages and obesity and other factors.

Results: The sugar-sweetened beverages (SSB) ranged widely from modern soft drinks and milk-based beverages to traditional sugar-added fruit and leaf juices. These beverages were very popular among 2,660 participants with 36% consuming at least one variety daily. Factors positively associated with the sugar-sweetened beverage consumption included a higher level of physical activeness, higher consumption of fast foods, and daily fruit and vegetable consumption. We found a protective effect of milk based SSB against overweight and obesity status of the students with every kcal more of fresh-milk-with-sugar can reduce an odd of 0.005 (95%CI [0.002-0.008]), $p<0.001$ and every kcal of condensed-milk can reduce an odd of 0.004 (95%CI [0.002-0.010]), $p=0.044$. None of other SSBs was significantly related to adolescent overweight and obesity.

Conclusion: Milk-based drinks potentially protect adolescents against overweight and obesity and further research to assess this protection is needed.

Keywords: soft drink, milk, sweetened beverage, adolescent, overweight, obesity, Vietnam

BACKGROUND

Overweight and obesity in children and adolescents can lead to various health consequences later in life, including cardiovascular diseases, diabetes, some cancers, and a lower quality of life. (1-3) Previous research has found that besides other factors, sugary beverages have a strong influence on child weight, especially in young teenagers. (4, 5) Sugar-sweetened beverages are increasingly attractive to children including adolescents in Vietnam. This is the result of urbanisation and globalisation leading to an increased social value for sugar-sweetened beverages, driven by the marketing strategies and advertisements of producers.(6)

High-income countries have regulations to control child consumption of sugary drinks, (7, 8) but less wealthy countries lack such regulations or the means to enforce their laws. Regulations to control sugary drinks are based on the supply-consume law theory. There are currently three main forms of sugar taxations, Excise taxes, Sales taxes and Taxes on commercial production. The exact form of tax varies greatly between implementing countries from direct tax of 5% - 20% (most common form, as in Australia, France, Spain, Hungary; several localities of the USA including Berkeley, San Francisco, Oakland, Albany of California, Philadelphia of Pennsylvania, Boulder of Colorado, Cook County of Illinois, Portland of Oregon, Seattle of Washington; Mexico, Chile in South America; Brunei, Thailand, the Philippines, Malaysia and various island nations and territories in the Pacific) to even as high as 80-100% (Norway, United Arab Emirates) for a sugary product to a sugar-level dependence levy (The UK, from 2016; South Africa, Ireland). Even though the form of taxation varies, the consequences of these regulations are remarkable as the SSB consumption and sales dropped from 5% to 20% in those implementing countries and obesity-related and diabetes-related cost reduced, and tens of thousands of lives saved yearly and these taxations are considered as an effective nation-wide tool to improve health for the population. Unfortunately, according to business reports and international estimates,(9) the market for sugar-sweetened beverages in developing countries is growing exponentially. Increased consumption of sugar-sweetened beverages may only put greater pressure on health expenses in those countries because their consumption increases the risks of many diseases including diabetes and metabolic diseases.(10, 11). Consumption of such energy-dense beverages can easily skew children’s daily nutrient intake towards one

type of macronutrient, sugar, and consequently and critically outweigh the body energy expenditure leading to a greater chance of becoming obese.

In recent years, Vietnam has made major socioeconomic improvements with a direct impact of the open market policy. However, the open market and increasingly Western-influenced life-style are also bringing the spread of famous soft drink brands across the country, especially in big cities such as Ho Chi Minh City (HCMC). Concurrently, epidemiological research showed that the prevalence of overweight and obesity in adolescents in HCMC, the nation's most populated urban area, has risen in recent years (12, 13). Although extensive local analyses revealed several major risk factors for adolescent obesity (i.e. physical inactivity and fast food consumption) little is known about the relationship of sugar-sweetened beverages and obesity (14). Indeed, researchers need both the details of patterns of consumption of sugar-sweetened beverages (SSB) by adolescents and their possible health consequences to direct their research focus and to use these insights to help tackle obesity more effectively. Thus, the objectives of this study are to identify the consumption patterns of sugar-sweetened beverages among the adolescents in HCMC and to identify their relationships to overweight and obesity in this young population. We hypothesise a positive relationship between the consumption of sugar-sweetened beverages and overweight/obesity status of adolescents.

METHODS

Study design and sample size

We analysed data of a population based cross-sectional study conducted in HCMC in 2008. The objectives of the original study were to identify the prevalence of overweight and obesity in adolescents aged 11 to 14, and to identify potential factors associated with overweight and obesity. The initial sample size was estimated to detect a prevalence of overweight and obesity as small as 10% (based on a previous study(13)) with the precision error of 2% and at a type 1 error of 5%. Then, the estimated sample size of 865 for this prevalence of overweight and obesity was calculated as in the formula below.

Sample size for prevalence = $Z^2_{(1-\alpha/2)} * p(1-p) / d^2$ (15)

In addition, the sampling method was multistage cluster sampling with the design effect of 2.1 (16) and the acceptance rate to participate in the study was estimated as 80%. These estimates required a total sample size of 2271 which our sample of 2712 students were well above this required number.

Sample selection

We selected the participants from the junior high schools across Ho Chi Minh City (HCMC), including both urban and suburban areas. With a high level of school attendance (>96%), the school student population can represent the general adolescent population in HCMC.

Of the total 136 public and 4 non-public junior high schools across HCMC at the time of survey, only 31 schools were chosen using probability proportionate to the total number of students at each school. In each nominated school, we prepared lists of classes from grade 6 to 7 (group 1) and grade 8 to 9 (group 2). We randomly selected one class from each group. All the students in the selected classes were invited to participate. Only those who consented to join were included. Details of the sampling have been described previously.(13, 17)

Data collection

Trained research assistants and health workers (who were not involved in data analysis) collected the data at the schools. Data include students' anthropometric measurements, dietary behaviours including consumption of sugar sweetened beverage, daily physical activity throughout the year and the family social economic indexes.

Anthropometry and other demographic information

Trained staff measured children's weight in the standing position, without shoes and heavy clothes, using a Tanita® electronic scale to the nearest 0.1 kg. Standing height was recorded without shoes using a suspended Microtoise tape to the nearest 1mm with standard methodology. Body mass index (BMI) was later calculated as weight in kilogram divided by square of height in meter. The status of overweight or obesity were defined using International Obesity Taskforce (IOTF) sex and age specific BMI cut-offs.(18)

Trained staff also collected demographic information included each student's gender, date of birth, current age (as of the time of data collecting), living area (as urban or suburban area), and pubertal status (using Tanner scale of sexual development).

Consumption of sugar sweetened beverages and drinking patterns

We conducted a pilot to find out the major food items and drinks consumed by students in junior high schools prior to the study. Among the items identified in the pilot, we selected 160 major food and drink based on their frequency and quantity consumed to include in the Food Frequency Questionnaire, which was validated in the same population previously.(19) Twelve beverages were recorded as the main sugar sweetened drinks which were soft drinks, tonic drinks, fruit juices (including sugar cane), green leaf juice with sugar, sugar-added coconut juice, industry-made iced tea, cacao powder drink, fresh milk with sugar, condensed milk, soya milk with sugar, and yoghurt. These sugar sweetened beverages were among the first items on the Food Frequency Questionnaire. The frequency of consumption of each sugar sweetened beverage ranged from never use to 2-3 times/day (details in result section). The quantity ranged from a quarter to full size portion. These portion sizes are listed in Annex table A2, based on local dietary research by Nutrition Centre in Ho Chi Minh City. To maintain the fidelity and consistency of the measurement of sugar sweetened beverage consumption we used life-sized colourful image booklets for all items (including beverages) mentioned in the FFQ. The data collectors were also trained to facilitate the use of the booklets by adolescents whenever necessary.

Consumption of fast food

Fast food consumption was measured using Food Frequency Questionnaire (validated in the same population previously (19). Information of frequency and the estimated amount of Western fast food consumption were collected by asking directly the adolescents. For a more precise estimation, a photo booklet which had life-size photos of hamburgers and fried chicken was used for every adolescent.

Physical activity and lifestyles

Physical activity of the students was measured using the Vietnamese Adolescent Physical Activity Recall Questionnaire which has been validated (20) in a similar population. We recorded the type of activity and the time spent on each activity using

frequency and average estimation at school and home throughout the school year, and the summer holidays. The data collectors approached the students and guided them to recall their daily activities (with the list of activities and where applicable the descriptions of the activity) and to estimate the average time spent doing each activity over the month preceding the interview. Activities were then categorised into moderate and vigorous subgroups based on the type and the intensity of the activity defined by the Compendium of Physical Activities.(21)

Social economic status

Using a self-reported questionnaire completed by the parents, we recorded the socio-economic status of the students' family, the level of parents' education and the parental BMI. We scored the economic status of the student's household based on the ownership of 14 household items which included television, radio, video cassette player, CD system, DVD player, computer/ laptop, telephone/mobile, car, motorcycle, bicycle, air conditioner, refrigerator, gas stove, and microwave based on a previously described method (22) but adjusted according to the Report on Economic Status of Populations in Ho Chi Minh City (23). We constructed a household wealth index using this inventory of items with a weight being assigned for each item from principal components analysis which has been used previously.(12, 13) We ranked the index scores and then divided them into five quintiles from lowest to highest.

Data processing and statistical analysis

Collected data were entered into computer files with data entry screens that included data error checks. We detected the missing data and omitted the case when the missing data occurred over half of food or drink variables or if any of the main variables of characteristics (anthropometric measurements or SSB variables) was missing. Data cleaning removed 52 cases and 2660 cases remained.

Analyses were conducted using STATA v.15 (STATA Corporation, College Station, TX, 2018) and all analyses adjusted for the cluster design of the study (school and class as clusters). We reported results as mean ± standard deviation for normally distributed continuous data and as percentages for categorical variables. Categorical data were tested with Pearson Chi-square, while normally distributed continuous data were tested with Student's t-test. We transformed skewed data (such as nutrient and consumption

patterns) into normally distributed values (for example using logarithmic transformation) for analysis but untransformed the final values for easier interpretation.

Sugar sweetened beverages (SSB) intakes

We calculated the estimated energy intake per month from each sugar sweetened beverage by multiplying the frequency (times per month) and the estimated quantity (mL each time) of consumption of that drink with the energy content (kcal per portion size) of the item (see Annex Table A1 for details of energy content of each drink). For total energy intake from all sugar-sweetened beverages we simply summed up the energy from each individual beverage. We divided the estimated intake from each and all drink items by 30 to have daily energy intakes for each sugar-sweetened beverage and all these beverages combined.

Assessing the associations between SSB intakes and overweight/obesity

We used Students t-test or ANOVA to assess the differences of mean energy intakes among subgroups of each characteristic. We explored and confirmed the correlation of sugar-sweetened beverage intakes with potential variables (demographic characteristics such as gender, age, urban/suburban, Wealth Index quintiles, pubertal status and habits of fast food and fruit &vegetable consumption) using Pearson r correlation to compare across subgroups.

We examined the relationship between the sugar-sweetened beverage intakes and overweight and obesity status using logistic univariate analysis. When the p-value of the univariate analysis was 0.25 or lower, we further investigated the associations between sugar-sweetened beverage intakes and overweight/obesity status using multivariate logistic regression models, with potential covariates (gender, urban/suburban, age, pubertal status, fast food consumption, fruit and vegetable consumption, moderate and vigorous activity time, and total energy intake). We analysed two logistic multivariate models to verify our findings where one model (Model 1) used total energy from all sugar-sweetened beverages (but not individually) and the other (Model 2) used the intakes for each of the 12 sugar-sweetened beverages.

We also examined the factors associated with the total energy from all sugar-sweetened beverages by plotting all potential covariates (as mentioned above) using linear

univariate regression and multivariate regression (for those covariates with p-value <0.25 in univariate model).

RESULTS

We included 1243 students from suburban and 1417 from urban areas of Ho Chi Minh City in this analysis of the cross-sectional data. Table 1 describes the characteristics of the participants. The participants from the urban areas had significantly higher age, weight, BMI, prevalence of overweight and obesity, and socio-economic status (wealth index and parental education). In contrast, the suburban participants had higher levels of physical activity and total daily energy intake. There were no differences between participants from urban versus suburban areas for gender, fast-food consumption, fruit and vegetable consumption, and total energy intake from all sugar-sweetened beverage.

Table 2 lists all the sugar-sweetened beverages in our study with frequency of use and mean amount consumed (in mL/day). Soft drinks, fruit juice and yoghurt were the three most frequently consumed beverages (lowest value from “Never” column). Yoghurt, soya milk with sugar, and cacao drink were the three sugar-sweetened beverages most frequently consumed daily. Annex Table A1 lists the details of packaging size and energy content of each type of sugar-sweetened beverage assessed in this analysis. Information from this table was used to estimate the energy intakes presented in the Table 3. Annex Table A2 presents additional information on the combined use of sugar-sweetened beverages. Nearly one in five students consumed at least one sugar-sweetened beverage daily, 17.7% consumed two or more sugar-sweetened beverages daily, and 4.0% consumed four or more sugar-sweetened beverages. Annex Table A3 presents the correlation of frequency of use and quantity of sugar-sweetened beverage consumed each time. Correlations were weak in most sugar-sweetened beverages except for fresh milk with sugar which had a moderate correlation (corr=0.33, p<0.001).

Table 3 presents the energy intakes from each and all sugar-sweetened beverages across subgroups of covariates. Significant differences (p<0.05) are marked with bold numbers. Generally, sugar-sweetened beverage consumption varied greatly across all subgroups of covariates. Specifically, there were only two sugar-sweetened beverages consumed significantly differently in the gender and age group subgroups, and these

beverages differed in each of these covariates. In contrast, in subgroups of moderate and vigorous activity the consumption patterns differed significantly for most sugar-sweetened beverages. In addition, when comparing all the sugar-sweetened beverages, we found that most energy was obtained from yogurt, sweetened fresh milk and leaf juice with sugar (mean energy intakes were 54.2, 36.2 and 30.6 kcal/day respectively). Mean energy intake from soft drink was ranked only 5th out of 12 sugar-sweetened beverages. Finally, total daily energy comes from all sugar-sweetened beverages combined was about 260 kcal/day in this study population (roughly about 10% of total energy intake, please also refer to Table 1).

Interestingly non-overweight and more active children consumed more energy from sweetened beverages than their overweight or less active peers (for both moderately active and vigorously active subgroups).

Table 4 presents the results of univariate and multivariate logistic regression models assessing the association between consumption of sugar-sweetened beverages (SSB) and adolescent overweight/obesity. The univariate analyses revealed low levels of protection for overweight/obesity from increasing consumption sugar-sweetened beverages, although only soft drinks, leaf juice with sugar, bird nest/tonic drink, cacao powder, fresh milk with sugar, and condensed milk) were significant. In the first multivariate model after adjusting for covariates (age, gender, pubertal status, wealth index, urban/suburban area, fruit and vegetable consumption, fast food consumption, and moderate and vigorous activity),within person correlation and the cluster sampling design there were only two sugar-sweetened beverages that had significant reverse associations with overweight/obesity status, namely, fresh milk with sugar (OR=0.995, 95%CI 0.992 to 0.998, p<0.001) and condensed milk (OR=0.995, 95%CI 0.992 to 0.999, p=0.016). In this model total energy from all foods other than sugar-sweetened beverages had a significant positive association with adolescent overweight/obesity.

In the second multivariate model (Table 4) energy consumption from milk-based sugar-sweetened beverages remained protective of overweight/obesity. However, energy intake from all other sugar-sweetened beverages combined showed slightly higher odds for overweight/obesity but was not significant. Total energy from all foods other than sugar-sweetened beverages had a significant positive association (odds greater 1) with adolescent overweight/obesity.

In both multivariate models, residence in suburban areas, older age groups, males, high frequency of consumption of fruit and vegetable, more moderate and vigorous physical activity and lower household wealth index were significantly protective for adolescent overweight/obesity (Table 4).

DISCUSSION

In our analysis, firstly we found that consuming milk based SSBs significantly reduced the odds of overweight/obesity of the adolescents in our survey, but consumption of all other non-milk SSBs slightly increased the odds of overweight/obesity, although this increased odd was not significant after we controlled for other co-factors. The total energy from SSBs accounted for no more than 10% of daily energy intake, with the total amount of energy from milk based SSB only around 2-3% of total daily energy intake. Thirdly, the energy intake from other foods (excluding SSBs) significantly increased the odds of obesity after adjustment for cofactors including physical activity. Although the increased odd was small for each kilo calorie consumed, the effect would be of public health significance as children consume on average about two thousand kilo calories per day. And fourthly, frequent consumption of fruit and vegetables and higher levels of physical activity were also significantly associated with reduced odds of overweight/obesity in children. Our findings are important because they indicate that SSBs may not be the key drivers of overweight/obesity in children and adolescents in Ho Chi Minh City. However, the non-milk SSB contribute to total energy intake which was associated with increased odds of child overweight/obesity.

The range of sugar-sweetened beverages in Ho Chi Minh City varies greatly from traditional sugar-added drinks, such as leaf (extract) juices and fruit juices, to modern soft drinks, tonic drinks and dairy drinks. Sugar-sweetened beverages are very popular as 99.7% of the participants consumed one type of sugar-sweetened beverage monthly and over one third (36%) of them consumed sugar-sweetened beverages daily. The consumption rate of sugar-sweetened beverages among Vietnamese adolescents was higher than their peers in Thailand (24), Brazil (25) and several EU countries (26) and comparable to the consumption in the US (27). However, there are several differences in our study compared to others. First, the range of sugar-sweetened beverages consumed by adolescents in this study included both modern carbonated (soft drinks,

sport drinks, fruit juices) and traditional sugar-added drinks (iced tea, sweetened milk-related products). Thus, the total consumption rate could be higher (Table 2). Second, there was a large difference between the patterns of the monthly and the daily sugar-sweetened beverage consumption (Annex Table A2). The high rate of the monthly consumption of soft drinks and fruit juices can indicate simply the popularity of these beverages rather than a constant behaviour of consumption. Indeed, on a weekly and daily basis, these drinks were among the least frequently consumed. Third, the types of sugar-sweetened beverages consumed by the adolescents in our study might have been influenced by social factors, especially peer influence, the aggressive advertisements of sugar-sweetened beverage producers, and the affluence of families.

Children and adolescents also often favoured one kind of sugar-sweetened beverage over the others, however, the portion consumed each time was not related to the frequency of consumption (Table 2). The reason behind this discrepancy can be attributed to the standard portion size of the drink (Annex Table A1). But portion size could not explain the case of yoghurt where the amount consumed was significantly higher for those who consumed frequently.

The mean daily energy from all sugar-sweetened beverages was 256.4 kcal, roughly 10% of their total daily energy intake (~2484kcal/day, see Table 1), which is high and comparable to that in several high-income countries. (26, 27) Also interestingly, as shown in Table 3, we observed significant differences in the energy intake from sugar-sweetened beverages among several subgroups. Among them the most surprising subgroups were the overweight, and the physically (moderately and vigorously) active adolescents. Results revealed that the overweight children generally consumed less sugar-sweetened beverage and the active adolescents significantly ingested more energy from the sugar-sweetened beverages. These observations might explain the non-significant findings between the consumption of several SSBs with the risk of overweight/obesity. Furthermore, as stated above, the findings might be the result of other important co-factors like moderate and vigorous activeness. Subgroups data revealed that the adolescents who were more active in our survey consumed more SSBs, and this patterns was also found in other studies.(28, 29)

The interesting finding of the protective relationship of milk based SSBs (both fresh milk and condensed milk) against overweight and obesity status. Logistic regression in the

Table 4 revealed that milk (either fresh milk with sugar or condensed milk) had the reverse relationship with overweight status. This result agreed with other studies suggesting the protective effect of milk over obesity (30, 31), probably due to calcium and other factors in the milk (32), which potentially have major influence over growing of the children too (33, 34). Unfortunately, the price of milk and milk products are relatively high in Vietnam and impede the benefits that these products could bring to most of the population, especially children and adolescents.

There are several weaknesses in the interpretation of our results. Most data come from self-reported questionnaires, and thus are prone to recall issues, especially in adolescents. While our questions on sugar-sweetened beverages were purposely and specifically developed for a survey of adolescents and have been validated, they are not very precise in estimating intakes. The cross-sectional design also limits the causal inferences and thus we can only report associations. Another weakness is that our data is over ten years old, and consumption patterns may have changed by now with soft drink perhaps more important. Overall the beverage market (excluding beer and alcohols) in Vietnam is still unchanged with a large proportion of the selling of sugar-sweetened drinks. At the end of 2017, a Prime Minister's Directive order (35) was administered to restrict the "selling" of sugary drinks in schools' canteen but the protective effect may need some years to take place. Despite these limitations, our study has several strengths including large and representative sample which captured major factors that may interact with weight gain, objectively measured anthropometry, validated questionnaires for sugar-sweetened beverage and important covariates (physical activity, other food items, pubertal status and wealth index), and additional use of life-size booklets for the sugar-sweetened beverage items to be examined. A novel aspect of our study was the combination of frequency of use and quantity consumed each time which gave fuller perspective of sugar sweetened beverages.

In summary, we believed that our analysis would benefit the researchers and the public and would draw more attention of professionals and policy makers to the research of impacts of sugar-sweetened beverages in cities in Vietnam. We suggest further investigations (especially the studies which can clarify causal links) be made to know the underlying factors influencing the consumption of sugar-sweetened beverage and their influences in the young population.

CONCLUSIONS

We found widespread use of sugar-sweetened beverages among adolescents in Ho Chi Minh City with 36% of the participants consumed daily. Total energy from SSBs contributed on average 10% of the daily energy intake of the city adolescents. Milk-based SSBs were found to have a protective effect against overweight and obesity in adolescents with every kcal more of fresh milk with sugar can reduce an odd of 0.005 (95%CI [0.002-0.008]), p<0.001 and every kcal of condensed milk can reduce an odd of 0.004 (95%CI [0.002-0.010]), p=0.044. Other non-milk SSB slightly increased the odds of overweight, but the relationship was removed when controlled with other more important co-factors (i.e. physical activity, fruit and vegetable consumption…). Thus, further studies focusing on sugar-sweetened beverages are encouraged to help explain this relationship and to apply the findings in overweight and obesity programs.

Ethical clearance

The study obtained ethics approval from the Health Service of Ho Chi Minh City, Vietnam, and the Human Research Ethics Committee of the University of Newcastle (Appendix section), Australia. All participants and their parents gave verbal consent after the aims and procedures of the survey had been explained to them. The results of the weight and height measurements were reported to the participants and their parents, and obese children were referred to the Nutrition Centre of Ho Chi Minh City for clinical appraisal.

List of abbreviations

BMI: Body Mass Index; HCMC: Ho Chi Minh City; SSB: Sugar Sweetened Beverages.

Competing of interest: The authors declare no competing interest.

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Authors' contribution

NMN, TKH and MJD contributed in the designing the analysis. TKH collected and cleaned the original data. NMN analysed the data and drafted the manuscript. MJD and TKH helped to check the consistency of the data analysis. AA and MJD contributed to the final version of the submitted manuscript.

Table 1. Characteristics of the study population (total N=2660)

Characteristic	**Suburban (n=**1243**)**		**Urban (n=**1417**)**		**p-value***
	Mean	SD	Mean	SD	
Age (year)	13.1	1.2	12.7	1.1	**<0.001**
Weight (kg)	42.7	9.7	45.2	10.6	**<0.001**
BMI (kg/cm^2)	18.3	3.1	19.3	3.4	**<0.001**
Daily Energy intake (kcal)	2524.5	898.7	2449.4	920.2	**0.017**
Total daily energy from all SSB (kcal)	255.2	6.8	256.8	6.1	0.428
Vigorous activity time (minutes/day)	35.9	36.1	32.7	33.2	**0.008**
Moderate activity time (minutes/day)	84.7	31.7	82.6	32.1	**0.044**
	%		**%**		**p-value**
Male gender *(%)*	49.8		50.3		0.79
Overweight and Obesity (%)	10.1		20.5		**<0.001**
Underweight (%)	4.9		3.2		**0.031**
Pubertal status (%)	23.57		24.6		0.553
Vigorous activity ≥45 min/day (%)	28.8		24.6		
Moderate activity ≥60 min/day (%)	66.1		65.3		
Fruit Vegetable consumption (%)					0.231
Once a month or less	29.5		32.8		
Twice/month to once/week	12.6		12.0		
2-6 times/week	13.0		13.6		
Once a day or more	44.8		41.6		
Fast-food consumption (%)					0.078
Once a month or less	17.9		14.7		
Once/month to once/week	80.7		83.6		
2-6 times/week	1.5		1.7		
Wealth Index Quintiles (%): Lowest	29.0		13.0		**<0.001**
Lower middle	22.6		16.7		
Middle	18.3		21.8		
Higher middle	14.6		27.2		
Highest	15.5		21.3		

*Bold results indicated significant different between urban/suburban groups

Table 2. Frequency of use (in % of total population, *italic numbers*) and mean quantity consumed (mL/day)

N=2660	Never	Once/month	2-4 times/month	Once/week	2-6 times/week	Once a day	2+ times/day	Total
(G1) Soft drink	*5.4*	*23.8*	*26.9*	*19.8*	*18.2*	*4.6*	*1.3*	*100*
Mean (mL/day)	0	9.0	28.1	42.0	158.4	264.0	693.0	68.0
(G1) Tonic drink*	*45.3*	*27.7*	*12.8*	*8.2*	*3.9*	*1.6*	*0.4*	*100*
Mean (mL/day)	0	7.1	22.5	32.6	131.4	232.5	625	24.9
(G2) Ice tea +sugar	*27.8*	*22.1*	*19.6*	*14.2*	*10.8*	*4.5*	*1.1*	*100*
Mean (mL/day)	0	2.8	7.8	11.8	51.4	100.0	200.0	21.0
(G2) Cacao powder	*38.3*	*19.6*	*13.7*	*10.9*	*9.7*	*6.6*	*1.2*	*100*
Mean (mL/day)	0	3.5	11.3	16.4	74.3	122.5	331.3	30.8
(G3) Fresh milk +sugar	*39.5*	*15.9*	*14.0*	*11.7*	*11.4*	*6.0*	*1.6*	*100*
Mean (mL/day)	0	6.8	21.7	32.5	135.7	230.0	581.3	61.5
(G3) Condensed milk	*51.7*	*16.7*	*11.2*	*9.6*	*6.7*	*3.4*	*0.7*	*100*
Mean (mL/day)	0	6.2	17.8	27.1	112.9	185.0	500.0	30.5
(G3) Yogurt	*13.1*	*15.9*	*21.1*	*18.3*	*20.0*	*9.1*	*2.6*	*100*
Mean (mL/day)	0	6.3	19.3	29.3	112.9	202.5	512.5	85.2
(G4) Soya milk +sugar	*23.3*	*20.0*	*17.4*	*16.4*	*14.1*	*7.1*	*1.5*	*100*
Mean (mL/day)	0	6.8	21.8	31.8	130.0	225.0	500.0	68.9
(G5) Fruit juice	*13.2*	*21.2*	*23.4*	*21.2*	*15.6*	*4.1*	*1.4*	*100*
Mean (mL/day)	0	7.1	22.0	32.1	130.0	217.5	543.8	66.2
(G5) Leaf juice +sugar	*24.3*	*21.3*	*18.8*	*16.8*	*14.4*	*3.4*	*1.1*	*100*
Mean (mL/day)	0	6.9	22.5	32.1	132.9	235.0	556.3	58.0
(G5) Coconut juice	*22.0*	*31.1*	*18.6*	*16.1*	*8.4*	*3.3*	*0.7*	*100*
Mean (mL/day)	0	8.9	28.8	42.9	173.7	296.0	640.0	35.9
Any drink frequency	*0.07*	*1.62*	*7.07*	*16.99*	*38.38*	*26.13*	*9.74*	*100*
Mean (mL/day)	0	6.6	20.8	31.0	123.6	204.1	511.9	157.5

*Tonic drink included bird nest drink and energy drinks

Table 3. Mean Energy (kcal/day) from Sugar Sweetened Beverages (SSB) across different characteristic groups *

N=2660	Soft drink	Tonic drink	Ice tea	Cacao powder	Fresh milk +sugar	Condensed milk	Yogurt	Soya milk +sugar	Leaf juice +sugar	Fruit juice	Coconut juice	All SSB
Urban (n=1417)	30.1	8.5	8.7	**10.8**	37.1	18.8	**56.1**	**27.9**	29.5	**20.3**	9.0	257
Suburban (n=1243)	27.2	8.0	8.1	**8.3**	35.2	22.3	**50.3**	**30.9**	31.9	**23.9**	9.3	254
Male (n=1332)	**31.8**	**10.1**	9.0	10.3	37.5	22.0	52.2	30.3	32.3	23.1	9.1	268
Female (n=1328)	**25.6**	**6.4**	7.8	8.9	34.9	19.0	54.5	28.4	28.9	20.1	9.2	245
Age 13-14 (n=1298)	29.5	7.7	8.1	9.1	35.2	19.5	**56.1**	28.9	32.2	**23.2**	9.5	259
Age 11-12 (n=1362)	28.0	8.8	8.7	10.1	37.1	21.3	**50.7**	29.6	29.0	**20.8**	8.8	253
Pre-pubertal (n=2019)	**29.6**	8.2	8.4	9.7	35.1	**19.3**	**55.5**	30.1	30.5	22.3	9.2	258
Pubertal (n=641)	**25.8**	8.3	8.3	9.4	39.7	**23.7**	**46.8**	26.8	30.9	21.1	8.9	249
Non-overweight (n=2244)	**29.8**	**8.7**	8.5	**10.0**	**39.1**	**22.0**	**54.5**	29.9	**31.8**	22.3	9.3	**265**
Overweight (n=416)	**22.9**	**5.9**	7.9	**7.3**	**20.2**	**12.0**	**47.6**	26.1	**24.4**	20.2	8.5	**202**
Moderate activity												
<60min/day (n=914)	**24.3**	**7.2**	**7.3**	**7.8**	**32.0**	18.3	**43.1**	**25.6**	**25.0**	**18.4**	**7.5**	**217**
≥60min/day (n=1746)	**31.1**	**8.8**	**9.0**	**10.6**	**38.4**	21.5	**58.8**	**21.3**	**33.5**	**23.9**	**10.0**	**277**
Vigorous activity												
<45min/day (n=1954)	**26.6**	**6.8**	**7.7**	**8.9**	**32.9**	**19.2**	**56.1**	**27.2**	**28.2**	**20.4**	**8.7**	**238**
≥45min/day (n=706)	**34.5**	**12.2**	**10.4**	**11.6**	**45.3**	**23.8**	**59.6**	**35.3**	**37.3**	**26.4**	**10.3**	**307**

Fruit & Vegetable**												
Once/month (n=832)	**22.9**	**6.1**	**6.7**	**7.7**	**27.1**	**16.6**	**40.4**	**24.0**	**26.4**	**16.2**	**7.6**	**202**
Twice/month - once/week (n=327)	**23.9**	**5.5**	**6.2**	**10.6**	**37.8**	**19.2**	**42.8**	**25.4**	**27.0**	**18.4**	**6.6**	**223**
2-6 times/week (n=355)	**29.2**	**8.3**	**9.0**	**9.7**	**42.0**	**17.6**	**52.9**	**21.7**	**26.2**	**21.7**	**8.4**	**247**
Daily or more (n=1146)	**34.2**	**10.6**	**10.0**	**10.7**	**40.5**	**24.4**	**66.0**	**36.7**	**36.1**	**27.3**	**11.2**	**308**
Fast food**												
Once/month (n=430)	27.4	**9.5**	8.6	**10.2**	**37.1**	**26.5**	**53.9**	**31.1**	**32.6**	**21.8**	9.6	**268**
Twice/month-once/week (n=2188)	29.3	**8.2**	8.5	**9.7**	**35.8**	**18.8**	**52.5**	**29.0**	**30.6**	**21.9**	9.1	**253**
2-6 times/week (n=42)	34.0	**16.5**	15.6	**20.1**	**84.6**	**64.6**	**138.3**	**58.3**	**59.6**	**40.2**	12.8	**545**
Wealth Index Quintiles**												
Lowest (n=545)	26.9	7.6	**6.8**	**8.5**	31.9	24.4	**46.6**	32.2	**40.4**	21.8	9.0	255
Lower middle (n=518)	29.2	7.4	**6.5**	**8.4**	31.4	24.1	**45.2**	30.8	**33.0**	20.2	8.3	245
Middle (n=536)	27.4	8.4	**7.9**	**8.6**	37.5	17.2	**56.5**	26.0	**25.4**	21.0	8.6	246
Higher middle (n=566)	30.8	9.3	**11.0**	**10.6**	40.3	17.0	**56.6**	27.9	**27.5**	22.8	10.2	263
Highest (n=495)	29.4	8.5	**10.0**	**12.1**	39.8	19.5	**62.4**	29.7	**26.6**	24.2	9.5	271
Total Mean+	28.7	8.3	8.4	9.6	36.2	20.4	54.2	29.8	30.6	22.0	9.1	260+

* T-test and **ANOVA were used to obtain significance difference (where p-value<0.05) between subgroups;
Numbers in bold when significant difference was found among subgroups (p<0.05)
+ because of rounding, total sum may not be equal to the sum of every sweetened beverages

Table 4. Assessment of the association between consumption of sugar-sweetened beverages (SSB) and adolescent overweight/obesity with adjustment for cofactors using logistic regression models.

Overweight/Obesity	Univariate logistic regression			Adj.# logistic regression Model 1			Adj.# logistic regression Model 2		
	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p
Energy from each SSB (kcal)									
Soft drink	***0.996***	***0.993 – 0.998***	***0.005***	0.996	0.992-1.001	0.096		Not included	
Coconut juice	0.998	0.99 – 1.00	0.434	1.003	0.996-1.011	0.432		Not included	
Fruit juice	*0.998*	*0.99 – 1.00*	*0.285*	1.003	0.999-1.007	0.090		Not included	
Leaf juice +sugar	***0.997***	***0.994 – 0.999***	***0.013***	1.002	0.998-1.005	0.302		Not included	
Iced tea	0.998	0.993 – 1.00	0.551	1.004	0.996-1.013	0.327		Not included	
Bird nest, tonic drink	***0.993***	***0.986 – 0.999***	***0.031***	0.997	0.989-1.005	0.455		Not included	
Cacao powder	***0.993***	***0.987 – 0.999***	***0.023***	0.996	0.988-1.003	0.273		Not included	
Soya milk +sugar	*0.998*	*0.996 – 1.001*	*0.156*	1.001	0.998-1.004	0.598		Not included	
Fresh milk +sugar	***0.994***	***0.992 – 0.997***	***<0.001***	**0.995**	**0.992-0.998**	**<0.001**	**0.995**	**0.992-0.998**	**<0.001**
Condensed milk	***0.994***	***0.991 – 0.997***	***<0.001***	**0.996**	**0.992-1.000**	**0.044**	**0.996**	**0.992-1.000**	**0.031**
Yogurt	0.999	0.999 – 1.000	0.127	1.000	0.999-1.001	0.320		Not included	
Energy from all SSB without fresh and condensed milk(kcal)	**Not included**			**Not included**			1.0005	0.9998-1.0011	0.142
Total daily energy intake without any SSB (kcal)	1.000	0.999-1.000	0.159	**1.0002**	**1.0001-1.0004**	**0.008**	**1.0002**	**1.0000-1.004**	**0.014**
Strata suburban	1.0			1.0			1.0		
urban	2.31	1.85-2.90	<0.001	**1.574**	**1.172-2.113**	**0.003**	**1.537**	**1.148-2.058**	**0.004**
Pubertal *prepubertal*	1.0						1.0		
pubertal	1.32	1.05-1.67	0.020	1.043	0.763-1.428	0.790	1.064	0.779-1.445	0.697
Age group age 14	1.00			1.00			1.00		
age 13	1.61	1.12 - 2.30	0.009	**2.116**	**1.350-3.317**	**0.001**	**2.081**	**1.331-3.252**	**0.001**
age 12	1.49	1.03 - 2.14	0.032	**2.154**	**1.381-3.359**	**0.001**	**2.090**	**1.344-3.251**	**0.001**
age 11	3.39	2.41 - 4.76	<0.001	**4.042**	**2.612-6.255**	**<0.001**	**3.976**	**2.574-6.140**	**<0.001**
Gender male	2.69	2.15-3.37	<0.001	**6.101**	**4.554-8.172**	**<0.001**	**5.860**	**4.391-7.821**	**<0.001**
Fast food ≤once/week	1.0	n/a	n/a	1.0			1.0		
Twice/month to 6 times/week	1.59	1.16-2.20	0.004	1.335	0.896-1.988	0.155	1.330	0.895-1.978	0.158
Once a day or more	0.61	0.18-2.06	0.427	0.943	0.216-4.120	0.938	0.933	0.216-4.032	0.927
Fruit-Vegetable consumption									
≤Once/month	1.0	n/a	n/a	1.0			1.00		
Once/month to once/week	0.52	0.37-0.73	<0.001	**0.615**	**0.402-0.940**	**0.025**	**0.592**	**0.388-0.904**	**0.015**
2-6 times/week	0.44	0.31-0.62	<0.001	**0.458**	**0.300-0.699**	**<0.001**	**0.450**	**0.297-0.684**	**<0.001**
Once a day or more	0.27	0.22-0.37	<0.001	**0.347**	**0.252-0.478**	**<0.001**	**0.344**	**0.250-0.474**	**<0.001**
Moderate activity minute/week)	0.91	0.89-0.92	<0.001	**0.911**	**0.897-0.924**	**<0.001**	**0.911**	**0.898-0.924**	**<0.001**
Vigorous activity (minute/week)	0.98	0.98-0.99	<0.001	**0.985**	**0.978-.0991**	**<0.001**	**0.984**	**0.978-0.991**	**<0.001**
Wealth Index lowest	1.0	n/a	n/a	1.0			1.00		
lower medium	2.24	1.46-3.43	<0.001	**1.877**	**1.132-3.110**	**0.015**	**1.873**	**1.133-3.095**	**0.014**
medium	2.82	1.87-4.26	<0.001	**2.612**	**1.592-4.286**	**<0.001**	**2.531**	**1.550-4.133**	**<0.001**
higher medium	3.92	2.63-5.83	<0.001	**3.826**	**2.357-6.212**	**<0.001**	**3.747**	**2.320-6.052**	**<0.001**
highest	3.92	2.62-5.88	<0.001	**4.348**	**2.643-7.151**	**<0.001**	**4.318**	**2.637-7.070**	**<0.001**

* Bold results are statistically significantly associated with overweight/obesity status

Adjusted with all other co-factors included above, and with other SSB intakes

Annex

Table A1. Portion size, sugar and energy content of each type of Sugar Sweetened Beverage

	Portion size (mL)	Sugary content per portion (gram)	Energy content per portion (kcal)
Soft drink	330	34.3	139
Coconut juice +sugar	250	19.2	84
Fruit juice	250	29.3	110
Green leaf juice +sugar	250	39.2	174
Ice tea	250	33.0	132
Bird nest/ tonic drink	250	28.0	110
Cacao powder	250	20.3	104
Soya milk +sugar	250	22.0	141
Fresh milk +sugar	250	20.8	193
Condensed milk*	250*	60.0*	251
Yogurt	200	32.4	206

*Condensed milk is diluted several times (with boiling water) to make drinking milk, thus making real portion size as low as 50gram per serving of drinking milk

Table A2. Characteristics of frequency of consumption of one main sugar-sweetened beverage and others in those who drink daily (once a day or more) as % of total participants, given that 958 or 36% of the participants (from Table 2) drank sugar-sweetened beverage daily.

N=2660	Only this type	With any 1 other	With any 2 others	With any 3 others	With any 4 others	With 5 or more
Soft drink	2.03	1.05	1.35	0.90	0.49	0.34
Bird nest, Tonic drink	0.3	0.34	0.53	0.38	0.3	0.38
Coconut juice	1.02	1.09	1.02	0.41	0.23	0.26
Fruit juice	1.43	1.39	1.54	0.60	0.34	0.56
Green leaf juice +sugar	1.54	0.83	0.71	0.71	0.45	0.60
Soya milk +sugar	2.52	2.11	2.03	1.32	0.56	0.53
Ice tea	1.24	1.47	1.47	0.68	0.53	0.53
Cacao powder	2.14	2.52	1.69	0.86	0.53	0.49
Fresh milk +sugar	2.26	2.14	1.47	1.28	0.38	0.45
Condensed milk	0.98	1.58	0.60	0.64	0.19	0.41
Yogurt	4.02	3.08	2.37	1.39	0.71	0.64
Any SSB*	**19.47***	**8.80***	**4.92***	**2.29***	**0.94***	**0.75***

*Because of rounding, total sum was not matched with 35.78% of total participants who drank daily.

Table A3. Spearman' rank correlation between frequency and quantity of SSB consumption by participants, positive coefficient signified positive relation between frequency and quantity.

	Number of observations	**Spearman's Coefficient**	**p value**
Soft drink	2570	0.0344	0.0813
Bird nest, Tonic drink	1489	0.1388	***<0.001***
Coconut juice	2117	0.1132	***<0.001***
Fruit juice	2357	0.0716	***<0.001***
Green leaf juice +sugar	2060	0.1488	***<0.001***
Soya milk +sugar	2079	0.1116	***<0.001***
Ice tea	1965	0.0420	0.0628
Cacao powder	1687	0.1538	***<0.001***
Fresh milk +sugar	1649	0.2062	***<0.001***
Condensed milk	1321	0.0522	0.058
Yogurt	2360	0.0810	***<0.001***

In **bold:** statistically significant

Table A4. Associations between adolescents' SSB intakes and overweight and obesity status

Energy from SSB intake (kcal/day)	Mean intake (kcal/day)	Overweight/Obesity[#] Univariate logistic regression			Overweight/Obesity[#] Adjusted logistic regression*		
		Odds ratio	95% CI	p	Odds ratio	95% CI	p
Soft drink	28.7	***0.996***	***0.993 – 0.998***	***0.005***	0.998	0.994 – 1.001	0.268
Coconut juice +sugar	9.1	0.998	0.99 – 1.00	0.434	n/a[$]		
Fruit juice	22.0	*0.998*	*0.99 – 1.00*	*0.285*	n/a[$]		
Leaf juice +sugar	30.6	***0.997***	***0.994 – 0.999***	***0.013***	1.001	0.998 – 1.004	0.454
Iced tea	8.4	0.998	0.993 – 1.00	0.551	n/a[$]		
Bird nest, tonic drink	8.3	***0.993***	***0.986 – 0.999***	***0.031***	0.996	0.988 – 1.003	0.243
Cacao powder	9.6	***0.993***	***0.987 – 0.999***	***0.023***	0.995	0.987 – 1.002	0.135
Soya milk +sugar	29.8	*0.998*	*0.996 – 1.001*	*0.156*	1.001	0.998 – 1.004	0.421
Fresh milk +sugar	36.2	***0.994***	***0.992 – 0.997***	***<0.001***	**0.995**	**0.992 – 0.998**	**<0.001**
Condensed milk	20.4	***0.994***	***0.991 – 0.997***	***<0.001***	**0.995**	**0.992 – 0.999**	**0.016**
Yogurt	54.2	0.999	0.999 – 1.000	0.127	1.000	0.999 – 1.001	0.398
All SSB	260.0	***0.991***	***0.988 - 0.993***	***<0.001***	0.995	0.992 – 1.000	0.009

[#] Overweight/Obesity was binary outcome

* Adjusted for age, sex, pubertal status, wealth index, urban/suburban area, fruit and vegetable intake, fast food intake, and moderate and vigorous physical activity.

[$] Coconut juice+sugar, Fruit juice, and Iced tea were not included in adjusted regression due to high p-value (p>0.25) in univariate regression.

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Chapter 4:

Longitudinal Cohort study

Energy intake, macronutrient intakes and the percentages of energy from macronutrients with adolescent BMI: a 5-year cohort data from Ho Chi Minh City, Vietnam

Ngoc-Minh Nguyen, Tang Kim Hong, Ashraful Alam, Michael John Dibley

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This chapter adds quantitative nutritional evidence by identifying the changes in energy and macronutrient intakes in a period of five years and their potential relations with overweight and obesity among adolescents in Ho Chi Minh City. Data were collected using a prospective design from 31 randomly selected schools across the city. Tracking of energy and macronutrient intakes was investigated using Spearman correlation coefficients and weighted kappa statistics. The association of tracking and obesity was explored using Generalized Linear Latent and Mixed Models. Results directly answered Objective number 3 of the Thesis.

Energy intake, macronutrient intakes and the percentages of energy from macronutrients with adolescent BMI: a 5-year cohort data from Ho Chi Minh City, Vietnam

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Running title Tracking changes of energy and macro-nutrient intakes in adolescents

Summary

Objective: To assess tracking of energy and nutrient intakes of adolescents of Ho Chi Minh City in five years and to explore the possible relationships between energy and percentage of energy from macronutrients with BMI in adolescents.

Methods: A 5-year prospective cohort study was conducted between 2004 and 2009. Height and weight were measured; and time spent for physical activity, TV viewing and dietary intake were collected annually among 759 junior high school students in Ho Chi Minh City. The extent of tracking of energy and macronutrient intakes (assessed by food frequency questionnaire) was investigated using Spearman correlation coefficients and weighted kappa statistics (k). Generalized Linear Latent and Mixed Models were used to investigate the association between energy intake and percentage energy from protein, carbohydrate and fat with BMI.

Results: There was a significant increase in mean BMI and median energy, macronutrient intakes with increasing age, higher in boys than in girls ($p < 0.001$). Tracking of energy and

macronutrient nutrient intakes at the individual level was only poor to fair, lowest for the percentage energy from carbohydrate or percentage energy from protein and highest for fat intakes (correlation coefficients and Kappa values were 0.38 & 0.29 for boys, and 0.29 & 0.27 for girls, respectively). The linear multilevel models showed two modest but significant positive associations with BMI. Specifically, every 100g higher of daily carbohydrate intake led to an increase of 0.61 unit of BMI in 5 years (p=0.001) and an increase of 100 minutes/week of screen time led to 0.14 unit of BMI increase in 5 years.

Conclusions: Observed positive relationship between daily carbohydrate intake and screen time with adolescent BMI are important long-term evidence. The poor to fair tracking observed in this cohort suggests that individual dietary patterns exhibited at the first year are unlikely to be predictive of energy and nutrient intake at the last year.

Keywords: energy, macro-nutrient intake, BMI, cohort, adolescents, multilevel linear model.

Background

The prevalence of obesity in children and adolescents in Ho Chi Minh City, Vietnam has been increasing dramatically since the early of 2000s. From 2002 to 2004 the prevalence of overweight doubled from 5.0% to 11.7%, while the prevalence of obesity increased three-fold from 0.8% to 2.0%.[1] Despite government step up and implementation of health promotion programs to prevent the obesity, the prevalence of overweight and obesity in the same population of adolescents still went up to 17.8% and 3.2% in 2010.[2] It is known that adolescent obesity increases the risk of adult obesity, and "the best evidence suggests that the majority of overweight adolescents go on to become overweight adults".[3-5] Thus, there should be an investigation to understand and prevent overweight and obesity in adolescents and limit the increasing of overweight and obesity in adults in the years ahead.

Adolescence is a period of life when dietary patterns, eating behaviours and nutrient intakes may have great influence on adult fatness and chronic disease experiences decades later.[6-8] The macronutrient composition of the diet (protein, fat) may play an important and contributing role to childhood obesity.[9-11] We need to track the nutrient intakes from adolescence into young adulthood in order to assess the maintenance of dietary behaviours and the relative position in rank of these behaviours over time because these routines formed in early life may influence the progression of chronic diseases later.[8 12] Interestingly, a number of longitudinal studies have investigated the extent of tracking of nutrient intakes from adolescence into young adulthood and the results have been inconsistent.[6] Furthermore, obesity is believed to arise due to an imbalance in the energy balance equation,[13] hence the need to investigate the relationship between energy intake and percentage energy intake from macronutrients with adiposity in adolescents. Several studies conducted to assess these relationships showed confounding results yet most of them were cross-sectional studies.[14-17] Thus this longitudinal study and analysis can be beneficial. Longitudinal data provided richer and more details on changes made over the years by the adolescent participants in this study. Behavioural changes could be reviewed over the years from early to mid-adolescent years (11-15 years old). These years are crucial in nutritional behaviour establishment as the participants make changes to a more social life in the junior

high schools and the family influence starts to become less important in the adolescence. Specifically, in this paper, we aim to assess primarily tracking of energy and macronutrient (carbohydrate, lipid and protein) intakes of adolescents in a five-year cohort study in Ho Chi Minh City, and secondarily the relationships between energy and percentage of energy from macronutrients with Body Mass Index (BMI) in adolescents.

Method

Subjects

The cohort study began from a multi-stage cluster cross-sectional survey in 2004 with 31 selected schools including 17 schools from wealthy urban districts, and 14 schools from less wealthy urban districts (n= 3319). To select the sub-sample for the cohort study, systematic random sampling was applied, and 18 schools were chosen from these 31 schools, of which 11 were from wealthy districts and 7 were from less wealthy districts. Then one class from either grade 6 or 7 was selected in each school, resulting in 784 students invited to join the cohort study. More details of the cohort design and results have been published elsewhere.[18 19]

Data collection

At each assessment round in each year, we measured the main outcome variables (anthropometric measurements) as well as the exposure factors. Standing height was measured using a portable direct-reading stadiometer (precision to 0.1cm) and body weight was measured using a digital scale (precision to 0.1kg). Dietary intake and diet behaviours were assessed using a validated Youth Food Frequency Questionnaire (YFFQ).[20] The YFFQ included questions regarding usual frequency of intake of 160 specific food items over the last 6 months. Energy, protein, carbohydrate and fat content of most foods were computed using EIYOKUN v.1,[21] a nutrient database developed from Vietnamese food consumption tables. Total daily nutrient intakes were then calculated by summing individual food values from frequency of consumption, mean amount eaten and nutrients per gram. We excluded implausible energy intakes <500 kcal/day or >5000 kcal/day.[22] BMI (kg/m^2) was calculated using height and weight as standard.

Data analysis

We reported the results as mean ± standard deviation if the data were normally distributed. We have presented the median and interquartile ranges because most of the nutrient distributions were right-skewed towards higher values. Paired t-tests were used to test differences in the mean of energy intakes and percentage energy from macronutrients including protein, carbohydrate and fat between year 2004 and 2009. Spearman correlation coefficients were computed to examine the correlation between dietary intake measures at baseline and at the 5-y follow-up. The cut-off value at 0.2 was chosen for suggesting the existence of tracking.[23] In the present study, daily energy or nutrient intake was considered to track well over time if subjects with *'low', 'medium' or 'high'* intakes at year 2004 maintained their ranking at year 2009. We divided energy intake and macronutrient intakes into tertiles: lowest tertile (L1), middle tertile (M1) and highest tertile (H1), and calculated the weighted Kappa values (k) for these categories. Tracking was defined as strong if the subjects remained in the same tertile at both the baseline and the 5-y follow-up. Tracking was classified as moderate if the subjects moved to the adjacent tertiles. And if they moved randomly into any of the tertiles at follow up, the tracking would be poor.

We examined the relationship between total energy intake, protein, carbohydrate, and lipid intakes and percentage energy from these three macronutrients with BMI. Linear multilevel mixed models were used to consider the cluster effect of schools, class and within-subject correlation from repeated measurements. Specifically we applied Generalized Linear Latent and Mixed Models (GLLAMM[24]) package in STATA 15 (STATA Corporation, College Station, TX, USA, 2018). We ran different forward and backward "stepwise" models to control for variables of gender, age, maturation level, time spent for physical activity, and screen time. BMI was used instead of BMI z-score as it is recommended practice for longitudinal research.[25] For the first baseline model, I screened all variables with univariate regression, and then I added these variables with a p-value equal or less than 0.25 to the multivariate baseline model. Then I used stepwise backward elimination with the baseline model and removed one variable at the time with the highest p-value. I repeated this step until I reached a stable model. Once I reached the stable model, I then crosschecked the

variables using stepwise forward addition from the most significant (smallest p-value) univariate model.

Ethical clearance

Prior to the start of the cohort, participants who have joint the screening cross-sectional were informed about the following cohort study and after systematic sampling was made, the children and their parents were directly contacted and informed by a written description of the purpose, the benefits and the inconveniences of joining this cohort study. Those who has parental consent (either father's or mother's) would be selected in the cohort study. The original data from the cross-sectional and cohort research work were approved by the Human Research Ethics Committee, University of Newcastle (Ethics Reference: H-879-0904).

Results

At baseline, 759 out of 784 students (selected from the cross-sectional study) consented to take part in the cohort study. Among them, seven observations were excluded due to mean energy intake being <500 kcal per day or >5000 kcal per day yielding 752 students with dietary intake data at the baseline. Characteristics of participants at the baseline (year 1) and the last year (year 5) were described in Table 1. There were significant differences in BMI, energy intake and protein, carbohydrate, fat intakes between boys and girls. Boys were also significantly heavier than girls. Between 2004 and 2009, the absolute increases in BMI were significant in both genders (20.1 kg/m^2 to 23.5 kg/m^2 for males and 18.1 kg/m^2 to 20.6 kg/m^2 for females). Boys had higher BMI values than girls ($p<0.001$). Increases in mean BMI can be seen every year; however, increases in boys were greater than those in girls.

Table 1 also shows that boys had higher energy and nutrient intakes. Macronutrient distribution on average was protein 15.0%, carbohydrate 49.9%, and fat 22.8% of energy intake in boys while in girls they are 14.7%, 41.9% and 21.4%, respectively. Over 5-year period, the energy intake and macro-nutrient intakes of boys and girls increased significantly ($p<0.001$) with increasing age.

Insert Table 1 here

The Spearman correlation coefficients and weighted kappa values for energy, macronutrient intakes and percentage of energy from macronutrients are presented in Table 2. In general, the tracking of energy intake and macronutrient intakes at the individual level was poor to fair, but lower for carbohydrate intakes. The weighted kappa values are fair for energy from carbohydrates. In most cases, the weighted kappa values are higher in boys than in girls, especially with energy from carbohydrates.

Insert Table 2 here

When subjects were grouped based on quartiles of BMI, a one-way ANOVA showed that those with a higher BMI consumed slightly more energy than their lower BMI counterparts. However, protein, carbohydrate and fat intake as well as percentage of energy from protein, carbohydrate and fat were similar across the groups. Among year 1 subjects, there was no difference in total energy and macronutrient intakes and percentage of energy from protein, carbohydrate and fat across the quartiles of BMI, but among year 5 subjects, there was a very slight difference (though statistically insignificant) in total energy intake and energy from fat across the quartiles of BMI (Table 3).

Insert Table 3 here

We found significant results using Generalized Linear Latent and Mixed Models (GLLAMM) in univariate analysis between BMI (as an independent variable) and major variables including energy, protein, carbohydrate, and lipid intakes, and percentage of energy from these 3 macronutrients intakes along with 4 more variables which are listed in the Table 4. Furthermore, in multivariate analyses, we found several variables which were significantly correlated with BMI. Specifically, every gram/day of Carbohydrate Intake and every minute/week of Screen Time correlated significantly with an increase of 0.0061 (95% CI 0.0024 to 0.0098) and 0.0014 (95%CI 0.0007 to 0.0020) unit of BMI over 5 years. Conversely, every additional minute/week of Time for Moderate to Vigorous Physical Activity and every percent of Percentage of energy from Carbohydrate negatively associated with BMI (coefficient of -0.0011 (95% CI -0.0017 to -0.0006) and 2.87 (95% CI -5.5038 to -0.2400)).

Insert Table 4 here

Further information about this cohort was included in the tables in the Annex section.

Discussion

The findings showed that at the group level, energy and macronutrient intakes significantly change over 5-year period. We used several methods to assess the tracking. At the individual level, tracking for energy and macronutrient intakes was poor to fair indicating a substantial drift of subjects between the low, medium and high categories of intake with increasing age. As it was stated that "tracking coefficient highly depends on the length of time interval",[26] the relatively low coefficients in this study could be good evidence of tracking as a 5-year period is long enough to make changes in eating habits as well as stability of food preferences. Thus, it could be expected that tracking for dietary intake is usually low,[27] and much lower than tracking for biological properties such as blood markers and anthropometrics.[28] Furthermore, the lowest tracking in carbohydrates and protein but higher in fat intake might be explained by the fact that less variation in food sources over time compared to protein and carbohydrate. In addition, upon our knowledge Vietnamese adolescents have higher consumption of energy from fat from "out of home" foods [29] which keeps the tracking of fat intakes and percentage energy from fat higher than other macronutrient intakes (and the latter nutrients might be declined in consumption).

We expected that high intakes of energy, high percentage energy from fat would be associated with high BMI. However, our findings do not support this hypothesis. Studies all over the world have not shown a consistent relationship between energy and macronutrient intake with BMI.[11 14 17 30 31] While several studies have suggested that the macronutrient composition of the diet (protein, carbohydrate, fat) plays an important contributing role in childhood obesity,[11 14 30] other studies found different findings,[17](more references) or even an inverse relationship.[31] A possible explanation for the lack of a relationship between energy intake (and percentage energy intake) from macronutrients and BMI might be due to the under-reporting of foods.[32] We also showed that total energy intake was more influential than the macronutrient composition of the diet in the development of adolescent obesity. In

our study we excluded “implausible” energy intake from the analysis to reduce the effect of underreporting, which can affect the association between BMI with macronutrient intake. With reference to underreporting risk we understand that this simple exclusion could not remove the effect of underreporting as this can happen in children within the included energy range but more likely in subgroup of children of higher BMI. In our study we took two steps to minimise this bias, first we spent few minutes to build trust and encourage them to report as much food and drinks they possibly used and second data collectors always checked if there were missing areas from the answered FFQ. However, to prevent or minimise this bias, we believed that better, or even maybe, more direct tools intertwined in FFQ should be developed.

In our study, only time spent for physical activity and screen time were significantly associated with BMI. The lack of association between energy intake and BMI might be due to altered eating behaviours of overweight/obese adolescents which has been reported elsewhere.[33] Furthermore, our data were collected among junior high school students who were vulnerable to unhealthy eating habits and sedentary behaviors, and also had closer ties with their peers during the transition to adulthood and the psychosocial importance attached to friendship and peer group relations increases, intensifying the potential for peer influence.[34] Thus, the food preferences/eating habits of adolescents in Ho Chi Minh City over time may be less stable leading to low tracking of energy and nutrient intakes.

Our study has several strengths. Firstly, the longitudinal design, which allowed us to study changes over time in energy and macronutrient intakes and in BMI, while accounting for growth and maturation. BMI typically goes up from year to year among students in this cohort, and we took these changes into account. Secondly, this study was conducted among junior high school students who could be followed strictly at least 3-4 years until they moved to different senior schools hence the data could be kept tracked well. Thirdly, we used different methods to assess the tracking patterns including correlation coefficients, percentage agreement, kappa values, all of which allowed for comparisons and testing the robustness of the related findings.

However, this study also bears some limitations. The data of adolescent obesity and dietary intakes was collected in HCMC in 2009 which is quite old. The dietary intakes and obesity level are likely to have deteriorated since 2009 but the intrinsic relationship between diet and obesity should remain the same. Data collection was based on the memory and perception of usual diet which is partly affected by the social desirability of the responses. Hence it is possible that the degree of memory and motivation required to complete the FFQ may change substantially year by year, thereby contributing to the apparently poor tracking observed in this study. Furthermore, the information on psychosocial factors was not collected. Some of these factors are likely to influence the changes in adolescents' diets and BMI over time. Also loss to follow-up (of more than 100 boys and girls over the 5 years) is also an impactful limiltation though there were measures to control this effect. In our expectation, we have assumed those who missed the last data collecting were those children within normal data range and thus final results were not totally over-estimated.

Despite these limitations, our findings indicate poor to moderate tracking patterns in the dietary intakes of urban adolescents over a 5-year follow-up. The poor to fair tracking observed in this cohort suggests that individual dietary patterns exhibited at the first year are unlikely to be predictive of energy and nutrient intake in the last year. This study also presents vital information on dietary intakes and adiposity of adolescents in Ho Chi Minh City, which may prove useful in refining policies to prevent excess weight gain.

List of abbreviations

NOVA Analysis of Variances

BMI Body Mass Index

GLLAMM Generalized Linear Latent and Mixed Models

YFFQ Youth Food Frequency Questionnaire

Competing interest

The authors declare no competing interest.

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Annex

Table 1. Physical characteristics of participants by gender in year 2004 and 2009

	Year 1 - 2004				Year 5 - 2009			
	Boys n = 360		Girls n = 392		Boys n = 248		Girls n= 285	
Normal distribution	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Age in years	11.8	0.6	11.9	0.7	15.7	0.6	15.9	0.7
Weight (kg)	44.6	9.6	41.0	7.4	63.6	13.4	56.5	10.0
Height (cm)	155.7	9.7	153.4	8.1	164.0	8.1	159.6	7.1
BMI (kg/m^2)	19.1	3.9	18.2	3.1	23.5	4.3	20.6	3.5
Total Screen time (minutes/week)	528.8	221.9	531.8	233.2	663.6	225.3	600.7	207.7
Skew distribution	***Median***	***[P_{25}; P_{75}]***	***Median***	***[P_{25}; P_{75}]***	***Median***	***[P_{25}; P_{75}]***	***Median***	***[P_{25}; P_{75}]***
Energy (Kcal)#	2515.4	[1933.1; 3234.8]	2294.5	[1718.0; 2904.8]	2837.8	[2299.5; 3661.6]	2489.9	[1958.5; 3063.1]
Protein (g)#	92.6	[68.1; 129.3]	85.6	[63.7; 115.8]	113.0	[85.3; 149.6]	102.4	[81.1; 130.2]
CHO* (g) #	311.8	[218.1; 454.6]	229.9	[178.7; 312.5]	401.4	[317.3; 554.8]	290.9	[211.3; 388.5]
Fat (g)	61.0	[39.8; 94.1]	56.6	[39.7; 79.9]	80.0	[56.9; 113.8]	67.3	[50.3; 89.2]
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
% energy from CHO#	49.9	[43.9; 54.8]	41.9	[35.6; 49.6]	55.9	[50.5; 59.6]	46.5	[42.7; 52.2]
% energy from Protein#	15.0	[11.5; 38.9]	14.7	[10.4; 40.2]	16.4	[13.4; 38.6]	15.3	[11.9; 36.7]
% energy from Fat	22.8	[12.5; 76.8]	21.4	[9.8; 72.7]	25.7	[22.6; 74.6]	21.2	[17.9; 24.7]
Time spent for MVPA**(minutes/week)#	116.1	[48.7; 364.8]	80.8	[47.9; 182.7]	63.1	[37.6; 173.0]	37.6	[17.1; 142.6]

* CHO = Carbohydrate; **MVPA= Moderate to vigorous physical activity. # variables with significant difference between baseline and final year

Table 2. Tracking of energy and macronutrient intakes in 5 years as estimated by correlation coefficients and weighted kappa values (k)

	Boys		**Girls**	
	Correlation coefficient	*95% CI*	*Correlation coefficient*	*95% CI*
Energy	0.27	0.17, 0.37	0.37	0.27, 0.45
Protein	0.30	0.20, 0.40	0.38	0.29, 0.46
CHO	0.20	0.09, 0.30	0.30	0.21, 0.39
Fat	0.38	0.27, 0.46	0.37	0.30, 0.47
Energy from protein	0.12	0.01, 0.22	0.12	0.02, 0.21
Energy from CHO	0.15	0.05, 0.26	0.10	0.00, 0.20
Energy from fat	0.30	0.20, 0.29	0.18	0.08, 0.27
	Kappa value	*95% CI*	*Kappa value*	*95% CI*
Energy	0.19	0.16, 0.25	0.26	0.22, 0.27
Protein	0.23	0.17, 0.29	0.28	0.23, 0.32
Carbohydrate	0.16	0.09, 0.19	0.20	0.16, 0.25
Fat	0.29	0.22, 0.34	0.27	0.21, 0.34
Energy from protein	0.07	0.03, 0.08	0.06	0.01, 0.10
Energy from CHO	0.20	0.17, 0.26	0.16	0.09, 0.21
Energy from fat	0.22	0.17, 0.24	0.05	0.02, 0.06

* CHO = Carbohydrate

Tracking was defined as strong if the subjects remained in the same tertile at both the baseline and the 5-y follow-up. Tracking was classified as moderate if the subjects moved to the adjacent tertiles. And if they moved randomly into any of the tertiles at follow up, the tracking would be poor.

Table 3. Energy, macronutrient intakes and percentage energy from macronutrients based on quartiles of BMI

	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Initial baseline survey	n = 830	n = 830	n = 830	n = 829
BMI (mean ± SD)*	16.9 ± 1.4	19.9 ± 0.7	22.4 ± 0.8	27.3 ± 3.1
Total Energy (median, [25%, 75%])	2409.7 [1933.7, 3095.9]	2516.9 [1954.4, 3223.1]	2546.5 [1972.7, 3227.3]	2590.1 [2134.0, 3325.5]
Protein (median, [25%, 75%])	99.2 [75.3, 125.9]	99.7 [76.6, 132.2]	101.1 [76.8, 130.0]	101.7 [78.7, 135.9]
Carbohydrate (median, [25%, 75%])	290.2 [196.2, 399.6]	291.3 [211.7, 419.0]	306.3 [222.0, 437.5]	310.4 [326.3, 449.4]
Fat (median, [25%, 75%])	59.3 [39.8, 80.8]	59.6 [41.1, 88.3]	60.3 [43.2, 88.9]	60.7 [45.5, 91.7]
%Energy from protein (median, [25%, 75%])	0.16 [0.15, 0.17]	0.16 [0.15, 0.18]	0.17 [0.14, 0.18]	0.17 [0.14, 0.19]
%Energy from Carbohydrate (median, [25%, 75%])	0.47 [0.39, 0.54]	0.47 [0.40, 0.54]	0.48 [0.42, 0.58]	0.49 [0.44, 0.57]
%Energy from fat (median, [25%, 75%])	0.21 [0.18, 0.25]	0.22 [0.18, 0.25]	0.22 [0.19, 0.26]	0.23 [0.19, 0.26]
Year 1 of the cohort	*n =168*	*n = 168*	*n = 168*	*n = 167*
BMI (mean ± SD)*	16.8 ± 1.3	19.8 ± 0.7	22.3 ± 0.9	27.6 ± 3.0
Energy (median, [25%, 75%])	2369.1 [1711.4, 2931.9]	2378.8 [1813.7, 2988.7]	2383.7 [1773.3, 3435.7]	2393.3 [1957.0, 2980.1]
Protein (median, [25%, 75%])	88.1 [61.9,116.4]	88.9 [64.1, 124.2]	89.8 [63.3, 139.2]	90.3 [68.8; 115.3]
Carbohydrate (median, [25%, 75%])	249.7 [185.3, 352.2]	250.0 [188.0, 411.9]	251.0 [185.0, 459.3]	252.0 [209.1, 383.7]
Fat (median, [25%, 75%])	57.3 [40.1, 81.8]	57.5 [38.1, 87.1]	59.9 [38.8, 97.4]	60.1 [40.6, 79.2]
%Energy from protein (median, [25%, 75%])	0.15 [0.14, 0.17]	0.15 [0.13, 0.16]	0.16 [0.14, 0.17]	0.16 [0.13, 0.17]
%Energy from Carbohydrate (median, [25%, 75%])	0.44 [0.38, 0.52]	0.45 [0.38, 0,54]	0.46 [0.38, 0.54]	0.46 [0.40, 0.52]
%Energy from fat (median, [25%, 75%])	0.22 [0.19, 0.28]	0.23 [0.18, 0.26]	0.24 [0.18, 0.28]	0.25 [0.18, 0.26]
Year 5 of the cohort	*n = 109*	*n = 109*	*n = 108*	*n = 108*
BMI (mean ± SD)*	17.2 ± 1.4	20.0 ± 0.7	22.5 ± 0.8	27.9 ± 3.4
Energy (median, [25%, 75%])	2560.7 [2029.9, 3356.1]	2598.8 [2044.8, 3223.1]	2684.8 [2129.1, 3433.7]	2791.8 [2292.3, 3562.8]
Protein (median, [25%, 75%])	100.7 [84.0, 148.9]	101.5 [80.5, 128.8]	102.2 [84.7, 148.2]	102.6 [86.2, 142.8]
Carbohydrate (median, [25%, 75%])	324.6 [225.1, 481.8]	324.7 [234.2, 461.4]	326.2 [247.9, 515.4]	327.0 [285.2, 400.7]
Fat (median, [25%, 75%])	66.4 [51.3, 106.2]	71.9 [51.3, 90.1]	72.8 [54.0, 109.2]	74.2 [54.1, 99.4]
%Energy from protein (median, [25%, 75%]	0.16 [0.15, 0.18]	0.16 [0.15, 0.17]	0.17 [0.15, 0.18]	0.17 [0.14, 0.18]
%Energy from Carbohydrate (median, [25%, 75%])	0.49 [0.44, 0.58]	0.50 [0.44, 0.57]	0.51 [0.45, 0.58]	0.52 [0.47, 0.58]
%Energy from fat (median, [25%, 75%])	0.23 [0.22, 0.29]	0.24 [0.21, 0.28]	0.26 [0.22, 0.28]	0.30 [0.21, 0.31]

*** only BMI was significantly difference among quartiles**; other factors including energy, protein and fat values were not significantly different among groups.

Table 4. Multilevel generalized linear regression between total energy intake, macronutrient intakes and percent energy from protein, fat and carbohydrates with adolescent BMI in 5 years.

BMI	GLMM*** Univariate				GLMM*** Multivariate		
	Coef	95% CI	p		Coef	95% CI	p
Energy (kcal/day)	0.0004	0.0003 to 0.0005	<0.001		0.0003	-0.0003 to 0.0009	0.364
Protein (g/day)	0.0089	0.0064 to 0.0113	<0.001		-0.0065	-0.0281 to 0.0151	0.556
CHO* (g/day)	**0.0041**	**0.0034 to 0.0049**	**<0.001**		**0.0061**	**0.0024 to 0.0098**	**0.001**
Fat (g/day)	0.0092	0.0062 to 0.0121	<0.001		-0.0106	-0.0384 to 0.0171	0.452
% energy from Protein	4.8172	2.4099 to 7.2244	<0.001		11.8640	-3.7418 to 27.4693	0.136
% energy from CHO*	**2.3821**	**1.6465 to 3.1177**	**<0.001**		**-2.8719**	**-5.5038 to -0.2400**	**0.032**
% energy from Fat	2.3780	1.129822 to 3.6261	<0.001		0.8447	-8.0019 to 9.6913	0.852
Time spent for MVPA*	***-0.0005***	***-0.0009 to -0.0002***	***0.004***		***-0.0011***	***-0.0017 to -0.0006***	***<0.001***
Total Screen time	***0.0008***	***0.0004 to 0.0013***	***<0.001***		***0.0014***	***0.0007 to 0.0021***	***<0.001***
Gender=boy	1.9457	1.4782 to 2.4133	<0.001		2.5229	1.9499 to 3.0958	<0.001
Age	0.0277	-0.0238 to 0.0791	0.292		0.0577	-0.0365 to 0.1520	0.230
Ongoing maturation	0.052	-0.280 to 0.383	0.760		Not included		
Completely matured	0.011	-0.346 to 0.069	0.950		Not included		

*CHO = Carbohydrate; **MVPA= Moderate to vigorous physical activity; ***Generalized Linear Mixed Model

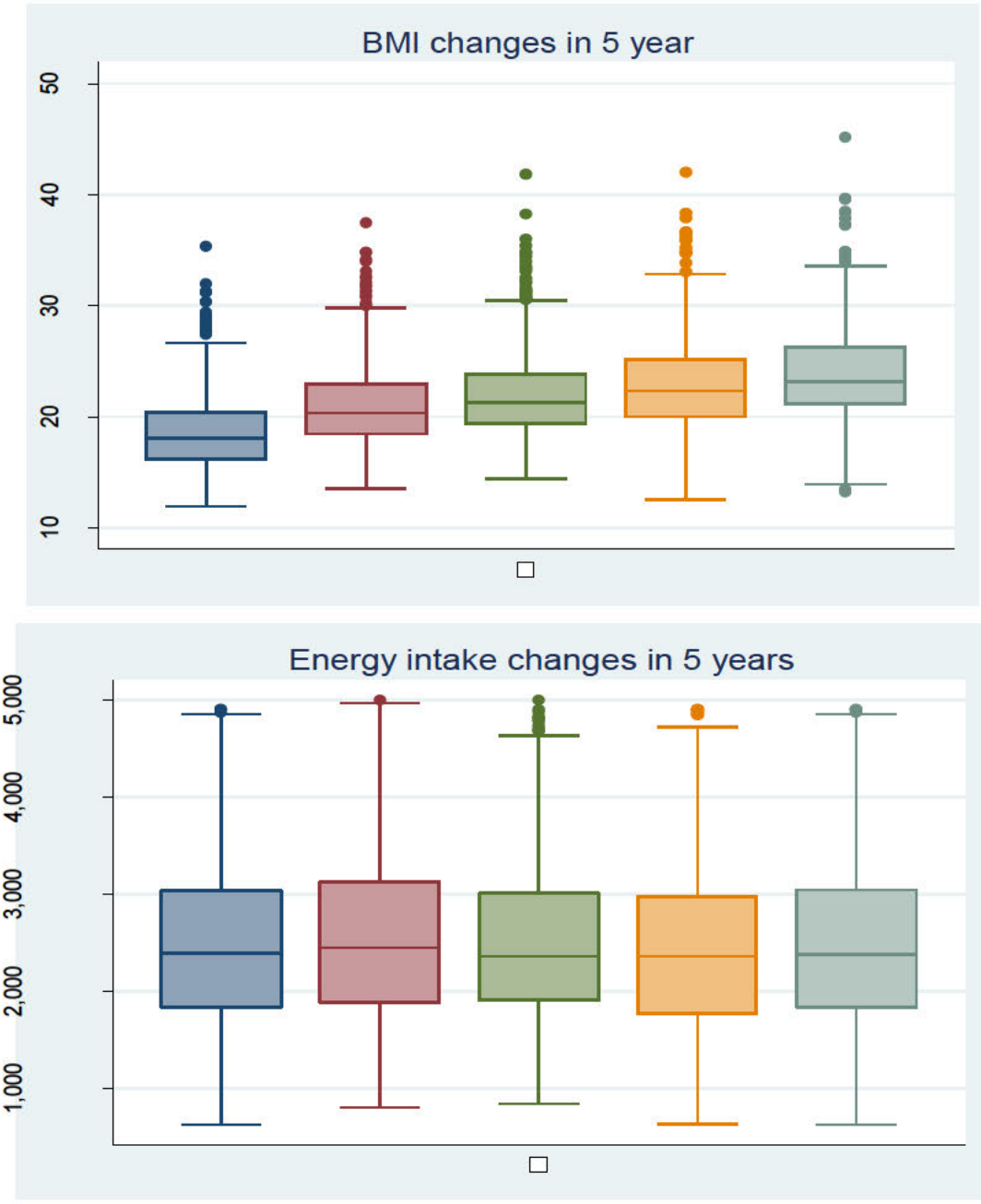

Figure A1. BMI and Energy intake over 5 years of study

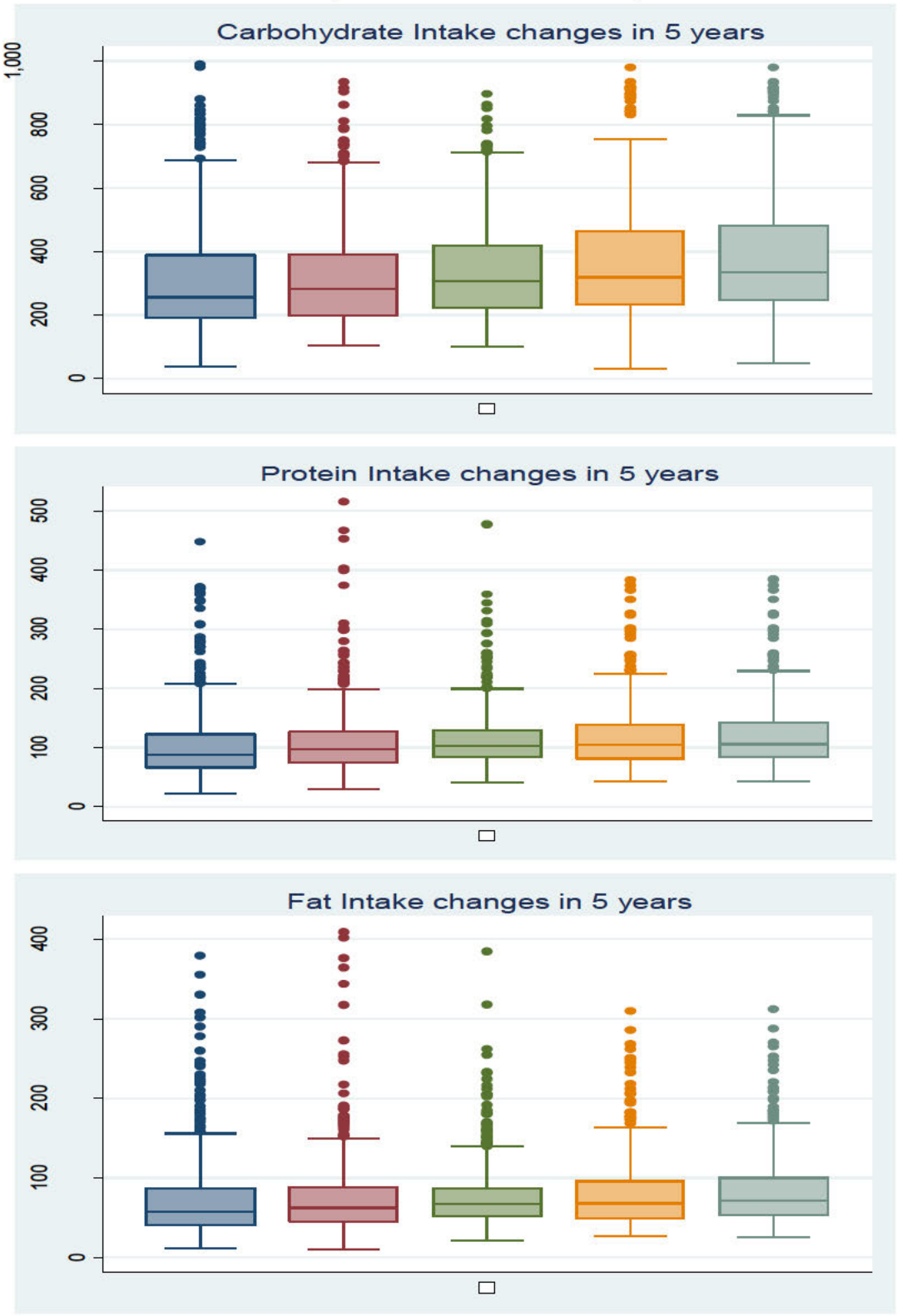

Figure A2. Macronutrient intake change over 5 year of study

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SECTION III:

Formulating Peer-led Intervention

Chapter 5:

Formative research (Published)

Perceptions and Practices Related to Obesity in Adolescent Students and their Programmatic Implications: Qualitative Evidence from Ho Chi Minh City, Vietnam

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This chapter provides in-depth knowledge of perceptions and practices on obesity, diet and other nutritional behaviours and physical activity among adolescents in two typical junior high school in an urban area where obesity prevalence has steeply increased in the past ten years. These invaluable inputs were collected using detailed explorative interviews with students, their parents, school PE teachers and a representative of the Department of Education of Ho Chi Minh City. All of the data was purposefully analysed to find programmatic implications for a culturally appropriate and feasible intervention to tackle child and adolescent obesity. This chapter gave answers to Objective number 1 and the partial framework for Objective number 5.

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Perceptions and Practices Related to Obesity in Adolescent Students and Their Programmatic Implications: Qualitative Evidence from Ho Chi Minh City, Vietnam

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Abstract *Background* Prevalence of obesity in children in Ho Chi Minh City is rising in the last 10 years. We conducted a formative study to explore the perceptions and practices related to obesity, diet and physical activity among the students in two junior high schools in two suburbs in Ho Chi Minh City to aid in the design of an intervention in preventing obesity among adolescent school children. *Method* We conducted in-depth interviews with twenty participants including students, their parents, physical education teachers and a representative of the Department of Education. Manually coded and organized data were analysed applying a thematic analysis approach to divulge trends, diversities and similarities among the emerging themes. *Results* The study revealed diversified perceptions of obesity, diet and physical activity and their relationship with adolescent obesity. The findings indicated low practice of physical activity among almost all students who participated in the study. The major barriers to obesity prevention included knowledge gaps, food environment in the school, devaluation of physical activity and academic burden. *Conclusion* The findings provide contextual insights to design a culturally appropriate and feasible intervention to tackle child and adolescent obesity by harnessing the perspectives of the target populations.

Keywords Adolescent obesity · Perceptions · Physical activity · Qualitative method · Vietnam

Abbreviations

HCMC	Ho Chi Minh City
PA	Physical activity
PE	Physical education
TV	Television

Significance

Despite increasing prevalence of obesity in urban settings in Vietnam, little research has been conducted to design efficient intervention to tackle this important public health problem. Our study generated valuable in-depth insight through the application of qualitative methods that will help develop efficient and culturally appropriate interventions. Our findings have relevance to identifying target populations and intervention delivery strategies.

Background

Obesity is strongly linked with diabetes, cardiovascular diseases and general mortality (Keith et al. 2013; Kodama et al. 2014; Park et al. 2013; Strazzullo et al. 2010; Freemantle et al. 2008). Recent systematic reviews found that childhood obesity also increased the risk of metabolic diseases and non-communicable diseases later in life (Lloyd et al. 2012, 2010; Adami and Vasconcelos 2008). Although

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the prevalence of obesity has stabilized in high income countries (Bluher et al. 2011; Olds et al. 2011; Wabitsch et al. 2014), the situation in low and middle income countries is deteriorating as more and more young people are gaining excess weight (Gupta et al. 2012). In fact, the prevalence of childhood obesity (5–19 years) in Asian countries is alarmingly high, for example 22% in India and over 20% in China (Gupta et al. 2012). Even in previously 'lower risk' countries in Southeast Asia, like Indonesia (Julia et al. 2008) and Vietnam (Trang et al. 2012; Nguyen et al. 2013), recent results from population-based cohort studies indicate that the prevalence of childhood obesity has risen quickly in the last decade especially in big cities, thus prompting the need to develop interventions to control this increasing rise and prevent longer term consequences.

Generally, bodyweight is regulated by multiple physiological mechanisms that maintain the balance between energy intake and expenditure (Lustig 2001). Dietary and physical activity practices are therefore, the most important behaviours (Patro and Szajewska 2010; Rauner et al. 2013) and influential factors for preventing obesity (Brown and Summerbell 2009). However, interventions to prevent and treat adolescent obesity are challenging and require social and professional actions. Recent systematic reviews of randomised controlled trials have shown that school-based interventions are convenient and effective for both the prevention (Doak et al. 2006) and treatment (Oude Luttikhuis et al. 2009) of obesity but require careful planning and coordination (Wirth et al. 2014). A formative research can inform the design of an efficient intervention by providing contextual information (Brown and Summerbell 2009).

Ho Chi Minh City (HCMC) is the most populous urban area of Vietnam. Recently there have been dramatic social and nutritional changes, including a rapid development of childhood obesity in the area (Trang et al. 2012). Yet, the situation has only been assessed by cross sectional surveys (Nguyen et al. 2010; Vietnam General Statistical Office 2009). The literature on the types of foods the children in HCMC consume and physical activity they practice, and the drivers of their choices is scarce. Local indices such as the high rate of school attendance (above 93%) (The World Bank 2013) and the long time spent at school give us an opportunity to explore the daily life of adolescents conveniently using a school-based research. In addition, school-based interventions are not only beneficial to the participants but also to the school environment (i.e. understanding context, inter-relationship and possibility to make changes happen effectively). However, the required contextualised knowledge to design acceptable, feasible and culturally appropriate interventions to tackle the rise of adolescent obesity in urban settings in Vietnam is inadequate. Thus, we conducted this qualitative study to generate knowledge of factors influencing adolescent's dietary and physical activity behaviours and the perceptions guiding these behaviours that would help formulate the design of an intervention for school-based adolescent obesity prevention.

Method

Study Design and Population

We used a qualitative explorative design to examine the perceptions and practices related to adolescent obesity, diet and physical activity among students, teachers and parents in HCMC. We purposively selected two junior high schools from Districts 1 and 5 in HCMC. These schools are average in size and have facilities and resources for possible obesity prevention programs. We focused on the students from the sixth to eighth grades (age range 11–15 years), their physical education (PE) teachers, their parents, and a representative of the Department of Education of HCMC.

Recruitment Process

In each school we randomly selected four classes (one from each grade from sixth to eighth). We informed the class teachers and the students of the purpose of our study, and invited the students to participate. The teachers helped in contacting the children and their parents by mail and with face-to-face meetings. Ten out of sixteen students who initially expressed their willingness to participate were available for interview. The interviews with students took place privately and after school on school premises. We intended to interview one parent of each student but only seven parents were available and interviewed. We organised prescheduled interviews with parents at their home when the

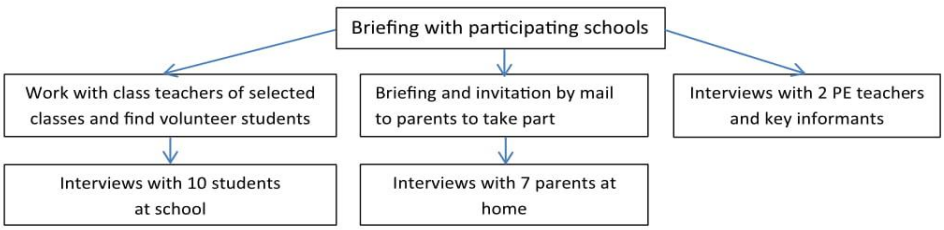

Fig. 1 Flowchart of interviews with students, parents, teachers and key informant

children were not home. Finally, separate sessions of interviewing with PE teachers and the key informants (representative from the Department of Education) took place at their workplace (Fig. 1).

Interviewing and Data Collection

We conducted in-depth one-on-one interviews with all participants. We started interviewing with a short ice-breaking conversation to facilitate and build trust among the respondents. Then, the students and their parents were asked about their perceptions of and attitude on obesity, perceptions of relationships between obesity and heath, the student's physical activities at home, school and outside, physical environment for physical activity, menus and cooking of meals at home, and children's eating behaviours. The PE teachers were asked about the physical education curriculum, the challenges of administering the curriculum and students' diets and physical activities within the school. The topics of interview with the representative of the Department Education included the policy and programme of school-based physical education and the challenges to implementing them.

We used separate flexible interview guideline for each type of respondents to guide the interview and keep track of the conversation. We asked related probing questions and prompts, and suggested the respondent to explain further when it was necessary. The interviews took lasted from 35 to 60 min. They were all digitally audio-recorded (with participants' consent) and then transcribed verbatim for analysis.

Ethical Procedure

We obtained ethical approval from the Ethical Review Board of Pham Ngoc Thach University of Medicine, HCMC, Vietnam. Informed written consents were obtained from the participants. All participants were assured of the confidentiality and anonymity of their information. Their participation was voluntarily with the right to withdraw at any stage of the interview and the study.

Data Analysis

We applied an inductive thematic analysis approach to analyse the data (Braun and Clarke 2006, 2014). Since our study was explorative in nature and a pioneering qualitative investigation into perceptions and cultural dimensions of diet and physical activity of adolescent students in urban Vietnam, we did not follow a pre-existing coding frame. All audio-recorded interviews were transcribed verbatim by two authors, Hong K. Tang (HKT) and Minh N. Nguyen (MNN), in Vietnamese and typed as Microsoft Word documents. At the beginning of the coding process, two authors, MNN and Ashraful Alam (AA) discussed three initial translated (English) transcripts. These authors then developed a draft thematic code list. They discussed the draft codes and developed a revised code list which was open to add new codes. MNN then continued reading each of the remaining transcripts in Vietnamese and added the new codes that emerged from the transcripts. The code list was finalised after all transcripts were read and coded. MNN compiled the text attached to each of the themes and sub-themes from all the transcripts into separate individual documents. Each file (compiled data on each theme) was labelled based on the theme it was attached to. Subsequently, the text pertaining to each thematic code was discussed and summarised in a document that presented the findings for each of the themes using quotes and tables.

Results

All of our study participants were from middle-income families. Detailed characteristics of the respondents are summarised in Table 4 in the Annex.

Perceptions of Obesity: Prevalence and Reasons

Our data revealed diverse perceptions of adolescent obesity among the participants. They defined obesity mostly based on the outlook of overall body, waist and weight. A PE teacher said:

> Oh when we compare them with their peers, they (obese children) are fatter, bigger and slower than their same-age peers. … Yeah, just a clear look right there [with eye-pointing to an obese student]. What a belly!

The participants reported that they noticed an increasing trend in obesity in the adolescent students that is reflected in the quote below:

> "Yes I see that (obesity prevalence) too in the school, and probably the same situation outside the school. Some students, when in year 6, they were small but tall (proportionally). But after one year when they go to class 7 or 8, then I can see their weight increased much more."—PE teacher

The majority of parents were aware of obesity in adolescents, but their perceptions of the causes of obesity were different from those among their children. While most students expressed that obesity was caused by "eating too much" or by consuming "sweetened food", most of their parents and teachers perceived it to be caused by "laziness"

Table 1 Perceived key features and causes of obesity

Obesity	Perceived reasons of obesity
Obesity features	Main causes
Outlook	Eating related
Bigger looking	Eating a large amount of food
	Drinking sweetened food and drink
Slowness in movement	High frequency of eating
	Eating fast food
	Physical activity related
Weight	Lack of exercise
	Insufficiency of physical activity
Imbalance between body weight and height	Spending too much time on screen (i.e. TV, computer, mobile phones/tab)
Excess of body weight	Combined causes
	Unhealthy (fatty and fast foods) eating and insufficient exercise

and "less physical activity." Viewpoints of different types of respondents are listed in Table 1.

Eating Practices of Children at School and at Home

Many students reported a habit of skipping breakfast. They mentioned that they skipped this meal due to lack of time and prepared food in the morning when their busy parents also had to rush to work.

> "I don't have breakfast, and only until after 11:00AM I eat. Sometimes I eat instant noodles at school but noodles are often very hot. … I don't have food (in the morning) because my dad usually takes my mom to her workplace very early and no one is there to prepare breakfast."—Student

The students had three main options for lunch: (1) lunch at school canteen with catered meal, (2) lunch at home during lunch break, and (3) eating in the restaurants or street food. The lunch in the school basically includes one main meal (i.e. meat, fish or vegetables) with rice and a bowl of soup. In general, the students did not like the lunch at the school canteen. The school canteen had pre-set lunch menu for each day of the week, but overall the students did not like the food.

> "Sometimes lunch is not tasty. Often rice is too soft and soaking wet, sometimes it's too dry."—Student

Besides the main meals, snacking in this young population was frequently reported and was linked to the availability of food in the school canteen, as reflected in the quote below.

> "I usually eat girdle-cake mixed with spices…because there's everything in there!"—Student

In addition to the canteen inside the school premises, the surroundings of the school had other food stores and street food vendors, some of them were located just in front of the school entrance and right across the road. Students frequently consumed foods from these sources.

> "Around the school front gate there are fried noodles, rice noodles sauté with beef, fried soya cheese and a street restaurants"—Student
>
> "You know there's a 'Mini-Market' [convenient store] in front of the school, recently opened. They sale foods, like canned food, fast food, diary and yeah (!) hamburger! So you know whenever he [her son] feels hungry, he just walks over to buy whatever (he likes). … And he can choose soft drinks, especially when he goes with friends."—Parent

Dinner, according to several students and their parents, was a chance of family meeting after a whole day. The dinner mostly included larger amount of food and dishes compared to lunch. The family members often gathered to have a lengthy dinner, but children usually had a quick grab of food late in the afternoon and then a "formal" dinner when they return from their after-hour tutoring classes in the evening. Sometimes children also had dinner outside (in local street restaurants, with many meal options) and/or a snack at home before going to bed.

Family food and meals were mainly chosen by parents, the mother in particular. Almost all families had a fridge with snacks and fruits and cooked meals stored inside, and sometimes leftovers from previous meals. The children had easy access to them. Even though parents were aware of their children's overweight status, there was no strict control over children's diet. Some parents expressed that their kids loved the food and snakes cooked by them because these foods contained "more meat" than the foods available in shops and restaurants.

Children usually did not involve in cooking at home, although parents often asked their choice of the menu and ingredients. Interestingly, neither the parents nor the children reported a clear calorie based approach to choosing daily meals.

A summary of the children's experience of food environment and their eating practices is described in the Table 2 below.

Physical Activity Practices of the Students

Students' physical activity took place at the physical education class, free plays during break times in the morning and afternoon, and yearly school sport events. Generally the

Table 2 Food environment at school and students' eating practices

Children's experience	Main meals & snacks	At		
		School	Home	Others
Food environment	6 am Breakfast	✓	✓	✓
▪ One-size-for-all portion of school lunch with uncontrolled additional rice and soup in school canteen	Snack and soft drink	✗✗	✗	
▪ Distasteful school lunch	Lunch	✓✓	✓	✓
▪ Lack of vegetable and fresh fruits		✗✗	✗	✗
▪ Abundance of fast foods and soft drinks in school canteen	Dinner		✓✓	✓
▪ Easy availability of street foods nearby school	11pm			
Eating practices				
▪ Irregular meal time (breakfast/dinner)			✗	✗
▪ Meal skipping (esp. breakfast)				
▪ Food sharing leading to skipping lunch				
▪ Limited involvement in choosing of food and cooking at home				

✓ Main meals ✗ Snack/soft drink Number of ✓ or ✗ corresponds to the frequency of the responses

students stated that physical education lessons are fun and beneficial, especially optional free sports.

"I enjoy physical (education) sessions and I wish I have more to relax and play with my friends. I think I am happier with the optional sessions [free sports time without direct supervision of the PE teacher] because I can play what I like."—Student

The students' motives to practice sports and participate in physical education, as they mentioned, were to

avail the opportunity to engage with friends, enjoy competitiveness and fun.

> "I think school sport sessions are good because they make me feel good and I run fast and faster than my friends."—Student

However, a PE teacher was not satisfied with the extent of students' engagement in physical education and opined that physical education should have brought under the school academic assessment profile to increase students' motivation to engage.

> "Many students don't recognise the essence of the physical education; they just practice lightly to pass. In addition to that, there is no marks for PE, so they are not very keen to PE at present."—PE Teacher

On the other hand, students pointed out some inconveniences resulting in their less involvement in the PE session.

> "I think it (physical education) is not scheduled appropriately in the sequence of the periods. My clothes are soaked with sweat afterwards (the physical dedication class). Besides, the afternoon PE sessions are also not suitable because my father can't drop me to the sports location as he works in the afternoon."—Student

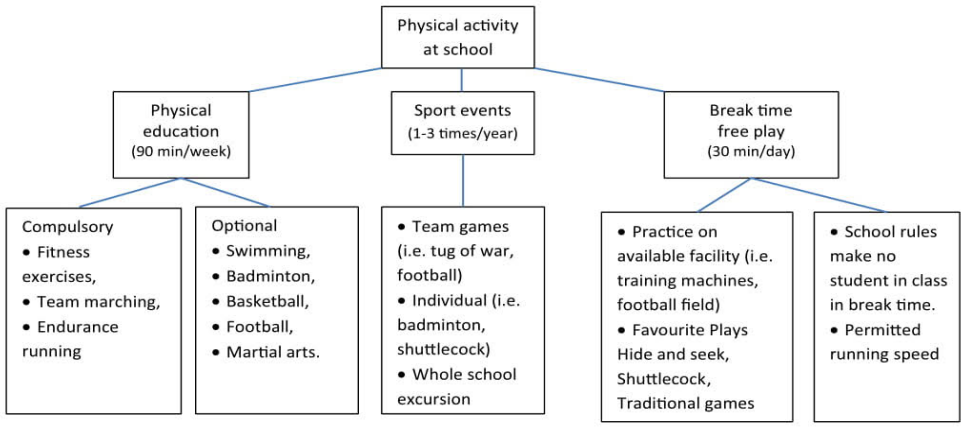

Fig. 2 Overview of students' physical activity at school

Table 3 Perceived barriers, reasons and suggested improvements on students' physical activity

Barriers	Explanations/reasons	Suggested improvement
Low value attitude towards PE	Students and parents do not consider PE necessary	Include clear statements by medical authorities that PE brings specific health gains (parent)
		Adapt attractive teaching methods (students)
Students' PE preferences are not fully considered	Due to unavailability of facility, space constrain at school and low communication about PE	Increase communication about PE at school (parent)
Activeness at school are not fully supported	Perceived bad effects and inconvenience caused by physical activeness (i.e. sweating, risk of accidents, and breaking the facility)	Adding a few more events like competition and excursions (student)
		Allow students to play freely in break times (student)
	Lack of focus on physical activity at school (fewer organised sports events per year, and little time allocated for PE class)	Let students play after class for some extra time and keep them confined to school premises to be safe from the street accidents (student and parents)
Academic burden and after-school tutoring	Parents' expectation of better results in exams	Educate parents for better understanding about the PE (teacher)
	Students' lack of academic self-esteem	Lower the school workload and homework (students and parent)

Next, we describe various options about physical activity at school and the underlying reasons for students' participation in the activity (Fig. 2).

Physical education sessions, free play in the break times and the school sports events are the three domains where the students engaged in physical activities. Forty five minutes are allocated to each of physical education class (compulsory) and free sports (optional) sessions. The free play time at school is limited to curtained types of sports due to space constraints and school rules. Types of physical activities at school and associated challenges encountered by the students are illustrated in the following quotes and the Table 3.

> "Yup, I can only play shuttlecock in the break time. The other sports like badminton is not allowed because they (school authority) are worried of possible accidents."—Student
> "After school they (school staff) let us play only inside just for a very short time and then they rush us out to shut the main gate and students have to play outside."—Student

Apart from physical activities in the school premises, we talked to the students about their activities at home and outside. Three students were currently involved in sports activities after school and during the weekends. According to them, engaging in a sport depended on skills, enjoyment and popularity of that sport. Many students mentioned about time constraints after school, tiredness, lack of parental encouragement, and lack of a sport-friendly space at home and the surroundings as the constraints for after-school physical activity. We particularly found academic burden and the culture of after-school tutoring to be important factors that restricted children's time and scope for engaging in physical activity. One parent shared her child's squashed schedule on a Sunday:

> "Oh! On Sunday she (her daughter) also needs to go to extra (tutoring) classes. She starts to go for a literature class from 6.45 am. Then at 8.30 starts her Catholic class until 11.30 am, and then lunch and napping time to 3:00 pm. If weather is good, I let her go swimming but if it's very sunny I won't let her go. From 5 to 6 pm I may take her out for a go-around for a little and then return home for her school homework."

Finally, interviews also revealed that many students claimed that sedentary activities, such as, watching television, and playing games on computers, tablets and smart phones were allowed at home and that these activities depleted many hours of their free time

Discussion

Our study revealed several key points to understand obesity in adolescent school children and how they make their dietary choices and engage in physical activity. The main challenging points that need to be considered to design a school-based obesity prevention program are the perceptions of obesity based on inappropriate knowledge among students and parents, environment and foods in the school canteen, undervaluing attitude of students toward physical activity, and students' academic burden.

First, the respondents expressed varied understandings of obesity and related issues. Our data show that although the students, parents and teachers acknowledged the increase in child obesity recently in their community, they did not consider it an urgent issue. We found a tendency of assessing obesity based on physical appearance, and an underestimation of obesity especially by parents. These findings are similar to those in other settings and may contribute to the susceptibility of the adolescents to obesity (Sylvetsky et al. 2013; Lin et al. 2007; Lundahl et al. 2014). Additionally, lack of awareness about nutrition and physical activity that our data revealed, can negatively affect obesity prevention practices of the adolescents. Inappropriate knowledge of energy-based food and nutritional ingredients among the adolescents and their parents refrained them from making healthy foods choices resulting the family members including children in gaining more weight (Patro and Szajewska 2010; Bray 2004). Systematic reviews confirmed that physical activity contributes to regulate excess energy accumulation and reduce fat and weight gain in human (Rauner et al. 2013; Ortega et al. 2013). However, the students participating in the study showed superficial understanding of the links between physical activity and obesity and thus, it is understandable that they engaged in low physical activity in their daily life.

Second, we found several external factors that prevented children from healthy eating. Participating students and parents identified time constraint for their skipping breakfast, but considering the local food environment as found in other studies, the availability of cheap fast foods might have also triggered this behaviour (Euromonitor International 2014). High calorie fast foods and drinks were advertised in the school canteen and the school surroundings with attractive images. Richly marketed snacks, fast foods and sweetened drinks paired with the strictly set menu with no alternatives in the school canteen shifted the healthy choices away from the students. In addition, the students found the school lunches, which were managed by the school authority and limited to only one type of meal each day, found not tasty. This might explain why some children shared food—most often high calorie snacks and artificially sweetened drinks that were bought from outside shops—with friends

leading them to avoid lunch at the canteen. Moreover, foods and eating habits at home were alarming because parents used food as a strong means of expressing their love to children. Very limited involvement of children in purchasing, cooking and preparing their meals was not only a reflection of local Asian culture, but also the lack of communication between generations within the family. The practice of storing leftovers and cooked foods in the fridge gave an opportunity of over-eating to the children, who were yet to gain adequate knowledge and motivation for healthy diets.

Third, in our study, physical education and activity were not highly valued by both the students and their parents, thus only a few of them reported being physically active. As mentioned earlier, students and parents lacked awareness of positive health effects of physical activity that explained, at least in part, their low motivation for physical activity. This was catalysed by the absence of grading for physical education lessons in the academic assessment at school which led to a lack of enthusiasm for students' participation in physical education classes. Although there was a variety of sports being played at school, the time allocated for these sports was less than half of the allocated physical education sessions.

As shown in Fig. 1 the total time allocated for a physical education sessions was limited to one and a half hours per week, which was far from enough to meet recommended level of child physical activity. The lack of time could be compensated by daily break-time when many students reported that they enjoyed free spots and running. School rules did not allow students to stay in the classroom during the break-time, but they were not permitted to play every sport of their choice because of safety concerns. Although there might be a higher chance of accidents in break times, the school authorities need to realize that the injury incidents at a school is only partially caused by sport activities(Zhang and Zhan 2007), and the accidents are preventable and should not restrict the students from engaging in active sports. Moreover, we argue that inclusion of students' favourite games and sports would encourage students' participation in the sport events. The PE teacher could encourage children to continue to be physically active when they return home. We also found that allowing children to stay and play inside the school while waiting for their parents to pick them up can help avoid the lack of security outside the school ground that might be posed by careless motorbike divers and street criminals(WHO 2010), which are faced mostly by younger kids.

Finally, we found that children in our study were facing strong parental expectation of high academic performance that prevented them from living their own life (Phan 2004). The academic burden for the students is a tangible issue in Vietnam (Dieu et al. 2012) indicated by the high presence of after-school couching classes (about 2 h per day on an average for a student in our study). The after-school tutoring when combined with a huge load of school homework decreased a student's time for physical activity. We argue that there is a need of negotiation between parents and teachers about lowering academic workload of the students. Physical activity outside school among the adolescents could be increased by efficient time management since many adolescents in this study managed to have free time to watch television and play electronic games that was found to have direct and long-term positive association with obesity.(Boone et al. 2007) The adolescents would certainly need parents support to manage their time efficiently.

This is a pioneering study in Vietnam that focuses on the views of students, their parents and physical education teachers on adolescent obesity, physical activeness and eating practices, which help explain the adolescents' behaviours related to obesity. Our study has limitations that should be considered when interpreting the findings. The students in this study were purposively selected from mainly a middle class social group, thus their experience may not represent all secondary high school students in Ho Chi Minh City. However, generalization of our findings to all secondary high school students is not our goal in this formative research. The study aims at generating contextual evidence for formulating a school-based intervention in preventing adolescent obesity in the similar settings. Further formative studies might be necessary to aid in the design of interventions in others settings. Originally, we targeted at including all parents of the participating students, but some of them were unable to take part in the study. This has further potential for limiting our data. We conducted long interviews in a conversational manner to generate maximum possible data and minimise this limitation. The inclusion of various types of informants who would have direct and indirect role in the intended intervention provided us scope of harnessing perspectives from multiple levels and enabled us to triangulate our data. In the end, the study generated sufficient amount of data to provide insights that will help design the intended intervention.

Conclusion and Recommendations

Our study revealed diversified perceptions of adolescent obesity and the role of physical activity and diets in adolescent obesity. The study also mapped out the adolescents' behaviours related to diets and physical activity in and outside school. We discovered that the key challenges to adolescent obesity prevention included: (i) the lack of science-based perceptions of obesity and the role of food and physical activity in developing obesity, (ii) the socio-economic factors which prevent healthy eating including regulations and marketing of calorie-dense fast

foods, (iii) lack of consideration of students' preferences and choices in the design of physical education curriculum, (iv) quality of foods and absence of healthy eating-friendly environment in the school canteen, (v) inadequate structural facility for physical activity within the school premises, (vi) high parental expectation of academic achievement in the exams and increasing academic workload and stress of the students that restricted them from having an active lifestyle, and (vi) lack of adolescent children's participation in meal preparation at home. We recommend the following aspect to consider in designing a school-based intervention that aims to reduce obesity in adolescents by promoting healthy life style in Ho Chi Minh City and similar settings. First, knowledge gaps in children and parents should be bridged with appropriate information of obesity and the factors contributing to it. Second, students' preferences and choices should be assessed and incorporated in the design of the physical education curriculum. Third, school canteen should provide more nutritious foods with a variety of food options based the taste of the students. Forth, inclusion of parents in the intervention is necessary. They can be counselled to extend their support to reduce academic pressure of their children and increase active life-style at home. Fifth, school authority and the Department of Education should consider incorporating food technology or cooking class in the regular junior high school curriculum. This would increase the nutrition literacy among the adolescents and motivate them to participate in food preparation at home. Finally, since the success of the intervention depends on multiple factors involving different layers in the society, we recommend that the intervention implementers consult the stakeholders from the school authority, the Department of Education, parents, students and fast food distributors, and address their suggestions to finalise the intervention design.

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Authors' Contributions AA designed the study. HKT supervised data collection. HKT and NMN collected the data. NMN was responsible for data analysis and developing the first draft of the manuscript. AA supervised data analysis and writing up the paper, and critically modified and finalised the manuscript. NMN and AA responded to the reviewers. MJD critically reviewed the manuscript.

Compliance with Ethical Standards

Conflict of interest Authors declare no competing interest.

Annex

See Table 4.

Table 4 Characteristics of the participants in this study

Characteristics	Number
Role of participants	
• Students	10
• Parents	07
• Teachers	02
• Authority	01
Gender	
• Male	10
• Female	10
Weight status	
• Obese	04
• Non-obese	16
Economic status	
• Middle high	10
• Middle	08
• Middle low	02
Class level of the children	
• Grade 6–7	05
• Grade 8–9	05
Education level of parents	
• Higher degree	04
• Senior high school	03
Home-school distance	
• Same district area	04
• Different district	13

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Chapter 6:

Systematic Review and Meta-Analysis

Effectiveness of Peer-led Programs vs Overweight and Obesity in Children: Systematic Review and Meta-analysis of Randomized Controlled Trials

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(submitted to Obesity Reviews)

This chapter evaluates the effectiveness of peer-led programs to prevent or reduce overweight and obesity in children and adolescents in eight main medical databases. The peer-led effects were assessed using obesity outcomes related to BMI, and through subgroups of intervention types, duration, program content and participants, and where data was available, a meta-analysis was conducted. The results answer Objective number 4 of the Thesis.

Effectiveness of Peer-led Programs vs Overweight and Obesity in Children: Systematic Review and Meta-analysis of Randomized Controlled Trials

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Summary

Background: Peer-led interventions have been used in childhood health promotion for decades but their effectiveness in childhood obesity is unknown, raising the need to conduct a systematic review.

Objectives: To assess the effectiveness of peer-led interventions on child and adolescent obesity using a range of adiposity outcomes (BMI, BMI z-score, BMI percentile, waist circumference, and body weight).

Search methods: We searched 8 databases MEDLINE, EMBASE, CINAHL, AMED, Cochrane Central, Web of Science, PsycINFO, and WHO Global Health Library and selected other trial registry platforms for interventions that matched our selection criteria.

Selection criteria: This review includes studies that used a peer-led approach as the main method for delivering the behaviour change content of the intervention to the children or adolescents, with a minimum intervention duration of four weeks. We accepted studies from all settings with varied behaviour change content. We included all studies where participants were children and adolescents or mixed with adults, but the data could be extracted separately for the children and adolescents. Included studies had to report the results of any of the outcomes, BMI, BMI z-score, BMI percentile, waist circumference, or body weight.

Data collection and analysis: Two reviewers independently extracted data and assessed the quality of each of the included studies. Data were extracted on study type (design, duration), participants (age, gender, weight status, and health condition), peer-leaders (age, gender, weight status, and ratio of peer-leader/children), interventions (duration, content details, number of participants, and size of effect), control details (content, number of participants, ratio with intervention, and size of effect).

Meta-analyses were conducted using the above outcomes followed by subgroup analyses for characteristics (for BMI only), and sensitivity analyses for internal validity.

Main results: The review included 15 studies of moderate to high quality from high-income countries. The age of the participants ranged from 3 years to 17 years. The duration of the intervention ranged from 5 weeks to 28 months. The peer-led content targeted physical activity alone, or a mixture of healthy lifestyle modifications. The meta-analysis of BMI involved 2506 children from 9 studies and demonstrated that programs were effective with a mean difference in BMI of -0.15kg/m^2 (95% confidence interval (CI) [-0.26, -0.03]), p=0.01. Heterogeneity was low (I^2=28%, p=0.19) for the children in the intervention group. The mean difference varied with subgroups with significantly greater effects from interventions focused on physical activity and with longer duration of implementation of the intervention. Sensitivity analysis revealed similar significant findings to the primary meta-analysis.

Author's conclusions: We found moderately strong evidence to support an advantageous effect of peer-led interventions for obesity prevention in children and adolescents. However, given the small number of studies included, and possible reporting bias, the results must be interpreted cautiously. Variations of elements have been used in these studies and our findings favoured the following as the more promising strategies:

- cluster randomised controlled trial in school settings
- with longer intervention time (from six months or above)
- targeting children age 11 or above
- focusing on physical activity.

Plain language summary

We need to prevent excess weight gain in children and adolescents to promote their health. Using peer and friend influence to promote healthy living seems to be an effective method for this age group. We combined the results of 15 studies from high-income countries with a variety of methods, but all had peer-leaders delivering the key health promoters. We found that peer-led interventions reduced body weight relative to height (Body Mass Index), especially when the target children were from schools, aged 11 or more, with interventions lasting 6 months or longer, and by promoting physical activity. However, we could only examine a limited number of studies, and we need to wait for the results from more studies to be sure this approach improves the health of children.

BACKGROUND

Obesity in children and adolescents is an important public health issue[1 2] and a heavy burden for many countries[3]. Research over the life course reveals that obesity in children dramatically increases the risk of cardiovascular diseases[4 5], type 2 diabetes[6 7], pulmonary[8], hepatic[9], renal, musculoskeletal and other complications in adulthood[10]. This condition is also linked with negative emotional states[11], an increased likelihood of high-risk behaviours[12], undesirable stigmas [11 13], and overall lower health-related quality of life.[14 15]

The prevalence of overweight and obesity in children and adolescents continues to grow globally,[3] and recently in many low- and middle-income countries[16 17]. The trends, however, have changed for some high-income countries where the prevalence of overweight and obesity in children and adolescents has become stable, although at a high level[16]. This achievement has been the result of a large effort and investment in obesity prevention programs in the past few decades[18]. This change highlights that prevention has worked or at least slowed the pandemic of childhood obesity. Childhood obesity prevention is currently one of the main themes of public health research and practice[19 20], and for good reason. First prevention is usually cheaper and easier in healthcare practice[21], and especially for obesity[22]. Second, evidence strongly indicates that once established obesity is difficult to reverse through interventions[23]. It can also track from childhood into later life through adulthood[23], often with adverse consequences. All of these arguments strengthen the case for primary intervention.

However, the childhood obesity is simply not just an excess of energy gain during a growing phase of life but rather a combination of inherited personal characteristics, lifestyles and environment, and social influences[24 25]. This means to tackle the issue, usually, multi-component interventions resonate better than single component interventions[26]. Among the other elements delivered during interventions, the persons who have direct contact with children and adolescents play a key role. Teachers, parents (or carers), and peers are the top characters that spend time the most with children and adolescents. While teachers and parents are traditionally respected for education and child care, the influence of the peers of the children or adolescent offer a potential channel for communication about nutrition and health. Peer influence seems to be a good choice for child and adolescent obesity prevention. First, children and adolescents usually consider peers as “insiders” having the their perspective[27], and share certain values and experiences that teachers and parents do not[28]. Second, in school settings, where teachers already have a large number of tasks and responsibilities, the additional task of covering obesity prevention can become burdensome. Although the teaching of lifestyle behaviour change can be effectively and professionally covered by teachers, it is very hard for teachers to maintain or control real behaviour changes[29]. In contrast, peers can spend more time together even after school hours. Indeed, for many schools, peers can be a role model where knowledge, behaviours and habits can be shared[30]. Next, peer influence can spread past different

barriers that teachers and others cannot achieve.[31] Finally, there is a great possibility that peer-involved prevention programs can be less costly because many children and adolescents are curious and volunteer for innovative messages and fun activities which can be used as vehicles for obesity prevention.

Indeed, peer assisted learning has been proven in education and psychological research as an excellent method for improvements on physical activity[32]. For health promotion and disease prevention, several randomised interventions have suggested the effectiveness of peer-led approach for a range of health problems[33] [34]. In the childhood obesity prevention field, several interventions suggest the effectiveness of this type of intervention[35] [36]. However, there are other randomized trials have revealed difficulties and non-effective results, which included labour intensiveness, relatively high cost, no promise of increasing physical activity or healthy eating and too complex for peer networks[37]. Indeed, it seems that there is no conclusion yet for the effectiveness of peer-led interventions on childhood obesity.

However, assessment of the effectiveness of obesity prevention also relies on the markers of use since fatness is not a clear and easy to capture as it looks. Among those markers of obesity in children, Body Mass Index is widely accepted outcome for several reasons. It has been validated many times through years of research and practice[38]. It is easy to measure and can be taken objectively under fieldwork conditions. Additionally, the use of BMI in different settings and locations make it a universal measure and thus make studies comparable. Thus, BMI is suitable as a marker of choice to measure the development and the progression of overweight and obesity.

We believe it is important to conduct a systematic review, and if possible a meta-analysis of studies, to expand the evidence about the effectiveness of peer-led obesity prevention programs on child and adolescent BMI. It is also necessary as it can inform other researchers and practitioners about the most effective methods for prevention of child and adolescent overweight and obesity.

OBJECTIVES

The main objective of this review is to evaluate the effectiveness of peer-led programs in reducing overweight and obesity in children and adolescent populations using BMI as the primary outcome. We also assess the effect of the interventions on other obesity-related outcomes which are BMI z-score, BMI percentile, waist circumference, and body weight. Other secondary objectives are to describe the details of the peer-led interventions which were examined and if possible to evaluate if different conditions and settings modified the effectiveness of the peer-led interventions.

METHODS

Criteria for considering studies for this review

Types of studies

We only included data from controlled trials (with or without a description of the randomization process), with at least four weeks of intervention and with the specific intention of preventing or reducing obesity. The terms “studies”, “trials”, "program", "project" are used interchangeably throughout this review. We accepted studies in which individuals or groups of individuals were randomised (either individually or cluster randomised trials) and we classify them into design categories as “cluster RCT” or “regular (individual) RCT”. We also categorised studies into “longer-term” (from six months or more) and “short-term” (at least four weeks to five months) however if the studies had multiple assessment time points we included results from both short-term and long-term if the data were available.

Types of participants

We included studies of children less than 18 years old at the beginning of the study, including studies where children were part of a group treatment with adults (i.e. family therapy, mixed community programs, etc…) if data from the children could be extracted separately. We accepted all studies with different status of body weight, from “underweight” to “obese”, however, we grouped and focused separately on those studies where participants were all overweight or obese. We included studies with children regardless of their health conditions, but we would categorise them as “healthy children” for generally healthy ones, and “children with illness” for those with co-morbidities.

Types of interventions

Strategies

We accepted all strategies for intervention, including educational, health promotion, psychological or behavioural therapy, counselling, or management strategies, however, interventions had to be carried out (fully or partially, with extractable results) by young peers of the participants.

Definition of “peers” and “peer-led programs”

We defined “peers” as young people who were less than ten years older at the commencement of study than the main child participants who were the target of the intervention. “Peers” could be anyone in the same age range of the participants, but we considered that in most cases they would be from similar school settings. “Peer-led programs” were defined as programs where peers were the key

persons for the successful implementation of the program, or the ones who delivered the main part of the program (not experts, not teachers, not parents/adult carers). Peers could be trained professionally by specialists or teachers but training had to occur before the intervention or separately and independently from the peer-led intervention.

Intervention contents

We included all studies with peer-led programs that involved diet and nutrition, physical activities (sport, exercises…), lifestyle and social support. We included interventions from all types of settings including (but not limited to) schools, out of school-hour care, home, community, childcare or preschool.

Types of comparison

We accepted studies which compared peer-led intervention with a non-peer-led (teachers, experts, parents) active control group or with a non-active control group who received usual care or regular school curriculum.

Types of outcome measures

We only included the studies with one or more of the following obesity outcomes, presenting a baseline and a post-intervention measurement, or a change from baseline. Obesity outcomes in our systematic review are

- *Body Mass Index* (*BMI, kg/m^2*): A measure of weight adjusted for height, calculated as the child's weight (in kilograms) divided by the square of their height (in metres).[39] A BMI value is a relative number, especially for children with younger age, because the cut points that define overweight and obesity in growing children varying with age and sex, and require BMI-for-age reference standards[39] (national and international reference standards are available, such as those from World Health Organization (WHO)[40] and International Obesity Taskforce (IOTF)[41]).
- *BMI z-score* (or *BMI standard deviation scores*): Also a measure of weight adjusted for height (BMI) but adjusted for child age and sex with an appropriate reference standard, and expressed as the number of standard deviation scores from the reference mean for the children age and sex.
- *BMI percentile* (or *BMI-for-age percentile*): A BMI percentile indicates the percentage of children in the BMI reference who have a lower BMI for the child's age and sex. It is similar to BMI z-score in that it requires a reference standard to determine the corresponding percentile of a BMI value. It is similar to BMI z-score but easier to understand and interpret in clinical settings.

- *Waist circumference (cm)*[42 43]: Is a *measurement* of the abdomen taken at the level of the umbilicus using stand methods recommended by WHO, CDC or NHS. *It is* a good indicator of body fat, especially internal fat deposits, and an indicator of the likelihood of developing weight-related metabolic disease.

- *Body weight*: Is measured by a scale in either kg or pound, with precision of at least 0.2 units.

Search methods for identification of studies

Electronic searches

We performed searches in January 2018 for relevant studies in 8 databases MEDLINE, EMBASE, CINAHL, AMED, Cochrane Central register for controlled trials (CENTRAL), Web of Science, PsycINFO, and WHO Global Health Library. We searched the databases since their inception date until January 19th, 2018. Details of the search strategy are included in the appendices.

Other resources

In March 2018 we also performed *searches on following websites* to identify other potential studies that may have been missed in the database searches.

- Registry of clinical trials of the United States National Library of Medicine at https://clinicaltrials.gov/
- European Clinical Trial Registry at https://www.clinicaltrialsregister.eu/ctr-search/search
- WHO International Clinical Trials Registry Platform (ICTRP) at http://www.who.int/ictrp/search/en/
- UK Clinical Trials Gateway at https://www.ukctg.nihr.ac.uk/#popoverSearchDivId
- Canadian Health Evidence at https://www.healthevidence.org/
- Google Scholar at https://scholar.google.com

We also checked the *reference lists* of systematic reviews relevant to our study (identified from the searches above), and the reference lists of the final studies included (once we finished screening the full-text) for information on peer-led interventions to identify potential additional studies for consideration.

Data collection and analysis

Selection of studies

We included studies that matched all the above criteria (randomized controlled design, children aged less than 18 years, peer-led intervention duration of four weeks or more, with a non-peer-led comparison, and obesity outcome measures. We did not limit the time of publication of the studies but did limit the language to English.

We rejected studies that violated any of the five main criteria such as those articles which did not have a controlled design (i.e. observational or cohort design, or reviews of RCT). Papers were also rejected if they did not aim to reduce or prevent child obesity or had no obesity outcomes in the objectives; or if there was no involvement of peers in any activity of the intervention; or if the participants were exclusively above 18 years, pregnant teenagers/young adults, or children less than three years; or if the duration of the trial was less than four weeks.

When a title or abstract could not be classified as “included” or “excluded”, we retrieved the full text of the article for further investigation. Two review authors independently assessed the studies for inclusion and resolved any disagreement by discussion, and when necessary in consultation with a third review author.

Data extraction and management

We developed the data extraction form based on our criteria of inclusion (design, participants, interventions, comparison and outcome measures) with subgroup characteristics in the design (as cluster RCT or regular RCT), participants (overweight/obesity only, mixed weight status), interventions (totally or partially peer-led), comparison group (non-peer led active control, non-active control) and outcome measures (BMI, BMI z-score, BMI percentile, waist circumference, body weight). We also extracted the peer leaders’ information which covered the number peer leaders, their gender, age, and the ratio of peer leaders to participants.

We first checked all included articles for the list of subgroup headings and then extracted the content in each article according to the extraction form including the quantitative outcomes (mean, SD, or 95%CI) for analysis in an Excel spreadsheet.

Assessment of risk of bias in included studies

We evaluated the risk of bias of included studies based on the tool provided by The Cochrane Collaboration[44]. The tool covered seven categories of bias: selection (random sequence generation and allocation concealment), performance, attrition, detection, reporting, and other bias (the last one to capture other potential threats to validity). Each category was judged as being at high, low, or

unclear risk of bias as set out in the data extraction template and suggestion by the Cochrane Consumers and Communication Review Group[45]. For each category, we only deemed the study at low risk of bias if we could find a clear and detailed description that matched the criteria of "Low risk of bias" suggested by the Cochrane Collaboration.

We also appraised the quality of included studies which were cluster randomised trials separately for other aspects of bias (recruitment bias, baseline imbalance, loss of clusters, incorrect analysis, and comparability with regular RCT). Two authors reviewed and classified the risk of bias categories for each study and the differences were resolved through discussion and in some cases involved the third author.

Overall, we chose to rank the RCTs with three important domains which are random sequence generation, allocation concealment and incomplete outcome data. We ranked studies as of high risk of bias if they scored as "High risk of bias" on any of these three domains (attrition bias). Studies were classified as "Unclear risk of bias" if they have at least one "Unclear risk of bias" on any of these three categories with no high risk of bias in the other domains. Studies were ranked as "Low risk of bias" if they scored as "Low risk" for all 3 categories.

Due to the type of intervention, it was almost impossible to blind the participants and personnel in these peer-led interventions, thus performance bias would be ranked as "High risk". However, as the outcomes we focused on were anthropometrics (BMI, BMI z-score, BMI percentile, waist circumference, body weight) which could be measured objectively it would be highly likely that the detection bias ranked as "Low risk". For the reporting bias, we scored the studies as "High risk" if any of the primary outcomes or most of the secondary outcomes were not reported, even when studies' authors stated non-significant findings (without numerical details). For the last criteria of Other bias, we only ranked the studies as "Low risk" if all other contributing criteria were ranked as "Low risk"; we ranked the studies as "Unclear risk" if there was at least one criterion as "Unclear risk"; and we ranked the studies as "High risk" if there was at least one criterion as "High risk".

Measures of treatment effect

We chose to use measured anthropometry (i.e. BMI, BMI z-score, BMI percentile, waist circumference, and body weight) as the outcomes to assess the effectiveness of the intervention. We did not consider child or adolescent overweight or obesity status as an outcome since there are discrepancies in definitions of overweight or obesity (CDC, IOTF…) which use different cut-off points of BMI thus making synthesis impossible. We also suspected the prevalence of overweight/obesity was not the most frequently reported outcome in these RCTs while BMI and other metrics were more frequently utilised.

We performed meta-analyses on each of the five anthropometric outcomes above separately. Each meta-analysis was performed when there were at least three studies that provided enough data and had similar characteristics (i.e. participants, intervention, or setting). We used *means* and *standard deviations* (SD) of change (from baseline to end of intervention) of the metrics from both intervention and control groups of included studies to calculate *mean differences* for meta-analyses. Where the SD was not directly provided we calculated the SD from either the standard error (SE) of the mean, or the 95% confidence intervals (CIs) using the equations provided in Chapter 9 of the Cochrane Handbook for Systematic Reviews of Intervention[46]. In cases where the only data reported was baseline and end of study mean and 95%CI, we estimated the correlation errors (corr E). A series of estimated corr E values were used and we reported the final effect using the mean corr E value as 0.55 and other values (corr E=0.35 and corr E=0.75) in the sensitivity analyses. When only partial data was provided, and no estimation could be imputed (i.e. lacking SE and 95%CIs), we emailed the authors of the study for further data.

For trials which reported more than one treatment arm, we utilised the data for each intervention arm compared with the control arm, with the number of participants in the control arm being divided by the number of treatment arms (i.e. halved in case of two arms) to ensure no inflated number of participants in control groups. For studies which reported one arm of peer-led intervention plus one or more arms of non-peer led intervention and the control group we used data from the peer-led arm as intervention and the control arm for the main meta-analysis but also extracted data from non-peer led arm for sensitivity analysis.

When the studies reported more than one data timepoint, only the data immediately post-intervention were included for the main meta-analysis. The longest follow-up data were also extracted and utilised for sensitivity analysis to assess the effect of the intervention in the long-term. The main meta-analysis included the previous list of five adiposity outcomes while further analysis (including sensitivity analysis) involved another outcome made by the combination of three BMI-related outcomes (BMI, BMI z-score, BMI percentile). For this combination, we used *standardised mean difference* method details in The Cochrane Handbook,[46] which is summarise here:

- The *standardized mean difference* (SMD) expresses the size of the intervention effect in each study relative to the variability observed in that study.
- $SMD = \frac{Difference\ in\ mean\ outcome\ between\ groups}{Standard\ deviations\ of\ outcome\ among\ participants}$

We used the I^2 statistic to provide a measure of heterogeneity of the included trials and random effect to estimate the mean of effectiveness. All analyses were conducted using Review Manager (RevMan) version 5.3 software provided by Cochrane Collaboration. Estimations of Correlation Errors were calculated using Microsoft Excel 2016 spreadsheet, also using the tools provided from Cochrane

Collaboration. All effectiveness results were reported in the format of *mean effect*, *SD*, *95%CIs*, and *P value*. If 95%CIs range did not include zero (P-value ≤0.05) and the mean carried a negative (-) sign, then the intervention was deemed to be effective in reducing the metric of interest. Similarly, if the 95%CIs did not cut zero and the mean effect carried a positive (+) sign (P-value also ≤0.05), then the control activity was deemed as more effective than the intervention. Otherwise, if the 95%CIs range contained zero then the intervention was assessed as "not significantly effective compared to the control" regardless of the sign of Mean.

Data synthesis

We summarize effectiveness results according to outcomes (BMI, BMI z-score, BMI percentile, waist circumference, and Body weight), as well as the types of study (RCT and Cluster RCT), age range of participants (less than 11 years old and from 11 to 18 years old), duration of intervention (short-term ≤6 months and long-term >6 months).

Assessment of reporting bias

Reporting bias was assessed using the computed funnel plots of two outcomes with highest number of involved trials. Funnel plots were executed using RevMan function and we visually evaluated the distribution of effects for all involved published studies. When uneven distributions were found we would suspect a high risk of reporting bias.

Subgroup analysis and investigation of heterogeneity

As mentioned above, we explored the heterogeneity by subgroups of types of study (RCT vs CRCT), the age of participants (<11 years old vs ≥11 years old), and the duration of the intervention (<6-months vs ≥6 months).

Sensitivity analysis (different correlation E=0.35 or E=0.75, using different methods i.e. random effect vs fixed effect; using combined BMI and BMI z-score with standardised mean change)

We conducted sensitivity analyses for the outcome which had the highest number of included studies using different estimations of the correlation error (0.35 and 0.75), different approaches (standardised mean difference vs mean difference) and different effects (random vs fixed effect).

RESULTS

Description of studies

Results of the search

We found 26 articles from 15 studies based on our search scheme (provided in Appendix section). Figure 1 below describes the search process results with the number of articles stated in each stage.

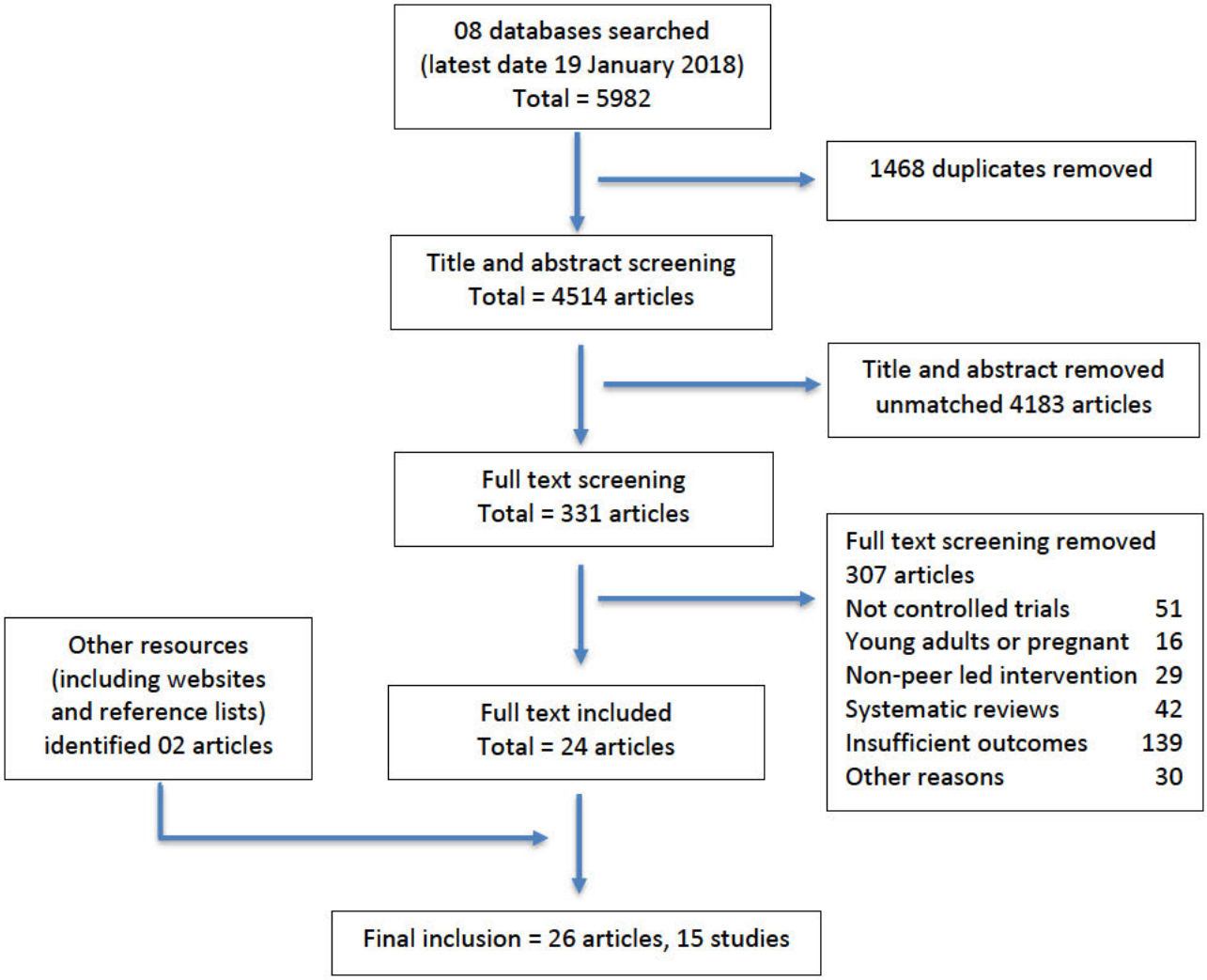

Figure 1. Flow diagram of the search and inclusion process for peer-led interventions to prevent obesity in children

Review authors (NMN and AA) independently assessed full text of 331 articles against the predefined inclusion criteria. We found 24 articles from 14 studies that matched all inclusion criteria. The first author (NMN) then identified 02 more articles (01 new studies and 01 article with a further data point of one already included study) through extended searches of websites and reference lists from the included articles and related systematic reviews. For this review, we will only assess data in trials and studies and thus articles were automatically grouped into related studies.

Included studies

Fifteen studies were found that matched all inclusion criteria.[35 36 47-59] All of them were from high-income countries as categorised by the World Bank economic classification 2017. Of these, nine studies were conducted in the United States, two in Canada, two in Europe (UK and Spain), and two in Australia. Ten out of 15 studies were cluster randomised trials and the others had a regular (individual) RCT design. For the age of participants, five studies had participants exclusively younger than 11 years old, nine studies had participants from 11-18 years old, and one study (Stock et al 2007) had a wide range of mixed ages (from kindergarten to 7th grade ~12 years old). Thus, we categorised this study into the younger age group as most children (90%) were less than 11 years old. Ten studies had mixed gender participants while three studies (Carlin et al 2018, Kulik et al 2015, and Rosenkranz et al 2010) had only girls and two with only boys (Smith et al 2014, Lubans et al 2011).

For the duration of intervention, ten out of 15 interventions had less than six months of intervention while the other five studies had at least six months of intervention. The longest follow-up time among all studies was three years (Tarro et al 2014), while the shortest one was only eight weeks (Smith et al 2013). Three out of 15 trials only targeted the promotion of physical activity while the rest used a mixed approach involving both physical activity and dietary behaviour, or lifestyle adjustment, or environmental change. Also, the three trials that only promoted physical activity used an active way of integrating the peer led activities (Carlin et al 2018, Smith et al 2013, Lubans et al 2011) while the studies using a mixed approach used educational methods, such as spreading knowledge, teaching sessions, some media sharing, and class lessons.

Please refer to Table 1 for more details of characteristics of included studies.

Excluded studies

From the full-text screening stage, a total of 307 articles were removed for reasons detailed in Figure 1 above. Among these reasons, a small number of articles were removed due to other reasons including ongoing studies (10 articles for 8 studies), duplicates (5 articles), laboratory/pharmaceutical early phase trials (8 articles), and not relevant (7 articles).

Risk of bias of included studies

Included studies were evaluated for their risk of bias across seven categories known to be crucial for internal validity, which was random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting and other bias. All studies had at least one high risk of bias score from the seven domains. However, we judged that selection and attrition biases were of greater importance (we discussed this

issue below and further in the Discussion) and many studies were ranked as low risk in these categories. We tried to reduce the cases of unclear risk of bias in the classification process by searching further related articles for the studies of interest (if we missed in the search process) and/or contacting the study authors to gain further insights (but only a few authors replied, in which they provided us with already identified articles and thus did not contribute much to resolve this issue). We ranked high risk of bias wherever we suspected a breach of quality or found insufficient evidence for high quality ranking (low risk of bias). Details of risk of bias were presented below in the next paragraphs, in Figure 2, 3 and in Annex tables A3 (for all trials), A4 (for Other bias), and A5 (for cluster-controlled trials).

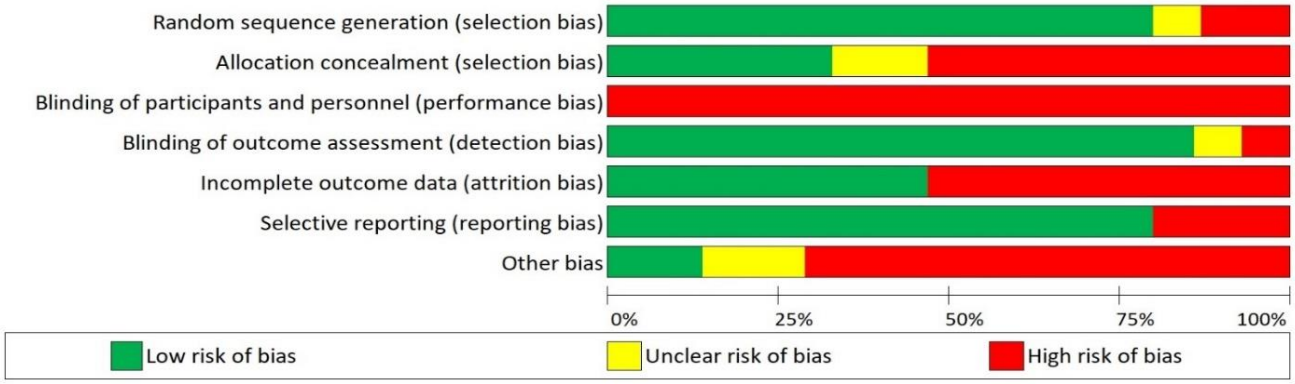

Figure 2. Review authors' judgments about each risk of bias category, presented as percentages across all included studies.

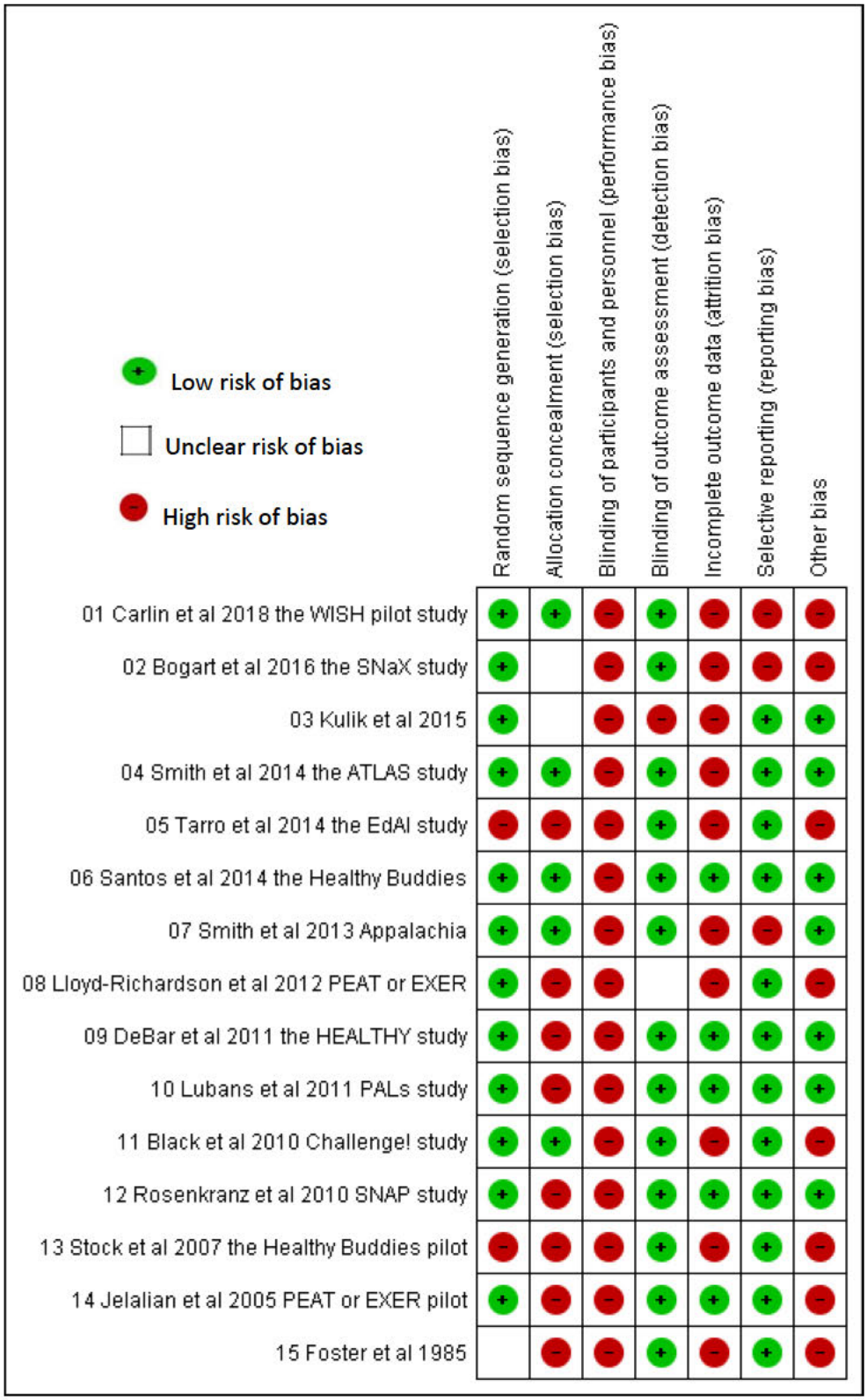

Figure 3. Risk of bias summary: review authors' judgements about each risk of bias item for included studies

Random sequence generation and allocation concealment

Twelve out of 15 included studies (80%) had low risk of bias for random sequence generation with one study at unclear risk of bias (Foster et al 1985, where we could not contact authors) and two studies ranked as high risk of bias (Tarro et al 2014, Stock et al 2007). Studies with low risk of bias stated clearly in the text that a random sequence generation had been conducted either via a computer-generated sequence or centrally generated or by independent personnel not involved in conducting and analysing the intervention. Two studies with high risk of bias were those that did not use a random sequence generator but rather used geographical boundaries (Tarro et al 2014) or no random number generator at all (Stock et al 2007). These two studies were also ranked at high risk for allocation concealment along with six other studies (Lloyd-Richardson et al 2012, DeBar et al 2011, Lubans et al 2011, Rosenkranz et al 2010, Jelalian et al 2005, and Foster et al 1985) where we either suspected no allocation concealment was available or poorly applied. Five studies (Carlin et al 2018, Smith et al 2014, Santos et al 2014, Smith et al 2013, and Black et al 2010) were ranked at low risk of bias for allocation concealment because authors clearly stated that the process of allocation was centrally conducted after the baseline assessments (Carlin et al 2018 and Smith et al 2014), or either because allocation was conducted in a concealed way by independent staff who were not involved in the studies (Santos et al 2014, Smith et al 2013, and Black et al 2010). Two studies remained at unclear risk of bias although we were quite confident that their randomization processes were qualified for low risk of bias (Bogart et al 2016 and Kulik et al 2015).

Blinding (performance bias and detection bias)

Given the nature of trials (Peer-led intervention) blinding was not feasible for both participants, who received the intervention (where researchers tried to use peers' contact to influence the children), and research personnel who had to observe and adjust the interactions between children and role model peers. Thus, all studies were deemed high risk of performance bias and in many cases, the studies' authors also mentioned that blinding was not possible. In contrast, we ranked 13 out of 15 studies at low risk for blinding of outcome assessment (detection bias) since the anthropometric data collection process was clearly stated with details indicating that these metrics were objectively measured with standard methods. Only one study was suspected of high risk of bias for this domain (Kulik et al 2015) because in this study the anthropometric data was a secondary objective with no further details on measurement methods. One study remained unclear to us because of lack of information and thus was classified as unclear risk of detection bias (Lloyd-Richardson et al 2012)

Incomplete outcome data (attrition bias)

We treated this domain seriously as incomplete outcome data could affect the assessment of the effectiveness of the interventions. We successfully resolved all unclear cases in the ways described above. We ranked eight studies at high risk of attrition bias wherever and whenever we found the missing data not provided by study groups, unbalanced completion rates in study groups, reasons for missing data not provided and differences in characteristics related to obesity outcomes between completers and non-completers. We ranked seven other studies at low risk of attrition bias because their authors clearly described the participant flow throughout the study with missing reasons and missing outcome data was quite similar between groups and they were unlikely to be related to the obesity outcomes (Carlin et al 2018, Santos et al 2014, Lloyd-Richardson et al 2012, DeBar et al 2011, Lubans et al 2011, Rosenkranz et al 2010, and Jelalian et al 2005).

Selective reporting (reporting bias)

We ensured our assessment by comparing the protocols of the studies with the published article after the studies were conducted. We compared the range of outcomes reported in these time points and followed the guidelines provided by the Cochrane Handbook for Systematic Reviews of Interventions. Eighty percent of the included studies (12 out of 15 studies) were assessed as low risk of reporting bias. This is because these studies clearly reported all primary and secondary outcomes (including adiposity-related ones) at the end of the intervention. Three studies were deemed as high risk of bias because they did not report detailed information on obesity variables, although their authors reported a non-significant change in these outcomes (Carlin et al 2018, Bogart et al 2016, and Smith et al 2013).

Other potential sources of bias

We assessed six additional items for other bias. These included the early stopping, baseline imbalance, blocked randomization in unblinded trials, differential diagnostic activity, inappropriate administration of an intervention (co-intervention), and selective reporting of subgroups. Only five studies remained at low risk for all six items (Kulik et al 2015, Smith et al 2014, DeBar et al 2011, Lubans et al 2011, and Rosenkranz et al 2010) and thus were assessed as low risk for other bias. Two studies were ranked unclear risk of bias since they had an unclear issue with early stopping (Smith et al 2013) and with a co-intervention (Santos et al 2014). The other eight studies were ranked high risk of bias due to issues with one or two additional items and details can be found in Annex Table A4 in the Appendix.

Overall evaluation for risk of bias for studies included in the meta-analysis

Overall, we ranked the quality of these 15 studies 'Moderate to Moderately High' for the reasons that all studies had at least several items ranked at low risk of bias. Due to the limited number of peer-led intervention studies found, we conducted the meta-analysis for all included studies which reported enough data for such analysis (mean change and SD of change; or both mean & SD value of the outcomes of interest at baseline and at the end of intervention; or enough data to convey and estimate the mean and SD of both intervention and control group).

Effects of interventions

We included all studies with appropriate outcome data in our meta-analysis. We did expect to have most studies to have BMI data, which we planned to conduct our main analysis. However, at the extracting stage (in May 2018) we found a few studies did not report the final BMI data and further attempts to contact the study authors by e-mail was lengthy and only two authors replied with enough data for use in the meta-analysis. Thus, we adapted with this situation by adding one meta-analysis with all BMI related variables (i.e. BMI, BMI z-score, BMI percentile) using *standardised mean difference* approach with random effect model at the end of our analyses.

Effect of interventions on children BMI

Nine studies provided data suitable for meta-analysis with one study provided as two separate subgroups of children thus appeared twice in the analysis (Stock et al 2007). Meta-analysis was conducted to evaluate the impact of peer-led intervention on BMI, the most common outcome measures for adiposity.

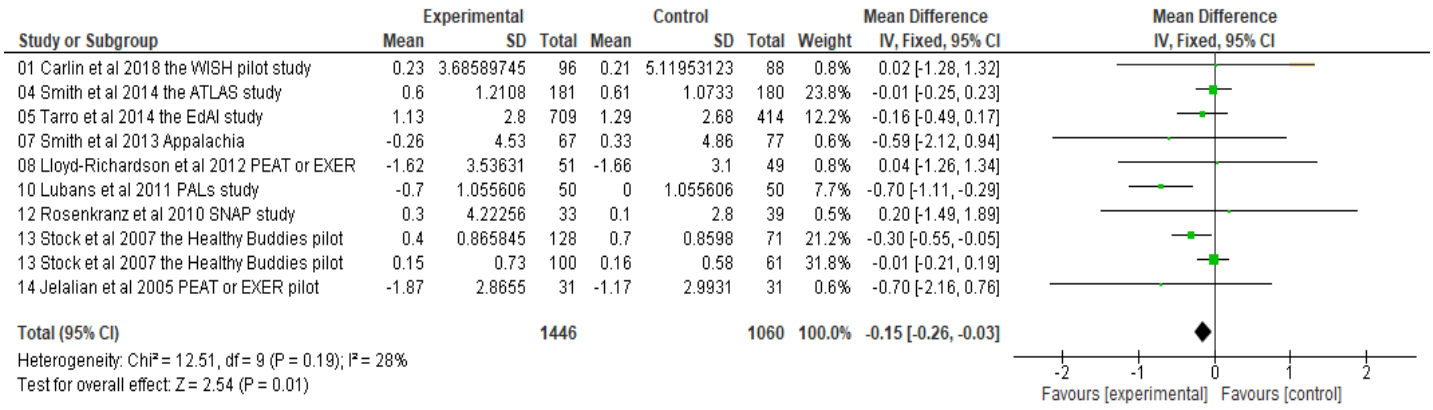

Figure 4. Forest plot of comparison of peer-led intervention versus control by using mean change in Body Mass Index (BMI) from baseline to post intervention.

The forest plot in Figure 4 above revealed rather low heterogeneity (suggested by visual observation and confirmed by heterogeneity test with I^2=28%, df=9, P=0.19). Thus, a fixed effect model was

applied. Overall the intervention was effective in reducing BMI by -0.15 unit with 95%CI [-0.26, -0.03], and P-value=0.01 for test of overall effect.

Effect of interventions on children BMI z-score

Six studies reported enough data to include them in a meta-analysis to assess the effectiveness of peer-led intervention on BMI z-score with the top four studies (in the below Figure 5) contributing to 85% of the weight in the meta-analysis. I^2 statistic (I^2=85%, P<0.00001) showed that there was large heterogeneity in the included studies, thus a random effect model was used for the meta-analysis. We found non-significant effect on BMI z-score with a mean difference was -0.08, 95%CI [-0.19, 0.04] and P=0.19. See more details in Figure 5 below.

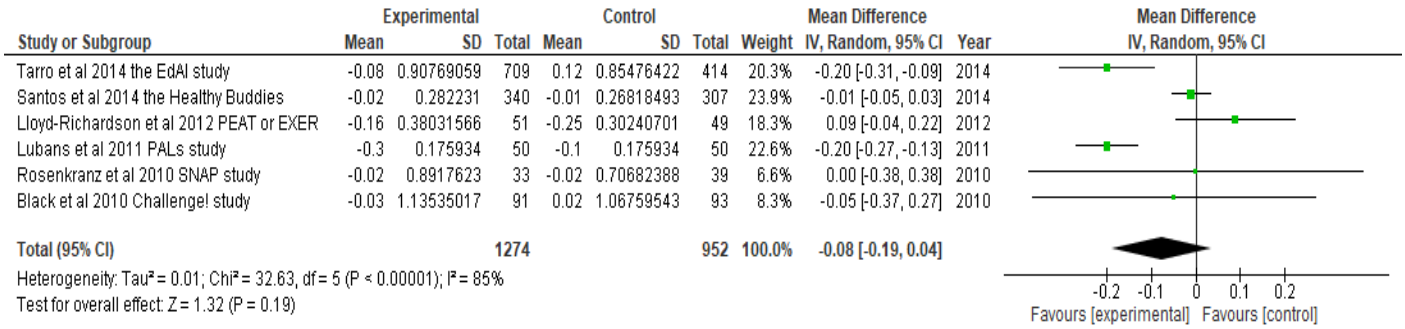

Figure 5. Forest plot of comparison of peer-led intervention versus control by using mean change in BMI z-score from baseline to post intervention.

Effect of interventions on children BMI percentile

Only three studies provided enough data for BMI percentile which involved 1697 participants in the intervention group and 2050 participants in the control group. No heterogeneity was found with I^2=0%, P=0.88, thus a fixed effect model was applied. No significant effect was found for this outcome, with mean difference is equal to -0.89, 95%CI [-2.60, 0.82] and P=0.31.

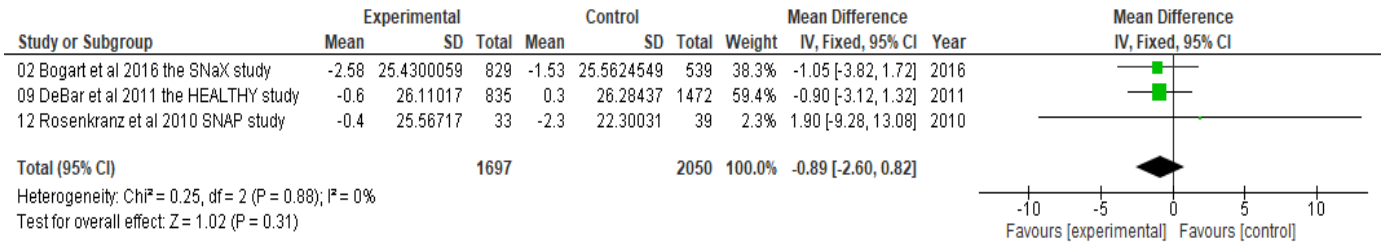

Figure 5. Forest plot of comparison of peer-led intervention versus control in BMI percentile (from baseline to post intervention) using Mean Difference estimation with fixed effect model.

Effect of interventions on child waist circumference

Five studies involved 1376 participants in intervention group and 1039 participants in the control group were found to have enough information for meta-analysis, which was reported in the Figure 6 below. We found no significant difference in waist circumference between the two groups, with mean difference equal to -0.07, 95%CI [-1.35, 1.21], P=0.92

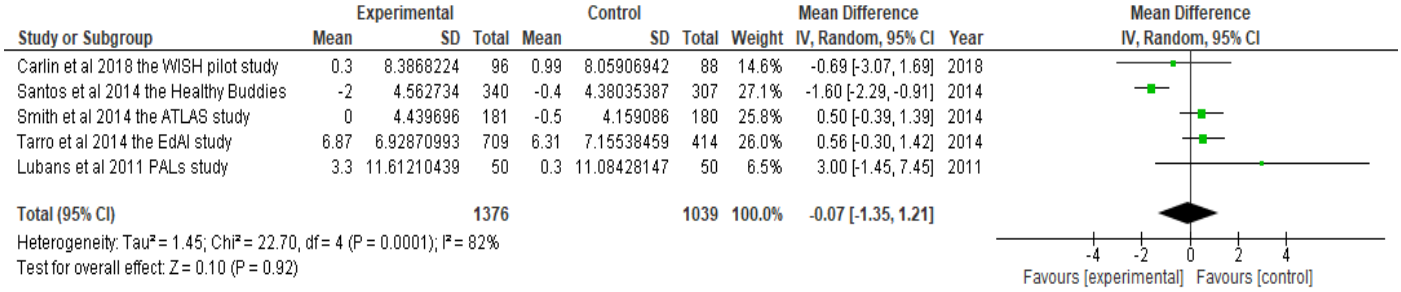

Figure 6. Forest plot of comparison of peer-led intervention versus control in Waist circumference (from baseline to post intervention) using mean difference estimation with random effect model.

Effect of interventions on children body weight

Six studies reported body weight as a direct adiposity outcome including the study of Foster et al conducted over 33 years ago when BMI was not used as commonly as it is today and the study of Kulik et al conducted just 3 years ago (we were unable to contact the authors for the BMI outcomes). The overall effect of the intervention was found almost significant with mean difference between intervention group and control group of -0.70 95%CI [-1.47, 0.07] and P=0.07. Heterogeneity was also revealed as I^2=82%

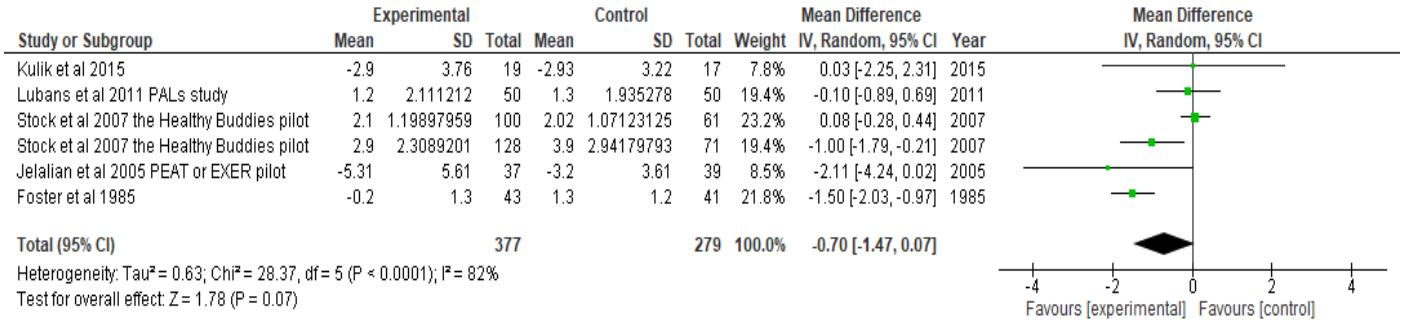

Figure 7. Forest plot of comparison of peer-led intervention versus control in Body weight (from baseline to post intervention) using mean difference estimation with random effect model.

Effect of interventions on children BMI, BMI z-score and BMI percentile (combined effect model)

In total, 13 studies reported either BMI, BMI z-score, or BMI percentile as the adiposity outcome measure. Over 7000 children age less than 18 years were included in this meta-analysis (3541 children in intervention groups).

Visual appraisal of the forest plot suggested that there was little heterogeneity in this meta-analysis and the statistical test confirmed this with the I^2 statistic = 8% (P=0.36). Thus, a fixed effect model was used to estimate the differences in the meta-analysis.

We found a significant difference between those children exposed to the peer-led intervention compared to those exposed to control, with a mean difference between groups of -0.06, 95%CI [-0.10, -0.01], P=0.03 as detailed in the following Figure 8.

For easier assessment of risk of bias of the included studies in this meta-analysis, a summary of risk of bias was added next to the forest plot. Overall all most studies were at low risk of bias especially for items of random sequence generation and blinding of outcome assessment.

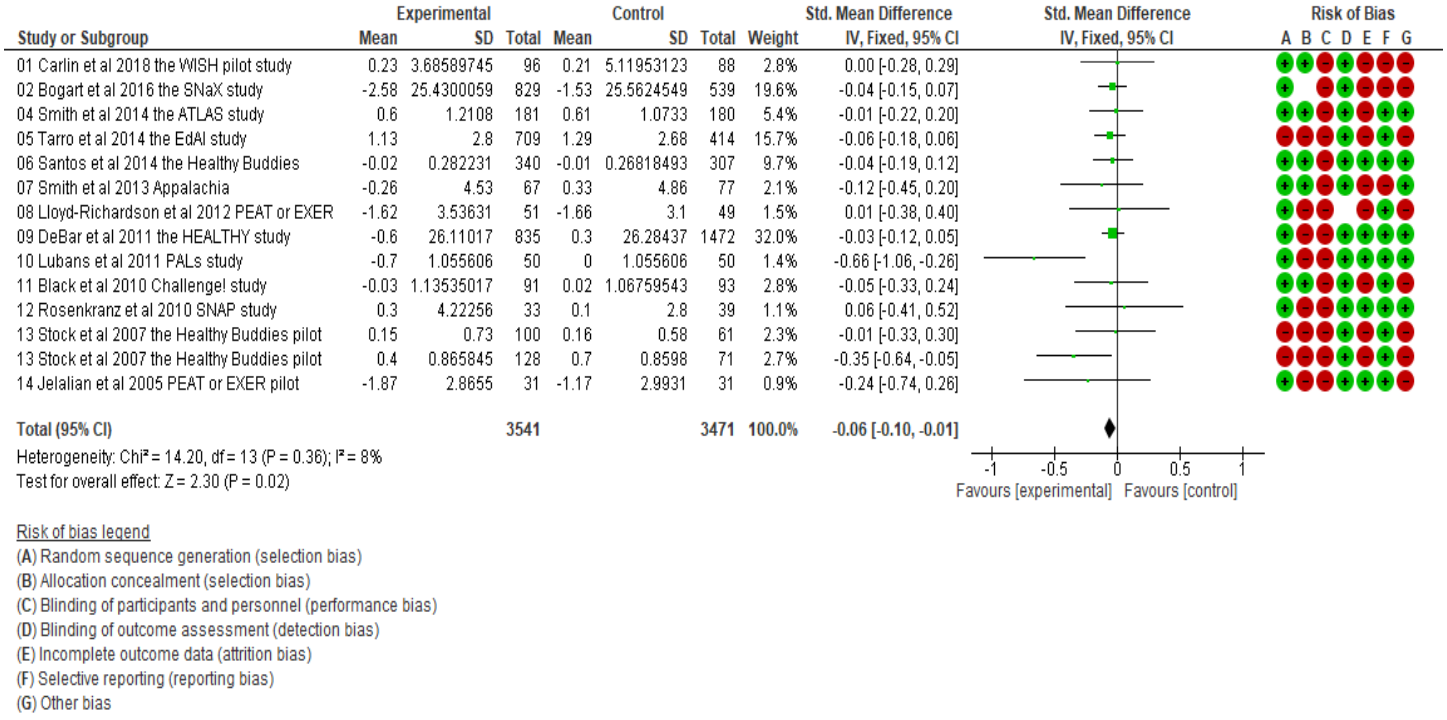

Figure 8. Forest plot of comparison of peer-led intervention versus control in BMI/BMIz-score/BMI percentile by using standardised mean difference with a fixed effect model.

Publishing bias (Reporting bias)

Publishing bias was assessed based on the most common outcome, BMI (in Figure 9), and on the combination of outcomes BMI/BMI z-score/BMI percentile (in Figure 10).

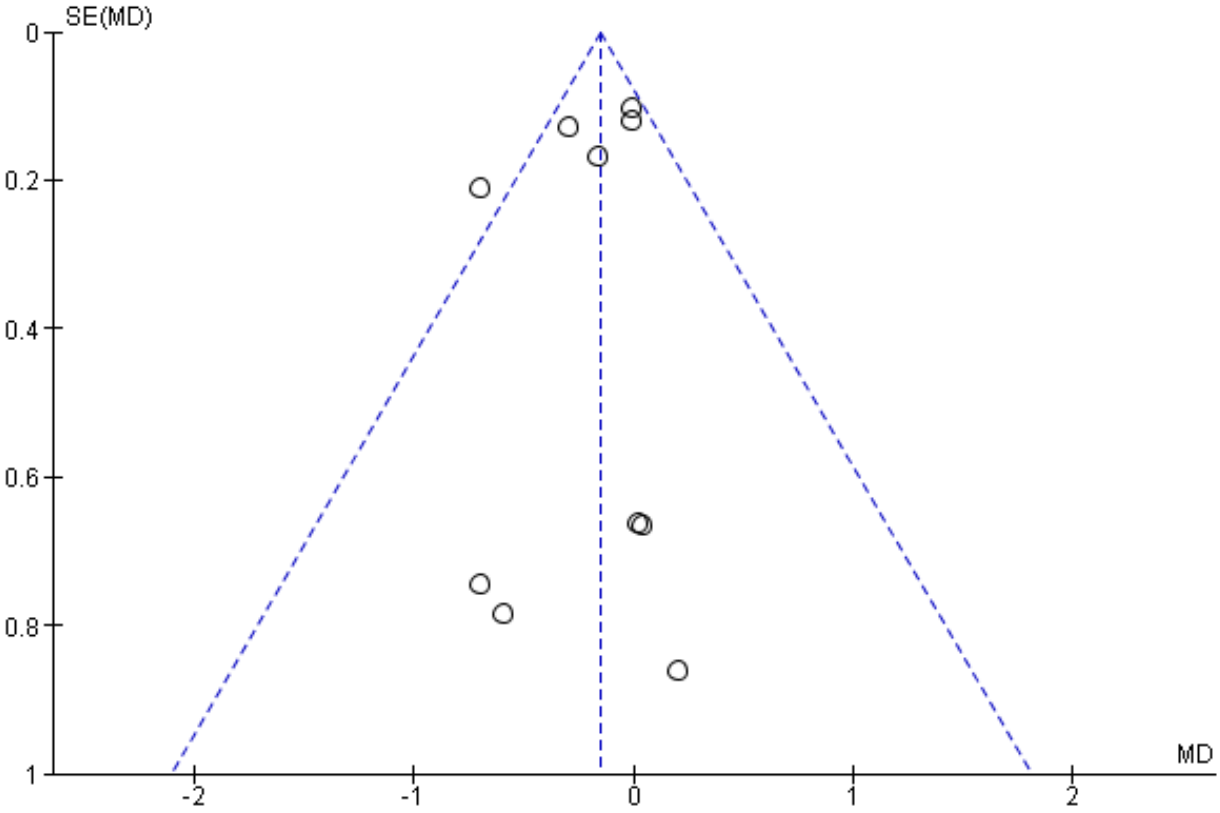

Figure 9. Funnel plot of comparison Peer-led intervention vs Control for BMI outcome (fixed effect) from baseline to post-intervention.

For BMI outcome alone, given the purpose of the intervention studies was to reduce the BMI thus the effect sign would be negative (towards the left side of the funnel plot), thus the above distribution of studies' effect sizes was asymmetric with the empty bottom right corner (where results favoured the control conditions, thus not published), which may signify that there was a likely risk of reporting bias.

Similarly, for the funnel plot comparing the effect sizes of the combined outcomes of BMI-related variables, the funnel plot in Figure 10 revealed that there might be some publishing bias as non-significant studies (favoured an increase in value, in the right side) were not likely to be published.

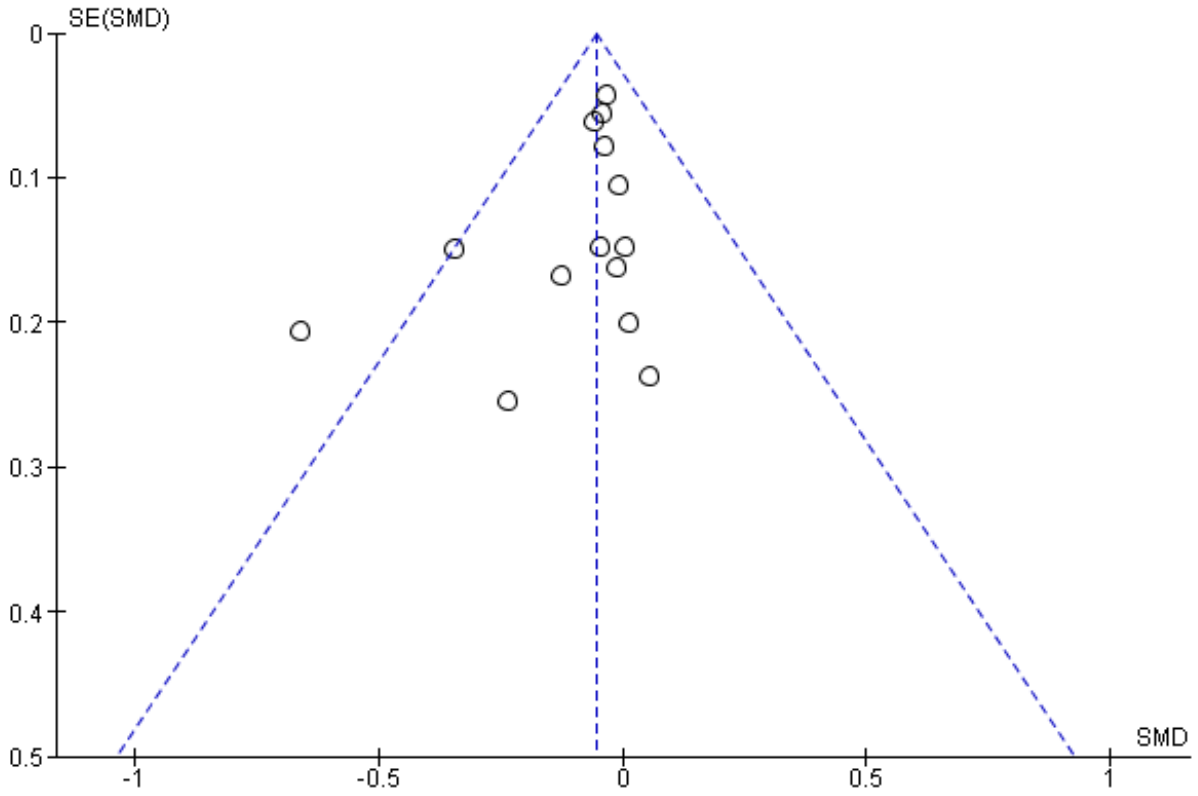

Figure 10. Funnel plot of comparison: Peer-led intervention vs Control for combined outcomes of BMI/BMI z-score/BMI percentile using standardised mean difference (fixed effect) from baseline to post-intervention.

Subgroup analysis

As stated earlier, subgroup analyses were conducted in subgroups of study design (regular RCT vs cluster RCT), participant age (<11 years old and from 11-18 years), duration of interventions (short term <6 months vs long term 6 months or above), and intervention contents (PA or Combination of PA and nutrition). Subgroup analyses were only conducted with the BMI outcome.

Design subgroups: regular RCT vs cluster RCT

Subgroup analysis with design type revealed that the effect of intervention was slightly stronger in the cluster RCTs compared to overall result, with mean difference in the cluster RCTs of -0.19, 95%CI [-0.37, -0.01], p=0.03. (Figure 11)

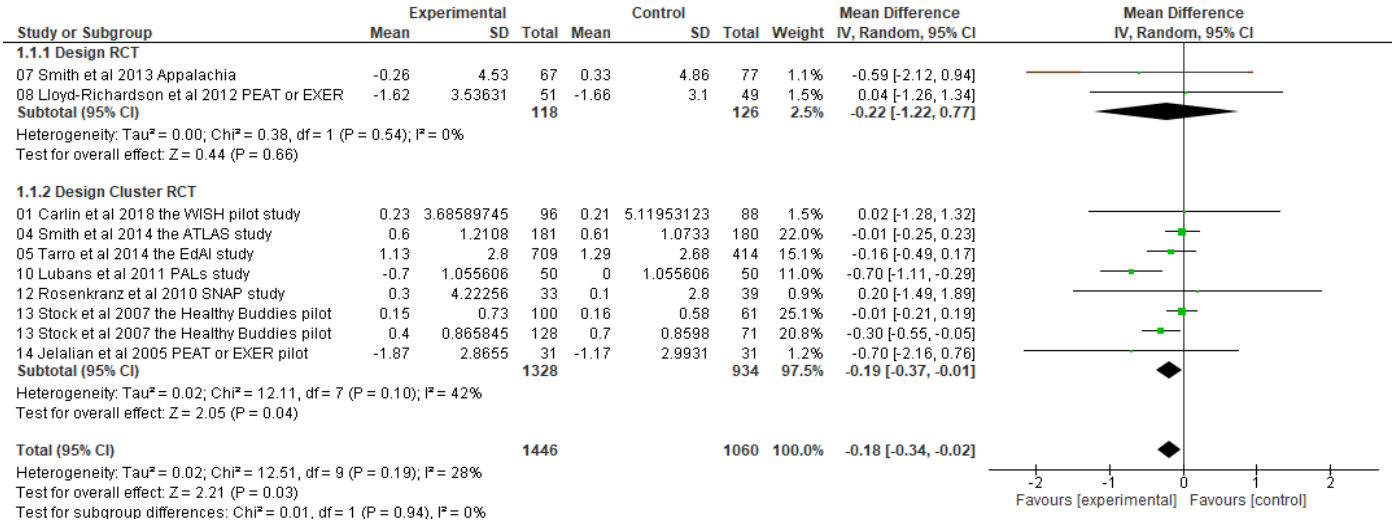

Figure 11. Subgroup analysis with Design types (RCT vs Cluster RCT) for the effect of intervention on the child BMI outcome.

Subgroups of Age of participants: younger age <11 years old vs 11-18 years old

We found a different strength of intervention effects between the age subgroups. The intervention effect was substantially higher in the children of 11-18 years old, although not significant due to the small number of studies with a mean difference of -0.28, 95%CI [-0.72, 0.16], p=0.21 (Figure 12)

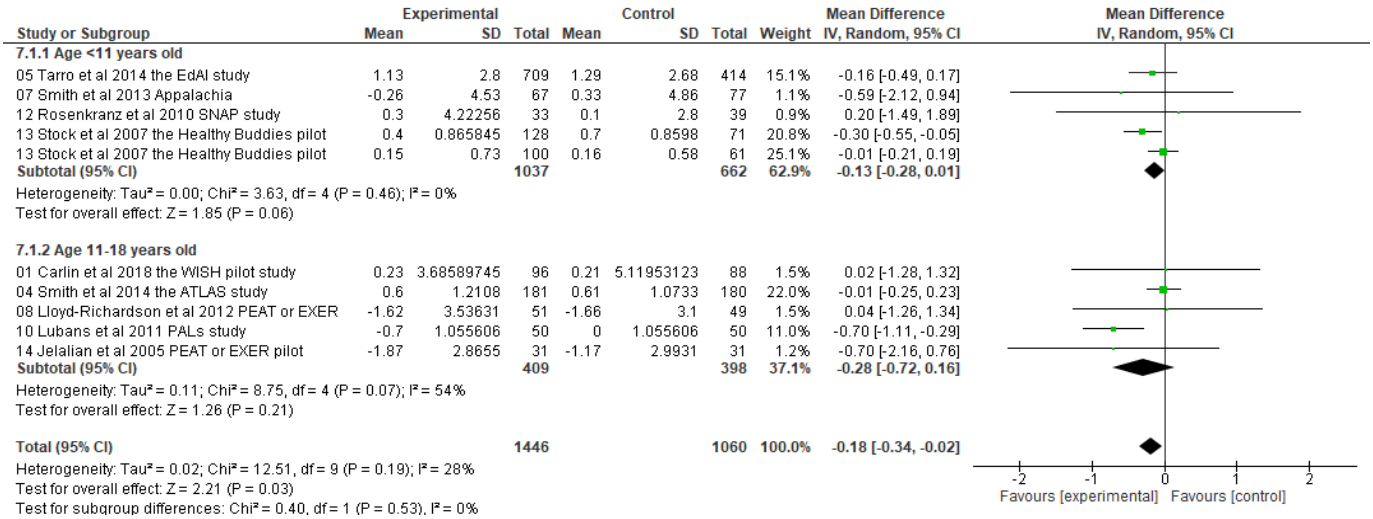

Figure 12. Subgroup analysis for age of participants (<11 years old vs 11-18 years old) for the effect of intervention on the child BMI outcome.

Subgroups of intervention duration: *short term <6 months vs long term 6 months or more*

The intervention effect was also substantially higher in the studies that had 6 or more months of intervention, although the effect was not significant because of the small number of included studies, with a mean difference of -0.37, 95%CI [-0.83, 0.09], p=0.11 (more details in Figure 13).

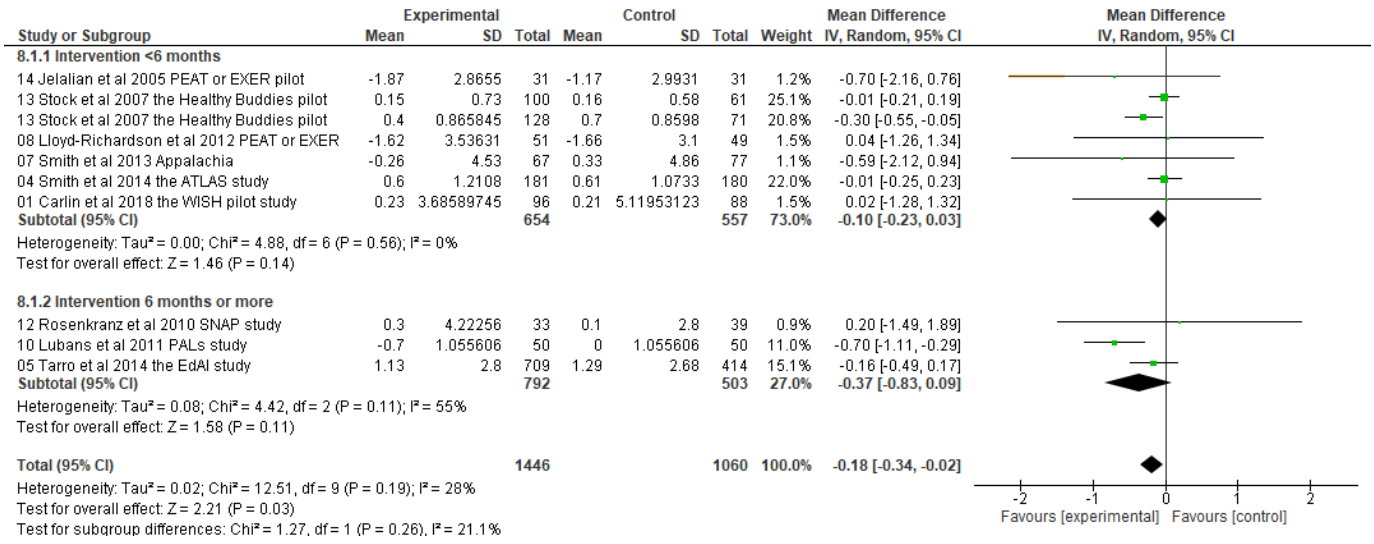

Figure 13. Subgroup analysis for duration of intervention (short term <6 months vs longer term from 6 months or more) for the effect of intervention on the child BMI outcome.

Subgroups of intervention contents: PA only or Combination of PA and nutrition

The effect of intervention was significant and six times stronger in the subgroup of peer-led interventions using the physical activity approach, with mean difference of -0.63, 95%CI [-1.01, -0.25] (p=0.001), compared to the mixed education approach that tackled both physical activity and diet and other aspects of lifestyle, with mean difference =of -0.10, 95%CI [-0.22, 0.02] (p=0.10). For both subgroups heterogeneity was extremely low (I^2 statistics=0%, P=0.58)

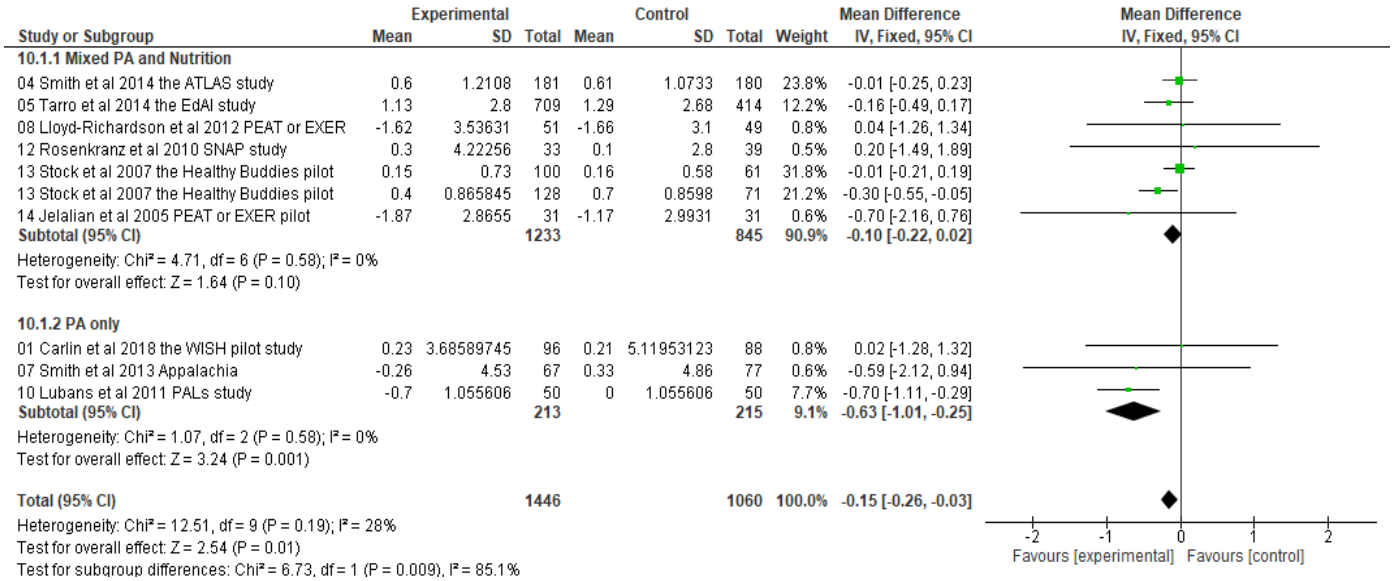

Figure 14. Subgroup analysis for content of interventions (Mixed PA and Nutrition vs PA only) for the effect of intervention on the child BMI outcome.

Sensitivity analyses *(different correlation error values, Corr E=0.35 or Corr E=0.75; using random effect on the child BMI outcome and using random effects on combined BMI related outcomes)*

We found that the sensitivity analyses all matched the main analysis. The mean difference (for BMI) and the standardised mean difference (for combined BMI related outcomes BMI/ BMI z-score/ BMI percentile) were all significant with the mean value for BMI of -0.18 and 95%CI not containing zero and P<0.05 (Figure 14, 15 and 16)

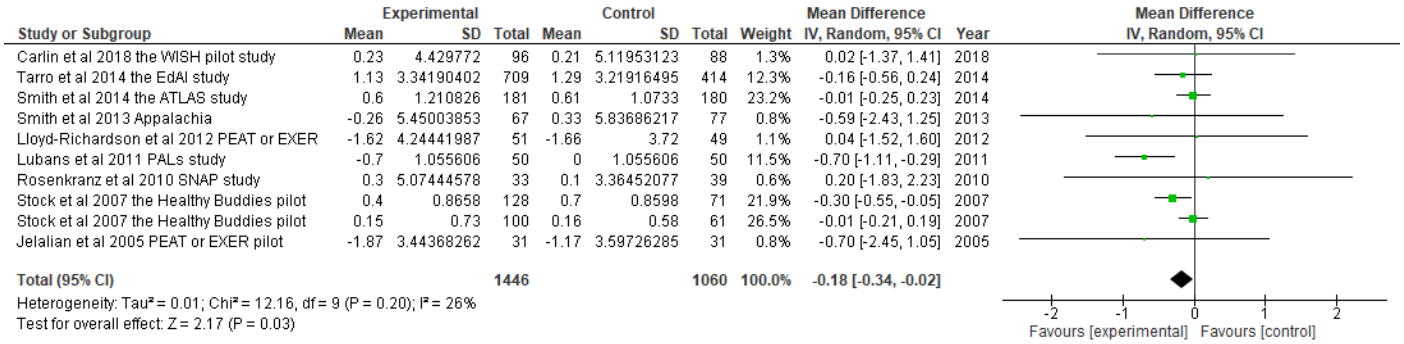

Fig 14. Sensitivity analysis with corr E=0.35 (BMI outcome).

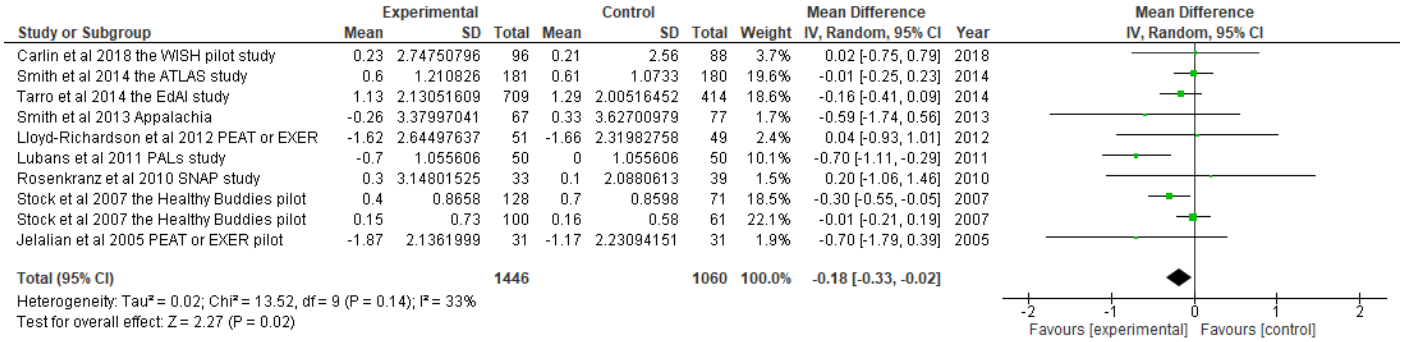

Figure 15. Sensitivity analysis with corr E=0.75 (BMI outcome).

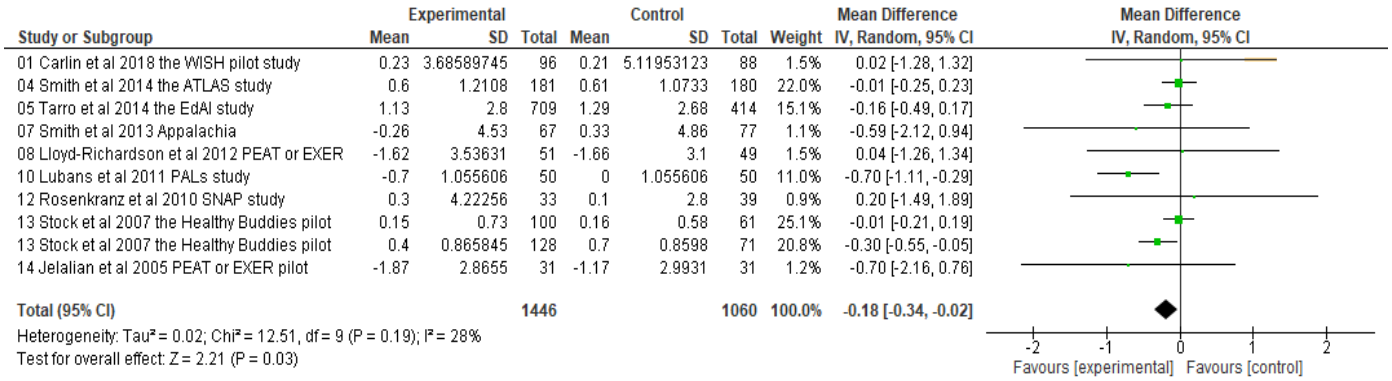

Figure 16. Sensitivity analysis with random effect (BMI outcome).

The standardised mean difference of the BMI related outcomes (BMI/ BMI z-score/ BMI percentile), using a random effect model revealed similar results to the fixed effect model (Figure 17 below vs Figure 8).

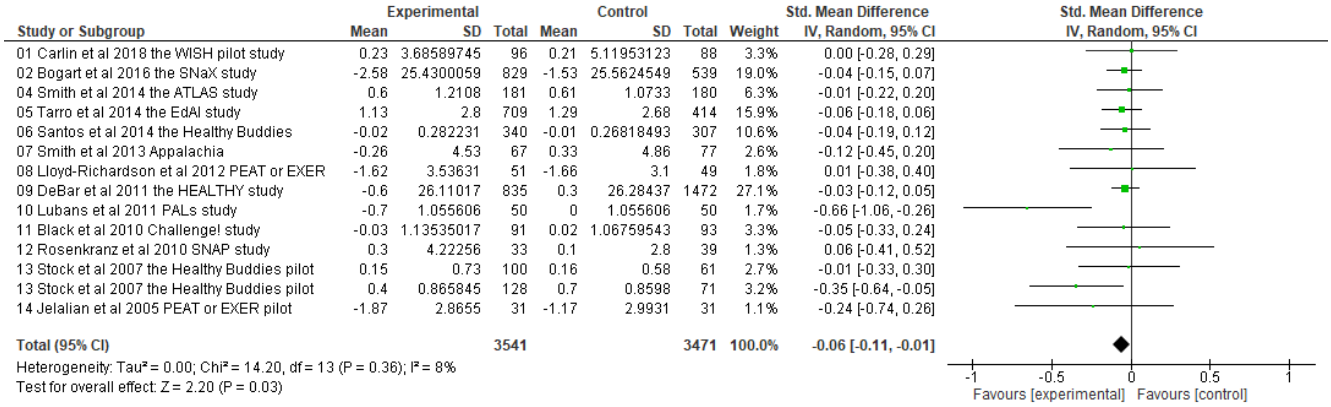

Figure 17. Sensitivity analysis with random effect (for BMI/ BMI z-score/ BMI percentile).

DISCUSSION

Summary of main results

We found a significant effect of peer-led interventions on both child BMI alone and combined BMI/BMI z-score/BMI percentile outcomes. The mean estimate of effect on BMI was a 0.15 kg/m^2 reduction (95%CI [-0.26, -0.03]) which was small but important in the public health context given that most of the peer-led interventions would take place in the community or school settings and usually involve large numbers of participants (detailed number of participants were listed in Annex Table A2). This effect made by the peer-led interventions can become even more significant for the population BMI if it is sustained over a longer time. Furthermore, the low heterogeneity (Figure 4) of the data observed was very encouraging, along with the similarity in subgroup analyses (Figures 11, 12, 13) and meaningful repeatability in the sensitivity analyses (Figures 14, 15, 16). These observations provide us confidence about the effectiveness of the peer-led interventions on child BMI. However, as the funnel plot in Figure 9 suggested, we may need to interpret our finding with caution at least until further studies are reported.

The majority of studies in the meta-analysis were cluster randomised controlled trials (seven out of nine), with six studies conducted in school settings. This was as expected because the peer effect usually occurs in schools where the children spend most of their daytime in many countries. Furthermore, the estimated effect from these cluster RCTs on child BMI was also significant and slightly stronger than the overall effect (-0.19 vs -0.18, please see Figure 11).

About two thirds of the 2506 children who participated in these studies were younger than 11 years although the number of studies which involved younger children was four out of nine (Tarro et al 2014, Smith et al 2013, Rosenkranz et al 2010, and Stock et al 2007). The age sub-group results revealed a distinctive difference of the effects (Figure 12) between younger children and older teenagers with the estimated effect of intervention twice as strong in the latter group. Although the finding was not significant in either group, it may be simply because of the small number of studies involved.

Nevertheless, the stronger effect of the peer-led intervention in teenagers of at least 11 years old was understandable for several reasons. First, the peer interaction and impact are well-known to be strong in these older ages,[30 60] thus any positive influences from peer-leaders may be reflected better in this age group. Second, the peer-led interventions of obesity prevention involving dietary and/or physical activity behaviour changes. These changes require, at least, some maturation in understanding and some control over the daily food intake[61] and habits which is also related to older aged teenagers.[62] Third, the robustness of the studies might have an influence on the findings. Those studies which involved teenagers 11 years or older were either those with better quality (mostly low risk of bias in three main domains mentioned in the Method section), or with smaller numbers of participants, or they were pilot studies where research staff more carefully implemented the interventions to make them successful.[36 58]

The effect of the intervention seems to be much stronger for the studies with long-term interventions (six months and more) compared to short-term interventions (Figure 13). This result, although not significant, can be expected from several causes. First, on the aspect of behaviour change, the longer exposure to new (and assumingly better) behaviours usually resulted in lasting changes[63], which in turn, will make stronger and more sustainable reductions in obesity and BMI. Second, longer exposure often results in higher dosage of the intervention[64]. Perhaps the most meaningful explanation is the similarities of the results from longer duration interventions from other systematic reviews in both children[23] and adults.[65]

The most interesting interpretation of the effectiveness of the peer-led intervention can be drawn from subgroup analysis for different intervention approaches used. Our significant finding suggests that peer-led intervention should focus on physical activity rather than a mixed set of interventions that are more difficult and often costly to cover all elements. However, readers should be aware that although highly significant, this result was inferred from limited evidence. More evidence available in the future may change the effect size. Nevertheless, promoting physical activity alone appeared to be a very effective approach in earlier meta-analyses.[20 66]

Finally, our findings on the BMI outcome have been analogously verified through wide estimation (different correlation errors) and conservative estimate method with a wider range of CI (random effect). With the current evidence, we conclude that peer-led interventions are effective in reducing

BMI, with an average value of -0.15 unit (95%CI [-0.26, -0.03]), relative to the change in the control group. The result corresponds well with earlier findings of recently published major systematic reviews of interventions for preventing obesity in children[23]. Furthermore, in an attempt to interpret the findings, we have estimated the results to average Australian children of similar ages to find how much the effect size could impact child BMI. For a child with a BMI of 18.5kg/m^2, an effect size of -0.15 kg/m^2 would be equal to a 0.81% reduction of the average BMI.

Overall completeness and applicability of evidence

We understand that our findings, in general, provide sufficient evidence to support peer-led interventions in children to prevent and reduce obesity. However, from an implementation perspective, it is hard to suggest a guaranteed model of approach due to the lack of evidence of target age, duration of intervention, settings, and the best model for the peer-leaders. With the current evidence, we can only suggest that interventions are likely to be more effective among the teenagers, and that more studies with peer-led methods are needed to verify the effect in the younger age group. Also, we suggest that interventions should be implemented for a longer duration to maximise the exposure effect. Another point is that schools can be an ideal place for peer-led interventions, but we suggest that the investigators try to replicate peer-led interventions in other settings, such as the community or home.

A consensus on the prototype of the ideal peer-leader and the role model is definitely needed. There are still a lot of questions to be answered. They include: To what extent the peer-leaders should lead? The best ratio between peer-leaders and child participants? The frequency of the contact between children and their peer-leaders? One additional key point, which is still missing in the literature, is the cost of peer-led interventions. We are lacking empirical and carefully conducted economic evaluations of this type of trial. From the characteristics of the included studies, we feel that economic evaluations should be conducted for the cost of both participants and peer-leaders including financial costs as well as time, effort, and other costs that are not immediately apparent.

We are reluctant to suggest an immediate widespread implementation of peer-led approach for several reasons. All of the included studies were from high-income countries, although a few came from poorer communities. There are significant differences between communities in high and low- and middle-income countries. The differences include the availability and access to supporting resources for children, and wider social issues such as safety, food security, and traditional norms. Rather we can only suggest that new and less experienced researchers from low and middle-income countries should work closely with those who have already conducted these trials in high income countries, or consult a broad range of professionals to ensure the feasibility and successfulness of the intervention when they plan for replicating these interventions in their own settings.

Quality of the evidence

In this systematic review, we used a stricter and more conservative approach to evaluate the quality of the study design and data. For example, the blinding of participants and personnel was judged in the way that if either participants or personnel were not blinded, then this domain be ranked “high risk”. A similar approach was applied for the other bias domain, with just one issue marked as “high risk”, the whole domain was marked “high risk”. We complied with the suggestion of the Cochrane Boards of Experts that “the risks in the interventions may never be fully known” and thus a conservative evaluation is necessary.

However, that does not mean we did not appreciate the values of the studies. All of the included studies were used in this meta-analysis, although separately in different models. None of the studies were ranked at “high risk” for all the domains. Rather they scored “low risk” for at least several categories. This suggests that all authors have tried to ensure the quality of their research. Specifically, we judged the risk of blinding of participants and personnel as of less importance as this domain is far more an issue for clinical and laboratory settings than for public health interventions. We judged (with evidence) the domain of outcome measurement as low risk as BMI and other metrics can be objectively obtained. Overall, the quality of the studies was acceptable and definitely suitable for meta-analysis.

The main problem that we remind and warn the readers is the quality of the cluster randomised controlled trial design included in this review. Half of them scored high risk in the two most important domain including the loss of clusters and incorrect analysis (Table Annex 4). This breach of quality endured seriously with one study that we are still trying to assess with the authors. Yet, in general, we only remind the audience to carefully apply this current evidence from the cluster RCTs. Another limitation of this systematic review is that we used measured anthropometry to quantify treatment effects and thus we have missed those studies using categorization of overweight/obesity. However, given BMI is still a fairly easy measurement and widely accepted as a standard in obesity research, we believed this limitation was minimal.

Potential biases in the review process

We acknowledged that reporting bias may likely exist as the funnel plots suggested (Figures 9 and 10). After all, reporting bias is beyond our capacity to fix but rather a research community effort to accept both significant and non-significant results. Another potential bias in this review is that we only included the studies that were published in English and thus we might have missed some studies.

Agreements and disagreements with other studies or reviews

This systematic review and meta-analysis revealed similar results with several major systematic reviews in the same scope of obesity prevention targeting children, using peer-led intervention to tackle health issues.

What is new?

We believe that with the currently available data we have answered the question of effectiveness of peer-led intervention on child BMI and recommended the use of peer-led interventions to prevent obesity in children, although after tailoring the design for low- and middle-income settings. We revealed useful information which favoured the application of peer-led interventions in the teenagers, at school settings with cluster RCT design, for longer durations of intervention and focusing on physical activity.

AUTHORS' CONCLUSION

Implication for practice

This review provides key information for implementation of peer-led interventions. From our perspective, the peer-led approach is feasible and suitable for children especially when they start to be more influenced by their friends rather than parents and teachers. Although the current evidence is still limited and only available from high income countries, there is no reason not to try to replicate these successful trials in other less affluent countries. In general, peer-led interventions have several advantages that should not be limited by the economic status of the participants. However, we are still in need of further innovative method sto explore the effectiveness of this type of intervention in different settings (outside of schools) and economic evaluations to assess the cost for both peer-leaders and children. Also, in practice implementers should be careful when exploiting this method as side effects are not clearly known. Children who became peer-leaders (although voluntarily) usually have a larger burden of responsibility/work which may not be easy for their age.

Implication for research

For research purposes, we think this review is beneficial in providing supporting information in highlighting the conditions where the largest effect sizes might be found (subgroups). Although the findings of effect sizes on BMI and combined BMI related outcomes were quite analogous and the heterogeneity was low in both cases, we still need more robust, high quality research on these interventions, not only to test the effectiveness of intervention but also to find out the best style of

peer-leading, the needed resources, the most effective content and the suitable settings and conditions for scaling up the intervention in the population.

For researchers who have an interest in conducting this type of intervention, it is necessary to emphasize that the trial design is prone to be compromised by non-random allocation and investigators need and should randomize the intervention being tested wherever they can. In case the randomisation and allocation concealment is not possible, other quality assurances (blinded outcome assessment and analysis) need to be prioritized to minimise bias. In future, we suggest larger, longer term interventions with enough power to detect small changes in normal child populations to cover the gaps in scaling up this type of intervention for the population.

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Contributions of authors

NMN and MJD drafted the idea and design of the systematic review. NMN and AA developed the search terms and searching schemes. NMN and MJD conducted the search. NMN, AA, and HKT contributed to the screening of manuscripts. NMN and AA extracted the data from included studies. NMN conducted the meta-analysis and MJD verified this process. NMN drafted the manuscript, and AA and MJD revised the manuscript.

Declaration of interest

Authors indicated no conflict of interest in conducting this systematic review and meta-analysis.

ANNEX

Table A1. Search scheme and terms used

1. child/

2. exp childhood/

3. adolescent/

4. adolescence.mp. or exp adolescence/

5. exp society/ or teen.mp.

6. teenage.mp. or exp adolescence/

7. adolescent/

8. boy.mp. or exp boy/

9. girl.mp. or exp girl/

10. kid.mp. or exp "kid (goat)"/

11. exp middle school student/ or exp elementary student/ or exp student/ or exp high school student/

12. exp peer group/ or exp peer counseling/ or exp peer pressure/ or peer.mp.

13. exp peer group/ or exp student/ or peer-led.mp. or exp health education/

14. peer support.mp. or exp peer group/

15. class.mp. or social class/

16. exp human relation/ or exp social behavior/ or classmate.mp. or exp health education/ or social support/

17. friend.mp. or exp friend/

18. exp social support/ or lay support.mp.

19. exp peer group/ or youth led.mp.

20. overweight.mp. or exp obesity/

21. exp obesity/ or obesity.mp.

22. exp weight control/ or exp body weight management/ or exp body weight/ or exp weight/ or exp body weight maintenance/ or exp weight gain/ or exp weight reduction/ or weight.mp.

23. Body mass index.mp. or exp body mass/

24. exp body mass/ or bmi.mp. or exp body weight/

25. exp controlled clinical trial/ or randomized trial.mp.

26. randomized.mp. or exp controlled clinical trial/ or exp "randomized controlled trial (topic)"/

27. 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19

28. 20 or 21 or 22 or 23 or 24

29. 25 or 26

30. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11

31. 27 and 28 and 29 and 30

32. remove duplicates from 31

Table A2. Summary of Characteristics of included studies

Authors, Year, Country	Setting; Retention	Duration, Follow-up	Study design	Peer-leaders			Participants*			Intervention description	Control description	Outcome scopes
				Nº, Sex	Age	Peer leader /Children ratio (P/C ratio)	Nº, Sex	Age	Intervention /Control (I:C ratio)			
Carlin et al, 2018, Northern Ireland, UK. "The WISH pilot study"	Post-primary schools; 199 → 187	12-week intervention; Baseline, Follow-up: at 6 months	School-based clustered RCT*	n/a	15-17	P/C ratio: n/a	199, F	11-13	I:C ratio= 101:98	Structured 10 to 15-minute brisk walks (led by walk leaders) across the school before the first bell, at mid morning break and at lunch time. Participants were initially instructed to attend at least three walking sessions per week (of 10-15 min in duration) and to increase the number of sessions that they attended to at least five walking sessions/week by week 12.	Continue with their normal PA habits. Schools were provided with study resources to implement their own walking program.	Primary: school-time PA (Actigraph GT3 accelerometer). Secondary: BMI, Waist circumference
Bogart et al, 2016, Los Angeles, USA "the SNaX study"	Middle high schools; 2439 → 1368	5-week education; Baseline, Follow-up: at 2 years.	Clustered randomized, wait-list control	454, F+M	12-13	P/C ratio: 454/2439	1368, M+F	12-13	I:C ratio= 829:539, 5 schools in each arm.	Intervention period = 5 weeks 1/ Environmental changes: greater variety of food and free chilled filtered water at lunch. SNaX posters promoting PA, cafeteria food, and healthy eating; and nutritional postings about cafeteria food. 2/ Seventh-grade Peer Leader (PL) club (goal: to increase student advocacy): PL were taught skills for approaching other students during lunchtime activities, as well as family members at home, to promote SNaX messages with a motivational interviewing style. Each PL also recruited another student (a partner) to assist with lunchtime activities... 3/ The social marketing aspect also included taste tests of cafeteria foods, delivered by PL, and a short film shown to entire 7th grade classes that encouraged PA and healthy eating.	Delayed SNaX program until the intervention ends (2-3 years later). Usual curriculum at control.	BMI percentiles, Weight

										4/ All 7th graders were given take-home activities to do with their parents during each week of the program.		
Kulik et al, 2015, USA	University research setting; 41 → 38	16 weeks intervention; Baseline, 4 weeks. at 16 weeks. No follow up	Randomized controlled trial	n/a	n/a	P/C ratio: not clear (?/41)	41, Girls	13-17	I:C ratio= 23:18	16 weeks with 08 sessions: The Enhanced group used smaller group activities to learn and practice core peer support skills. Peer support was continued online in-between sessions using Facebook. Participants were asked to: 1) chat for 10-15 min with either the group leader or a peer in the program, and 2) check-in with three peers in the program using a structured contact card to guide online discussions.	The Standard group participated in a whole group activity that reinforced the content	Weight, BMI, Percent overweight

Smith et al, 2014, NSW, Australia "the ATLAS study" (feasibility study)	School-based; 361 → 293 (81.2%)	20 weeks intervention; Baseline, 6 months. Follow-up at 9 months, and 18 months.	Cluster randomized controlled trial	n/a	n/a	P/C ratio: not clear (361/?)	361; Boys	12.7± 0.5	I:C ratio Baseline= 181:180; I:C ratio= At 8 months 154:139; 7 schools each arm	Multiple components (20 weeks): 1/ Teacher professional development (02 x 6h workshops) 2/ 20 x Enhanced school sport 90-min sessions 3/ 06 x Lunch-time 20 min physical activity sessions: Students partnered with a younger peer and provided corrective feedback during a Gymstick and bodyweight resistance exercises. 4/ 03 x Interactive researcher-led seminars. 5/ Smartphone app + website (15 weeks) to support program 6/ Provision of equipment to schools 7/ Pedometers (for 17 weeks) 8/ Parental strategies to reduce screen-time (04 newsletters).	The control group participated in usual practice (ie, regular school sports and physical education) but will receive an equipment pack (~1,000 AUD) and a condensed version of the program after 18-months (equipment pack provided based on individual school requirements)	BMI, Waist circumference
Tarro et al, 2014, Spain The EdAl study	Primary School-based; 2350 → 1939 (82.5%)	Three school-years intervention (28 months); Baseline, 12 months, Follow-up at 28 months.	Randomized	60 HPAs,	not reported	P/C ratio: 60/1550	2350, boys + girls	7-8 (end 10-11)	I:C ratio= 1550:800; (24 schools: 14 schools)	Undergrad students as Health Promoting Agents (HPA) at intervening schools, implemented 04 activities (1h each) per school per academic year over 3 years 1/ *Classroom practice* by the HPA to highlight 8 healthy lifestyle habits, (educational intervention activities); 2/ *Teaching practice* by the HPA using specially-designed booklets which focused on the same lifestyle topics 3/ Parental activities to be included with that of their children.	Regular program at schools	Prevalence of obesity (IOTF definition); Changes in BMI z-score and waist circumference

Santos et al, 2014, Manitoba Canada. The Healthy Buddies	Primary school-based; 687 → 647	One school-year intervention (10 months); Baseline, at 10months No follow up	Clustered randomised controlled trial	182	10-12 (grade 4-6)	P/C ratio: 182/158	647, boys + girls	6-8 (grade 1-3)	I:C ratio= 340:347; 10 schools in intervened arm	Healthy Buddies plan (10months): 1/ A 2-day training seminar (for teachers) at the start of the year. 21 lessons were provided to teachers to be delivered during the school year to older students. 2/ In the school-year, an older class was paired with a younger class. Each week, the older students, Peer Mentors (PM), got a 45-min healthy living lesson from their teacher. 3/ Later that week, the PM taught two 30-min "Go Move!" lessons (structured aerobic fitness) to their younger "buddies" (encouraged to perform at a vigorous intensity). PM also delivered the "Go Fuel!" component which included lessons about distinguishing nutritious from unhealthy foods and beverages. In the "Go Feel Good!" component, students were taught to value themselves and classmates based on individual traits.	Regular program at schools	BMI z-score Waist circumference
Smith et al, 2013, Appalachia, USA	School-based; 160 →	8-week intervention; Baseline, At 8 weeks, no follow-up	Randomized controlled study	32 teen mentors	16-17	P/C ratio: 1/1 ratio (mixed groups)	160, Boys + girls	9.24 ±0.68	I:C ratio= 72:88 (3 schools in total with 160 children)	*Just for Kids!* Curriculum via teen mentors (TM). TM–led groups met immediately after school for 60 min (in separate areas from the teacher-led groups). Each session consisted of 45 min of structured activities and 15 min of non-competitive physical activities. Each school hosted the program on a different day of the week. TM and their assigned mentees met in the gymnasium. Mentoring maintained 1:1 ratio. Mentoring dyads were distanced from other dyads as much as possible and outside distractions were controlled via limited access to the room during the sessions. *"Just for Kids!"* also provided children with homework, worksheets, themed stories and take-home activities.	*Just for Kids!* Curriculum via an adult classroom teacher.	BMI

Lloyd-Richardson et al, 2012, USA PEAT or EXER	Hospital-based; 118 → 89 (74.8%)	16-week intervention; Baseline, At 16 weeks, Follow-up: at 12 months, and at 24 months	Randomized controlled trial	n/a	n/a	P/C ratio: n/a	118 obese boys+ girls	13-16 (14.33 ±1.02)	I:C ratio=62: 56	Groups met twice a week for 16 weeks, once for BWC intervention content and once for on-site physical activity (PEAT). 1/ Weekly BWC intervention consisted of nutrition intervention (balanced-deficit diet of 1400-1600 calories), physical activity PA prescription, and topics on behavior modification (conducted by doctoral-level psychologists). The PA prescription included gradual increase to a minimum of 30 min/day of aerobic activity for 5 days/ week. Each adolescent participated in the BWC intervention with a parent, attending concurrent but separate group meetings. Parent group sessions focused on similar content, plus guidance regarding family-level support & implementation of behavioural changes. 2/ Weekly peer-based physical activity (PEAT) based on the principles of Outward Bound and designed to increase teamwork, social skills, and self-efficacy. Sessions were structured sequentially to target increasingly challenging activities.	BWC + aerobic exercise (EXER): Adolescents participated in weekly supervised aerobic exercise sessions. These activity sessions were supervised by either an exercise physiologist or physical therapist.	BMI, BMI z-score
DeBar et al, 2011, USA The HEALTHY intervention	School-based; 4603 students (secondary analysis)	5 semesters of middle schools; Baseline, Follow-up at 3 years	Clustered (school) randomized controlled trial	318, Boys + girls	11-12 (n/a)	P/C ratio: 318/2307	4603, Boys + girls	11-12	I:C ratio= 2307:2296 (21 schools in each arm)	The HEALTHY intervention (3 years) comprised 4 components: nutrition, physical education, behavior; and communications. These 4 components were integrated by a series of themes targeting specific behaviors and built on each other. 1/ Public Commitment Activities: Student Peer Communicators (SPC) endorsed and promoted study activities to their peers and provided informal feedback to HEALTHY study staff. Participation was voluntary. All SPCs attended a one-hour initial training by study staff, followed in subsequent weeks by supplemental 30-min trainings specific to weekly activity.	Regular curriculum at schools	BMI z-score, Waist circumference, Prevalence of obesity.

										Public Commitment schools included only 835 students, while Non-Public Commitment schools 1472 students. 2/ Student-Generated Media One year into the intervention, approach changed to the creation of "Student-Generated Media" as the core of the communications approach. Study-wide posters and DVD templates consistent with each semester's intervention theme were provided to the local study sites' staff, which then conducted school-specific photo shoots and allowed students to provide photographs, artwork, audio clips, and video clips for use in the communication campaign. Media materials distributed throughout the latter stages of the intervention depicted students' own experiences and highlighted their public commitment to the study and its healthy goals.		
Lubans et al, 2011, Hunter region NSW, Australia "PALs study"	School-based (secondary); 100 →65	2 school terms or 6 months (from June to Dec 2009) Baseline, at 6 months. No follow-up	Clustered (school) randomized controlled trial	50, Boys	14-15	P/C ratio: not clear (50/?)	100, Boys only	14.3 ±0.6	I:C ratio= 50:50; (Two schools in each arm)	The PALs program was a multi-component intervention and included 1) 10 x 90min school sport sessions, 2) 3 x 30min interactive seminars, 3) 8 x 30min lunch-time activities, 4) physical activity and nutrition handbooks (9 weeks), 5) 6 x 30min leadership sessions, 6) pedometers (for 6 months total). The intervention was focused on the promotion of lifestyle and lifetime activities. In the Lunch-time sessions students participated in self-directed elastic tubing resistance training. Sessions were supervised by teachers but were organized and run by students. In the Leadership sessions, Physical Activity Leaders or PALs (trained previously by study staff) were required to recruit and instruct grade 7 students on how to safely use the elastic tubing resistance training devices,	Regular curriculum at schools in Australia with extra-curricular/ co-curricular school sport programs often delivered off campus (may involve weekly fees).	BMI, BMI z-score, Waist circumference (Evaluation of Peer leaders only)

										using strategies of being a model or demonstrating the behaviors, prompting identification as a role model, giving general encouragement and graded tasks.		
Black et al, 2010, USA, Challenge! study Sensitivity analysis	Mixed (medical centre, home-based, community based)	One academic year or 11 months. Baseline, at 11 months. Follow-up at 24 months.	Randomized controlled trial	No report	No report	P/C ratio: no report	235, M+F	13.3 (sd=1)	I:C ratio= 121:114	12-session intervention, "Challenge!", using principles of mentorship (role modelling and support), participatory learning and goal setting. Sessions delivered at adolescent's home by mentors and mentors accompanied them on field trips to community sites. Each session included a challenge and each adolescent set a personal goal related to diet or PA. The mentors (trained 40 hours in motivational interviewing). helped the participants plan to meet the challenge and formulate a realistic goal. During subsequent sessions, adolescents discussed their progress with meeting challenges and goals, analysing successes and failures, and identifying strategies to overcome barriers. Taste tests, recipes for healthy snacks, and recommendations for PA were included (with mentors).	Usual routines. Not described clearly.	BMI z-score, % overweight

Rosenkranz et al, 2010, USA. SNAP study	Mixed community-based (Girl Scout organization, troop leaders' home, community center)	06 months program. Baseline, 6 months. No follow-up	Clustered (Troops) randomized controlled trial in a nested cohort	76, girls only	Grade 4-5	P/C ratio: 7/76	7, Girls only	4^{th}-5^{th} grade	I:C ratio = 34:42 (3 troops: 4 troops)	The intervention consisted of: 1) an interactive educational curriculum delivered by Troop Leaders (TL); 2) troop meeting policies implemented by TL; 3) Badge assignments at home by Girl Scouts with parental assistance. The educational curriculum consisted of 8 modules (60-90mins), delivered over 04 months. The modules were designed with flex bility allowed for specified program activities and module order. TL underwent 02 hours of training by the first author prior to intervention commencement. Regular and ongoing email and phone support took place throughout the program.	Standard care (routine habits)	BMI, BMI z-score
Stock et al, 2007, Canada "the Healthy Buddies program" pilot	Elementary schools	21-week program Baseline, 1 year	School randomized; pilot study	199, M+F	Grade 4^{th} to 7^{th}	P/C ratio: 1/1	161, M+F	Kinder garten to 3^{rd} grade	I:C ratio= 228:132 (One school in each arm)	The program's content is based on 3 main components of healthy living: being physically active, eating healthy foods, and having a healthy body image. ("Go Move!", "Go Fuel!" and "Go Feel Good!"). At the beginning of the school year, students in 4^{th} - 7^{th} grade were paired with kindergarten - 3^{rd} grade buddies. Each week, older students received a 45-min healthy-living lesson through direct instruction from the intervention teacher. Older students then acted as peer educators, teaching 30min lessons to younger buddies. 1/ Regular Physical Activity: "Go Move!". The buddy pairs spent 2 sessions per week doing 30-min structured aerobic fitness sessions. 2/ Healthy Eating: "Go Fuel!". Students learned about nutritious and non-nutritious foods and beverages and were exposed to numerous examples 3/ Healthy Body Image, Self-esteem, and Social Responsibility: "Go Feel Good!". Students learned about valuing themselves	Regular program at elementary schools in Canada	BMI, Weight

										and others based on the inside not the outlooks.		
Jelalian et al, 2005, Rhode Island, USA. PEAT or EXER	Hospital-based	16-week program. Baseline, 4 months, 10 months.	Randomized control trial	76, M+F Obese BMI = 32.48 ±3.07	14.51 yo	Peer/child ratio:	76, M+F	14.51 yo	I:C ratio= 37:39	CBT+PEAT 1/ Cognitive behavioural therapy (CBT): included 16 weekly sessions, with parents and adolescents attending separate concurrent meetings, followed by 4 monthly maintenance sessions. Adolescents were prescribed a balanced 1400–1600 calories deficit diet and asked to gradually increase physical activity to a minimum of 30 min daily for 5 days a week. CBT weight loss intervention was standard across both group conditions and was modelled on child & adult weight control programs. 2/ Peer-enhanced adventure therapy (PEAT): consisted of an initial 'warm-up' activity that included physical activity, followed by the primary challenge for the group, processing of the activity, and establishing weekly personal goals. Group activities consisted of both	CBT+EXER 1/ CBT: same as in CBT+PEAT group. 2/ EXER: Aerobic activities (treadmills, stationary bicycles, and brisk wa king within the hospital setting). Each session included a 10-min warm-up, 30-min of physical activity, and a 20-min wrap-up ('cool down' and review of weekly physical activity goals)	Weight, BMI

										physical and mental challenges that were aimed at development of social skills, problem-solving abilities, and self-confidence.		
Foster et al, 1985, USA	Elementary school; 90%	12-week intervention, Baseline, At 12 weeks, at 18 weeks.	RCT Pilot	89, M + F Obese	8th grade	Peer/child ratio: 1: 3 to 1:4	16, M + F	Grade 2-5	I:C ratio= 1:1	Counselling and social support by Peer Counsellors (PC). PC received 15min/week instruction of behavioural techniques and 15min/week exercise-class by one of the authors. 1/ three-time weekly meetings with lunchbox-check for “green”, “yellow” and “red” food. Rewards with stickers and verbal praise. 2/ children were weighted weekly, rewarded for weight losses of ½ lb (0.23kg)	No program conducted. Three weigh-ins for 3 follow-ups	Weight (kg), %Overweight

Table A3. Summary of risk of bias of included studies (general biases for internal validity)

Studies	Selection bias		Performance bias	Detection bias	Attrition bias	Reporting bias	Other bias	Overall risk of bias
	Random sequence generation	Allocation concealment	Blinding of participants & personnel	Blinding of outcome assessment	Incomplete outcome data	Selective reporting	Other sources of bias	
Carlin et al, 2018, the WISH pilot	Low risk	Low risk	High risk	Low risk	Low risk	High risk	High risk	Low risk
Bogart et al, 2016, the SNaX study	Low risk	Unclear	High risk	Low risk	High risk	High risk	High risk	Unclear
Kulik et al, 2015	Low risk	Unclear	High risk	High risk	High risk	Low risk	Low risk	Unclear
Smith et al, 2014, the ATLAS study	Low risk	Low risk	High risk	Low risk	High risk	Low risk	Low risk	High risk
Tarro et al, 2014 the EdAl study	High risk	High risk	High risk	Low risk	High risk	Low risk	High risk	High risk
Santos et al, 2014, the Healthy Buddies study	Low risk	Low risk	High risk	Low risk	Low risk	Low risk	Unclear	Low risk
Smith et al, 2013	Low risk	Low risk	High risk	Low risk	High risk	High risk	Unclear	High risk
Lloyd-Richardson et al, 2012, the PEAT study	Low risk	High risk	High risk	Unclear	Low risk	Low risk	High risk	High risk
DeBar et al, 2011	Low risk	High risk	High risk	Low risk	Low risk	Low risk	Low risk	High risk
Lubans et al, 2011, the PAL study	Low risk	High risk	High risk	Low risk	Low risk	Low risk	Low risk	High risk
Black et al, 2010	Low risk	Low risk	High risk	Low risk	High risk	Low risk	High risk	High risk
Rosenkranz et al, 2010, the SNAP study	Low risk	High risk	High risk	Low risk	Low risk	Low risk	Low risk	High risk
Stock et al, 2007, the Healthy Buddies pilot	High risk	High risk	High risk	Low risk	High risk	Low risk	High risk	High risk
Jelalian et al, 2005, PEAT pilot	Low risk	High risk	High risk	Low risk	Low risk	Low risk	High risk	High risk
Foster et al, 1985	Unclear	High risk	High risk	Low risk	High risk	Low risk	High risk	High risk

Table A4. Other potential threats to validity (other sources of bias)

	Design type	Early stopping	Baseline imbalance	Blocked randomization in unblinded trials	Differential diagnostic activity	Further bias: inappropriate administration of intervention	Further bias: Selective reporting of subgroups
1/ Carlin et al, 2018, the WISH pilot	CRCT	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
2/ Bogart et al, 2016, the SNaX study	CRCT	Low risk	High risk	Low risk	Low risk	High risk	High risk
3/ Kulik et al, 2015	RCT	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
4/ Smith et al, 2014, the ATLAS study	CRCT	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
5/ Tarro et al, 2014, the EdAl study	CRCT	Low risk	High risk	High risk	Low risk	Low risk	High risk
6/ Santos et al, 2014, the Healthy Buddies	CRCT	Low risk	Low risk	Low risk	Low risk	Unclear	Low risk
7/Smith et al, 2013, Appalachia	RCT	Unclear	Low risk	Low risk	Low risk	Low risk	Low risk
8/ Lloyd-Richardson et al, 2012	RCT	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
9/ DeBar et al, 2011	CRCT	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
10/ Lubans et al, 2011, the PAL study	CRCT	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
11/ Black et al, 2010, Challenge!	RCT	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
12/Rosenkranz et al, 2010, SNAP study	CRCT	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
13/ Stock et al, 2007, Healthy Buddies pilot	CRCT pilot	Low risk	High risk	High risk	Low risk	Low risk	Low risk
14/ Jelalian et al, 2005,	RCT	Low risk	Low risk	High risk	Low risk	Low risk	High risk
15/ Foster et al, 1985	CRCT pilot	Low risk	Low risk	High risk	Low risk	Low risk	Low risk

Table A5. Summary of risk of bias of included clustered controlled trial studies

Study name	Recruitment bias	Baseline imbalance	Loss of clusters	Incorrect analysis	Comparability with regular RCT
Carlin et al, 2018, the WISH pilot study	Low risk	High risk	Low risk	High risk	High risk
Bogart et al, 2016, the SNaX study	Low risk	High risk	Low risk	Low risk	Low risk
Smith et al, 2014, the ATLAS study	Low risk	Low risk	Low risk	Low risk	Low risk
Tarro et al, 2014, the EdAl study	High risk	High risk	High risk	High risk	High risk
Santos et al, 2014, the Healthy Buddies study	Low risk	Low risk	High risk	Low risk	Low risk
DeBar et al, 2011.	Low risk	Low risk	Low risk	Low risk	Low risk
Lubans et al, 2011, the PAL study	Low risk	Low risk	High risk	Low risk	Low risk
Rosenkranz et al, 2010, the SNAP study	Low risk	Low risk	Low risk	Low risk	Low risk
Stock et al, 2007, the Healthy Buddies pilot	High risk	Low risk	High risk	Low risk	Low risk
Foster et al, 1985	High risk	Low risk	Low risk	High risk	High risk

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Chapter 7:

Peer Education and Peer Support (PEPS) pilot study

Healthier lifestyles through a peer-education and peer-support system: a school-based pilot project in adolescents in Ho Chi Minh City, Vietnam

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This chapter proposes a pilot programme in a school-setting of four weekly education sessions about healthy choices of food and drinks and usefulness of physical activity. The programme also included a school and online support system to help maintain the effectiveness of the education sessions. Both the education and support stages were led by students (as peer-leaders) to take advantage of peer influence among junior high school students. This pilot project assesses the feasibility and acceptability of the peer-led programme in local settings which is important for Objective number 5.

Case for support

1. Project Information

- Full title: Healthier lifestyles through a peer-education and peer-support system: a school-based pilot project in adolescents in Ho Chi Minh City, Vietnam
- Duration: 24 months
- Total funding requested: GBP 149,085.00
- Principle questions to be address by the trial development grant: What is the feasibility and acceptability to students, their teachers and their family of a school-based peer-education and peer-support system to promote and maintain healthier lifestyles of adolescents in Ho Chi Minh City?
- Principle research question for a future trial: what is the impact of a school-based peer-education and peer-support system to promote and maintain healthier lifestyles among junior high school students in Ho Chi Minh City on the adolescents' level of physical activity, sedentary behaviour and dietary patterns?

2. Project Summary

Overweight and obesity in junior high school students has been rising sharply over recent years in Ho Chi Minh City. Obesity is dangerous as it makes children more prone to a series of diseases including heart and blood problems, diabetes and even some types of cancer. Recent studies have found that low physical activity and high consumption of fast foods and soft drinks are among the main causes of childhood obesity. The research team has planned for a program to tackle this problem at junior high schools around the city. It consists of four weekly education sessions of why and how to choose food & drinks healthily and also how to be more physically active. Additionally, the program includes a school and online support system to help maintain the efforts of the students. Both of the education sessions and the support system will be run by students (peer leaders) to take advantage of the influence between the children themselves. This first small-scale project is for the purpose of checking the acceptance of the interventions by the students, their teachers, and their family members and to assess the possibility of successfully implementing the program in school settings for a future larger program across Ho Chi Minh City. This purpose will be achieved through interviews and group discussions with the students, the peer leaders, the teachers and the parents.

3. Project description:

- Location of the research: Ho Chi Minh City, Vietnam

- Targeted health issues: Physical activity, sedentary behaviours and dietary patterns of adolescents that lead to overweight and obesity.
- Target population: Junior high school students (age 11-14 years)
- Specific questions to be addressed by the trial development phase:
    - Is the peer-education and peer-support system feasible in the junior high school settings?
    - Is the peer-education and especially peer-support system acceptable to participating students, their teachers and their parents?
- How will answering to these above questions be useful in informing the design of future trial?

The results from this development study (pilot) will give clues and insights to identify possible strengths, weaknesses, opportunities and threats to the intervention. By assessing the feedback from students, teachers and parents we can adjust the design of our intervention including our messages, participant activities and monitoring support system.

- Project plan to address the trial development grant research questions
    - Methodology: For this pilot, the research team intend to test on a small scale at two junior high schools, the feasibility and acceptability of a behaviour change intervention that we would evaluate in a future school-based randomised trial. At this stage, four schools (each arm two schools) will be selected conveniently from the list of schools in Ho Chi Minh City taking into account the school facilities to support the program. At the control schools, the research team will observe the implementation of the usual programs. At the two schools with the peer-education and peer-support program, the team will monitor the intervention and additionally interview students, their parents and teachers on their experience with the intervention activities and support system.
    - Competitiveness of the pilot: the main advantage of this pilot is the use of combining education program and the support system which will be run by student peer leaders. For the adolescents, there are significant amount of evidence showing that peer-influence can play a major role in behaviour modification. An additional strength of our study is the combining of cultural understanding and research experience of team members in child physical activity and dietary behaviours and child obesity in Ho Chi Minh City over the last decade, which will ensure the success of the planned research.
    - Particular care: peer to peer interaction is of great sensibility as they require right approach and by right people. Given the leaders are also students yet more senior, the influence of the peer leaders is likely to be important from the student's perspective.

4. Importance: why is this research needed now and in this proposed location?

Child overweight and obesity is one of the major risks for later life health problems including cardiovascular diseases, some cancers and lower quality of life in general. [1-3]

In Vietnam, the prevalence of overweight and obesity in children and adolescents is rapidly increasing in urban areas. Within the last decade, the research team has found a dramatic increase in the prevalence of overweight and obesity in junior high school students in Ho Chi Minh City, the main urban area of the country, from 5.0% and 0.8% in 2002 to 11.7% and 2.0% in 2004, respectively.[4] This upward trend has continued with the prevalence of overweight and obesity increasing from 14.2% to 21.8% over 5-year period from 2005 to 2009.[5]

Multivariate analyses of our recent survey data conducted on 2684 junior high schools students found that community and school environments as well as individual characteristics and lifestyle behaviours were significantly associated with overweight/obesity in adolescents in HCMC.[6] Specifically, the research team found that mean time spent on physical activity decreased significantly in the 5-year cohort period from 87 to 50 minutes/day while time spent on sedentary behaviours increased sharply from 512 to 600 minutes/day. Compared with normal-weight adolescents, overweight and obese adolescents were doing 40% (rate ratio = 0.60, 95% CI = 0.53, 0.67) less moderate-to-vigorous physical activity (MVPA). Furthermore, the results from our research also showed that consumption of sugar sweetened beverages and high energy dense foods were popular among junior school students[7]. These dietary behaviours could accelerate increases in the prevalence of obesity in this population in the very near future in the absence of healthy lifestyle intervention programs.

Recently, while conducting an interview with a senior official from the Education Department on childhood obesity[8], the research team found that they were committed to increasing the level of physical activity in students to help prevent the risk of obesity among junior high schools in the city. However, the current physical education curriculum in junior high schools only consists of roughly two hours of both theory and practice of sport, which is far lower than similar programs in developed countries[9 10], and well below the recommendations from WHO.[11]

Educational interventions play important role in behavioural modifications to prevent/treat obesity in children. Cognitive-behavioural learning theories[23-29, 35] support the strategy of spaced and repetitive sessions for effective learning especially for new knowledge (including facts and concepts)[2-4], skill and motor learning[5,6] and in generalization of conceptual knowledge in children[10] (which are useful for nutritional and physical activity applications). This timely repeated strategy also showed effective results in classroom settings[7-9] which are suitable for student obesity programs.

Systematic reviews have provided evidence that multi-component interventions have stronger effects on children obesity than physical activity or dietary alone programs[12 13] . However, there have been no interventions developed in Ho Chi Minh City to promote healthy lifestyles in

adolescents. There is currently an urgent need for a high quality, evidence-based programs, which include both nutrition and physical education and a behaviour-change support system. In reality, systematic reviews of effective interventions also revealed that most of the educational parts of those interventions involves several weekly sessions. In Australia, a similar peer-education SALSA program of Professor Smita Shah[14] has shown effective results in Western Sydney high schools. Her works have been thus replicated in several lower to middle income countries including in Jordan and China.

We thus plan to develop a peer education and support system to promote healthy lifestyles in adolescents to counter the main factors contributing to overweight and obesity in junior high schools in Ho Chi Minh City. And at this initial stage, we plan to conduct a pilot to test of the feasibility and acceptability of a potentially sustainable intervention, which will be a crucial step to allow us to implement a full scale intervention and impact evaluation trial.

5. Goal and objectives:

5.1. *Primary objectives: To assess the feasibility and acceptability of a sustainable healthy lifestyle promotion program using nutrition and physical education and peer-support system for junior high school students in Ho Chi Minh City (HCMC).*

5.2. *Secondary objectives:*

To assess the feasibility and acceptability of peer led education and support system with

5.2.1. The targeted students of the intervention,

5.2.2. The peer leaders who will teach the lifestyle classes and maintain the peer support system

5.2.3. The family members of the participating students.

6. Description of Intervention:

The intervention combines peer-led education and a peer-led support system. The figure below illustrates the steps involved in implementing the intervention in schools. Preparations for the program will include explaining the intervention and seeking support with project partners, including the school principal, school staff and parental associations. The first step is a training workshop for the year 8 peer leaders conducted by medical students covering the content of the classes, the approach to teaching and developing communication skills to empower the peer leaders.

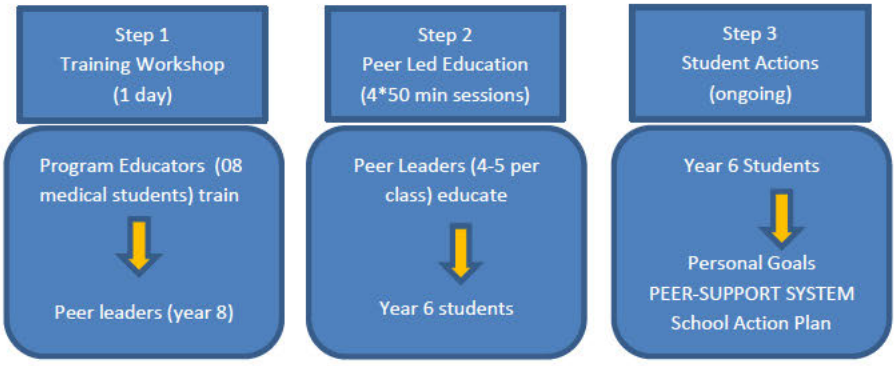

Figure 1. Summary of the peer-led education and peer-support program

The training workshop will cover crucial knowledge and updates of healthy active lifestyles and communication skills for the peer leaders to gain trust and build strong influence to lead their adolescent peers in this behaviour changing pilot intervention. Adolescent factors and challenges will also be dealt with based on the principle of transparency, care and student's benefit.

The second step is the peer education consisting four 50-minute teaching sessions conducted by the peer leaders and monitored by the class teacher. The details of the education program are outlined in the figure 2 below. Each session comprises of two main parts involving theory and practice skills. The theory part is based on specific facts and active learning which involves student participation and peer to peer interaction. Practice skills are sketched through the team or individual games and problem solving.

A peer supporting system will include a **behaviour reinforcement monitoring system** and **social network support** which will all be run and led by peers but also monitored by school teachers. The reinforcement monitoring system consists of a personal healthy record diary (HRD), a classroom *merit board* (monthly) and school awards every semester. We will also support every school to have a student community/social platform (Facebook, Zalo, ZingVN or other networks) which will be managed by peers with teacher monitoring to share experiences and answer questions or help solve challenges.

Figure 2. Content of peer-led education program

In our pilot, along with the initiating of the above intervention, we will collect feedback from all participants and institutions after each class. Feedback content will be about the message quality, the instruction of the peer leaders, and the participation of students. Every step will be closely monitored and audio or video recorded for later analysis. A selection of students and parents will also be invited to qualitative feedback sessions along with meetings with peer leaders weekly in the first month and each month afterwards.

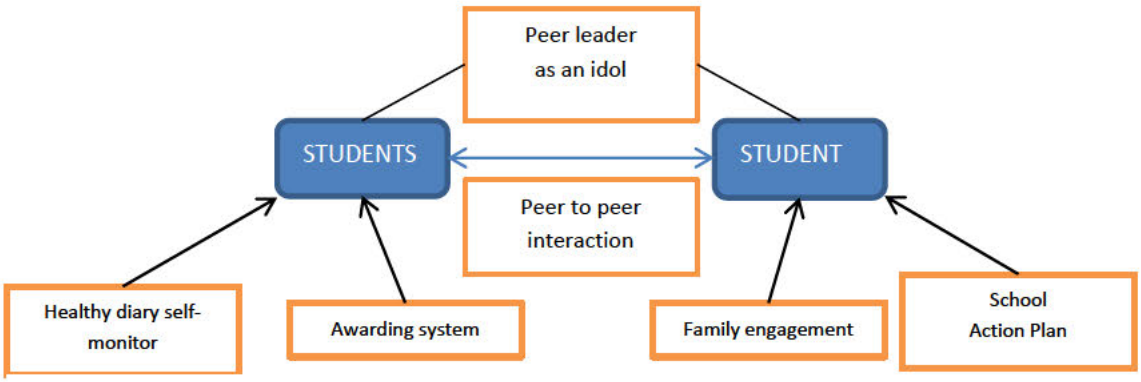

Figure 3. Overview of underlying factors influencing the change of behaviour

To ensure fidelity of the intervention and the content of peer-led programme, the process of guaranteeing the passing of information was taken. First at each step of teaching, as in training the medical students and grade 8 student, the investigator was in place to make sure the transferring content was the same. Second, all medical students in the training were asked to demonstrate the teaching session with rehearsals where contents were doubly checked by core team members. They only taught at school once passed these rehearsals. Third, all grade 8 students did the rehearsals of teaching with the present of medical students and one core team member to make sure the grade 8th students got the appropriate contents.

7. Impact Summary

This pilot study is a major setup for later full-scale intervention to tackle three issues the low level of physical activity, the increased time spent in sedentary behaviours and high-energy dietary patterns (including fast food and sugar-sweetened beverages) of the junior high school students. At this stage, the research team believes that the people who benefit the most are the students and the peer leaders of the intervention program because they will have the greatest chance to have a more precise understanding of nutrition and physical activity to make a better decision to maintain the healthy life. Their family members including parents and any sisters or brothers living in the same household are also benefited from the child who is attending the intervention school as there is a section of the education program which also encourages the student to spread knowledge and to inspire others to be active. At the school level, teachers will be

informed and they will increase the preparedness to help children actively prevent obesity through healthier lifestyles. Also, the Department of Education of Ho Chi Minh City will have another method/approach to engage the child obesity.

8. Evaluation Plan

At the methodology level, the team benefits from the valuable feedbacks from the participants to maintain, modify and upgrade both education program and support system to create a more successful intervention in the future.

Level of evaluation	Impact	How to assess	Tool of assessment	Who does assessment	When	Notes
Impact of this Pilot (program provider)	Feasibility of program	1/ Assessment of school & student' conditions 2/ Feedbacks from partners	1/ Checklist of feasibility 2/ Qualitative assessment of partner' feedbacks	Program evaluation team	Mid and end of pilot	Modifications of objectives
	Acceptability of students	Feedbacks from participants	1/ Performance of students in PA tests 2/ Qualitative assessment of interviews/meetings	Program officers	First month and every semester (total 3 times)	Solutions for problems

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SECTION IV:

CONCLUSION

Chapter 8:

Conclusion

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1. Overviews of key findings:

This research work investigated and assessed the evidence of factors related to overweight and obesity in adolescents in Ho Chi Minh City and other evidence of peer-led obesity prevention programs. With the findings, we can finally be confident that an appropriate intervention approach has been reached using effective peer-led intervention focusing on physical activity. The findings contributed to our knowledge of overweight and obesity in adolescents in Vietnam and these new results are summarized in the chapters by the following topics.

Sugar Sweetened Beverages vs Overweight and Obesity in Adolescents:

We found that the consumption of Sugar Sweetened Beverages (SSB) is more popular than we anticipated in adolescents in Ho Chi Minh City, however, the total energy from SSB accounted about 10% of daily energy intake. Among these SSB, fresh milk plus sugar and condensed milk both demonstrated a protective effect against overweight and obesity. Specifically, every kcal of fresh milk plus sugar reduced the odds ratio by 0.995 (95%CI [0.992-0.998]), $p<0.001$. Every kcal of condensed milk reduced the odds ratio by 0.996 (95%CI [0.992-1.000]), $p=0.044$.

We did not find a relationship between other non-milk SSB with overweight and obesity.

Changes of nutrient intakes and dietary behaviours among adolescents:

There was a significant increase in BMI and median energy, macronutrient intakes with increasing age, higher in boys than in girls (p <0.001). Tracking of energy and macronutrient nutrient intakes at the individual level was only poor to fair, lowest for the percentage energy from carbohydrate or percentage energy from protein and highest for fat intakes.

The linear multilevel models showed two modest but significant positive associations with BMI. Specifically, every 100g of higher daily carbohydrate intake led to an increase of 0.61 (95%CI [0,24 – 0,98]) units of BMI over 5 years (p=0.001) and an increase of 100 minutes/week of screen time led to 0.14 (95%CI= [0,07 – 0,21]) units of BMI increase over 5 years (p<0,001).

Perceptions and practices related to obesity in adolescent students

The study revealed diversified perceptions of obesity, diet and physical activity and the relationship of these factors with adolescent obesity. Findings indicated a low practice of physical activity among participants. The major barriers to obesity prevention included knowledge gaps, food environment in schools, devaluation of physical activity and academic burden.

Effectiveness of peer-led obesity prevention program versus obesity in children and adolescents:

We searched through main databases and several other important trial registries. Two reviewers independently screened 5982 articles to include 26 articles of 15 studies that matched the inclusion criteria, and then separately extracted the data and assessed the quality of each studies using the tool from Cochrane Collaboration.

The review included 15 studies of moderate to high quality from high-income countries. The age of the participants ranged from 3 years to 17 years. The duration of the intervention ranged from 5 weeks to 28 months. The peer-led content targeted physical activity alone, or a mixture of healthy lifestyle modifications. The meta-analysis of BMI involved 2506 children from 9 studies and demonstrated that programs were effective

with a mean difference in BMI of -0.15kg/m2 (95% confidence interval (CI) [-0.26, -0.03]), p=0.01. Heterogeneity was low (I2=28%, p=0.19) for the children in the intervention group. The mean difference varied with subgroups with significantly greater effects from interventions focused on physical activity and with longer duration of implementation of the intervention. Sensitivity analysis revealed similar significant findings to the primary meta-analysis.

2. Main outcomes in comparison with previous literature

The consumption rate of sugar-sweetened beverages among Vietnamese adolescents was higher than their peers in Thailand(1), Brazil(2) and several EU countries(3) and comparable to the consumption in the US(4). However, there are several differences in our study compared to others. First, the range of sugar-sweetened beverages consumed by adolescents in this study included both modern carbonated (soft drinks, sport drinks, fruit juices) and traditional sugar-added drinks (iced tea, sweetened milk-related products). Thus, the total consumption rate could be higher. The mean daily energy from all sugar-sweetened beverages was 256.4 kcal, roughly 10% of their total daily energy intake (~2484kcal/day, see Table 1), which is high and comparable to that in several high-income countries.(3, 4)

The interesting finding of the protective relationship of milk based SSBs (both fresh milk and condensed milk) against overweight and obesity status. Logistic regression in the Table 4 revealed that milk (either fresh milk with sugar or condensed milk) had the reverse relationship with overweight status. This result agreed with other studies suggesting the protective effect of milk over obesity (5, 6), probably due to calcium and other factors in the milk (7), which potentially have major influence over growing of the children too (8, 9). Unfortunately, the price of milk and milk products are relatively high in Vietnam and impede the benefits that these products could bring to most of the population, especially children and adolescents.

The change of nutrient intakes and dietary behaviours was significant over the 5 year of study. At the individual level, tracking for energy and macronutrient intakes was poor to fair indicating a substantial drift of subjects between the low, medium and high

categories of intake with increasing age. We expected that high intakes of energy, high percentage energy from fat would be associated with high BMI. However, our findings do not support this hypothesis. In comparison, we found that studies all over the world have not shown a consistent relationship between energy and macronutrient intake with BMI(10-14). A possible explanation for the lack of a relationship between energy intake (and percentage energy intake) from macronutrients and BMI might be due to the under-reporting of foods(15). In our study, only time spent for physical activity and screen time were significantly associated with BMI. The lack of association between energy intake and BMI might be due to altered eating behaviours of overweight/obese adolescents which has been reported elsewhere (16). Furthermore, our data were collected among junior high school students who were vulnerable to unhealthy eating habits and sedentary behaviours, and also had closer ties with their peers during the transition to adulthood and the psychosocial importance attached to friendship and peer group relations increases, intensifying the potential for peer influence (17).

In our formative study (qualitative) our data show that although children, parents and teachers acknowledged the increase in child obesity recently in their community, they did not consider it an urgent issue. In specific, tendency of assessing obesity based on physical outlook and underestimation about obesity especially by parents are similar to other settings and may contribute to the susceptibility to obesity (18-20). Additionally, we found several external factors that prevented children from healthy eating. Children and parents identified time constraint for their skipping breakfast but considering the local food environment as found in other studies, availability of cheap fast food might have triggered this behaviour (21).

Furthermore, in our study physical education and activity were not highly valued by both children and parents thus only few of them actually put that in practice. As mentioned previously students and parents showed lack of awareness of the positive effects of physical activity and thus it explained their low motivation. This was catalysed by the unmarked system of the physical education curriculum at school and failed to generate enough enthusiasm for students' participation in physical education class. Finally, we found that children in our study were facing parents' strong expectation of high academic performance that prevented them to live their own life (22). Academic burden

for school students (23) is a real issue in Vietnam with the fact that children have to go to after-school couching classes from very early year of their academic life.

We found a number of new knowledge from our systematic review. We found significant effect of peer-led interventions on both child BMI along and combined BMI/BMI z-score/BMI percentile in our systematic review and meta-analysis. The result corresponds well with earlier findings of recently published major systematic reviews of interventions for preventing obesity in children (24). We found the stronger effect of the peer-led intervention in teenagers of at least 11 years old, and this is understandable for several reasons. First, the peer interaction and impact are well-known to be strong in these older ages (25, 26), thus any positive influences from peer-leaders may be reflected better in this age group. Second, the peer-led interventions of obesity prevention involving dietary and/or physical activity behaviour changes. These changes require, at least, some maturation in understanding and some control over the daily food intake (27) and habits which is also related to older aged teenagers (28). Third, the robustness of the studies might have an influence on the findings. Those studies which involved teenagers of 11 years or older were either those with better quality (mostly low risk of bias in three main domains mentioned in the Method section), or with smaller numbers of participants, or they were pilot studies where research staff more carefully implemented the interventions to make them successful (29, 30).

The effect of the intervention seems to be much stronger for the studies with long-term interventions (six months and more) compared to short-term interventions. On the aspect of behaviour change, the longer exposure to new (and assumingly better) behaviours usually resulted in lasting changes (31), which in turn, will make stronger and more sustainable reductions in obesity and BMI. Furthermore, longer exposure often results in higher dosage of the intervention (32). Perhaps the most meaningful explanation is the similarities of the results from longer duration interventions from other systematic reviews in both children (24) and adults (33).

The most interesting interpretation of the effectiveness of the peer-led intervention can be drawn from subgroup analysis for different intervention approaches used. Our significant finding suggests that peer-led intervention should focus on physical activity rather than a mixed set of interventions that are more difficult and often costly to cover

all elements. However, readers should be aware that although highly significant, this result was inferred from limited evidence. More evidence available in the future may change the effect size. Nevertheless, promoting physical activity alone appeared to be a very effective approach in earlier meta-analyses (34, 35).

Finally, there are several highlights for our proposed peer-led intervention to prevent/reduce overweight and obesity in adolescents in Ho Chi Minh City, Vietnam. WHO recognizes obesity as one of the most pressing global public health problems. Adolescent obesity increases the risk of adult obesity (36) and mortality (37). The proposed trial will provide evidence on the efficacy of multi-component, peer-led behavioural change education with parents' support to promote healthy behaviours to prevent excess weight gain in adolescents, improve dietary patterns, increase levels of physical activity and reduce sedentary behaviour. The trial will establish if a school-based approach with parents' support to obesity prevention works in a large urban population in Vietnam. The proposed interventions are feasible to implement within schools across Vietnam using currently available resources.

The proposed trial will provide high level evidence of the efficacy and cost effectiveness of school-based peer-led education intervention with support from parents at home on overweight and obesity in adolescents in urban settings in Vietnam. This trial of a theory-based approach to evaluate the impact of combined school- and home-based intervention on adolescent obesity will be an important study to show an efficacious and cost-effective approach to reducing child in low- and middle-income populations.

3. Strengths and limitations:

Strengths and limitations for each research have been mentioned in each manuscript. However, we now evaluate the overall strengths and limitations of the thesis as a whole. This thesis has several important strengths. First, the thesis developed a holistic summary of evidence from both local evidence and context for an implementation of intervention. It also extracted and combined quality data from the literature to draw a full evaluation of the intended peer-led intervention. Second, the data from the secondary analysis were investigated carefully and extensively to seek meaningful and valid

information which have not been achieved previously. For some data (sugar sweetened beverages), the findings were original. Third, the author of the thesis has gone through a standard and recognized process of implementing an intervention which involved systematic review, formative research, pilot study and full-scale intervention. This process assured that the final aim could be met with advantageous points which, in turn, would be necessary for the author's learning.

One of the research work limitations is the secondary data were quite old, which cannot reflect the current situation of the factors affecting child obesity. Yet, we believe that although the data were old, the trend and the patterns of data are still similar. Nonetheless, other systematic review data and formative data are very recent and can compensate for these secondary population-based data. The other issue is the missing of longitudinal data of several key variables, including nutritional factors, is impairing the fullness of data and may prevent/delay the implication of obesity prevention program.

4. Implications and Recommendations from our Research Results

This research work examined the relationship of nutritional factors with overweight and obesity in adolescents in Ho Chi Minh City and for the purpose of finding an appropriate intervention for obesity prevention. The findings of this research are useful for both practice and academic implications. These practical applications and the future academic intentions that could be deduced from this work are suggested below.

For public health nutrition practice, there are a number of changes that the government, schools and parents can do to help tackle obesity in HCMC. The popularity of sugar-sweetened beverages and their easy accessibility needs to be reversed as we know from the literature that overconsumption of SSB is a clear risk of obesity in adolescents (38). Although there might be some local or social reasons behind the high prevalence of SSB consumption that we have reported in Chapter 3, we should be careful when drawing conclusions or directing measure to this group of beverages as the government has done since 2017 (39). The policy should also include a clear differentiation of milk-based products from other non-milk beverages as they have beneficial effects on both child growth and obesity prevention. For example, there should be a price policy to help low-income families to have sufficient milk products for

their children. Fortunately, the government has very recently confirmed that it would provide milk drinks for children at schools as an enhanced nutrition national program (40) which may benefit both groups of children of low-income families and obesity-at-risk.

Another point for preventing obesity is from the education perspective. We believe that effective communication to children to fill their knowledge and practice gaps of obesity-related risk factors (including low physical activity and nutritional/dietary issues) and to start working with families are among the top strategies to prevent obesity. In this aspect, obesity prevention can be made possible from its source, in each family. Indeed, family members can observe and help each other to improve their home food environment with healthier food and drinks). Furthermore, effective programs need to be based on local social and experience context, which was not available before our work. Our qualitative work (Chapter 5) and systematic review (Chapter 6) have purposefully examined the barriers and found a potentially effective approach for the local adolescent population. We have identified major barriers to obesity prevention including specific knowledge gaps on risky foods and drinks, unhealthy dietary behaviours, a quite toxic food environment (which was recently improved by government policies), devaluation of physical activity and unresolved school academic burden. The intervention was consequently designed to prompt children about the urgency of obesity prevention and specific information of obesity risk factors (with specific food and drink items, health dietary behaviours, realizing the importance of physical activity and utting it into actions) and how to influence each other to prevent obesity using peer-effects amongst them. While piloting the peer-led program at four junior high schools, we also expect to enhance school capacity through establishing groups of peer-leaders, which are school students, along with creating new channels for students to interact with their teachers to sustain new behaviours. Nevertheless, peer-led education and support are only one of the possible approaches that we specifically found to be effective. There is still ample opprotunities for other approaches, including traditional mass media program, family approaches and the new social networks through phone apps, to influence lifestyle behavours and risks of obesity. And with short informative broadcast/videos and interactive online platforms, we believe we can help tackle obesity in a new way targeting those who are at risk using game strategy.

For research purposes, we also believe that we have pointed out several other research areas that could be further explored. The trend in SSB consumption among adolescents would be valuable research work to fully understand the differences in consumption as adolescents get older and also the trends over time. We also suggest to further examine the effect of milk-based drinks on overweight and obesity to fully understand this group beverage. Furthermore, there are several other aspects for future studies such as longitudinal examination of nutritional factors, or sleep-related factors and their relationship with overweight and obesity. Nonetheless, the very important direction of research is finding and testing the best approach for obesity prevention. We are actually planning for this task through a city-wide application of our peer-led pilot work (which was presented in Chapter 7). For specific information, I have attached the intervention protocol in the appendices.

5. Final Conclusion

This thesis has revealed important data and characteristics of sugar sweetened beverage consumption, longitudinal nutrient intakes and dietary changes and the potential relationship of these covariates with overweight and obesity in adolescents in Ho Chi Minh City. It also highlighted barriers and contexts for intervention and the most important part is the revelation of effectiveness of peer-led interventions in childhood obesity prevention which paved the way for formal pilot and full scale interventions in the future.

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Appendices

Appendix 1

GRANT PROPOSAL - NHMRC/NAFOSTED Joint Call for Collaborative Research Projects

Application ID: APP1157954

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A. Research Proposal

The 2016 Lancet Commission on Adolescent Health and Wellbeing reported that the prevalence of adolescent overweight and obesity has increased in almost all countries since 1990.[1] Overweight and obesity are estimated to cause 3.4 million deaths, 4% of years of life lost, and 4% of disability-adjusted life-years (DALYs) worldwide[2,3]. Despite the paucity of data, child overweight and obesity seems to be rising rapidly in low-income and middle-income countries[4] (LMIC) including Vietnam. Adolescent obesity is a major predictor of lifetime obesity and ill health[5].

Multiple public-health approaches will be required to reverse the child and adolescent obesity epidemic in Vietnam, including environmental changes, but there will remain a need for effective health promotion interventions to support healthy diets and encourage a physically active lifestyle. Schools provide an appropriate setting for health promotion.[6] A recent review found *strong evidence of the impact of interventions delivered at schools on childhood obesity prevention.*[7] Although most school-based, obesity prevention interventions have led to changes in obesity-related behaviours, the results are mixed for preventing excess weight gain in adolescents.[8-12] This study will help fill this evidence gap about effective interventions to prevent excess weight gain in adolescents in LMIC & generate new insights about peer-led education in future prevention efforts.

We **aim** to collect high-level evidence of whether an intensive, multi-component, school and home-based health promotion intervention using innovative educational methods can reduce overweight/obesity, and improve diet and physical activity in urban Vietnamese adolescents.

Intervention: The peer education will consist of i) Identifying and training medical students as Peer Educators, who then train selected Year 8 students as Peer Leaders.
ii) The Peer Leaders deliver four classes to Year 6 students over a school term, working in small teams and guided by the Peer Leader's Manual. The classes cover healthy eating, movement, lifestyle, and an action project.
iii) The year 6 students decide on actions to promote physical activity and healthy eating in the school, guided by the Peer Leaders and teachers. Peer support comes from Peer Leader led behaviour reinforcement monitoring and social network support with monitoring by schoolteachers. The home component includes parents meeting on healthy diets and cooking, and physical activity to increase their ability to create a supportive environment for healthy lifestyles for their children.

Primary hypothesis: In a school-based, cluster randomized controlled trial of grade 6 high school students from Ho Chi Minh City Vietnam, a **multi-component, peer-led lifestyle behaviour change education and support** will reduce mean adolescent BMI by 0.15 BMI Z scores from 0.39 Z in the adolescents in schools with standard education programs to 0.24 Z in intervention group.

Secondary hypotheses: Peer-led lifestyle behaviour change education and support, compared to adolescents with no intervention will: 1) *increase* the frequency of consumption of fruit, vegetables, and breakfast, while *reduce* the frequency of consumption of soft drinks; 2) *increase* the confidence of the adolescents in choosing healthy foods (dietary self-efficacy) and their control over food selection choices (dietary

locus of control); 3) *increase* the mean duration of physical activity (minutes/day) of adolescents assessed by questionnaire and by accelerometer measurements; and 4) *reduce* the mean duration of time spent on a screen (minutes/day).

This research builds on our work with the HCMC Youth Cohort study, which established the risk factors for adolescent obesity in HCMC (CIB, C, D & F), our efforts to develop peer education in Australia, Jordan and China (CIC & E), our MRC-UK funded pilot study (CIA, B, C, D, F & G).
A multi-disciplinary team of Australian and Vietnamese researchers with an established record of collaboration and research productivity will bring together international research experience and local knowledge combined with specific skills in epidemiology, school health and peer education, health social science, biostatistics, and health economics to assess this innovative intervention.

The findings will have global significance by expanding our knowledge about how to improve lifestyles and reduce excess weight gain in adolescents in. The findings will be of use for obesity prevention programs in other cities in Vietnam and other countries in Southeast Asian countries.

Background

Child and adolescent obesity in Vietnam – the magnitude of the problem

In East Asia and South East Asia including Vietnam, rapid urbanisation and socio-economic development combined with changes in eating habits and physical activities have led to an increase in obesity in adults and children.[13] In 2005, the National Survey on overweight and obesity showed that the prevalence among adults in Vietnam was about 16.3% in urban areas. The prevalence among children less than 5 years almost doubled in 3 years, rising from 3.2% in 2002 to 6.3% in 2005. In Ho Chi Minh City (HCMC), the largest urban setting in Vietnam, a study conducted in 2004 that used International Obesity Taskforce (IOTF) cut-offs revealed the prevalences of overweight and obese adolescents in HCMC were 11.7% and 2.1% respectively. A cross-sectional study in 2002 reported a prevalence of overweight and obesity among adolescents of HCMC of 5.9% and 0.7%.[14] These results demonstrate the high increase of overweight and obesity in adolescents from HCMC over two years. Child and adolescent overweight and obesity are still increasing steadily over recent years in HCMC. From just merely less than 1% in 2002,[14] the prevalence of obesity has jumped to more than 20% in 2012.[15] Although the children and adolescents living in wealthier families were more overweight and obese, the problem was also present in their counterpart from less well-off families in this city.[16]

The HCMC youth cohort study

CIB Tang, CIC Dibley, CID Ming, CIF Trang and CII Phuong have conducted cohort studies to assess changes in the prevalence of overweight and obesity among adolescents in urban districts of Ho Chi Minh City between 2002 and 2010.[14,16] Two surveys were conducted among high school students (11-16 years) in 2002 (n=1003 students) and 2004 (n=2684). International Obesity Taskforce (IOTF) sex and age-specific BMI cut-offs were used to define overweight and obesity. Underweight was defined as a BMI-for-age z-score < - 2, based on the US Centers for Disease Control and Prevention (CDC) 2000 growth reference. In 2002, students completed a questionnaire about household assets. In 2004, parents answered questions about their weight, height, education, occupation, and ownership of 14 household assets. The studies revealed the prevalence of overweight and obesity increased from 5.0% and 0.6% in 2002 to 11.7% and 2.0% in 2004, respectively ($p<0.001$), while the prevalence of underweight decreased from 13.1% to 6.7%. There was a significant increase in the prevalence of overweight and obesity by gender over the two years: the 113% increase in the prevalence of overweight and obesity in boys was significantly greater than the 39% increase in girls ($p<0.001$). The percentage increase in overweight and obesity was considerably lower in adolescents from the poorest households (33%) than from the other quintiles of wealthier households (ranging from 77% to 124%) ($p<0.001$). The studies concluded that the prevalence of overweight and obesity among adolescents in HCMC was increasing rapidly and that there is an urgent need to implement strategies for prevention and control amongst the adolescents in HCMC and other urban settings in Vietnam. These cohort studies provided a fundamental experience in understanding the adolescent obesity situation, research settings and logistics in HCMC, and developed a functional collaboration between Australian and Vietnamese CIs to design and implement large studies on adolescent health issues in Vietnam.

Interventions to improve lifestyle, and overweight and obesity

A Cochrane review revealed strong evidence of a reduction in BMI of children as a result of childhood intervention programmes.[12] Another recent systematic review[7] of obesity interventions in children aged 2-18 that included school, family or community-based interventions found 'at least moderately strong' evidence to support the effectiveness of school-based interventions for preventing childhood obesity. Another review of school-based trials with a broad range of interventions directed at dietary and physical activity behaviours, and anthropometry as the outcome, found statistically significant reductions in body mass index (BMI) or skinfold thickness in the intervention group in 68% (17/25) of the studies.[9] Other systematic reviews[8,10,17] of trials with a primary aim to prevent childhood overweight and obesity found that approximately half of the studies were effective in reducing overweight, obesity or an adiposity measure in at least one subgroup. However, nearly all these previous school-based intervention studies have reported some improvement in diet or physical activity. The key findings include: moderate reductions in dietary intake of fat,[18-23] decreases in soft drink consumption,[24] increases in fruit and vegetable intake,[25] increased consumption of breakfast,[18] increases in physical activity,[18,20-22,26-34] and reductions in sedentary behaviours,[25,35,36] with 22 studies reporting changes,[23-32,34-45] and 9 studies no changes in adiposity indicators.[18-22,33,46-48]

Many factors may account for the different responses reported by these trials. The early trials[19,22,30,37,45] aimed to reduce cardiovascular disease risks and focused the dietary interventions on reducing fat intake alone, rather than a range of energy-dense foods and drinks. Also, these early studies were conducted 20 to 25 years ago when the prevalence of childhood overweight and obesity was half the current level. Several studies[20,30,45] focused on knowledge change even though this does not lead to behaviour change.[49] Some studies[18,19,36,40,46] had inadequate power to detect changes in adiposity indicators. Variations in the content, duration and intensity of the interventions may also have contributed. Finally, most studies have not assessed, which mediators of behaviour change ("attitudes, self-efficacy, perceived benefits, barriers to change and social support for change") were most important, or if they responded to the intervention.[50]

Multi-component educational interventions are most likely to alter dietary behaviours and physical activity related to excess weight.[51] The educational messages of effective interventions have targeted behaviour change rather than the acquisition of knowledge, and have been directed at specific behaviours, for example increasing fruit and vegetable intake, or reducing soft drink consumption, rather than overall changes in diet.[51] Interventions designed to decrease sedentary behaviours were more effective if targeted at specific sedentary behaviours, for example, TV viewing, and were more effective than interventions to increase physical activity. A review of school-based physical activity programs[52] found an impact of these programs on increasing the duration of physical activity, reducing television viewing and improving fitness, but little influence on leisure-time physical activity or BMI. These findings highlight the need for multi-component obesity prevention programs.

Recent systematic reviews have identified multi-component interventions that promote physical activity, and education about a healthy diet and physical activity are more likely

to be effective than single interventions physical activity or dietary alone programs.[1,10,53,54] Evidence has also been generated by recent reviews that the interventions implemented in schools with home involvement had the highest rates of impact[7], and the inclusion of intervention of parent support and home activities that encourage children to be more active, eat more nutritious foods and reduce sedentary time has been recommended.[12]

However, in many school-based obesity prevention trials, the initial positive impacts of the school-based interventions were greatly reduced or neutralised in the long run once the teachers/health workers were no longer on-site. In other words, the teacher-led or professional-led interventions are somewhat costly and hard to maintain in the long run. In contrast, the peer-led programs can be an achievable and effective alternative in the economy-constricted settings. Moreover, the importance of peer relationships and influence intensify during secondary schooling[1,3] and peers have a greater influence on health behaviours of adolescents than parents, teachers or health professionals.[6,55]

This study will fill in the information gap about school-based obesity prevention by evaluating innovative interventions, based on social cognitive theory[56] and prior research[57,58], and align with the World Health Organisation's Health Promoting Schools Framework.[3] Our findings will help us understand the importance of peer-led healthy lifestyle education program for adolescents in low- and middle-income settings. Our study is designed to collect level-1 evidence and has adequate power to measure intervention effects with precision. Previous interventions have shown merit in pilot studies in Australia and Asia,[57,58] and the approaches are sustainable using current resources and collaboration with schools, and the Department of Education developed through our formative research[59] and existing MRC funded feasibility project in Ho Chi Minh City.

Peer-led education intervention – SALSA example in Australia and China

Students As Life Style Activists (SALSA) pilot study,[57,58,60] the proposed peer-led education program aims to decrease screen viewing, to increase physical activity and improve nutritional choices in adolescents. This approach to lifestyle education enhances self-efficacy and creates a supportive school environment in which health promotion messages and actions about healthy lifestyle are more likely to be accepted by the students. CI-E urban developed this program, and it builds on her experience of using a similar model for adolescent asthma management (Adolescent Asthma Action) which has been shown to improve asthma outcomes in adolescents in RCTs in secondary schools in Australia[61] and Jordan.[61]

In 2005/06 the program was pilot tested in a multi-cultural, low SES high school in Western Sydney. In this pilot, CI-C and CI-E undertook a formative evaluation and assessment of the feasibility of SALSA.[62] Based on the formative research experience they implemented and evaluated a project in 88 schools in the Western Sydney region of Australia during 2014-15. In the project Year 10 peer leaders in each school were selected who were trained to deliver the SALSA program to their Year 8 peers. The peer-leader training workshop was delivered by volunteer university students (SALSA educators) from health and education faculties who had received SALSA educator training from project staff. There were significant increases in the proportion of Year 10 peer leaders (n = 415)

who reported eating ≥2 serves fruit/day fruit from 54 to 63% (P < 0.01); eating ≥5 serves vegetables/day from 8 to 12% (P < 0.01); and drinking <1cup/day of SSBs from 56 to 62% (P < 0.01). Change in ≥60 min MVPA participation/day depended on gender (P < 0.01): Boys increased 14% while girls decreased −2%. Changes in eating breakfast daily also depended on gender (P < 0.004): Boys increased 13% while girls decreased −0.4%. The change in peer leaders recreational screen time differed by socioeconomic status (P < 0.05): above average communities decreased by −2.9% while below average communities increased 6.0%. The lifestyle intentions of the peer leaders significantly shifted except for MVPA, which remained stable.[58] Among the Year 8 students, the increase in fruit (2/more serves a day), and vegetable (4 serves) intake was 5% and 3% (p<.001). Furthermore, there was a 5% decrease in drinking more than one cup per day of sugar-sweetened beverage per day. The teachers and the school principal found SALSA was easy to integrate into the mandatory school health curriculum. Student satisfaction with the program was high. Overall students and teachers considered the program valuable with increased awareness of healthy lifestyles.[63]

CI-C and CI-E with their PhD student and local research partners replicated the SALSA program in China where they found a significant impact on sedentary behaviours of the students. The treatment group students spent 20 min less sedentary time per day on weekdays (p=0.020) compared with control group. This reduction was mainly due to a reduction of 14 min/day in computer usage on weekdays (p=0.0009). There were no significant differences in time on other sedentary behaviours, including television and DVD, video game, extracurricular reading, writing, drawing and listening to music, passive commuting and sitting to talk. There was also no significant difference in time in moderate-to-vigorous physical activity between intervention and control group.[57]

Formative research and pilot study

Several CIs in this proposal (CIs A, B, C, D & F) conducted a formative research in 2015 in two high schools in HCMC that identified diversified perceptions of obesity, diet and physical activity and their relationship with adolescent obesity among students, teachers and parents. The findings indicated low practice of physical activity among the students. The major barriers to obesity prevention included lack of knowledge about the healthy food, food environment in the school, devaluation of physical activity and academic burden of the students.[59] This study generated insights to design a culturally appropriate SALSA program to pilot in HCMC. We used this experience to develop the Peer Education and Peer Support (PEPS) pilot project funded by the MRC-UK.

The PEPS pilot project is being implemented in 4 (two each in treatment and control group) high schools in HCMC. The intervention combines peer-led education and a peer-led support system. The first step involved a one-week training workshop for the medical/public health students to become peer-educators. In the second step, these peer-educators trained the Year 8 students who work as peer-leaders. The training included crucial knowledge and updates of healthy active lifestyles and communication skills for the peer leaders to gain trust and build strong influence to lead their adolescent peers in this behaviour changing pilot intervention. The third step comprises of peer education consisting four 50-minute teaching sessions conducted by the peer leaders with

monitoring by the class teacher. Each session comprises of two main parts involving theory and practice skills. The theory part is based on facts and active learning, which involves student participation and peer-to-peer interaction. Practice skills are sketched through the team and individual games and problem solving. A peer support system includes a behaviour reinforcement monitoring system consisting of a personal healthy record diary (HRD), a classroom merit board (monthly) and school awards in each semester. The intervention will be delivered during two school semesters. The control school students receive usual government program. We will assess feasibility and acceptability of the intervention and behaviours change in physical activity, screen time spending, sweetened drink consumption, fruits & vegetables intake, and BMI (of a sub-sample) using mixed-methods.

Experience of research team with the intervention and evaluation methods

This project will bring together a highly qualified and experienced **multidisciplinary team** from Australia and Vietnam who have strengths in public health and nutritional epidemiology, health social science, human nutrition, adolescent and child malnutrition, peer-led nutrition and health education, biostatistics and health economics. CIB Hong, CIC Dibley, CIF Trang and CID Minh conducted one of the first studies to assess risk factors for adolescent obesity – the HCMC Youth Cohort study. CIA Alam, CIB Hong, CIC Dibley, CIF Trang and CID Minh conducted formative studies, and are currently conducting a pilot study to assess the feasibility and impact of the peer-led adolescent life-style, behaviour change communication, intervention in HCMC. CIE Shah and CIC Dibley have extended experience in the peer-led education training and intervention from her development and upscaling of the SALSA (Students As Life Style Activists). CI Dibley and CIE Shah have replicated the SALSA intervention in China. CIB Hong, CIC Dibley and CIF Trang, the lead investigators on the pioneering Youth Cohort study are highly experienced in objective measurements of physical activity and sedentary behaviour using the accelerometer, and dietary patterns of Vietnamese adolescents. CI Alam, Dibley and Agho are highly experienced in designing and implementing community based randomised controlled trials of child nutrition in Asia. CI Huda is experienced in economic analysis.

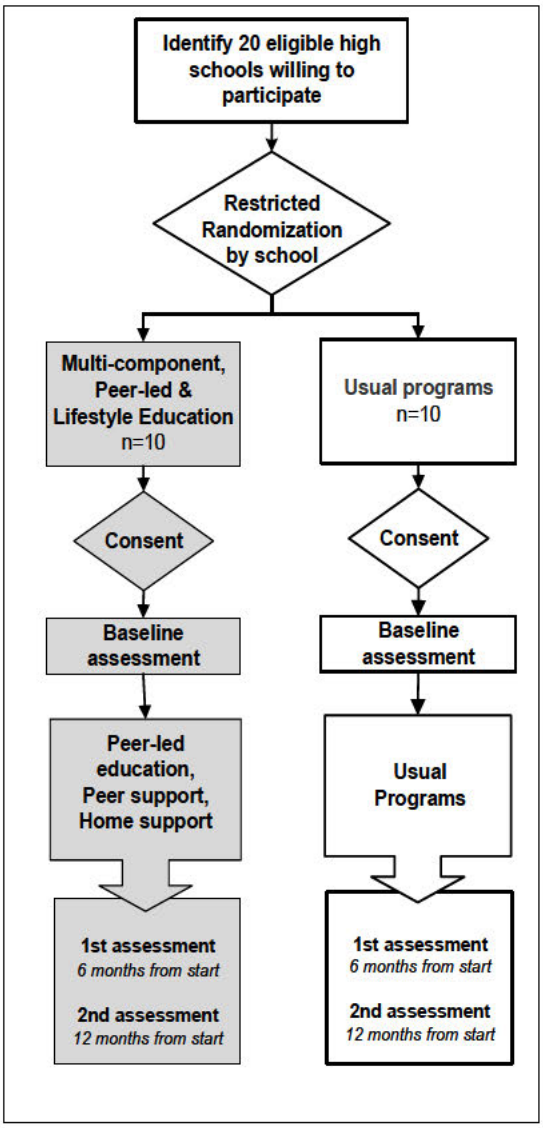
Research Plan – Methods and techniques

1. Experimental design

a. Study design

We will use a *school-based cluster randomised controlled trial* (*CRCT*) to examine the impact of a multi-component, theory-based intervention, with peer-led lifestyle behaviour change education & parents support, to reduce excess weight gain and prevent overweight & obesity in adolescents in Ho Chi Minh City. This will result in two study groups (see diagram). The *outcome* assessments *will be made on a cohort of adolescents* measured at baseline and over 12 months follow up, because we expect small follow-up losses & a likely high correlation between baseline & follow up outcome measures.[64]

We will conduct the trial in 20 schools, with 10 schools in each study group. We will deliver the peer education intervention in two waves at the start of each school year over 3 months for all new Year 6 adolescents in the allocated schools, followed by peer support and home engagement activities over 9 months till the end of the school year. To increase the participation of schools, we will use a *"delayed - intervention"* in the *control schools*, which will be given the opportunity to implement them at the end of the study.



We will conduct outcome assessments in students from 3 classes from the grades involved in the study with an expected 2,460 students for each study group. There will be a baseline assessment and two post-intervention assessments: the first immediately after the intervention to assess the short-term impact; and the second at the end of the school year to assess the sustained impact on the change in adiposity indicators and diet and physical activity (see evaluation plan for details).

In this cluster RCT we will allocate the *interventions at a school level*, but the *outcome assessments will be at the individual level*. This is the best comparative design for the proposed interventions, which to avoid contamination of the intervention, have to be delivered to a school grade. A three-year study is required to ensure we deliver an adequate "dose of the intervention" in the school and to give time to evaluate the sustained impact of the interventions.

b. Sampling scheme

To select the high schools for the trial, we will use an existing frame of 268 public lower secondary schools in Ho Chi Minh City[65] with 371,489 students in 2015. We will select schools from wealthy districts in the city and construct a database with information about each school from the Department of Education. The variables will include the size of the student population, the number of grade 6 classes, the average size of classes, the location of the school, and the physical characteristics of the school, e.g. size of playgrounds, number and type of sporting facilities. Using this information, we will conduct cluster analysis to select the 20 to 30 most similar schools.

We will conduct the outcome, and process evaluation on a representative sample of students in the participating grade for the key outcome and process indicators.

c. Recruitment and inclusion/exclusion criteria for schools

The set of 20-30 schools with similar characteristics selected from the frame will be eligible for the study if they have at least 6 classes in grade 6 available to participate in

the study, and if in the control group, they are willing not to change curriculum for the 2 years of the study. These criteria will ensure a similar size and type of school will be enrolled. The research team will write to the principals of the potentially eligible schools with written information about the project, and one week later we will seek approval for their school to participate.

d. Assignment of treatments – restricted randomisation

We will assign the interventions to the eligible clusters using a fixed randomization scheme with uniform allocation ratio of interventions. Because it is only feasible to use twenty school clusters to ensure balance of potential confounders we will assign the treatments using restricted randomization.

We will use the database of key variables constructed to select 20 similar schools and the approach described by Moulton[66] and his SAS macro. The procedure will be as follows:

1. Using the previously selected 20 similar schools, we will create all possible 184,756 combinations of schools for intervention and control groups using the Moulton SAS macro.
2. For each of these combinations, we will calculate the mean of each of the indicators, and then calculate the absolute difference between intervention and control groups for each combination.
3. We will calculate the mean difference and standard deviation of all the possible combinations. We will then use these numbers to guide us in determining the maximum allowable difference between intervention and control groups for the balanced combination. Before we select the balanced combinations, we will establish the criteria for determining balance between the groups.
4. We will use the SAS macro to identify all the balanced combinations, and then make a random selection of one balanced combination as the schools for intervention and comparison groups.

e. Recruitment and consent of students and their families

We will invite the students randomly selected for the impact assessments, and their parents, to participate in the trial. We will send an information sheet and consent form home for the parents and child to consider. We will obtain signed parental consent in advance of the baseline assessment, but the students will also need to give written consent prior to each of the assessments. We will hold meetings for parents with the support of the school to further explain the study and answer any questions. Based on experience with school surveys in Vietnam we expect that at least 90% of students will consent to participate.

2. Intervention plan

We selected the trial interventions because we have tested their feasibility, and piloted them, in Australian, Chinese and Jordanian high schools[57,58,63] and are thus likely to be sustainable in the future, yet to be of sufficient intensity to alter BMI and obesity-related behaviours. We will not need much time for preparation to start the intervention. Our existing MRC-funded PEPS pilot study has given us experience with the intervention and

assessments, and the logistic preparations. We will deliver the interventions to all Year 6 students in the schools allocated to receive them in two waves at the start of the school year in the first and second year of the project.

a. Peer-led behaviour change education

We will implement the peer-led intervention using a 3-step process over 12 weeks:

i) The first step is to build capacity to implement the intervention by identifying and training Peer Educators and Peer Leaders. Sixteen medical or public health student volunteers per intervention school will be selected as Peer Educators by the Vietnamese CIs and undergo a one-day training workshop by the project staff under supervision of the CI-E who has thirty years of experience in peer-education training. Training will cover all activities of the four lessons the peer educators will deliver to Year 8 students (Peer Leaders). In the first stage, we will introduce the peer educators to the program activities and in the second stage will practice leading the activity in a group setting. Each group will have an opportunity to practice a component of the program and receive feedback on their delivery. Training will also covers how to use the Peer Leader's Manual in preparation and delivery of the peer-led classes. We have translated the manual to Vietnamese and used it in the PEPS pilot project. The class teachers will recruit Year 8 Peer Leaders by following a guideline. The Peer Educators will train the Peer Leaders who will deliver the behaviour change intervention to their Year 8 peers.

ii) In the second step, the Peer Leaders will implement the behaviour change intervention over one school term, working in small teams and using the Peer Leader's Manual as a guide. They will conduct four lessons (75 minutes each) for students from Year 6, covering healthy eating, movement, lifestyle, and an action project. The class teacher will join the lessons to support the peer leaders and to minimize risks with class control. The education program will include a video, games and active learning activities, such as a lunch box quiz to interest the students.

iii) In the third step, the students will decide on actions to influence the school environment, guided by the Peer Leaders and school staff, to promote physical activity and healthy eating in the school. These actions could include activities such as cooking sessions, poster presentation, plans for more physical activity at school, competitions encouraging healthy lifestyles and promotion of healthy foods in the canteen. These activities will run over one school term.

b. Peer support Our peer support intervention will include a behaviour reinforcement monitoring and social network support, which the Peer Leaders will run and led but with monitoring by schoolteachers. The reinforcement monitoring system consists of 1) personal healthy record diary (HRD) maintained by all students, 2) classroom merit board (monthly) and 2) school awards in every semester. We will also support every school to have a student community/social platform (Facebook, Zalo, ZingVN or other networks suggested by the peer leaders and students and allowed by the school authority) which the Peer Leaders will manage but with teacher monitoring to share experiences and answer questions or help solve challenges regarding healthy diet and physical activity.

c. Parents' support for creating supportive environment at home

We will arrange six-monthly meetings with parents of the Year 6 students. We will provide the parent with information about: 1) healthy diets for adolescents, healthy cooking, and healthy shopping (i.e. more fruits & vegetables, less sweetened soft drinks); 2) the benefits of physical activity including improve school performance, and the harms from sedentary activities; 3) motivation to create supportive environment in the home for their children to practice healthy eating and life-styles. We will give the parents an innovative culturally appropriate leaflet to place in their kitchen to reinforce how to create a supporting home environment. The first parents meeting will take place immediately after the peer-education and further refresher meeting 6 months. We will try to link these with routine school meetings with parents.

d. Management of interventions

To facilitate the implementation process, an advisory committee consisting of a school principal, teachers, student and parent representatives, and the Department of Education representatives, other health professionals (e.g. dietitians) and project staff will help guide the research team and will meet every 3 months as the project progresses.

3. Outcomes and Significance

a. Outcome assessment

i) Key trial outcomes

- Change in mean BMI measured over the year of intervention.
- Dietary patterns including the frequency of consumption of fruit and vegetables, soft drinks and energy dense fast foods, and breakfast, as well as usual intake of macronutrients.
- An indicator of the confidence the adolescents feel in choosing healthy foods (dietary self-efficacy) and their control over food selection choices (dietary locus of control)
- Change in level of physical activity and sedentary behaviour as measured by questionnaire to capture activity patterns, record time in different levels of intensity of physical activity, and in a sub sample, accelerometer readings to validate the physical activity self-report with objective measurements.

ii) Measurements

1. Anthropometry trained research assistants will collect anthropometric measurements (weight, height, waist and hip circumferences) using established methods[67] in a private setting where the results will be confidential. These measurements will be standardised before and during the data collection. IOTF BMI cut offs will be used to define overweight and obesity.[68]
2. Dietary measures
   ♦ Dietary intake will be measured by a validated self-administered youth food frequency questionnaire (FFQ) developed and validated in Ho Chi Minh City, Vietnam.[69] This FFQ, which can be completed in 20 minutes, records usual frequency of consumption over the prior 6 months of 160 foods representing eight groups: (i) processed foods; (ii) rice, breads and cereals; (iii) meat, fish and seafood; (iv) fruits and vegetables; (v) sweets and snacks; (vi) milk and dairy; (vii) drinks; and (viii) miscellaneous; plus information about breakfast and frequency of out of home meals.

♦ Soft drink intake will be calculated from consumption of soft drinks recorded on the FFQ.

3. Indicators of confidence and control over healthy food choices
♦ Dietary self-efficacy will be measured using an 11-item scale,[70] with 5-point Likert scales ranging from `not confident at all' (1) to 'very confident' (5). Questions include confidence about choosing healthy foods and drinks when bored, sad or tense; eating with friends, family, alone, in a hurry or when eating take-away foods; or when someone else eats unhealthy foods. Self-efficacy is derived from the 11-item scale to give a score out of 5 with a high score indicating high self-efficacy related to healthy eating. High internal reliability coefficients for this scale (a = 0.90) have been reported.[JOD7]

♦ Dietary locus of control[70] will be measured using an 8-item scale with a 5-point Likert scale ranging from `never' (1) to `always' (5). Questions will include how often students had control over food purchase, preparation, individual food choices, quantity of food eaten, consumption of breakfast and types of food chosen for school lunch and foods eaten away from the home. We will calculate a score out of 5 from the 8-item scale with a high score indicating high dietary locus of control. Previous use of this scale found acceptable internal reliability coefficients (a = 0.76). We will need to adjust this scale for use in Vietnam.

4. Level of physical activity will be assessed by questionnaire with validation by accelerometer:
♦ The Adolescent Physical Activity Recall Questionnaire, which has been validated and has moderate reliability and validity in Vietnamese adolescents will be used. Activities are assigned a metabolic equivalent score (METs) according to the "compendium of physical activities".[71]

♦ The Adolescent Sedentary Activities Questionnaire, which has good to excellent reliability and good face validity in Vietnamese adolescents, will be used to measure sedentary behaviours including time for TV, playing games, computer and homework, and sedentary hobbies.

♦ Accelerometers will provide objective measures of physical activity in a randomly selected sub-sample of 200 trial participants from each treatment arm (n=400) to corroborate the questionnaire physical activity data. The accelerometer is worn around the waist for 8 days during waking hours[72] to assess usual physical activity levels.[73] Data are reduced with special purpose software into energy expenditure and intensity level categories and will be compared with physical activity reported in the questionnaire.[74] Previously reported methods will be used to maximize compliance with the use of the accelerometers.[75]

b. Sample Size & Power We estimate the sample size for the trial with the following assumptions:

- There will be about 8 to 10 Year 6 classes in each school with an average of 45 students per school giving approximately 350 to 450 adolescents for the evaluation in each school
- 90% power and 5% two-sided alpha
- Design effect of 1.835 & intracluster correlation coefficient (icc) of 0.0035 assuming cluster size of 243 [*based on reported school level design effects and icc for children and adolescents adjusted by age and gende*][76]
- Expected difference in mean BMI for age Z score between groups of 0.15 Z score as reported in recent meta-analysis of school-based combined physical activity and dietary intervention studies.[12] The mean BMI-for-age Z score is expected to be 0.39 Z score with standard deviation of 1.16 from results of HCMC Youth Cohort[77] for children of both sexes from wealthy districts aged 12 years.

Using standard formula.[64] the sample size required would be 4920 adolescents (2460 per group) from 20 clusters with 246 adolescents per school cluster. Taking account of the potential loses to follow up of 10%, we would need to recruit 5412 adolescents or 270 students per school to ensure this sample size for the outcome assessment.

c. Statistical Analyses Data analysis will be by intention to treat. Analyses will be conducted at the individual level, but appropriately adjusted for clustering within schools.[78] The primary analyses will compare the mean BMI-for-age Z scores at the final follow-up between the control and intervention groups using T tests and 95% confidence intervals for the group difference, adjusted for clustering. Secondary analyses will be conducted for the repeated measures for each outcome variable (minutes of moderate to vigorous physical activity per day, minutes of sedentary behaviour per day, and reported daily frequency consumption of fruit and vegetables, soft drinks, energy dense fast foods, and breakfast) using separate mixed models. We will use linear mixed models for the continuous outcomes (e.g. physical activity), generalized linear mixed models for non-continuous outcomes (e.g. logistic mixed models for binary outcomes). Models will include treatment group as a fixed effect, student as a random effect to account for the repeated measurements, and school as a random effect to account for the cluster effect. The models will be able to evaluate the impact of the interventions over time by testing for an interaction between time and intervention group. We will conduct analyses to identify the baseline characteristics of students who may benefit most from the intervention. We will check model assumptions and make appropriate adjustments to the analysis where necessary. We will conduct all analyses using STATA version 15 (StataCorp, College Station, Texas, USA)

d. Economic analyses We will calculate the Incremental cost effectiveness ratio (ICER) both for cost per case of overweight and obesity prevented and cost per unit of BMI, BMI Z-score (BAZ) reduction. We will first calculate the increment in costs, and differences in number of overweight & obesity cases across both intervention and control arms. We will then divide the cost differences by the differences between number of overweight and obesity cases. Similarly, we will calculate the ICER for BMI and BMI Z-score. We will conduct one-way sensitivity analysis around key variables, and a probabilistic sensitivity analysis to estimate the joint uncertainty in all parameters. We will plot a cost-effectiveness acceptability (CEA) curve as this provides information

about the probability that an intervention is cost-effective, given the willingness to pay for each case of overweight & obesity prevented.

e. Qualitative assessments will complement quantitative measurements and provide in-depth information for further contextualised interpretation of the findings. We will conduct qualitative surveys at baseline, mid-tern and endline assessments by using in-depth interviews and focus groups of Year 6 students, teachers and parents.

f. *Process assessment* is needed to examine the fidelity, dose, reach and intensity of interventions. We will document and assess: i) Participation rate in training sections and evaluation of training by participants; ii) self-reported adherence to lesson plans by peer leaders and teachers; iii) teachers reports and students assessments of the peer educators; and iv) contextual factors hindering and facilitating participants' healthy diet and physical activity behaviours. We will collect the data during the implementation of the interventions, and by in-depth interviews and focus groups of students, peer leaders, peer educators, teachers and parents at the end of the intervention.

4. Outcomes and Significance

Importance of the problem & planned outcome: WHO recognizes obesity as one of the most pressing global public health problems. Adolescent obesity increases the risk of adult obesity[79] and mortality.[80] The proposed trial will provide evidence on the efficacy of multi-component, peer-led behavioural change education with parents' support to promote healthy behaviours to prevent excess weight gain in adolescents, improve dietary patterns, increase levels of physical activity and reduce sedentary behaviour. The trial will establish if a school-based approach with parents' support to obesity prevention works in a large urban population in Vietnam. The proposed interventions are feasible to implement within schools across Vietnam using currently available resources.

Potential significance of the research: If the proposed interventions are efficacious in reducing overweight and obesity in adolescents and altering behaviours associated with excess weight gain, they will have wide application across Vietnam and in other low-and-middle income settings. The findings from this project will help us understand the relative importance of peer-led education and parents' support for lifestyle behaviour change. Most importantly, the interventions have the potential to reduce excess weight gain in adolescents thereby protecting them from a lifetime of ill health.

B. Project Schedule and Milestones Work plan

Stage & Methods	Year 1				Year 2				Year 3			
	1	2	3	4	1	2	3	4	1	2	3	4
Preparation: Institutional contracts, HREC approvals and develop tools & protocols												
Develop and adjust peer education materials												
Recruitment and training of Peer-Educators and Peer-Leaders												
Randomization process*												
Peer-led behaviour change education intervention (at intervention schools												
Peer support intervention												
Home engagement (parents support) intervention												
Evaluation Process*												
Data Collection for impact evaluation*												
Data cleaning, analysis, economic, analysis*												
Report and manuscript writing, dissemination*												

**Each of the following processes is planned to take place independently with specific staff to minimize potential bias: training, randomization, data collection, evaluation, analysis and reporting.*

Collaborative arrangements between participating institutions

We have already demonstrated an excellent capacity to work together on large projects that are geographically diverse with many research outputs and cross publications. There is existing research collaboration between 7 CIs through multiple NHMRC and MRC-UK funded. In addition CIA and CIC have worked extensively with 3 Vietnamese CIs including current MRC funded pilot project on adolescent obesity. CIC supervised CIs B & F, CIs A & C supervised CID's PhD. CIC worked with CIs B & F and implemented pioneering adolescent obesity cohort study in 2004-2009. Key elements in our approach to collaboration include: 1) using a schedule of in-country meetings, and regular internet communication 2) visiting Vietnam at the start to develop a field plan & data collection system; 3) participating in training & monitoring field activities in biannual visits; 4) holding monthly online team meetings to review & discuss project activities; & 5) developing mutually acceptable publication plans that will equitably allocate research products across the team reflecting research skills & team member contributions.

Assignment of individual research tasks and responsibilities

University of Sydney will lead the process of developing all intervention and evaluation tools, and peer education training. PNT University of Medicine will be responsible for implementation of both intervention and evaluation in the field. Uni Syd will lead the process evaluation. University of Sydney and PNTUM will jointly conduct data analysis and dissemination of results.

Expected outcomes of the research proposal

The proposed trial will provide high level evidence of the efficacy and cost effectiveness of school-based peer-led education intervention with support from parents at home on overweight and obesity in adolescents in urban settings in Vietnam. This trial of a theory-based approach to evaluate the impact of combined school- and home-based intervention on adolescent obesity will be an important study to show an efficacious and cost effective approach to reducing child in low- and middle-income populations. **Justification for the duration requested:** We have requested for 3 year funding. We have kept 6 months for preparation of study, which will include institutional agreements, ethical clearance at both University of Sydney and Vietnamese authorities, and development of all education, and peer and home support intervention material messages in appropriate format in both Vietnamese and English languages. We would recruit our participants in 3 months and would require providing intervention at least for 24 months. During the last 6 months we will perform the analysis and disseminate our results.

C. References

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Appendix 2

Response to reviewers' comments

Authors' response to reviewers

Manuscript title: *Perceptions and practices related to obesity in adolescent students and their programmatic implications: Qualitative evidence from Ho Chi Minh City, Vietnam.*

Manuscript ID: MACI-D-16-00792R1

Dear Editor,

We would like to thank the reviewers for their constructive comments that helped us improve the manuscript. Below we have addressed the comments point by point. We have also revised the manuscript based on the comments and highlighted the relevant changes.

Reviewer 2

We thank this reviewer for identifying some potential limitations of our study and suggesting us to address questions as limitations and potentially incorporate them into recommendations in the manuscript. In general, we have modified the limitation paragraphs of the discussion section (page 19) and the 'Conclusion and recommendations' section (page 20-21) in the revised version of the manuscript.

Below, we have addressed the reviewer's comments point by point.

1. *Sample size is quite small, and codes were developed based on only 3 interviews. Stratified analysis of a larger sample would have been helpful, especially allowing for separate consideration by gender and age subgroups (and perhaps BMI or obesity status).*

Sample size: We thank the reviewer for this feedback. We consider the sample size of this qualitative exploratory study adequate. Since our aim is not to provide results in a statistical form, this qualitative study does not require a large sample size. Our aim is to identify a range of key issues that have potential influence for an intervention designed to reduce risk of obesity in adolescent school children. We included varies types of respondents who would have roles in such an intervention such as, students, their physical education teachers, parents and education department official in our sample population. We are confident, the various types of respondents including direct and proximal target populations provided us data to achieve our objective. Moreover, the total number of respondents included in the study is not small for our qualitative explorative study comparing with many other published qualitative studies on the similar topic. We agree that stratified analysis of a larger sample would be helpful for a quantitative analysis, but our study adopts a focused qualitative explorative approach. We addressed these issues in the paragraphs on potential limitation in pages 19-20 in the revised manuscript.

Coding: A draft code list was developed based on the three translated interviews independently by the senior author (Alam) and the first author (Nguyen). These two authors discussed the draft code list and developed a revised code list which was open

to add new codes. Nguyen then continued reading each of the remaining transcripts in Vietnamese and added the new codes that emerged from the transcripts. The final code list was developed after all transcripts were read and coded. Thus, the codes developed from the three translated interviews was a draft list that was finalised based on all interviews included in the analysis. We have described the coding process on page 6 of the paper, and noted the possible limitations regarding coding process in the limitation section of the revised manuscript in pages 19-20.

2. *What limitations are imposed by restriction to a middle class population and students in Ho Chi Minh City?*

There is potential limitation of studying the students from middle class population residing in Ho Chi Minh City in regard to generalizability of findings. Given the scope of this qualitative explorative study aiming to generate knowledge to inform the design of an intervention targeting the same population, we do not consider it a major limitation of this study. However, we have addressed this issue as a potential limitation when we described the limitations of the study in pages 19-20 in the revised manuscript.

3. *Is obesity truly a risk factor or more likely a risk marker?*

We thank the review for raising this interesting question. While obesity is widely regarded as a risk marker, it can also be considered an independent risk factor as studies have accumulated evidence of obesity as a precursor of non-communicable health problems such as diabetes and cardiovascular diseases as reported by Mandviwala and colleagues in a recent systematic review.[1]

4. *To what extent are the intended interventions primary prevention as opposed to secondary or tertiary prevention and treatment? Is middle school/junior high school too late for primary prevention?*

Many high-income countries have implemented interventions to tackle obesity many years ago. Unfortunately, the situation in Vietnam is different where obesity prevention program is still a new area. The junior high schools are a good field of intervention because it would be an age where students can actually start to build up their healthy life style. Primary school students and younger children might be over-protected by the parents because of their too young age and thus attempts to intervene might fail. However, we agree to the reviewer that the intended intervention will be secondary or tertiary in nature. This could be a potential limitation of the intended intervention, not this study and the paper as the current study was designed and conducted to inform the design of the proposed intervention.

5. *Literature on "addiction" to electronic devices and Internet activity should be considered.*

We agree that excessive use of electronic devices and large amount of time spent on the Internet by the adolescent students are crucial aspects hindering healthy life style

[1] Mandviwala T, Khalid U & Deswal A. (2016). Obesity and cardiovascular disease: a risk factor or a risk marker? *Curr Atheroscler Rep* 18(5):21.

that should be considered in the desired intervention. Our interviews also revealed sitting time and time spent on screens as an aspect of the students' current behaviour that we descried in pages 15 and 19. We have also cited a relevant literature (Ref # 38).

6. *In addition to academic burden of after-school classes and pressure for high performance, are family responsibilities important (perhaps more so for girls)?*

Family responsibilities are important for girls than boys in Ho Chi Minh City in general. A few girl students mentioned about it spontaneously during the interview. However, our data do not support the issue of family responsibility as a significant issue that has an impact on healthy life style, probably because of our focus on urban middle class and younger age population in the study. Moreover, family responsibilities would also include household chores that might have a role in reducing obesity by increasing physical activity.

7. *Did any respondents discuss body image, shaming about obesity, or other social pressures? Is it possible that overweight is a sign of affluence and not stigmatized? Might this have different significance for males and females?*

We presented data on body image as many participants perceived obesity as just "looking fat." However, no body shaming was reported. One girl felt unhappy with her body, but did not mentioned about the shaming clues from anyone. Overweight as a perceived sign of affluence was not vividly evident in our data, although we think general people might draw an association between wealth and obesity.

8. *What about restrictions on exercise due to air pollution, traffic, and other environmental factors near school and home?*

We thank the reviewer for this insight. Air pollution and congested road traffic, and social environment issues such as robbery limit physical exercise opportunity outside home for young children in Ho Chi Minh City. We will consider these issues in the intended intervention.

9. *The example of Thailand would be a useful case study -- national effort to curb the growth of obesity due to consumption of extra snacks and meals (especially for middle class, and especially for boys due to differential feeding practices and allocation of resources) was quite effective as obesity emerged as a problem. Cooking classes and summer camps for boys as well as girls included educational efforts and attempts at culture shift.*

We thank the reviewer for providing this thoughtful insight and information. Thailand and Vietnam have lots of cultural and economic seminaries. The experience in Thailand should be beneficial to use in Vietnam. We will consider the suggestions when we design the intervention.

Reviewer 3

1. *Although I find the subject quite worthy of researching, the manuscript was too difficult to read through and score because of grammatical issues. It seems highly*

likely that the first language of the authors is not English. Too many of the sentences lacked clarity of meaning. Please see uploaded manuscript edits in PDF.

We gratefully thank the reviewer for making edits and sending the PDF which was immensely useful. We have incorporated the edits into the revised manuscript. In addition, we have further edited the paper thoroughly to fix the errors, and increase readability and clarity.

2. *Also, the numerous inclusions of statements from students, teachers and such made reading very difficult to follow. These statements may be better served only within tables.*

We included quotes of the respondents from the interviews. We understand, too many quotes would potentially create difficulty in following the flow of a scientific paper. We have revised and reduced the number of quotes considerably in the modified manuscript. We followed the standard writing style widely used by qualitative researchers and cited the quotes in the main body of the paper. We would retain this style, but have reduced the amount of quotes.

Reviewer 4

1. *My major gratification is with the methodology. This work projects no leniency and or weaknesses of the research design and methodology and manuscript formation. Reviewers' only contention is with the presentation and interpretation of the findings which could have been in more concise manner. The present study makes a decent contribution to the advancement of knowledge, theory, or practice.*

We very much thank the review for her/his comment and suggestions for a more concise presentation and interpretation of the findings. We have revised the manuscript to adhere to the reviewer's comments.

Please find attached the revised manuscript. Thank you for considering publishing our manuscript in your well-regarded journal.

Appendix 3

Ethical clearances

ỦY BAN NHÂN DÂN TPHCM
TRƯỜNG ĐẠI HỌC Y KHOA PHẠM NGỌC THẠCH

CỘNG HOÀ XÃ HỘI CHỦ NGHĨA VIỆT NAM
Độc lập – Tự do – Hạnh phúc

Số: 3783 /GXN-TĐHYKPNT

Thành phố Hồ Chí Minh, ngày 16 tháng 10 năm 2017

GIẤY XÁC NHẬN

Đề tài đã được xét duyệt và thông qua vấn đề y đức trong nghiên cứu y học

Hiệu trưởng Trường Đại học Y khoa Phạm Ngọc Thạch xác nhận:

Đề tài: "Can thiệp nhằm thay đổi lối sống năng động hơn thông qua giáo dục giữa bạn bè đồng trang lứa và hệ thống hỗ trợ của bạn bè đồng trang lứa: một nghiên cứu thí điểm thực hiện tại trường học trên trẻ vị thành niên TPHCM, Việt Nam", do PGS.TS. Tăng Kim Hồng - Phó trưởng Phòng Nghiên cứu Khoa học, Trưởng Bộ môn Dịch tễ học, Trường Đại học Y khoa Phạm Ngọc Thạch (Trường ĐHYK PNT) làm Chủ nhiệm đề tài. Đề tài đã được trình qua Hội đồng xét duyệt của Trường ĐHYK PNT (Quyết định thành lập số 2276/QĐ-TĐHYKPNT do Hiệu trưởng trường Đại học Y khoa Phạm Ngọc Thạch ký ngày 14 tháng 07 năm 2017) và đã thông qua vấn đề y đức trong nghiên cứu y học trong quá trình xét duyệt.

Ngày xét duyệt: vào lúc 10 giờ 30 ngày 24 tháng 07 năm 2017

Thời gian thực hiện đề tài dự kiến kéo dài trong 2 năm, bắt đầu từ tháng 08/2017 và sẽ thực hiện tại 4 trường Trung học cơ sở TPHCM.

Trân trọng kính chào./.

Nơi nhận:
- Như trên
- Lưu VT, P. NCKH, B (8b)

HIỆU TRƯỞNG,

TRƯỜNG ĐẠI HỌC Y [redacted] PHẠM NGỌC TH

PGS.TS. Ngô Minh Xuân