Childhood obesity in China:
prevalence, determinants and health

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Obesitas bij kinderen in China: prevalentie, determinanten en gezondheid

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For my parents, my son and my husband

ABSTRACT

Childhood obesity in China: prevalence, determinants and health

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Over the past two decades, China has been undergoing rapid socio-economic and nutrition transitions. Along with these transitions, childhood obesity and its related metabolic and psychological abnormalities are becoming serious public health problems in China. However, no national figures on the occurrence of childhood obesity, its determinants and its relationship with metabolic syndrome were available in China, until now.

Data of 44880 youngsters aged 7-17 years from the nationally representative 2002 China National Nutrition and Health survey was used to study the prevalence of childhood obesity. This thesis indicates that, the overweight prevalence of Chinese youngsters was 4.4% and the obesity prevalence was 0.9%, as defined by International Obesity Task Force criteria. The estimated total number of overweight youngsters was 12 million, which means that one in thirteen overweight children worldwide was living in China. Both the overweight and obesity prevalence and their increment were higher in urban than in rural areas and higher in boys than in girls. The prevalence increased with the family's income level and the mother's educational level. Compared with children with normal weight parents, the prevalence increased if one or both parent(s) were overweight or obese, up to more than 10 fold (Prevalence ratio 12.2, 95% CI: 7.2-20.7) in case both parents were obese.

Compared to their normal weight counterparts, overweight children consumed significantly more dietary energy (4.8%), protein and fat, but less carbohydrate; more cooking oil, meat and meat products, and dairy products, but less cereal grains and

vegetables. On average, overweight children spent half an hour less on moderate/vigorous activities, and 2.3 hours more on low intensity (sedentary) activities per week. The prevalence ratio (0.6) of children who walked to and from school was statistically significant, indicated that children who walked to/from school have a 60% lower prevalence of overweight and obesity compared to those who went to/from school by bus. Other significant prevalence ratios were: moderate/vigorous activities ≥ 45 min/day (0.8); low intensity physical activities >2 hours/day (1.3); consumption of ≥ 25 g/d cooking oil (1.4); ≥200 g/d meat and meat products (1.5); ≥100 g/d dairy products (1.8).

Overweight and obese children had higher risk of metabolic syndrome, body dissatisfaction and depression. It is estimated that more than 3 million Chinese adolescents aged 15 to 19 years have the metabolic syndrome (3.7%). Of the adolescents having parents with metabolic syndrome, once they are overweight or at risk of overweight, their risk of metabolic syndrome would be much higher (46.4%).

Overweight girls, but not boys, had mildly but significantly higher total Children Depression Inventory score; both obese girls and obese boys showed a higher level of negative self-esteem scores, which was partially explained by body dissatisfaction. About seven in ten children were not satisfied with their body weight. More than one fifth underweight girls still wanted to be thinner while more than one third obese boys wanted to be heavier. Children who wanted to be thinner showed significantly higher scores of ineffectiveness and negative self-esteem.

In conclusion, obesity is an increasing problem among youngsters in China, especially in urban areas. Since childhood obesity prevalence is positively associated with socio-economic status, the rapid economic development in China may result in a sharp rise in overweight and obesity prevalence unless effective preventive actions are taken. Fat intake, low intensity activities and active transport to/from school may be suitable targets for overweight prevention among Chinese school children.

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Introduction

Over the past two decades, China has been undergoing rapid socio-economic and nutrition transitions. A 10-fold increase in the gross domestic product parallels an increase in more energy-dense foods, a decrease in transport related physical activity, and an increase in leisure time inactivity.[1,2] With these rapid transitions, China is experiencing a shift from under- to over-nutrition problems. Overweight prevalence increased from 6.4% to 7.7% during 1991-1997 based on a survey in eight provinces.[3] In developed countries and to a lesser extent in China the rise in childhood obesity was reported to be related to an increase in metabolic and psychological abnormalities.[4-18] However, no national figures on the occurrence of childhood obesity, its determinants and its relationship with metabolic syndrome are currently available in China.

This thesis presents 1) national estimates of overweight and obesity prevalence for youngsters aged 7-17 years in China in 2002, as well as the trend in the last 20 years; 2) information on the determinants of childhood obesity in China; 3) national estimates of metabolic syndrome prevalence and distribution among Chinese youngsters in 2002; 4) the relationship between body weight, body dissatisfaction and depression symptoms.
In this first chapter, we will display the worldwide epidemic of childhood obesity, and its determinants. The related metabolic and psychosocial abnormalities will be discussed next. Against this background, the aims, research questions, and the outline of the thesis will be presented.

PREVALENCE OF CHILDHOOD OBESITY AND TRENDS

According to the latest estimates by the International Obesity Task Force (IOTF), ten percent of the world's school-aged children are estimated to be overweight, a total of 155 million.[19] Approximately 30-45 million within that figure are classified as obese - accounting for 2-3% of the world's children aged 5-17 years.[19] Prevalence varies greatly worldwide. By the IOTF definition, more than 30% children in the Americas, around 20% in European countries, and less than 10% in Asia-pacific countries are overweight (including obesity).[19]

Increasing trends of childhood obesity prevalence have been observed in both developed and developing countries.[3,20-22] The prevalence of overweight among non-

Hispanic black and Mexican-American adolescents increased more than 10 percentage points between 1988-1994 and 1999-2000.[22] The latest figures in England,[23] based on official data from the Health Survey for England for 2001/2, show that rates of overweight among both boys and girls in the 7-11 year age groups are four times the level found 30 years ago. The original overweight figure in 1974 was 7%, rose to 20% in 1998, and leapt even higher to 27% four years later. The percentage of obese children in this age group increased from 1% in 1974 to 7% in 2001/2. The prevalence of obesity in Cremona (Italy) children aged 6-11 years rose from an overall level of 6.1% in 1990 to 13.6% in 1998. In Brazil, the prevalence of overweight increases from 4.1% in 1975 to 13.9% in 1997.[24,25] Data from eight provinces in China show a similar but weaker trend, from 6.4% in 1991 to 7.7% in 1997.[3]

Previous studies conclude that the prevalence of obesity is negatively correlated with socioeconomic status (SES) in developed countries, in contrast, positively correlated with SES in developing countries.[19,26-28] For example, in the US, overweight is high in rural areas, in poor families, and in children of mothers having low education level.[27-31] To the contrary, Brazilian adolescents of the high-income group are two to three times more liable to overweight and obesity, and the prevalence is higher in urban than in rural areas.[24,25] Similar results are also found in China.[32] A survey in four provinces showed that obesity is more common in urban areas, positively related with family income level and more common in children of mothers with higher education. The possible explanation is that those with higher income and education, urban living are more likely to be "westernized" and therefore experience higher risk of obesity.[32]

Nationally representative data for childhood obesity are available in many developed countries and some developing countries. Such as the "National Health and Nutrition Examination Survey" in US,[22] "Health Survey for England" in England,[23] "Estudo Nacional sobre Despesa Familiar–ENDEF" in Brazil.[24,25] In China, several surveys have examined the problem of childhood obesity. The "National Surveys on Students Constitution and Health"[33] routinely investigate the obesity prevalence in 31 provinces of China, but are only limited to students. School-aged children not going to school are not included. The "China Health and Nutrition Survey"[34] is based on data from eight provinces and the "Dietary Behaviour Survey in 4 cities"[32] from four provinces. They

all provided valuable information on childhood obesity in China, but are not nationally representative.

In conclusion, childhood obesity is rapidly emerging as a global epidemic that will have profound public health consequence. National estimates of the problem are necessary for both public health research and policy making. Up till now no national figures of the occurrence of childhood obesity and its distribution are available in China.

DETERMINANTS OF CHILDHOOD OBESITY

The epidemic of obesity results from a combination of genetic susceptibility, increased availability of high-energy foods and decreased opportunities for physical activity.[19,35-38]

Family and genetic effect

It is clear that obesity often tracks in families. Family studies yield estimates of the fraction of the variation in the population that is inherited (the heritability).[39] Having obese relatives increases one's risk for obesity, even if family members do not live together or share the same patterns of exercise and food intake.[40-42] A review by Allison *et al*.[35] note that adoption and family studies have found heritability in the range 25–50%, while monozygotic twin studies report a heritability of BMI as high as 85%, with the typical estimate of heritability at 50%, meaning about one-half of the variation in body mass within a population is a result of inherited factors. [40,41,43] Genetic research suggests that, overall, more than 600 genes, markers, and chromosomal regions have been associated or linked with human obesity phenotypes.[44]

Previous studies indicate that parental body weight is the most potent risk factor for childhood obesity.[45-49] Treuth and colleagues[48] found a stepwise increase in gains in fat mass and percent body fat over time occurred with increasing parental body weight status. The association reflects both genetic and environmental influence on the development of overweight. Besides the high genetic similarity among members of a family,[47] parents play an important role in the development of children's physical

activity patterns,[46] eating behaviors and attitudes.[45] Parents' socioeconomic status also has important effect on childhood obesity.[27,30,31]

However, rapid changes in the numbers of obese children within a relatively stable population do not indicate a change in genetic background. Genes for overweight only express where the environment allows and encourages their expression. These obesity-promoting environmental factors are sometimes referred to as 'obesogenic' (or 'obesigenic').[19] Allison *et al*.[35] review previous studies and suggest that some 10% of the population may become overweight even in environments that mitigate weight gain, and a similar proportion of the population might have a strong genetic predisposition to remain thin even in obesogenic environments. The majority of the population carries combinations of genes that may have evolved to cope with food scarcity. Such a genetic predisposition is maladaptive in an environment of ready availability of calorie-dense food and where low energy expenditure is the norm. It has been said that a child's genetic make-up 'loads the gun' while their environment 'pulls the trigger'.[50]

Energy, nutrients and food pattern

Total energy intakes, as assessed by the doubly labelled water method, predicts increases in body fat during childhood. The WHO MONICA Project indicates that between country differences in temporal trends of total energy supply per capita explain 41% of the variation of the trends in mean BMI, the effect is similar upon the prevalence of overweight and obesity. Trends in percent of energy supply from total fat per capita explain 7% of the variation of the trends in mean BMI when the total energy supply per capita is adjusted for. [51]

The key dietary factors that have been most often associated with weight gain or obesity include high dietary fat intakes,[52-54] overconsumption of energy-dense foods,[55,56] and based on recent research, diets characterized by a greater reliance on carbohydrate-rich foods with a high glycemic index compared to those with a low glycemic index.[57] Consumption of high fat foods is thought to be a particularly powerful predictor of weight gain because of the efficiency with which fat is metabolized and its high caloric density and palatability. Furthermore, because fat intake produces weak satiety signals relative to other macronutrients, it results in greater overall intake.[26] Experiments in

laboratory animals have repeatedly shown that there is a strong positive relationship between dietary fat intake and body weight.[58,59] Using laboratory techniques to determine body composition and energy expenditure, the body fat mass was positively correlated with intakes of total fat, saturated and monounsaturated fatty acids.[60] In contrast to animal experiments and clinical studies, the epidemiologic studies of diet and body weight have shown mixed results, ranging from a positive to an inverse relationship.[61-63] Cross-sectional studies are generally in agreement that dietary fat is positively associated with relative weight,[62] whereas the prospective studies of diet in relation to weight change give inconsistent results.[53,61,63] Fiber limits energy intakes by lowering a food's density and allowing time for appetite control signals to occur before large amounts of energy have been consumed. As reviewed by Drewnowski *et al*, energy density is related to the diet's fat content and higher energy intakes, usually fail to suppress appetite, and in some cases, associated with modest weight gain.[64]

Analyzing food balance data from developing countries, Drewnowski and Popkin[65] suggested that the classical correlation between income and dietary pattern has been drastically changed by the globalization of food production and marketing. Even lower income countries appear to consume a higher percentage of calories from fat, a fact attributed to the widespread availability and low cost of vegetable oils.[66] There is increasing evidence that dairy intakes are associated with body weight regulation among both adults[67-69] and children.[70-74] Increasing dietary calcium may lessen diet-induced adiposity by modulating adipocyte intracellular Ca^{2+} and thereby leading to a reduction in lipogenesis and the stimulating of lipolysis.[70-76] Other compounds within dairy products, such as whey protein,[70-74,76] conjugated linoleic acid,[77] and branched chain amino acids,[78] may also act in concert with dietary calcium to produce antiobesity effects. Fruit and vegetable consumption may affect energy intake and body weight because these foods are high in water and fiber and low in energy.[79] Increased consumption of fruit and vegetables could help to reduce energy intake, promote satiety, and aid weight management.[80] Of the two cross-sectional analyses in children, one shows that lower vegetable intake was associated with overweight in both boys and girls,[81] whereas the other showed an association in boys only.[82]

Energy expenditure, physical activity and sedentary behavior

A second determinant of obesity that follows from the energy balance model is caloric expenditure. When the level of total caloric expenditure is lower than caloric intake, accumulation of adipose tissue ensues. Thus, low physical activity and/or increasing sedentariness are widely thought to be related to weight gain.[83] Childhood overweight has been found in some studies to be associated with low levels of physical activity[84,85] and high levels of sedentary activities,[63] although these findings are not universal.[86,87] High daytime activities, measured by a motion sensor, of children aged 4-8 y of age has been associated with reduced childhood adiposity.[88] Furthermore, increasing physical activity levels have been associated with reduced levels of body fat in preschool children and young school-aged children.[89-91] The meta-analysis by Rowlands *et al.*[92] concluded that there was a weak to moderate relation between body fat and activity in children. Physical activity level has been shown to be inversely associated with percentage body fat in both younger children and adolescents with correlation of -0.52 and -0.53, respectively.[90,93]

In adults, walking has been demonstrated to be beneficial to health and weight control,[94,95] while motorized vehicle use seems to be associated with overweight and other disorders. Among U.S. young adults, the proportion of individuals using active transportation is higher among non-overweight compared to overweight ones (to work: 9.2% vs 6.8%; to school: 29.7% vs 22.6%).[94] Among Chinese adults, going to and from work by walking or bicycle seems to reduce risk of overweight by half compared to going by bus.[96] Men who acquired a motor vehicle experience a 1.8 kg greater weight gain and have two to one odds of becoming obese.[97]

Multivariate studies have found that television viewing and video games playing for longer periods of time promotes obesity.[86,98-105] Andersen reported that boys and girls who watch four or more hours of television each day have more body fat and a greater body mass index than those who watch less than two hours per day recently.[103] Dietz and Gortmaker[104] reported that the amount of television viewing is related to obesity in both cross-sectional and longitudinal investigations and this result was repeated in 1996.[105] The results show a strong dose–response relationship between number of

hours of television viewing and the prevalence of overweight at the end of the period, even after adjusting for previous overweight, baseline maternal overweight, socioeconomic status, household structure, ethnicity, and maternal and child aptitude test scores. Those children watching television the most (over 5 h day^{-1}) were five times as likely to be overweight than those watching fewer than 2 h day^{-1}.

Socioeconomic status

Socioeconomic status (SES) is usually presented as a composite index combining income, education, occupation and, in some developing countries, place of residence (urban/rural). [26]

The relation between the prevalence of obesity and socioeconomic status has been reviewed by Sobal and Stunkard.[27] They concluded that obesity was negatively correlated with obesity in developed countries, but is positively related with obesity in populations of developing countries. In China, Ma *et al.*[32] found significantly more obese children in high-income families than in low-income families. This confirmed previous findings in Brazil, where Brazilian adolescents in a high-income group were two to three times more liable to obesity than their lower-income counterparts.[106]

Martorell *et al.* showed that in developing countries overweight was more common in children of mothers with higher educational achievement.[107] In China, children of well-educated parents tended to be more obese than their counterparts with poorly educated parents.[32] Parents' educational level with higher income may be associated with increased away-from-home consumption of high fat items and increased consumption of meat, and/or more sedentary transportation, less house work, and less active work, which in turn is associated with higher risk of developing childhood obesity.[26]

In conclusion, obesity is a multi-factorial disease and its development is the result of multiple interactions between genes and environment. Dietary factors and physical activity patterns have a strong influence on the energy balance and can be considered to be the major modifiable factors through which many of the external forces promoting weight gain act. Higher socioeconomic status may be linked to high risk of

obesity. National estimates of the determinants of childhood obesity would be very important for developing prevention programs in China.

METABOLIC SYNDROME

Obesity is now so common that it is beginning to replace under-nutrition and infectious diseases as the most significant contributor to ill health. In particular, obesity is associated with diabetes mellitus, coronary heart disease, dyslipidemia, as well as metabolic syndrome.

Metabolic syndrome refers to a clustering of specific cardiovascular disease risk factors.[108] There are several syndrome definitions for adults, such as the World Health Organization (WHO) criteria[109] and the Third Report of the National Cholesterol Education Program's Adult Treatment Panel (ATP III) criteria.[110,111] Pediatric metabolic syndrome has been reported in many populations, but the results are incomparable because a unanimous definition is lacking[4,6,9-12]. Based on the ATP III criteria[110,111], Cook *et al.*[5] proposed pediatric metabolic syndrome criteria for U.S. children and adolescents defined as having three or more of the following abnormalities: high fasting glucose level, hypertension, abdominal obesity, high triglyceride level and low high-density-lipoprotein cholesterol (HDL-C) level.

High fasting glucose

Body mass index is a significant predictor of both glucose and insulin levels, independent of age and sex.[112] Obesity beginning in childhood often precedes the hyperinsulinemic status.[113] Obesity leads to insulin resistance and increases circulating insulin concentrations over time. It seems that at some point a loss of control of blood glucose begins to emerge, resulting in dietary glucose intolerance. This ultimately results in type 2 diabetes.[113] In a study of childhood diabetes, Scott *et al*.[114] found excess body weight among over 90% of adolescents with type 2 diabetes while among children with type 1 diabetes excess bodyweight was found in about 25% of cases. Obese children are at increased risk of being classified as having diabetes or impaired fasting glucose (odds ratio 5.1, 95% CI 1.51, 17.0).[112] Parallel to the increase in prevalence and severity of obesity in childhood and adolescence, the frequency of

diabetes seems to increase.[113,115,116] In Cincinnati the prevalence of adolescent type 2 diabetes increased 10-fold from 0.7 to 7.2 cases per 100 000 population in the period 1982 to 1994.[115]

Hypertension

Although hypertension is a less common medical consequence of childhood obesity than of adult obesity, several studies have shown an association between blood pressure and BMI in obese children and adolescents.[117-120] Obese adolescents have a blood pressure distribution that is skewed to the right.[119] The mean blood pressure for the obese group is one standard deviation higher than the mean blood pressure for the general population.[119] Obesity is frequently associated with hypertension in children. Up to 30% of obese children suffer from hypertension,[117] and among adolescents one survey found 56% of those with persistently elevated blood pressure are also overweight.[121] Another study has shown that overweight school children were 2.4 times as likely as normal weight children to have an elevated level of diastolic blood pressure, and 4.5 times to have elevated systolic blood pressure.[118] Among Chinese students aged 6-15 years, Wang *et al.*[120] found that the relative risk for hypertension in overweight and obesity groups were 3.0 and 4.9, respectively, as compared to their normal weight counterparts. The most reasonable hypothesis to explain the pathogenesis of obesity hypertension is that hypertension is primarily related to selected insulin resistance, which could result in sodium retention and alterations in ion transport. [119,122-124]

High triglyceride level and low HDL-C level

Childhood obesity has been frequently observed to be associated with a significant decrease in HDL-C and increased levels of triglycerides.[118,125,126] Increases in the body mass index have been found to be associated with the levels of triglycerides and HDL-C, as well as the risk of elevated triglycerides and decreased HDL-C, in both US and China. [11,118,127] The Bogalusa Heart Study indicated that overweight schoolchildren are 7.1 times as likely as their normal weight counterparts to have an elevated level of triglycerides and 3.4 times to have low HDL-C.[118] Steinberger and Rocchini have determined that the lipid abnormalities observed in obese adolescents are directly associated with insulin resistance.[113,119] It is suggested that hyperinsulinemia increased

triglycerides through enhanced hepatic very-low-density-lipoprotein synthesis and through a defect in very-low-density-lipoprotein removal. An increased rate of degradation of the apoprotein angiotensin I (the major lipoprotein in HDL-C) is believed to be a major cause for the reduced level of HDL-C observed in many insulin resistant subjects.[119]

Clustering of the risk factors

The combination of cardiovascular risk factors has been well documented in adults.[111] Recent studies have shown that potential risk factors for cardiovascular diseases already tend to cluster in childhood and they are strongly associated with obesity.[4-7,11,118] Metabolic syndrome is found in nearly 1 in 10 American adolescents, two third has at least one metabolic abnormality. Nearly one third (31.2%) of overweight/obese adolescents have metabolic syndrome.[7] The prevalence of the metabolic syndrome increases with the severity of obesity and reaches 50 percent in severely obese youngsters.[11] The use of overweight as screening tool could identify 50% of schoolchildren who had two or more risk factors.[118] In Hungary, the percentage of obese children who had at least 1, 2, 3 and 4 risk factors were 33.3%, 28.3%, 15.0% and 8.9%, respectively, while in the normal weight group, it was 16.7%, 3.8%, 0.4% and 0, respectively.[6] A recent report of adolescents in Taiwan found that 55% overweight girls and 70% overweight boys had at least one risk factor and 25% had two or more.[4]
Hypertension and hyperlipidemia were also found in Chinese overweight and obese children, though no mention was made of the metabolic syndrome until recently. Hypertension prevalence of normal weight, overweight and obese children was 6.7%, 19.7% and 32.2%, respectively.[120] An increasing trend of serum total cholesterol and triglyceride and a decreasing trend of HDL-C are found with increasing BMI.[128] Increased clustering of cardiovascular disease risk factors is found with elevated levels of BMI among Chinese adults.

In conclusion, as childhood obesity increases, its medical consequences are becoming more common and more frequently recognized. Although studies have examined metabolic abnormalities, the metabolic syndrome has not been well characterized in Chinese children and adolescents at the national level.

PSYCHOLOGICAL STATUS

Obesity is a stigmatizing condition, because obese people live in a culture that condemns their physical appearance, and perhaps more importantly, blames them for it. It is conceivable that they would suffer emotionally from the negative attitudes, and discrimination.[129-132] Children as well as adults stereotype the obese as lazy, ugly and stupid, and weight-related teasing is common place.[129-132] As a result, it has been assumed that obese people, especially children and adolescents, will experience poor psychological as well as physical health. Psychological problems associated with childhood obesity include negative self-esteem, poor body image, depression, avoiding interaction with peers, school performance difficulties, anxiety, lack of emotional well-being and the feeling of chronic rejection.[132]

Body image and body dissatisfaction

In 1935, Schilder defined body image as "the picture of our own body which we form in our own mind". Body image is an important underlying psychological factor associated with body weight. Overemphasis on thinness among children and adolescents may lead to negative self-esteem, depression, unhealthy dieting practices and eating disorders, whereas underestimation of body weight may increase risk of the development of overweight and obesity.[26]

Body dissatisfaction is most frequently defined as the discrepancy between a person's perceived size and the size they would like to have, ideally.[133,134] There are consistent findings of a relationship between BMI and body dissatisfaction in children, particularly in girls.[132,135]

Consistently, researchers have shown that both boys and girls who have a greater BMI desire to be thinner.[136,137] For example, Rolland *et al*. found that 78% of the girls who are overweight want to be thinner while only 30% of the normal-weight girls want to be thinner. Similarly, 60% of boys who are overweight want to be thinner.[137] Page and Allen found that girls expressing the greatest body dissatisfaction are those who believe they are overweight.[138] Several studies of children in the USA and England have revealed that, the majority of girls agree that it is bad to be fat, half express a desire to be thinner, and about a third express a fear of becoming fat.[137,139,140] BMI influences the

children's perception of ideal size. Overweight and obese children are more likely to select thinner figure as the ideal size than non-overweight children, the higher the BMI, the thinner the ideal body size that was chosen (correlation coefficient -0.16 for boys and -0.11 for girls).[141]

Community-based cross-sectional studies document greater body dissatisfaction in heavier children and adolescents. [142-149] Studies among adult women and adolescent girls have shown a connection between body weight and body dissatisfaction.[150,151] Body dissatisfaction was also found in overweight boys, but to a lesser extent.[152] Davison *et al.*[153] found that this already starts at the age of 5 years, that is, BMI among girls of 5 years is associated with body dissatisfaction, but lower than at the age of 9. Among 11,868 Native American adolescents, Neumark-Sztainer *et al.*[154] reported that, weight dissatisfaction is expressed by 30.7%, 44.8%, and 55.9% of non-overweight, moderately overweight and very overweight boys, respectively. Weight dissatisfaction is expressed more frequently by girls: 59.1%, 76.9% and 84.4% among non-overweight, moderately overweight and very overweight girls, respectively.[154]

The association between BMI and body dissatisfaction is also found in prospective studies. Presnell *et al*. found higher BMI is associated with increases in body dissatisfaction 9 months later in girls.[145] In addition, girls who show greater increases in weight across age 7 to 9 reported greater increases in body dissatisfaction. Stice and Whitenton[146] also found the elevated adiposity emerged as one of the most potent predictors of increases in body dissatisfaction. Results from a meta-analysis suggest that being overweight is moderately related to body image distortion and that this effect is consistent across studies.[155] It has been suggested that perceived pressure to be thin from one's social environment fosters body dissatisfaction because repeated messages that one is not thin enough would be expected to produce discontentment with physical appearance.[156,157] There is also experimental evidence that an intervention that decreases thin-ideal internalization resulted in reduced body dissatisfaction.[158]

Childhood obesity and depression

The word "depression" can be used to refer to a feeling state or mood, a "syndrome", or a psychiatric diagnosis. The typical symptoms associated with a depression include

dysphonic mood, a sense of worthlessness, or hopelessness, persistent thoughts of death or suicide, difficulties in concentration or decision-making, disturbance in sleeping or eating patterns, and a lack of energy.[133]

A strong link between obesity and depression is often observed in clinical setting whether the focus of treatment was obesity or a depression disorder.[159] The depression scores in the Children's Depression Inventory and the prevalence of depressive disorders in the clinical obese group are significantly higher than in the non-clinical obese group, while both of the obese groups were more depressed than the control group.[13] In the literature, obese adolescents showed significant depression.[14,160,161] Erickson's population-based samples show manifest more depression symptoms among overweight girls, but not boys,[14] similar to Falkner's observation.[162]

A prospective study indicated that chronic obesity in boys is associated with depression during the 8-year study period.[160] Weight loss study found that severely obese subjects, especially younger women with poor body image, are at high risk for depression.[161] A weight loss was associated with a significant and sustained fall in depression (Beck Depression Inventory) scores.[161] The results of meta-analysis of obese individuals presenting for weight loss or general population controls suggest a moderate effect of obesity on depression and that this result is consistent across studies.[155]

As number of mechanisms exist through which depression and obesity may be linked or interact.[161] Symptoms of depression correlated significantly with reported body image dissatisfaction, which may aggravate depression. The severely obese person certainly suffers stigmatization, and major psychosocial disturbance, which may also cause or aggravate a depression illness.

Depression may also be linked to weight gain through a number of changes in behavior leading to changes in diet or physical activity. Some prospective studies indicated that depressive symptoms would predict obesity onset.[163-165] Pine *et al.*[165] showed that childhood depression was associated with an increased body mass index (BMI) in adulthood. Depressed mood in adolescence is associated with an increased risk for the development and persistence of obesity. As indicated by Goodman and Whitaker,[163] among those adolescents not yet obese at baseline, the odds of becoming obese in the

next year are doubled if they had a depression mood at baseline. A four year follow up study of Stice *et al.*[163] shows more than a fourfold increase in risk for obesity onset for each additional depression symptom at baseline. So depression may also be cause of obesity. Studies on the psychological correlates and sequence of obesity have usually characterized the relationship between depression and obesity as unidirectional, depression may be cause or consequence of obesity, no conclusion by now.

Childhood obesity and self-esteem

Self-esteem is defined by William James (1890) in terms of a balance between a person's attainments and their goals or aspirations. Others emphasize the social aspect of self, such that whether we have high or low self-esteem depends at least partly upon how others regard and treat us. In the clinical and public health literature there appears to be consensus about the fact that self-esteem is one of the casualties of obesity in children and adolescents. This is in spite of a review of 35 studies by French and colleagues[166] which concluded that the association between obesity and low self-esteem is modest, and that the scores in overweight and obese children generally fall within the normal range. Various studies found lower self-esteem among 6-18 years old obese children, compared with their non-obese counterparts.[167-171] The decrease in global self-worth score per 10 kg/m^2 increasing in BMI is 0.19.[172] Age/gender standardized BMI accounts for 9% of the variance in appearance self-esteem in children 8 years and older.[173]

The association between weight and self-esteem has been found in many cross-sectional studies including both clinic and community based.[147,174-177] Significantly negative association between adiposity and the level of self-esteem is found in girls as young as 9 years.[174] Lean children have higher self-esteem than obese children.[178] Zeller *et al.*[177] found a significant proportion of adolescents reporting low self-esteem (based on a sample of clinical obese subjects) than their normative samples, and in Braet *et al.*'s survey,[167,179] all obese children regardless of help-seeking had lower self-esteem. Phillips and Hill's[175] general population based study has shown that overweight is associated with reduced self-esteem in some, but not all, areas of the lives of British girls aged 9 years. Based on the school sample of 2863 children aged 5-13 years, Wake

et al.[176] indicated that obese children are twice as likely to suffer low self-esteem as their normal weight peers. Hill also found that obese young adolescent children were 2-4 times more likely than normal weight peers to have low perceived athletic competence, physical appearance and global self-worth.[180] French *et al.*[166] reported in their review that 13 of the 25 published cross-sectional studies show significantly lower self-esteem in obese youngsters.

A prospective study reported that higher BMI z-score in 5-10 year old children at baseline predicts poorer self-esteem 4 years later.[181] Studies that look at the impact of weight loss treatment on self-esteem typically report improvements in some if not all dimensions of self-esteem. Walker and colleagues[182] found dose-response effect of weight loss and improvements of self-esteem, that greater weight loss is associated with higher increases in self-esteem, which suggest that obesity may be causally related to lower self-esteem. Influences such as societal emphasis on having a slim figure, high level of peer victimization, and rejection associated with obesity, as well as beliefs endorsed by many obese children that obesity hinders social interactions, may lower the self-evaluations of obese youngsters.

Interaction of body weight, body dissatisfaction, self-esteem and depression

Based on the previously referred studies, we propose perceived pressure to be thin, thin-ideal internalization and body dissatisfaction are intermediates in the relationship between overweight/obesity and mood problems for children and adolescents.[183,184]

Theoretically, elevated body mass results in body dissatisfaction, because being overweight is not currently considered socially desirable. This body dissatisfaction in turn may contribute directly to depression, because appearance is a central evaluative dimension in Western cultures. Several studies have found that body dissatisfaction increases the risk of subsequent onset of depression among children and adolescent.[15,158,183]

In general, the studies found a positive correlation between body image satisfaction and various measures of self-esteem. Both Wood *et al.*[185] and Tiggemann and Wilson-Barrett[157] have found overall significant relationships between body dissatisfaction and self-esteem. Children who report higher levels of body dissatisfaction report lower

global self-worth, poorer self-esteem, and are generally dissatisfied with other aspects of their lives such as school achievement.[135,186,187] It has been suggested that children who blame their obesity on their own behavior suffer from lower self-esteem than those who feel that external causes (e.g., genetics, medical problems) are linked to their obesity.[169,178] In a meta-analysis of the relationship between weight and self-esteem, Miller and Downey reported that even in children, perceived size was a better predictor of self-esteem than was actual body weight.[188]

In the studies reported by Rierdan and Koff [15] and Kaplan *et al.*[178], it was weight-related body image concern and perception of body weight, not the objective BMI or actual weight categories that significantly predicted depressive symptoms. Likewise Kim and Kim[189] showed that 15–19 year old Korean girls who perceived themselves to have a weight problem were at increased risk of depression and low self-esteem, regardless of actual BMI. These results suggest that body image or weight perception may have a mediating effect on the relationship between actual body weight and depressive psychological symptoms. It might also be the case that non-weight-related aspects of body image disturbances (e.g., dissatisfaction with the appearance of certain body parts) are more important than weight per se in promoting depression. This interpretation is supported by the fact that body mass only accounted for 18% of the variance in body dissatisfaction.[158]

Research in China

A somewhat heavier body has been considered to be a symbol of family fertility and wealth in the traditional culture of China. Although this belief may still exist in some rural, less economically developed areas, it seems to have become an element of the past in urban areas. As indicated by Ma *et al.*,[32] body dissatisfaction scores are significantly related to BMI in both boys and girls above 5 years old, and the absolute value of these correlations increase with age. The average absolute value of body dissatisfaction scores for obese girls is 2.0, which revealed that obese girls desired, on average, a two-figure thinner body size than their current body size. Body dissatisfaction is more prominent in obese children and adolescents; 37.5% of the obese boys and 47.2% of the obese girls are moderately dissatisfied with their body weight.

Examination of the direction of body dissatisfaction shows that 69.7% obese boys and 69.6% obese girls wish to be thinner.

Depression symptoms are very frequent among children in China, it is estimated that one fifth children catch depression.[190] Parents having too high expectations of their only one child is thought to be the main cause. Perception of overweight in Chinese adolescents is also associated with more experience of depression. A sub-cohort of 2179 Chinese adolescents indicates that perceived overweight boys and girls are more likely to experience anxiety and depression than perceived normal and underweight subjects.[18] Other studies conducted in China suggest that those students who are overweight or obese experienced more emotional problems and lower social cooperation skills than normal weight students.[191,192]

In conclusion, there is a common belief that overweight children are unhappy with their weight and experience more psychosocial distress, particularly negative self-esteem, poor body image and depression. Body image or weight perception may have a mediating effect on the relationship between actual body weight and depressive psychological symptoms. But there is limited information on the relationship between body weight and depression, as well as body dissatisfaction and depression among younger Chinese children.

RATIONALE

Indirect evidence from a variety of sources indicates that obesity is preventable and that the prevention of weight gain is easier, less expensive, and more effective than treating obesity after it has fully developed. National estimates of childhood obesity (Chapter 2) are needed to evaluate the problem in China and related determinants (Chapter 3) are necessary for developing effective prevention strategies. WHO[26] indicates that prevention efforts can be separated into three levels (1) universal/public health prevention (directed at everyone in the population); (2) selective prevention (directed at subgroups of the population with an above average risk of developing obesity); (3) targeted prevention (directed at those with existing weight problems and those at high risk of diseases associated with overweight).[193] Study the obesity related metabolic syndrome (Chapter 4) and depression (Chapter 5) would be helpful for a targeted prevention approach.

RESEARCH QUESTIONS

As described in the **Rationale**, the following research questions will be studied:

1. *What is the prevalence of **childhood obesity** in China? Is there a time trend?*
2. *Which are the **determinants** of childhood obesity in China?*
3. *What is the prevalence and distribution of pediatric **metabolic syndrome in China?** Is there an association with childhood obesity?*
4. *What is the relationship between **body dissatisfaction, depression** and childhood obesity in China?*

National estimates of childhood obesity, its determinants and pediatric metabolic syndrome were based on the 2002 National Nutrition and Health Survey. It is a nationally representative cross-sectional survey that covered 31 provinces, autonomous regions and the municipalities directly affiliated to the Central Government (Hong Kong, Macao and Taiwan were not included). In order to investigate the relationship between body weight, body dissatisfaction and depression symptoms among Chinese children, third and fourth grade students (N=3886, aged 9 or 10 years) from 20 schools in Beijing, China, were measured for fasting body weight and height, were asked to choose the

figures of body image and to complete the self-reported Children's Depression Inventory (CDI) questionnaire.

OUTLINE

This paragraph gives an outline of the following chapters in this thesis.

In **Chapter 2**, the prevalence and its trend from 1982 to 2002 of overweight and obesity among youngsters in China are described. The data of children aged 7-17 years from three cross-sectional national surveys including "China National Nutrition Survey of 1982" (5 334 boys and 4 793 girls), "China National Nutrition Survey of 1992" (8 048 boys and 7 453 girls) and "2002 China National Nutrition and Health Survey" (23 242 boys and 21 638 girls) are used in this study.

In order to investigate the determinants of childhood overweight and obesity in China, the prevalence of overweight (including obesity) is compared among different dietary and physical activity patterns and parental body weight status (**Chapter 3**). A total of 6826 children aged 7-17 years from the 2002 China National Nutrition and Health Survey are included in the study. Information on food intakes are collected using 3 days 24-hour dietary recall method by trained interviewers. The amounts of cooking oil and condiments consumed are weighed. An interview-administered one-year physical activity questionnaire is used to collect physical activity information.

Since no national figure of the occurrence of metabolic syndrome is currently available in Chinese adolescents, **Chapter 4** aims to estimate its prevalence and distribution among Chinese youngsters. Applying the criteria for US adolescents, we estimated the prevalence of metabolic syndrome among 2761 adolescents aged 15 to 19 years using data of the 2002 China National Nutrition and Health Survey. The association between pediatric metabolic syndrome and childhood obesity is also studied, after considering the effect of parents' metabolic syndrome status.

In **Chapter 5**, we investigate the relationship between body weight, body dissatisfaction and depression symptoms among Chinese children. The study population is a representative sample of 9 and 10 years students in 2005 of the third and fourth grade from 20 schools in urban Beijing, China. Classroom surveys and physical measures are

completed during regular school days by trained investigators. Body image is assessed by the Ma silhouette,[8] which was developed from Collins silhouette[194] and adapted to the Chinese situation. The Children's Depression Inventory (CDI) developed by Kovacs [133] is used to measure depression symptoms among children.

In the final chapter of this thesis, we reflect on the main findings of the previous chapters, and discuss their implications for the childhood obesity prevention strategies in China (**Chapter 6**).

REFERENCES

1. National Bureau of Statistics of China: *China Statistic Year Book 2000*. Beijing: China Statistic Press; 2000.
2. Wang L: *Report of China Nationwide Nutrition and Health Survey 2002 (1): Summary Report.* Beijing: People's Medical Publishing House.; 2005.
3. Wang Y, Monteiro C, Popkin BM: Trends of obesity and underweight in older children and adolescents in the United States, Brazil, China, and Russia. *Am J Clin Nutr* 2002, 75(6):971-977.
4. Chu NF, Rimm EB, Wang DJ, Liou HS, Shieh SM: Clustering of cardiovascular disease risk factors among obese schoolchildren: the Taipei Children Heart Study. *Am J Clin Nutr* 1998, 67(6):1141-1146.
5. Cook S, Weitzman M, Auinger P, Nguyen M, Dietz WH: Prevalence of a metabolic syndrome phenotype in adolescents: findings from the third National Health and Nutrition Examination Survey, 1988-1994. *Arch Pediatr Adolesc Med* 2003, 157(8):821-827.
6. Csabi G, Torok K, Jeges S, Molnar D: Presence of metabolic cardiovascular syndrome in obese children. *Eur J Pediatr* 2000, 159(1-2):91-94.
7. de Ferranti SD, Gauvreau K, Ludwig DS, Neufeld EJ, Newburger JW, Rifai N: Prevalence of the metabolic syndrome in American adolescents: findings from the Third National Health and Nutrition Examination Survey. *Circulation* 2004, 110(16):2494-2497.
8. Li Y, Hu X, Ma W, Wu J, Ma G: Body image perceptions among Chinese children and adolescents. *Body Image* 2005, 2:91-103.
9. Vanhala M, Vanhala P, Kumpusalo E, Halonen P, Takala J: Relation between obesity from childhood to adulthood and the metabolic syndrome: population based study. *BMJ* 1998, 317(7154):319.
10. Vanhala MJ, Vanhala PT, Keinanen-Kiukaanniemi SM, Kumpusalo EA, Takala JK: Relative weight gain and obesity as a child predict metabolic syndrome as an adult. *Int J Obes Relat Metab Disord* 1999, 23(6):656-659.

11. Weiss R, Dziura J, Burgert TS, Tamborlane WV, Taksali SE, Yeckel CW, Allen K, Lopes M, Savoye M, Morrison J *et al*: Obesity and the metabolic syndrome in children and adolescents. *N Engl J Med* 2004, 350(23):2362-2374.
12. Yoshinaga M, Tanaka S, Shimago A, Sameshima K, Nishi J, Nomura Y, Kawano Y, Hashiguchi J, Ichiki T, Shimizu S: Metabolic syndrome in overweight and obese Japanese children. *Obes Res* 2005, 13(7):1135-1140.
13. Erermis S, Cetin N, Tamar M, Bukusoglu N, Akdeniz F, Goksen D: Is obesity a risk factor for psychopathology among adolescents? *Pediatr Int* 2004, 46(3):296-301.
14. Erickson SJ, Robinson TN, Haydel KF, Killen JD: Are overweight children unhappy?: Body mass index, depressive symptoms, and overweight concerns in elementary school children. *Arch Pediatr Adolesc Med* 2000, 154(9):931-935.
15. Rierdan J, Koff E: Weight, weight-related aspects of body image, and depression in early adolescent girls. *Adolescence* 1997, 32(127):615-624.
16. Sheslow D, Hassink S, Wallace W, DeLancey E: The relationship between self-esteem and depression in obese children. *Ann N Y Acad Sci* 1993, 699:289-291.
17. Wadden TA, Stunkard AJ: Psychopathology and obesity. *Ann N Y Acad Sci* 1987, 499:55-65.
18. Xie B, Liu C, Chou CP, Xia J, Spruijt-Metz D, Gong J, Li Y, Wang H, Johnson CA: Weight perception and psychological factors in Chinese adolescents. *J Adolesc Health* 2003, 33(3):202-210.
19. Lobstein T, Baur L, Uauy R: Obesity in children and young people: a crisis in public health. *Obes Rev* 2004, 5 Suppl 1:4-104.
20. Kain J, Uauy R, Vio F, Albala C: Trends in overweight and obesity prevalence in Chilean children: comparison of three definitions. *Eur J Clin Nutr* 2002, 56(3):200-204.
21. Lobstein T, Frelut ML: Prevalence of overweight among children in Europe. *Obes Rev* 2003, 4(4):195-200.
22. Ogden CL, Flegal KM, Carroll MD, Johnson CL: Prevalence and trends in overweight among US children and adolescents, 1999-2000. *JAMA* 2002, 288(14):1728-1732.

23. International Obesity Task Force data: Obesity and overweight rates have risen dramatically among English schoolchildren. http://www.iotf.org/childhoodobesity.asp (Accessed 4 Oct, 2006).
24. Monteiro CA, Conde WL: Secular trends in malnutrition and obesity among children in the city of Sao Paulo, Brazil (1974-1996). *Revista de Saude Publica* 2000, 34(6 Suppl):52-61.
25. Monteiro CA, MH DAB, Conde WL, Popkin BM: Shifting obesity trends in Brazil. *Eur J Clin Nutr* 2000, 54(4):342-346.
26. World Health Organization: *Obesity: preventing and managing the global epidemic. Report on a WHO consultation on obesity (WHO/NUT/NCD/98.1)*. Geneva: WHO; 1997.
27. Sobal J, Stunkard AJ: Socioeconomic status and obesity: a review of the literature. *Psychol Bull* 1989, 105(2):260-275.
28. Wang Y: Cross-national comparison of childhood obesity: the epidemic and the relationship between obesity and socioeconomic status. *Int J Epidemiol* 2001, 30(5):1129-1136.
29. Stunkard AJ: Socioeconomic status and obesity. *Ciba Foundation symposium* 1996, 201:174-182; discussion 182-177, 188-193.
30. Kimm SY, Obarzanek E, Barton BA, Aston CE, Similo SL, Morrison JA, Sabry ZI, Schreiber GB, McMahon RP: Race, socioeconomic status, and obesity in 9- to 10-year-old girls: the NHLBI Growth and Health Study. *Ann Epidemiol* 1996, 6(4):266-275.
31. Gordon-Larsen P, Adair LS, Popkin BM: The relationship of ethnicity, socioeconomic factors, and overweight in US adolescents. *Obes Res* 2003, 11(1):121-129.
32. Ma G: *Environmental factors leading to pediatric obesity in the developing world.* Shanghai,China: Lippincott Williams & Wilkins; 2002.
33. Ji CY, Sun JL: Analyses of the epidemiological status of overweight and obesity in Chinese students and the prevalence changes in recent 15 years. *J Peking University* 2004, 36(2):194-197.

34. Wang Y, Ge K, Popkin BM: Tracking of body mass index from childhood to adolescence: a 6-y follow-up study in China. *Am J Clin Nutr* 2000, 72(4):1018-1024.
35. Allison D, Martz P, Pietrobelli A, Zannoli R, Faith M: *Genetic and environmental influences on obesity.* Totowa, New Jersey: Human press; 1999.
36. Bandini LG, Dietz WH: Myths about childhood obesity. *Pediatr Ann* 1992, 21(10):647-652.
37. Maffeis C: Aetiology of overweight and obesity in children and adolescents. *Eur J Pediatr* 2000, 159 Suppl 1:S35-44.
38. Rosenbaum M, Leibel RL: The physiology of body weight regulation: relevance to the etiology of obesity in children. *Pediatrics* 1998, 101(3 Pt 2):525-539.
39. Haines J, pericak-Vance M: *Approaches to gene mapping.* New York: Wiley; 1998.
40. Allison DB, Faith MS, Nathan JS: Risch's lambda values for human obesity. *Int J Obes Relat Metab Disord* 1996, 20(11):990-999.
41. Allison DB, Kaprio J, Korkeila M, Koskenvuo M, Neale MC, Hayakawa K: The heritability of body mass index among an international sample of monozygotic twins reared apart. *Int J Obes Relat Metab Disord* 1996, 20(6):501-506.
42. Cummings DE, Schwartz MW: Genetics and pathophysiology of human obesity. *Annual review of medicine* 2003, 54:453-471.
43. Kopelman PG: Obesity as a medical problem. *Nature* 2000, 404(6778):635-643.
44. Perusse L, Rankinen T, Zuberi A, Chagnon YC, Weisnagel SJ, Argyropoulos G, Walts B, Snyder EE, Bouchard C: The human obesity gene map: the 2004 update. *Obes Res* 2005, 13(3):381-490.
45. Benton D: Role of parents in the determination of the food preferences of children and the development of obesity. *Int J Obes Relat Metab Disord* 2004, 28(7):858-869.
46. Bogaert N, Steinbeck KS, Baur LA, Brock K, Bermingham MA: Food, activity and family--environmental vs biochemical predictors of weight gain in children. *Eur J Clin Nutr* 2003, 57(10):1242-1249.

47. Jacobson KC, Rowe DC: Genetic and shared environmental influences on adolescent BMI: interactions with race and sex. *Behav Genet* 1998, 28(4):265-278.

48. Treuth MS, Butte NF, Sorkin JD: Predictors of body fat gain in nonobese girls with a familial predisposition to obesity. *Am J Clin Nutr* 2003, 78(6):1212-1218.

49. Veugelers PJ, Fitzgerald AL: Prevalence of and risk factors for childhood overweight and obesity. *CMAJ* 2005, 173(6):607-613.

50. Bray G: Press Statement. Finger points to corn syrup in obesity epidemic. International Congress on Obesity, Sao Paulo, Brail, 26-30 Aug 2002. http://www.iotf.org/media/syrup.htm (Accessed 4 Oct 2006).

51. Silventoinen K, Sans S, Tolonen H, Monterde D, Kuulasmaa K, Kesteloot H, Tuomilehto J: Trends in obesity and energy supply in the WHO MONICA Project. *Int J Obes Relat Metab Disord* 2004, 28(5):710-718.

52. Drewnowski A, Kurth C, Holden-Wiltse J, Saari J: Food preferences in human obesity: carbohydrates versus fats. *Appetite* 1992, 18(3):207-221.

53. Lissner L, Heitmann BL: Dietary fat and obesity: evidence from epidemiology. *Eur J Clin Nutr* 1995, 49(2):79-90.

54. Sherwood NE, Jeffery RW, French SA, Hannan PJ, Murray DM: Predictors of weight gain in the Pound of Prevention study. *Int J Obes Relat Metab Disord* 2000, 24(4):395-403.

55. Cox DN, Perry L, Moore PB, Vallis L, Mela DJ: Sensory and hedonic associations with macronutrient and energy intakes of lean and obese consumers. *Int J Obes Relat Metab Disord* 1999, 23(4):403-410.

56. Gates JC, Huenemann RL, Brand RJ: Food choices of obese and non-obese persons. *J Am Diet Assoc* 1975, 67(4):339-343.

57. Ludwig DS: Dietary glycemic index and obesity. *J Nutr* 2000, 130(2S Suppl):280S-283S.

58. Salmon DM, Flatt JP: Effect of dietary fat content on the incidence of obesity among ad libitum fed mice. *Int J Obes* 1985, 9(6):443-449.

59. Schemmel R, Mickelsen O, Motawi K: Conversion of dietary to body energy in rats as affected by strain, sex and ration. *J Nutr* 1972, 102(9):1187-1197.

60. Dreon DM, Frey-Hewitt B, Ellsworth N, Williams PT, Terry RB, Wood PD: Dietary fat:carbohydrate ratio and obesity in middle-aged men. *Am J Clin Nutr* 1988, 47(6):995-1000.
61. Berkey CS, Rockett HR, Field AE, Gillman MW, Frazier AL, Camargo CA, Jr., Colditz GA: Activity, dietary intake, and weight changes in a longitudinal study of preadolescent and adolescent boys and girls. *Pediatrics* 2000, 105(4):E56.
62. Gazzaniga JM, Burns TL: Relationship between diet composition and body fatness, with adjustment for resting energy expenditure and physical activity, in preadolescent children. *Am J Clin Nutr* 1993, 58(1):21-28.
63. Klesges RC, Klesges LM, Eck LH, Shelton ML: A longitudinal analysis of accelerated weight gain in preschool children. *Pediatrics* 1995, 95(1):126-130.
64. Drewnowski A, Almiron-Roig E, Marmonier C, Lluch A: Dietary energy density and body weight: is there a relationship? *Nutr Rev* 2004, 62(11):403-413.
65. Drewnowski A, Popkin BM: The nutrition transition: new trends in the global diet. *Nutr Rev* 1997, 55(2):31-43.
66. Beare-Rogers J, Ghafoorunissa Korver O, Rocquelin G, DSundram K, Uauy R: Dietary fat in developing countries. *Food Nutr Bull* 1998, 19:251-267.
67. Marques-Vidal P, Goncalves A, Dias CM: Milk intake is inversely related to obesity in men and in young women: data from the Portuguese Health Interview Survey 1998-1999. *Int J Obes (Lond)* 2006, 30(1):88-93.
68. Mirmiran P, Esmaillzadeh A, Azizi F: Dairy consumption and body mass index: an inverse relationship. *Int J Obes (Lond)* 2005, 29(1):115-121.
69. Zemel MB, Richards J, Milstead A, Campbell P: Effects of calcium and dairy on body composition and weight loss in African-American adults. *Obes Res* 2005, 13(7):1218-1225.
70. Barba G, Troiano E, Russo P, Venezia A, Siani A: Inverse association between body mass and frequency of milk consumption in children. *Br J Nutr* 2005, 93(1):15-19.
71. Carruth BR, Skinner JD: The role of dietary calcium and other nutrients in moderating body fat in preschool children. *Int J Obes Relat Metab Disord* 2001, 25(4):559-566.

72. Moreira P, Padez C, Mourao I, Rosado V: Dietary calcium and body mass index in Portuguese children. *Eur J Clin Nutr* 2005, 59(7):861-867.
73. Skinner JD, Bounds W, Carruth BR, Ziegler P: Longitudinal calcium intake is negatively related to children's body fat indexes. *J Am Diet Assoc* 2003, 103(12):1626-1631.
74. Weaver CM, Boushey CJ: Milk--good for bones, good for reducing childhood obesity? *J Am Diet Assoc* 2003, 103(12):1598-1599.
75. Zemel MB: Regulation of adiposity and obesity risk by dietary calcium: mechanisms and implications. *J Am Coll Nutr* 2002, 21(2):146S-151S.
76. Zemel MB: Mechanisms of dairy modulation of adiposity. *J Nutr* 2003, 133(1):252S-256S.
77. Belury MA, Mahon A, Banni S: The conjugated linoleic acid (CLA) isomer, t10c12-CLA, is inversely associated with changes in body weight and serum leptin in subjects with type 2 diabetes mellitus. *J Nutr* 2003, 133(1):257S-260S.
78. Layman DK: The role of leucine in weight loss diets and glucose homeostasis. *J Nutr* 2003, 133(1):261S-267S.
79. Blundell JE, King NA: *Overconsumption as a cause of weight gain: behavioral physiological interactions in the control of food intake (appetite)*. Chichester, Wiley. 1996.
80. Rolls BJ, Ello-Martin JA, Tohill BC: What can intervention studies tell us about the relationship between fruit and vegetable consumption and weight management? *Nutr Rev* 2004, 62(1):1-17.
81. Lin BH, Morrison RM: Higher fruit consumption linked with lower body mass index. *Food Review* 2002, 25:28-32.
82. Field AE, Gillman MW, Rosner B, Rockett HR, Colditz GA: Association between fruit and vegetable intake and change in body mass index among a large sample of children and adolescents in the United States. *Int J Obes Relat Metab Disord* 2003, 27(7):821-826.
83. Must A, Tybor DJ: Physical activity and sedentary behavior: a review of longitudinal studies of weight and adiposity in youth. *Int J Obes (Lond)* 2005, 29 Suppl 2:S84-96.

84. Moore LL, Nguyen US, Rothman KJ, Cupples LA, Ellison RC: Preschool physical activity level and change in body fatness in young children. The Framingham Children's Study. *Am J Epidemiol* 1995, 142(9):982-988.

85. Moussa MA, Shaltout AA, Nkansa-Dwamena D, Mourad M, Alsheikh N, Agha N, Galal DO: Factors associated with obesity in Kuwaiti children. *Eur J Epidemiol* 1999, 15(1):41-49.

86. DuRant RH, Baranowski T, Johnson M, Thompson WO: The relationship among television watching, physical activity, and body composition of young children. *Pediatrics* 1994, 94(4 Pt 1):449-455.

87. Dwyer JT, Stone EJ, Yang M, Feldman H, Webber LS, Must A, Perry CL, Nader PR, Parcel GS: Predictors of overweight and overfatness in a multiethnic pediatric population. Child and Adolescent Trial for Cardiovascular Health Collaborative Research Group. *Am J Clin Nutr* 1998, 67(4):602-610.

88. Berkowitz RI, Agras WS, Korner AF, Kraemer HC, Zeanah CH: Physical activity and adiposity: a longitudinal study from birth to childhood. *J Pediatr* 1985, 106(5):734-738.

89. Ball EJ, O'Connor J, Abbott R, Steinbeck KS, Davies PS, Wishart C, Gaskin KJ, Baur LA: Total energy expenditure, body fatness, and physical activity in children aged 6-9 y. *Am J Clin Nutr* 2001, 74(4):524-528.

90. Davies PS, Gregory J, White A: Physical activity and body fatness in pre-school children. *Int J Obes Relat Metab Disord* 1995, 19(1):6-10.

91. Deheeger M, Rolland-Cachera MF, Fontvieille AM: Physical activity and body composition in 10 year old French children: linkages with nutritional intake? *Int J Obes Relat Metab Disord* 1997, 21(5):372-379.

92. Rowlands AV, Ingledew DK, Eston RG: The effect of type of physical activity measure on the relationship between body fatness and habitual physical activity in children: a meta-analysis. *Annals of human biology* 2000, 27(5):479-497.

93. Ekelund U, Aman J, Yngve A, Renman C, Westerterp K, Sjostrom M: Physical activity but not energy expenditure is reduced in obese adolescents: a case-control study. *Am J Clin Nutr* 2002, 76(5):935-941.

94. Gordon-Larsen P, Nelson MC, Beam K: Associations among active transportation, physical activity, and weight status in young adults. *Obes Res* 2005, 13(5):868-875.

95. Hu G, Pekkarinen H, Hanninen O, Yu Z, Tian H, Guo Z, Nissinen A: Physical activity during leisure and commuting in Tianjin, China. *Bull World Health Organ* 2002, 80(12):933-938.

96. Hu G, Pekkarinen H, Hanninen O, Yu Z, Guo Z, Tian H: Commuting, leisure-time physical activity, and cardiovascular risk factors in China. *Med Sci Sports Exerc* 2002, 34(2):234-238.

97. Bell AC, Ge K, Popkin BM: The road to obesity or the path to prevention: motorized transportation and obesity in China. *Obes Res* 2002, 10(4):277-283.

98. Wake M, Hesketh K, Waters E: Television, computer use and body mass index in Australian primary school children. *J Paediatr Child Health* 2003, 39(2):130-134.

99. Janz KF, Levy SM, Burns TL, Torner JC, Willing MC, Warren JJ: Fatness, physical activity, and television viewing in children during the adiposity rebound period: the Iowa Bone Development Study. *Prev Med* 2002, 35(6):563-571.

100. Dennison BA, Erb TA, Jenkins PL: Television viewing and television in bedroom associated with overweight risk among low-income preschool children. *Pediatrics* 2002, 109(6):1028-1035.

101. Robinson TN: Reducing children's television viewing to prevent obesity: a randomized controlled trial. *JAMA* 1999, 282(16):1561-1567.

102. Hernandez B, Gortmaker SL, Colditz GA, Peterson KE, Laird NM, Parra-Cabrera S: Association of obesity with physical activity, television programs and other forms of video viewing among children in Mexico city. *Int J Obes Relat Metab Disord* 1999, 23(8):845-854.

103. Andersen RE, Crespo CJ, Bartlett SJ, Cheskin LJ, Pratt M: Relationship of physical activity and television watching with body weight and level of fatness among children: results from the Third National Health and Nutrition Examination Survey. *JAMA* 1998, 279(12):938-942.

104. Dietz WH, Jr., Gortmaker SL: Do we fatten our children at the television set? Obesity and television viewing in children and adolescents. *Pediatrics* 1985, 75(5):807-812.

105. Gortmaker SL, Must A, Sobol AM, Peterson K, Colditz GA, Dietz WH: Television viewing as a cause of increasing obesity among children in the United States, 1986-1990. *Arch Pediatr Adolesc Med* 1996, 150(4):356-362.

106. Neutzling MB, Taddei JA, Rodrigues EM, Sigulem DM: Overweight and obesity in Brazilian adolescents. *Int J Obes Relat Metab Disord* 2000, 24(7):869-874.

107. Martorell R, Kettel Khan L, Hughes ML, Grummer-Strawn LM: Overweight and obesity in preschool children from developing countries. *Int J Obes Relat Metab Disord* 2000, 24(8):959-967.

108. Kahn R, Buse J, Ferrannini E, Stern M: The metabolic syndrome: time for a critical appraisal: joint statement from the American Diabetes Association and the European Association for the Study of Diabetes. *Diabetes Care* 2005, 28(9):2289-2304.

109. WHO: Definition, Diagnosis, and Classification of Diabetes Mellitus and its Complications: Report of a WHO Consultation. Geneva: World Health Org; 1999.

110. Executive Summary of The Third Report of The National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, And Treatment of High Blood Cholesterol In Adults (Adult Treatment Panel III). *JAMA* 2001, 285(19):2486-2497.

111. Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) final report. *Circulation* 2002, 106(25):3143-3421.

112. Young TK, Dean HJ, Flett B, Wood-Steiman P: Childhood obesity in a population at high risk for type 2 diabetes. *J Pediatr* 2000, 136(3):365-369.

113. Steinberger J, Daniels SR: Obesity, insulin resistance, diabetes, and cardiovascular risk in children: an American Heart Association scientific

statement from the Atherosclerosis, Hypertension, and Obesity in the Young Committee (Council on Cardiovascular Disease in the Young) and the Diabetes Committee (Council on Nutrition, Physical Activity, and Metabolism). *Circulation* 2003, 107(10):1448-1453.

114. Scott CR, Smith JM, Cradock MM, Pihoker C: Characteristics of youth-onset noninsulin-dependent diabetes mellitus and insulin-dependent diabetes mellitus at diagnosis. *Pediatrics* 1997, 100(1):84-91.

115. Pinhas-Hamiel O, Dolan LM, Daniels SR, Standiford D, Khoury PR, Zeitler P: Increased incidence of non-insulin-dependent diabetes mellitus among adolescents. *J Pediatr* 1996, 128(5 Pt 1):608-615.

116. Troiano RP, Flegal KM, Kuczmarski RJ, Campbell SM, Johnson CL: Overweight prevalence and trends for children and adolescents. The National Health and Nutrition Examination Surveys, 1963 to 1991. *Arch Pediatr Adolesc Med* 1995, 149(10):1085-1091.

117. Figueroa-Colon R, Franklin FA, Lee JY, Aldridge R, Alexander L: Prevalence of obesity with increased blood pressure in elementary school-aged children. *South Med J* 1997, 90(8):806-813.

118. Freedman DS, Dietz WH, Srinivasan SR, Berenson GS: The relation of overweight to cardiovascular risk factors among children and adolescents: the Bogalusa Heart Study. *Pediatrics* 1999, 103(6 Pt 1):1175-1182.

119. Rocchini AP: Adolescent obesity and hypertension. *Pediatr Clin North Am* 1993, 40(1):81-92.

120. Wang W, Wang K, Chen C, Cao R, Bai Y, Ma L, Fu Z, Chen J, Liu J, Bai J *et al*: The study on relationship of body mass index and blood pressure in children and adolescents of Beijing. *Zhong Hua Liu Xing Bing Xue Za Zhi* 2004, 25(2):109-112.

121. Rames LK, Clarke WR, Connor WE, Reiter MA, Lauer RM: Normal blood pressure and the evaluation of sustained blood pressure elevation in childhood: the Muscatine study. *Pediatrics* 1978, 61(2):245-251.

122. Ferrannini E, Buzzigoli G, Bonadonna R, Giorico MA, Oleggini M, Graziadei L, Pedrinelli R, Brandi L, Bevilacqua S: Insulin resistance in essential hypertension. *N Engl J Med* 1987, 317(6):350-357.

123. Ferrannini E, Taddei S, Santoro D, Natali A, Boni C, Del Chiaro D, Buzzigoli G: Independent stimulation of glucose metabolism and Na+-K+ exchange by insulin in the human forearm. *Am J Physiol* 1988, 255(6 Pt 1):E953-958.

124. Rocchini AP, Katch V, Kveselis D, Moorehead C, Martin M, Lampman R, Gregory M: Insulin and renal sodium retention in obese adolescents. *Hypertension* 1989, 14(4):367-374.

125. Deurenberg-Yap M, Chew SK, Deurenberg P: Elevated body fat percentage and cardiovascular risks at low body mass index levels among Singaporean Chinese, Malays and Indians. . *Obes Rev* 2002, 3(3):209-215.

126. Plourde G: Impact of obesity on glucose and lipid profiles in adolescents at different age groups in relation to adulthood. *BMC family practice [electronic resource]* 2002, 3:18.

127. Zhou B, Wu Y, Yang J, Li Y, Zhang H, Zhao L: Overweight is an independent risk factor for cardiovascular disease in Chinese population. *Obese Review* 2002, 3(3):147-156.

128. Zhai F, Zhang L, Wng C, Duan J, Cao R, Wang H, Zhang J: Validation of lipids on body mass index reference recommended by Obesity Working Group, International Life Science Association of China. . *Zhong Hua Liu Xing Bing Xue Za Zhi* 2004, 25(2):117-119.

129. Latner JD, Stunkard AJ: Getting worse: the stigmatization of obese children. *Obes Res* 2003, 11(3):452-456.

130. Neumark-Sztainer D, Story M, French SA, Hannan PJ, Resnick MD, Blum RW: Psychosocial concerns and health-compromising behaviors among overweight and nonoverweight adolescents. *Obes Res* 1997, 5(3):237-249.

131. Puhl R, Brownell KD: Bias, discrimination, and obesity. *Obes Res* 2001, 9(12):788-805.

132. Wardle J, Cooke L: The impact of obesity on psychological well-being. *Best Pract Res Clin Endocrinol Metab* 2005, 19(3):421-440.

133. Kovacs M: *Children's Depression Intentory*. North Tonawanda, NY.: Multi-Health System; 1992.
134. Schilder P: *The body image and appearance of the human body*. New York: International Universities Press; 1935/1950.
135. Ricciardelli LA, McCabe MP: Children's body image concerns and eating disturbance: a review of the literature. *Clin Psychol Rev* 2001, 21(3):325-344.
136. Candy CM, Fee VE: Underlying dimensions and psychometric properties of the Eating Behaviors and Body Image Test for preadolescent girls. *J Clin Child Psychol* 1998, 27(1):117-127.
137. Rolland K, Farnill D, Griffiths RA: Children's perceptions of their current and ideal body sizes and body mass index. *Percept Mot Skills* 1996, 82(2):651-656.
138. Page RM, Allen O: Adolescent perceptions of body weight and weight satisfaction. *Percept Mot Skills* 1995, 81(1):81-82.
139. Rolland K, Farnill D, Griffiths RA: Body figure perceptions and eating attitudes among Australian schoolchildren aged 8 to 12 years. *Int J Eat Disord* 1997, 21(3):273-278.
140. Shapiro S, Newcomb M, Loeb TB: Fear of fat, disregulated-restrained eating, and body-esteem: prevalence and gender differences among eight- to ten-year-old children. *J Clin Child Psychol* 1997, 26(4):358-365.
141. Olvera N, Suminski R, Power TG: Intergenerational perceptions of body image in hispanics: role of BMI, gender, and acculturation. *Obes Res* 2005, 13(11):1970-1979.
142. Davison KK, Birch LL: Weight status, parent reaction, and self-concept in five-year-old girls. *Pediatrics* 2001, 107(1):46-53.
143. Hill AJ, Draper E, Stack J: A weight on children's minds: body shape dissatisfactions at 9-years old. *Int J Obes Relat Metab Disord* 1994, 18(6):383-389.
144. Lunner K, Werthem EH, Thompson JK, Paxton SJ, McDonald F, Halvaarson KS: A cross-cultural examination of weight-related teasing, body image, and eating disturbance in Swedish and Australian samples. *Int J Eat Disord* 2000, 28(4):430-435.

145. Presnell K, Bearman SK, Stice E: Risk factors for body dissatisfaction in adolescent boys and girls: a prospective study. *Int J Eat Disord* 2004, 36(4):389-401.

146. Stice E, Whitenton K: Risk factors for body dissatisfaction in adolescent girls: a longitudinal investigation. *Dev Psychol* 2002, 38(5):669-678.

147. Stradmeijer M, Bosch J, Koops W, Seidell J: Family functioning and psychosocial adjustment in overweight youngsters. *Int J Eat Disord* 2000, 27(1):110-114.

148. van den Berg P, Wertheim EH, Thompson JK, Paxton SJ: Development of body image, eating disturbance, and general psychological functioning in adolescent females: a replication using covariance structure modeling in an Australian sample. *Int J Eat Disord* 2002, 32(1):46-51.

149. Vander Wal JS, Thomas N: Predictors of body image dissatisfaction and disturbed eating attitudes and behaviors in African American and Hispanic girls. *Eat Behav* 2004, 5(4):291-301.

150. Thompson JK, Coovert MD, Richards KJ, Johnson S, Cattarin J: Development of body image, eating disturbance, and general psychological functioning in female adolescents: covariance structure modeling and longitudinal investigations. *Int J Eat Disord* 1995, 18(3):221-236.

151. Thompson SH, Sargent RG: Black and White women's weight-related attitudes and parental criticism of their childhood appearance. *Women Health* 2000, 30(3):77-92.

152. Cohane GH, Pope HG, Jr.: Body image in boys: a review of the literature. *Int J Eat Disord* 2001, 29(4):373-379.

153. Davison KK, Markey CN, Birch LL: A longitudinal examination of patterns in girls' weight concerns and body dissatisfaction from ages 5 to 9 years. *Int J Eat Disord* 2003, 33(3):320-332.

154. Neumark-Sztainer D, Story M, Resnick MD, Blum RW: Psychosocial concerns and weight control behaviors among overweight and nonoverweight Native American adolescents. *J Am Diet Assoc* 1997, 97(6):598-604.

155. Friedman MA, Brownell KD: Psychological correlates of obesity: moving to the next research generation. *Psychol Bull* 1995, 117(1):3-20.

156. Thompson SH, Corwin SJ, Sargent RG: Ideal body size beliefs and weight concerns of fourth-grade children. *Int J Eat Disord* 1997, 21(3):279-284.

157. Tiggemann M, Wilson-Barrett E: Children's figure ratings: relationship to self-esteem and negative stereotyping. *Int J Eat Disord* 1998, 23(1):83-88.

158. Stice E, Hayward C, Cameron RP, Killen JD, Taylor CB: Body-image and eating disturbances predict onset of depression among female adolescents: a longitudinal study. *J Abnorm Psychol* 2000, 109(3):438-444.

159. Byrne S: Obesity and depression: what is the nature of the relationship? In *10th International Congress on Obesity*. Sydney, Australia: Blackwell Publishing; 2006.

160. Mustillo S, Worthman C, Erkanli A, Keeler G, Angold A, Costello EJ: Obesity and psychiatric disorder: developmental trajectories. *Pediatrics* 2003, 111(4 Pt 1):851-859.

161. Dixon JB, Dixon ME, O'Brien PE: Depression in association with severe obesity. *Arch Intern Med* 2003, 163:2058-2065.

162. Falkner NH, Neumark-Sztainer D, Story M, Jeffery RW, Beuhring T, Resnick MD: Social, educational, and psychological correlates of weight status in adolescents. *Obes Res* 2001, 9(1):32-42.

163. Goodman E, Whitaker RC: A prospective study of the role of depression in the development and persistence of adolescents obesity. *Pediatrics* 2002, 109:497-504.

164. McGuire M, Wing RR, Klem M, Lang W, Hill J: What predicts weight regain in a group of successful weight losers? *J Consult Clin Psychol* 1999, 67:177-185.

165. Pine DS, Goldstein RB, Wolk S, Weissman MM: The association between childhood depression and adulthood body mass index. *Pediatrics* 2001, 107(5):1049-1056.

166. French SA, Story M, Perry CL: Self-esteem and obesity in children and adolescents: a literature review. *Obes Res* 1995, 3(5):479-490.

167. Braet C, Mervielde I, Vandereycken W: Psychological aspects of childhood obesity: a controlled study in a clinical and nonclinical sample. *J Pediatr Psychol* 1997, 22(1):59-71.

168. Pesa JA, Syre TR, Jones E: Psychosocial differences associated with body weight among female adolescents: the importance of body image. *J Adolesc Health* 2000, 26(5):330-337.

169. Pierce JW, Wardle J: Cause and effect beliefs and self-esteem of overweight children. *J Child Psychol Psychiatry* 1997, 38(6):645-650.

170. Strauss CC, Smith K, Frame C, Forehand R: Personal and interpersonal characteristics associated with childhood obesity. *J Pediatr Psychol* 1985, 10(3):337-343.

171. Strauss RS: Childhood obesity and self-esteem. *Pediatrics* 2000, 105(1):e15.

172. Brown KM, McMahon RP, Biro FM, Crawford P, Schreiber GB, Similo SL, Waclawiw M, Striegel-Moore R: Changes in self-esteem in black and white girls between the ages of 9 and 14 years. The NHLBI Growth and Health Study. *J Adolesc Health* 1998, 23(1):7-19.

173. Young-Hyman D, Schlundt DG, Herman-Wenderoth L, Bozylinski K: Obesity, appearance, and psychosocial adaptation in young African American children. *J Pediatr Psychol* 2003, 28(7):463-472.

174. Kimm SY, Barton BA, Berhane K, Ross JW, Payne GH, Schreiber GB: Self-esteem and adiposity in black and white girls: the NHLBI Growth and Health Study. *Ann Epidemiol* 1997, 7(8):550-560.

175. Phillips RG, Hill AJ: Fat, plain, but not friendless: self-esteem and peer acceptance of obese pre-adolescent girls. *Int J Obes Relat Metab Disord* 1998, 22(4):287-293.

176. Wake M, Salmon L, Waters E, Wright M, Hesketh K: Parent-reported health status of overweight and obese Australian primary school children: a cross-sectional population survey. *Int J Obes Relat Metab Disord* 2002, 26(5):717-724.

177. Zeller MH, Saelens BE, Roehrig H, Kirk S, Daniels SR: Psychological adjustment of obese youth presenting for weight management treatment. *Obes Res* 2004, 12(10):1576-1586.

178. Kaplan KM, Wadden TA: Childhood obesity and self-esteem. *J Pediatr* 1986, 109(2):367-370.

179. Braet C, Tanghe A, Decaluwe V, Moens E, Rosseel Y: Inpatient treatment for children with obesity: weight loss, psychological well-being, and eating behavior. *J Pediatr Psychol* 2004, 29(7):519-529.

180. Hill AJ: How can the psychological impact of obesity in children and adolescents be overcome? In *10th International Congress on Obesity*. Sydney: Blackwell Publishing; 2006.

181. Hesketh K, Wake M, Waters E: Body mass index and parent-reported self-esteem in elementary school children: evidence for a causal relationship. *Int J Obes Relat Metab Disord* 2004, 28(10):1233-1237.

182. Walker LL, Gately PJ, Bewick BM, Hill AJ: Children's weight-loss camps: psychological benefit or jeopardy? *Int J Obes Relat Metab Disord* 2003, 27(6):748-754.

183. Stice E, Bearman SK: Body-image and eating disturbances prospectively predict increases in depressive symptoms in adolescent girls: a growth curve analysis. *Dev Psychol* 2001, 37(5):597-607.

184. Stice E, Killen JD, Hayward C, Taylor CB: Support for the continuity hyperthesis of bulimic pathology. . *J Consult Clin Psychol* 1998, 66:784-790.

185. Wood KC, Becker JA, Thompson JK: Body image dissatisfaction in preadolescent children. *J Appl Devel Psy* 1996, 17:85-100.

186. Folk L, Pedersen J, Cullari S: Body satisfaction and self-concept of third- and sixth-grade students. *Percept Mot Skills* 1993, 76(2):547-553.

187. Mendelson BK, White DR: Relation between body-esteem and self-esteem of obese and normal children. *Percept Mot Skills* 1982, 54(3):899-905.

188. Miller CT, Downey KT: A meta-analysis of heavyweight and self-esteem. *Pers Soc Psychol Rev* 1999, 3:68-84.

189. Kim O, Kim K: Body weight, self-esteem, and depression in Korean female. *Adolesc* 2001, 36(142):315-322.

190. One fifth children catch depression for too expectation and concern from parents. In *Gong Ren Ri Bao*. Beijing: http://news.xinhuanet.com/edu/2005-2012/2015/content_3925071.htm (Accessed 5 Oct 2006).

191. Yu Y, Hu Y, Liang S: A case-control study on psychological characteristics in obese adolescents. *Zhong Guo Xin Li Wei heng Za Zhi* 1996, 10:70-71.

192. Zhang H, Tao F, Zeng G: Effects of depression symptoms and other psychological factors on unhealthy weight reducing behaviors of adolescents. *Zhong Guo Xin Li Wei heng Za Zhi* 2000, 21:348-349.

193. Gill TP: Key issues in the prevention of obesity. *Bri Med Bulletin* 1997, 53:359-388.

194. Collins M: Body figure perceptions and preferences among preadolescent children. *Int J Eating Disord* 1991, 10:199-208.

2

Obesity Prevalence and Time Trend among Youngsters in China, 1982-2002

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ABSTRACT

Objective: To describe prevalence and trend of overweight and obesity, as well as its co-existence with stunting, among youngsters in China, 1982-2002.

Design and subjects: The data of children aged 7-17 years from three cross-sectional national surveys including "1982 China National Nutrition Survey" (5 334 boys and 4 793 girls), "1992 China National Nutrition Survey" (8 048 boys and 7 453 girls) and "2002 China National Nutrition and Health Survey" (23 242 boys and 21 638 girls) were used in this study.

Methods: Overweight and obesity were defined according to age, sex, specific BMI cut-off points of International Obesity Task Force (IOTF).

Results: Overweight prevalence of Chinese youngsters was 1.2%, 3.7% and 4.4%, while the obesity prevalence was 0.2%, 0.9% and 0.9% in 1982, 1992 and 2002, respectively. Both the overweight and obesity prevalence and their increment were higher among boys in urban areas. The prevalence increased along with the family economic levels and mother's educational levels. In 1982, 28.4% of overweight and 69.6% of obese youngsters were stunted, decreased to 22.0% and 46.4% in 1992, and then to 5.7% and 7.7% in 2002, respectively.

Conclusion: The prevalence of overweight and obesity of Chinese youngsters were low in 1982. There has been a rapid increase since then, especially in large cities. Stunted youngsters among overweight and obese decreased dramatically at the same time.

Key words: Chinese youngsters, overweight, obesity, trend, stunt

INTRODUCTION

During the past two decades, China has experienced rapid socio-economic and nutritional transitions. A 10-fold increase in the per capita gross domestic product paralleled an increase in energy-dense foods, a decrease in transport related physical activity and an increase in leisure time inactivity.[1-6] Average daily food intake from animal source increased from 61g in 1982 to 159g in 2002, cooking oil consumption increased by 10g each 10 years, while the cereal grains and vegetable intakes decreased more than twenty percent.[2] At the same time, television and car ownership increased remarkably, while public transport became more and more popular in China.[1]

With these rapid transitions, China is experiencing a double burden of malnutrition and over-nutrition. Previous studies indicated that overweight and obesity prevalence among Chinese youngsters increased rapidly during last two decades, but these were based on the data from only a few provinces in China.[7,8] The "National Surveys on Students Constitution and Health" routinely investigate the obesity prevalence in 31 provinces of China, but body weight was not measured in the fasting state, which will have decreased the accuracy of the obesity estimation.[9] So the purpose of current study is firstly to present national estimates of overweight and obesity prevalence for youngsters between 7 and 17 years in China, as well as its trends in the last 20 years.

The phenomenon of childhood obesity accompanied by stunting has been reported in developing countries as well as in developed countries, particularly in countries experiencing economic transition, where stunting remains a major problem, changes in incomes and eating practices lead to obesity at the same time. Popkin, Richards and Montiero found a significant association between stunting and overweight status in children of Russia, Brazil, China and Republic of South Africa.[10] The income-adjusted prevalence ratios of being overweight for a stunted child ranged from 1.7 to 7.8. Similar associations were also found among Chinese children under 5 years, the overweight prevalence increased less rapidly or even decreased when the prevalence of stunting decreased.[11] But no study had considered the co-existence of stunting when they reported the obesity prevalence and its trends among youngsters in China. These individuals with increased weight and shorter length need specific attention, especially

from the side of public health. So, the second purpose of present paper was to describe the phenomenon of co-existence of stunting and obesity, as well as its trends in the last 20 years.

SUBJECTS AND METHODS

Sampling Procedure

Three national surveys on nutrition were conducted respectively in 1982, 1992 and 2002, i.e. 1982 China National Nutrition Survey (1982 CNNS), 1992 China National Nutrition Survey (1992 CNNS) and 2002 China National Nutrition and Health Survey (2002 CNNHS).

1982 CNNS covered 25 provinces and three municipalities, all administrative units directly under the control of central government with the exception of Tibet.[12] A two-stage random sampling method was used to select the survey households. Four to 20 survey sites were chosen in each province/municipality proportional to its population size, and a cluster of 50 households were randomly sampled from each selected survey site. A total of 256 survey sites was finally chosen, including about 12, 000 households and 71, 000 individuals. In addition 546 institutional units covering 166, 000 individual were surveyed, including factories, schools, kindergartens, and governmental institutions etc.[12] The characteristics of the study population were compared with those of the 3rd National Population Census (1980), and no significant differences were found, indicating a good representation of the total population.[13]

Stratified multi-stage cluster random sampling method calling the "8×2×2×30 program" was used in the 1992 CNNS. The primary unit was country/city, the secondary unit was township/district and the tertiary unit was village/neighborhood. There were eight primary units sampled from each province, two secondary units from each primary unit, two tertiary units (study sites) from each secondary unit. Thirty two study sites were selected in each province and a total of 960 study sites were randomly selected. Thirty households were sampled from each study site as subjects of the survey. Finally, a total of 100 201 subjects aged 2 years above from 28 000 households completed the survey.[14] The characteristics of the study population were compared with those of the 4th

National Population Census, and no significant differences were found, indicating representative of the whole population.[15]

The 2002 China National Nutrition and Health Survey is a nationally representative cross-sectional survey that covered 31 provinces, autonomous regions and the municipalities directly affiliated to the Central Government (Hong Kong, Macao and Taiwan were not included). Multistage cluster sampling method was used for subject selection. Stage 1: all the 2860 counties/districts/cities of China were divided into six areas (big cities, medium and small cities, rural 1, 2, 3 and 4) based on its type and the level of economic development (from high to low). Twenty-two counties/districts/cities from each area were randomly selected. A total of 132 counties/districts/cities were randomly selected at this Stage. Stage 2: three townships/sub-districts were randomly selected from each selected counties/districts/cities. A total of 396 townships/sub-districts was randomly selected at this Stage. Stage 3: two villages/neighborhood committees were randomly selected from the selected townships/sub-districts. A total of 792 villages/neighborhood committees were randomly selected at this Stage. Stage 4: 90 households were randomly selected from each village/neighborhood, and finally, a total of 71 971 households were randomly selected to represent the national data.[16] The comparison of the characteristics of study population with the 5th National Population Census showed that the study population is representative for the whole population.[17]

The present samples were subgroups of the 1982 CNHS, 1992 CNHS and 2002 CNNHS, subjects aged 7 to 17 years old were included in the present study.

Anthropometrical measurement

Fasting body weight was measured in the morning to the nearest 0.10 kg with a balance-beam scale while the subjects were wearing lightweight clothing. Height was measured to the nearest 0.1 cm using a standard steel strip stadiometer in bare footed subjects.

The estimation of the prevalence of overweight and obesity was based on cut-off points derived from international data as recommended by the Childhood Obesity Working Group of the International Obesity Task Force.[18]

Stunting was defined as height-for-age below -2 standard deviation (Z-score) from the NCHS/WHO reference median value.[19]

The protocol of the survey was approved by the Ethical Committee of the National Institute for Nutrition and Food Safety, Chinese Center for Disease Control and Prevention. Signed consent forms were obtained from both their parents or guardians and the children themselves.

Statistical analysis

Considering the sampling method of equal-sample-size of the six areas and the proportion difference between the sampling and whole population, the overweight and obesity prevalence in 2002 was weighted by the population proportion of six classified areas according to the data of the China Fifth National Population Census.[1] In order to adjust for changes in age distribution across the surveys, estimates of overweight and obesity prevalence were age-adjusted by the indirect method to the sex specific age distribution of the Fifth National Population Census.[1] Stunting proportion was calculated among the overweight and obese subjects. Trend estimates for urban and rural areas separately were available only for 1992 to 2002 because these surveys had similar urban/rural information. Cox regression analysis was used to estimate the Prevalence Ratios of overweight and obesity between boys and girls, as well as between urban and rural youngsters, where survival time is artificially set equal to 1.

RESULTS

The sample size from the three national surveys is shown in Table 1.

Prevalence

The prevalence of overweight and obesity of Chinese youngsters aged 7-17 years in 2002 was 4.4%, the obesity prevalence 0.9% (Table 2). More boys and more urban children tended to be overweight or obese than their respective counterparts. After adjusted the confusing factors including family economic level, parents' educational level and careers, as well as relative effects of sex, living areas and age, the adjusted overweight and obese prevalence ratio of boys to girls was 1.5 and the urban to rural

was 2.5, respectively.

Trends

Trends of the overweight and obesity prevalence from 1982 to 2002 are shown in Table 2. The age standardized prevalence of overweight and obesity increased three fold in 20 years. Age-standardized prevalence of obesity among boys increased from 0.2% in 1982 to 1.0% in 1992, and continued to 1.1% in 2002. Among girls, a remarkable increase of obesity prevalence was found from 1982 to 1992, but not between 1992 and 2002. The obesity prevalence decreased from 1.4% in 1992 to 0.7% in 2002 for girls aged 7-12 years, while the rate increased from 0.1% to 0.5% for girls aged 13-17 in the same period (Table 2).

Among urban youngsters, from 1992 to 2002, the overweight prevalence increased by 38% and obesity by 5%, among rural youngster, the overweight prevalence increased by 17%, while the obesity prevalence decreased by 7%. Separately by boys and girls, increasing trends were found among boys of both overweight and obesity prevalence and in both urban and rural areas. The largest increase of overweight was 42% found in urban boys, while least in rural girls (Figure 1). The trends of obesity prevalence was increasing among boys and decreasing among girls, especially among rural girls.

Co-existence of stunting and obesity

The percentage of stunted youngsters among the overweight youngsters was 28.4%, 22.0% and 5.7% in 1982, 1992 and 2002, respectively, which was 69.6%, 46.4% and 7.7% among the obese youngsters in 1982, 1992 and 2002, respectively.

The percentage of stunted youngsters among the overweight and obese in urban and rural areas was compared in Table 3. In 1992, 34.1% of the obese youngsters in urban areas were stunted and 56.2% in rural areas. This decreased dramatically from 1992 to 2002. In 2002, 2.9% of obese youngsters in urban area were stunted, which was 21.6% in rural area. In 1992, among overweight and obese subjects, stunting was more frequent among 7-12 years old than 13-17 years old youngsters, while in 2002, it was the reverse.

Subgroup Analysis

Large differences in overweight and obesity prevalence were observed between youngsters living in different areas. Those living in large cities had the highest prevalence. Those living in medium or small cities or in rural 1 also had high prevalence, while their counterparts living in rural 4 had the lowest (Table 4).

The overweight and obesity prevalence increased along with socioeconomic status. Educational level of parents also showed positive relationship with children's risk of being overweight or obese, after adjusted other factors, significant effect was only found of mother's educational level. Youngster whose parents were manager or officer showed higher prevalence of overweight and obesity than the farmers' children, unemployed mother's children also showed significantly higher risk of overweight and obesity.

DISCUSSION

The results of the present study provide compelling evidence for a strong increase in overweight and obesity prevalence among youngsters in China. Not being a problem in the 80's of last century, in 2002, the overall overweight prevalence reached 4.4% while obesity reached 0.9%, being higher in boys than in girls, in urban than in rural areas, and among high than among low socio-economic status groups.

The prevalence and trend of childhood obesity could be compared to other studies in China. The "National Surveys on Students Constitution and Health (CNSSCH) " investigated the physical status and fitness of students in 31 provinces of China, excluding school-age children not going to school.[9] The obesity prevalence estimated by the 2000 CNSSCH using Chinese standard was 4.4% and 1.5% for urban and rural boys, 2.3% and 1.0% for urban and rural girls, which was similar to our results.[9] The "China Health and Nutrition Survey" is a longitudinal study in eight provinces, that confirms the results of our cross sectional comparisons.[9] The increase in the childhood obesity prevalence was of a similar magnitude.

Compared to other countries, the overweight and obesity prevalence in 2002 were still relatively low in China. As defined by IOTF standards, the overweight (including obesity) prevalence of Chinese youngsters was 5.3% (9.7% in urban and 3.8% in rural), while it was more than 30% in the USA and almost 20% in the European.[20] Nevertheless,

the estimated absolute total number of overweight youngsters based on IOTF standards was 12 million in China. Compared to the latest estimates from the report by Lobstein, one in 10 children worldwide is overweight, total 155 million,[21] which means that 1 in 13 overweight children worldwide is living in China.

The present study found a decreasing trend of obesity prevalence among younger ones from 1992 to 2002, which may be due to a prevalence of stunting. Same trend was also found in children under 5 years in China.[11] The overweight prevalence among Chinese children under 5 years was 1.7% in 1990, rapidly rising to 11.1% in 1995, but decreasing to 4.2% in 1998 and 3.1% in 2000. The association with increased weight and shorter length is thought to be a changed hormonal response in combination with a poor dietary content, rich in carbohydrates and poor in protein, which resulted in failure of linear growth.[22,23] When stunted children are faced with a higher-energy dense, higher fat diet, weight gain will coincide with sub-optimal linear growth.[22-27] Previous studies suggested that fat metabolism of stunted children was impaired to an extent that might lead to increased obesity and other metabolic shifts.[26,28] Energy intake per kilogram body weight and fasting respiratory quotient was significantly higher, while the resting metabolic rate and fasting fat oxidation were significantly lower in the stunted children compared with the control children, leading to obesity in at risk populations.[25,26,28] From 1982 to 1992, the overweight and obesity prevalence increased rapidly, partly due to the rapid increasing of body weight but less rapid increasing of height (high stunting prevalence), while from 1992 to 2002, the stunted proportion among overweight and obese ones decreased rapidly, so the increasing trend of childhood obesity was not as quickly as previous decade, even decreased among the younger ones. The average increment of height from 1992 to 2002 was 3.4-3.9cm and 2.0-3.3cm of youngster aged 7-12 y and 13-17y, respectively.[29]

The strength of our data is that all three surveys are nationally representative. Both the fasting body weight and height of a large number of children were measured by trained investigators. In order to estimate the reproducibility, body weight of 2396 subjects and height of 2418 subjects in CNNHS 2002 were measured twice by different investigators. A high correlation was found between the two measurements (Weight: r=0.98, $P<0.01$; Height: r=0.99, $P<0.01$), the coefficients of variation between two measurements were

0.17% for weight and 0.12% for height. Detailed information about the quality control was given elsewhere.[30] The most important problem is the comparability of the measurements over time since the different surveys spanned a period of 20 years. In order to minimize this problem, the training programs of the investigators were kept similar, and measurements were all carried out with same type of scales, organized by the same institute. Unfortunately, there was no exact record about the participation rate of individuals. Among the 792 villages/neighborhood committees randomly selected, 65 (8.2%) refused to participate in CNNHS 2002. In such cases, another village/neighborhood committee was randomly chosen from the remaining ones.[30] According to the investigators who carry out the measurements in 2002, once the village/neighborhood committee decided to participate, the individual response rate was always more than ninety percent. In 1982 and 1992, it is expected to have been even more. [30]

In conclusion, obesity is an increasing problem among youngsters in China, especially in urban areas, although prevalence is still lower than in developed countries, particularly in rural areas. The prevalence of overweight and obesity reached epidemic proportion since 1992. The trend continued to increase until 2002 and is expected to rise further, especially in large cities. The stunted prevalence among overweight and obese youngsters decreased dramatically at the same period. This implies that 'simple and well-designed intervention studies in obese children and adolescents, which can be transferred into usual clinical practice' are also urgently needed by China. [31]

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REFERENCES

1. National Bureau of Statistics of China: China Statistic Year Book 2000. Beijing: China Statistic Press, 2000.
2. Zhai F, He Y, Ma G, Li Y, Wang Z, Hu Y, Zhao L, Cui Z, Li Y, Yang X: Study on the current status of food consumption among Chinese population. Zhong Hua Liu Xing Bing Xue Za Zhi 2005, 26(7):485-488.
3. Liu Y, Zhai F, Popkin BM: Trends in eating begaviours among Chinese children (1991-1997). Asia Pac J Clin Nutr 2006, 15(1):72-80.
4. Tudor-Locke C, Ainsworth BE, Adair LS, Du S, Popkin BM: Physical activity and inactivity in Chinese school-aged youth: the China Health and Nutrition Survey. Int J Obes Relat Metab Disord 2003, 27(9):1093-1099.
5. Waller CE, Du S, Popkin BM: Patterns of overweight, inactivity, and snacking in Chinese children. Obes Res 2003, 11(8):957-961.
6. Wang Y, Popkin B, Zhai F: The nutritional status and dietary pattern of Chinese adolescents, 1991 and 1993. Eur J Clin Nutr 1998, 52(12):908-916.
7. Ma G: Environmental factors leading to pediatric obesity in the developing world. Shanghai,China: Lippincott Williams & Wilkins, 2002.
8. Wang Y, Monteiro C, Popkin BM: Trends of obesity and underweight in older children and adolescents in the United States, Brazil, China, and Russia. Am J Clin Nutr 2002, 75(6):971-977.
9. Ji CY, Sun JL: Analyses of the epidemiological status of overweight and obesity in Chinese students and the prevalence changes in recent 15 years. Journal of Peking University 2004, 36(2):194-197.
10. Popkin BM, Richards MK, Montiero CA: Stunting is associated with overweight in children of four nations that are undergoing the nutrition transition. J Nutr 1996, 126(12):3009-3016.
11. Chen C, He W, Fu Z, Chang Y, Chang S, Wang Y, Fu G: Growth of children aged under 5 and its trend in China. Beijing: People's Medical Publishing House, 2004.
12. Ge K, Weisell R, Guo X, Cheng L, Ma H, Zhai F, Popkin B: The body mass index of Chinese adults in the 1980s. Eur J Clin Nutr 1994, 48(Suppl.

3.):S148-S154.

13. Jin D, Chen C: Report of China National Nutrition Survey of 1982. Beijing: Chinese Preventive Medicine Publishing, 1985.
14. Ge K: Dietary and Nutritional Status of Chinese people in 90th: report of China National Nutrition Survey of 1992. Beijing: People's Medical Publishing House, 1995.
15. Lin H, Zhai F, Xue H, Ge K: Three population-age distribution indics of the samples of national nutrition survey in 1992. Wei Sheng Yan Jiu 1996, 25: 57-61.
16. Ma G, Li Y, Jin Y, Zhai F, Kok FJ, Yang X: Phytate intake and molar ratios of phytate to zinc, iron and calcium in the diets of people in China. Eur J Clin Nutr 2006, 30 August, ePub.
17. Yang X, Kong L, Zhai F, Ma G, Jin S: The 2002 China National Nutrition and Health Survey (1): Design, sampling and statistic methods. Zhong Hua Liu Xing Bing Xue Za Zhi 2005, 26(7): 471-474.
18. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH: Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ 2000, 320(7244): 1240-1243.
19. WHO. Young People's Health-A Challenge for Society. Report of a WHO Study Group on Young People and Health for All by the Year 2000. Technical Report Series No. 731. Geneva: WHO 1986.
20. International Obesity Task Force data, based on population-weighted estimates from published and unpublished surveys, 1990-2002 (latest available) using IOIF-recommended cut-offs for overweight and obesity. http://www.iotf.org
21. Lobstein T, Baur L, Uauy R: Obesity in children and young people: a crisis in public health. Obes Rev 2004, 5 Suppl 1: 4-104.
22. Trowbridge FL: Prevalence of growth stunting and obesity: Pediatric Nutrition Surveillance System, 1982. MMWR CDC Surveill Summ 1983, 32(4): 23SS-26SS.
23. Mamabolo RL, Alberts M, Steyn NP, Delemarre-van de Waal HA, Levitt NS: Prevalence and determinants of stunting and overweight in 3-year-old black

South African children residing in the Central Region of Limpopo Province, South Africa. Public health nutrition 2005, 8(5):501-508.

24. Lukito W, Wahlqvist ML: Weight management in transitional economies: the " double burden of disease" dilemma. Asia Pac J Clin Nutr 2006, 15 Suppl: 21-29.
25. Grillol LP, Siqueira AF, Silva AC, Martins PA, Verreschi IT, Sawaya AL: Lower resting metabolic rate and higher velocity of weight gain in a prospective study of stunted vs nonstunted girls living in the shantytowns of Sao Paulo, Brazil. Eur J Clin Nutr 2005, 59(7): 835-842.
26. Hoffman DJ, Roberts SB, Verreschi I, Martins PA, de Nascimento C, Tucker KL, Sawaya AL: Regulation of energy intake may be impaired in nutritionally stunted children from the shantytowns of Sao Paulo, Brazil. J Nutr 2000, 130(9):2265-2270.
27. Sawaya AL, Grillo LP, Verreschi I, da Silva AC, Roberts SB: Mild stunting is associated with higher susceptibility to the effects of high fat diets: studies in a shantytown population in Sao Paulo, Brazil. J Nutr 1998, 128(2 Suppl): 415S-420S.
28. Hoffman DJ, Sawaya AL, Verreschi I, Tucker KL, Roberts SB: Why are nutritionally stunted children at increased risk of obesity? Studies of metabolic rate and fat oxidation in shantytown children from Sao Paulo, Brazil. Am J Clin Nutr 2000, 72(3):702-707.
29. Yang X, Li Y, Ma G, Hu X, Wang J, Cui Z, Wang Z, Yu W, Yang Z, Zhai F: Study on weight and height of the Chinese people and the differences between 1992 and 2002. Zhong Hua Liu Xing Bing Xue Za Zhi 2005, 26(7): 489-493.
30. Piao J, Zhang J, Zhao W, You Y, Yang X: China National Nutrition and Health Survey (2): Quality Control in China Nutrition and Health Survey. Design, sampling and statistic methods. Zhong Hua Liu Xing Bing Xue Za Zhi 2005, 26(7):475-477.
31. Common wealth of Australia 2003: NHMRC clinical practice guideline for the management of overweight and obesity in children and adolescents. ISBN 1 864961 90 2. www.obesityguidelines.gov.au. 2003.

Table 1 Number and percentage of participants in sex and age groups by survey

(yrs)	CNHS1982				CNHS1992				CNNHS2002			
	Boys		Girls		Boys		Girls		Boys		Girls	
7-	138	2.6	147	3.1	801	10.0	730	9.8	2655	11.4	2444	11.3
8-	318	6.0	281	5.9	801	10.0	690	9.3	2705	11.6	2487	11.5
9-	322	6.0	359	7.5	784	9.7	690	9.3	2751	11.8	2566	11.9
10-	368	6.9	364	7.6	929	11.5	847	11.4	2727	11.7	2657	12.3
11-	364	6.8	387	8.1	770	9.6	651	8.7	2864	12.3	2745	12.7
12-	475	8.9	440	9.2	750	9.3	667	8.9	3013	13.0	2791	12.9
13-	448	8.4	418	8.7	763	9.5	701	9.4	1888	8.1	1689	7.8
14-	515	9.7	417	8.7	702	8.7	654	8.8	1592	6.8	1479	6.8
15-	477	8.9	504	10.5	605	7.5	622	8.3	1351	5.8	1274	5.9
16-	757	14.2	692	14.4	624	7.8	607	8.1	989	4.3	867	4.0
17-	1152	21.6	784	16.4	519	6.4	594	8.0	707	3.0	639	3.0
Total	5334	100.0	4793	100.0	8048	100.0	7453	100.0	23242	100.0	21638	100.0

Table 2 Overweight and obesity prevalence (%)[1,2] among Chinese youngsters in 1982, 1992, 2002

Sex	Age	Overweight			Obesity			Overweight and Obesity		
	(y)	1982	1992	2002	1982	1992	2002	1982	1992	2002
Boy	7-12	1.7	3.9	5.0	0.3	1.5	1.4	2.0	5.4	6.5
	13-17	0.5	3.7	4.6	0.1	0.4	0.7	0.7	4.1	5.3
	Total	1.1	3.8	4.9	0.2	1.0	1.1	1.4	4.8	5.9
Girl	7-12	1.3	3.9	3.3	0.2	1.4	0.7	1.5	5.3	4.0
	13-17	1.2	3.0	4.6	0.0	0.1	0.5	1.3	3.1	5.2
	Total	1.3	3.5	3.9	0.1	0.8	0.6	1.4	4.3	4.5
Total	7-12	1.5	3.9	4.2	0.2	1.4	1.1	1.7	5.4	5.3
	13-17	0.8	3.4	4.6	0.1	0.2	0.6	0.9	3.6	5.2
	Total	1.2	3.7	4.4	0.2	0.9	0.9	1.3	4.4	5.2

[1] Overweight and obesity defined using International Obesity Task Force standards;[18]

[2] The prevalence was age standardized according to the Fifth National Population Census.[1]

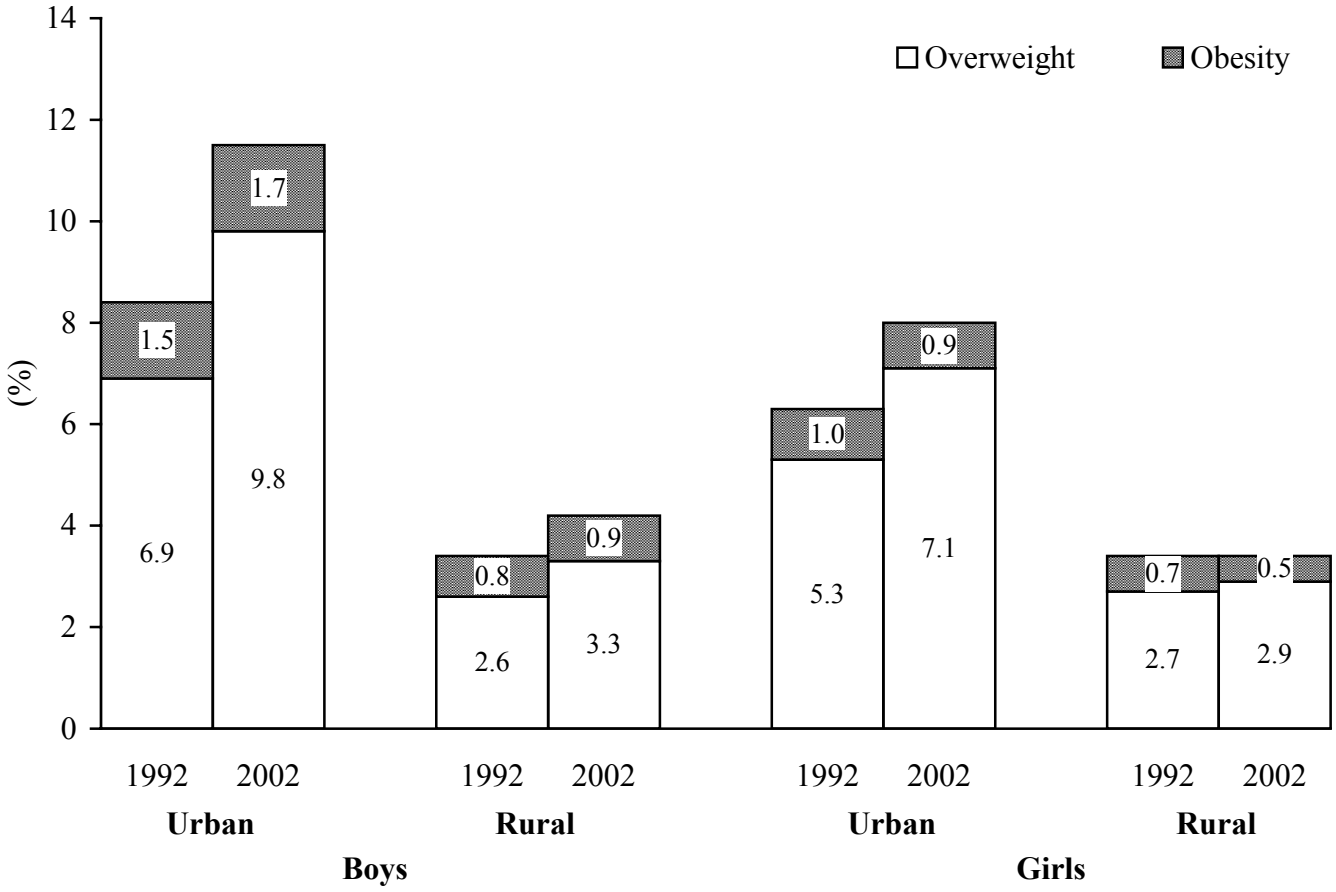

Figure 1 Comparison between 1992 and 2002 of overweight and obesity among Chinese youngsters aged 7-17 years by urban and rural

[1] Overweight and obesity defined using International Obesity Task Force standards;[18]

[2] The prevalence was age standardized according to the Fifth National Population Census.[1]

Table 3 Stunting[1] proportion (%) among overweight and obese[2] youngsters

Sex	Age	Among normal weight youngsters (%)				Among overweight youngsters (%)				Among obese youngsters (%)			
		Urban		Rural		Urban		Rural		Urban		Rural	
	(y)	1992	2002	1992	2002	1992	2002	1992	2002	1992	2002	1992	2002
Boy	7-12	15.7	4.6	33.9	19.4	10.8	1.9	34.8	10.3	34.7	1.9	56.3	20.4
	13-17	17.8	10.4	35.9	25.1	2.9	4.0	23.9	15.4	21.4	2.3	50.0	16.3
	Total	16.6	5.5	34.7	21.5	7.6	2.2	30.8	12.2	31.7	1.9	55.4	19.4
Girl	7-12	15.7	4.8	35.7	21.4	17.0	2.6	42.3	8.4	36.1	3.5	57.7	27.7
	13-17	14.9	8.8	27.8	21.3	16.3	7.8	21.6	15.3	40.0	14.3	50.0	17.9
	Total	15.3	5.4	32.3	21.4	16.7	3.5	30.8	12.3	36.4	4.4	57.0	25.0
Total	7-12	15.7	4.7	34.7	20.4	12.9	2.2	37.6	9.6	35.5	2.5	57.0	23.1
	13-17	16.3	9.6	31.9	23.3	8.5	5.8	22.6	15.3	26.3	7.6	50.0	17.0
	Total	16.0	5.5	33.6	21.5	11.0	2.7	30.8	12.2	34.1	2.9	56.2	21.6

[1] The subjects whose height for age z score less than -2 according to CDC/WHO 1978 reference;

[2] Overweight and obesity defined using International Obesity Task Force standards.[18]

Table 4 Overweight and obesity prevalence among Chinese youngsters in 2002[1]

	Children aged 7-12yrs					
	Boys			Girls		
	N	Overweight (%)	Obesity (%)	N	Overweight (%)	Obesity (%)
Domicile Region						
Large-City	3699	18.7	5.3	3714	12.7	2.3
Small -City	4475	8.5	1.8	4318	5.8	0.7
1st level village	1770	4.5	1.6	1602	3.2	0.7
2st level village	2181	3.3	1.1	1944	1.7	0.6
3st level village	2158	4.3	1.0	1984	2.8	0.9
4st level village	2432	2.0	0.7	2128	1.9	0.3
Family Income (Yuan/Year/Number)						
<800	2298	3.7	1.4	2308	2.8	0.6
800-1999	4876	4.4	1.0	4429	2.9	0.5
2000-4999	4154	7.5	2.1	3715	5.4	1.1
5000-9999	2388	11.4	3.5	2192	8.9	1.5
≥10000	1376	17.6	4.6	1420	11.1	1.7
Educational Level of Mother						
Illiterate	932	2.1	1.5	849	1.6	0.4
Primary	3889	3.0	1.0	3557	2.1	0.4
Junior high school	5601	7.0	1.7	5185	5.0	1.0
Senior high school	2754	13.6	3.7	2747	9.9	1.9
College and higher	1535	17.2	4.4	1492	10.9	0.9
Educational Level of Father						
Illiterate	260	2.7	1.5	222	0.5	0.0
Primary	2665	3.0	0.7	2492	2.1	0.7
Junior high school	6201	5.8	1.5	5765	4.2	0.9
Senior high school	3306	11.7	3.4	3045	7.9	1.4
College and higher	2036	15.5	4.1	2011	11.0	1.1
Career of Mother						
Farmer	5962	2.8	0.9	5369	1.9	0.5
Unemplyed	3083	7.5	2.3	2971	5.9	1.0
Technician/worker	3329	13.3	3.9	3224	9.1	1.3
Manager/officer	1188	15.7	3.0	1164	10.7	1.5
Others	1096	12.4	2.6	1058	7.6	1.8
Career of Father						
Farmer	5843	2.9	0.9	5320	2.3	0.5
Unemplyed	845	10.3	2.7	843	6.8	1.1
Technician/worker	4335	10.9	2.9	4131	8.0	1.1
Manager/officer	1676	13.9	3.9	1585	9.2	1.7
Others	1714	10.8	2.7	1610	6.2	1.5

(continue)

	Children aged 13-17yrs					
	Boys			Girls		
	N	Overweight (%)	Obesity (%)	N	Overweight (%)	Obesity (%)
Domicile Region						
Large-City	667	13.5	1.8	640	9.2	0.5
Small -City	795	7.4	0.6	781	6.0	0.9
1st level village	1116	4.8	0.6	951	4.2	0.4
2st level village	1294	3.3	0.5	1207	3.6	0.4
3st level village	1346	3.6	0.7	1220	4.6	0.2
4st level village	1309	1.3	0.2	1149	2.9	0.3
Family Income (Yuan/Year/Number)						
<800	1133	2.2	0.6	1220	4.0	0.3
800-1999	2575	3.4	0.3	2267	3.7	0.4
2000-4999	1738	5.9	0.7	1462	6.0	0.5
5000-9999	692	8.7	1.3	613	5.4	0.7
≥10000	283	10.2	1.4	295	6.4	0.0
Educational Level of Mother						
Illiterate	729	2.3	0.4	704	3.8	0.4
Primary	2189	2.6	0.2	1896	3.2	0.3
Junior high school	2259	5.3	0.7	2065	5.7	0.6
Senior high school	800	10.0	1.4	750	6.5	0.5
College and higher	125	12.8	2.4	140	4.3	0.0
Educational Level of Father						
Illiterate	216	2.3	1.4	228	4.4	0.4
Primary	1527	2.6	0.4	1340	3.4	0.5
Junior high school	2802	4.3	0.8	2510	5.0	0.3
Senior high school	1188	7.0	0.3	1075	5.0	0.6
College and higher	224	12.1	1.3	220	6.8	0.5
Career of Mother						
Farmer	3524	2.9	0.4	3152	3.5	0.4
Unemplyed	1468	6.5	0.9	1393	6.5	0.5
Technician/worker	676	8.3	1.3	631	6.2	0.6
Manager/officer	221	8.6	1.4	217	6.9	0.9
Others	196	7.7	0.0	150	3.3	0.0
Career of Father						
Farmer	3577	2.6	0.3	3212	3.7	0.3
Unemplyed	359	8.4	1.4	315	8.9	0.6
Technician/worker	1228	7.3	1.0	1061	5.7	0.7
Manager/officer	392	9.7	0.8	400	6.8	0.5
Others	385	6.0	1.3	367	3.8	0.5

[1] Overweight and obesity defined using International Obesity Task Force standards developed by Cole *et al.*[18]

3

Determinants of Childhood Overweight and Obesity in China

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ABSTRACT

Objective: In order to investigate the determinants of childhood overweight and obesity in China, the prevalence of overweight (including obesity) was compared according to different dietary and physical activity patterns and parental body weight status.

Design and subjects: A total of 6826 children aged 7-17 years from the 2002 China National Nutrition and Health Survey were included in the study.

Methods: Information for dietary intake was collected using 3 consecutive 24-h recalls by trained interviewers. The amounts of cooking oil and condiments consumed were weighed. An interview-administered 1-year physical activity questionnaire was used to collect physical activity information.

Results: The heavier the parental body weight, the higher the overweight prevalence in children. The prevalence ratio increased if parent(s) were overweight and/or obese, up to 12.2 if both parents were obese. Overweight children consumed significantly more dietary energy, protein and fat, but less carbohydrate than their normal weight counterparts. On average, overweight children spent 0.5 h less on moderate/vigorous activities, and 2.3 h more on low intensity activities per week. The following prevalence ratios were statistically significant: walking to and from school (0.6); moderate/vigorous activities ≥ 45 min/d (0.8); low intensity physical activities >2 h/d (1.3); the consumption of ≥ 25 g/d cooking oil (1.4); ≥200 g/d meat and meat products consumption (1.5); ≥100 g/d dairy products (1.8). After adjustment for parental body weight status and socioeconomic status, only cooking oil consumption and walking to and from school remained significantly related to child overweight.

Conclusion: Parental weight status is an important determinant. Fat intake, low intensity activities and active transport to/from school may be suitable entry points for overweight prevention among Chinese school children.

INTRODUCTION

Not being a problem at all in the 1980s, the prevalence of overweight and obesity among children in China were approximately 5% and 2% respectively in 2002.[1] Compared to that in developed countries, childhood obesity is still relatively rare in China, however, the risk for metabolic syndrome among overweight adolescents is similar to those living in the USA. Moreover, childhood obesity and its adverse health consequences may persist to adulthood. A positive relationship was found between childhood obesity and increased morbidity and mortality in adulthood.[2]

Obesity is a multi-factorial disease and its development is the result of multiple interactions between genes and environment.[3,4] Twins adoption, and family studies have found that heritability of BMI was in the range of 25-85%, but it is the environment that allows the expression of obesity .[3,4]

The purpose of the present study is to investigate the important determinants of childhood overweight and obesity in China, including dietary intakes, leisure time physical activity patterns, parental weight status and socioeconomic status, using the data of the 2002 China National Nutrition and Health Survey. This is the first national representative survey addressing the relationship among diet, physical activity and obesity of children and their parents together in China. The findings will be helpful for developing national strategies for the prevention of childhood overweight and obesity in China.

METHODS

The 2002 China National Nutrition and Health Survey is a nationally representative cross-sectional survey[5] that covered thirty-one provinces, autonomous regions and the municipalities directly affiliated to the Central Government (Hong Kong, Macao and Taiwan are not included). A multi-step cluster sampling method (equal sample size at each step) was used for subject selection. All 2860 counties/districts/cities were divided into six categories (big cities, medium and small cities, rural 1, 2, 3 and 4) based on its type and the level of economic development (from high to low). From each of six categories, twenty-two counties/districts/cities were selected using a systematic

sampling method and a total of 132 counties/districts/cities were chosen at Step 1. Three townships/sub-districts were randomly chosen from each selected country/district/city and a total of 396 at Step 2. Two villages/neighborhood committees (792 in total) were randomly chosen from the selected townships/sub-districts at Step 3. Ninety households were randomly selected from each village/neighborhood, giving a total of 71,971 households. From each village/neighborhood thirty out of ninety households were randomly selected for dietary and physical activity assessments. Sampling involved a total of 272 023 subjects aged 2-101 years, representing the national population, one third of them randomly selected for the dietary and physical activity investigation and of these subjects, 8861 were aged 7 to 17 years.

Data collection

Subjects went to the study sites (such as neighborhood committee center, the office of the village leader, etc.) for the anthropometric measurements. Investigators made home visits to collect the food and activity information.

Fasting body weight was measured in the morning to the nearest 0.10 kg with a balance-beam scale (Liaoning) while the subjects were wearing lightweight clothing. Height was measured to the nearest 0.1 cm using a standard steel strip stadiometer (Liaoning) in bare footed subjects.[5] The standard procedure was followed by all trained investigators.

Trained interviewers went to subjects' home to collect the information on food intake using the 24-h dietary recall method for three consecutive days (two weekdays and one weekend day) and to weigh the home cooking oil and condiment consumption of all the family members in these 3 d.[5] The percentage of the oil and condiments from home that child consumed was calculated by the ratio of child's energy requirement : energy intakes of all family members. The energy and nutrient intakes were calculated using the data of dietary intake in conjunction with the China Food Composition Table.[6] Energy density of each subjects was calculated as average energy intake (kJ) divided by average food weight (g) per d,[7] all beverages except water were included in the food weight calculation.

Information on leisure time physical activity was collected using a 1-year physical

activity questionnaire administered by trained interviewers. The questionnaire consisted of four domains: transport; exercise; sedentary activities; housework. Active transport was defined as going to/from school mainly by bike or by walking, while inactive transport was defined as going by bus, motor-cycle, car or sitting at the back of a parent's bike. Sedentary activities included television viewing, computer use, video games, reading and study. Housework included cooking, washing by hand, cleaning the house and taking care of elders/babies. Moderate to vigorous activities included sports/exercise, active transport and housework, and low intensity activities included sedentary activities, inactive transport and studying.

The protocol of the survey was approved by the Ethical Committee of the National Institute for Nutrition and Food Safety, Chinese Center for Disease Control and Prevention. Signed consent forms were obtained from both their parents or guardians and the children themselves.

Definition of overweight

Overweight was defined using age- and sex- specific BMI cut-off points developed by the Working Group for Obesity in China (2004), as BMI for age- and sex- specific categories between the 85th and 95th percentile, whereas obesity was defined as BMI at 95th percentile or higher.[8] In the present study, overweight (≥ 85th percentile) among children included both overweight and obesity.

Adult (parent) overweight and obesity were defined as BMI 24-28 kg/m^2 and BMI ≥ 28 kg/m^2 respectively as recommended by the Working Group for Obesity in China.[9]

Statistical methods

Only one child from the 1775 families that have more than one child living together was randomly selected for the analysis, then 6828 from the 8861 children were included in the present study.

Dietary intakes and physical activity patterns were presented by overweight and normal weight children. Differences between the overweight and normal weight groups were compared using Wilcoxon's signed rank sum test for continuous values, while χ^2 tests were applied to proportions for those with and without certain patterns. Cox regression

analysis[10,11] was used to estimate the Prevalence Ratios (PR) of overweight between different dietary or physical activity patterns, where survival time is artificially set equal to 1. The cut-off points of the food intakes used in Cox regression analysis (see Table 5) were defined according to the Food Pagoda for Chinese people.[12] The moderate to vigorous physical activity duration cut off was taken at 45 minutes per day that had been thought to be minimally required to prevent the transition to overweight or obesity.[13]

The data of body weight and height information of the parents were available in a random subgroup of 4596 children. Prevalence of childhood overweight was calculated by parental weight status groups, and the prevalence ratio was calculated using Cox regressions.

Because parental weight and socioeconomic status may influence child weight independently, as well as through eating/activity, we included the results both with and without adjustment of parental weight and socioeconomic status in the results part.

All statistical analyses were done with the SAS (version 9.1), and the significant level was set at 0.05.

RESULTS

Weight, height and body mass index (BMI) of the 6828 subjects are shown in Table 1. Overweight and obesity percentage of the present sample was 4.5 and 2.2, respectively.

Dietary intake

The dietary energy and nutrient intakes of overweight and normal weight children are described and compared in Table 2. Overweight children consumed significantly more dietary energy, protein and fat and less carbohydrate than their counterparts with normal weight. Protein and fat contributed significantly more, while carbohydrate contributed significantly less to the daily energy intake among overweight children.

The contribution of several food items to total food weights is shown in Table 3. Overweight children consumed less cereal grains and vegetables, and more fruits, meats, cooking oil, egg, fish, milk and legumes.

Physical activity

Table 4 presents the average duration of leisure time activities among all children in the sample and among children participating in the respective activities. Overweight children spent less time on housework and active transport and also performed less total moderate/vigorous activities, but they spent longer time on low intensity activities, including leisure time reading, computer use, video games, study and inactive transport. On average, overweight children spent 2.3 h per week more on low-intensity activities and 0.5 h less in moderate/vigorous activities than their counterparts with normal weight.

Parental weight status

The prevalence of childhood overweight by parental weight status is shown in Table 5. The heavier the parental body weight, the higher the overweight prevalence in children. Among the children whose parents were both obese, 39.1% were overweight. The prevalence ratio increased if parent(s) were overweight and/or obese, up to 12.2 if both parents were obese. After including the dietary and physical activity patterns of children in the model, the prevalence ratio still increased steadily with parental weight status (Table 5).

Prevalence analysis

Overweight prevalence and prevalence ratios of children with different lifestyles are shown in Table 6. Overweight prevalence among children who spent more than 45 min/day on moderate/vigorous activities or walked to school was less than their counterparts who spent less than 45 min/d on moderate/vigorous activities or went to school by bus. A significantly higher prevalence of overweight was observed among those who spent more than 2 h on low intensity activities, consumed ≥ 25 g cooking oil, ≥ 200 g meat and meat products and/or ≥ 100 g dairy products daily. The prevalence ratios were 1.3, 1.4, 1.5 and 1.8, respectively.

Adjustment for parental weight status, family income and mother's educational levels resulted in loss of significance of the prevalence ratio of moderate/vigorous activities ≥ 45 min/d, low-intensity physical activities ≥ 2 h, ≥ 200 g meat and meat products and ≥

100 g dairy products but the prevalence ratios of walking to/from school and ≥ 25 g cooking oil were still significant (0.6 and 1.3, respectively). The prevalence ratios and 95% CI of middle and high family income levels were 1.4 (1.1, 1.8) and 1.7 (1.1, 2.5), of middle and high mother's educational levels were 1.3 (1.0, 1.7) and 1.7 (1.1, 2.6), respectively.

DISCUSSION

Based on present cross-sectional observation, overweight children consumed significantly more dietary energy, protein and fat but less carbohydrate than their counterparts with normal weight. On average, overweight children spent 0.5 h less on moderate/vigorous activities, but 2.3 h more on low intensity activities per week. Several dietary and physical activity factors are related to overweight among Chinese children. Parental body weight is also an important determinant. The addition of parental body weight status, family income level and mother's education to the model made some of the associations disappear. However, it can be argued that this may lead to over-adjustment, since income and educational status may be part of the same causal pathway.

Unlike in the USA, where obesity prevalence increased while the reported dietary fat intakes decreased in recent decades,[14] in China, obesity increased parallel with dietary fat increment. The average daily dietary fat intake among Chinese people increased from 48 g to 58 g during 1982-1992, and continued to increase to 76 g per d during 1992-2002. Among Chinese adolescents, contribution of dietary fat to total energy increased one to two points in only 2 years (from 1991 to 1993).[15] Energy and fat intakes have been found to be positively associated with BMI among male adults and energy intake among women in China.[16] The present results show that overweight Chinese children reported high energy and fat intakes. Over consumption of cooking oil may be one of the contribution factors for overweight. The recommended consumption of fats and oil is 25 g/d (Chinese Nutrition Society), however, 70.1% of overweight children failed to follow this recommendation. Over consumption of oil was also observed in overweight Chinese women.[17] Current results about energy density is in direct opposition to data found elsewhere, specifically the USA,[18] because the Chinese

diet is still plant food based. It really looks paradox when the overweight eat more high-energy density foods such as meat, cooking oil, fish, eggs, etc, while their diet is low energy density. From table 3, it can be seen that those foods account for a very low percentage of the total foods, in contrast rice, wheat and their products contributed 40% total foods and >50% energy. Therefore, the energy density of these diets depends relatively more on the cereals.

Low physical activity and/or increasing sedentary activities are widely thought to be related to weight gain.[18] The current study shows that overweight children spent less time on moderate/vigorous physical activities, especially housework and active transport, but not exercise. In adults, walking has been demonstrated to be beneficial to health and weight control,[17,20] while motorized vehicle use seems to be associated with overweight and other disorders. Among US young adults, the proportion of individuals using active transportation was higher among non-overweight compared to overweight ones (to work 9.2 vs 6.8%; to school 29.7 vs 22.6%).[20] Among Chinese adults, going to and from work by walking or bicycle seems to reduce the risk of overweight by 50% compared with going by bus.[17] Men who acquired a motor vehicle experienced a 1.8 kg greater weight gain and had 2:1 odds of becoming obese.[21]

The present study is in line with previous studies,[22-26] concluding that parental overweight was the most potent risk factor for childhood obesity. Treuth and colleagues[22] found that a stepwise increase in gains in fat mass and percent body fat over time occurred with increasing parental body weight status. The association reflects both genetic and environmental influence for the development of overweight. In addition to the high genetic similarity among members of a family,[23] parents play an important role in the development of children's physical activity patterns[24] and eating behaviors and attitudes.[25] Parents may be responsible for the over consumption of cooking oil by children. Parents' socioeconomic status also has important effect on childhood obesity.[26]

Being nationally representative and comprising both diet and physical activity information and parental information are strengths of the present study. The limitation is that the results are based on cross-sectional observation. Therefore, it is not possible to

demonstrate a cause-and-effect relationship. The observed associations may be either causal in direction or a consequence of childhood obesity.

Based on the associations we found, the following points might be considered in further studies and if confirmed, in prevention programs: (1) the tradition of going to/from school by walking or by bike should be encouraged; (2) limiting the fat intake and particularly the over-consumption of cooking oil in China is a challenge, given the habit of frying foods; (3) reduce low-intensity activities and encourage the children to be more active; (4) parental participation and family involvement may enhance the effect of such programs on childhood obesity in China.

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REFERENCES

1. Li Y, Chen C, Kong L, Yang X, Zhai F, Zhang J & Ma G (2005) Child obesity in China: prevalence, determinants and its relationship to cardiovascular risk factors. Abstracts 18th international congress of nutrition, September 19-23, 2005, Durban, South Africa, Nutrition Safari for Innovative solutions. Medical and Scientific Publishers.
2. Wabitsch M: Overweight and obesity in European children: definition and diagnostic procedures, risk factors and consequences for later health outcome. Eur J Pediatr 2000, 159 Suppl 1:S8-13.
3. Allison D, Martz P, Pietrobelli A, Zannoli R, Faith M: Genetic and environmental influences on obesity. Totowa, New Jersey: Human press; 1999.
4. Lobstein T, Baur L, Uauy R: Obesity in children and young people: a crisis in public health. Obes Rev 2004, 5 Suppl 1:4-104.
5. Wang L: Report of China Nationwide Nutrition and Health Survey 2002 (1): Summary Report. Beijing: People's Medical Publishing House; 2005.
6. Yang Y, Wang G, Pan X: China Food Composition Table 2002. Beijing: Beijing Medical University Publishing House; 2002.
7. Drewnowski A, Almiron-Roig E, Marmonier C, Lluch A: Dietary energy density and body weight: is there a relationship? Nutr Rev 2004, 62(11):403-413.
8. Group of China Obesity Task Force: Body mass index reference norm for screening overweight and obesity in Chinese children and adolescents. Zhong Hua Liu Xing Bing Xue Za Zhi 2004, 25(2):97-102.
9. Cooperative Meta-analysis Group of China Obesity Task Force: Predictive value of body mass index and waist circumference to risk factors of related diseases in Chinese adults population. Zhong Hua Liu Xing Bing Xue Za Zhi 2002, 23(1):5-10.
10. Barros AJ, Hirakata VN: Alternatives for logistic regression in cross-sectional studies: an empirical comparison of models that directly estimate the prevalence ratio. BMC Med Res Methodol 2003, 3:21.
11. Schiaffino A, Rodriguez M, Pasarin MI, Regidor E, Borrell C, Fernandez E: Odds ratio or prevalence ratio? Their use in cross-sectional studies. Gac Sanit

2003, 17(1):70-74.

12. Chinese Nutrition Society: Balance Dietary Pogada. http://www.cnsoc.org/asp-bin/EN/?page=8&class=42&id=131. (Accessed on 6 Jun 2005).
13. Saris WH, Blair SN, van Baak MA, Eaton SB, Davies PS, Di Pietro L, Fogelholm M, Rissanen A, Schoeller D, Swinburn B *et al*: How much physical activity is enough to prevent unhealthy weight gain? Outcome of the IASO 1st Stock Conference and consensus statement. Obes Rev 2003, 4(2):101-114.
14. Trends in intake of energy and macronutrients--United States, 1971-2000. MMWR Morb Mortal Wkly Rep 2004, 53(4):80-82.
15. Wang Y, Popkin B, Zhai F: The nutritional status and dietary pattern of Chinese adolescents, 1991 and 1993. Eur J Clin Nutr 1998, 52(12):908-916.
16. Paeratakul S, Popkin BM, Keyou G, Adair LS, Stevens J: Changes in diet and physical activity affect the body mass index of Chinese adults. Int J Obes Relat Metab Disord 1998, 22(5):424-431.
17. Hu G, Hu G, Pekkarinen H, Hanninen O, Tian H, Jin R: Comparison of dietary and non-dietary risk factors in overweight and normal-weight Chinese adults. Br J Nutr 2002, 88(1):91-97.
18 Ledikwe JH, Blanck HM, Kettel Khan L, Serdula MK, Seymour JD, Tohill BC & Rolls BJ (2006) Dietary energy density is associated with energy intake and weight status in US adults. Am J Clin Nutr 83 (6), 1362-1368.
19. Must A, Tybor DJ: Physical activity and sedentary behavior: a review of longitudinal studies of weight and adiposity in youth. Int J Obes (Lond) 2005, 29 Suppl 2:S84-96.
20. Gordon-Larsen P, Nelson MC, Beam K: Associations among active transportation, physical activity, and weight status in young adults. Obes Res 2005, 13(5):868-875.
21. Bell AC, Ge K, Popkin BM: The road to obesity or the path to prevention: motorized transportation and obesity in China. Obes Res 2002, 10(4):277-283.
22. Treuth MS, Butte NF, Sorkin JD: Predictors of body fat gain in nonobese girls with a familial predisposition to obesity. Am J Clin Nutr 2003, 78(6):1212-1218.

23. Jacobson KC, Rowe DC: Genetic and shared environmental influences on adolescent BMI: interactions with race and sex. Behav Genet 1998, 28(4):265-278.
24. Bogaert N, Steinbeck KS, Baur LA, Brock K, Bermingham MA: Food, activity and family--environmental vs biochemical predictors of weight gain in children. Eur J Clin Nutr 2003, 57(10):1242-1249.
25. Benton D: Role of parents in the determination of the food preferences of children and the development of obesity. Int J Obes Relat Metab Disord 2004, 28(7):858-869.
26. Veugelers PJ, Fitzgerald AL: Prevalence of and risk factors for childhood overweight and obesity. CMAJ 2005, 173(6):607-613.

Table 1 Characteristics of the children (Mean±SD)

	Overweight	Normal Weight
N	458	6368
Girls (%)	36.5	42.9
Age (y)	11.4±2.8	11.2±2.7
Height (cm)	148.3±15.8	141.5±15.8
Weight (kg)	52.0±15.2	33.7±11.2
BMI (kg/m^2)	23.1±2.9	16.3±2.2

Table 2 Energy and nutrients intakes of overweight and normal weight children (Mean±SD)

	Overweight	Normal Weight
Energy (MJ/day) [1]	8.5±2.7	8.1±2.7*
Protein (g/d) [1]	63.7±23.7	56.2±21.4*
Protein (%)[2]	12.7	11.8*
Fat (g/d) [1]	79.3±41.9	65.6±42.1*
Fat (%)[2]	34.7	29.6*
Carbohydrate (g/d) [1]	264.9±102.3	279.3±97.8*
Carbohydrate (%)[2]	52.6	58.7*
Fiber (g/mJ) [1]	1.2±0.7	1.3±0.7*
Food weight (g)	1008.1±340.6	912.7±308.2*
Energy density (kJ/g) [1]	8.7±2.1	9.1±2.1*

Mean values were significantly different: *P<0. 05;

[1]Wilcoxon's signed rank sum test;

[2] χ^2-test.

Table 3 Food patterns of overweight and normal weight children

(Mean)

	Food Weight				Energy			
	(g)		(%)[1]		(kJ)		(%)[2]	
	Over weight	Normal weight	Over weight	Normal weight	Over weight	Normal weight	Over weight	Normal weight
Rice/Wheat	372.7	391.5*	39.4	44.9*	4406.6	4791.1	52.4	60.3*
Vegetable	216.5	220.5	21.3	23.9*	222.0	231.2	2.7	3.0*
Meat/products	87.4	64.7*	8.4	6.8*	979.4	772.0*	11.2	9.0*
Fruit	64.3	53.9*	5.5	5.1*	107.8	94.5*	1.3	1.2*
Oil	40.8	35.9*	4.2	4.0*	1530.3	1343.9*	17.8	16.0*
Milk/Dairy	55.8	24.3*	4.7	2.2*	138.8	65.2*	1.7	0.8*
Egg	31.7	20.4*	3.2	2.3*	174.7	112.0*	2.1	1.5*
Fish	38.9	24.0*	3.6	2.5*	114.1	72.3*	1.4	0.9*
Bean/products	15.5	13.0*	1.6	1.5*	232.4	216.5*	2.7	2.6*
Others	84.5	64.4*	8.1	6.9*	572.7	380.4*	6.5	4.6*

[1]Percentage of total food intake (food weight of each kind (g) / total food intake (g));

[2]Percentage of total energy intake (energy intake from each kind of food (kcal) / total energy intake (kcal));

*$P<0.05$, Wilcoxon's signed rank sum test.

Table 4 Physical activity patterns of overweight and normal weight children

	Duration[1] (h/week, Mean±SD)		Participation Rate (%)		Duration[2] (h/week, Mean±SD)	
	Over weight	Normal weight	Over weight	Normal weight	Over weight	Normal weight
Mod/Vig Physical activity						
Exercise	1.1±2.1	0.8±1.9	41.7	41.2	2.7±2.6	2.0±2.6*
Housework	1.1±3.1	1.7±4.0	29.5	39.8*	3.6±4.7	4.3±5.3*
Active transport	1.9±1.6	2.2±1.9	84.5	91.6*	2.3±1.5	2.4±1.9
Moderate/Vigorous Physical activity time	4.1±4.1	4.7±4.9	93.7	96.4*	4.4±4.1	4.9±4.9
Low intensity activities (Inactive)						
Television	9.3±6.5	9.4±6.4	91.7	90.2	10.1±6.1	10.5±5.8*
Leisure reading	5.1± 6.6	4.6±6.4*	67.7	57.4*	7.5±6.8	8.0±6.7*
Computer	0.9±2.8	0.5±2.4*	13.3	6.7*	6.9±4.1	7.4±5.9
Video games	0.5±2.1	0.3±1.7*	9.2	5.4*	5.9±4.4	5.3±4.9
Studying	7.9±4.3	6.9±4.1*	98.7	97.4	8.0±4.3	7.1±4.0*
Inactive transport	0.4±1.4	0.2±0.9*	14.4	5.9*	3.0±2.5	3.0±2.3
Total inactive time	24.2± 11.7	21.9±11.2*				

Duration[1]: Average duration among all children in sample;

Duration[2]: Average duration among participating children;

*$P<0.05$, Wilcoxon's signed rank sum test for mean comparison, and χ^2-test for participate rate.

Table 5 Prevalence of childhood overweight by parental weight status

Parental Weight Status	Childhood Overweight		
	Prevalence (%)	*Prevalence Ratio*[1] (95%CI)	
		Unadjusted	Adjusted[2]
At least one underweight	3.0	0.9 (0.5, 1.8)	1.0 (0.5, 1.9)
Both normal weight	3.2	–	–
One normal weight, one overweight	6.9	2.2 (1.6, 3.0) *	1.9 (1.4, 2.7) *
Both overweight	11.4	3.6 (2.5, 5.0) *	3.1 (2.2, 4.3) *
One overweight, one obesity	22.0	6.9 (4.7, 10.0) *	5.6 (3.8, 8.3) *
Both obesity	39.1	12.2 (7.2, 20.7) *	9.5 (5.5, 16.3) *

[1]Prevalence ratio of having overweight or obese children compared to the group that both parents are normal weight, Cox regression analysis, *P<0.05;

[2] Other factors included in the model: Energy and food intakes, leisure time physical activity and inactivity patterns, mother's educational and family income levels.

Table 6 Association between determinants and overweight status

Risk Factors	N	Overweight prevalence[1]	*Prevalence Ratio*[2]
			OR (95%CI)
Sex			
Boys	3925	7.4	
Girls	2901	5.8*	0.8 (0.7-1.0) *
Moderate/vigorous activity (min/day)			
< 45	4809	7.2	
≥ 45	2017	5.6*	0.8 (0.6-1.0) *
Transport to/from school			
By bus	440	15.0	
By bike	1156	9.0	0.7 (0.5-1.1)
By walk	5230	5.5*	0.6 (0.5-0.8) *
Inactivity (hours/day)			
≤ 2	1626	4.9	
> 2	5200	7.3*	1.3 (1.0-1.7) *
Meat and meat products (g/day)			
< 200	5531	5.6	
≥ 200	1295	11.3*	1.5 (1.2-1.8) *
Cooking oil (g/day)			
< 25	2782	4.9	
≥ 25	4044	7.9*	1.4 (1.2-1.8) *
Diary product (g/day)			
< 100	6161	5.9	
≥ 100	665	14.3*	1.8 (1.4-2.3) *

[1] *$P<0.01$, χ^2-test;

[2] *$P<0.05$, Cox regression analysis, other factors included in the model but not significant at 0.05 level are energy intake, cereal, vegetable/fruit, and legume consumption.

4

Prevalence of Metabolic Syndrome in Chinese Adolescents

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ABSTRACT

Objective: Since national figures on the occurrence of metabolic syndrome among Chinese adolescents are lacking, this study aims to estimate its prevalence and distribution among Chinese youngsters.

Design and subjects: The 2002 China National Nutrition and Health Survey (CNNHS) is a nationally representative cross-sectional study.

Methods: Applying the criteria for US adolescents, we estimated the prevalence of metabolic syndrome among 2761 adolescents aged 15 to 19 years.

Results: The prevalence of the metabolic syndrome among Chinese adolescents overall was 3.7% (10% in US adolescents). It was 35.2%, 23.4% and 2.3% among adolescents who were overweight (BMI ≥95th percentile), at risk of overweight (BMI between 85th and 95th percentile) and normal weight (BMI below the 85th percentile), respectively. Urban boys had the highest rate (5.8%) compared to girls and rural youngsters. Among adolescents who had a BMI ≥85th percentile and one or two parent(s) with the metabolic syndrome, the prevalence was 46.4%. A total of 96% of overweight adolescents had at least one and 74.1% overweight adolescents had at least two abnormalities of the metabolic syndrome. Based on these figures it is estimated that more than three million Chinese adolescents have metabolic syndrome.

Conclusions: Both overweight and metabolic syndrome prevalence among adolescents are still relatively low in China, but the prevalence of metabolic syndrome among Chinese overweight adolescents is similar to those living in the USA.

INTRODUCTION

Metabolic syndrome refers to a clustering of specific cardiovascular disease risk factors.[1] There are several definitions of metabolic syndrome for adults,[2-7] such as the International Diabetes Federation definition,[4] WHO criteria[7] and the Third Report of the National Cholesterol Education Program's Adult Treatment Panel (ATP III) criteria.[2] Pediatric metabolic syndrome has been reported in many populations, but the estimations are difficult to compare because a unanimous definition is lacking.[8-13] Based on the ATP III criteria, Cook et al[14] proposed pediatric metabolic syndrome criteria for US children and adolescents defined as having three or more of the following abnormalities: high TAG level; low HDL-C level; high fasting glucose level; abdominal obesity; hypertension. In 2004, de Ferranti *et al.*[15] developed less restrictive criteria analogous to ATP III. According to de Ferranti's definition, the prevalence of metabolic syndrome among US adolescents was 10%, and nearly 30% among overweight/obese US adolescents.[15]

In China, pediatric overweight and obesity emerged only during the last few decades. Being very low in the 1980's, the overall prevalence of overweight and obesity among children in China were approximately 5% and 2%, respectively, in 2002.[16] Along with the rise of childhood obesity, related metabolic abnormalities began to be routinely observed and reported.[8-13,15] But no national representative data about metabolic syndrome of Chinese adolescent have been published. The purpose of the current study is to estimate the prevalence and distribution of the metabolic syndrome among Chinese adolescents using the national representative survey data of 2002 China National Nutrition and Health Survey.

SUBJECTS AND METHODS

Sampling

The 2002 China National Nutrition and Health Survey is a nationally representative cross-sectional survey that covered 31 provinces, autonomous regions and the municipalities directly affiliated to the central government (Hong Kong, Macao and

Taiwan were not included). Detailed information of the sampling method has been described elsewhere.[17] Briefly, a multi-step cluster sampling method was used for subject selection. A total of 272 023 subjects aged 2-101 years old representative for the Chinese population were surveyed . The sample consisted of 8456 adolescents aged 15-19 years old and one third of the selected families (*n* 2913) were randomly selected to have blood samples drawn.

Among the 2913 adolescents, missing values for height/weight, waist, blood pressure and blood samples accounted for 1.8%, 0.8%, 2.1% and 2.1%, respectively. A total of 2761 adolescents had complete measurements of waist circumference, blood pressure, plasma glucose, TAG, HDL, and were not currently pregnant. Children younger than 15 years were recruited, but did not have waist circumference and blood pressure measurements taken. There was no significant difference in age, weight, height, BMI and sex ratio between adolescents who had complete measurements and those who did not.

Among the 2761 subjects, 2469 adolescents' mothers (response 89.4%) and 2186 adolescents' fathers (response 79.2%) participated in the investigation, 2326 mothers (response 94.2%) and 2064 fathers (response 94.4%) had complete measurements for metabolic syndrome. Of them, 1861 adolescents had full information of both mother and father. There was no significant difference in weight, height and BMI between parents who had complete measurements and those who did not. Parents who completed the measurements were 0.4 year older than those who did not.

Measurements

The fasting body weight, height, waist circumference, and blood pressure of the adolescents and their (biological) parents were measured following standardized procedures by trained interviewers. The waist circumference was measured to the nearest 0.1cm at the midpoint between the bottom of the rib cage and the top of the iliac crest at the end of exhalation.[18] Subjects' seated resting blood pressure was measured twice to the nearest 2 mmHg. The first and fifth Korotkoff sounds were used to represent the systolic and diastolic blood pressure.[18] The mean of these two measurements was recorded.

Fasting blood samples (5ml) of the adolescents and their (biological) parents were collected after approximately 10-14 h overnight fast, drawn into tubes containing heparin as an anticoagulant for preparation of plasma. After the blood was draw, the tubes were gently shaken and then separated by centrifugation at 3200 rpm for 10-15 min. Plasma glucose level was measured with a spectrophotometer within 4 h after a fasting blood sample was obtained. Other plasma samples were moved into airtight storage tubes and stored at -80°C prior to shipment on dry ice to the Chinese Center for Disease Control and Prevention for lipid measurements. Plasma total cholesterol, TAG and HDL-cholesterol were measured enzymatically with a Hitachi 7060, 7180 auto-analyzer (Hitachi, Tokyo, Japan).[18]

The protocol of the survey was approved by the Ethical Committee of the National Institute for Nutrition and Food Safety, Chinese Center for Disease Control and Prevention. Signed consent forms were obtained from both their parents or guardians and the adolescents themselves.

Quality control of physical measurements

Fasting body weight, height and blood pressure were all objectively measured by trained investigators and the duplicate measurements in subgroups showed very high reproducibility (correlation coefficients of duplicate measurements was 0.99 for height and 0.98 for weight). Plasma was separated immediately and all fasting glucose samples were measured within 4 h. Every tenth sample was measured twice (correlation coefficients of duplicate measurements was 0.98), at the same time, one reference sample, one quality control sample and one blind sample were measured before every thirtieth sample[18]. Blind serum samples provided by the US Center for Disease Control were analysed in our lab (China Center for Disease Control) seven times at regular intervals over the course of the analysis of the samples from the 2002 China National Nutrition and Health Survey; the relative difference ranged from -7.02% to 1.60% for TAG, and from -1.05% to 4.21% for HDL-cholesterol.[18]

Definition

Metabolic syndrome was defined using the criteria proposed by de Ferranti *et al.*,[15] as three or more of the following variables and cutoff points: (1) fasting TAG ≥1.1mmol/l

(100mg/dl); (2) HDL-cholesterol boys: <1.2mmol/l (45mg/dl); girls: <1.3mmol/l (50mg/ dl); (3) fasting glucose ≥6.1mmol/l (110mg/dl); (4) waist circumference >75th percentile for age and sex for US adolescents; (5) systolic blood pressure and/or diastolic blood pressure >90th percentile for sex, age and height recommended by the National Heart, Lung, and Blood Institute (USA.).[19] The ATP III criteria[2] were used for the definition of the adults (parents) metabolic syndrome. BMI was calculated as body weight divided by the square of height (kg/m^2), in order to compare with US adolescents, the BMI status was classified by age-, sex- specific BMI standards for US adolescents (<85th, 85th-95th and ≥95th percentile by age and sex).[20]

Statistical analysis

The prevalence of metabolic syndrome was estimated overall, by gender, by region (urban or rural), by BMI and stratified by the presence of parental metabolic syndrome. BMI was estimated using the US historical percentiles that were derived from the NHANES III survey: normal weight: <85th; at risk of overweight: 85th-95th and overweight: ≥95th percentile of US adolescents by age and sex.[20] Prevalence values were compared using χ^2 tests. Sampling weights were applied to national estimates according to the data of the Fifth National Population Census[21]. All statistical analyses were done with the SAS (8.2e for Windows, SAS Institute Inc. Cary, NC, USA), and the significant level was set at 0.05.

RESULTS

Characteristics of adolescents and their parents are shown in Table 1. A total of 2761 adolescents (boys 1478; girls 1283) aged 17.1 ($_{SD}$ 1.5) (15-19) years participated in the investigations. A total of 2326 adolescents' mothers aged 42.7 ($_{SD}$ 4.9) years and 2064 adolescents' fathers aged 44.9 ($_{SD}$ 5.6) years finished all measurements for metabolic syndrome; among them, there were 1861 couples.

Prevalence of metabolic syndrome is shown in Table 2. The overall prevalence of metabolic syndrome in Chinese adolescents aged 15-19 years was 3.7%. Based on population weighting, we have estimated that more than three million Chinese

adolescents have the metabolic syndrome. Metabolic syndrome was present in 35.2% of overweight adolescents (BMI ≥95th percentile) compared with 23.4% of at-risk adolescents (BMI 85th to <95th percentile) and 2.3% of those with a BMI below the 85 percentile (P<0.01). The prevalence of the metabolic syndrome by sex and region is shown in the Fig. 1. Urban boys had the highest rate at 5.8%, whereas their rural counterparts (2.9%) had the lowest rate (*P*<0.01). Urban girls had comparable prevalence as their rural counterparts (3.5% *v.* 3.7%).

Adolescents having parent(s) with metabolic syndrome had a higher rate of metabolic syndrome than their counterparts (10.7% *v.* 3.0%, *P*<0.01; Table 2). The prevalence of metabolic syndrome by adolescents' BMI status and parental metabolic syndrome status is shown in Fig. 2. Among normal weight adolescents, metabolic syndrome prevalence was low whether they had parents with (5.1%) or without (2.1%) metabolic syndrome. Once they developed overweight or were at risk of overweight, the prevalence increased dramatically, especially if their parent(s) had metabolic syndrome. More than 40% (46.4%) of adolescents who had BMI ≥85th percentile and parent(s) with metabolic syndrome met the criteria of metabolic syndrome.

The proportion of subjects with one or more metabolic abnormalities is also shown in Table 1, 96.3% overweight adolescents had at least one and 74.1% had at least two abnormalities of metabolic syndrome. The distribution of each metabolic abnormality is shown in Table 3. Overall, low HDL-cholesterol levels were the most common, whereas high fasting glucose levels and abdominal obesity were the least common abnormality. Central obesity, high fasting glucose, high TAG level and hypertension all significantly worsened with increasing body weight status.

The prevalence of metabolic syndrome of children with a high family income was significantly higher than their counterparts whose family income was low or intermediate. No significant association was found between mother's educational level and the child's metabolic syndrome (Table 2). Family income status was also positively associated with the risk of having four metabolic abnormalities, but the children from poor families were at a significantly higher risk of having at least one metabolic abnormality. Family income status was also positively related to the prevalence of

abdominal obesity and negatively related to HDL-cholesterol level. The prevalence of low HDL-cholesterol level among children whose mother's educational level was low (49.6%) or high (45.8%) was both lower than those whose mother's educational level was medium (54.2%) (Table 3).

DISCUSSION

This is the first study examining the prevalence and distribution of metabolic syndrome among 15- to 19-year-old Chinese adolescents using a national representative sample. Compared with their US counterparts, the prevalence of metabolic syndrome is still low in China (about 10% in the USA *v.* 3.7% in China).[15] The prevalence of metabolic syndrome among overweight adolescents is quite similar in China and in the USA (27.7% *v.* 31.2%). Overweight adolescents who had one, two, three and four items of the metabolic abnormalities are also comparable between Chinese (75.9%, 51.9%, 20.4% and 5.6%) and USA adolescents (88.5%, 56.0%, 28.7% and 5.8%) (both applying the criteria developed by Cook *et al.*).[14]

Comparing the different individual metabolic abnormalities between Chinese and US adolescents,[14,15] the prevalence of abdominal obesity and high TAG levels was lower, while the prevalence of low HDL-cholesterol level and elevated blood pressure was higher among Chinese than US adolescents. The differences may be caused by genetic factors, dietary habits, physical activity patterns or other lifestyle differences that need further research. High levels of HDL-cholesterol have previously been reported in some Chinese populations,[22] more recent data, however, suggested that the lipids profile of Asian populations is changing with a trend toward decreased HDL-cholesterol and increased total cholesterol and LDL-cholesterol, possibly as a result of the changing lifestyles.[23,24] Serum lipid concentrations of various Chinese population samples are now closer to that of Western populations.[25,26] In order to compare with the US adolescents, we used the old cut-point for high glucose level of 110mg/Dl. When the new cut-point of 100mg/dL was applied, 2.8% of Chinese adolescents had a high glucose level.

One limitation of the present study is that the estimation of the metabolic syndrome is

based on a proposed definition for US adolescents using the historical cut-points from the NHANES III due to the lack of a metabolic syndrome definition for Chinese adolescents. Whether the US criteria are applicable for Chinese adolescents is still questionable. As previous studies found a higher body fat percentage at the same BMI among Asian adults, specific overweight (BMI ranging from 24.0 kg/m^2 to 27.9 kg/m^2) and obesity (BMI equal or above 28 kg/m^2) definitions were then developed.[27-29] Using the US upper limits for waist circumference may have underestimated the prevalence, while using the US lower limit for HDL-cholesterol level may have overestimated the prevalence, considering the generally lower adult weight and waist circumference of Chinese compared with US adults. Another limitation of the present study is that we compared the Chinese adolescents aged 15-19 years with US adolescents aged 12-19 years. As similar results were found for older and younger adolescents in the USA,[14,15] our comparison may still be valid.

Strengths of the study were the national representativeness, and the high quality control of physical examination and laboratory analysis.[18] High reproducibility was observed in our duplicate measurements; moreover, there is good agreement between Chinese and American laboratory measurements in TAG and HDL-cholesterol. Evaluating parental history of metabolic syndrome was also a strengthen of the present study.

In conclusion, the prevalence of metabolic syndrome is lower among Chinese than US adolescents. But among overweight subjects, the prevalence of metabolic syndrome is comparable. It is estimated that more than three million Chinese adolescents aged 15 to 19 years have metabolic syndrome and 40% of them have elevated body weight. Of the adolescents having parents with metabolic syndrome, once they are overweight or at risk of overweight, their risk of metabolic syndrome would be much higher. The present findings highlight the need for effective childhood obesity prevention strategies and actions in China, especially among the adolescents having parents with metabolic syndrome.

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REFERENCE

1. Kahn R, Buse J, Ferrannini E, Stern M: The metabolic syndrome: time for a critical appraisal: joint statement from the American Diabetes Association and the European Association for the Study of Diabetes. *Diabetes Care* 2005, 28(9):2289-2304.
2. Executive Summary of The Third Report of The National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, And Treatment of High Blood Cholesterol In Adults (Adult Treatment Panel III). *JAMA* 2001, 285(19):2486-2497.
3. Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, And Treatment of High Blood Cholesterol In Adults (Adult Treatment Panel III) final report. *Circulation* 2002, 106(25):3143-3421.
4. Alberti KG, Zimmet P, Shaw J: The metabolic syndrome--a new worldwide definition. *Lancet* 2005, 366(9491):1059-1062.
5. Balkau B, Charles MA, Drivsholm T, Borch-Johnsen K, Wareham N, Yudkin JS, Morris R, Zavaroni I, van Dam R, Feskins E *et al*: Frequency of the WHO metabolic syndrome in European cohorts, and an alternative definition of an insulin resistance syndrome. *Diabetes Metab* 2002, 28(5):364-376.
6. Einhorn D, Reaven GM, Cobin RH, Ford E, Ganda OP, Handelsman Y, Hellman R, Jellinger PS, Kendall D, Krauss RM *et al*: American College of

Endocrinology position statement on the insulin resistance syndrome. *Endocr Pract* 2003, 9(3):237-252.

7. WHO: Definition, Diagnosis, and Classification of Diabetes Mellitus and its Complications: Report of a WHO Consultation. Geneva: World Health Org; 1999.
8. Chu NF, Rimm EB, Wang DJ, Liou HS, Shieh SM: Clustering of cardiovascular disease risk factors among obese schoolchildren: the Taipei Children Heart Study. *Am J Clin Nutr* 1998, 67(6):1141-1146.
9. Csabi G, Torok K, Jeges S, Molnar D: Presence of metabolic cardiovascular syndrome in obese children. *Eur J Pediatr* 2000, 159(1-2):91-94.
10. Vanhala M, Vanhala P, Kumpusalo E, Halonen P, Takala J: Relation between obesity from childhood to adulthood and the metabolic syndrome: population based study. *BMJ* 1998, 317(7154):319.
11. Vanhala MJ, Vanhala PT, Keinanen-Kiukaanniemi SM, Kumpusalo EA, Takala JK: Relative weight gain and obesity as a child predict metabolic syndrome as an adult. *Int J Obes Relat Metab Disord* 1999, 23(6):656-659.
12. Weiss R, Dziura J, Burgert TS, Tamborlane WV, Taksali SE, Yeckel CW, Allen K, Lopes M, Savoye M, Morrison J *et al*: Obesity and the metabolic syndrome in children and adolescents. *The New England journal of medicine* 2004, 350(23):2362-2374.
13. Yoshinaga M, Tanaka S, Shimago A, Sameshima K, Nishi J, Nomura Y, Kawano Y, Hashiguchi J, Ichiki T, Shimizu S: Metabolic syndrome in overweight and obese Japanese children. *Obes Res* 2005, 13(7):1135-1140.
14. Cook S, Weitzman M, Auinger P, Nguyen M, Dietz WH: Prevalence of a metabolic syndrome phenotype in adolescents: findings from the third National Health and Nutrition Examination Survey, 1988-1994. *Arch Pediatr Adolesc Med* 2003, 157(8):821-827.
15. de Ferranti SD, Gauvreau K, Ludwig DS, Neufeld EJ, Newburger JW, Rifai N: Prevalence of the metabolic syndrome in American adolescents: findings from the Third National Health and Nutrition Examination Survey. *Circulation* 2004, 110(16):2494-2497.

16. Li Y, Chen C, Kong L, Yang X, Zhai F, Zhang J, Ma G: Child obesity in China: prevalence, determinants and its relationship to cardiovascular risk factors. In *Abstracts 18th international congress of nutrition, September 19-23, Nutrition Safari for Innovative solutions 2005; Durban, South Africa*. Medical and Scientific Publishers; 2005.

17 Li Y, Zhai F, Yang X, Schouten EG, Hu X, He Y, Luan D, Ma G. Determinants of childhood overweight and obesity in China. *Br J Nutr* 2007, 97: 210-215.

18 Wang L: *Report of China Nationwide Nutrition and Health Survey 2002 (1): Summary Report.* Beijing: People's Medical Publishing House; 2005.

19. National High Blood Pressure Education Program Working Group on Hypertension Control in Children and Adolescents. Update on the 1987 Task Force Report on High Blood Pressure in Children and Adolescents National High Blood Pressure Education Program. A working group report. *Pediatrics* 1996, 98: 649-658.

20. Centers for Disease Control. CDC growth chart: United States (Database online). Available from http://www.cdc.gov/nchs/data/nhanes/growthcharts/bmiage.txt. (Accessed 20 Jul 2005).

21. National Bureau of Statistics of China: *China Statistic Year Book 2000*. Beijing: China Statistic Press; 2000.

22. Kesteloot H, Huang DX, Yang XS, Claes J, Rosseneu M, Geboers J, Joossens JV: Serum lipids in the People's Republic of China. Comparison of Western and Eastern populations. *Arteriosclerosis* 1985, 5(5):427-433.

23. Chen Z, Peto R, Collins R, MacMahon S, Lu J, Li W: Serum cholesterol concentration and coronary heart disease in population with low cholesterol concentrations. *BMJ* 1991, 303(6797):276-282.

24. Davis CE, Williams DH, Oganov RG, Tao SC, Rywik SL, Stein Y, Little JA: Sex difference in high density lipoprotein cholesterol in six countries. *Am J Epidemiol* 1996, 143(11):1100-1106.

25. Campbell TC, Parpia B, Chen J: Diet, lifestyle, and the etiology of coronary artery disease: the Cornell China study. *Am J Cardiol* 1998, 82(10B):18T-21T.

26. McGladdery SH, Pimstone SN, Clee SM, Bowden JF, Hayden MR, Frohlich JJ: Common mutations in the lipoprotein lipase gene (LPL): effects on HDL-cholesterol levels in a Chinese Canadian population. *Atherosclerosis* 2001, 156(2):401-407.

27. Cooperative Meta-analysis Group of China Obesity Task Force: Predictive value of body mass index and waist circumference to risk factors of related diseases in Chinese adults population. *Zhong Hua Liu Xing Bing Xue Za Zhi* 2002, 23(1):5-10.

28. Group of China Obesity Task Force: Body mass index reference norm for screening overweight and obesity in Chinese children and adolescents. *Zhong Hua Liu Xing Bing Xue Za Zhi* 2004, 25(2):97-102.

29. International Diabetes Institute: *The Asia-Pacific Perspective: Redefining Obesity and its Treatment: WHO Regional Office for the Western Pacific with the international Association for the Study of Obesity and the International Obesity Task Force.* Sydney: Health Communications Austrilia; 2002.

Table 1 Characteristics of adolescents and their parents

(Mean±SD)

	Adolescents	Mother	Father
n	2761	2326	2064
Age (years)	17.1±1.5	42.7±4.9	44.9±5.6
Height (cm)	162.3±8.8	155.9±6.0	166.6±6.4
Weight (kg)	53.2±10.2	57.3±9.7	64.7±11.2
BMI (kg/m^2)	20.1±3.0	23.5±3.4	23.2±3.3

Table 2 Number of Metabolic Syndrome Risk Factors among Chinese Adolescents aged 15-19 years, 2002CNNHS (%)

	No. of Subjects	No. of risk factors			
		≥ 1	≥ 2	≥ 3(**MetS**)	≥ 4
Adolescent Characteristics					
Total	2761	68.5	23.3	**3.7**	0.6
Sex					
Boy	1478	65.0	23.0	**3.4**	0.6
Girl	1283	72.6	23.9	**4.0**	0.5
Region					
Urban	833	60.5	19.2	**4.2**	1.5
Rural	1928	72.0	25.1	**3.5**	0.1
BMI status, percentile					
Normal (<85th)	2613	67.0**	20.6**	**2.3****	0.0
At risk (85th to <95th)	94	81.9	60.6	**23.4**	6.4
Overweight (≥95th)	54	96.3	74.1	**35.2**	18.5
Parent Characteristics					
Mother's MetS status					
No	2218	67.5**	22.5**	**3.3****	0.5**
Yes	108	81.5	37.0	**11.1**	3.7
Father's MetS status					
No	1920	67.6	22.4**	**3.3****	0.5**
Yes	144	72.9	36.1	**11.8**	3.5
Parental MetS status					
No (Both)	1656	67.1**	22.3**	**3.0****	0.4**
Yes (1 or both)	205	76.6	34.6	**10.7**	3.4
Mother's educational level					
Low (illiterate)	255	67.3	23.2	**2.0**	0.0
Middle (Primary or Junior middle school)	1208	69.9	24.7	**4.1**	0.5
High (Senior middle school Or above)	398	64.2	20.5	**4.6**	1.8
Family's economic level (Yuan/Year/Per family member)					
<2000	837	71.8**	25.6	**3.0***	0.4**
2000-10000	860	66.3	22.6	**4.3**	0.6
≥10000	140	60.0	17.9	**7.1**	3.6

Abbreviation: CNNHS: China National Nutrition and Health Survey;
MetS: Metabolic syndrome, with 3 or more risk factors;
χ^2-test of prevalence of metabolic syndrome risk factors between subgroups, $^{*}P<0.05$, $^{**}P<0.01$.

Table 3 Prevalence of Individual Metabolic Syndrome Risk Factors among Chinese Adolescents Aged 15 to 19 Years, 2002 CNNHS (%)

	Abdominal Obesity	High Glucose Level	High TAG Levels	Low HDL-C Level	Elevated BP
Adolescents Characteristics					
Total	3.8	0.8	19.6	53.8	18.2
Sex					
Boy	4.0	0.8	16.2	50.1	21.2
Girl	3.6	0.8	23.7	58.1	14.8
Region					
Urban	7.4	1.0	17.9	42.5	16.9
Rural	2.3	0.7	20.3	58.7	18.7
BMI status, percentile					
Normal (<85th)	1.0**	0.8**	19.1**	52.4	16.6**
At risk (85th to <95th)	43.6	3.2	34.0	55.3	36.2
Overweight (≥95th)	85.2	3.7	42.6	57.4	37.0
Parent Characteristics					
Mother's MetS status					
No	3.8**	0.9**	19.6	52.0	17.5**
Yes	13.9	5.6	25.9	60.2	28.7
Father's MetS status					
No	3.5**	0.9**	19.7*	51.9	17.6**
Yes	13.9	3.5	28.5	52.8	26.4
Parental MetS status					
No (Both)	3.1**	1.0*	19.8**	51.3	17.7**
Yes (1 or both)	13.3	3.0	27.6	55.2	27.1
Mother's educational level					
Low (illiterate)	2.0**	1.2	22.8	49.6**	16.9
Middle (Primary or Junior middle school)	3.4	1.3	20.6	54.2	19.6
High (Senior middle school Or above)	7.9	1.3	19.2	45.8	17.1
Family's economic level (Yuan/Year/Per family member)					
<2000	2.0**	1.0	22.9	57.7**	17.1
2000-10000	5.1	1.4	19.0	47.7	20.7
≥10000	11.4	2.1	17.1	41.4	16.4

Abbreviation: CNNHS: China National Nutrition and Health Survey;
MetS: Metabolic syndrome, with 3 or more risk factors; BMI, body mass index; HDL-C, high-density lipoprotein cholesterol; BP, blood pressure;
χ^2-test of prevalence of individual metabolic syndrome between subgroups, $^{*}P<0.05$, $^{**}P<0.01$.

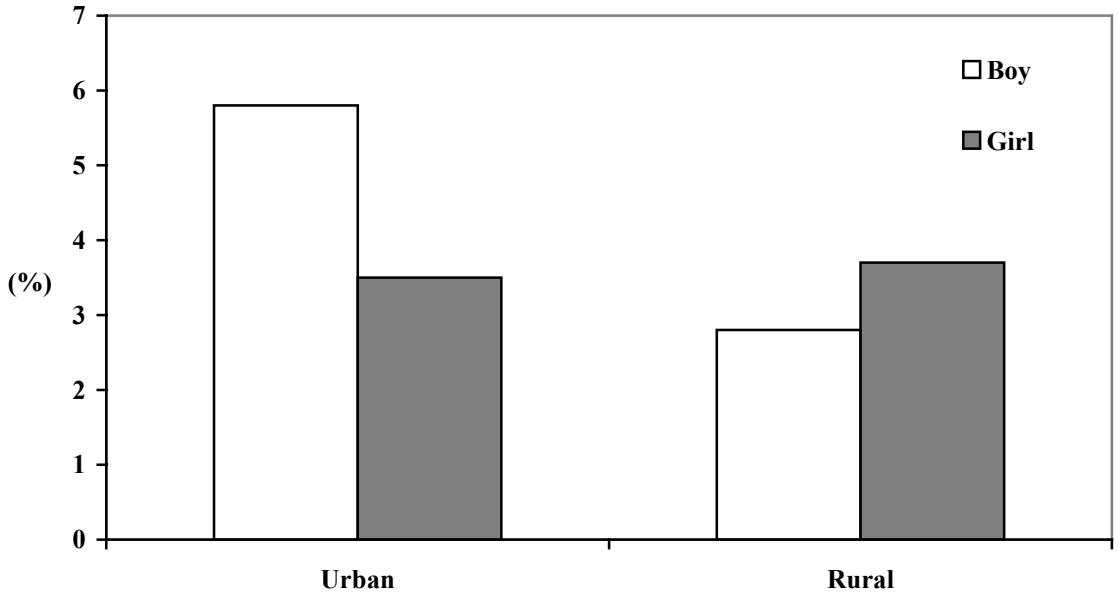

Figure 1 Prevalence of the Metabolic Syndrome by Sex and Area

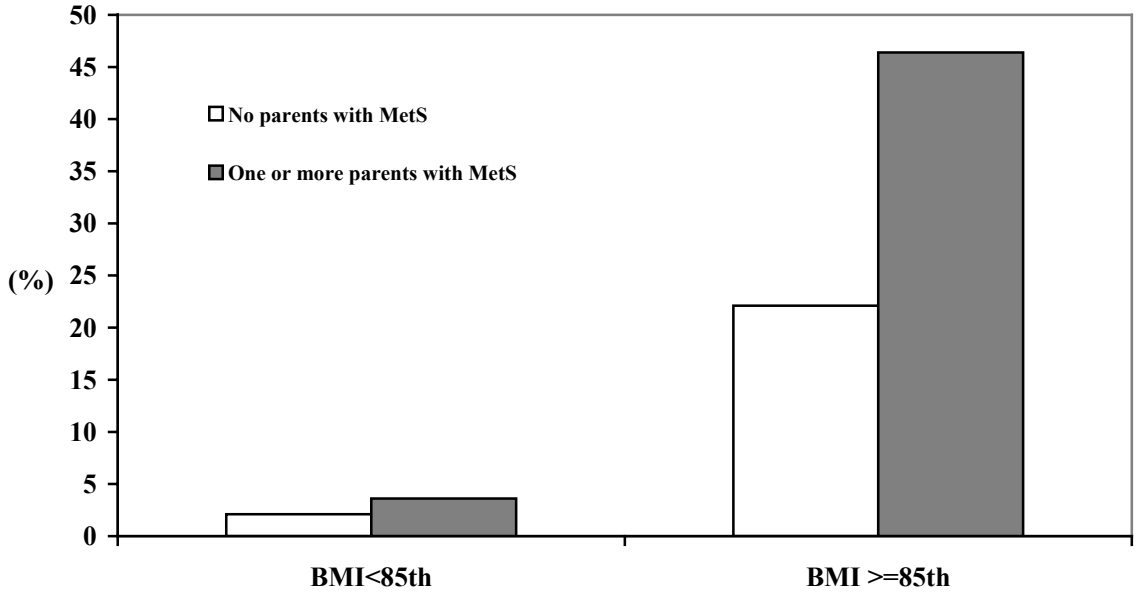

Figure 2 Prevalence of Adolescent's Metabolic Syndrome by their BMI Status and Parental MetS Status

5

Body Weight, Body Dissatisfaction and Depression Symptoms of Chinese Children aged 9-10 years

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ABSTRACT

Objective: To investigate the relationship between body weight, body dissatisfaction and depression symptoms among Chinese children.

Methods: The fasting body weight and height of third and fourth grade students (*n* 3886, aged 9 or 10 y) from 20 schools in Beijing, China, were measured, and the students were asked to choose the figures of body image and to complete the self-reported children's depression inventory (CDI) questionnaire.

Results: The CDI Cronbach's alpha was 0.81. The total CDI score was 9.60±7.50, 13.2% of children (boys 16.7% *v.* girls 9.5%) were at risk of depression symptoms. Overweight girls, but not boys, had significantly higher total CDI score than their normal weight counterparts. Both obese girls and obese boys showed a higher negative self-esteem scores. More than one fifth underweight girls still wanted to be thinner while more than one third obese boys still wanted to be heavier. Children who wanted to be thinner showed slightly higher scores of ineffectiveness and negative self-esteem. After introducing the body dissatisfaction into the model, overweight was still associated with total CDI score among girls and obesity was still associated with negative self-esteem among both boys and girls.

Conclusion: Overweight girls show significantly higher depression symptom score than their normal weight counterparts, which maybe partially explained by body dissatisfaction. Obese boys and girls are both more likely to suffer from low self-esteem, which is partially explained by body dissatisfaction.

INTRODUCTION

It is commonly believed that overweight children are unhappy with their weight and experience more psychosocial distress, particularly depressive symptoms.[1,2] BMI is related to body dissatisfaction in children, particularly in girls. Body dissatisfaction is higher in overweight and obese children and adolescents than in their normal-weight counterparts.[3,4] Researches have shown that adult women and female adolescents have a connection between depression and body weight.[5-8] Among a clinical sample of obese children and adolescents, 50 percent of subjects are classified as depressed,[8] Erermis *et al.*[9] reported that obese group has a slightly higher score. Rierdan and Koff[10] reported that it was weight-related body image and perception of body weight rather than the objective BMI or actual weight categories that significantly predict depressive symptoms. The relationship between depression symptoms and BMI in preadolescent girls seems to be explained by an excess of overweight concerns.[1] It is hypothesised that body image or weight perception might have a mediating effect on the relationship between actual body weight and depressive psychological symptoms.

Higher body dissatisfaction has also been found among overweight and obese girls and boys in China.[11] Among Chinese adolescent girls, high BMI is significantly related to higher self-reported depression symptoms.[12] Perceived overweight adolescent boys and girls are more likely to experience depression than their normal weight and underweight counterparts.[13] But there is limited information on the relationship between body weight and depression, as well as between body dissatisfaction and depression among younger children in China.

This study focused on the following aspects in a large population-based sample of nine and ten year old girls and boys living in Beijing, China:

Whether body weight is associated with depression symptoms;

Whether body weight is associated with body dissatisfaction;

Whether body dissatisfaction is associated with depression;

Whether body dissatisfaction could account for a relationship between body weight and depression symptoms.

SUBJECTS AND METHODS

Subjects

The study population was a representative sample of 9 and 10 years old students in 2005 of the third and fourth grade from 20 schools in urban Beijing, China. Parents were informed of the study in writing and given the opportunity to refuse their children's participation. Children could refuse participation at any time. The study obtained a response from 96% of the selected student population. Approximately 2% of these responses were excluded because of missing or invalid information. Classroom surveys and physical measures were completed during regular school days by trained investigators.

The Human Investigations Review Committees at the National Institute for Nutrition and Food Safety, Chinese Center for Disease Control and Prevention, provided ethical approval. Written informed consent was obtained from all parents and subjects before the start of the study.

Measures

Body Weight Status

Fasting body weight was measured in the morning using a digital electronic scale (Seca, model 890, Hamburg) to the nearest 0.1kg with the subject only wearing underwear. Height was measured to the nearest 0.1 cm using a standard steel strip stadiometer in bare footed subjects.

Overweight was defined using age- and sex- specific BMI cut-off points developed by the Working Group for Obesity in China (WGOC), as body mass index (BMI) for age- and sex- between 85th and 95th percentile, whereas obesity was defined as BMI at the 95th percentile or higher, underweight was defined as BMI at 5th percentile or lower.[14]

Body Dissatisfaction

Body image was assessed by the Ma silhouette,[11] which was developed from Collins silhouette[15] and adapted to the Chinese situation. There were two arrays of pictures for children, boys or girls, respectively. Each array had seven black-white line-drawn silhouettes ranging from very thin to very fat.[11] Subjects were asked to select one picture

that fits best with each of the following statements: (1) “looks most like YOU” (for current own body image), (2) “you would most want to look like” (for ideal body image). A higher score indicates a larger body image.

Subtracting the ideal body image from the current body image yields the body dissatisfaction (BD) rating. The BD rating ranges from –6 to 6. BD = 0 means no discrepancy between the current and ideal body image. A mismatch of one position was described as body dissatisfaction (BD≥1 or BD≤-1). A BD rating of >0 indicated that the boy/girl’s current body image was bigger than his/her ideal body image (want to be thinner), while a BD rating of <0 indicated that the boy/girl’s current body image was smaller than his/her ideal body image (want to be heavier)

Depression Symptoms

The Children’s Depression Inventory (CDI) developed by Kovacs[16] has been used most often to measure depression symptoms among normal children, which was designed to survey cognitive, effective, and behavior manifestations of depression in children and adolescents. It contains 27-item self-rating scales ranging from 0 to 2 that yield total scores from 0 to 54, where a higher score reflects greater symptomatology. Kovacs[16] has specified a 19-point cutoff as the ideal threshold discriminating children at risk of depression from non-depressed children. The CDI has shown good test-retest reliability, internal consistency, and construct validity.[17] The validity and reliability of the Chinese version are sufficient.[18]

The CDI factors are labeled as negative mood, interpersonal problems, ineffectiveness, andedonia, and negative self-esteem, the definitions of the CDI self-report factor scales are listed in the CDI manual,[16] where ineffectiveness reflects negative evaluation of one’s ability and school performance, and negative self-esteem reflects low self-esteem, self-dislike, feeling of being unloved, and a tendency to have thoughts of suicide.

Total score was the overall depressive symptomatology across the five factor scales.

Statistical analysis

Bivariate Analyses

As recommended by Matthey and Petrovski[19] that the CDI is better suited as a continuous measure of mood but not the cutoff scores which should not be used to screen for the likely presence or absence of depression. We compared the total CDI score and five factor scores among underweight, normal weight, overweight and obese children, as well as among the children who was or not satisfied with their body image, by analysis of variance (ANOVA) with the Tukey post-hoc comparisons. The proportion of body dissatisfaction was described by gender and by BMI status.

Multivariate analyses

Multivariate tests of the effect of underweight, overweight and obesity on the total CDI score and factor scores were conducted. The data were then analyzed while the body dissatisfaction status was further controlled.

Hierarchical linear model of SAS PROC MIXED was used to examine the outcomes as a function of both student level characteristics and school level predictors.

RESULTS

The CDI Cronbach's alpha was 0.81 in the current study, while internal consistency reliability estimates for the 5 subscales of the CDI were 0.75, 0.48, 0.71, 0.81 and 0.75 for negative mood, interpersonal problem, ineffectiveness, andedonia and negative self-esteem, respectively.

A total of 3886 students were selected from grade three and four of 20 primary schools in urban Beijing in the summer of 2005. The characteristics of the students are shown in Table 1. No significant difference was found in age, parent's BMI status, parent's educational level and family economic level between boys and girls. Significantly more boys were classified as overweight or obese than girls. The total CDI score of boys were 10.8±7.9, which was significantly higher than that of girls. Totally, 13.2% of children (boys 16.7% vs girls 9.5%, $P<0.05$) were at risk of developing depression symptoms (CDI≥19).

Bivariate analysis

Overweight girls had significantly higher total CDI score, but the absolute difference was small. Overweight and obese girls also showed a significantly higher level of

ineffectiveness score than underweight girls. Both obese boys and girls showed a significantly higher negative self-esteem score than their normal weight counterparts (Table 2).

One third children wanted to be thinner and one third wanted to be heavier. After stratified by BMI status, more underweight boys wanted to be heavier than underweight girls, while relatively more obese girls wanted to be thinner than obese boys (Table 3). More than one fifth underweight girls still wanted to be thinner while more than one third obese boys still wanted to be heavier (Table 3).

Boys who wanted to be thinner showed significantly higher scores of ineffectiveness and negative self-esteem than those who wanted to keep their current body image. Girls who wanted to be heavier and thinner showed a significantly higher total CDI score and a higher score of the four factor including negative mood, ineffectiveness, andedonia, and negative self-esteem (Table 4).

Multivariate analyses

Among girls, the estimated Z value of school and residual was 1.72 (P=0.04) and 30.63, respectively. These estimates suggested that schools differed in their average total CDI score and there were even more variations among students within schools. Similar results were found after body dissatisfaction was introduced into the models.

The overweight girls still showed a significantly higher CDI score after the body dissatisfaction was introduced into the model, but the estimated value was a little less (Table 5). Overweight and obese girls all showed a significantly higher negative self-esteem score (Table 5).

Only negative self-esteem score was significantly higher in obese boys, which was still significant after the body dissatisfaction was introduced into the model (Table 5).

DISCUSSION

This study suggested that boys living in urban Beijing had a higher CDI score than girls, and more boys were at risk of developing depression symptoms. Overweight girls showed significantly higher depression symptom score than their normal weight counterparts,

which maybe partially explained by body dissatisfaction. Both obese boys and girls were more likely to suffer from low self-esteem, which could be partially explained by body dissatisfaction.

Depression is one of the most psychological problems in adolescents[20] and the rates of depression have been increasing over the last several decades.[21,22] As reported by Scheidt *et al.*[23] 49% of adolescent girls and 34% of adolescent boys showed weak depression symptoms, while 29% USA youth[24] and 35%-50% Mexican-American youths[25] have depression symptoms. The CDI has been used most often to measure depressive symptoms among normal children. The prevalence of depressive risk in our sample was 13.2% when the cutoff point of 19 was used as the threshold. This figure is in line with other epidemiologic studies that reported prevalence rates of depressive risk ranging from 5~20% using self-report CDI.[26-31]

Overweight children display more psychosocial problems though the extent of these problems is usually small. In our sample, overweight was associated with mildly increased depression symptoms among girls. Previous studies showed that adult women and female adolescents have a connection between depression and body weight in western countries[5-8] and China.[12] Our results indicate that in younger Beijing girls, body weight is also associated with depression symptoms. We also found a higher body dissatisfaction among overweight and obese Beijing children.

Theoretically, elevated body mass results in body dissatisfaction because overweight is not currently considered socially desirable,[32] and body dissatisfaction may in turn increase the chance of depression.[5,10,33] So body dissatisfaction is thought to be related with body mass and depression. Cognitive aspects of body-image disturbance, rather than actual body dimensions, may play a more important role in the etiology of depression.[1,32] However, in our sample, both overweight and body dissatisfaction were associated with depression symptoms, the relationship between body weight and depression symptoms could only partially explained by body dissatisfaction. It might also be the case that non-weight-related aspects of body dissatisfaction, as well as other characteristics related with body weight, are also very important in promoting depression.

This is the first study in Chinese younger children to explore the relationship between body

weight, body dissatisfaction and depression symptoms in China. The results indicate that body weight-related body dissatisfaction and depression symptoms occur in younger children, which should be considered in the future pediatric weight management programs in China. The international childhood depression measurement of CDI used in our study could also provided the chance to compare the results with other studies. The Chinese version CDI was translated from English and vice verse for construct validity and had shown higher validity and reliability in Chinese children.[18] The Cronbach's coefficient alpha estimate was 0.85 and split half reliability was 0.83 of the Chinese version CDI,[18] no less than the English versions.[16,25] In the current sample, the Cronbach's coefficient alpha estimates were 0.81 for total score and 0.48-0.81 for subscales.

One limitation of the present study is that the results are based on cross-sectional observations. Therefore, whether the associations represent cause or consequence of childhood overweight remains unknown. Another limitation is that we did not include information on body weight teasing and eating behavior, as teasing from family, peers and teachers may account for the relationship between body weight, body dissatisfaction and depression.[34-37] Children's diet and physical activity patterns may be related to body weight and depression,[38-41] but they were not included in current analyses. Further analyses of our project should focus on the association of diet and physical activity patterns with depression, and the intervention effect of diet and physical activity on the improvement of depression symptoms in younger children living in Beijing.

There is evidence that even moderate levels of depression have a negative impact on children and are associated with significant impairment in school and peer functioning in children.[42,43] Gotlib *et al.*[44] found that adolescents with a high score on depression questionnaires, but do not meet diagnostic criteria for depression have as much psychosocial dysfunction as those who meet diagnostic criteria for depression. So the expert panels recommend a multidisciplinary approach to pediatric weight management programs, including psychosocial factors in the assessment and therapeutic programs.[45,46] Some body weight intervention programs focusing a healthy lifestyle do result in positive psychological improvement.[38,40,47] We are currently implementing a school-based and parents involved obesity intervention program focusing on physical activity in Beijing. The improvement of depression and anxiety symptoms will be evaluated after 1 year

intervention.

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REFERENCES

1. Erickson SJ, Robinson TN, Haydel KF, Killen JD: Are overweight children unhappy?: Body mass index, depressive symptoms, and overweight concerns in elementary school children. *Arch Pediatr Adolesc Med* 2000, 154(9):931-935.
2. Wadden TA, Stunkard AJ: Psychopathology and obesity. *Ann N Y Acad Sci* 1987, 499:55-65.
3. Ricciardelli LA, McCabe MP: Children's body image concerns and eating disturbance: a review of the literature. *Clin Psychol Rev* 2001, 21(3):325-344.
4. Wardle J, Cooke L: The impact of obesity on psychological well-being. *Best Pract Res Clin Endocrinol Metab* 2005, 19(3):421-440.
5. Allgood-Merten B, Lewinsohn PM, Hops H: Sex differences and adolescent depression. *J Abnorm Psychol* 1990, 99(1):55-63.
6. Palinkas LA, Wingard DL, Barrett-Connor E: Depressive symptoms in overweight and obese older adults: a test of the "jolly fat" hypothesis. *J Psychosom Res* 1996, 40(1):59-66.
7. Rose JB, Theroux MC, Katz MS: The potency of succinylcholine in obese adolescents. *Anesth Analg* 2000, 90(3):576-578.
8. Sheslow D, Hassink S, Wallace W, DeLancey E: The relationship between self-esteem and depression in obese children. *Ann N Y Acad Sci* 1993, 699:289-291.
9. Erermis S, Cetin N, Tamar M, Bukusoglu N, Akdeniz F, Goksen D: Is obesity a risk factor for psychopathology among adolescents? *Pediatr Int* 2004, 46(3):296-301.

10. Rierdan J, Koff E: Weight, weight-related aspects of body image, and depression in early adolescent girls. *Adolescence* 1997, 32(127):615-624.
11. Li Y, Hu X, Ma W, Wu J, Ma G: Body image perceptions among Chinese children and adolescents. *Body Image* 2005, 2:91-103.
12. Xie B, Chou CP, Spruijt-Metz D, Liu C, Xia J, Gong J, Li Y, Johnson CA: Effects of perceived peer isolation and social support availability on the relationship between body mass index and depressive symptoms. *Int J Obes (Lond)* 2005, 29(9):1137-1143.
13. Xie B, Liu C, Chou CP, Xia J, Spruijt-Metz D, Gong J, Li Y, Wang H, Johnson CA: Weight perception and psychological factors in Chinese adolescents. *J Adolesc Health* 2003, 33(3):202-210.
14. Group of China Obesity Task Force: Body mass index reference norm for screening overweight and obesity in Chinese children and adolescents. *Zhong Hua Liu Xing Bing Xue Za Zhi* 2004, 25(2):97-102.
15. Collins M: Body figure perceptions and preferences among preadolescent children. *International Journal of Eating Disorders* 1991, 10:199-208.
16. Kovacs M: *Children's Depression Intentory*. North Tonawanda, NY.: Multi-Health System; 1992.
17. Sitarenios G, Kovaxs M: *Use of the Children's Depression Inventory*. 2nd edition: Mahwah, NJ:Erlbaum; 1999.
18. Xie D, Li X: Preliminary use of the children's depression inventory in China. *Zhong Guo Xin Li Wei heng Za Zhi* 2000, 14(4):225-227.
19. Matthey S, Petrovski P: The Children's Depression Inventory: error in cutoff scores for screening purposes. *Psychol Assess* 2002, 14(2):146-149.
20. Lewinsohn PM, Hops H, Roberts RE, Seeley JR, Andrews JA: Adolescent psychopathology: I. Prevalence and incidence of depression and other DSM-III-R disorders in high school students. *J Abnorm Psychol* 1993, 102(1):133-144.
21. Reinherz HZ, Giaconia RM, Hauf AM, Wasserman MS, Silverman AB: Major depression in the transition to adulthood: risks and impairments. *J Abnorm Psychol* 1999, 108(3):500-510.
22. Stice E, Bearman SK: Body-image and eating disturbances prospectively predict

increases in depressive symptoms in adolescent girls: a growth curve analysis. *Dev Psychol* 2001, 37(5):597-607.

23. Scheidt P, Overpeek MD, Wyatt W, Aszmann A: *Adolescents general health and wellbeing.* Copenhagen: World Health Organization; 2000.
24. Daniels J: Weight and weight concerns: are they associated with reported depressive symptoms in adolescents? *J Pediatr Health Care* 2005, 19(1):33-41.
25. Roberts RE, Chen YW: Depressive symptoms and suicidal ideation among Mexican-origin and Anglo adolescents. *J Am Acad Child Adolesc Psychiatry* 1995, 34(1):81-90.
26. Almqvist F, Kumpulainen K, Ikaheimo K, Linna SL, Henttonen I, Huikko E, Tuompo-Johansson E, Aronen E, Puura K, Piha J *et al*: Behavioural and emotional symptoms in 8-9-year-old children. *Eur Child Adolesc Psychiatry* 1999, 8 Suppl 4:7-16.
27. Canals J, Marti-Henneberg C, Fernandez-Ballart J, Domenech E: A longitudinal study of depression in an urban Spanish pubertal population. *Eur Child Adolesc Psychiatry* 1995, 4(2):102-111.
28. Charman T, Pervova I: Self-reported depressed mood in Russian and U.K. schoolchildren. A research note. *J Child Psychol Psychiatry* 1996, 37(7):879-883.
29. Davanzo P, Kerwin L, Nikore V, Esparza C, Forness S, Murrelle L: Spanish translation and reliability testing of the Child Depression Inventory. *Child Psychiatry Hum Dev* 2004, 35(1):75-92.
30. Frigerio A, Pesenti S, Molteni M, Snider J, Battaglia M: Depressive symptoms as measured by the CDI in a population of northern Italian children. *Eur Psychiatry* 2001, 16(1):33-37.
31. Swallen KC, Reither EN, Haas SA, Meier AM: Overweight, obesity, and health-related quality of life among adolescents: the National Longitudinal Study of Adolescent Health. *Pediatrics* 2005, 115(2):340-347.
32. Stice E, Hayward C, Cameron RP, Killen JD, Taylor CB: Body-image and eating disturbances predict onset of depression among female adolescents: a longitudinal study. *J Abnorm Psychol* 2000, 109(3):438-444.
33. Cole DA, Martin JM, Peeke LG, Seroczynski AD, Hoffman K: Are cognitive errors

of underestimation predictive or reflective of depressive symptoms in children: a longitudinal study. *J Abnorm Psychol* 1998, 107(3):481-496.

34. Halvarsson K, Lunner K, Sjoden PO: Assessment of eating behaviours and attitudes to eating, dieting and body image in pre-adolescent Swedish girls: a one-year follow-up. *Acta Paediatr* 2000, 89(8):996-1000.
35. Lunner K, Werthem EH, Thompson JK, Paxton SJ, McDonald F, Halvaarson KS: A cross-cultural examination of weight-related teasing, body image, and eating disturbance in Swedish and Australian samples. *Int J Eat Disord* 2000, 28(4):430-435.
36. Strauss RS, Pollack HA: Social marginalization of overweight children. *Arch Pediatr Adolesc Med* 2003, 157(8):746-752.
37. van den Berg P, Wertheim EH, Thompson JK, Paxton SJ: Development of body image, eating disturbance, and general psychological functioning in adolescent females: a replication using covariance structure modeling in an Australian sample. *Int J Eat Disord* 2002, 32(1):46-51.
38. Braet C, Tanghe A, Bode PD, Franckx H, Winckel MV: Inpatient treatment of obese children: a multicomponent programme without stringent calorie restriction. *Eur J Pediatr* 2003, 162(6):391-396.
39. Goran MI, Reynolds K: Interactive multimedia for promoting physical activity (IMPACT) in children. *Obes Res* 2005, 13(4):762-771.
40. Sacher PM, Chadwick P, Wells JC, Williams JE, Cole TJ, Lawson MS: Assessing the acceptability and feasibility of the MEND Programme in a small group of obese 7-11-year-old children. *J Hum Nutr Diet* 2005, 18(1):3-5.
41. Strauss RS, Rodzilsky D, Burack G, Colin M: Psychosocial correlates of physical activity in healthy children. *Arch Pediatr Adolesc Med* 2001, 155(8):897-902.
42. Nolen-Hoeksema S, Girgus JS, Seligman ME: Predictors and consequences of childhood depressive symptoms: a 5-year longitudinal study. *J Abnorm Psychol* 1992, 101(3):405-422.
43. Twenge JM, Nolen-Hoeksema S: Age, gender, race, socioeconomic status, and birth cohort differences on the children's depression inventory: a meta-analysis. *J Abnorm Psychol* 2002, 111(4):578-588.

44. Gotlib IH, Lewinsohn PM, Seeley JR: Symptoms versus a diagnosis of depression: differences in psychosocial functioning. *J Consult Clin Psychol* 1995, 63(1):90-100.

45. Barlow SE, Dietz WH: Obesity evaluation and treatment: expert committee recommendations. *Pediatrics* 1998, 102:1-11.

46. Hill AJ, Draper E, Stack J: A weight on children's minds: body shape dissatisfactions at 9-years old. *Int J Obes Relat Metab Disord* 1994, 18(6):383-389.

47. Walker LL, Gately PJ, Bewick BM, Hill AJ: Children's weight-loss camps: psychological benefit or jeopardy? *Int J Obes Relat Metab Disord* 2003, 27(6):748-754.

Table 1 Subjects Characteristics (%)

	Boys	Girls	All
Total (N)	1987	1899	3886
Age (years)			
9	47.2	46.7	46.9
10	52.8	53.3	53.1
BMI status[1,*]			
Underweight	4.4	5.0	4.7
Normal Weight	61.1	74.8	67.8
Overweight	16.9	10.4	13.7
Obesity	17.6	9.8	13.8
Mother's BMI status[2]			
Underweight	6.4	6.4	6.4
Normal Weight	69.3	67.0	68.1
Overweight	19.8	20.8	20.3
Obesity	4.5	5.8	5.2
Father's BMI status[2]			
Underweight	2.3	2.3	2.3
Normal Weight	43.6	44.2	43.9
Overweight	49.3	48.9	49.1
Obesity	4.8	4.6	4.7
Mother's educational level[3]			
Low	18.9	17.3	18.1
Middle	33.8	35.6	34.7
High	47.3	47.1	47.2
Father's educational level[3]			
Low	17.8	15.6	16.7
Middle	37.0	37.5	37.2
High	45.2	46.9	46.1
Family's income[4]			
Low	28.4	29.7	29.0
Middle	57.2	53.4	55.3
High	14.4	16.9	15.7
Children's Depression Inventory Score (CDI, M±SD)	10.8±7.9	8.3±6.8	9.6±7.5
Depression (CDI≥19)	16.7	9.5	13.2

[1]Defined according to the Chinese reference developed by the Working Group for Obesity in China (WGOC), overweight: BMI between 85th and 95th percentile, obesity: BMI≥ 95th percentile, underweight: BMI≤5th percentile, significantly difference between boys and girls, χ^2-test, $P<0.05$;

[2]Body weight of parents, underweight: BMI<18.5; overweight: BMI between 24 and 25; obesity: BMI≥28;

[3]Educational level: Low, lower than junior middle school; Middle, high middle school; High, college/university or above;

[4]Family's income: Low, <2000Yuan/Month; Middle, 2000-6000Yuan/Month; High≥6000Yuan/Month.

Table 2 Children's depression inventory score according to their BMI status
(Mean±SD)

BMI status	Children's Depression Inventory Score					
	Total	Negative Mood	Interpersonal Problem	In-effective	Endogenous Depression	Negative Self-Esteem
Boys						
Underweight	12.0±8.9	2.8±2.5	1.5±1.6	2.1±1.8	3.5±3.3	2.1±2.1[a,b]
Normal Weight	10.7±7.9	2.4±2.2	1.6±1.4	1.8±1.8	3.0±2.9	1.9±1.9[b]
Overweight	10.3±7.8	2.3±2.2	1.6±1.4	1.7±1.8	2.7±2.7	1.9±1.8[a,b]
Obesity	11.3±7.4	2.6±2.2	1.7±1.4	1.9±1.8	2.9±2.6	2.2±1.8[a]
Girls						
Underweight	7.0±5.1[b]	1.6±1.6	1.1±0.9	0.8±1.2[b]	2.3±2.0	1.2±1.5[c]
Normal Weight	8.2±6.7[a,b]	1.9±2.0	1.2±1.0	1.1±1.4[a,b]	2.4±2.6	1.5±1.7[bc]
Overweight	9.4±7.3[a]	2.3±2.1	1.3±1.1	1.3±1.6[a]	2.6±2.8	1.8±1.8[ab]
Obesity	8.7±7.5[a,b]	1.8±2.1	1.3±1.1	1.2±1.5[a,b]	2.4±2.8	2.0±1.9[a]

[a,b,c]One-way ANOVA performed with Tukey post-hoc analysis to compare the effects of BMI status and body dissatisfaction on depression symptoms, [a,b,c] Values not sharing the same superscript denote significant difference.

Table 3 Distribution of body dissatisfaction according to BMI status

BMI status	Body Dissatisfaction (*n*, %)				
	≤-3	-2 or -1	0	1 or 2	≥3
Boys					
Underweight	39 (44.8)	22 (25.3)	17 (19.5)	6 (6.9)	3 (3.5)
Normal Weight	280 (23.1)	143 (11.8)	506 (41.7)	108 (8.9)	176 (14.5)
Overweight	19 (5.7)	62 (18.5)	63 (18.8)	78 (23.2)	114 (33.8)
Obesity	49 (14.0)	64 (18.2)	34 (9.7)	143 (40.7)	61 (17.4)
Total	387 (19.5)	291 (14.7)	620 (31.2)	335 (16.9)	354 (17.7)
Girls					
Underweight	7 (7.5)	38 (40.4)	29 (30.9)	11 (11.7)	9 (9.5)
Normal Weight	225 (15.9)	266 (18.7)	463 (32.6)	320 (22.5)	146 (10.3)
Overweight	37 (18.7)	23 (11.6)	19 (9.6)	84 (42.4)	35 (17.7)
Obesity	20 (10.7)	23 (12.3)	5 (2.7)	94 (50.3)	45 (24.1)
Total	289 (15.2)	350 (18.4)	516 (27.2)	509 (26.8)	235 (12.4)

Body dissatisfaction (BD) = current body image - ideal body image. A BD rating of >0 indicated that the boy/girl's current body image was bigger than his/her ideal body image (want to be thinner), while a BD rating of <0 indicated that the boy/girl's current body image was smaller than his/her ideal body image (want to be heavier).

Table 4 Children's depression inventory score according to their body dissatisfaction status (Mean±SD)

BD status	Children's Depression Inventory Score					
	Total	Negative Mood	Interpersonal Problem	In-effective	Endogenous Depression	Negative Self-Esteem
Boys						
Want to be heavier	10.6±7.8	2.4±2.2	1.6±1.4	1.8±1.7[ab]	2.9±2.8	1.9±1.8 [ab]
Keep same	10.4±8.0	2.3±2.3	1.7±1.4	1.7±1.8[b]	2.9±2.9	1.8±1.8[b]
Want to be thinner	11.3±7.8	2.5±2.2	1.7±1.4	1.9±1.8[a]	3.1±2.8	2.2±2.0[a]
Girls						
Want to be heavier	8.7±7.2[a]	2.1±2.1[a]	1.2±1.1	1.2±1.5[ab]	2.5±2.7[a]	1.6±1.7[a]
Keep same	7.3±6.3[b]	1.6±1.9[b]	1.2±0.9	1.0±1.4[b]	2.1±2.4[b]	1.3±1.6[b]
Want to be thinner	8.6±6.7[a]	2.0±2.0[a]	1.2±1.0	1.2±1.5[a]	2.5±2.6[a]	1.7±1.7[a]

[a,b,c]One-way ANOVA performed with Tukey post-hoc analysis to compare the effects of BMI status and body dissatisfaction on depression symptoms, [a,b,c] Values not sharing the same superscript denote significant difference.

Table 5 Hierarchical linear analysis of the effect of BMI status on children's depression symptoms with or without introducing body dissatisfaction

	Total CDI score		Negative self-esteem score	
	Estimate	Standard Error	Estimate	Standard Error
Girls				
Model 1				
Underweight	-1.2	0.7	-0.3	0.2
Overweight	1.3*	0.5	0.3*	0.1
Obese	0.6	0.5	0.4*	0.1
BMI status effect	F(3,56)=3.59 *P*=0.02		F(3,56)=6.79 *P*=0.01	
Model 2				
Underweight	-1.2	0.7	-0.3	0.2
Overweight	1.1*	0.5	0.3	0.1
Obese	0.3	0.5	0.4*	0.1
Want to be heavier	1.2*	0.4	0.3*	0.1
Want to be thinner	1.0*	0.4	0.3*	0.1
BMI status effect	F(3,56)=2.65 *P*=0.06		F(3,56)=4.73 *P*=0.01	
Body dissatisfaction effect	F(2,38)=5.19 *P*=0.01		F(2,38)=4.13 *P*=0.02	
Boys				
Model 1				
Underweight	1.1	0.9	0.2	0.2
Overweight	-0.4	0.5	0.0	0.1
Obese	0.6	0.5	0.3*	0.1
BMI status effect	F(3,56)=1.46 *P*=0.24		F(3,56)=3.35 *P*=0.03	
Model 2				
Underweight	1.2	0.9	0.2	0.2
Overweight	-0.7	0.5	0.0	0.1
Obese	0.3	0.5	0.2*	0.1
Want to be heavier	0.0	0.5	0.1	0.1
Want to be thinner	1.0	0.5	0.3*	0.1
BMI status effect	F(3,56)=1.69 *P*=0.18		F(3,56)=2.20 *P*=0.10	
Body dissatisfaction effect	F(2,38)=2.77 *P*=0.08		F(2,38)=4.00 *P*=0.03	

Hierarchical linear model of SAS PROC MIXED was applied, *$P<0.05$

6

General Discussion

This thesis addresses childhood obesity in China, with regard to the prevalence, determinants and related health risks. The study was conducted as part of the 2002 China National Nutrition and Health Survey (CNNHS), conducted to describe the nutrition status, prevalence of selected diseases and associated risk factors. The psychological status of Chinese children and its relationship with childhood obesity was investigated in 9 and 10 years children in urban Beijing, China.

In the present chapter, we first give an overview of the main findings, followed by a discussion of the internal validity and external validity. After that, we discuss the interpretation of the associations, and continue with the implications and recommendations for future research.

MAIN FINDINGS

The prevalence of overweight and obesity of Chinese children and adolescents was low in 1982. There has been a rapid increase since then, especially in large cities. If this trend continues, overweight will soon reach the epidemic propositions. As defined by IOTF criteria, the overweight prevalence of Chinese youngsters in 2002 was 4.4% while the obesity prevalence was 0.9% The estimated total number of overweight youngsters was 12 million, which means that one in thirteen overweight children worldwide was living in China. (**Chapter 2**)

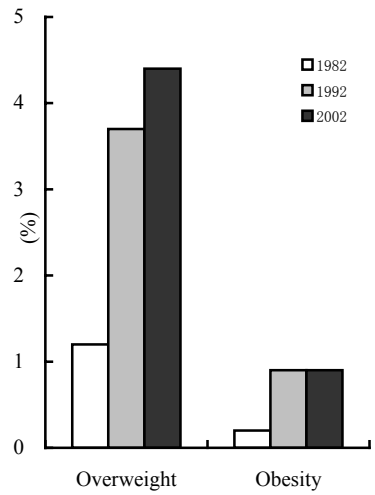
Both the overweight and obesity prevalence and their increment were higher in urban than in rural areas and higher in boys than in girls. The prevalence increased with the family's income level and the mother's educational level **(Chapter 2)**. Compared with children with normal weight parents, the prevalence increased if one or both parent(s) were overweight or obese, up to a ratio of 12.2 in case both parents were obese. Compared to their normal weight counterparts, overweight children consumed significantly more dietary energy, protein and fat, but less carbohydrate; more cooking oil, meat and meat products, and dairy products, but less cereal grains and vegetables.

On average, overweight children spent half an hour less on moderate/vigorous activities, and 2.3 hours more on low intensity activities per week. The overweight prevalence was also significantly lower among children who walked to and from school. (**Chapter 3**)

Overweight and obese children had higher metabolic syndrome prevalence (**Chapter 4**), body dissatisfaction and depression (**Chapter 5**). It is estimated that more than three million Chinese adolescents aged 15 to 19 years have the metabolic syndrome (3.7%), and 40% of them have elevated body weight. Of the adolescents having parents with metabolic syndrome, once they are overweight or at risk of overweight, their risk of metabolic syndrome would be much higher. (**Chapter 4**)

Overweight girls, but not boys, had mildly but significantly higher total Children Depression Inventory score; both obese girls and obese boys showed higher level of negative self-esteem scores, which was partially explained by body dissatisfaction. A large percentage of children were not satisfied with their body weight, more than one fifth underweight girls still wanted to be thinner while more than one third obese boys still wanted to be heavier. Children who wanted to be thinner showed significantly higher scores of ineffectiveness and negative self-esteem. (**Chapter 5**)

Our findings highlight the need for effective prevention strategies and actions for childhood obesity in China, especially among the children having parents with higher body weight or metabolic syndrome.



Childhood overweight and obesity prevalence increased dramatically.

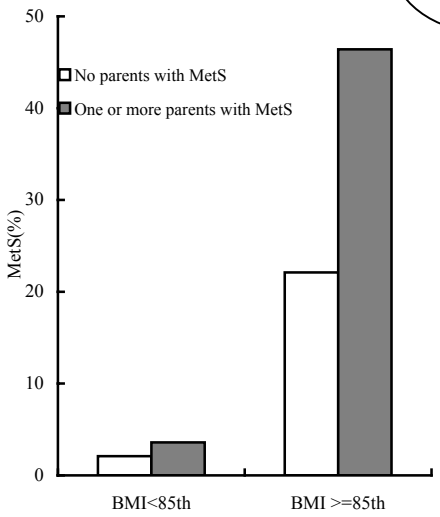
PREVALENCE (Chapter2)

Risk Factors	Overweight (%)	Prevalence Ratio
Transport to/from school		
By bus	15.0	
By bike	9.0	0.7 (0.5, 1.1)
Walking	4.5	0.6 (0.5, 0.8)
Cooking oil (g/d)		
<25	4.9	
≥25	7.9	1.4 (1.2, 1.8)

Less physical activity, inactive transportation, high meat and edible oil intakes, high SES and parental obesity were all related to obesity.

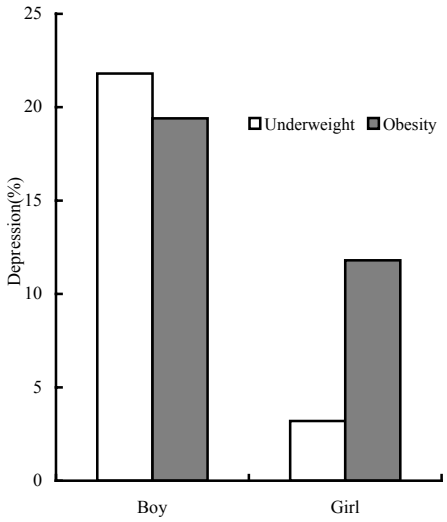
DETERMINANTS (Chapter 3)

Childhood Obesity



Interaction bbetween overweight of adolescents and parental metabolic syndrome

METABOLIC SYNDROME (Chapter 4)



Higher prevalence of depression in obese boys and girls, as well as underweight boys.

DEPRESSION (Chapter 5)

Figure 1 The main findings of this thesis

INTERNAL VALIDITY

Representativeness

The data used in **Chapter 2-4** were from the 2002 China National Nutrition and Health Survey (CNNHS), which is a nationally representative survey.[1] In order to be nationally representative and to have sufficient representation of urban and rural areas, respectively, a four stage stratified random sampling method with equal-sample-size was used.

Demographic characteristics (gender ratio, family size, and proportion of minority) of the sample of the 2002 CNNHS were compared with that of the 2000 China National Population Census,[2] and differences were small and not significant. The test of goodness of fit was used to compare the age distributions of the two surveys, and no significant differences were found.[3] Myer's Index was only 4.2, indicating absence of age related selection.[3]

There was no record about the participation rate of individuals. Among the 792 villages/neighborhood committees randomly selected, 65 (8.2%) refused to participate in 2002 CNNHS. In such cases, another village/neighborhood committee was randomly selected from the remaining ones. According to the investigators who carry out the measurements in 2002, once the village/neighborhood committee decided to participate, the individual response rate was always more than ninety percent.

We are convinced that the study sample was sufficiently representative of Chinese children at a national scale.

Definition of childhood obesity

Currently, the two most widely used international classification references for overweight and obesity of children and adolescents are those of the WHO/NCHS and the International Obesity Task Force (IOTF). They are suitable for research use and for monitoring and evaluating changes in populations, because the cut-off points provide a

standard benchmark against which all population groups can be compared and trends assessed.[4] In order to compare with USA adolescents, the WHO/NCHS childhood obesity classification was used in **Chapter 4**. The IOTF definition was applied in **Chapter 2** for national estimate of the prevalence and trends of childhood obesity in China, because the IOTF definition was developed basing on six countries data and was thought more suitable for international comparisons.[5]

The Working Group for Obesity in China (WGOC) recommended an age-, sex- specific BMI classification reference for Chinese children in 2003.[6,7] Association with disease risk indicates that the WGOC is a better reference for Chinese children and adolescents than the IOTF. Applying the WGOC reference, hypertension (age-, sex-, height- specific systolic and/or diastolic blood pressure >90 percentile), prevalence of normal weight, overweight and obesity was 6.7%, 19.7% and 32.2%, respectively.[8] An increasing trend of serum total cholesterol and triglyceride and a decreasing trend of HDL-C are also found with the increasing of BMI.[9] Evaluation of the performance of BMI percentile as a screening indicator of metabolic syndrome showed that Youden's index reached its peak at the 85th percentile (WGOC overweight), representing the point in the ROC graph that is nearest to the upper left corner. This means that this WGOC overweight cut-off point has optimal sensitivity and specificity to predicting the metabolic syndrome.[10]

It is concluded that the BMI classification reference for overweight and obesity recommended by the WGOC is the better predictor of health risks among Chinese children and adolescents and can be used as a basis for prevention. Therefore, it is used as the primary reference in this thesis (Chapter 3 & 5).

Children's Depression Inventory (CDI)

The Children's Depression Inventory (CDI) used in **Chapter 5** was first developed in 1975, and revised several times. The currently used version was developed in 1992.[11]

CDI has shown good test-retest reliability, internal consistency, and construct validity, with total score reliabilities ranging from 0.80 to 0.88 in the normative samples.[11] It has been translated to different languages and hundreds of studies have been conducted using CDI as a measure of depression. In 2000, Xie and Li introduced it to China.[12] The Chinese version CDI was translated from English, and vice versa in order to evaluate construct validity. It showed high validity and reliability in Chinese children.[12] Cronbach's alpha coefficient of the Chinese version was 0.85 and split half reliability was 0.83,[12] similar to the English versions.[11,13] In the current sample, the Cronbach's alpha was 0.81 for total score and 0.48 to 0.81 for subscales. The prevalence of depressive risk in Chinese children was 13.2% **(Chapter 5)**,which is in line with other epidemiologic studies that reported prevalence of depressive risk ranging from 5~20% using same definition.[14-19]

In conclusion, the assessment of depression mood in the present study is reliable.

Measurements

Accurate measurement of anthropometry is extremely important for the assessment of the physical growth and development. A scale and measuring tape for weight and height produced by the same factory were provided to each study site. The equipments were recalibrated daily. The investigators were trained for one week and only those who past the exam qualified for the investigation. The measurements were taken twice by trained investigators following a standard procedure[20] and the average of the two measurements was computed.[1] The quality control results indicated that the duplicate measurements in subgroups showed a high reproducibility (correlation coefficients of duplicate measurements was 0.99 for height and 0.98 for weight).[21]

All fasting glucose samples were measured within 4 hours. Every tenth sample was measured twice (correlation coefficients of duplicate measurements was 0.98), one reference sample, one quality control sample and one blind sample were measured

before every 30th sample.[1] Blind serum samples from the U.S. CDC were analysed in our lab (China CDC) seven times at regular intervals during the period of the analysis of the 2002 CNNHS samples. The relative difference ranged from -7.02% to 1.60% for triglyceride, and from -1.05% to 4.21% for HDL-C.[1]

We conclude that the quality of anthropometric and blood sample measurements in the present study is adequate.

Confounders

A confounder in the relationship between childhood obesity and its determinants is a factor that is associated with childhood obesity, and also related to the studied determinants, but not part of the causal chain. A confounder is, at least in part, responsible for an observed association between childhood obesity and its determinants.

Age is an important example of a confounder in the relationship between childhood obesity and its determinants. Childhood obesity increased until 12 (boy)/13 (girl) years old after which it declined.[22] Children's lifestyles including dietary behaviors and physical activity patterns also changed with their growth.[23,24] Adjustment for age was therefore performed in the study of the association between childhood obesity and its determinants (**Chapter 3**).

Other potential confounders include socioeconomic status and parent's educational levels. Parental weight and socioeconomic status may influence child weight independently, as well as through eating/activity, so we included the results both with and without adjustment of parental weight and socioeconomic status in **Chapter 3**.

Socioeconomic status may also be a potential confounder of the association between childhood obesity and metabolic syndrome, which may influence the onset of obesity and may be related to the metabolic syndrome. We did not adjust the confounding of socioeconomic status in present study of the association between childhood obesity and metabolic syndrome for not enough samples for multiple analysis (**Chapter 4**), but

adjustment for these factor was performed in another paper, which did not change the significant association between childhood obesity and metabolic syndrome.[25]

EXTERNAL VALIDITY

Childhood obesity prevalence

The prevalence and trend of childhood obesity reported in **Chapter 2** could be compared to data from other surveys in China, which had different methodological advantages and disadvantages compared to the 2002 CNNHS.

The "National Surveys on Students Constitution and Health (CNSSCH) "[26] routinely investigate the obesity prevalence in 31 provinces of China, but only limited to students, excluding school-age children not went to school. Body weight was not measured in the fasting state, which will have decreased the accuracy of the obesity prevalence estimation.[26]

The "China Health and Nutrition Survey (CHNS)"[27] is eight provinces based. These eight provinces are all in the middle and east of China, no one from the west of China, which are typical poverty provinces in China. Therefore the CHNS was not nationally representative, especially not for the rural areas, which will result in overestimation of the problem in rural areas. The overweight prevalence defined by IOTF standard was 6.4% of rural and 12.4% of urban children in 1997 CNHS.[27] Our estimating based on same definition is 2.0% of rural and 12.5% of urban children in 2002. "China Health and Nutrition Survey" is longitudinal survey design, while our trend estimation was based on the comparison between nationally representative cross-sectional surveys. Both studies showed a clear increase in the childhood obesity prevalence and the trends in time were similar. Thus, the different designs of the study lead to different prevalence estimates of childhood obesity but still in same order of magnitude.

Based on the external comparisons, we conclude that our estimated prevalence of

childhood overweight and obesity, being 4.4% and 0.9%, respectively, is likely to be close to the true prevalence.

Concurrent obesity and stunting

Co-existence of overweight/obesity and stunting was found among Chinese children in 1982, 1992 and in rural areas in 2002 (**Chapter 2**), especially among the girls. The phenomenon of childhood obesity accompanied by stunting has been reported in developing countries as well as in developed countries, particularly among girls and women.[28-34] Popkin et al[28] found a significant association between stunting and overweight status in children of Russia, Brazil, China and Republic of South Africa. The income-adjusted prevalence ratios of being overweight for a stunted child ranged from 1.7 to 7.8. Similar associations were also found among Chinese children under 5 years, the overweight prevalence increased less rapidly or even decreased when the prevalence of stunting decreased.[35]

The association with increased BMI and shorter length is likely due to the quality of the diet content, rich in carbohydrates and poor in protein, which resulted in failure of linear growth.[36,37] When stunted children are faced with a higher-energy dense, higher fat diet, weight gain will coincide with sub-optimal linear growth.[34,36-40] Studies by Hoffman *et al.*[33,40] suggested that fat metabolism of stunted children was impaired to an extent that might lead to increased obesity and other metabolic shifts. Energy intake per kilogram body weight and fasting respiratory quotient was significantly higher, while the resting metabolic rate and fasting fat oxidation were significantly lower in the stunted children compared with the control children,[33,39,40] leading to obesity in at risk populations.

These results imply that concurrent overweight/obesity and stunting is an important public health issue in China, ,complicating the fight against obesity.

Pediatric metabolic syndrome

Prevalence of the metabolic syndrome among Chinese adolescents reported in **Chapter**

3 could be compared to data from Hong Kong and Taiwan, and other surveys in mainland of China.[41,42] Though they applied different metabolic syndrome definitions, they all showed high risk of metabolic syndrome among overweight and obese adolescents.

Among 176 obese adolescents in Taiwan, 74.6% had at least one out of the following metabolic abnormalities: high TC, low HDL, high TG, hypertension or diabetes; 20.3% had at least two and 4.2% had three or more metabolic abnormalities.[41] In Hong Kong, metabolic syndrome was found in 9.6% boys and 5.5% girls. The percentage of children having one, two, three and four items of the metabolic abnormalities was 30.8%, 14.0%, 7.1% and 2.2% among boys, and 40.0%, 15.8%, 4.6% and 0.9% among girls.[42]

The prevalence of metabolic syndrome among overweight adolescents in China is quite similar to that in U.S. (27.7% vs 31.2%). The percentages of overweight adolescents who had one, two, three and four of the metabolic abnormalities are also similar between Chinese (75.9%, 51.9%, 20.4% and 5.6%) and U.S. adolescents (88.5%, 56.0%, 28.7% and 5.8%) (both applying the criteria developed by Cook et al).[42]

In conclusion, overweight and metabolic syndrome prevalence among adolescents are still relatively low in China, but the prevalence of metabolic syndrome among Chinese overweight adolescents is similar to those living in the U.S.

INTERPRETATION OF THE ASSOCIATIONS

The associations between childhood obesity and the possible determinants (**Chapter 3**) were based on cross-sectional observations, which limit causal inference. Reverse causation has been reported in adults. Obese adults always control their dietary intakes, and often are very keen on doing physical exercise to control their body weight, giving rise to spurious associations between obesity and certain behavioral factors. Diseases related to obesity may also lead to dieting and weight loss, possibly giving rise to reverse causation.

Fortunately, reverse causation plays less of a role in childhood than adulthood. Firstly, the obesity of young children will not have lasted long enough to cause diseases that lead to weight loss. Secondly, dietary behaviors and physical activity patterns of obese children do not change as much as those of obese adults.

Nutrition/physical activity transition and results from a two year cohort study in China support a causal role of diet and physical activity considered in this study on childhood obesity. Preceding the onset of childhood obesity in China, the proportion of energy from fat increased quickly whereas physical activity decreased.[44] Children who remained overweight during two years were more likely to have a high-fat or high-meat diet, but less likely to have a diet high in carbohydrate or vegetable and fruit and seemed even to have increased meat and fat intakes.[45] Evidence from intervention studies also gave support to the hypothesis. After one year of 10 minutes physical activity (per school day) intervention, the overweight prevalence decreased in intervention group but increased in control group.[46]

PUBLIC HEALTH IMPLICATIONS

From this thesis, it can be concluded that childhood obesity has become a public health problem in China, it is associated with a high risk of pediatric metabolic syndrome and depression, which will lead to increased health care costs in the near future. It is of great public health importance to develop obesity prevention programs.

Childhood obesity prevalence was higher in high socio-economic status groups. This positive association is contrary to the negative relation observed in developed countries. Since childhood obesity prevalence is positively associated with socio-economic status, the rapid economic development in China may result in a sharp rise in overweight and obesity prevalence unless effective preventive actions are taken. This indicatesthat the beginning of 21 century may be a critical period for efforts to control the obesity epidemic in China. Treatment of obesity is much more expensive and in the long run

less effective than prevention.

As a developing country facing nutrition transition, concurrent obesity and stunting increases the difficulties in the fight against obesity. The diet of these children may be relatively adequate in quantity but inadequate in quality of nutrient intake.[36] China is going through a remarkably fast but undesirable nutrition transition characterized by a high energy density diet and a high edible oil intake. Dietary fat intake contributed about 35% energy of overweight children in the present study, being the upper limit of the fat intake recommendation.[44,47,48] The coexistence of obesity and stunting poses a challenge to public programs, since the aims of programs to reduce under-nutrition are obviously in conflict with those for obesity prevention, how to control the body weight increment but keep the growth of height would be a challenge not only for children but also for the family and public health.

As the present thesis indicates, increased energy and particularly fat intake, high consumption of cooking oil, more sedentary activities, less cereal grains and vegetables consumption and less vigorous/moderate activities are all related to childhood obesity **(Chapter 3)**. Minor changes in energy intake or energy expenditure had a potentially important effect on changes in the prevalence of obesity. However, previous prevention programs aimed at individual behavior modification were generally disappointing. Children are vulnerable to the social and environmental pressures that raise the risk of obesity. Although they can be encouraged to increase their self-control in the face of temptation, and although they can be given knowledge and skills to help understand the context of their choices, children cannot be expected to bear the full burden of responsibility for preventing excess weight gain.

Significant similarity between parents and their children was also found in current thesis **(Chapter 3)**. The association reflects both genetic and environmental influences. Besides the high genetic similarity among members of a family,[49] parents play an important role in the development of children's physical activity/inactivity patterns,[50]

eating behaviors and attitudes.[51] Parents' socioeconomic status also has important effect on childhood obesity.[52] So family should be an important setting for childhood obesity preventive actions.

School is another ideal setting for preventive interventions.[53-55] School offers regular contact with children and provides opportunities for nutrition education and promotion of physical activity both within the formal curriculum, and informally via the provision of appropriate facilities within the school environment such as healthy school meals, break-time snack provision and playground equipment. Thus schools not only influence the knowledge and attitudes of children but also provide opportunities for experiential learning and the development of a sense of self-efficacy. Furthermore the school can also provide links with the family and the wider community. Several famous childhood obesity prevention programs have developed in different countries, such as 'APPLES' in UK,[56,57] 'Trim and Fit' in Singapore,[58] 'Tackling the record rise in obesity' in Greek island of Crete,[59] 'Playing less for health'[60-62] and 'Watching less TV' in USA,[63,64] and 'Agita São Paulo' programme in Brazil.[65,66]

In China, the **Happy 10** program was developed,[46] which is a classroom-based physical activity program for elementary students based on the principle of "TAKE 10!™" (www.Take10.net) Program developed by Health Promotion Center of International Life Science Institute in USA. It is designed as a stand-alone program, led by classroom teachers to provide children with planned periods of brief, moderate- to vigorous repetitive movements. The pilot study indicated that girls' BMI decreased in intervention schools and increased in control schools after 1 year **Happy 10** program, 10 minutes each school day. This program is becoming more and more popular in Beijing, and will spread to other cities soon.

Interventions at the family or school level will need to be matched by changes in the social and cultural context so that the benefits can be sustained and enhanced. The goal of prevention is not to find a single program that works, but to stimulate regional,

national and local initiatives that are suitable for their context. Approaches that specifically target children include changes in the food and activity options in schools, improving infrastructure for walking and access to safe and affordable outdoor play areas, and regulating food advertising on television, particularly advertising that is aimed at children. Such prevention strategies will require a coordinate effort between the medical community, health administrators, teachers, parents, food producers and processors, retailers and caterers, advertisers and the media, recreation and sport planners, urban architects, city planners, politicians and legislators.[4,67]

CONCLUSION

Obesity is an increasing problem among youngsters in China, especially in urban areas. Prevalence is still lower than in developed countries, particularly in rural areas. However, the prevalence of metabolic syndrome and depression among Chinese overweight adolescents is similar to those living in the developed countries. It is of public health importance to develop obesity prevention programs. Strategies to prevent obesity in a child population – such as encouraging healthful diets and plentiful physical activity – will benefit the health of all children, whether at risk of obesity or not.

SUGGESTIONS FOR FUTURE RESEARCH

In view of our previous reflections, this paragraph gives suggestions for future research.

- ⇨ Short and long-term **prospective** investigations are needed to study the range of factors implicated in childhood obesity development in China, both from individual and population perspective. In particular, the relative importance of dietary factors and physical activity patterns associated with childhood obesity development should be investigated further.
- ⇨ The role of **culture** in childhood obesity is also worth studying, as well as **psychological** factors.
- ⇨ Simple and well-designed **intervention** studies in obese children that can be transferred into usual practice are really needed by China.
- ⇨ The development of effective strategies for the **prevention** of childhood obesity are likely to be more cost-effective and have greater positive impact on the long term control of body weight than strategies designed to deal with obesity once it has fully developed. So to develop effective prevention strategies based on the development and maintenance of life-long healthy eating and physical activity patterns should be a next research topic.
- ⇨ Further investigations are needed to determine whether the documented successful management programs for overweight in children and adolescents can be **replicated** under different situations and in different populations.

REFERENCES

1. Wang L: *Report of China Nationwide Nutrition and Health Survey 2002 (1): Summary Report.* Beijing: People's Medical Publishing House; 2005.
2. National Bureau of Statistics of China: *China Statistic Year Book 2000*. Beijing: China Statistic Press; 2000.
3. Yang X, Kong L, Zhai F, Ma G, Jin S: The 2002 China National Nutrition and Health Survey (1): Design, sampling and statistic methods. *Zhong Hua Liu Xing Bing Xue Za Zhi* 2005, 26(7):471-474.
4. Lobstein T, Baur L, Uauy R: Obesity in children and young people: a crisis in public health. *Obes Rev* 2004, 5 Suppl 1:4-104.
5. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH: Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ* 2000, 320(7244):1240-1243.
6. Cooperative Meta-analysis Group of China Obesity Task Force: Predictive value of body mass index and waist circumference to risk factors of related diseases in Chinese adults population. *Zhong Hua Liu Xing Bing Xue Za Zhi* 2002, 23(1):5-10.
7. Group of China Obesity Task Force: Body mass index reference norm for screening overweight and obesity in Chinese children and adolescents. *Zhong Hua Liu Xing Bing Xue Za Zhi* 2004, 25(2):97-102.
8. Wang W, Wang K, Chen C, Cao R, Bai Y, Ma L, Fu Z, Chen J, Liu J, Bai J *et al*: The study on relationship of body mass index and blood pressure in children and adolescents of Beijing. *Zhong Hua Liu Xing Bing Xue Za Zhi* 2004, 25(2):109-112.
9. Zhai F, Zhang L, Wng C, Duan J, Cao R, Wang H, Zhang J: Validation of lipids on body mass index reference recommended by Obesity Working Group, International Life Science Association of China. *Zhong Hua Liu Xing Bing Xue*

Za Zhi 2004, 25(2):117-119.

10. Ma GS, Li YP, Hu XQ, Cui ZH, Yang XG, Chen CM: Report on childhood obesity in China (2). Verification of BMI classification reference for overweight and obesity in Chinese children and adolescents. *Biomed Environ Sci* 2006, 19(1):1-7.
11. Kovacs M: *Children's Depression Intentory*. North Tonawanda, NY.: Multi-Health System; 1992.
12. Xie D, Li X: Preliminary use of the children's depression inventory in China. *Zhong Guo Xin Li Wei heng Za Zhi* 2000, 14(4):225-227.
13. Roberts RE, Chen YW, Solovitz BL: Symptoms of DSM-III-R major depression among Anglo, African and Mexican American adolescents. *J Affect Disord* 1995, 36(1-2):1-9.
14. Almqvist F, Kumpulainen K, Ikaheimo K, Linna SL, Henttonen I, Huikko E, Tuompo-Johansson E, Aronen E, Puura K, Piha J *et al*: Behavioural and emotional symptoms in 8-9-year-old children. *Eur Child Adolesc Psychiatry* 1999, 8 Suppl 4:7-16.
15. Canals J, Marti-Henneberg C, Fernandez-Ballart J, Domenech E: A longitudinal study of depression in an urban Spanish pubertal population. *Eur Child Adolesc Psychiatry* 1995, 4(2):102-111.
16. Charman T, Pervova I: Self-reported depressed mood in Russian and U.K. schoolchildren. A research note. *J Child Psychol Psychiatry* 1996, 37(7):879-883.
17. Davanzo P, Kerwin L, Nikore V, Esparza C, Forness S, Murrelle L: Spanish translation and reliability testing of the Child Depression Inventory. *Child Psychiatry Hum Dev* 2004, 35(1):75-92.
18. Frigerio A, Pesenti S, Molteni M, Snider J, Battaglia M: Depressive symptoms as measured by the CDI in a population of northern Italian children. *Eur Psychiatry* 2001, 16(1):33-37.

19. Swallen KC, Reither EN, Haas SA, Meier AM: Overweight, obesity, and health-related quality of life among adolescents: the National Longitudinal Study of Adolescent Health. *Pediatrics* 2005, 115(2):340-347.

20. World Health Organization: *Physical statusL the use and interpretation of anthropometry. Report of a WHO expert committee technical report series, No 854*. Geneva: World Health Organization; 1995.

21. Piao J, Zhang J, Zhao W, You Y, Yang X: China National Nutrition and Health Survey (2): Quality Control in China Nutrition and Health Survey. Design, sampling and statistic methods. *Zhong Hua Liu Xing Bing Xue Za Zhi* 2005, 26(7):475-477.

22. Ma G: *Environmental factors leading to pediatric obesity in the developing world.* Shanghai,China: Lippincott Williams & Wilkins; 2002.

23. Liu A, Li Y, Cui Z, Hu X, Luan D, Ma G: Analysis on average time of physical activity in a school day among Chinese students. *Chin J School Health* 2006, 27(6):473-475.

24. Wang Y, Bentley ME, Zhai F, Popkin BM: Tracking of dietary intake patterns of Chinese from childhood to adolescence over a six-year follow-up period. *J Nutr* 2002, 132(3):430-438.

25. Li YP, Yang XG, Zhai FY, Piao JH, Zhao WH, Zhang J, Ma GS: Disease risks of childhood obesity in China. *Biomed Environ Sci* 2005, 18(6):401-410.

26. Ji CY, Sun JL: Analyses of the epidemiological status of overweight and obesity in Chinese students and the prevalence changes in recent 15 years. *Beijing Da Xue Xue Bao* 2004, 36(2):194-197.

27. Wang Y, Ge K, Popkin BM: Tracking of body mass index from childhood to adolescence: a 6-y follow-up study in China. *Am J Clin Nutr* 2000, 72(4):1018-1024.

28. Popkin BM, Richards MK, Montiero CA: Stunting is associated with overweight in children of four nations that are undergoing the nutrition transition. *J Nutr*

1996, 126(12):3009-3016.

29. Duran P, Caballero B, de Onis M: The association between stunting and overweight in Latin American and Caribbean preschool children. *Food Nutr Bull* 2006, 27(4):300-305.

30. Fernald LC, Neufeld LM: Overweight with concurrent stunting in very young children from rural Mexico: prevalence and associated factors. *Eur J Clin Nutr* 2006.

31. Cameron N, Wright MM, Griffiths PL, Norris SA, Pettifor JM: Stunting at 2 years in relation to body composition at 9 years in African urban children. *Obes Res* 2005, 13(1):131-136.

32. Mukuddem-Petersen J, Kruger HS: Association between stunting and overweight among 10-15-y-old children in the North West Province of South Africa: the THUSA BANA Study. *Int J Obes Relat Metab Disord* 2004, 28(7):842-851.

33. Hoffman DJ, Sawaya AL, Verreschi I, Tucker KL, Roberts SB: Why are nutritionally stunted children at increased risk of obesity? Studies of metabolic rate and fat oxidation in shantytown children from Sao Paulo, Brazil. *Am J Clin Nutr* 2000, 72(3):702-707.

34. Sawaya AL, Grillo LP, Verreschi I, da Silva AC, Roberts SB: Mild stunting is associated with higher susceptibility to the effects of high fat diets: studies in a shantytown population in Sao Paulo, Brazil. *J Nutr* 1998, 128(2 Suppl):415S-420S.

35. Chen C, He W, Fu Z, Chang Y, Chang S, Wang Y, Fu G: *Growth of children aged under 5 and its trend in China.* Beijing: People's Medical Publishing House; 2004.

36. Trowbridge FL: Prevalence of growth stunting and obesity: Pediatric Nutrition Surveillance System, 1982. *MMWR CDC Surveill Summ* 1983, 32(4):23SS-26SS.

37. Mamabolo RL, Alberts M, Steyn NP, Delemarre-van de Waal HA, Levitt NS: Prevalence and determinants of stunting and overweight in 3-year-old black South African children residing in the Central Region of Limpopo Province, South Africa. *Public health nutrition* 2005, 8(5):501-508.

38. Lukito W, Wahlqvist ML: Weight management in transitional economies: the " double burden of disease" dilemma. *Asia Pac J Clin Nutr* 2006, 15 Suppl:21-29.

39. Grillol LP, Siqueira AF, Silva AC, Martins PA, Verreschi IT, Sawaya AL: Lower resting metabolic rate and higher velocity of weight gain in a prospective study of stunted vs nonstunted girls living in the shantytowns of Sao Paulo, Brazil. *Eur J Clin Nutr* 2005, 59(7):835-842.

40. Hoffman DJ, Roberts SB, Verreschi I, Martins PA, de Nascimento C, Tucker KL, Sawaya AL: Regulation of energy intake may be impaired in nutritionally stunted children from the shantytowns of Sao Paulo, Brazil. *J Nutr* 2000, 130(9):2265-2270.

41. Chu F: Childhood obesity and adverse health effects in Taiwan. In *Conference on obesity and related disease control in China: 2006; Beijing*. ILSI China; 2006:208-217.

42. Chan C: Childhood obesity and adverse health effect in Hong Kong. In *Conference on obesity and related disease control in China: 2006; Beijing*. ILSI China; 2006:218-225.

43. Cook S, Weitzman M, Auinger P, Nguyen M, Dietz WH: Prevalence of a metabolic syndrome phenotype in adolescents: findings from the third National Health and Nutrition Examination Survey, 1988-1994. *Arch Pediatr Adolesc Med* 2003, 157(8):821-827.

44. Du S, Lu B, Zhai F, Popkin BM: A new stage of the nutrition transition in China. *Public health nutrition* 2002, 5(1A):169-174.

45. Wang Y, Ge K, Popkin BM: Why do some overweight children remain overweight, whereas others do not? *Public health nutrition* 2003, 6(6):549-558.

46. Liu A, Hu X, Ma G, Cui Z, Pan Y, Chang S, Zhao W, Chen C: Evaluation of a classroom-based physical activity promoting program. *Biomed Environ Sci* 2007, 20(1):19-23.

47. Popkin BM, Gordon-Larsen P: The nutrition transition: worldwide obesity dynamics and their determinants. *Int J Obes Relat Metab Disord* 2004, 28 Suppl 3:S2-9.

48. Popkin BM, Du S: Dynamics of the nutrition transition toward the animal foods sector in China and its implications: a worried perspective. *J Nutr* 2003, 133(11 Suppl 2):3898S-3906S.

49. Jacobson KC, Rowe DC: Genetic and shared environmental influences on adolescent BMI: interactions with race and sex. *Behav Genet* 1998, 28(4):265-278.

50. Bogaert N, Steinbeck KS, Baur LA, Brock K, Bermingham MA: Food, activity and family--environmental vs biochemical predictors of weight gain in children. *Eur J Clin Nutr* 2003, 57(10):1242-1249.

51. Benton D: Role of parents in the determination of the food preferences of children and the development of obesity. *Int J Obes Relat Metab Disord* 2004, 28(7):858-869.

52. Veugelers PJ, Fitzgerald AL: Prevalence of and risk factors for childhood overweight and obesity. *CMAJ* 2005, 173(6):607-613.

53. Garrow J: Importance of obesity. *Bmj* 1991, 303(6804):704-706.

54. Neumark-Sztainer D, Story M: Recommendations from overweight youth regarding school-based weight control programs. *J Sch Health* 1997, 67(10):428-433.

55. Neumark-Sztainer D, Story M, Perry C, Casey MA: Factors influencing food choices of adolescents: findings from focus-group discussions with adolescents. *J Am Diet Assoc* 1999, 99(8):929-937.

56. Sahota P, Rudolf MC, Dixey R, Hill AJ, Barth JH, Cade J: Randomised

controlled trial of primary school based intervention to reduce risk factors for obesity. *BMJ* 2001, 323(7320):1029-1032.

57. Sahota P, Rudolf MC, Dixey R, Hill AJ, Barth JH, Cade J: Evaluation of implementation and effect of primary school based intervention to reduce risk factors for obesity. *BMJ* 2001, 323(7320):1027-1029.

58. Toh CM, Cutter J, Chew SK: School based intervention has reduced obesity in Singapore. *BMJ* 2002, 324(7334):427.

59. Mamalakis G, Kafatos A, Manios Y, Anagnostopoulou T, Apostolaki I: Obesity indices in a cohort of primary school children in Crete: a six year prospective study. *Int J Obes Relat Metab Disord* 2000, 24(6):765-771.

60. French SA: Pricing effects on food choices. *J Nutr* 2003, 133(3):841S-843S.

61. French SA, Story M, Jeffery RW, Snyder P, Eisenberg M, Sidebottom A, Murray D: Pricing strategy to promote fruit and vegetable purchase in high school cafeterias. *J Am Diet Assoc* 1997, 97(9):1008-1010.

62. Hannan P, French SA, Story M, Fulkerson JA: A pricing strategy to promote sales of lower fat foods in high school cafeterias: acceptability and sensitivity analysis. *Am J Health Promot* 2002, 17(1):1-6, ii.

63. Robinson TN: Reducing children's television viewing to prevent obesity: a randomized controlled trial. *JAMA* 1999, 282(16):1561-1567.

64. Robinson TN: Can a school - based intervention to reduce television use decrease adiposity in children in grades 3 and 4 ? *The Western J Med* 2000, 173(1):40.

65. Matsudo V: The "Agita Sao Paulo" experience in promoting physical activity. *West Indian Med J* 2002, 51 Suppl 1:48-50.

66. Matsudo V, Matsudo S, Andrade D, Araujo T, Andrade E, de Oliveira LC, Braggion G: Promotion of physical activity in a developing country: the Agita Sao Paulo experience. *Public health nutrition* 2002, 5(1A):253-261.

67. World Health Organization: *Obesity: preventing and managing the global*

epidemic. Report on a WHO consultation on obesity (WHO/NUT/NCD/98.1). Geneva: WHO; 1997.

SUMMARY

Over the past two decades, China has been undergoing rapid socio-economic and nutrition transitions. A 10-fold increase in the gross domestic product parallels an increase in more energy-dense foods, a decrease in transport related physical activity and an increase in leisure time inactivity. Average daily food intake from animal source increased from 61g in 1982 to 159g in 2002, cooking oil consumption increased by 10g each 10 years, while the cereal grains and vegetable intakes decreased more than twenty percent. At the same time, television and car ownership increased considerably, while public transport became more and more popular in China. With these rapid transitions, China is experiencing a double burden: malnutrition as well as over-nutrition. Previous studies indicated that overweight and obesity prevalence among Chinese youngsters increased rapidly during last two decades, but these were based on the data from only a few provinces in China.

Therefore, this thesis addresses childhood obesity in China, with regard to the prevalence, determinants and related health risks, based on the data analyses of the 2002 China National Nutrition and Health Survey (CNNHS), which was a nationally representative survey, conducted to describe the nutrition status, the prevalence of selected diseases and associated risk factors. The following information is presented in this thesis: 1) national estimates of overweight and obesity prevalence for youngsters aged 7-17 years in China in 2002, as well as the trend in the last 20 years; 2) information on the determinants of childhood obesity in China; 3) national estimates of metabolic syndrome prevalence and distribution among Chinese youngsters in 2002; 4) the relationship between body weight, body dissatisfaction and depression symptoms.

Chapter 2 describes the prevalence and trend of overweight and obesity, using data of children aged 7-17 years from three cross-sectional national surveys including “1982 China National Nutrition Survey” (5 334 boys and 4 793 girls), “1992 China National Nutrition Survey” (8 048 boys and 7 453 girls) and “2002 China National Nutrition and

Health Survey" (23 242 boys and 21 638 girls)**.** The results indicated that the prevalence of overweight and obesity of Chinese children and adolescents was low in 1982. There has been a rapid increase since then, especially in large cities. If this trend continues, overweight will soon reach epidemic proportions As defined by IOTF criteria, the overweight prevalence of Chinese youngsters in 2002 was 4.4% while the obesity prevalence was 0.9%. The estimated total number of overweight youngsters was 12 million, which means that by that time one in thirteen overweight children worldwide was living in China. The percentage of stunting among overweight youngsters was 28.4%, 22.0% and 5.7% in 1982, 1992 and 2002, respectively, and 69.6%, 46.4% and 7.7% among obese youngsters in 1982, 1992 and 2002. There was a large difference in this respect between urban and rural areas. In 1992, 34.1% of the obese youngsters in urban areas were stunted and 56.2% in rural areas. This decreased 2.9% in urban areas in 2002 and 21.6% in rural areas. (**Chapter 2**)

In order to investigate the determinants of childhood overweight and obesity in China, the prevalence of overweight (including obesity) was compared according to different dietary and physical activity patterns and parental body weight status in **Chapter 3**. A total of 6826 children aged 7-17 years from the 2002 China National Nutrition and Health Survey were included in the study. The results show an association between parental body weight and overweight prevalence in children. The prevalence ratio increased if parent(s) were overweight and/or obese, up to 12.2 if both parents were obese. Overweight children consumed significantly more dietary energy, protein and fat, but less carbohydrate than their normal weight counterparts. On average, overweight children spent half an hour less on moderate/vigorous activities, and 2.3 hours more on low intensity activities per week (**Chapter 3**). Both the overweight and obesity prevalence and their increment were higher in urban than in rural areas and higher in boys than in girls. The prevalence increased with the family's income level and the parent's educational level (**Chapter 2**).After adjustment for parental body weight status

and socioeconomic status, only cooking oil consumption and walking to and from school remained significantly related to child overweight (**Chapter 3**).

Since no national figure is currently available of the occurrence of metabolic syndrome among Chinese adolescents, we estimated the prevalence of metabolic syndrome among 2761 adolescents aged 15 to 19 years in **Chapter 4**. It is estimated that more than 3 million Chinese adolescents aged 15 to 19 years have the metabolic syndrome (3.7%). The prevalence of metabolic syndrome was 35.2%, 23.4% and 2.3% among adolescents who were overweight (BMI ≥P95), at risk of overweight (BMI between P85and P95) and normal weight (BMI < P85), respectively. Urban boys had the highest rate (5.8%) compared to girls and rural youngsters. Among adolescents who had a BMI ≥85th percentile and one or two parent(s) with the metabolic syndrome, the prevalence was 46.4%. Ninety six percent overweight adolescents had at least one and 74.1% overweight adolescents had at least two abnormalities of the metabolic syndrome. (**Chapter 4**)

Relationship between body weight, body dissatisfaction and depression symptoms among Chinese children was observed in third and fourth grade students (N=3886, aged 9 or 10 years) from 20 schools in Beijing, China **(Chapter 5)**. 13.2% children (boys 16.7% vs girls 9.5%) were at risk of depression. Overweight girls, but not boys, had mildly but significantly higher total CDI score. Both obese girls and obese boys showed a higher level of negative self-esteem scores. More than one fifth underweight girls still wanted to be thinner while more than one third obese boys still wanted to be heavier. Children who wanted to be thinner showed significantly and slightly higher scores of ineffectiveness and negative self-esteem. After introducing the body dissatisfaction into the model, overweight was still associated with total CDI score among girls and obesity was still associated with negative self-esteem among both boys and girls. **(Chapter 5)**

The main findings from the present study are summarized and discussed in the general discussion (**Chapter 6**). Subsequently, we reflect several issues concerning the validity and external validity. Firstly, we discuss the internal validity including representativeness, definition of childhood obesity, definition of children's depression inventory, measurements of anthropometry and blood samples, such as fasting glucose, triglyceride and HDL-C, confounders, i.e. age, socioeconomic status and mother's educational levels, parental weight, dietary factors and physical activity. Next, we reflect on the external validity including childhood obesity prevalence, concurrent obesity and stunting, pediatric metabolic syndrome. Secondly the associations between childhood obesity and the possible determinants are interpreted. Next, we address the possible implications of our results for public health, focusing on the childhood obesity prevention in China. Lastly, several directions for future research are given.

In conclusion, obesity is an increasing problem among youngsters in China, especially in urban areas. Prevalence is still lower than in developed countries, particularly in rural areas. However, the prevalence of metabolic syndrome and depression among Chinese overweight adolescents is similar to those living in the developed countries. It is of public health importance to develop obesity prevention programs. Fat intake, low intensity activities and active transport to/from school may be suitable targets for overweight prevention among Chinese school children. Strategies to prevent obesity in a child population – such as encouraging healthful diets and plentiful physical activity – will benefit the health of all children, no matter whether obese, overweight or normal weight.

SAMENVATTING

De laatste twee decennia heeft China in hoog tempo sociaal-economische veranderingen en voedingsveranderingen ondergaan. Een 10-voudige stijging van het Bruto Nationaal Product ging gepaard met een toename van energiedichte voedingsmiddelen, een daling in transportgerelateerde lichamelijke activiteit en een toename van inactiviteit in de vrije tijd. De gemiddelde dagelijkse inname van dierlijke voedingsmiddelen steeg van 61 gram per dag in 1982 naar 159 gram in 2002; het gebruik van olie tijdens het koken steeg 10 gram per dag per 10 jaar; en de consumptie van ontbijtgranen en groente daalde meer dan 20 procent. Tegelijkertijd nam het aantal mensen met een televisie en een auto aanzienlijk toe en werd openbaar vervoer steeds populairder. Door deze snelle veranderingen is er in China een tweeledig probleem ontstaan: ondervoeding en overgewicht. Hoewel uit eerdere studies is gebleken dat de prevalentie van overgewicht en obesitas de laatste twee decennia snel is toegenomen, zijn deze prevalentiecijfers gebaseerd op gegevens van slechts enkele Chinese provincies.

Dit proefschrift beschrijft daarom de prevalentie, determinanten en gerelateerde gezondheidsrisico's van obesitas bij kinderen in China. De bevindingen zijn gebaseerd op gegevens van de 2002 *China National Nutrition and Health Survey (CNNHS)*. Dit is een representatief landelijk onderzoek naar de voedingsstatus, de prevalentie van ziekten en gerelateerde risicofactoren. In dit proefschrift komen de volgende onderwerpen aan bod: 1) schattingen voor de landelijke prevalentie van overgewicht en obesitas bij kinderen en tieners in de leeftijd van 7-17 jaar, inclusief de trend over de afgelopen 20 jaar; 2) informatie over determinanten van obesitas bij kinderen in China; 3) schattingen van de landelijke prevalentie van het metabool syndroom, inclusief de prevalentie bij Chinese kinderen en tieners in 2002; 4) de relatie tussen lichaamsgewicht, onvrede over het lichaam en symptomen van depressie.

Hoofdstuk 2 beschrijft de prevalentie en trend van overgewicht en obesitas bij kinderen van 7-17 jaar. Hiervoor hebben we gebruik gemaakt van gegevens uit drie

cross-sectionele landelijke onderzoeken: '*1982 China National Nutrition Survey'* (5334 jongens en 4793 meisjes), '*1992 Cina National Nutrition Survey*' (9048 jongens en 7453 meisjes) en '*2002 China National Nutrition and Health Survey'* (23242 jongens en 21638 meisjes). De prevalentie van overgewicht en obesitas bij Chinese kinderen en jong volwassenen was laag in 1982, maar neemt sindsdien snel toe, vooral in de grote steden. Als deze trend door blijft zetten zullen overgewicht en obesitas snel epidemische proporties aannemen. In 2002 was de prevalentie 4,4% voor overgewicht en 0,9% voor obesitas (gedefinieerd volgens de *'International obesity task force'* criteria). Naar schatting is het totaal aantal kinderen en tieners met overgewicht 12 miljoen, hetgeen betekent dat 1 op de 13 kinderen met overgewicht wereldwijd op dat moment in China woonde. Het percentage kinderen en tieners met overgewicht dat te klein voor de leeftijd is was 28,4% in 1982, 22,0% in 1992 en 5,7% in 2002, hetgeen betekent dat deze kinderen in de vroege jeugd ondervoed zijn geweest. Voor obese kinderen en tieners was dit 69,6% in 1982, 46,4% in 1992 en 7,7% in 2002. Deze percentages verschilden sterk tussen stedelijke gebieden en plattelandsgebieden: in 1992 was 34,1% van de obese kinderen en tieners in de stedelijke gebieden te klein voor hun leeftijd ten opzichte van 56,2% in de plattelandsgebieden. In 2002 was dit percentage 2,9% gedaald in stedelijke gebieden en 21,6% in plattelandsgebieden. (**Hoofdstuk 2**)

In **Hoofdstuk 3** vergelijken we de prevalentie van overgewicht (inclusief obesitas) aan de hand van verschillende patronen van voeding, lichamelijke activiteit en overgewichtstatus van de ouders om determinanten van overgewicht bij Chinese kinderen te bepalen. In totaal werden 6826 kinderen van 7-17 jaar van de 2002 *China National Nutrition and Health Survey* geïncludeerd in de studie. We vonden een verband tussen het gewicht van de ouders en de prevalentie overgewicht bij kinderen. De prevalentieratio nam toe als de ouder(s) overgewicht hadden en/of obees waren (tot 12.2 als beide ouders obees waren). Kinderen met overgewicht consumeerden significant meer energie, eiwit en vet, maar minder koolhydraten ten opzichte van de

kinderen met een normaal gewicht. Kinderen met overgewicht besteedden per week gemiddeld een half uur minder tijd aan matige/zware activiteiten en 2.3 uur meer aan activiteiten met een lage intensiteit (**Hoofdstuk 3**). De prevalentie van overgewicht en obesitas, inclusief stijging, was hoger in stedelijke gebieden dan in plattelandsgebieden en hoger in jongens dan in meisjes. De prevalentie was eveneens hoger naarmate het gezinsinkomen en opleidingsniveau van de ouders steeg (**Hoofdstuk 2**). Na correctie voor lichaamsgewicht en sociaal-economische status van de ouders bleef alleen het gebruik van olie tijdens het koken en het lopen van en naar school significant gerelateerd aan overgewicht van het kind (**Hoofdstuk 3**).

Aangezien er nog geen prevalentiecijfers bekend zijn voor het metabool syndroom bij Chinese adolescenten, hebben we dit berekend bij 2761 adolescenten in de leeftijd van 15 tot 19 jaar (**Hoofdstuk 4**). Naar schatting hebben meer dan 3 miljoen Chinese adolescenten van 15 tot 19 jaar het metabool syndroom (3,7%). De prevalentie van het metabool syndroom was 35,2% voor adolescenten met overgewicht (BMI≥P95), 23,4% voor adolescenten met een verhoogd risico op overgewicht (BMI tussen P85 en P95) en 2,3% voor adolescenten met normaal gewicht (BMI<P85). Voor jongens uit de steden was dit percentage (5,8%) hoger dan voor meisjes en tieners van het platteland. De prevalentie was 46,4% voor adolescenten met een BMI groter of gelijk aan het 85^{e} percentiel en met een of twee ouder(s) met het metabool syndroom. Van de adolescenten met overgewicht had 96% tenminste één kenmerk en 74,1% tenminste twee kenmerken van het metabool syndroom (**Hoofdstuk 4**).

De relatie tussen lichaamsgewicht, onvrede over het lichaam en symptomen van depressie is onderzocht bij 3886 Chinese kinderen (9 -10 jaar) van 20 scholen in Beijing (**Hoofdstuk 5**). 13,2% van de kinderen vertoonden depressieve kenmerken (jongens 16,7% en meisjes 9,5%). Meisjes met overgewicht hadden een significant hogere score voor depressie, terwijl dit voor jongens niet het geval was. Zowel obese meisjes als

jongens scoorden negatief met betrekking tot gevoel van eigenwaarde. Meer dan een vijfde van de meisjes met ondergewicht wilde nog slanker worden, terwijl een derde van de obese jongens nog zwaarder wilde zijn. Kinderen die slanker wilden zijn hadden een negatiever zelfbeeld en een negatiever beeld van hun schoolprestaties. Nadat we de variabele 'onvrede over het lichaam' hadden toegevoegd aan het model, was overgewicht nog steeds geassocieerd met totale depressie score bij meisjes en obesitas was nog steeds geassocieerd met negatief zelfbeeld bij zowel jongens als meisjes (**Hoofdstuk 5**).

In de algemene discussie (**Hoofdstuk 6**) worden de belangrijkste bevindingen van dit project samengevat en bediscussieerd. Vervolgens reflecteren we op een aantal zaken betreffende interne en externe validiteit. Ten eerste bediscussiëren we de interne validiteit inclusief representativiteit, definitie van obesitas bij kinderen, definitie van depressie bij kinderen, anthropometrie, bloedmonsters (nuchter glucose, triglyceride en HDL-C) en confounders zoals leeftijd, sociaal-economische status, opleidingsniveau van de moeder, gewicht van de ouders, voedingsfactoren en lichamelijke activiteit. Daarnaast reflecteren we op de externe validiteit inclusief de prevalentie van obesitas bij kinderen, het hebben van obesitas en tegelijkertijd te klein zijn voor de leeftijd en het metabool syndroom. Ten tweede interpreteren we de relatie tussen obesitas bij kinderen en mogelijke determinanten. Ook behandelen we mogelijke implicaties van onze bevindingen voor de volksgezondheid met een focus op preventie van obesitas bij Chinese kinderen. Tenslotte geven we diverse richtingen aan voor vervolgonderzoek.

Samengevat, obesitas is een toenemend probleem bij kinderen en tieners in China, vooral in stedelijke gebieden ondanks dat de prevalentie nog wel lager is dan in ontwikkelde landen (vooral in de plattelandsgebieden). De prevalentie van het metabool syndroom en depressie bij Chinese adolescenten met overgewicht is echter hetzelfde als in ontwikkelde landen. Vanuit het oogpunt van de volksgezondheid is het van belang om

preventieprogramma's voor obesitas te ontwikkelen. Vetinneming, activiteiten met lage intensiteit en actief vervoer van/naar school zouden mogelijk aanknopingspunten zijn voor de preventie van overgewicht bij Chinese schoolkinderen. Strategieën om obesitas bij kinderen te voorkomen –zoals gezonde voeding en voldoende lichamelijke activiteit- zijn overigens waardevol voor de gezondheid van alle kinderen, ongeacht of ze obees zijn, overgewicht of een normaal gewicht hebben.

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总结

中国儿童肥胖现状和影响因素及其对健康的危害

随着社会经济发展和物质生活水平的提高，高能量密度膳食、低体力活动和久坐少动的生活方式越来越普及。中国居民平均每天肉类食物消费量从 1982 年的 61 克增加到 2002 年的 159 克，每天食用油消费量平均每 10 年增加 10 克，而粮谷类食物和蔬菜消费量在过去 20 年间降低了 20%。与此同时，电视机和汽车拥有量迅速增加，公共交通工具也越来越普及。中国居民同时面临着营养不良和营养过剩的双重挑战。研究发现，近年来中国儿童肥胖率逐渐上升，但目前还缺乏有全国代表性的资料。

2002 年“中国居民营养与健康状况调查”在全国范围内展开，该调查融合了以往的营养、高血压、糖尿病、肥胖和血脂调查，并加入了生活方式的调查，为研究我国儿童肥胖现状及其影响因素以及肥胖对儿童健康的影响提供了很好的机会。本论文利用具有全国代表性的 2002 年中国居民营养与健康状况调查数据对中国儿童肥胖问题进行了分析和阐述。

论文包括以下内容 1) 2002 年中国 7-17 岁儿童少年超重肥胖率现况及其在过去 20 年中的变化趋势；2) 中国儿童肥胖的影响因素; 3) 2002 年中国儿童少年代谢综合症的现状和分布及其与肥胖的关系; 4) 儿童体重、对体型不满意程度及抑郁症之间的关系。

论文第二章利用“1982 年中国居民营养调查”（男孩 5 334 名、女孩 4 793 名）、“1992 年中国居民营养调查”（男孩 8 048 名、女孩 7 453 名）和“2002 年中国居民营养与健康状况调查”的数据对我国儿童肥胖的现状及其变化趋势进行了分析。调查结果显示：1982 年中国儿童少年肥胖率还很低，随后迅速增长，2002 年呈持续增长趋势,如果该增长趋势不能得到很好控制,我国儿童肥胖将很快达到流行水平。根据国际肥胖专家组指定的儿童肥胖定义，2002 年我国 7-17 岁儿童少年超重率为 4.4%，肥胖率为 0.9%，全国有一千二百万儿童少年超重或肥胖，占全世界超重肥胖儿童的 1/13。在儿童少年超重肥胖率增加的同时，超重肥胖儿童少年中身高发

育不足（生长迟缓）的比例逐渐降低。1982、1992 和 2002 年，超重儿童少年中生长迟缓的比例分别为 28.4%、22.0%和 5.7%，肥胖儿童少年中生长迟缓的比例则分别为 69.4%、46.4%和 7.7%。农村超重肥胖儿童少年中生长迟缓者所占的比例明显高于城市。1992 年，城市和农村肥胖儿童少年中生长迟缓的比例分别为 34.1%和 56.2%，到 2002 年，该比例分别降低到 2.9%和 21.6%。

为了探索有效的肥胖防治措施，**论文第三章**对我国超重肥胖儿童和正常体重儿童的膳食模式、体力活动模式、社会经济学特征及其父母的肥胖状态进行了比较。共 6826 名 7-17 岁儿童少年完成了 2002 年中国居民营养与健康状况调查的膳食和体力活动调查。比较结果显示：父母肥胖程度越高，儿童肥胖的危险性越大。与父母体重均正常的儿童相比，父母双方均肥胖的儿童超重肥胖的危险性增加 12.2 倍。与正常体重儿童相比，超重或肥胖的儿童膳食能量、蛋白质及脂肪摄入量高，而碳水化物摄入量比较低；食用油及肉和奶的消费量高，而粮谷类食物和蔬菜消费量低。超重肥胖儿童平均每天比正常体重儿童少进行半个小时的高强度体力活动，而久坐少动的静态活动时间平均每天多 2.3 小时。每天步行上下学的孩子中，超重肥胖率也比较低（**论文第三章**）。儿童超重率、肥胖率及其增长率均有明显的城乡差异和性别差异，城市高于农村，男孩高于女孩，并随家庭经济水平和父母文化程度的增加而增加（**论文第二章**）。 多因素分析结果表明，控制父母体重和社会经济学特征的相对影响后，食用油消费量和步行上下学是影响儿童肥胖的最主要的两个生活方式（**论文第三章**）。

超重肥胖儿童患代谢综合症的危险性增加（**论文第四章**）。由于我国目前尚没有全国性的关于儿童少年代谢综合症的资料及其与儿童少年肥胖关系的研究，该论文利用 2002 年中国居民与健康状况调查资料对全国 2761 名 15-19 岁少年的代谢综合症现况及其与肥胖关系进行了分析。结果表明：2002 年中国 15-19 岁少年代谢综合症患病率为 3.7%， 估计患病少年人数达到三百万。体重正常（BMI<第 85 百分位数）、超重（BMI：第 85-95 百分位数）和肥胖（BMI≥第 95 百分位数）的少年中代谢综合症患病率分别为 2.3%、23.4%和 35.2%。相对于其他孩子，城市男孩代谢综合症患病率最高，达到 5.8%。如果父母罹患代谢综合症，自己体型又超重或

肥胖的少年罹患代谢综合症的危险性明显增加，其代谢综合症患病率达到 46.4%。96%的超重肥胖少年至少有一项代谢异常，74.1%的超重肥胖儿童患有至少两项代谢异常。

超重肥胖儿童的心理问题越来越得到人们的关注。为了了解我国超重肥胖儿童的心理健康，我们在北京市的 20 所学校的 3886 名 9-10 岁的三、四年级学生中进行了抑郁量表测试（**论文第五章**）。测试结果表明：13.2%的儿童有患抑郁症的危险，其中男孩为 16.7%，女孩为 9.5%。超重女孩的抑郁症评分显著高于正常体重女孩。超重男孩和超重女孩的自信心均显著降低。超过五分之一的低体重女孩仍然想更瘦一些，而三分之一以上的肥胖男孩还想增加体重。那些希望自己更瘦一些的儿童效率指数和自信心指数均显著降低。控制对体型不满意程度的相对影响后，超重女孩的抑郁症指数仍然显著高于正常体重女孩，肥胖男孩和女孩的自信心也仍然显著低于正常体重男孩和女孩。

论文的第六章对本论文的主要发现进行了总结和讨论，并针对研究的内部和外部有效性展开了讨论。首先对其内部有效性进行了讨论，包括样本代表性、儿童肥胖的定义、儿童抑郁的定义、体格测量、血生化指标如空腹血糖、甘油三脂和高密度脂蛋白的测定，以及混杂因素，后者包括身高、社会经济状况、父母受教育程度、父母体重、膳食摄入和体力活动方式等。随后，与其它研究进行了比较，讨论了其外部有效性。该部分内容包括有关我国儿童肥胖率的不同研究之间的比较、有关肥胖者中生长迟缓比例的不同研究的相互比较以及不同的探讨我国少年代谢综合症问题的研究之间的比较。进而**论文的第六章又**对我国儿童肥胖影响因素研究结果进行了解释和讨论。在此基础上提出了本研究结果的公共卫生学意义，尤其是本研究对我国儿童肥胖防治可能有的贡献。最后，本论文提出了几个可能的今后研究的方向。

综上所述，虽然与发达国家相比，中国儿童肥胖率还比较低，尤其是农村地区，但儿童肥胖已经成为一个严重的公共卫生问题，尤其是在城市。中国超重肥胖儿童罹患代谢综合症及抑郁症的危险性均比较高。因此制定简单可行持续有效的儿童肥胖防治策略应该成为我国公共卫生研究的一个重要任务。鼓励儿童健康饮食

和多做体力活动，如控制脂肪摄入量、静态活动时间、鼓励步行上下学，无论对肥胖儿童还是正常体重儿童的健康都有促进作用。

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Curriculum Vitae

Yanping Li was born on Jan 22th 1972, in Hengshui, Hebei Province, China. After completing the middle school at “Qingliangdian Zhongxue” and high school at “Wuyi Zhongxue” in Hengshui, she started the bachelor program “Nutrition and Food Safety” in Tianjin Medical University. Within this program, she performed the research project “Nutrition status of swimming athletes in Tianjin” and obtained her bachelor degree in July 1995. She enrolled her master program in the Chinese Academy of Preventive Medicine (now Chinese Center for Disease Control and Prevention) in 1997, and her master thesis was on “relative effect of diet and physical activity on body composition among Chinese adults living in urban Beijing”, which was cooperated with Jean Mayer USDA Human Nutrition and Research Center on Aging at Tufts University.

From July 1995, Yanping Li worked in Epidemic Prevention Station of Hebei Province for two years. During this period, she participated in the scientific project “Child Nutrition Monitoring”, which was supported by Chinese government and UNICEF. From the autumn of 2000 by now, Yanping has been working in the Department of Student Nutrition, National Institute for Nutrition and Food Safety (INFS), Chinese Center for Disease Control and Prevention. She enrolled in several scientific projects in the field of obesity, physical activity, dietary measurements and body composition, including “School based childhood obesity prevention program in Beijing” supported by Nutricia Research Foundation, “risk factors of obesity among Chinese elders” and its follow up study supported by IAEA, “body composition of Chinese children”, “comparison of dietary methods including weighted food record, 24 hour dietary recall and food frequency questionnaire”, and “2002 China National Nutrition and Health Survey (CNNHS)”. From August 2003, she started her Sandwich PhD program between INFS and Wageningen University, and will defense her thesis on 17 December 2007 in Aula of Wageningen.

Research Publications

Publication in Peer-Reviewed English Journals

1. **Li Y**, Zhai F, Yang X, Schouten EG, Hu X, He Y, Luan D, Ma G: Determinants of childhood overweight and obesity in China. *Bri J Nutr* 2007, 97: 210-215.
2. **Li Y**, Ma G, Schouten EG, Hu X, Cui Z, Wang D, Kok FJ: Report on Childhood Obesity in China (5): Body weight, body dissatisfaction, and depression symptoms of Chinese children aged 9-10 years. *Biomed Environ Sci* 2007, 20: 11-18.
3. **Li Y**, Yang X, Zhai F, Kok FJ, Zhao W, Piao J, Zhang J, Cui Z, Ma G: Prevalence of metabolic syndrome among Chinese adolescents. *Bri J Nutr* 2007 Jun 30: 1-6 (Epub ahead of print)
4. **Li Y**, Schouten EG, Hu X, Cui Z, Luan D, Ma G: Obesity prevalence and time trend among youngsters in China. Asia Pac J Clin Nutr 2007 (Accepted)
5. **Li Y**, Hu X, Ma W, Wu J, Ma G: Body image perceptions among Chinese children and adolescents. *Body Image* 2005, 2: 91-103.
6. **Li Y**, Yang X, Zhai F, Piao J, Zhao W, Zhang J, Ma G: Disease risks of childhood obesity in China. *Bio Environ Sci* 2005, 18: 401-410.
7. **Li Y**, Ma G, Zhang Q, Du W and Pan H: Validity of body fat percentage using skinfold measurements in 12-14-year-old Chinese boys and girls. *Int J Body Comp Res* 2003, 1(2): 53-58.
8. **Li Y**, Zhang Q, Du W, Liu A, Pan H and Ma G: Comparison between air-displacement plethysmography and dual energy X-ray absorptiometry in 176 Chinese adolescents. *Int J Body Comp Res* 2003, 1(4): 131-136.
9. Ma G, **Li Y**, Jin Y, Du S, Kok FJ, Yang X: Assessment of intake inadequacy and

food sources of zinc of people in China. *Public Health Nutr* 2007; 19: 1-7.

10. Ma G, **Li Y**, Hu X, Cui Z, Yang X, Chen C: Report on childhood obesity in China (2) verification of BMI classification reference for overweight and obesity in Chinese children and adolescents. *Int J Body Comp Res* 2006;19:1-7.

11. Ma G, **Li Y**, Jin Y, Zhai F, Kok FJ, Yang X: Phytate intake and molar ratios of phytate to zinc, iron and calcium in the diets of people in China. *Eur J Clin Nutri* 2007, 61(3): 368-374.

12. Cui Z, **Li Y**, Di Y, Ba L, Hu X, Ma G: Relative risk of metabolic syndrome in middle aged adults with different weight living in urban Beijing, China. *J Comm Nutr* 2004: 6(3): 131-136.

13. Cui Z, **Li Y**, Di Y, Ba L, Hu X, Ma G: The relative influence of diet and physical activity on obesity in China. *J Comm Nutr* 2004: 6(3): 125-130.

14. Ma G, **Li Y**, Hu X, Ma W, Wu J: Effect of television viewing on pediatric obesity. *Biomed Environ Sci* 2002, 15(4): 291-297.

15. Ma G, Jin Y, **Li Y**, Zhai F, Kok FJ, Jacobsen E, Yang X: Iron and zinc deficiencies in China: what is a feasible and cose-effective strategy? *Public Health Nutr* 2007: Sep 26: 1-7 (Epub ahead of print)

16. Yao M, McCrory MA, Ma G, **Li Y**, Dolnikowski GG, Roberts SB: Energy requirements of urban Chinese adults with manual or sedentary occupations, determined with the doubly labeled water method. *Eur J Clin Nutr* 2002, 56: 575-584.

17. Gao X, Yao M, McCrory MA, Ma G, **Li Y**, Robert SB, Tucker KL: Dietary pattern is associated with homocysteine and B vitamin status in an Urban Chinese population. *J Nutr* 2003, 133: 3038-3042.

Publication in Chinese Journals

1. **Li Y**, Wang D, He Y, Hu X, Zhai F, Yang X, Ma G: Comparison of assessment of energy and nutrients intakes by using 3 dietary survey methods. *Zhong Guo Man Xing Bing Yu Fang Yu Kong Zhi* 2007, 15(2): 79-83.
2. **Li Y**, He Y, Zhai F, Yang X, Hu X, Zhao W, Ma G: Comparison of assessment of food intakes by using 3 dietary survey methods. *Zhong Hua Yu Fang Yi Xue Za Zhi* 2006, 40(4): 273-280.
3. **Li Y**, Song J, Pan H, Yao M, Hu X, Ma G: Validity of food frequency questionnaire to investigate the dietary energy and nutrients intake. *Ying Yang Xue Bao (Acta Nutrimenta Sinica)*. 2006, 28(2): 143-147.
4. **Li Y**, Hu X, Ma W, Ma G: The relationship between breakfast frequency and obesity prevalence among four cities in China. *Zhong Guo Xue Xiao Wei Sheng (Chi J School Health)* 2005, 26(1): 10-12.
5. **Li Y,** Ma G, Pan H, Cui Z, Zhang C, Song J, Hu X: The comparison of prevalence of overweight and obesity of adolescents using different references. *Zhong Guo Man Xing Bing Yu Fang Yu Kong Zhi* 2003, 11(6): 281-282.
6. Di Y, **Li Y**, Zhao B, Song J, Pan H, Ma G: Comparison of energy expenditure and physical activity level between different body weight adults. *Zhong Guo Lin Chuang Kang Fu* 2006, 10(24): 1-3.
7. Liu A, **Li Y**, Cui Z, Hu X, Luan D, Ma G: Analysis on average time of physical activity in a school day among Chinese students. *Zhong Guo Xue Xiao Wei Sheng* 2006, 27(6): 473-475.
8. Yang X, **Li Y**, Ma G, Hu X, Wang J, Cui Z, Wang Z, Yu W, Yang Z, Zhai F: Study on weight and height of the Chinese people and the differences between 1992 and 2002. *Zhonghua Liu Xing Bing Xue Za Zhi* 2005; 26(7): 489-493.

9. Ma G, **Li Y**, Wu Y, Zhai F, Cui Z, Hu X, Luan D, Hu Y, Yang X: The prevalence of body overweight and obesity and its changes among Chinese people during 1992 to 2002. *Zhonghua Yu Fang Yi Xue Za Zhi* 2005; 39(5): 311-315.

10. Ma G, **Li Y**, Han X, Ren H, Xu Y. The perception and attitudes on obese adolescents of Huiwen High School students in Beijing. *Zhong Guo Jian Kang Jiao Yu*. 2004, 20(11): 975-978.

11. Ma G, **Li Y**, Ma W, Wu J, Hu X: The relation between the frequency of fast food consumption and obesity prevalence among children and adolescents living in 4 cities of China. *Ying Yang Xue Bao* 2004, 26(6): 486-489.

12. Liu A, **Li Y**, Song J, Pan H, Han X, Ma G: Study on the validation of the computer science application's activity monitor in assessing the physical activity among adults using doubly labeled water method. *Zhonghua Liu Xing Bing Xue Za Zhi* 2005, 26(3): 197-200.

13. Ma G, **Li Y**, Pan H, Du W, Zhang Q, Liu A: The determination of percent body fat of 177 adolescents living in rural Beijing. *Ying Yang Xue Bao* 2003, 25(4): 353-356.

14. Ma G, Luan D, **Li Y**, Liu A, Hu X, Cui Z, Zhai F, Yang X: The association of physical activity and metabolic syndrome among employed population in China. *Obes Rev* 2008 (Accepted).

15. Ma G, Luan D, **Li Y**, Hu X, Liu A, Cui Z, Kong L, Yang X: The descriptive analysis of exercise participation of residents in China. *Zhong Guo Man Xing Bing Yu Fang Yu Kong Zhi* 2006, 14(1): 8-11.

16. Ma G, Cui Z, **Li Y**, Hu X, Wang J, Yang X: The survey about the use of dietary supplements by Chinese adults. *Ying Yang Xue Bao* 2006, 28(1): 8-10.

17. Ma G, Liu A，**Li Y**, Qu H, Yang H, Hu X: The physical activity patterns of children in 4-6 grades living in urban Beijing, China. *Zhong Guo Xue Xiao Wei Sheng* 2003, 24(4): 307-309.

18. Ma G, Luan D, Liu A, **Li Y,** Cui Z, Hu X: Physical activity level and its influencing factors among employed population in China. *Ying Yang Xue Bao (Acta Nutrimenta Sinica)* 2007, 29(4): 319-323.

19. Ma G, Luan D, Liu A, **Li Y,** Cui Z, Hu X: Design and evaluation of physical activity questionnaires among employed population in China. *Ying Yang Xue Bao (Acta Nutrimenta Sinica)* 2007, 29(3): 217-221.

20. Cui Z, Hu X, Luan D, **Li Y,** Zhun D, Wang J, Ma G: The juice consumption pattern of people in China. *China Food and Nutr* 2007, 8: 34-37.

21. Ma G, Cui Z, Hu X, Li Y, He Y, Zhai F, Yang X: The food consumption and outside eating behavior of Chinese residents. *China Food and Nutr* 2006, 12: 4-8.

22. Ma G, Hu X, Luan D, Li Y, Zhai F, Yang X: The eating practice of people in China. *Ying Yang Xue Bao (Acta Nutrimenta Sinica)* 2005, 27(4): 272-275.

23. Zhai F, He Y, Ma G, **Li Y**, Wang Z, Hu Y, Zhao L, Cui Z, Li Y, Yang X: Study on the current status and trend of food consumption among Chinese population. *Zhonghua Liu Xing Bing Xue Za Zhi* 2005, 26(7): 485-488.

24. Ma G, Kong L, Luan D, **Li Y**, Hu X, Wang J, Yang X: The Descriptive Analysis of the Smoking Pattern of People in China. *Zhong Guo Man Xing Bing Yu Fang Yu Kong Zhi* 2005, 13(5): 195-199.

25. Wu Y, Ma G, Hu Y, Li Y et al. Prevalence of overweight and obesity of Chinese people. *Zhong Hua Yu Fang Yi Xue Za Zhi* 2005, 39(5): 316-320.

26. Ma G, Liu A, Cui Z, **Li Y**, Hu X, Luan D, Yang X. The situation of television viewing of people in China. *Zhong Guo Jian Kang Jiao Yu* 2006, 22(3): 167-170.

27. Ma G, Cui Z, Hu X, **Li Y**, Liu A, Luan D, Kong L, Yang X. Analysis on sleeping time among Chinese population. *Zhong Guo Man Xing Bing Yu Fang Yu Kong Zhi* 2006, 14(2): 68-71.

Book chapters in Chinese

1. Report of 2002 China National Nutrition and Health Survey (9): behavior and life style. Beijing: People's Medical Publishing House. 2006.
2. Report of 2002 China National Nutrition and Health Survey (2): dietary and nutrition. Beijing: People's Medical Publishing House. 2006.
3. Report of 2002 China National Nutrition and Health Survey (3): physical development. Beijing: People's Medical Publishing House. 2006.
4. Nutrition and health of students in China. Beijing: Zhong Guo Ren Kou Chu Ban She.2006
5. Nutrition and health of students according to their family economic level. Beijing: Zhong Guo Ren Kou Chu Ban She.2007.

Overview of completed training activities

Discipline specific activities

- VLAG course nutritional and lifestyle epidemiology, 2002, 2004, 2006
- NAASO Annual meeting, Florida, USA, 2003
- The 9th National Nutrition Conference of China Nutrition Society, Beijing, China, 2004
- Physical activity pattern of Chinese population workshop, Beijing, China, 2004
- International physical activity and health workshop, Beijing, China, 2004
- Obesity among Chinese population workshop, Beijing, China, 2005
- Physical status of Chinese population workshop, Beijing, China, 2005
- Dietary and nutrition of Chinese population, Beijing, China, 2005
- 18th International nutrition congress, Durban, South Africa, 2005
- 6th International congress of obesity, Sydney, Australia, 2006
- Conference on obesity and related disease control in China, Beijing, China, 2006
- International cooking oil and health workshop, Beijing, China, 2006
- BODPOD technology and body composition research workshop, Beijing, China, 2006
- Project meeting of prevention of childhood malnutrition in Asia, Beijing, China, 2007
- International beverage forum on sport and health, Beijing, China, 2007
- Lifestyle and chronic disease prevention in China, Beijing, China, 2007

General courses

- Scientific writing in English, CENTA, 2003
- Upper intermediate English, CENTA, 2003
- Organizing and supervising MSc thesis work, China, 2006, 2007

Optional courses and activities

- Preparation PhD research proposal, 2003
- HNE course Epidemiology and public health, 2003
- HNE course Problem oriented training in nutrition and health, 2003
- PhD study tour USA, 2007