Intervention for Childhood Obesity in Beijing, China

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**Abstract**


Childhood obesity appears to be increasing throughout the world. China has joined the global epidemic. Childhood obesity is not only a chronic disease which is associated with lifestyle, but also a public health problem in children. Obesity intervention should become a public health priority in China. This thesis reports on intervention to treat and prevent childhood obesity. The field work was implemented in Beijing, China.

This thesis is based on four papers: Paper I evaluated the feasibility and impact of family-based behavior treatment on obese children. Two years of intervention resulted in obese children with improvements in body mass index, total cholesterol, triglycerides, and blood pressure.

Paper II assessed the effects of a school-based intervention on obesity among primary school children. After a three-year intervention, the prevalence of overweight and obesity were significantly lower in the intervention schools than in the control schools. Fewer non-obese children became obese in the intervention schools than in the control schools.

Paper III explored the family related factors of overweight in 2- to 6-year-old children. Significant associations were observed between children’s overweight and parent characteristics for frequency of eating in restaurants, daily time spent viewing television, and engaging in physical activity. Child overweight was associated with parental overweight, low maternal education level and television watching ≥2h/d.

Paper IV investigated how grandparents influence their young grandchildren’s eating behaviors in Chinese three-generation families, using qualitative method. Three domains identified through the seven themes included: (1) Grandparents as primary caretakers of children in the three-generation family, (2) Grandparents’ attitudes to child nutrition and healthy eating habits, and (3) The role of food as an educational and emotional tool. The results showed that nutrition education involving grandparents is thus a potential framework for improving healthy dietary behaviors in young children.

**Keywords:** Obesity, intervention, childhood, behavior modification, risk factors, family influence

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List of Papers

This thesis is based on the following four articles, which will be referred to in the text by their respective Roman numbers:

I  
A two-year family-based behaviour treatment for obese children
  Jiang JX, Xia XL, Greiner T, Lian GL, Rosenqvist U
  *Archives of Disease in Childhood* 2005; 90 (12): 1235-1238

II  
Three-year school-based intervention to reduce the prevalence of obesity
  Jiang Jingxiong, Xia Xiulan, Ted Greiner, Wu Guangchi, Urban Rosenqvist.
  *Child: Care, Health & Development, Submitted and revised*

III  
Risk factors for overweight in 2- to 6-y-old children in Beijing, China
  Jingxiong Jiang, Urban Rosenqvist, Huishan Wang, Ted Greiner, Yi Ma, André Michael Toschke

IV  
Influence of grandparents on eating behaviors of young children in Chinese three-generation families
  Jiang Jingxiong, Urban Rosenqvist, Wang Huishan, Ted Greiner, Lian Guangli, Anna Sarkadi
  *Appetite* 2006; Submitted and revised

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Introduction

This thesis reports on the intervention of childhood obesity in Beijing, China. China is a developing country. Infectious diseases and malnutrition were the main health problems in children in China before the 1990s. With reforms and the opening of China since 1980s, the economic status of the population has developed. Lifestyle has also changed considerably with increased family income. The changes are especially prominent in cities. Children’s nutrition status has also improved with the economic development and obese children are more often seen in urban areas. The prevalence of obesity was 1% in children under 6 years old and 3% in school children in Beijing in the middle of the 1980s (Ding, 1988). It increased to 3% and 10% in children under 6 years old and school children, respectively in the middle of the 1990s (Jiang, 1999; Luo & Hu, 2002).

Obesity is an energy imbalance in combination with genetic and environmental factors (Ravussin & Bogardus, 2000) that promotes excessive fat deposition. Although many studies have highlighted the role of genetics in body weight regulation (Bouchard & Tremblay, 1990; Maes, 1997), the behavioral and environmental factors, such as sedentary lifestyles (Cordain, 1998) and unhealthy dietary patterns and eating habits which cause excess energy intake (Bray & Popkin, 1998; Hill, 2000), are primarily responsible for the increasing prevalence of obesity. The high prevalence of childhood obesity and recent evidence linking childhood obesity to increased morbidity and mortality (Dietz, 1998; Goran, 1998) have led to a consensus that childhood obesity interventions should be of high priority (Wilson, 2003; Ells, 2005). The complexity of the causes of obesity presents a challenge in addressing this health problem. Intervention should be chosen that impact both at public health (or large scale) and at individual levels. The level of awareness of child obesity as a health problem should also be increased.

I work in the Department of Child Health Care, National Center for Women’s and Children’s Health, Chinese Center for Disease Control and Prevention. I have worked in the field of childhood obesity for nearly twenty years. For intervention of childhood obesity, from my public health worker’s perspective, I have been always thinking about the age, place and target of intervention. Obesity is a lifestyle disease and also a public health problem in China now. When the prevention should start, where the intervention should be implemented and who should be involved in the intervention program are the main questions which should be dealt with in the childhood obesity inter-
vention. In this thesis, I will describe the work which I have done to answer these three questions.

It is critical to understand the course and contributing factors of obesity before deciding an intervention approach. Genetic factors are related to obesity, but the increasing prevalence of childhood obesity in China highlight the importance of environment factors. They include energy intake, family feeding practice, school and social environment, and traditions. Treatment of obesity can be successful if realistic goals are set; a balanced low-fat/high-fiber diet is stressed; increased physical activity is stressed as much as diet; parental support is strong; and behavior therapy is provided during the course of treatment to help both child and parent achieve the diet, exercise, and behavior goals (Himes & Dietz, 1994). Individual behavior treatment and school-based intervention are described in this thesis. Lifestyle is the key factor to obesity. Related factors of overweight in children 2-6 years old in Beijing have been explored in this thesis. This was an important step for early intervention of childhood obesity. In Chinese tradition, people like to show their love with food. Many Chinese families have only one child due to family planning policy. The only one child was overly cared for and overfed often in many families, especially in three-generation families. The influence of grandparents on eating behaviors of young children in Chinese three-generation families has been qualitatively explored in this thesis. This study showed that grandparents were dominant in shaping child’s eating behaviors in some three-generation families in Chinese urban areas. The findings may be useful for a framework of childhood obesity prevention.

Aims

The overall aim of this doctoral thesis was to find out the approaches to reduce childhood obesity, a public health problem, which has appeared in China. The aim also focused on 1) what the appropriate age for child obesity control was, 2) where the suitable place to implement intervention program was, 3) what the contributing factors of child obesity in Chinese family were, and 4) what the strategy for control of childhood obesity would be.

Specific aims

1. To find out if behavior modification of childhood obesity was feasible by family intervention in China and to evaluate its effects (Paper I).
2. To evaluate the effects of a school-based intervention program on the prevalence of obesity in primary schools in Beijing, China (Paper II).
3. To assess the prevalence of overweight among preschool children in Beijing and to explore common lifestyle risk factors of childhood obesity in families (Paper III).
4. To investigate how grandparents influence their young grandchildren’s eating behaviors in Chinese three-generation families (Paper IV).

Definition of childhood obesity

Obesity is a chronic nutrition disease with abnormal or excessive accumulation of fat in adipose tissue (Kiess, 2004). Body fat content can be estimated by the dual-energy X-ray, underwater body density measurement, magnetic resonance imaging, and computed tomography. These methods are not used commonly because costly equipment are needed. Index of body weight was used widely in population surveys and clinical health screening. Body mass index (BMI, kg/m\(^2\), body weight divided by height squared) was used often and has been shown to correlate strongly with body fatness (Reilly, 2005). Body fatness has been shown to vary by age and gender. The sex- and age-specific BMI cut-points have been developed by the International Obesity Task Force (Cole, 2000) and have been used in many countries. Anthropometric measures are the most common method to define overweight and obesity in children. Weight for height in sex group is another reference for childhood overweight and obesity and has been recommended by WHO (Dibley, 1987; de Onis M, 2006; WHO Multicentre Growth Reference Study Group, 2006).

Health damages of obesity in children

Obesity in childhood is associated with medical problems related to physical and physiological changes. Some studies have considered the long-term effects of childhood obesity on adult disease (Clinton, 2004; Li, 2004). Obesity appear to be at an increased risk for unhealthy levels of serum cholesterol due to increased body fatness (Friedland, 2002). There is also some evidence that obesity that develops during childhood could increase adult morbidity and mortality (Dietz, 1998; Deckelbaum & Williams, 2001). This may be because early obesity can increase the prevalence of cardiovascular diseases and diabetes in adulthood. Risk factors for coronary heart disease are present in obese children, including increased serum lipids and blood pressure (He, 2000; Ghannem, 2001), and a reduced physical fitness level. The reduction of obesity prevalence in childhood is therefore one important way to reduce cardiovascular disease later in life. Some people, especially women, who were obese in childhood are more likely to have psychosocial
consequences, including completing fewer years of education, lower household income, higher rates of poverty, and lower rates of marriage. Childhood obesity often leads to obesity in adulthood and is associated with an increased risk for later cardiovascular disease. It may also have a profound negative effect on the psychological health of children. These are the important reasons why obesity should be managed as early as possible.

Environmental risk factors of childhood obesity

Many environmental factors contribute to the increased prevalence in urban areas of China. The food industry plays an important role by marketing high-calorie, energy-dense foods in large portion sizes and by focusing advertising efforts increasingly toward children. Children’s access to these food choices has increased with the proliferation of fast-food restaurants and the increased presence in schools of high-fat, high-sugar snack foods in vending machines.

Physical inactivity is also a contributor to obesity in children. The computer industry, manufacturers of video games, and the growth of the internet are contributing to inactivity and sedentary lifestyles among children. Studies have demonstrated the contribution of excessive sedentary television viewing to inactivity and its link with obesity in children (Janssen, 2004). Chinese students are under great pressure to achieve scholastically. A university education gives the passport to a good job. Instead of being engaged in after school exercises and activities, most Chinese children spend their time doing homework. The increased use of cars might also play a role in discouraging physical activity, including walking and cycling.

Family eating patterns of child obesity

Parents may be blamed for the rise in child obesity. In Chinese urban areas, more than half of families have only one child (Ding & Hesketh, 2006). In those one-child families, children receive intense attention from the parents and grandparents. Parents and grandparents like to show their love to children with foods. Overfeeding and overeating may be one of the most important reasons for child obesity. Since eating behaviors of children are influenced by family eating environment we must consider the influence of both parents and grandparents. Many families with young children today are three-generation families. In urban areas, around one third of preschool children are looked after by grandparents mainly. The attitude, feeding practice and meal style of grandparents may influence the child’s eating behaviors. There is evidence that parenting style may be linked to children’s overeating
behaviors (Johnson & Birch, 1994). Some studies show that mothers’ child-
feeding practices influence children’s risk of becoming overweight (Birch &
Fisher, 2000). Very little data are available on a possible link between influ-
ence of grandparents and children’s eating behavior (Green, 2003; Polley,
2005).

Other factors can influence eating behavior, such as the way the food is
provided, shaping the eating environment, modeling of eating behaviors, and
infant and young child feeding practices (Hodges, 2003). It has been asserted
that reliance on external factors to determine food intake, such as parental
control of amount consumed or control of unwanted behavior through food
reward or deprivation, can undermine the infant and young child's ability to
attend to their internal cues of hunger and satiety (Birch & Fisher, 1998).

**Intervention against childhood obesity**

Intervention includes prevention and treatment. For the control of obesity in
childhood, prevention is more advantageous than treatment. Prevention may
be easier to achieve for children because it can be implemented before the
unhealthy lifestyle is established. Some overeating and inactivity behaviors
are difficult to be changed. An obese state may be associated with potentially
physical and psychological alterations that may be difficult to reverse. Pre-
vention may be more effective because it can be done before such altera-
tions. Preventive strategies may have consequent benefits such as general
disease risk reduction associated with improved healthy diet and physical
activity-related behaviors (Lobstein, 2004; Council on Sports Medicine and
Fitness and Council on School Health, 2006). Treatment is useful and neces-
sary for obese children, especially for the high-risk obese children. It can be
effective. However, some treatment options, such as operation, drug therapy,
very low calorie intake, and hunger, are not applicable for children. Treat-
ment is usually targeted at the individual and therefore is generally more
labor intensive and costly than prevention at the population level. Prevention
can be applied at the population level. It may be more effective and cost-
effective because it can be done before physical and psychological altera-
tions occur. Early prevention of childhood obesity may promote an optimal
physiological development of body weight regulation. Thus preventive
strategies may provide more favorable risk-benefit proportions for larger
numbers of individuals (Lobstein, 2004).
Behavior treatment

Childhood obesity is a serious health problem that should be treated as early as possible since obese children contribute to approximately one third of obese adults. Many treatments for childhood obesity have been developed and evaluated (Racette, 2003). Behavioral treatments is a cornerstone of all weight control programs for obese children and have been the most widely studied approaches to childhood obesity and have generally been success (Epstein, 2001; St Jeor, 2002). Among them, family-based behavioral treatment outcomes have had particularly beneficial effects on dietary practices (Levine, 2001). Several studies have demonstrated a greater effectiveness of comprehensive behavior modification programs (Berkowitz, 2003; Wilson, 2003). Usually, children learn their eating behavior from their parents as well as the pattern of intake and food selection at home. They also adopt their lifestyle, including exercise pattern, from their family. The parents’ food preferences, the quantities and variety of foods in the home, the eating behavior, and the physical activity patterns influence the children’s body weight (Edmunds & Hill, 1999; Birch & Davison, 2001). Family-based behavioral treatment was the most extensively studied therapy (Epstein, 1996; St Jeor, 2002). Some studies showed that family involvement was needed in the treatment and could be beneficial to both children and parents. Several studies demonstrate that parents were vital for a good outcome as they can help their children improve dietary behaviors. The rate of change of eating and exercise varies between children. The parenting behaviors are also different in different families. Individual treatment could therefore be more effective compared with group treatment for childhood obesity, but more manpower is needed and the cost-effectiveness may thus be lower than with group intervention.

Theory of behavior modification for obese children

The theoretical basis of behavior modification is social learning theory. It is applied commonly to treat specific maladaptive behaviors and has been used in many childhood obesity intervention programs (Cole, 2006). Children learn eating and activity behaviors in their family initially. Social and interpersonal influences are important in behavior change. Incorporated cognitive processes are the mediators of behavior change as well. The principles of behavior modification include self-monitoring, reinforcement, stimulus control, and modeling (Drohan, 2002). Self-monitoring involves keeping records of eating behaviors, foods consumption and physical activities. Self-monitoring increases awareness of maladaptive behavior. It is an important component in the process of behavior change. Praise and contracting are two
basic positive reinforcement techniques for behavior modification. Praise is a very useful and positive approach to support behavior change. Children's good behavior should be praised as soon as it was noticed. This connection of behavior and praise will increase the likelihood of children repeating behavior. Contracting is also a common way for positive reinforcement (Salmon, 2005). Contracting includes having a child earn a privilege by reaching specified behavior goals. Stimulus control includes identifying the environmental cues related to overeating and inactivity. Parents can change the obese child's environment and help them to achieve targeted behaviors (Golan, 2006). If the parents do not want their obese children to repeat some of the parents' own behaviors, the parents should not behave in this way in front of their children. Parents’ good behavior should be a model that their children can imitate.

School-based intervention approach

Obese adolescents are more likely to become obese adults (Whitaker, 1997; Sahota, 2001; Krassas & Tzotzas, 2004). Therefore, an early intervention of obesity should be prioritized. Individual treatment cannot cope with the rapid increased prevalence of child obesity. An intervention during primary school years is therefore important and schools represent important places for intervention programs. Schools have access to large numbers of students and have structures and systems to support intervention programs. Many school-based approaches have targeted obese children in primary schools (Sahota, 2001; Cole, 2006). Some school-based intervention programs demonstrated that promotion of physical activity, and a modification of dietary intake, and a reduction of sedentary time (Harrell, 1998; Gortmaker, 1999) can be effective. Behavioral modification in school and at home can lead to a negative energy balance for obese children. Parents may need to be taught new parenting skills to avoid using food as a reward and encouraging children to eat. Some successful interventions have linked the school with family and focused on all students in the school (Frenn, 2003).
Methods

Treatment and prevention were used for the intervention of childhood obesity in this thesis. In order to understand the related factors of obesity and control obesity as early as possible, a cross-sectional survey was done in 2-to 6-year-old children in five kindergartens in urban Beijing. Grandparents’ role was paid attention to in the survey. So a qualitative study approach was used to find out the influence of grandparents on children’s eating behavior.

Behavioral treatment for individual obese children

I started the intervention of childhood obesity by behavior treatment in a small sample. The study was conducted in one middle school in Beijing, China. Informed consent was obtained from 75 families, including verbal consent from the obese children before the initial assessment. The children were then divided randomly to treatment (36 children) and control (39 children) groups at baseline. Seven children did not complete the two-year program because of family moves (3 in the treatment and 4 in the control group). Children in the treatment group received family-based behavioral treatment for two years. The controls had a normal school and family life and did not receive any special intervention. Assessments were conducted at baseline, at six-month intervals, and at the end of the two-year intervention. This program was approved and funded by the Ministry of Health in China.

The treatment focused on dietary behavior modification. One or two main behaviors that were related to obesity were chosen for each child based on an assessment of relevant diet at baseline. Then the goal behavior and interval behaviors were defined. Each goal and interval behavior was discussed with the child and the parents and was agreed to by the child. A diary was kept by the children on their behavior in order to monitor adherence to the recommended lifestyle changes. The parents monitored the diary and their child’s progress in achieving the new behavior.

Throughout the study, the researchers in this study team visited the families once per month. During the visit the researchers observed the family environment and looked at where foods were stored, cooking styles and what kinds of foods were used commonly in the family. The researcher checked the behavioral diary and discussed gaps in the recordings. Potential methods
of reinforcement were also discussed with the parents and children during home visits.

During the 2-year family-based behavioral treatment, a detailed dietary modification plan was implemented in each treatment group family. A “traffic light” food item list was given to the children to help decrease energy intake and promote a balanced diet: “red light” foods were those high in fat or calories; “green light” foods were low in fat and calories; and “yellow light” foods were intermediate. We urged the children to eat less red light foods and more green light foods. We also encouraged the parents to buy more green light foods instead of red light foods. What the child ate every day was recorded in the diary. The researchers checked the diary at home visits and evaluated the dietary intake. Dietary suggestions were given to the family after each evaluation.

Height and weight measurements were performed by a trained researcher in this study team. All children in the two groups were measured for height and weight every 6 months at the same time periods. Blood pressure (BP) and serum lipids were measured at baseline and after 2 years. Serum total cholesterol and triglycerides were determined using venous blood samples.

SPSS (version 11.0, SPSS Inc., Chicago, USA) was used for the statistical analyses. Independent t-tests, Mann-Whitney test, ANOVA, and correlation were used to compare the differences between groups. Statistical significance was assigned at the 0.05 level of probability.

Population intervention for primary school children

Behavior modification is the basis of childhood obesity intervention. After observing the implementation of behavior treatment in a small sample of obese children, I found that behavior modification could be feasible in Beijing, China. I also found that behavior change was difficult when the unhealthy dietary and activity behaviors had persisted for a long time. It would be better to intervene in child obesity earlier. Then I started the second step of childhood obesity intervention—the school-based population intervention program. Comparing with the initial behavior treatment in middle school student, this intervention was implemented in a large sample of younger children (primary school children).

There are six urban districts in Beijing, China. Five primary schools were randomly selected as sample schools from all the schools that have more than 400 students in two urban districts. They were divided into two interventions (from two districts) and three controls (from two districts) randomly. Information describing the intervention program was sent to all the students and parents in all participating schools. The obesity/non-obesity ratio, gender and age range were similar between the children who partici-
pated and those who did not participate in the study both in intervention and control schools. This study was approved by the Ethics Committee of the Beijing Health Bureau before it was implemented.

The intervention program focused on reducing the prevalence of obesity in the schoolchildren both by reducing obesity among those already obese and by preventing new cases. The main component of the intervention program was nutrition education aimed at both the children and their parents. A nutritional lecture was given by the researcher in this study team to all the parents once per semester at the routine parents’ meetings organized by the school. The contents of these lectures included health consequences of childhood obesity, the food pyramid, and elements of a healthy lifestyle (increasing consumption of vegetables and fruits and physical activity; avoiding overeating, eating in restaurants frequently and eating in the absence of hunger; reducing consumption of western fast foods, television viewing, and computer games). Educational materials on childhood obesity prevention were distributed to all the parents. They were designed by this study team and included the weight and height references by age and gender, obesity references, and methods of obesity prevention.

An extra meeting for parents with overweight and obese children was arranged by intervention schools and the study team once per semester. A “traffic light” food item list which was tested in behavior treatment for obese children before was given to the parents to help children decrease their energy intake and consume a balanced diet. The parents were informed about daily calorie requirements, based on the Chinese Recommended Daily Allowance. We also gave Chinese food composition tables to the parents, so they could calculate the calorie intake of their child every day and compare with the calorie requirements. Some methods of behavior modification that had been tested in teenage obese children before were also suggested to the family in order to avoid overeating. Parents were also informed of methods to achieve a healthy lifestyle of all family members. For parents who encouraged their overweight or obese children to overeat we sought to analyze the reasons for this behavior and to modify it. Parents were taught to limit their child’s sedentary time at home and advised to take a walk with their child after supper. We also encouraged these parents to weigh their child every week.

A meeting was also arranged for all the overweight and obese children once every semester. The styles of the meeting consisted of lectures, group discussions, question-and-answer sessions, and experience sharing. The children were advised to avoid high fat foods and fast food, and to increase their intake of fruits and vegetables. The children were asked whether their parents encouraged them to eat more. We also urged the children to decrease sedentary time, e.g. watching TV and to go for a walk after supper instead.

The intervention aimed to increase physical activity as well. In the afternoon from Monday to Thursday, all the overweight and obese children, along with the children who failed to pass routine school physical fitness
tests were asked to run for 20 minutes after class. The physical education teachers monitored this activity.

Measurements taken for data analysis included heights and weights taken. After baseline measurement, all children in intervention schools were classified as normal weight, overweight and obese. Weight and height were measured for all students in the intervention schools twice each semester. This higher frequency of measurement was a part of the intervention program. The children’s weight status was defined after each measurement and parents were informed of the results. Throughout the 3-year period normal weight children who became overweight were involved in an additional intervention program and the overweight or obese children whose weight recovered to normal then were exempted from these additional sessions. Thus the students and parents attending the meetings for overweight and obese children changed somewhat each semester. The weight and height of control children were measured once every year and their parents were also informed of the results. The data analyzed and reported in this study came only from the baseline and end line measurements. Overweight and obesity were defined in this paper according to sex- and age-specific BMI cut-points proposed by the International Obesity Task Force (Cole TJ, Bellizzi MC et al. 2000).

All data analyses were preformed using SPSS for Windows. Significance level was set to a random error of $\alpha=0.05$. Differences of weight, height, BMI and prevalence of overweight and obesity between intervention and control schools were tested by independent t-test and chi-square test. In multiple regression analyses to predict obesity at end line, the baseline predictors of obesity (obesity, age, BMI, and school size) were controlled. Boys and girls were estimated using separate regressions.

Exploring risk factors of overweight in preschool children

The prevalence of overweight and obesity was quite high in first grade children in primary schools in Beijing. The invention should be started earlier in preschool children. The social environment is changing in Beijing, China. Understanding the contributing factors of obesity is an important step in early intervention. For this reason, I conducted a cross-section survey in five kindergartens in Beijing. The five kindergartens were randomly selected in two urban districts in Beijing. All children from these kindergartens were invited to participate. Parents provided written consent for their own and for their children’s participation before data collection. Parents were asked to complete the questionnaire at home. If a family had two children in the kindergarten, they completed the questionnaire only for the older child. The
potential number of participating families was 1045. Questionnaires were
given to 1045 parents and 930 parents returned completed questionnaires
(response rate = 89.1%).

Participating families were asked about the following: parental height,
weight and educational level; family dietary habits, feeding style; amount of
parental and child’s vigorous physical activity excluding physical activity in
kindergarten for children; and amount of parental and child’s TV consump-
tion and usage of computer games. Family structure (number of children in
family and whether they live with grandparents or not) and attitude of par-
ents and grandparents to child obesity were also asked. Children’s weight
and height data were collected by trained researchers. Anthropometric meas-
urements were performed without shoes in light clothing. Each measurement
was performed twice and the average was used for the analysis. Overweight
and obesity were defined according to the sex- and age-specific BMI cut-off
points proposed by the International Obesity Task Force (Cole, 2000). Pa-
rental overweight was defined as BMI ≥ 25kg/m² according to recommenda-
tions for adults (Cole, 2000). The study was approved by the Ethics Commit-
tee of the Chinese National Center for Women’s and Children’s Health.

All calculations were carried out using the statistical software packages
SAS 9.1 (SAS Institute Inc., Cary, NC, USA). The significance level was set
at p=0.05. Differences in the prevalence of overweight and obesity between
age groups were tested by the Cochran-Armitage trend test. Variables with
significant associations with children’s overweight in the bivariate analyses
(p<0.05; Fisher’s exact test for categorical variables and independent t-test
for continuous variables) were analyzed in logistic regression model adjust-
ing for sex, age, and family income. Clustering was considered with kinder-
gartens as respective clusters.

Eating behaviors of young children in three-generation
families

A high proportion of young children are looked after by their grandparents in
Beijing. The grandparents have different opinions about child overweight
and obesity to the parents in many families. I learnt from the survey that
some parents could not control their obese children’s eating because of the
grandparents’ excessive care and overfeeding. How the grandparents influ-
enced the young children’s eating behaviors could not be explored in the
quantitative survey. Therefore I started a qualitative study to find out the role
of grandparents in three-generation families.

Twenty-three parents and grandparents were recruited as interviewees
from 23 different families in two different districts in Beijing, China. We
selected participants to reflect a range of different characteristics in terms of
income levels, occupational status, and living place. All the 23 families were three-generation families and each family parented a single child. The children’s age range was 3-6 years old (4.4 years on average) and there were 13 boys and 10 girls. Thirteen (57%) of the children were obese according to the IOTF BMI reference (Cole, 2000). There were four grandfathers, seven grandmothers, three fathers and nine mothers among the 23 interviewees. The interviews were semi-structured and an interview guide was used including the following questions:

1. *Who looks after the young child mainly in your family?*
2. *Who is responsible for family meals?*
3. *What is your own view on how a small child should be fed?*

The audiotapes were transcribed verbatim and analyzed systematically by the research team to identify recurrent dietary-related patterns from the original research questions. The transcripts were read by each of our local team members. Main codes were evaluated by the research team. Seven major themes were identified by group discussion and consensus and then organized into three domains. The study was approved by the Ethics Committee of the Chinese National Center for Women’s and Children’s Health. Informed consent was obtained from participants before the interviews.
Results

Paper I

Change in height, weight and BMI

During the two-year follow-up, both groups of children had a similar linear growth velocity. Mean height increased 8.2 cm and 8.0 cm in treatment and control groups, respectively, \( p = 0.846 \). Children in the treatment group decreased 0.3 kg in weight, while the control group increased by 5.5 kg (Table 1). There was significant difference in weight change between the two groups (\( p < 0.001 \)).

Table 1   Height and weight changes over a two-year period among obese children in a Beijing school (mean±SD)

<table>
<thead>
<tr>
<th></th>
<th>Treatment (( n=33 ))</th>
<th>Control (( n=35 ))</th>
<th>( P ) value*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline</strong></td>
<td><strong>Follow-up</strong></td>
<td><strong>Change</strong></td>
<td><strong>Baseline</strong></td>
</tr>
<tr>
<td>Height (cm)</td>
<td>161.2 ± 4.1</td>
<td>170.4 ± 6.0</td>
<td>8.2 ± 4.3</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>70.1 ± 5.7</td>
<td>69.7 ± 4.4</td>
<td>-0.3 ± 4.3</td>
</tr>
<tr>
<td>BMI</td>
<td>26.6 ± 1.7</td>
<td>24.0 ± 0.9</td>
<td>-2.6 ± 1.6</td>
</tr>
</tbody>
</table>

* Comparison of the treatment and control groups regarding changes between baseline and follow-up, using independent t-test.

Mean BMI-SDs (Z scores) at various follow-up times for each group are displayed in Figure 1. There were significant differences in change of BMI-SDs between the two groups by repeated measures ANOVA (\( F = 9.3 \) for groups, \( F = 103.8 \) for times, \( F = 50.9 \) for time and groups, \( p < 0.001 \)). Compared with the initial value, the average BMI showed a significant reduction only in the treatment group (Mean change = 2.6, 95% confidence interval, 2.06-3.18, \( p < 0.001 \)).
Figure 1. Mean BMI-SDS in different follow-up time in treatment and control group. There was significant difference in change of BMI-SDS between the two groups by repeated measures ANOVA.

Change in BP and serum lipid

In the treatment group, there was a significant correlation between change in BMI and change in triglycerides (mmol/L) \( (r = 0.488, P = 0.004) \). Table 2 shows that after two years of treatment, total cholesterol decreased 5.5% and triglycerides 9.7% in the treatment group. There were no significant changes in the controls. Between-group changes in systolic blood pressure (SBP), diastolic blood pressure (DBP), total cholesterol, and triglycerides were also statistically significant.
### Table 2  Changes in BP and serum lipid values between baseline and follow-up for children in the treatment vs control groups (mean ± SD)

<table>
<thead>
<tr>
<th></th>
<th>Treatment</th>
<th>Control</th>
<th>p value*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>Follow-up</td>
<td>Change</td>
</tr>
<tr>
<td><strong>SBP, mmHg</strong></td>
<td>116.1±4.3</td>
<td>116.2±4.9</td>
<td>-1.5±2.5</td>
</tr>
<tr>
<td><strong>DBP, mmHg</strong></td>
<td>72.9±4.8</td>
<td>72.5±3.2</td>
<td>-0.8±1.8</td>
</tr>
<tr>
<td><strong>Cholesterol, mmol/L</strong></td>
<td>4.57±0.30</td>
<td>4.32±0.39</td>
<td>-0.26±0.14</td>
</tr>
<tr>
<td><strong>Triglyceride, mmol/L</strong></td>
<td>0.72±0.12</td>
<td>0.65±0.13</td>
<td>-0.08±0.05</td>
</tr>
</tbody>
</table>

SBP: systolic blood pressure. DBP: diastolic blood pressure.

*Comparing the treatment and control groups in changes between baseline and follow-up by independent t-test or Mann-Whitney test

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### Paper II

#### Sample characteristics

Data were collected from the students in grades 1 to 4 in intervention and control schools at baseline who consented to take part in the study and from this same cohort when they completed grades 3 to 6 at end line three years later. The study samples included 2489 students (1056 students in intervention schools and 1433 students in control schools) at baseline. Sixty-four students lacked end line data due to either school transfer or school absence. Among the students without end line data, 27 students were in intervention schools (24 nonobese children and 3 obese children) and 37 in the control schools (31 nonobese children and 6 obese children). Their data were eliminated and data from the other 2425 students (1029 in intervention and 1396 in control) were included. At baseline there were no significant differences in age, gender ratios and prevalence of overweight and obesity between the intervention and control schools (Table 3).
### Table 3 Characteristics of sample children at baseline and end line in intervention and control schools in Beijing*

<table>
<thead>
<tr>
<th></th>
<th>Intervention</th>
<th></th>
<th>Control</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total n=1029</td>
<td>Boys n=531</td>
<td>Girls n=498</td>
<td>Total n=1396</td>
</tr>
<tr>
<td><strong>Baseline</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (y)</td>
<td>8.4±1.4</td>
<td>8.4±1.3</td>
<td>8.3±1.4</td>
<td>8.2±1.5</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>28.4±6.5</td>
<td>28.9±6.8</td>
<td>27.3±5.3</td>
<td>28.8±6.8</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>129.4±5.6</td>
<td>129.2±5.4</td>
<td>129.5±5.8</td>
<td>130.0±5.0</td>
</tr>
<tr>
<td>BMI</td>
<td>17.6±2.9</td>
<td>18.1±3.3</td>
<td>17.0±2.5</td>
<td>17.5±2.7</td>
</tr>
<tr>
<td>Overweight (%)</td>
<td>13.3</td>
<td>15.0</td>
<td>11.4†</td>
<td>12.6</td>
</tr>
<tr>
<td>Obesity (%)</td>
<td>11.7</td>
<td>14.5</td>
<td>8.6‡</td>
<td>11.5</td>
</tr>
<tr>
<td><strong>End line</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (y)</td>
<td>11.2±1.3</td>
<td>11.2±1.2</td>
<td>11.2±1.3</td>
<td>10.9±1.4</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>40.3±8.5</td>
<td>40.4±9.2</td>
<td>40.0±6.8</td>
<td>43.9±8.6</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>147.7±6.1</td>
<td>147.5±6.4</td>
<td>147.9±5.3</td>
<td>146.8±7.0</td>
</tr>
<tr>
<td>BMI</td>
<td>18.2±2.6</td>
<td>18.4±2.9</td>
<td>18.1±2.4</td>
<td>20.3±3.4*</td>
</tr>
</tbody>
</table>

* Data presented are mean ± SD except where % is indicated.
† Comparing boys with girls, p<0.05. ‡ Comparing boys with girls, p<0.01.
# Comparing control group with intervention group, p<0.01.

### Change in prevalence of obesity with intervention

At follow-up the prevalence of overweight and obesity were significantly lower in intervention schools than in control schools (Table 4). The prevalence of overweight decreased 26.3% in intervention schools and increased 14.3% in control schools. The prevalence of obesity decreased 32.5% in intervention schools and increased 15.7% in control schools.
Table 4  Prevalence of overweight and obesity at end line in intervention and control schools in Beijing

<table>
<thead>
<tr>
<th></th>
<th>Intervention (%)</th>
<th>Control (%)</th>
<th>Adjusted ORs*</th>
<th>95% CI</th>
<th>p value§</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Overweight</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>9.8</td>
<td>14.4</td>
<td>0.614</td>
<td>0.465, 0.788</td>
<td>0.001</td>
</tr>
<tr>
<td>Boys</td>
<td>11.9</td>
<td>18.5</td>
<td>0.564</td>
<td>0.391, 0.756</td>
<td>0.001</td>
</tr>
<tr>
<td>Girls</td>
<td>7.6†</td>
<td>10.1‡</td>
<td>0.670</td>
<td>0.461, 1.068</td>
<td>0.085</td>
</tr>
<tr>
<td><strong>Obesity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>7.9</td>
<td>13.3</td>
<td>0.556</td>
<td>0.413, 0.738</td>
<td>0.001</td>
</tr>
<tr>
<td>Boys</td>
<td>9.4</td>
<td>16.0</td>
<td>0.502</td>
<td>0.383, 0.785</td>
<td>0.001</td>
</tr>
<tr>
<td>Girls</td>
<td>6.2‡</td>
<td>10.4‡</td>
<td>0.568</td>
<td>0.389, 0.901</td>
<td>0.036</td>
</tr>
</tbody>
</table>

* Adjusted odds ratio controlled for baseline obesity, age, BMI, school, and family socio-economic status. Regression estimates were calculated using the generalized estimating equation method to account for clustering of observations within schools.
§ Significance level, intervention vs control.
† Comparing boys with girls, p<0.05. ‡ Comparing boys with girls, p<0.01.

More nonobese children became obese in the control schools than in the intervention schools (7.0% vs. 2.4%, OR 0.338, 95%CI 0.214, 0.538, p=0.002). Among the children who were obese at baseline, 49.2% remained obese at end line in intervention schools whereas 61.9% remained obese in control schools. Remission of obesity was significantly higher in intervention students than in control students (50.8% vs. 38.1%, OR 1.668, 95%CI 1.030, 2.610, p=0.001) (Figure 2). A difference in obesity remission by gender was observed between intervention and control students. Remissions were 49.4% vs. 40.6% (OR 1.426, 95%CI 0.784, 2.593, p=0.324) in boys and 53.5% vs. 33.9% (OR 2.243, 95%CI 1.002, 5.023, p<0.001) in girls between intervention and control students.
Figure 2  Flow graph of obesity changes from baseline to end line in children in intervention and control schools
Overweight risk factors in 2- to 6-y-old children

The mean age of the subjects was 4.6 ± 1.1y with an age range of 2-6 years. Overall overweight and obesity prevalence was 10.7% (95% CI 8.7% - 12.8%) and 4.2% (95% CI 3.0% - 5.7%). There was no significant difference in prevalence of overweight and obesity between boys and girls (10.0% vs 11.4% and 4.4% vs 3.9%). The data were divided into three age groups in the data analysis: 1) Two years old up to 3 years and 11 months; 2) 4 years old up to 4 years and 11 months; and 3) 5 years old up to 6 years and 11 months. The prevalence of overweight and obesity increased with increasing age group (Table 5).

Table 5    Prevalence of overweight and obesity by age group and sex (%)

<table>
<thead>
<tr>
<th>Age groups</th>
<th>Boys (n=518)</th>
<th></th>
<th>Girls (n=412)</th>
<th></th>
<th>Both boys and girls (n=930)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Overweight</td>
<td></td>
<td>Overweight</td>
<td></td>
<td>Overweight</td>
<td></td>
</tr>
<tr>
<td>2-3 y (n=322)</td>
<td>1.2</td>
<td></td>
<td>8.6</td>
<td></td>
<td>4.7</td>
<td></td>
</tr>
<tr>
<td>4 y (n=260)</td>
<td>9.7</td>
<td></td>
<td>9.6</td>
<td></td>
<td>9.6</td>
<td></td>
</tr>
<tr>
<td>5-6 y (n=348)</td>
<td>17.8</td>
<td></td>
<td>15.8</td>
<td></td>
<td>17.0</td>
<td></td>
</tr>
<tr>
<td>Overall (n=930)</td>
<td>10.0</td>
<td></td>
<td>11.4</td>
<td></td>
<td>10.7</td>
<td></td>
</tr>
</tbody>
</table>

* p<0.001 for differences between age groupings, Cochran-Armitage trend test.

Family characteristics and child overweight

Significantly more children from overweight families (overweight father or overweight mother) were overweight. The prevalence of child overweight was 14.1% and 7.7% in overweight families and non-overweight families respectively, with a corresponding unadjusted odds ratio of 1.98 (95% CI 1.29-3.04). Other significant associations between child and parental characteristics could be observed for BMI, frequency of eating out, television hours, and physical activity hours (Table 6).
Table 6 Correlations between parents and child for body mass index (BMI), eating out, activity hours and television (TV) viewing hours

<table>
<thead>
<tr>
<th>Parent’s variable</th>
<th>Child’s variable</th>
<th>BMI</th>
<th>Frequency of dinner in restaurant</th>
<th>TV viewing hours (daily)</th>
<th>Physical activity hours (daily)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Father</td>
<td></td>
<td>0.080 (0.015)*</td>
<td>- 0.117 (0.000)**</td>
<td>0.057 (0.081)</td>
<td>- 0.039 (0.233)</td>
</tr>
<tr>
<td>Mother</td>
<td></td>
<td>0.128 (0.000)**</td>
<td>0.094 (0.004)**</td>
<td>0.040 (0.223)</td>
<td>0.041 (0.211)</td>
</tr>
<tr>
<td>Frequency of eating dinner in restaurant</td>
<td></td>
<td>0.063 (0.056)</td>
<td>0.452 (0.001)**</td>
<td>0.075 (0.022)*</td>
<td>- 0.024 (0.468)</td>
</tr>
<tr>
<td>Father</td>
<td>0.028 (0.395)</td>
<td>0.625 (0.001)**</td>
<td>0.091 (0.006)**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mother</td>
<td></td>
<td>0.015 (0.639)</td>
<td>0.017 (0.607)</td>
<td>0.210 (0.000)**</td>
<td>0.033 (0.314)</td>
</tr>
<tr>
<td>TV viewing hours (daily)</td>
<td></td>
<td>0.030 (0.363)</td>
<td>0.022 (0.500)</td>
<td>0.237 (0.000)**</td>
<td>0.054 (0.098)</td>
</tr>
<tr>
<td>Father</td>
<td>0.019 (0.566)</td>
<td>0.037 (0.259)</td>
<td>0.028 (0.397)</td>
<td></td>
<td>0.146 (0.001)**</td>
</tr>
<tr>
<td>Mother</td>
<td></td>
<td>0.019 (0.566)</td>
<td>0.037 (0.259)</td>
<td>0.028 (0.397)</td>
<td>0.146 (0.001)**</td>
</tr>
</tbody>
</table>

*Data are presented as correlation coefficient (p value)
* Significant difference at P<0.05. ** Significant difference at P<0.01

Risk factors for child overweight

In addition to parental overweight, low maternal education (high school not completed), high TV viewing, and mothers’ restriction of snacks for the child, were associated with overweight. Mother’s encouragement of eating for the child was a related factor for child overweight (overweight vs normal weight: 60.6% vs 72.7%, p=0.01). After adjustment for sex, age, family income, and as potential confounders, and for specific kindergarten (to adjust for cluster design), the multivariate analysis yielded parental overweight, low maternal education, children’s TV viewing more than 2 hours/day, and mother’s restriction of snacks for children as significantly related to child overweight (Table 7).
Table 7  Potential risk factors of child overweight from multivariate analysis

<table>
<thead>
<tr>
<th>Risk factor (risk factor exposure)</th>
<th>Unadjusted proportion (%) of overweight if risk factor was present</th>
<th>Adjusted p-value(^a)</th>
<th>Adjusted odds ratio (95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parental overweight</td>
<td>14.1% yes 7.5% no</td>
<td>0.001</td>
<td>2.43 (1.78, 5.69)</td>
</tr>
<tr>
<td>Low maternal education</td>
<td>16.8% yes 9.0% no</td>
<td>&lt;0.001</td>
<td>2.22 (1.39, 3.55)</td>
</tr>
<tr>
<td>Child’s TV viewing more than 2 h/d</td>
<td>16.6% yes 9.3% no</td>
<td>0.012</td>
<td>1.56 (1.17, 2.09)</td>
</tr>
<tr>
<td>Mother’s encouragement of child to eat more often</td>
<td>5.9% yes 22.6% no</td>
<td>&lt;0.001</td>
<td>0.22 (0.14, 0.34)</td>
</tr>
<tr>
<td>Mother’s restriction of snacks for child</td>
<td>12.9% yes 5.2% no</td>
<td>&lt;0.001</td>
<td>2.68 (1.64, 4.29)</td>
</tr>
</tbody>
</table>

Among the 930 sample children, 92% were only child in their families. Three-generation families covered 56% of all sample families. Among the 520 three-generation families, comparing with the parents, more grandparents were satisfied with their overweight grandchildren’s weight and more grandparents thought that overweight meant healthy children (Table 8).

Table 8  Attitudes to child overweight in three-generation families (%)\(^8\)

<table>
<thead>
<tr>
<th></th>
<th>Father</th>
<th>Mother</th>
<th>Grandparents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overweight meant healthy children (n=520)</td>
<td>5.9</td>
<td>4.4</td>
<td>24.0*</td>
</tr>
<tr>
<td>Overweight meant good care in children (n=520)</td>
<td>9.6</td>
<td>9.0</td>
<td>26.7*</td>
</tr>
<tr>
<td>Overweight meant strong capacity against diseases (n=520)</td>
<td>10.6</td>
<td>7.7</td>
<td>35.0*</td>
</tr>
<tr>
<td>Positive toward overweight in children (n=98)(^9)</td>
<td>36.7</td>
<td>28.6</td>
<td>55.0*</td>
</tr>
</tbody>
</table>

\(^a\) When there were two grandparents in the three-generation family, opinion was taken from one grandparent who was the main caretaker of child in the family.

\(^*\) Comparing grandparents with father and mother, p<0.01 by chi-square.

\(^9\) Data was obtained from the three-generation families with overweight or obese children.

Paper IV

Three domains identified through the seven themes included: (1) Grandparents as primary caretakers of children in the three-generation family, (2) Grandparents’ attitudes to child nutrition and healthy eating habits, and (3) The role of food as an educational and emotional tool.
Domain 1. Grandparents as primary caretakers of children in the three-generation family

The grandparents were the ones to look after the child in all of the interviewed families. Most grandparents had retired and therefore had time to take the children to kindergarten in the morning and pick them up in the afternoon. The children spent much more time with their grandparents than they did with their parents after kindergarten. All parents worked full time and letting the grandparents take care of the child was viewed as both convenient and a necessity.

Theme 1. The role of grandparents in planning and cooking family meals

Grandparents were responsible for shopping and bought food in most interviewed three-generation families. The reason given for this was that grandparents usually had time to do the shopping, whereas the parents were busy working. The parents only cooked on some weekends. In most interviewed families, the grandmother cooked the family meal each day. They did so according to their own preferences and what they believed was good and nutritious for the whole family. Grandparents originating from the Northern parts of China preferred foods based on wheat, whereas those from the South preferred rice. Grandparents who liked salty foods put more salt in the food and the same was true for sugar. The young children, in turn, tended to follow their grandparents’ preferences since they were used to their cooking style.

Theme 2. Weighed by the responsibility of fostering a child

It was important for the grandparents in this study to do a good job in fostering the child in the absence of parents. They did not want to be accused of not doing well in taking care of the family’s only child. A central aspect in this caretaking duty was feeding the child. Most grandparents thought that a heavy child was a healthy child and was the result of successful feeding and caring. Thus, the fostering responsibility was in fact a motivation for grandparents to overfeed their grandchildren.
Domain 2. Grandparents' attitudes to child nutrition and healthy eating habits

Theme 3. Grandparents’ perceptions of healthy child nutrition

“Good and nourishing food” was what grandparents wanted to select for their families. In their opinion, good foods were expensive and of a kind that could not be bought easily before the reform and opening in China. Most of the grandparents believed that meat was a special nutrient and a desirable component of the family’s diet. They asserted that growing children need meat especially. Several grandparents also emphasized that children’s being heavy at a young age would ensure that they become tall in the future. It is interesting how grandfathers also had strong opinions about healthy child nutrition and influenced food choices.

Theme 4. Grandparents’ experience of poverty

All the grandparents had experienced food shortage in their lives and they seemed to have a vivid memory of hunger and poverty. With this experience, they did not want their grandchildren to ever have to be hungry now that both food and money were available. They wanted to let the children experience a “happy life” by providing them with plenty of food. Although many grandparents knew that they should not always satisfy their grandchildren with food, they could not restrict themselves because they were reminded of their own experience of hunger when their grandchild demanded food. Another aspect of having experienced poverty was the imperative to save food. Grandparents could not bear the thought of throwing away what was left over from a meal.

Theme 5. Conflicting ideas about child nutrition between generations

In many interviewed families, the grandparents had different opinions from parents concerning the child’s eating patterns. Grandparents tended to want the children to eat more meals and larger portions at served meals, whereas parents were of a different opinion. Almost all the young children in interviewed families were encouraged by their grandparents to have supper after they had had supper at kindergarten. In addition, children were provided with ample snacks and sweets despite the parents’ disapproval. The conflict about child nutrition between generations was especially obvious in families with obese children. Several parents expressed frustration over not being able to
influence the grandparents’ way of feeding the child. The main problem seemed to be that, whereas parents defined the child’s obesity as a problem, the grandparents strongly disagreed.

Usually, mothers were most concerned about the child’s weight. However, because they had so little power in the current constellation of a three-generation family home, to live separately was the most common proposal to solve the conflict.

Domain 3. The role of food as an educational and emotional tool

Theme 6. Shaping child behavior through food

Most grandparents tended to control child behavior through food reward or deprivation. Young children’s good behavior was rewarded with snacks. The first response of most grandparents to their grandchildren’s good behavior was often to say: “Let me know what you want to eat!” Western fast foods were commonly used to influence young children’s behaviors because almost all the young children liked them. Threatening not to go to McDonald’s was used, for example.

Theme 7. Expressing love and caring through foods

Most grandparents thought that satisfying children with food was the basic way to love them. They enjoyed watching their grandchild eat because food was viewed as a way to transmit love. Grandparents chose and bought foods for their families according to young children’s preference.

They always took the child’s wishes into consideration when buying and preparing meals. Grandparents were likely to purchase food items that the child asked them to buy after having seen them in the supermarket. The young child’s preference was considered important enough to be satisfied at all costs.
Discussion

Why is childhood obesity a public health issue?

Recent epidemic studies have demonstrated that 10-20% of children are considered overweight or obese in many developed counties (James, 2001; Ogden, 2002). China has joined the globe epidemic. The prevalence of overweight and obesity among Chinese children in cities is comparable to some industrial countries (Ding, 1998; Cheng, 2001; Luo & Hu, 2002; Luo, 2002). The data from the 2002 national nutrition and health survey showed that there were 184 million overweight people and 31 million obese people in China (Wu, 2006). Of these, 14 million overweight children and 6 million obese children. Obesity can predispose children to hyperinsulinaemia (Freedman, 1999), hypertension (Sorof, 2002), cardiovascular disease (Geiss, 2001) and type 2 diabetes (Kiess, 2003). Obesity may also cause a negative self-image and low self-esteem (Davison & Birch, 2001), depression (Roberts, 2000), and social or behavior problems (Friedman & Brownell, 1995). Obesity has been identified as one of the non-communicable diseases with have heavy and growing burden in the 57th World Health Assembly in 2004 (WHO, 2004). Once established, obesity is difficult to treat (Racette, 2003). Obesity in childhood and adolescence is predictive of weight status in adulthood (Whitaker, 1997; Krassas & Tzotzas, 2004). This evidence has showed that childhood obesity has become a public health problem in China and should be considered as a public health priority.

What approach can be used for childhood obesity intervention?

Treatment and prevention are the main approaches of intervention. Targeted population, age and place should be considered in childhood obesity intervention. Behavior treatment was the initial approach which I chose for childhood obesity intervention. In this program, I selected obese teenage children as targeted sample, and family and school as intervention place. Behavior
modification is the key point for obesity intervention in children. Comparing with young children, older children have stronger ability of self-monitoring. That makes it easier for implementation of behavior modification. That is why I started childhood obesity intervention by behavior treatment in middle school students.

For growing obese children, it is not suitable to evaluate treatment effects by weight loss. Weight maintenance, rather than weight loss, may for many be a more appropriate goal. Development of a healthier life style for the long term may also be more important than short-term weight loss. Many behavioral programs have improved both diet and physical activity having either short-term or long-term beneficial effects on BMI in participants (Smith, 1997; Eliakim, 2002). In this study, family-based behavioral treatment decreased BMI significantly in school children in the treatment group. At 24 months, the obese children in the treatment group had a 9.8% reduction in initial BMI and the controls had none. The overall impact was related not just to weight loss but to the high rate of height growth at this age.

The complications of obesity that are associated with cardiovascular disease include hypertension and dyslipidemia (Ghannem, 2001). In this study, the blood pressure was lower in the treatment group at the two-year follow-up, an effect which has been demonstrated earlier (Sorof & Daniels, 2002). Obesity is associated with hyperlipidemia not only in adults, but also in children (Friedland, 2002). Significant improvements were observed in total cholesterol and triglyceride levels in our study, as in earlier studies (Wadden, 1999; Sothern, 2000). We also found a significant correlation between BMI reduction and triglyceride reduction in the treatment group, suggesting that the treatment may have had a beneficial effect on serum lipids. These obese children thus benefited from a reduction in key cardiovascular disease risk factors with behavioral treatment in this study.

No adverse effects were observed with the treatment. The obese children in both groups had a similar linear (height) growth to that of normal weight children. During two years of treatment, neither any parents nor any children in the treatment group had such serious problems with the program that they dropped out of it. Thus the behavior treatment approach that we adopted produced similar positive results to those found in other studies, suggesting that it is feasible to adopt in China. However, we used a large quantity of highly skilled manpower in implementing the treatment program. That was the main weak point of this treatment.

In the view of the public health worker, the aim of childhood obesity intervention is to decrease the prevalence of obesity in children. To deal with the prevalence of obesity, both treatment of obese children and prevention of new obese individuals should be considered. For the lifestyle related chronic disease, it is better to do the intervention as early as possible. In the following step of obesity intervention, I chose obese and non-obese children as targeted population, school as intervention place and primary school students (6-12 years old) as the age of intervention.
There are only a few studies of obesity interventions focused on the prevalence of obesity in children. Most population-based interventions showed some improvement in health knowledge and health-related behaviors, including consumption of a low-fat diet, more vegetable and fruit consumption, less sedentary time, and more physical activity (Braet, 1997; Epstein, 1998; Frenn, 2003; Harrell, 2005). Prevalence of obesity as an indicator of public health problems should be given attention.

Implementation of this school-based intervention was successful. The prevalence of overweight and obesity were no different between intervention and control schools at baseline. Over the three-year intervention period it decreased significantly among children in intervention schools and increased in control schools, leading to significant differences between the two groups at end line. The incidence of obesity and remissions also indicated statistically significant intervention effects. This suggests that the intervention impacted not only on obese children but also on those at risk of becoming obese.

The prevalence of overweight and obesity were significantly higher in boys than in girls, both in intervention and control children, and both at baseline and at the end. In Chinese tradition, people treat boys and girls differently. Obese boys are considered to be strong and while obese girls are thought to be fat. Obese boys are much more accepted by parents than obese girls. Society also places greater importance on weight and body shape in females than in males. Girls want to be like the slim ladies shown in advertisements. These may be some of the reasons that the prevalence of obesity was higher in boys than in girls. In another recent study of children, the prevalence of overweight was 27.7% in boys and 14.1% in girls (Iwata, 2003). However in the survey of children 2-6 years old in Beijing in this thesis, overweight was not found to depend on gender. The difference in gender appears in older children. More scientific evidence is needed to support this hypothesis in order to help identify the important targeted population for prevention.

Both treatment and prevention are needed to help overweight and obese children improve their BMI as they grow in height as well as to prevent new cases of obesity. In our intervention program, a school-based approach was used for all the students as well as special interventions directed at overweight and obese students. The average BMI was no different between intervention and control children at baseline. It increased in both groups, but was significantly lower in intervention children comparing with control children at end line. It also showed a positive result in prevention of obesity in one aspect. In our experience, regular height and weight measurement was itself a useful intervention. Overweight and obese children can be screened and parents informed about their child's nutrition status over time. Most urban Chinese families have only one child. Parents tend to overfeed their children if they do not think that their children are overweight. “Don’t encourage your child to eat more when the child feels full” was a major mes-
sage in the program, not a particularly difficult behavior for the parents to encourage.

No adverse effects were observed among the children with the intervention. The children in intervention schools had a similar linear (height) growth to that of control children.

School-based intervention programs can be implemented in a school setting, offering regular contact with children and parents. The eagerness of the teachers, students and parents in the intervention schools to participate in the program was a great asset. We believe that this intervention was more effective than only targeting obese children individually would have been.

After this study was completed, obesity intervention has been integrated into the routine school health work by Beijing Education Bureau. I was invited to develop the “Guideline for School Health Work in Beijing (2006-2010)” and was responsible for the part on obesity intervention. The intervention methods used in this study were included in the guidelines. The Beijing Education Bureau and Beijing Health Bureau then approved these guidelines and introduced them in 2006 in all Beijing schools.

The main finding in this study

Early prevention is the best way to control childhood obesity because therapeutic interventions are expensive and tend to have poor long-term results. Prevention needs to begin before children are at school, especially before “adiposity rebound”, the critical period of childhood for the development of adult obesity, which occurs at 5.5 years of age on average (Dietz, 1994). With a high proportion of overweight in preschool children, school-based prevention strategies alone are too late to prevent overweight for this population of children. For the children aged 3-5 years old, their eating behavior may be influenced mainly by their family dietary environment (Birch & Fisher, 2000). Therefore identifying family risk factors of obesity is important for early obesity intervention.

In this investigation, the combined prevalence of overweight and obesity in 2- to 6-year-old children living in Beijing was 14.9%, similar to that seen in several European industrialized countries (Janssen, 2005). An increased prevalence of overweight with increasing age was also observed. This suggests that the prevalence of obesity may be higher in school children in the future without intervention.

Parental overweight was associated with childhood overweight in this study. Parental overweight may increase the risk of overweight through genetic mechanisms or by shared familial characteristics in the environment such as food preferences and various lifestyle factors (Francis, 2003). The results of this study also indicate a strong association between parents’ and children’s habits of eating, television watching and physical activity. Asso-
Associations between parental and child dietary intake and lifestyle have been found in several studies (Brown & Ogden, 2004; Polley, 2005) but have not been previously studied in China. Young children’s eating behavior and activity habits are mainly influenced by their family dietary environment and lifestyle. Family environmental factors may work synergistically with genetic factors to produce intergenerational similarities in eating, activity and overweight. The results from the present study indicate that in addition to simply educating parents about healthy dietary behavior for children, the parent’s own dietary habits may also need to be addressed - this might be a major target for health education on childhood obesity in cities in China. Parents should be encouraged to recognize that their own eating behavior and lifestyle have an important influence on their children.

Dietary intake has a major influence on childhood obesity (Richketts, 1997). Parental control of food intake can be regarded as protective. However in this study, it was observed that overweight children were more likely to have mothers who restricted snacks and who did not encourage their children to eat often. There were no data to show whether the restriction came first and the overweight followed in this survey. The survey could only show that quite a proportion of mothers restricted snacks for their overweight children. Restriction and control over food intake is a common way to encourage good eating habits for obese children. However some studies have found that restriction may actually promote the desire to obtain the restricted foods and may increase consumption of those foods in the absence of parental restriction, even in the absence of hunger (Fisher & Birch, 1999; Brown & Ogden, 2004). Provision of education to parents about the potential negative consequences of food restriction may be an aspect of health promotion for childhood obesity intervention.

High levels of television watching have been associated with childhood overweight and obesity in cross-sectional studies in China (Tudor-Locke, 2003). In the current study there was also a link with inactive lifestyle (television watching more than 2 hours/day) and overweight. Low maternal education was associated with childhood overweight in our study. Many studies have demonstrated that children of less well educated mothers are more likely to be overweight than children of more highly educated mothers (Gnavi, 2000; Chen & Kennedy, 2005). Mothers are usually the main caregivers for young children comparing with fathers, although grandparents are also primary caretakers for young children in many three-generation families in China. Additionally mothers with higher educational level tend to have better nutrition knowledge (Wardle, 2000). Mothers’ (and grandparents’) actual child feeding practices, their own dietary habits and knowledge, as well as the beliefs and attitudes of healthy nutrition seem to have a powerful influence on developing healthy eating habits of young children. The findings of the present study suggest that it may be particularly important to target less well educated mothers for health promotion intervention.
This study showed that parental overweight, lower maternal education level, more time watching TV, and parental lifestyle were associated to overweight in children aged 2-6 years old in Beijing. This study could only identify one aspect about overweight related factors in children, perhaps in part because of the limited sample size. I am arranging a national survey for childhood obesity. It covers 15 cities in China and the sample is around 200,000 children 0-18 years old. The data collection will be finished by the end of 2006 and the results of this survey may identify the risk factors of childhood obesity more completely. The study focused on risk factors of childhood obesity as the basis of early intervention. Education about maintaining a healthy weight could be introduced much earlier in families with high-risk children. Such an approach could help protect children from unfavorable environmental factors predisposing to weight gain and obesity, which is difficult to reverse once established.

In the cross-section survey I found that three-generation families comprised almost half of the sample families. The grandparents had different opinions than the parents regarding young children’s overweight. Many grandparents did not realize that obesity was a health problem to children. The role of grandparents in childhood obesity and obesity prevention should be considered.

In this qualitative study, I have observed the influence of grandparents on several aspects of children’s eating behavior. Grandparents were the primary caretakers and the ones providing the immediate family food environment for their grandchildren. Their views and ideals of healthy child nutrition were colored by their own experiences of poverty, the conception that obesity is a sign of health, and that their fostering duty comprised providing the family’s only child with ample food of a kind that the child likes and which they thought were nutritious. These findings may have revealed a key concern in the childhood obesity epidemic of China: the major role of grandparents in children's nutritional intake and the fostering of their eating habits. Our study showed that the family environment in many three-generation families did not provide an opportunity to engage children in healthy eating. Despite the high levels of parent knowledge about healthy foods, this knowledge did not generally translate into child-feeding practice and children’s healthy eating behaviors. Clearly grandparents play a crucial role in forming the family dietary environment. Their eagerness to care well should be taken as a starting point for information.

Because of their own experience of poverty and hunger and the belief that caring for and loving children means feeding them well, grandparents tended to provide young children with excessive food. However, pressuring a child to eat in the absence of hunger may have detrimental effects on the child’s ability to regulate energy intake. Birch and Davison (Birch & Davison, 2001) have indicated that pressuring children to eat was effective in increasing their energy intake. In addition, providing children with free access to palatable snacks immediately following a meal eaten to satiety pro-
duced a substantial additional intake in another study (Fisher & Birch, 1999). It is therefore quite plausible that the grandparents’ pattern of feeding their grandchildren may contribute to the emergence of obesity, especially in children who are genetically predisposed. We also found that grandparents offered high energy density food as rewards to promote better conduct in children. Using food as a reward, however, tends to increase preference for the reward foods (Birch, 1992), leading to less healthy food preferences in children.

Whereas several parents considered their child’s overweight to be a problem, in general grandparents believed, on the contrary, that overweight children were happy, strong, and healthy. Very few grandparents agreed with parents when it came to restricting obese children’s overeating. We observed that it was grandparents with higher educational levels who showed such agreement. It is plausible that grandparents with higher levels of education might be more prone to health education messages, although more evidence is needed to support this hypothesis.

How can we make childhood obesity intervention more effective?

Because grandparents seem to have the role of primary caregivers in most three-generation families, conventional ways of conveying information to parents through the maternal and child health care system will not be useful in influencing grandparents’ parenting practices. Given that grandparents’ ideas of healthy nutrition in childhood seem too often diametrically opposed to what is thought to be a healthy diet for children today, a key issue in prevention is how their attitudes might be altered in a way that carries a lower risk for the children of becoming obese. One possible strategy is to consider the grandparents as the primary caretakers they are and offer them parenting education along with the parents where appropriate. To pursue such education, a home-based approach might be useful, mindful of the venues where children, parents and grandparents congregate. As food seems to have a major role as reward and as an expression of love towards their grandchildren, this might be a possible opening in planning a public health campaign directed at grandparents. Obviously, practices deeply rooted in tradition, a collective history of famine, and children's like for fatty and sweet foods makes a change in attitudes and behavior especially difficult. One important lesson is, however, that the specific cultural context in China requires special attention to grandparents as stakeholders in any efforts addressing children's nutrition.

Health promotion is the effective intervention for public health problem (Pencheon, 2001). WHO has developed the “Global Strategy on Diet, Physi-
cal Activity and Health” to address the lifestyle diseases including obesity-related conditions (WHO, 2004). It has been unanimously endorsed by WHO's 192 Member States as well as those from official observers and non-governmental organizations in 2004. Health promotion, including education, social mobilization and advocacy, is needed for childhood obesity intervention. More consideration has been given to starting obesity prevention early in life, even during pregnancy and at birth (Burdette, 2006). Family child feeding may be one important target of prevention effort. For early childhood obesity intervention, parental feeding style should be addressed. Since more than half of young children are looked after by their grandparents in China, the children in three-generation families should be considered. The grandparents should also be targeted in the intervention program. They are eager to care well for their entrusted grandchild.

Future study

Obesity is a chronic disease which is related to lifestyle. Children learn eating behavior and lifestyle from their family in early childhood. Early intervention focused on establishing healthy dietary habits and lifestyle in young children should be an important and effective strategy to control child obesity. The objective of the intervention may be to modify family food behaviors which are associated with obesity by health education and to decrease the risk factor of obesity in children. Infant and young child feeding practices, parents’ lifestyle and cost-effective approaches toward health education should be explored and studied in the intervention. The intervention program may include monitoring of anthropometry and food intake, nutrition education (lecture, leaflet, poster, and group discussion), family home visiting, and consulting in community clinics. The effects of intervention may be evaluated regarding prevalence of obesity, dietary intake, feeding practice, change tendency of BMI, and growth velocity. The targeted population would be young children and their parents. The intervention place would be family, kindergarten and community. The age of intervention would be 0-6 years old.

Conclusions

Obesity has become an increasingly important health problem among children in China. Childhood obesity interventions should be of high priority. The identification of risk factors is the key to prevention. Better understanding of the factors associated with obesity would be helpful to combat the epidemic. Our cross-sectional study found that parental overweight, lower
maternal education level, more time watching TV, and parental lifestyle were related to overweight in children aged 2- to 6-y-old in Beijing. More research is needed to determine whether of these are important causes of obesity in China, worthy of attention in the design of large-scale interventions. Education about maintaining a healthy weight could be introduced much earlier in families with high-risk children. Parental models of healthy lifestyle should be considered. Such an approach could help protect children from unfavorable environmental factors predisposing to weight gain and obesity, which is difficult to reverse once established.

In many three-generation families in Beijing, grandparents were the primary caretakers of children in the three-generation family. They played an important role in planning and cooking family meals. These grandparents' attitudes are almost certain to influence young children’s nutrition and eating habits. The findings from this qualitative study suggest that preventive interventions for childhood obesity should target grandparents in obesity prevention programs.

Behavior modification is an important approach of all weight control programs for obese children. Our study showed that family-based behavioral treatment targeting dietary and exercise change was adapted to the needs of and feasible to implement for individual obese children in Beijing, China. After a two-year follow-up, the treatment group achieved greater improvement in BMI, blood pressure, total cholesterol and triglyceride levels.

We also wanted to examine the impact of similar interventions that utilize less highly trained manpower to see whether they might be more cost-effective. For example, behavioral modification could possibly be achieved in larger population groups through nutrition education approaches that reach larger groups of grandparents, parents and children. Our school-based intervention appeared to be successful in reducing the prevalence of overweight and obesity in intervention schools. In addition, fewer non-obese children became obese and there was a higher remission rate of obesity in the intervention schools than in the control schools. This school-based intervention approach has been adopted in the “Guideline of School Health Work in Beijing (2006-2010)” by Beijing Education Bureau and Beijing Health Bureau and has been carried out in 2006 in whole schools in Beijing.

Of particular concern is that many of the children in both approaches were not helped—at least not much. Thus, other approaches, which probably cannot have such an apparently high cost-effectiveness, must also be developed to help these more challenging cases.

Obesity in children is a serious and worsening problem. Early prevention may be the key to controlling it. There is no evidence for any rapid shift in genotype to explain the rise in obesity. Environmental factors caused by changes in physical activity and diet more likely explain it. Obesity seems the result of an interaction of a normal physiologic system with an obesity-promoting environment. The obesity-promoting environment itself is one obvious target for preventive interventions, one that we include in our ex-
periments up to and including family and school levels. Important for combating strategy about child obesity in China should be identifying and demonstrating effective intervention efforts within child health care, school and community that can fit the specific social environment; to raise awareness of childhood obesity issues and stimulate a support at the local and national level. The opportunity of the Olympic Games to promote a new view of the male shape can be tested.
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A doctoral dissertation from the Faculty of Medicine, Uppsala University, is usually a summary of a number of papers. A few copies of the complete dissertation are kept at major Swedish research libraries, while the summary alone is distributed internationally through the series Digital Comprehensive Summaries of Uppsala Dissertations from the Faculty of Medicine. (Prior to January, 2005, the series was published under the title “Comprehensive Summaries of Uppsala Dissertations from the Faculty of Medicine”.)