



UNIVERSITI PUTRA MALAYSIA

***DEVELOPMENT OF NUTRITION PRACTICE GUIDELINES AND ITS
EFFICACY IN COMBINATION WITH N3-LCPUFA SUPPLEMENT FOR
THE MANAGEMENT OF CHILDHOOD OBESITY***

NOR BAIZURA BINTI MD. YUSOP

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By

NOR BAIZURA BINTI MD. YUSOP

**Thesis Submitted to the School of Graduate Studies,
Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of
Doctor of Philosophy**

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

DEVELOPMENT OF NUTRITION PRACTICE GUIDELINES AND ITS EFFICACY IN COMBINATION WITH N3-LCPUFA SUPPLEMENT FOR THE MANAGEMENT OF CHILDHOOD OBESITY

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January 2017

Chairperson : Professor Zalilah Mohd Shariff, PhD
Faculty : Medicine and Health Science

The worldwide prevalence of overweight and obese children has steadily increased from 4.7% in 1990 to 6.7% in 2012. Dietary intake and physical activity modification are the first line of treatment for obesity in any weight management programme. However, both are highly dependent on the child's ability to follow recommendations. A combination of long-chain polyunsaturated fatty acids (n-3 LCPUFA), docosahexaenoic acid (DHA), eicosapentaenoic acid (EPA) and lifestyle modification showed positive results in weight management among adults.

There were three phases in the study. Phase I was aimed to develop Nutrition Practice Guidelines (NPG) for the Management of Childhood Obesity; the aim of phase II was to evaluate the effectiveness of the NPG; and phase III was aimed to determine the effect of Stage-based Lifestyle Modification for the Management of Childhood Obesity and n-3 LCPUFA supplementation on body composition, biochemical profile, diet and physical activity of obese children. Phase I had two parts. In part I, a survey was conducted to assess dietitians' current practices in the management of childhood obesity. In part II, a survey on the use of practice guidelines by dietitians in other countries was conducted. A comparison of the current practices of local dietitians and practice guidelines used by dietitians in other countries was conducted to identify relevant practice components for the development of the NPG.

In Phase II, a pilot study including 40 obese children aged 7–11 years old was conducted for a duration of 24 weeks. The intervention group received the NPG, while the control group received standard treatment for the management of childhood obesity. Outcome measurements of the intervention study including stages of change (SOC), dietary intake, body composition and physical activity were taken at baseline and every four weeks. None of the dietary intake outcomes had significantly different between the groups, while physical activity mean change difference between groups was significant ($p < 0.05$).

The post-treatment mean of weight and WC between the intervention group and the control group also did reach significance level ($p < 0.05$). Overall, the results demonstrated that the developed NPG are effective in managing childhood obesity.

In phase III, 37 obese children were included in a randomised controlled trial of effects of n-3 LCPUFA supplementation for the management of childhood obesity. Both groups received stage-based lifestyle modification, and the intervention group was also required to consume n-3 LCPUFA for a duration of 16 weeks. Outcome measurements of the study including body composition, biochemical profile, dietary intake and physical activity were taken at baseline, week 16 and week 24. The results showed that none of the differences in dietary intake, physical activity and body composition outcomes did reach significance level ($p < 0.05$) between groups. Only, LDL was significantly different between the two treatments. However, there were interactions of time and group for physical activity, weight, HDL, LDL and TC-HDL, which indicated that the values changed over time due to the treatments. N-3 LCPUFA is effective in improving the lipid profile but not dietary intake, physical activity and body composition of obese children.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

**PEMBANGUNAN PANDUAN AMALAN PEMAKANAN DAN
KEBERKESANANNYA DALAM KOMBINASI DENGAN N3 – ASID LEMAK
RANTAI PANJANG POLITAKTEPU UNTUK PENGURUSAN KANAK-
KANAK OBES**

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Prevalens kanak-kanak yang berlebihan berat badan dan obesiti seluruh dunia semakin meningkat daripada 4.7 % pada tahun 1990 kepada 6.7% pada tahun 2012. Modifikasi diet dan aktiviti fizikal adalah rawatan pertama untuk obesiti dalam program pengurusan berat badan. Walau bagaimanapun, kedua-duanya amat bergantung kepada keupayaan kanak-kanak untuk mengikuti saranan. Gabungan asid lemak rantai panjang politaktepu (n-3 LCPUFA), asid docosahexaenoic (DHA), asid eicosapentaenoic (EPA) dan pengubahsuaian gaya hidup menunjukkan keputusan yang positif dalam pengurusan berat badan dikalangan orang dewasa.

Terdapat tiga fasa dalam kajian ini. Fasa I adalah bertujuan untuk membangunkan Garis Panduan Amalan Pemakanan (NPG) bagi Pengurusan Kanak-kanak Obes; tujuan untuk fasa II adalah untuk menilai keberkesanan NPG; dan fasa III bertujuan untuk menentukan kesan pengubahsuaian gaya hidup berasaskan peringkat untuk pengurusan kanak-kanak obes dan suplemen n-3 LCPUFA terhadap komposisi badan, profil biokimia, diet dan aktiviti fizikal kanak-kanak obes. Fasa I mempunyai dua bahagian. Dalam bahagian I, satu survei telah dijalankan untuk menentukan amalan semasa pegawai dietetik dalam pengurusan kanak-kanak obes. Dalam bahagian II, survei mengenai amalan penggunaan garis panduan oleh pakar diet di negara-negara lain telah dijalankan. Perbandingan antara amalan semasa pegawai dietetik tempatan dan amalan garis panduan yang digunakan oleh pegawai dietetik di negara-negara lain telah dibuat untuk mengenal pasti komponen amalan yang relevan untuk membuat NPG.

Dalam fasa II, kajian rintis melibatkan 40 kanak-kanak obes berusia 7-11 tahun telah dijalankan untuk tempoh 24 minggu. Kumpulan intervensi menerima NPG, manakala kumpulan kawalan menerima rawatan standard bagi pengurusan kanak-kanak obes. Pengukuran hasil kajian intervensi termasuk peringkat perubahan (SOC), pengambilan diet, aktiviti fizikal dan komposisi badan diambil pada awal percubaan dan setiap empat

minggu. Tiada hasil pengambilan makanan yang mempunyai perbezaan yang signifikan di antara kumpulan, manakala aktiviti fizikal menunjukkan perubahan min antara kumpulan yang signifikan ($p < 0.05$). Min pasca-rawatan berat badan dan WC antara kumpulan intervensi dan kumpulan kawalan mencapai tahap signifikan ($p < 0.05$).

Dalam fasa III, kajian klinikal melibatkan 37 kanak-kanak obes telah dijalankan untuk menentukan kesan suplemen n-3 LCPUFA bagi pengurusan kanak-kanak obes. Kedua-dua kumpulan menerima pengubahsuaian gaya hidup berasaskan peringkat (termasuk NPG), dan kumpulan intervensi juga dikehendaki mengambil n-3 LCPUFA untuk tempoh 16 minggu. Pengukuran hasil kajian termasuk komposisi badan, profil biokimia, pengambilan makanan dan aktiviti fizikal yang diambil pada awal kajian, minggu ke 16 dan minggu ke 24. Hasil kajian menunjukkan bahawa tiada perbezaan dalam pengambilan makanan, aktiviti fizikal dan komposisi badan yang mencapai tahap signifikan ($p < 0.05$) antara kumpulan. Hanya LDL yang berbeza di antara kumpulan tersebut ($P < 0.05$). Walau bagaimanapun, terdapat interaksi masa dan kumpulan untuk aktiviti fizikal, berat badan, HDL, LDL dan TC-HDL, yang menunjukkan perubahan yang berbeza disebabkan rawatan yang diterima. N-3 LCPUFA berkesan dalam memperbaiki profil lipid tetapi tidak untuk pengambilan makanan, aktiviti fizikal dan komposisi badan kanak-kanak obes.

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I certify that a Thesis Examination Committee has met on 18 January 2017 to conduct the final examination of Nor Baizura bt Md. Yusop on her thesis entitled "Development of Nutrition Practice Guidelines and its Efficacy in Combination with N3-LCPUFA Supplement for Management of Childhood Obesity" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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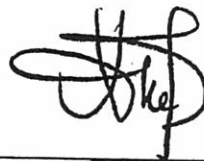
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LIST OF ABBREVIATIONS

BMI	Body Mass Index
BP	Blood pressure
CVD	Cardiovascular disease
DBP	Diastolic blood pressure
DHA	Docosahexaenoic acid
DM	Diabetes mellitus
EDTA	Ethylenediaminetetraacetic acid
ELISA	Enzyme-linked immunosorbent assay (ELISA)
EPA	Eicosapentaenoic acid
FAME	Fatty acid methyl esters
FBS	Fasting blood sugar
FFM	Fat free mass
FM	Fat mass
FMHS	Faculty of Medicine and Health Sciences
GC	Gas chromatography
HDL-C	High-density lipoprotein cholesterol
HOMA-IR	Homeostatic model assessment of insulin resistance
HPT	Hypertension
hs-CRP	High-sensitivity C-reactive protein
ITT	Intention-to-treat
LDL-C	Low-density lipoprotein cholesterol
MAC	Mid-arm circumference
MetS	Metabolic syndrome
MUAMC	Mid-upper arm muscle circumference

MUFA	Monounsaturated fatty acids
n3-LCPUFA	n-3 long-chain polyunsaturated fatty acid
NGP	Nutrition Practice Guideline
PAQ-C	Physical Activity Questionnaire for Children
PUFA	Polyunsaturated Fatty Acids
SBP	Systolic blood pressure
SFA	Saturated fatty acids
SOC	Stages of change
T2DM	Type 2 diabetes mellitus
TC	Total cholesterol
TG	Triglycerides
TTM	Transtheoretical Model
WC	Waist circumference
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

1.1 Childhood Obesity

Childhood obesity is a worldwide problem and its prevalence is increasing, particularly in developing countries undergoing nutrition transition. According to the World Health Organization (2014), the worldwide prevalence of overweight and obese children has steadily increased from 4.7% (31 million) in 1990 to 6.7% (44 million) in 2012 (Figure 1.1). Although global increment in number of overweight and obese children has been high, which is more than 10 million in 22 years, the percentage increment has been relatively low (less than 5.0%). Majority of national prevalence of childhood obesity remain moderate from 5.0% to 9.9% (WHO, 2014). It is projected that the prevalence of childhood overweight and obesity worldwide would reach 9.1% in 2020, which is equivalent to 60 million children (De Onis et al., 2010).

Although the prevalence of overweight and obese children in developed countries was higher than that of developing countries (11.7% vs 6.1%), the relative percentage change from 1990 to 2010 was higher for developing (65%) as compared to developed countries (48%) (De Onis et al., 2010). A report from the Organisation for Economic Co-operation and Development (OECD) revealed stable trends for the prevalence of childhood obesity between 2006 and 2012 in the United States of America, France, England and Mexico, ranging from 18.1% to 17.2% for boys and 14.1% to 13.6% for girls (OECD, 2014). Wabitsch et al. (2014) reported that while the prevalence of childhood obesity in developed countries remains stable, it is increasing in developing countries. The prevalence of childhood obesity in developed countries is stable due to the effectiveness of public health programmes that are aimed to reduce obesity through promotion of healthy lifestyle, such as increased physical activity, reduced television viewing and decreased consumption of sugar-sweetened soft drinks.

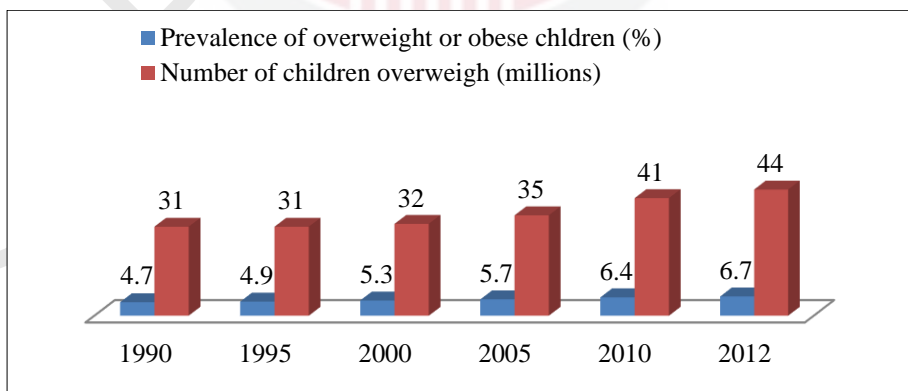


Figure 1.1: The number and prevalence of overweight or obese children globally, 1990–2012

(Source: WHO, 2014)

In Asia, the prevalence of childhood obesity is also on the rise. Since the 1970s, the average weight of children and adolescents has progressively increased (Ng et al., 2014). Childhood obesity was more prevalent in urban, small and medium-sized cities rather than in rural areas (Zong and Li, 2014). De Onis et al. (2010) reported that the prevalence of childhood obesity among children aged less than 5 years in 2010 was lower in Asia (4.6%) compared to Africa (8.5%), although the number of overweight and obese children was higher in Asia (17.7 millions) than in Africa (10.6 millions). Within Asia, the prevalence of obesity among pre-school children was highest in the Western region (14.7%), followed by the Eastern (5.2%), South Eastern (4.6%) and South Central (3.5%) regions (Figure 1.2). However, the South Eastern region (including Malaysia) was estimated to have the second highest prevalence of overweight and obese children in 2015 and 2020 (De Onis et al., 2010).

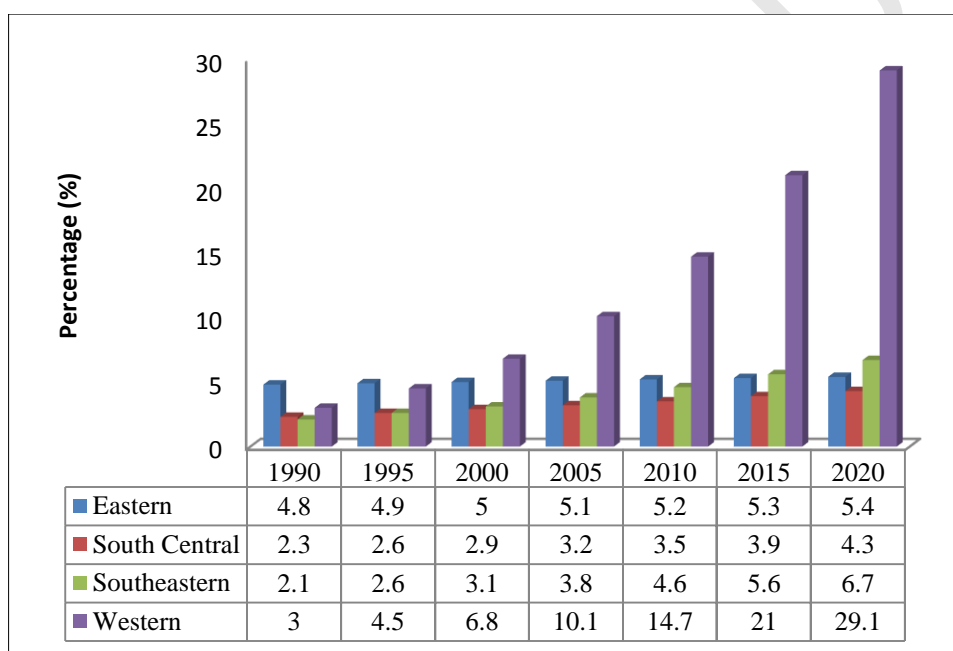


Figure 1.2: The prevalence of overweight and obese children aged 0–5 y from 1990 to 2010, and projections for 2015 and 2020
(Source: De Onis et al., 2010)

The Fourth Malaysian National Health and Morbidity Survey (NHMS) (2011) reported that the prevalence of obesity among children 0-18 year olds was 3.9%. Four years later, the Malaysian NHMS (2015), reported that the prevalence of obesity among children in the same age group was 11.9%. Meanwhile, data from the Nutrition Survey of Malaysian Children (SEANUTS Malaysia) showed that the prevalence of overweight and obesity in children aged 6 months to 12 years were 9.8 % and 1.8 %, respectively (Poh et al., 2013).

Obesity is a public health problem that requires urgent and effective intervention. Although childhood obesity has not been defined as a disease, it is known to be a predictor of obesity in adults and later life health problems such as high blood pressure, hyperlipidemia and hyperinsulinaemia (He et al., 2000). Metabolic syndrome (MetS) risk factors, including diastolic blood pressure, systolic blood pressure and waist circumference, worsened with increasing obesity (Quah et al., 2010) (Figure 1.3). Obese children were more likely to have higher weight for height ratio, percentage of body fat in subcutaneous fat and levels of liver enzymes, (Lee et al., 2008).

Quah et al. (2010) reported that, based on the criteria for the International Diabetes Federation (IDF) (2005), MetS was more prominent among obese children than non-obese children. In another study, majority of obese children (84%) had at least one risk factor for MetS and a quarter of them met the criteria for a diagnosis of MetS (Lee et al., 2011). In a recent systematic review, Friend et al. (2013) estimated that the global population prevalence of MetS among obese children was 3% and was higher in the Americas (4.8%) and Middle East (6.5%) compared to Europe (2.1%) and the Far East (3.3%). Wee et al. (2011) found that overweight and obese children were 16.3 times more likely than normal weight children to develop MetS.

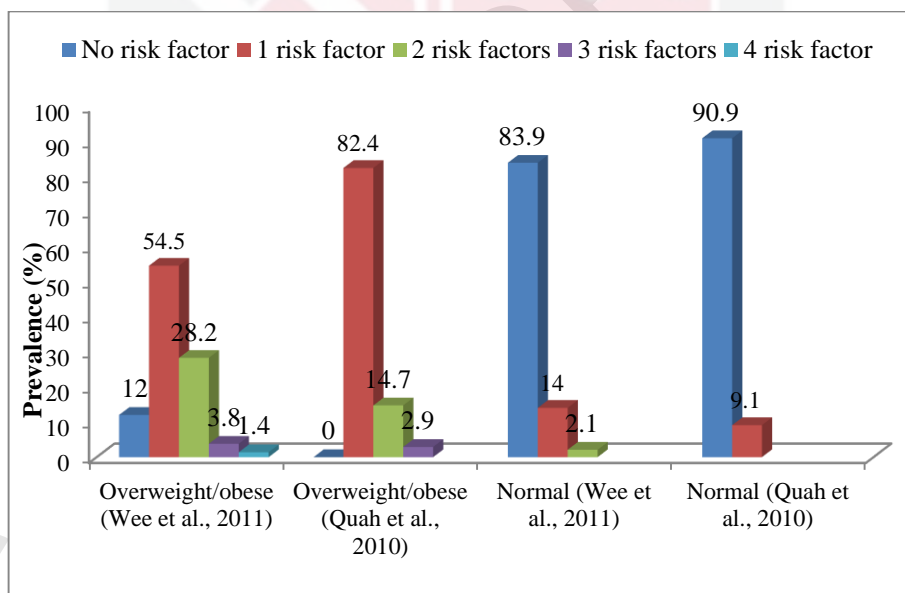


Figure 1.3: Metabolic syndrome among overweight/obese and normal weight children aged 8 to 11 years
(Source: Quah et al., 2010; Wee et al., 2011)

Risk factors of obesity among children at an early age (1 to 3 years) include genetics (fat mass and obesity-associated gene), high maternal pre-pregnancy BMI, maternal smoking during pregnancy, high birth weight, rapid weight gain during infancy, and early introduction of solid foods (Weng et al., 2012). As children grow, other contributing

factors were identified including dietary patterns and sedentary lifestyle (Vos et al., 2011; Reilly et al., 2005). Risk factors of childhood obesity vary by age and children at different ages appear to have different risk factors of obesity (Reilly et al., 2005).

1.2 Problem Statement

Dietary intake and physical activity modifications are the first line of treatment for obesity in any weight management programme (CPG, 2004). A reduction of total energy intake could be achieved by reducing the intake of high energy foods, increasing the intake of fruits and vegetables, and reducing fat consumption (Vernarelli et al., 2011). Physical activity is an essential component to achieve energy balance among obese children and improve body composition (Lazaar et al., 2007). However, weight management programmes for obese children have produced inconsistent results due to the lack of dietary compliance among these children, particularly compliance to the recommendation of fruits, vegetables and saturated fats. Compliance to dietary intake and physical activity modifications are highly dependent on children's ability to follow recommendations. (Huang et al., 2011, Horn et al., 2005). Therefore, weight management programmes for obese children required more effective counselling and monitoring process of these actions.

Difficulties in managing childhood obesity have led to the use of alternative methods to reduce or delay weight gain. One of the alternatives is to incorporate nutritional supplement in the weight management program (Rogovik et al., 2010). Combination of Long Chain Polyunsaturated Fatty Acids (n-3 LCPUFA) (docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA)) and lifestyle modification showed more positive results in weight management. Several studies on lifestyle modifications combined with n-3 LCPUFA supplements have been conducted among overweight and obese children, and adults for weight reduction and to lower the risk of MetS (Verduci et al., 2011; Pedersen et al., 2010; Fontani et al., 2005). N-3 LCPUFA improves energy balance, insulin resistance, body composition and reduce tumour necrosis factor alpha (TNF- α), adiponectin and leptin of adults and obese children (Lopez-Alarcon et al., 2011; Clarke, 2007).

However, there are limited clinical trials have been conducted among obese children. Pedersen et al. (2011) did not find any effect of n-3 LCPUFA on body mass index (BMI) or waist circumference, but showed a reduction in body fat percentage among boys. Other clinical trials (Dangardt et al., 2012; López-Alarcón., 2011) also did not find significant changes in body composition at the end of interventions with n-3 LCPUFA. Results from the trials were disparate and varied, and made it difficult to draw a robust conclusion because of different in study design, duration of the study, n3-LCPUFA dosage given to the participants and medium of n3-LCPUFA used. Nevertheless, in most of the trials, dietary intake and physical activity modifications were not systematically conducted. A trial that combine a comprehensive dietary intake and physical activity modifications and n-3 LCPUFA should be conducted to further investigate the effectiveness of the n-3 LCPUFA in weight management of obese children. A combination of these treatments could have a meaningful effect on childhood obesity management.

The prevalence of obesity among children in Malaysia continues to increase (Poh et al., 2013; NHMS, 2015). The increasing prevalence of overweight and obese children in Malaysia requires an effective treatment in the management of childhood obesity to prevent the development of chronic diseases in future. However, there are limited intervention studies focus on the management of childhood obesity. Sharifah et al. (2011) had conducted a well-designed trial to test best-practice individualised behavioural programme that emphasis on diet, physical activity, and sedentary behaviour. However, due to low intensity intervention programme, the study was failed to reduce BMI z score and increase level of physical activity.

Instead of intensity of intervention programme, the successful of the intervention programmes are determined by several factors such as children not ready to make changes (diet and physical activity modification), weight not decreasing after several appointments, children wanting to leave the programme and the programme not meeting their parent's or child's expectations (Skelton et al., 2011). Thus, it is important to find out an alternative method that can be used in Malaysia to accelerate the effects of weight management in children. N3-LCPUFA was found to have beneficial effects in reduced BMI, waist circumference and increased weight loss (Micallef et al., 2009). Therefore, it is a potential method to be used in the management of childhood obesity and there is no study has been conducted to test the effects of N3-LCPUFA in the weight management of childhood obesity in Malaysia.

1.3 Study Objective

There are three phases of this study. The first phase was the development of nutrition practice guidelines for the management of childhood obesity. The guidelines covered nutritional status assessment, determination of energy requirements, dietary prescriptions and modification of physical activity. The second phase assessed the effectiveness of the nutrition practice guidelines. The third phase focused on the effects of dietary n-3 LCPUFA supplement on body composition, biochemical profile, diet and physical activity of obese children.

Phase I: Development of Nutrition Practice Guidelines for the Management of Childhood Obesity

Main Objective:

To develop a Nutrition Practice Guidelines (NPG) for the Management of Childhood Obesity in Malaysia

Specific objectives:

1. To assess current practices of dietitians in the management of childhood obesity, including nutritional assessment, determination of energy requirements, dietary prescriptions and physical activity modifications; and
2. To compare the current practices with practice guidelines in other countries and identify practice components for the development of NPG for the Management of Childhood Obesity in Malaysia

Phase II: The Effectiveness of Nutrition Practice Guidelines for the Management of Childhood Obesity

Main Objective:

To evaluate the effectiveness of NPG for the Management of Childhood Obesity

Specific objectives:

1. To compare changes in:
 - a. Primary outcome: BMI-for-age
 - b. Secondary outcomes:
 - i. Body composition (waist circumference [WC], mid-upper arm muscle circumference [MUAMC] and body fat percentage)
 - ii. Energy and nutrient intakes (macronutrients, Saturated Fatty Acids [SFA], sugar and dietary fibre)
 - iii. Physical activity

between children receiving the NPG (i.e. intervention group) and the standard treatment (i.e. control group) for the management of childhood obesity.

Phase III: The Effects of Long Chain Polyunsaturated Fatty Acids (LCPUFA) Supplements on Body Composition, Biochemical Profile, Diet and Physical Activity of Obese Children

Main objective:

To determine the effect of Stage-based Lifestyle Modification for the Management of Childhood Obesity and n-3 LCPUFA (DHA and EPA) supplements on body composition, biochemical profile, diet and physical activity of obese children

Specific objectives

1. To compare changes in:
 - c. Primary outcome: BMI-for-age
 - d. Secondary outcomes:
 - iv. Body composition (waist circumference [WC], mid-upper arm muscle circumference [MUAMC] and body fat percentage)
 - v. Biochemical profile:
 - Lipid profile (total cholesterol [TC], triglyceride [TG], low-density lipoprotein [LDL] and high-density lipoprotein [HDL])
 - Fasting blood glucose (FBG), insulin and homeostasis model assessment insulin-resistance index (HOMA-IR index)
 - Fatty acid composition (DHA and EPA)
 - Others: adiponectin, high-sensitivity C-reactive protein (hs-CRP) and serum ferritin
 - vi. Energy and nutrient intakes (macronutrients, Saturated Fatty Acids [SFA], Polyunsaturated Fatty Acids [PUFA], Monounsaturated Fatty Acids [MUFA], cholesterol and sugar and dietary fibre)
 - vii. Physical activity

between children receiving Stage-based Lifestyle Modification for the Management of Childhood Obesity with or without supplementation of 1320 mg of n-3 LCPUFA (DHA and EPA).

1.4 Study Hypotheses

Phase II

- i. Body composition (i.e. BMI, WC, MAC, MUAMC and fat percentage) improves significantly in obese children receiving the NPG compared to children receiving the standard treatment for the management of childhood obesity.
- ii. Energy and nutrient intakes improve significantly in obese children receiving the NPG compared to children receiving the standard treatment for the management of childhood obesity.
- iii. Physical activity improves significantly in obese children receiving the nutrition practice guidelines compared to children receiving the standard treatment for the management of childhood obesity.

Phase III

- i. Anthropometric measurements (BMI, WC, MAC, MUAMC and fat percentage) improve significantly in obese children receiving the n-3 LCPUFA (DHA and EPA) supplements compared to those who do not receive the supplements.
- ii. Biochemical profiles (TC, TG, LDL-C, HDL-C, TC/HDL, glucose, insulin, HOMA-IR, hs-CRP, adiponectin and serum ferritin) improve significantly in obese children receiving the n-3 LCPUFA (DHA and EPA) supplements compared to those who do not receive the supplements.
- iii. Dietary intake (energy and nutrient intakes) and physical activity improve significantly in obese children receiving the n-3 LCPUFA (DHA and EPA) supplements compared to those who do not receive the supplements.

1.5 Research Conceptual Framework

Figure 1.4 shows the conceptual framework for this study. Overall, the study was conducted to develop nutrition practice guideline (NPG) and assess the efficacy of NPG in combination with n3-LCPUFA supplement for the management of childhood obesity. In the Phase I, NPG was developed based on data from surveys that conducted in local and other countries on dietetic practices in the management of childhood obesity. NPG was further tested in Phase II. Phase II was conducted to evaluate the effectiveness of NPG for the Management of Childhood Obesity. Nevertheless, phase III was the most important phase.

This randomised intervention study assessed the effectiveness of n-3 LCPUFA (DHA and EPA) for the management of childhood obesity. The experimental groups consisted of intervention and control groups with both groups receiving stage-based lifestyle modification (NPG for the Management of Childhood Obesity). In addition, the intervention group also was required to consume n-3 LCPUFA in the form of a capsule for a duration of 16 weeks. Outcome measurements were taken at baseline, at week 16 and at week 24.

The measurements were body composition (i.e. BMI-for-age z-score, WC, MAC, MUAMC, skinfold thickness and fat percentage), biochemical profile (lipid parameters, the levels of glucose and insulin, hs-CRP, free fatty acids (FFA), adiponectin and ferritin), clinical data (i.e. blood pressure), dietary intake (i.e. energy, carbohydrates, protein, fat, saturated fatty acids (SFA), polyunsaturated fatty acids (PUFA) and monounsaturated fatty acids (MUFA), dietary fibre, sugar, calcium and sodium) and physical activity.

The n-3 LCPUFA supplement was given in the form of fish oil capsules. Two fish oil capsules were consumed to achieve 1,320 mg of n-3 LCPUFA, providing 792 mg of eicosapentaenoic acid (EPA, 20: 5n-3) and 528 mg of docosahexaenoic acid (DHA, 22: 6n-3). The ratio between EPA and DHA was 1.5:1. The dosage of the supplements was determined based on the Recommended Nutrient Intake (RNI) for Malaysia and recommendations from previous studies (Lopez-Alarcon et al., 2011; Pedersen et al., 2010; NCCFN, 2005). Each participant was given sufficient fish oil capsules (60 capsules) for one month (30 days) during the intervention period. The participants were instructed to consume the capsules once a day before breakfast.

Participants in both groups also receiving a stage-based lifestyle modification intervention based on the NPG for the Management of Childhood Obesity. The guidelines consisted of four components, which include assessment of nutritional status (anthropometry, biochemical data and diet), determination of energy requirements, dietary prescriptions (a balanced diet of macronutrients, a low dietary fat and high fibre diet) and physical activity modifications (decrease sedentary behaviour and increase physical activity).

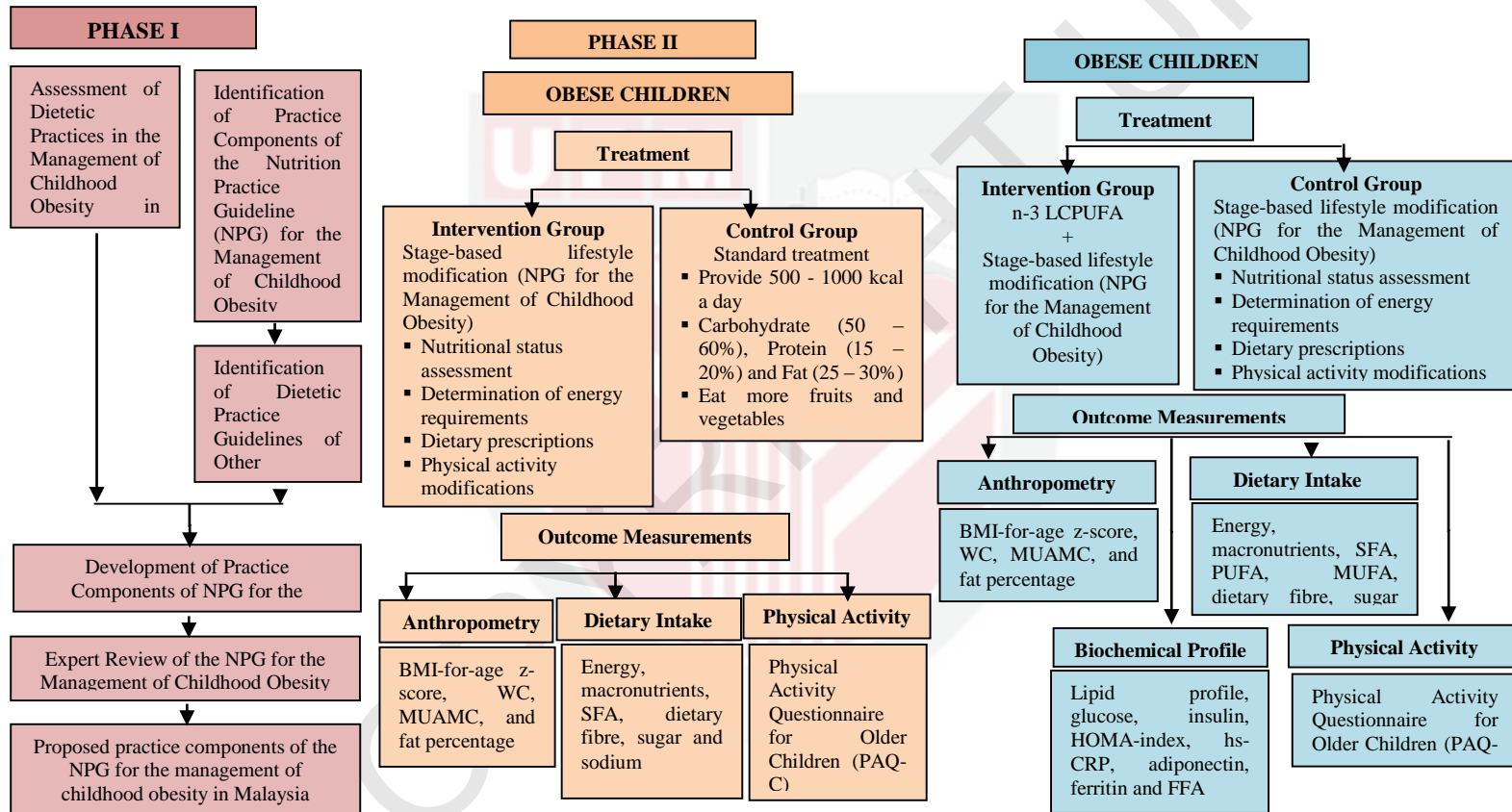


Figure 1.4 : Research conceptual framework

1.6 Study Importance

Despite the ever-growing body of research on obesity and efforts to investigate the causes and possible solutions for the problem, the prevalence of obesity in Malaysia continues to increase. The increasing prevalence of overweight and obese children in Malaysia requires an effective treatment strategy to prevent the development of chronic diseases in the future. Studies on weight management strategies for obese children have produced inconsistent findings due to the low rate of dietary compliance, particularly compliance to the recommended intake of fruits, vegetables and saturated fatty acids (Huang et al., 2011, Horn et al., 2005). Therefore, the use of dietary supplements for the management of childhood obesity as an alternative method should be further investigated.

One of the potential alternative treatments is supplementing the diet of obese children with n-3 LCPUFA. Increasing the intake of n-3 LCPUFA could assist in reduction of body weight and fat through multiple mechanisms. The n-3 LCPUFA, especially EPA and DHA have a unique ability to reduce the deposition of fatty acids in the body by enhancing thermogenesis. The metabolic action of n-3 LCPUFA in adipose tissue exerts numerous beneficial effects, such as improving energy balance and insulin resistance (Clarke, 2007)(Clarke, 2007)(Clarke, 2007)(Clarke, 2007). It could also reduce BMI, waist and hip circumference, and increase weight loss. Supplementing with fish oil stimulates β -oxidation, decrease adipose tissues and increases the regulation of mitochondrial biogenesis. In addition, it affected adipocyte differentiation, which could contribute to weight loss and decreased waist circumference. It also enhances post-prandial satiety that leads to reduced food intake (Parra et al., 2008)(Parra et al., 2008)(Parra et al., 2008)(Parra et al., 2008). Dietary supplement of n-3 LCPUFA could also reduce blood pressure associated with childhood obesity increased diastolic and systolic (Damsgaard et al., 2013). Childhood obesity was associated with several components of MetS, including diastolic and systolic blood pressure, as well as waist circumference worsening with increased obesity. Supplementing with n-3 LCPUFA could be beneficial in reducing the risk factors of MetS.

Dietitians play an essential role in the management of childhood obesity in that they could provide comprehensive dietary management. It is important for dietitians to know the most effective approaches and strategies for the treatment of childhood obesity. These approaches and strategies are important to ensure the most appropriate clinical decision-making takes place during counseling sessions to give the best possible outcomes. Consistency of treatment by dietitians is also important but at present, there are no local guidelines that specifically designed to be used in managing childhood obesity. One of the available guidelines is the Clinical Practice Guidelines on Management of Obesity (2004), which produced mainly for adults. The NPG for the management of childhood obesity was developed to standardize the treatment for childhood obesity and ensure consistency in approaches to lifestyle changes and dietary modifications. The guidelines have been developed along with national consensus and recommendations for the management of childhood obesity from other countries. The proposed NPG consists of a nutritional status assessment, determination of energy requirements, dietary prescriptions and recommendations for physical activity modification.

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