博士論文の要約

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学位論文題名

Obesity in elementary school children in Northeast China:
affecting factors, the effect of intervention, and
the impact of body image on weight reduction
（中国東北部における小学生の肥満について―影響因子・介入効果・
ボディイメージの体重減少に対する影響―）

Ⅰ：*Diet, fitness and nutritional status of school children* [Chapter 1]

Background

Childhood obesity has become a major health issue. Although developed countries have a higher rate of childhood obesity, the total number of obese children in developing countries is greater than in developed countries. Moreover, over the last decade, childhood obesity rates in developed countries stabilized while rates in developing countries continue to rise.

Poor physical fitness in children has also increased considerably. Issues surrounding childhood obesity and poor physical fitness are more serious in economically developing Asian countries, relative to those of Japan.

Obesity and poor physical fitness are risk factors for lifestyle-related diseases such as high blood pressure, coronary heart disease, and stroke. While symptoms usually manifest in midlife, these conditions develop progressively over time with signs appearing as early as childhood and adolescence.

Objective

The purpose of this study is to investigate nutritional status and physical fitness level in local elementary school children and explore factors associated with obesity.

Materials and methods

Anthropometric measurements, a dietary survey, and a physical fitness test were performed to assess 971 primary school children. Education levels of both father and mother, and monthly income were collected using a self-attested questionnaire at the parents' meeting.

Results

There was a high proportion of overweight and obese subjects: urban boys: 49%; rural boys: 35%; urban girls: 33%; and rural girls: 20%.

Except for the skipping rope score, mean scores exceeded cut-off values for passing marks in urban boys. Compared to the rural children, there was a higher proportion of failing scores in the urban children. Besides, skipping ropes for one minute was correlated with upper arm muscle in both urban and rural children ($P < 0.05$).

Energy intake, macronutrient intake (protein, fat, and carbohydrates), energy ratio (ratio for total energy intake), and intake of nine food groups was calculated for urban and rural children. Intakes of energy, protein, and fat were significantly higher in urban children than in rural children. Intake of grains, meat, eggs, and beans was higher compared to the Chinese recommended dietary allowance, while intake of fruit, fish, and milk was lower.

Skipping rope ($\beta = - 0.34$, $P < 0.01$); daily exercise time ($\beta = - 0.30$, $P < 0.01$); daily screen time ($\beta = 0.24$, $P < 0.01$); edible oils ($\beta = 0.15$, $P < 0.01$), grain ($\beta = 0.13$, $P < 0.01$); family income ($\beta = 0.11$, $P < 0.01$); and sex ($\beta = 0.10$, $P < 0.01$) were significant predictive factors of overweight and obese for both urban and rural children.

Discussion

In this study, we found that school children in Northeastern China have high rates of overweight and obesity. The proportions of overweight and obese subjects were lowest in rural girls relative to those of the other groups; however, 20% of rural girls were considered overweight or obesity. The prevalence of overweight or obesity in this study was higher than the China national survey results (21.1%), except for rural girls. Intake of nine food groups was relatively higher in urban children than in rural children, consistent with the finding that intakes of energy, protein, and fat were higher in urban children than in rural children. These results could be related to our findings that anthropometric measurement values in urban children exceeded those of rural children.

Signs of poor physical fitness have also been found, compared to the results of China

national survey. Results for 50-m run time, long-seat body anteflexion, and skipping rope were better than in this study. In addition, results for the 50-m run and long-seat body anteflexion in the Japanese physical fitness test were better than in this study. Similar to results found by the China national survey and in other developing countries, rural children performed better on their physical fitness tests than urban children. Similar to results found by the China national survey and in other developing countries, rural children performed better on their physical fitness tests than urban children.

Improvement in diet, such as reducing grain and edible oils intake, are essential, and increasing exercise to promote muscle mass are recommended. Finally, by increasing muscle mass, skipping ropes can help reduce obesity and improve physical fitness.

II : ***Effects of a combined intervention of rope skipping and nutrition for overweight children*** [Chapter 2]

Background

There are various kinds of methods for exercise and nutrition interventions. For exercise interventions, sports like swimming, jumping, skipping rope, cycling, tennis, and running are often used separately or with a combination of 2 or more sports. Exercise interventions combining rope skipping with other sports are effective for improving obesity. The advantages of rope skipping were recognized in the national physical fitness survey for Chinese elementary school and secondary school students. This study chose skipping rope as a measure of physical fitness, which has relatively higher metabolic equivalents. For nutrition interventions, 2 methods dietary restriction and nutrition education are implemented separately or simultaneously.

Nutrition education as an intervention has long-term effects that are maintained. Currently, there is no conclusion on whether the sole use of exercise or nutrition as an intervention is more effective than the combination of the two. There is only a limited number of studies that have focused on changes soon after the intervention in addition to conducting a long-term follow-up survey assessing the effect of the intervention. By clarifying short-term and long-term advantages of a single intervention involving exercise or nutrition education as well as the combination of the 2 types of interventions, the findings can be used as a reference for developing interventions to decrease childhood obesity and for conducting similar studies in the future.

Objective

This study aimed to compare the effects of 3 methods for improving body measurements—exercise or nutrition education as sole interventions and the combination of exercise and nutrition education—and to verify the maintenance of the effects of the 3 types of interventions 1 year later for overweight and obese elementary school children in a rural area of China.

Materials and methods

We selected 2 of 3 rural elementary schools with the largest number of students in one district of Benxi City, Liaoning Province, in Northeast China. 221 primary school children aged 9 to 12 years determined as overweight/obese were randomly assigned to 1 of 4 groups: exercise intervention (E), nutrition education (N), combination of both (EN), and control (C). Anthropometric measurements and nutrition knowledge test were administered at baseline, after 2 months (post intervention), and 1 year later (follow-up).

Nutrition education:

A textbook widely used in China was adopted by a local nutritionist to give a 45-minute lecture about nutrition education once a week for 2 months (8 lectures, 6 hours in total).

Exercise intervention:

This study chose skipping rope, which has relatively high METs (METs = 10.0) and the effects can be achieved in a short amount of time. The exercise intervention involved 30 minutes of rope skipping on the school sports grounds every morning before class.

Results

Scores on the nutrition knowledge test significantly increased after the intervention (40% to 82%) in both girls and boys in the 2 groups (N and EN) who took the nutrition education class ($P < 0.05$). The test scores significantly decreased at follow-up 1 year later, but were still significantly higher than at baseline ($P < 0.05$). On the contrary, in the C group and E group, except for girls in the E group at follow-up and boys in the E group at post intervention, there was no significant change among girls and boys at post intervention and follow-up.

When the E group completed the intervention, the percentage of children with an exercise habit increased considerably. On the other hand, the percentage of children who had an exercise habit in the N group did not increase at post intervention, but increased considerably at follow-up compared with baseline. The EN group experienced both short-

and long-term effects.

The effect of the intervention by the amount of change in body mass index standard deviation scores (BMI-SDS) was confirmed. Combined intervention was found to be most effective for the score of BMI-SDS followed by exercise intervention and nutrition education. Combined intervention was also most effective for the gap in the score of BMI-SDS between following-up and baseline followed by nutrition education and exercise intervention.

Discussion

Nutrition education has not yet been conducted in both urban and rural areas in China. Thus, we assume that learning about food and nutrition was something new and fresh for the elementary school students, which was an important reason as to why they retained what they had learned about nutrition. As for energy intake, it decreased significantly after the intervention and the decrease lasted for 1 year after the intervention, suggesting that nutrition education can be an effective intervention for overweight and obese children in rural areas of China.

The development of exercise habits is the key to long-term effects of the exercise intervention. In this study, there are no students who dropped out of the two-month exercise intervention. In addition, it can be suggested that PE- teacher supervision and active participation of students in exercise intervention are the most effective elements that contribute to short-term effect on obesity reduction. However, exercise behaviors are difficult to sustain long term. Very few people exercise without positive intentions, and persuasive messages emphasizing health and weight management benefits are good for motivating exercisers to continue exercising. The lack of such messages for the participants in the exercise group may be a reason for why the exercise intervention did not have long-term effects.

Overall, the combined intervention had both strongest short-term and long-term effects compared to the other interventions. The exercise intervention had a better short-term effect than nutrition education, while nutrition education had a better long-term effect than the exercise intervention. This refers to the connotation that nutritional education has a larger impact in the long run, highlighting the importance of enlightening the children in nutritional aspects persistently.

III: ***The association of parents' perceptions of body image on children's obesity*** [Chapter 3]

Background

Body image is a psychosocial dimension and it is viewed as central to many aspects of human functioning, including emotions, thoughts, behaviors and relationships. Therefore, body image may affect eating habits and exercise habits. Body image has an important relationship with eating disorders and active participation in sports.

In addition to media, parents are another factor that influences the body image. Most of the important information that children receive about their self-worth and body image was seen and heard at home. The diet of adults and the problem of body image are very likely to be transmitted to children.

Body image is recognized as part of the spectrum of conditions related to disordered eating, and given its increasing trend, its relationship with body image and dissatisfaction has become a focus of research. Moreover, there are not many longitudinal studies on body dissatisfaction and its effects on weight reduction; thus, the causal relationship between body dissatisfaction and weight reduction needs to be clarified.

Objective

The aim of this study was to examine gender differences in parents' dissatisfaction with their children's body and body dissatisfaction among children themselves, and lastly to investigate the factors affecting weight reduction.

Materials and methods

We selected two elementary schools in the rural areas of Benxi City, Liaoning Province, Northeast China. These children participated in a rope skipping exercise intervention and nutrition education conducted from August to September 2015. We surveyed 218 students aged 11-14 years and their parents, who agreed to cooperate in this study conducted from August to September 2017. For height and weight, we used physical examination data collected in June 2017 and the data authors measured in June 2015. BMI (kg/m^2) was calculated using height and weight. Ideal weight for children was reported by children themselves and their parents. Body dissatisfaction of children was calculated considering children's actual BMI (2015) and the ideal BMI (2017) values by children themselves, their fathers, and their mothers.

Results

For girls, their own and their mothers' body dissatisfaction were significantly higher than their fathers' ($P < 0.05$). The level of body dissatisfaction of girls was significantly higher than that of boys ($P < 0.05$). There was no difference in the level of body dissatisfaction of the fathers according to their children's gender; however, mothers' dissatisfaction with their daughters' bodies was significantly higher than with their sons' bodies ($P < 0.05$).

Multiple regression analysis was performed to identify the factors that contributed to weight reduction for each gender. For girls, mother's dissatisfaction with daughters' body ($\beta = 0.43$, $P < 0.01$), BMI of mothers ($\beta = -0.37$, $P < 0.01$), girls' own body dissatisfaction ($\beta = -0.24$, $P < 0.01$), and age ($\beta = 0.17$, $P < 0.01$) were significant predictive factors of weight loss. For boys, mother's dissatisfaction with sons' body ($\beta = 0.28$, $P < 0.01$), boys' own body dissatisfaction ($\beta = -0.28$, $P < 0.01$), education level of fathers ($\beta = 0.22$, $P < 0.01$), household monthly income ($\beta = 0.20$, $P < 0.01$), and BMI of fathers ($\beta = -0.20$, $P < 0.01$) were significant predictive factors of weight loss.

Discussion

According to the results of this study, boys and girls did not differ in BMI; however, mothers' level of dissatisfaction with their daughters' body was higher than that with their sons' body. With the increased presence of the media not only in the West but also in China, the concept that women's slim figure is beautiful has been deeply rooted in the public's mind. In modern society, women tend to consider a slim figure as one of the conditions to gain more benefits. Parent's dissatisfaction with their children's body type has been known to affect the body image of children, particularly in girls. Therefore, girls are more likely to change their lifestyle habits when parents criticize their body type.

The impact of body image on weight reduction was also investigated. Mothers' dissatisfaction with their children's body was found to significantly predict weight reduction in children. However, children's body dissatisfaction negatively predicted weight reduction. Higher BMI of father and mother negatively affected weight reduction of their same-sex children. Our findings indicate the importance of examining gender roles in body image perceptions of parents and children in order to address obesity issues in rural China.

IV: Conclusions

Cross-sectional study (Chapter I) implicated that skipping ropes may enhance muscle mass while intake of edible oil and grain may exacerbate obesity of children. The findings of the intervention study (Chapter II) revealed that the combined intervention had the best short-term and long-term effects for overweight children of all interventions. Furthermore, the exercise intervention had a better short-term effect than nutrition education, while nutrition education had a better long-term effect than the exercise intervention. In psychological aspects, body image perceptions of parents and children had an important impact on weight reduction (Chapter III).