Nutritional Management in Childhood Obesity

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The increasing prevalence of overweight and obese children and adolescents poses a major concern worldwide. Dietary practice in these critical periods affects physical and cognitive development and has consequences in later life. Therefore, acquiring healthy eating behaviors that will endure is important for children and adolescents. Nutrition management has been applied to numerous childhood obesity intervention studies. Diverse forms of nutrition education and counseling, key messages, a Mediterranean-style hypocaloric diet, and nutritional food selection have been implemented as dietary interventions. The modification of dietary risk in terms of nutrients, foods, dietary patterns, and dietary behaviors has been applied to changing problematic dietary factors. However, it is not easy to identify the effectiveness of nutritional management because of the complex and interacting components of any multicomponent approach to intervention in childhood obesity. In this review, we describe the modifiable dietary risk factors and nutritional components of previous nutrition intervention studies for nutritional management in childhood obesity. Furthermore, we suggest evidence-based practice in nutrition care for obese children and adolescents by considering obesity-related individual and environmental dietary risk factors.

Key words: Pediatric obesity, Nutrition therapy, Diet therapy

INTRODUCTION

The childhood obesity epidemic has reached 124 million individuals, and nearly one in five children and adolescents are overweight or obese.¹ The worldwide trend in childhood obesity shows a steadily increasing body mass index (BMI) in children and adolescents across four decades. In East and South Asia, including South Korea, the BMI increase among children and adolescents has accelerated since 2000.² The prevalence of obesity in children and adolescents increased from 11.6% in 2008 to 17.3% in 2017.³ Obesity in early life is of concern due to health consequences and its influence on later life.⁴ Increased adiposity levels are strongly associated with developing metabolic disorders and signs of adverse cardiometabolic diseases.⁵ The severity of these comorbidities typically increases with the severity of the obesity.⁶

Dietary- and health-related behaviors and food preferences are established in early childhood and continue into adulthood.⁷ Poor food choices and overconsumption are associated with a higher risk of developing obesity.⁸ The prevalence of diet-related metabolic disorders such as obesity, glucose intolerance, elevated blood pressure, and dyslipidemia is increasing due to unbalanced food intake among adolescents.⁹ Dietary factors are the most important factors associated with childhood obesity,¹⁰ and prevalence rates of nutrition-related noncommunicable diseases such as obesity and diabetes in children and adolescents have prompted prioritizing healthy diets.¹¹

Dietary intervention and multisectoral approach intervention studies have reported positive changes in body composition and dietary factors for overweight and obese children and adolescents.¹¹⁻¹⁶ Dietary components such as energy-dense foods, sugar-sweetened beverages (SSBs) and patterns of processed food consumption are discussed among the modifiable risk factors associat-
ed with obesity in children and adolescents. In the present review, we describe the dietary risk factors associated with childhood obesity and summarize the previous efforts at nutrition management in multisectoral interventions. In addition, we suggest customized nutrition care for obese children and adolescents to improve young children’s dietary factors.

**DIETARY RISK FACTORS IN CHILDHOOD OBESITY**

Numerous diet-related modifiable risk factors (nutrients, foods, dietary patterns, and eating behaviors) have been considered in previous clinical research studies and suggested in guidelines on childhood obesity (Table 1). A higher intake of saturated fats and carbohydrates, including the overconsumption of energy-dense foods such as pizza, soda, and SSBs, has been associated with obesity in children and adolescents. Dietary patterns during childhood have identified associations between diet and diseases such as diabetes, hypertension, cardiometabolic risk, and childhood obesity. The Western dietary pattern, which contains high amounts of saturated fatty acids, is energy-dense, is micronutrient poor, and is limited in non-starch polysaccharides (fiber), is known to be a dietary risk factor encouraging childhood obesity. Diet patterns that are rich in meat, soda, fried food, instant noodles, burgers, and pizza increased the risk of obesity by 30% compared to diet patterns rich in whole grains, legumes, potatoes, fish, mushrooms, seaweed, fruits, and vegetables.

Unhealthy eating habits and patterns formed during childhood have been associated with nutrition-related noncommunicable diseases such as obesity and diabetes.

Sedentary behavior among children and adolescents, higher intake of snacks, consumption of SSBs, fast food consumption, eating while watching television, skipping breakfast, reduced numbers of family meal times spent eating together, and lower daily intake of milk, fruits, and vegetables have all been associated with increased rates of childhood obesity, leading to adverse health and dietary outcomes.

Meanwhile, an adequate nutritional intake of vitamins and minerals, whole grains, milk and dairy products, fruits, and vegetables in a balanced diet has been found to not only protect growth but also manage childhood obesity. In addition, it is recommended that proper dietary behaviors with family support include meals at home, eating together as a family, regular mealtimes, and portion sizes appropriate for the daily requirements of children and adolescents.

**NUTRITION-BASED MULTIDISCIPLINARY INTERVENTION COMPONENTS AFFECTING CHILDHOOD OBESITY**

Systematic reviews have suggested that multiple strategies and components and a multilevel approach that focuses on diet and health-related activities have provided the most sustainable and beneficial effects on childhood obesity intervention, rather than single-component interventions. Furthermore, social support such as individualized coaching, text messaging, face-to-face communication, and Internet-based approaches with a theoretical back-

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**Table 1. Diet-related modifiable factors affecting childhood obesity**

| Factor                        | Harmful                                                                 | Beneficial                                                                 |
|-------------------------------|-------------------------------------------------------------------------|---------------------------------------------------------------------------|
| Nutrient                      | Excessive intake of total energy, proteins (from animal products), fat, saturated fat, sodium | Adequate intake of vitamins C and D, non-starch polysaccharides (fiber), calcium, folate, iron |
| Food                          | Excessive intake of energy-dense foods: pizza, fast food, discretionary food, soda, sugar-sweetened beverages, and ice cream | Adequate intake of whole grains                                           |
| Dietary pattern               | Westernized dietary patterns high in saturated fatty acids, dense in energy, and poor in micronutrients | Balanced diet based on five food groups                                    |
|                               | Processed food dietary patterns, including meat, soda, fried food, instant noodles, burgers, and pizza | Stop-light/traffic-light diet, with food divided into three categories: green (low-energy, high-nutrient foods), yellow (moderate-energy foods), and red (high-energy, low-nutrient foods) |
| Dietary behaviors and eating habits | Eating while watching TV, Skipping breakfast, Frequent snacking and eating | Family mealtimes, eating together, Portion control, Regular mealtimes   |

Guidelines and recommendations of diet-related modifiable factors for nutritional management in childhood obesity.
ground have been adapted to change obesity-related dietary behaviors in children and adolescents. The most promising approaches for childhood obesity management are intervening with support at levels ranging from individual to community via sustainable and multisectoral strategies.

Let’s Move was a program of the U.S. government in collaboration with the American Academy of Pediatrics intended to provide Internet-based resources for BMI and diet and to develop activity screening in primary care, including counseling and advocacy methods for healthcare professionals. Consistent with this initiative, innovative use of health information technology was implemented via individualized coaching for behavior change, text messaging to provide outreach support for obesity management, and study-specific website and email programs, which had achievements similar to those found with face-to-face support.

The B’More Healthy Communities for Kids trial was a multilevel childhood obesity prevention intervention guided by social cognitive theory, social ecology, and systems theory. According to these theories, psychosocial factors, social-environmental factors, and physical factors interact at multiple levels to shape health-related outcomes. In this study, wholesalers, corner stores, take-out restaurants, recreation centers, and households worked together to improve availability, purchasing, and consumption of healthier foods and beverages (low sugar, low fat) in low-income African American zones in the city of Baltimore, MD, USA.

The Childhood Obesity Demonstration (CORD) project was designed to cover 4 years, including three grantees, Massachusetts (MA CORD), California (CA CORD), and Texas (TX CORD), funded by the Centers for Disease Control and Prevention. This set of three unique multilevel, multi-setting demonstration projects aimed to prevent childhood obesity by supporting healthy eating and active living among 2- to 12-year-old children. The results from the MA CORD study included changes in organizational policies and environments to better support healthy living and improvements in health behaviors of children, parents, and stakeholders.

The identification and prevention of dietary- and lifestyle-induced health effects in children and infants (IDEFICS) study was developed by eight European countries to implement and evaluate diet- and lifestyle-related diseases and was strongly focused on childhood obesity in a large population-based cohort of 16,228 European children aged 2 to 9 years. The IDEFICS intervention focused on the three main concepts of nutrition, physical activity, and stress, and it formulated six key messages. The prospective study reported that children consistently allocated to the “processed” cluster increased their BMI, waist circumference, and fat mass gain compared to children allocated to the “healthy” cluster. Being in the “processed”–“sweet” cluster combination was also linked to increased BMI, waist circumference, and fat mass gain over time compared to the “healthy” cluster.

**RECENT DIETARY INTERVENTIONS AND OUTCOMES**

We performed a systematic review of the literature for identifying the effectiveness of nutritional interventions using the electronic databases PubMed, Cochrane Library, and Web of Science, covering the past 5 years (2015 through August 2019). The following search terms were used: childhood obesity, obese children and adolescents, nutritional intervention, and dietary outcomes. Trials published in English were included in this study; the primary outcomes examined were energy, nutrient intake, fruit and vegetable consumption, and dietary behaviors.

**Dietary interventions**

Only articles on dietary outcomes were extracted from the databases by two researchers. Six studies are summarized in Table 2 among the dietary intervention studies that were selected by titles and abstracts. Nutritional components (nutrition education, key messages, Mediterranean-style hypocaloric diet, and nutritional food selection) and outcomes (energy and nutrient intake; fruit, vegetable, and dairy product consumption; and dietary behaviors) of the dietary intervention studies are presented in Table 2.

Nutrition education was delivered by health instructors at selected schools. Face-to-face training was used, with a book for guidance when necessary, for weekly nutrition sessions for the participants. Monthly lifestyle education sessions focusing on childhood obesity and its causes, cooking methods, and plans to reduce inactivity were provided to parents of the participants. Curtin University’s Activity, Food and Attitudes Program (CAFAP) study focused on healthy food choices and key messages: eat more fruit;
eat more vegetables; and eat less junk food. Regarding general nutritional themes, energy balance, food labeling, diet variety, fast food, lunchbox food, portion size, and recipe modification were the key topics reinforced in each session, delivered in 12 group education sessions with parents and adolescents together. Parents took part in nutritional sessions and in practical training in shopping at a

Table 2. Changes in dietary factors and weight status of children and adolescents after participating in nutritional interventions

| Study                                      | Subject                          | Duration | Intervention                                                                 | Nutritional component                                                                 |
|--------------------------------------------|----------------------------------|----------|-------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| Amini et al. (2016)                        | Fourth to sixth grades, overweight or obese, based on World Health Organization standards | 18 wk    | Nutrition education and increased PA for the pupils, lifestyle modification for the parents, and changes in food items sold at the schools’ cafeterias. | (1) Provided face-to-face training, the book General Knowledge of Nutrition whenever necessary, and a guide for health instructors; 15 to 45 minutes, once a week; 12 weekly sessions; concepts of overweight and obesity, food groups and energy, and obesogenic situations and strategies to overcome them (2) No nutrition education |
| Smith et al. (2015)                        | Aged 11–16 years, a BMI for the age and sex above the 85th percentile | 8 wk (follow-up 12 mo) | Twice-weekly group sessions at local community site (CAFAP) targeting the PA, sedentary behavior, and healthy eating behaviors of overweight adolescents | 12 Group education sessions with parents and adolescents together regarding general nutrition, energy balance, food labeling, diet variety, fast food, lunchbox food, portion size, and recipe modification, with the key messages reinforced in each session; cooking classes focusing on the preparation of healthy foods containing fruits and vegetables |
| Ojeda-Rodríguez et al. (2019)             | Aged 7–16 years, waist circumference above the 90th percentile according to national data | 8 wk (follow-up 22 mo, ongoing); data present only for 8 wk | (1) Moderate hypocaloric Mediterranean diet and received nutritional education (2) A 30-min individual session with the dietitian and five monitoring visits to assess anthropometric parameters | (1) Children were taught several topics such as food preparation, portion control, eating behavior, food composition. Intensive care participants followed a Mediterranean-style diet based on high consumption of fruit, vegetables, whole grains, legumes, nuts, seeds, and olive oil, minimally processed foods; moderate consumption of dairy products, fish, and poultry; and low consumption of red meat. (2) No nutrition education |
| Kustiani et al. (2015)                     | Aged 10–15 years, obese          | 5 wk     | (1) Nutrition education and PA intervention (2) Nutrition education and fruit intervention (3) Nutrition education, PA and fruit intervention | Nutrition education intervention was conducted for 30 minutes every week. Intervention of fruit was conducted on every school day (5 times/week) with 1–2 servings of fruit. (1) Fiber intake↑ (2) Fiber intake↑ (3) Fiber intake↑ |
| Serra-Paya et al. (2015)                   | Aged 6–12 years, overweight or obese | 8 mo     | (1) Family-based multicomponent behavioral intervention (2) Usual advice from their pediatrician on healthy eating and PA | Three behavior strategy sessions were designed to reinforce the acquisition of healthier PA and eating habits within the family. (1) Fruits (pieces/day)↑, processed meats (servings/day), fish (servings/day)↑, vegetables (servings/day)↑, legumes/pulses (servings/day)↑, superfluous foods (servings/day)↑, sugar-sweetened juices and soft drinks (servings/day)↑ (2) Fruits (pieces/day)↑, processed meats (servings/day), fish (servings/day)↑, vegetables (servings/day)↑, legumes/pulses (servings/day)↑, superfluous foods (servings/day)↑, sugar-sweetened juices and soft drinks (servings/day)↑ No significant difference of BMI between the two groups at post intervention |

(Continued to the next page)
supermarket and cooking classes for healthy foods such as fruits and vegetables.46

The Intervention Grupo Navarro de Estudio de la Obesidad Infantil study consisted of an 8-week phase and a 2-year follow-up program. The usual care group received standard pediatric recommendations and anthropometric measurements, while the intensive care group was advised to adhere to a Mediterranean-style hypocaloric diet. Nutritional theme-based topics included controlling healthy lifestyle behavior, food preparation, portion control, eating behavior, food composition, and the importance of being physically active during leisure time. In addition, information on healthy lifestyles and how to manage obesity-related problems was provided to the caregivers by dietitians.48

The Nereu Program (NP) was an intensive, 8-month, family-based, multicomponent behavioral intervention on healthy eating and physical activity in 6- to 12-year-old children who were overweight and obese. The NP consisted of the following four components: physical activity, family theoretical and practical training for parents, a behavioral component for both children and parents, and activities. For the usual treatment group, a 10-minute monthly family meeting based on the same NP components was provided over an 8-month period. Based on the food frequency questionnaire and main nutritional characteristics, the intervention addressed the following foods for participants and their families: all fruits, which have high levels of antioxidants, fiber, and vitamins; processed meats, which contain fatty acids; superfluous foods characterized by a high level of lipid content and/or simple sugars; and soft drinks, which have a high simple sugar content without nutrients.49

The school-based Educació en Alimentació (the EdAl study)50 program was designed to verify the sustainability of the benefits from a previous EdAl study by assessing the obesity-related outcomes and lifestyles of 13- to 15-year-old adolescents. The EdAl program was comprised of 12 educational intervention activities that were based on improving health-related habits such as nutritional food selection, hand washing, and avoiding sedentary behavior.50

Outcomes

Energy and nutrient intake

Two studies reported higher energy, protein, and fat intake after the intervention compared to baseline.45,46 Despite the lack of positive changes in macronutrient intake, lower levels of saturated fat and sugar consumption were presented in the CAFAP cohort study. In another multidisciplinary intervention study, lower energy intake and macronutrient intake were reported after the dietary intervention (at 8 weeks) in both the usual care group and the intensive care group.47

Consumption of fruits, vegetables, and dairy products

Improvements in consumption of fruits and vegetables among the children and adolescents were reported in three of the multi-component-approach intervention studies.46-48 Smith et al.46 stated that perceived fruit consumption and vegetable consumption of the participants were higher after the dietary intervention. Ojeda-Rodríguez et al.47 and Serra-Paya et al.49 presented higher levels of dairy product consumption as well as fruit and vegetable consump-

| Study | Subject | Duration | Intervention | Nutritional component | Outcome* |
|-------|---------|----------|--------------|-----------------------|----------|
| Llauradó et al. (2018)[50] | (n = 349) 13- to 15-year-old adolescents with childhood obesity | 4-yr follow-up | Twelve educational intervention activities that focused on eight lifestyle topics selected based on scientific evidence to improve nutritional food selection, healthy habits, and overall adoption of behaviors that encourage PA | (1) To encourage the intake of healthy drinks (and the avoidance of unhealthy carbonated sweetened beverages) (2) To increase the consumption of vegetables and legumes (3) To decrease the consumption of candies and pastries while increasing the intake of fresh fruits and nuts (second year) (4) To increase fruit intake (5) To improve dairy product consumption and to increase fish consumption | Only the intervention girls showed reduced BMI z-scores. |

Outcomes: (after the intervention) ↑: increase, ↓: decrease.

PA: physical activity; BMI, body mass index; CAFAP: Curtin University’s Activity, Food and Attitudes Program.
Unhealthy dietary behaviors

Lower consumption levels of sugar-sweetened juices and soft drinks and sweet, superfluous foods (cookies, pastries, dairy-based desserts, and French fries, which contain high levels of lipids and/or simple sugars) were shown after the dietary intervention in three of the preceding studies.46,47,49

Body composition

Most of the studies showed decreased BMI z-scores of obese children and adolescents after 6 weeks to 6 months for each of the intervention studies. Theme-based nutritional sessions, involving portion size and food groups,51 feelings of hunger and satisfaction,52 nutrition counseling and phone calls,53 nutrition education group sessions and leaflets for caregivers,54 healthful and balanced diet with fruits and vegetables,55 and healthy beverage intake and increased consumption of fruits, nuts, legumes, vegetables, fish, and dairy products50 were implemented in childhood obesity intervention studies (data not shown).

EFFECTS OF INDIVIDUALIZED NUTRITIONAL MANAGEMENT ON CHILDHOOD OBESITY

There are numerous risk factors for obesity in children and adolescents, and these factors interact with a high level of complexity. The nutritional care process model (NCP)56 (Fig. 1) could be adapted well to this complex task through dietitian-delivered lifestyle interventions.57 The Academy of Nutrition and Dietetics developed the NCP, a highly qualified systematic approach to care, by employing four interrelated steps: nutritional assessment, diagnosis, intervention, and monitoring/evaluation. There is a requirement for standardizing the NCP and increasing the quality and consistency of nutritional care by using the International Dietetics and Nutrition Terminology (IDNT).58,59 Previously, we developed a study protocol60 to manage the dietary problems of moderately to severely obese children and adolescents by adopting the NCP and IDNT. Three general domains—nutrition intake, nutrition clinical, and nutritional behavioral—were employed for nutritional diagnosis (Table 3). Nutrition diagnosis is the act of identifying a disease or condition from its signs and symptoms by a dietetics profession. An identified nutritional problem is summarized into a structured

Figure 1. Nutrition Care Process and Model. Academy of Nutrition and Dietetics. Adapted from Lacey and Pritchett. J Am Diet Assoc 2003;103:1061-72, with permission from Elsevier.56
sentence called a PES (Problem, Etiology, Symptom) statement. This statement is linked by the connecting terms problem/nutrition diagnosis related to etiology as evidenced by the signs and symptoms. The identified etiology, signs and symptoms point to a certain type of nutrition intervention and monitoring/evaluation that is needed. It is an important process in the implementation of a nutrition intervention and monitoring/evaluation of the NCP. A structured recommendation for nutritional management of childhood obesity was presented as a tool in another research study that helped practitioners structure their actions according to the four interrelated steps of the NCP model. This practice-based, evidence-informed approach assisted not only the dietitians but also the professionals in pediatric obesity. The NCP four-step structured framework made it possible to structure patient-centered nutritional care and management of childhood obesity.

**CONCLUSION**

Dietary intervention with a multisectoral approach has had positive outcomes in modifying obesity-related dietary risk factors for obese children and adolescents. Excellent results from previous meta-analyses have reported a reduction in SSB intake and changes in body fatness, reduction in high-fat food and sugary beverages, increased intake of fruits and vegetables, reduction in snacks, and maintenance of a balanced diet.

These positive changes were found immediately after the intervention; however, unfavorable outcomes were reported after long-term follow-up in terms of weight fluctuation, increased energy intake, macronutrient intake, and unhealthy dietary behaviors. Furthermore, it is hard to distinguish isolated impacts of nutrition care in childhood obesity because of the complex and interacting components of the multidisciplinary interventions. Behavioral modification and motivational interviewing on the health and diet of children and adolescents, to improve their self-control and mindful eating for sustainable healthy weight and nutritional status, are required to provide nutritional education and management.

From this viewpoint, evidence-based practice in dietary problem solving can suggest effective methods by considering behavioral approaches.
and environmental risk factors in a diet and providing tailored nutritional therapy according to the stages of change among children and adolescents. In spite of these beneficial effects, we are facing barriers to providing this intervention due to the time and cost of developing more methods for countering childhood obesity. For this reason, individual, familial, social, and political-level involvement are recommended for effective and sustainable nutritional management of childhood obesity. In addition, practical key messages for health and diet may be helpful in establishing healthful habits and lifestyles in this public health crisis.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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AUTHOR CONTRIBUTIONS

Study concept and design: HL; analysis and interpretation of data: JK; drafting of the manuscript: all authors; critical revision of the manuscript: all authors; administrative, technical, or material support: JK; and study supervision: HL.

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