Dietary Patterns and Their Associations With Overweight/Obesity Among Preschool Children in Dongcheng District of Beijing: A Cross-sectional Study

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Abstract

Background

Few studies investigated associations between dietary patterns and overweight/obesity among Chinese preschool children. Thus, the study aimed to explore dietary patterns among preschool children in the Dongcheng District of Beijing, and their associations with overweight/obesity.

Methods

With a stratified proportionate cluster sampling, the study included 3,373 pairs of preschool children and their guardians. Children's weight and height were measured by school nurses, and their food and beverage consumption frequencies were reported by guardians via a food frequency questionnaire. Children's age, gender, physical activity time, and sedentary time, as well as their parents' highest level of educational attainment, occupation, weight, and height were also collected. Dietary patterns were identified through an exploratory factor analysis. Among these identified dietary patterns, the one with the largest factor score was defined as the predominant dietary pattern for each child. Associations between predominant dietary patterns and overweight/obesity were tested by two-level random-intercept logistic models with cluster-robust standard errors.

Results

Four dietary patterns, i.e., a “Sugar-sweetened beverage (SSB) and snack” pattern, a “Chinese traditional” pattern, a “Health conscious” pattern, and a “Snack” pattern, were identified. Among the children, 21.02% (95% CI: 19.68% to 22.43%) were predominated by the “SSB and snack” pattern, 27.78% (95% CI: 26.29% to 29.32%) by the “Chinese traditional” pattern, 24.90% (95% CI: 23.47% to 26.39%) by the “Health conscious” pattern, and 26.30% (95% CI: 24.84% to 27.81%) by the “Snack” pattern. After controlling for potential confounders, the “SSB and snack” pattern characterized by fresh fruit/vegetable juice, flavored milk drinks, carbonated drinks, flavored fruit/vegetable drinks, tea drinks, plant-protein drinks, puffed foods, fried foods, and Western fast foods was associated with a higher risk of overweight/obesity (OR: 1.61, 95% CI: 1.09 to 2.38), compared with the “Chinese traditional” pattern.

Conclusions

A preference for foods high in energy density but low in nutritional value was prevalent among preschool children in the Dongchen District of Beijing. Comprehensive measures to simultaneously reduce consumption of SSBs and unhealthy snacks among preschool children should be taken urgently to fight against rising childhood obesity in China, particularly in metropolises.

Background

Maintaining a healthy weight status in childhood is important, given that childhood obesity can increase the risk of short- and long-term adverse consequences, both physically and mentally (1). It's worrying that the prevalence of overweight and obesity among children and adolescents has increased all over the world (2), and very young children are affected — about forty-one million children aged under five were overweight or
obese in 2016 globally, with almost half of them living in Asia (3). Although there appears to be a plateau of obesity epidemic among children and adolescents in some developed countries (4), the prevalence of obesity among children and adolescents aged seven to eighteen increased from 0.1% to 7.3% in China from 1985 to 2014 (5). Besides, inequalities in the prevalence of overweight and obesity are documented in China — a greater prevalence increase was observed among higher socioeconomic status (SES) children (6). For example, in Beijing, the Capital of China, the prevalence of overweight and obesity among preschool children (19.44% in 2016 in Shijingshan District) (7) was comparable to some developed countries where the rate was estimated to be 11.7% in 2010, and expected to reach 12.9% in 2015 (8).

Eating habits in the early years are likely to track into later childhood, and form the basis of eating patterns in adulthood (9, 10). Unhealthy eating is increasingly contributing to the surging global burden of non-communicable diseases (11). In China, where dietary patterns have been changing significantly in the past four decades, along with the rapid economic development (12), children have been exposed to unhealthy food environments (13) which would potentially facilitate unhealthy dietary patterns. For example, China is Coke’s third-largest market by volume (14), and consumption of sugar-sweetened beverages (SSBs) has become popular among children and adolescents (15). Dietary patterns have been used to summarize dietary consumption and evaluate how diets are associated with diseases in epidemiological researches (16). Few studies investigated associations between dietary patterns and overweight/obesity among Chinese preschool children (17), while some did in other countries (18-21). The present study aimed to identify dietary patterns among preschool children in the Dongcheng District of Beijing, and examine their associations with overweight/obesity.

Methods

Study design and participants

Study settings

The study was conducted in local kindergartens, that is, schools that provide normal education to children aged three to six in the Dongcheng District, the eastern half of the downtown area of Beijing. The study was approved by the Ethics Committee of Dongcheng Center for Disease Control and Prevention (DCCDPCIRB-20180416-1).

Eligibility criteria

As children in the third year of kindergarten are going to attend primary schools, eligible participants were children registering in the first year and the second year of the chosen kindergartens at the time of recruitment. One guardian of these children was also required to participate.

Sampling and survey procedures

Taking each class as a cluster, a stratified proportionate cluster sampling was used. The number of classes to recruit was determined by a sample size estimation formula:

\[ N = k \times \frac{\frac{u_1^2}{2}}{\delta^2} \]
Assuming the prevalence of overweight/obesity among children in the first year and the second year of kindergarten in the Dongcheng District \( (P) \) was 15\% (estimated through a pilot study), a two-sided significance level of 5\% (\( \alpha = 1.96 \)), a minimally detectable rate difference (\( \delta \)) of 1.5\%, and a 10\% non-response rate and a 1.5 design effect of cluster sampling (\( k = 1.65 \)), the number of child-guardian dyads needed was calculated to be 3,592. On the basis of 20 to 30 children per class, and 4 to 10 classes of the first year and the second year per kindergarten, approximately 150 classes of 20 kindergartens were required. A full list of the forty-four kindergartens in the Dongcheng District was extracted from the local education bureau, and stratified by financing sources and implementation of health promotion activities. Random numbers were generated to select kindergartens by stratification. Principals of the selected twenty kindergartens were contacted prior to the survey for their approval of participation, and fifteen agreed. With written informed consent from themselves and their legal guardians, all of the 4,237 children in classes of the first year and the second year from the fifteen kindergartens, along with one of their guardians, were invited to participate from April 2018 till the end of the Spring Semester of 2017/2018 Academic Year. Questionnaires with unique ID numbers were distributed by teachers in charge of classes who had received standardized training and were responsible for providing necessary instructions to guardians. Guardians then took questionnaires home and completed them anonymously on behalf of their children, considering preschool children were not capable of reading and writing. One week later, questionnaires were collected and preliminarily checked by teachers in charge of classes. Blank questionnaires were permitted if children or guardians refused to participate. A total of 3,585 child-guardian dyads participated in the survey, with a response rate of 84.61\% (3585/4237), and incomplete information resulted in 212 dyads further eliminated from analyses. Figure 1 provides details on sampling procedures.

**Measurements**

**Weight and height**

Children's weight and height were measured annually (usually at the end of a semester, which is close to the survey date) by trained school nurses following standardized anthropometry measurement protocols developed by the Child Care Center of Beijing Health Bureau to the nearest 0.1 kg and 0.1 cm, with children wearing light clothes and no shoes. Children's weight and height were also attached to unique ID numbers, enabling matching with their questionnaire data. Children's body mass index (BMI) was calculated, and weight status was defined by criteria developed by the World Health Organization (WHO) (22-24): the children aged three to four whose BMI z-scores greater than 2 standard deviations \((SDs)\) and 3 \(SDs\) from medians of specific age and gender groups were classified as overweight and obesity, respectively, and for children aged five, the cut-points were 1 \(SD\) and 2 \(SDs\).

**Dietary consumption frequencies**

In reference to *The Dietary Guidelines for Chinese Preschool Children 2016* (25), a validated food frequency questionnaire (FFQ) (26) was adapted and developed to measure children's usual consumption frequencies of twenty-five food and beverage groups frequently consumed by the Chinese with seven alternatives (never, less than once a week, once a week, twice to four times a week, five to six times a week, seven times a week, and more than seven times a week) scored 0 to 6, and several examples were annotated for some confusing groups to improve interpretability. Portion sizes were not collected, as better validity correlations were obtained.
in FFQs not assessing them (27). Additional file 1 is an English version of the FFQ. Food and beverage groups were deemed to be “consumed” when their consumption frequencies were between less than once a week and more than seven times a week. Test-retest reliability of the FFQ was pretested in a pilot study among a convenience sample of 175 pairs of preschool children and guardians, and the results are available in Additional file 2. Given the low consumption frequencies and poor reliability of coffee drinks and energy drinks or sports drinks, they were eliminated from the analyses of dietary patterns and their associations with overweight/obesity. In that condition, reliability of the adapted FFQ was moderate and comparable to the original one (26).

**Covariates**

Age, gender, daily average time of moderate-to-vigorous physical activities (MVPA) on weekdays and weekends, and daily average sedentary time on weekdays and weekends of the children, as well as the highest level of educational attainment, occupation, weight, and height of their parents were also collected via single questions. Parents’ SES scores (28) and BMI were calculated, and their weight status was defined by criteria developed by the Working Group on Obesity in China (WGOC) (29): BMI of 24 kg/m$^2$ and 28 kg/m$^2$ were taken as cut-points for overweight and obesity, respectively.

**Statistical analyses**

Normally-distributed continuous, skewedly-distributed continuous, and categorical variables were presented as means (SDs), medians (25th and 75th percentiles), and frequencies (percentages), respectively. Dietary patterns were identified through an exploratory factor analysis (EFA) (30) whose applicability was confirmed by the Bartlett’s test of sphericity and the Kaiser-Meyer-Olkin (KMO) value. The number of retained factors was determined by eigenvalues (greater than 1) and interpretability, and factors were rotated with an orthogonal (varimax) rotation to minimize mutual correlations and improve interpretability. Factor loadings represented correlations between each food and beverage group and each factor – loadings greater than 0.3 stood for positive correlations, while those less than -0.3 for negative. In accordance with descriptions of these correlations, each factor was named a specific dietary pattern. Through weighting standardized consumption frequencies of food and beverage groups by their factor loadings and adding up all these values, pattern-specific factor scores were calculated for each child, and the dietary pattern with the largest factor score was defined as the predominant dietary pattern. Differences across predominant dietary patterns in children’s age were tested by one-way analysis of variance, in children’s gender and consumption proportions of food and beverage groups by Pearson’s chi-square tests, and in children’s BMI and weight status, parents’ SES scores and weight status, and consumption frequencies of food and beverage groups by Kruskal-Wallis tests.

Considering the multi-stage sampling procedure adopted where classes were taken as clusters, two-level random-intercept logistic models with cluster-robust standard errors, extensions of standard logistic models that treated intercepts as random variables to account for the clustering of one-level units (children) within two-level units (classes) (31), were conducted to estimate associations between predominant dietary patterns and overweight/obesity, a binary outcome. A null model without any independent variable was run firstly to verify the hierarchy of data, and subsequently, the first model (model 1) only including predominant dietary patterns, the second model (model 2) including adjustment for children’s age and gender, the third model (model 3) including further adjustment for children’s daily average time of MVPA and daily average sedentary
time, on weekdays and on weekends respectively, and the fourth model (model 4) including further adjustment for parents’ SES scores and BMI were fitted. Correlations were expressed as odds ratios (ORs) with 95% confidence intervals (CIs). Please refer to Additional file 3 for variable definitions and Stata codes of these models. Lastly, a sensitivity analysis was carried out in the same way as model 4, but defining overweight/obesity by criteria specific to Chinese preschool children (32). Data imputation was applied in the EFA and the two-level models by using means, medians, and modes to replace missing data in normally-distributed continuous, skewedly-distributed continuous, and categorical variables, respectively. All the analyses were completed using Stata/SE 16.0 for Windows (StataCorp, College Station, Texas, USA). Statistical significance was considered when $P \leq 0.05$ (two-sided).

**Results**

Table 1 provides characteristics of the children and their parents. A total of 3,373 children with a mean age of 4.24 ($SD: 0.67$) years participated in the study. Over half (52.33%) of them were boys, and 8.19% were either overweight or obese. The majority (94.40%) of the guardians who participated in the survey were either children’s mothers (70.01%) or fathers (23.39%). About one fifth (17.79%) of the mothers and over half (57.58%) of the fathers were classified as either overweight or obese.

Table 2 shows consumption proportions and frequencies for each food and beverage group. Nearly two thirds of the children consumed fruits (71.66%) and vegetables (61.52%) more than seven times a week, while the proportion was smaller for milk (49.81%) and yogurt or other dairy products (30.74%). Meanwhile, approximately one fifth (21.20%) of the children did not consume any one of the seven SSB groups (flavored milk drinks, carbonated drinks, flavored fruit/vegetable drinks, energy drinks or sports drinks, tea drinks, plant-protein drinks, and coffee drinks), and only 11 children consumed none of the five high-energy snack groups (sweets, pastries, puffed foods, fried foods, and western fast foods).

The Bartlett’s test of sphericity was statistically significant ($P < 0.001$), and the KMO value was 0.828, both indicating the applicability of an EFA. Although there were six factors with eigenvalues greater than 1, only four were retained by the reason of interpretability, which altogether accounted for 43.22% of the total variance. Table 3 presents loadings on the four factors of food and beverage groups after rotation. The first factor was named the “SSB and snack” pattern, as being positively related to fresh fruit/vegetable juice, flavored milk drinks, carbonated drinks, flavored fruit/vegetable drinks, tea drinks, plant-protein drinks, puffed foods, fried foods, and Western fast foods. Likewise, the second factor characterized by fruits, vegetables, dark-green vegetables, other dark-color vegetables, meat or poultry, and other protein-rich foods was named the “Chinese traditional” pattern. The third pattern characterized by soybean milk, milk, yogurt or other dairy products, nuts, wheat or wheat foods, fishery products, and other protein-rich foods was named the “Health conscious” pattern. The fourth pattern characterized by sweets, pastries, puffed foods, fried foods, and Western fast foods was named the “Snack” pattern. Among the children, 21.02% (95% CI: 19.68% to 22.43%) were predominated by the “SSB and snack” pattern, 27.78% (95% CI: 26.29% to 29.32%) by the “Chinese traditional” pattern, 24.90% (95% CI: 23.47% to 26.39%) by the “Health conscious” pattern, and 26.30% (95% CI: 24.84% to 27.81%) by the “Snack” pattern.
Table 4 describes the differences in participants’ characteristics and consumption proportions of food and beverage groups by predominant dietary patterns, and Additional file 4 includes more detailed information on the differences in consumption frequencies of food and beverage groups. In relative to other dietary patterns, BMI medians of the children predominated by the “SSB and snack” pattern and the “Snack” pattern were larger, but parents’ SES scores were smaller for the children predominated by the “SSB and snack” pattern. Apart from fruits, vegetables, and yogurt or other dairy products, consumption proportions of 20 food and beverage groups were statistically different across predominant dietary patterns.

The null model confirmed the hierarchy of data (intraclass correlation coefficient = 0.10, 95% CI: 0.06 to 0.18). Table 5 displays associations between predominant dietary patterns and overweight/obesity. After adjusting for potential confounders, the “SSB and snack” pattern was positively related to overweight/obesity — compared with the “Chinese traditional” pattern, the odds of being overweight/obesity for the children predominated by the “SSB and snack” pattern increased to 1.61 (95% CI: 1.09 to 2.38).

Similar results were obtained from the sensitivity analysis: under a criteria specific to Chinese preschool children (32), 17.76% (95% CI: 16.48% to 19.09%) of the children were either overweight or obese, and compared with the “Chinese traditional” pattern, solely the “SSB and snack” pattern was positively associated with overweight/obesity (OR: 1.47, 95% CI: 1.12 to 1.91) after controlling for potential confounders.

**Discussion**

In the cross-sectional study conducted among preschool children in the Dongcheng District of Beijing, four dietary patterns, i.e., a “SSB and snack” pattern, a “Chinese traditional” pattern, a “Health conscious” pattern, and a “Snack” pattern, were identified. Roughly half of the children had a preference for the “SSB and snack” pattern and the “Snack” pattern which were high in energy density but low in nutritional value. After controlling for potential confounders, the “SSB and snack” pattern was associated with a higher risk of overweight/obesity, compared with the “Chinese traditional” pattern.

Although types and numbers of dietary patterns identified among preschool children vary across countries, several main patterns considered as healthy, less healthy, and traditional have been observed (17-21, 33, 34), with which the dietary patterns identified in the current study share many characteristics. For example, five dietary patterns were identified among children aged three to six in Ma’anshan City, China, including a “Beverage” pattern characterized by flavored milk, drinks, carbonated beverages, and yogurt, a “Protein” pattern by red meat, poultry, egg, fish and other fishery products, and fruits, and a “Snack” pattern by sweets, chocolate, biscuits or cake, puffed foods, and milk-based puddings and custard (34). Given unhealthy eating in early years could track to mid-childhood and even later life (9, 10), it is important to promote healthy dietary patterns among preschool children. Nonetheless, nearly half of the children in the present study were predominated by the “SSB and snack” pattern and the “Snack” pattern, both characterized by diets high in energy density but low in nutritional value. It would be well worth noting that a “Health conscious” pattern characterized by soybean milk, milk, yogurt or other dairy products, nuts, wheat or wheat foods, fishery products, and other protein-rich foods was identified in the present study, as well as a previous study in Wuhu City, China (33), reflecting a possibly raising awareness of nutrition and health among guardians of Chinese
preschool children. We expect this to be a predictor of children's adherence to healthy dietary patterns, and additional in-depth study to explore correlates and effects of this pattern would be worthwhile.

In China, preschool children in underdeveloped areas, such as western rural areas, still suffer from undernutrition, while in metropolises, such as Beijing, overweight and obesity are increasingly prevalent (35). The epidemiological evidence on associations between dietary patterns and overweight/obesity is inconsistent among Chinese population — a study among school-aged children and adolescents from seven provinces reported a dietary pattern characterized by fried foods, snacks, western fast foods, soft drinks, and eating outside was a risk factor for overweight/obesity (36), whilst another study conducted among the same age group in Ningxia, an underdeveloped area, did not find such association (37). One potential explanation of the contradiction in cross-sectional studies is that overweight/obese children could have changed their dietary behaviors by the time when the survey was carried out (38). In the present study, compared with the “Chinese traditional” pattern, the correlation between the “SSB and snack” pattern and overweight/obesity was statistically significant. This pattern indicates that SSB consumers were more likely to snack. According to the hypothesis proposed by a previous study, the preference for sweet taste triggered by repeated exposure to SSBs (or unhealthy snacks) may cause high consumption of unhealthy snacks (or SSBs) (39), which eventually leads to more energy intake. As the sweet preference of children can be modified by even a short period of repeated exposure (39), comprehensive measures to simultaneously reduce the exposure to SSBs and unhealthy snacks among children are reasonable and urgent.

In the present study, the children predominated by high-energy and low-nutrient dietary patterns had parents in lower SES, which is consistent with previous studies (18, 40, 41). Existing evidence suggests that parenting practices, such as serving unhealthy foods and beverages at meals, and providing them to children whenever they want, mediate the association between parents’ SES and children's unhealthy eating (42, 43) are more likely to make healthy food choices for their children (46, 47). Thus, it is beneficial to help low SES parents improve knowledge and ability for understanding and using nutrition labels. In addition, imposing taxes on SSBs and unhealthy snacks to control demands for them has also been proved effective among low SES population in some countries (48, 49), as when costs of these products get higher, the availability of them in low SES families might accordingly become lower (50). Further studies should be conducted in China to help children move towards healthier eating.

Findings of the present study should be interpreted with consideration of following limitations. Firstly, the study was based on a cross-sectional survey, where children's dietary consumption and weight status were obtained at the same time, leading to difficulties in confirming cause-effect relationships. Secondly, among the twenty representative kindergartens initially sampled, five declined to participate, which may weaken generalizability of the results. Thirdly, the study got responses from children's guardians, and they might be unable to accurately capture children's dietary consumption and physical activities out of home (mainly at kindergartens). This limitation may not have major impacts on the results, since guardians were in close contact with kindergartens to keep track of their children's dietary, physical activities, etc. Fourthly, the EFA adopted to identify dietary patterns involved several arbitrary decisions, including the number of factors to extract and the method of rotation (51). Hence, dietary patterns identified in the present study might be difficult to exactly replicate among other populations. Finally, associations between predominant dietary patterns and overweight/obesity were possibly biased by residual confounding effects, especially from variables difficult to
measure precisely with a questionnaire, such as dietary consumption and physical activities. This problem could be dealt with in future studies by adopting more objective and accurate measurement tools, such as wearable automated cameras and accelerometers.

**Conclusion**

Nearly half of the children had a tendency to choose dietary patterns high in energy density but low in nutritional value. A “SSB and snack” pattern characterized by SSBs and high-energy snacks was positively associated with overweight/obesity, compared with a “Chinese traditional” pattern. In fighting against childhood obesity in China, particularly in metropolises, these findings highlight the importance and urgency of taking comprehensive measures to simultaneously reduce consumption of SSBs and unhealthy snacks among preschool children.

**Abbreviations**

BMI: body mass index

CI: confidence interval

EFA: exploratory factor analysis

FFQ: food frequency questionnaire

KMO value: Kaiser-Meyer-Olkin value

\( M (Q_1, Q_2) \): median (25th and 75th percentiles)

MVPA: moderate-to-vigorous physical activities

OR: odds ratio

SD: standard deviation

SE: standard error

SES: socioeconomic status

SSB: sugar-sweetened beverage

WGOC: Working Group on Obesity in China

WHO: World Health Organization

**Declarations**

Ethics approval and consent to participate
This study was approved by the Ethics Committee of Dongcheng Center for Disease Control and Prevention (DCCDPCIRB-20180416-1). All participants provided written informed consent for participating, and for the preschool children, written informed consent was obtained from themselves and their legal guardians.

Consent for publication

Not applicable.

Availability of data and materials

According to private and confidential clauses stated in the informed consent, the dataset generated and analysed during the current study is ethically restricted and not publicly available. It would be available from Prof. Juan ZHANG (E-mail: zhangjuan@sph.pumc.edu.cn) on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

JZ, JW, FS, LW, GL, and YJ conceived and designed the survey. JZ, WL, SC, KM, YL, and PZ designed the questionnaires. SC, KM, YL, PZ, KY, and LS performed the survey. KM analyzed the data, interpreted results, and drafted and edited the manuscript. JZ, TA, and XF revised the manuscript. All authors read and approved the final manuscript.

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Tables

Table 1. Characteristics of Participants ($N = 3373$)
| Characteristics                                                                 | Statistics                      |
|-------------------------------------------------------------------------------|---------------------------------|
| **Children**                                                                  |                                 |
| Children's age (years), mean $(SD)$                                            | 4.24 (0.67)                     |
| Three-year-old, $n$ (%)                                                        | 464 (13.76)                     |
| Four-year-old, $n$ (%)                                                         | 1652 (48.98)                    |
| Five-year-old, $n$ (%)                                                         | 1257 (37.27)                    |
| Children's gender, $n$ (%)                                                     |                                 |
| Boy                                                                            | 1765 (52.33)                    |
| Girl                                                                           | 1608 (47.67)                    |
| Children's grades, $n$ (%)                                                     |                                 |
| The first year of kindergarten                                                 | 1736 (51.47)                    |
| The second year of kindergarten                                                | 1637 (48.53)                    |
| Children's BMI $(kg/m^2)$, $M (Q1, Q2)$                                        | 15.34 (14.49, 16.27)           |
| Children's weight status, $n$ (%)                                              |                                 |
| Underweight or normal weight                                                   | 3097 (91.82)                    |
| Overweight                                                                    | 179 (5.31)                      |
| Obesity                                                                       | 97 (2.88)                       |
| Relationships between participating guardians and children, $n$ (%)            |                                 |
| Father-child                                                                  | 789 (23.39)                     |
| Mother-child                                                                  | 2395 (71.01)                    |
| Other relationships                                                           | 160 (4.74)                      |
| Data missing                                                                  | 29 (0.86)                       |
| Children's parents                                                             |                                 |
| Parents' age$^a$ (years), mean $(SD)$                                          |                                 |
| Father                                                                        | 37.12 (4.39)                    |
| Mother                                                                        | 35.16 (3.45)                    |
| Parents' highest level of educational attainment, $n$ (%)                      |                                 |
| Father                                                                        |                                 |
| Technical college or below                                                     | 778 (23.07)                     |
| University                                                                    | 1600 (47.44)                    |
| Characteristics                          | Statistics         |
|-----------------------------------------|--------------------|
| Postgraduate or above                   | 956 (28.34)        |
| Data missing                            | 39 (1.16)          |
| Mother                                  |                    |
| Technical college or below              | 657 (19.48)        |
| University                              | 1789 (53.04)       |
| Postgraduate or above                   | 882 (26.15)        |
| Data missing                            | 45 (1.33)          |
| Parents’ occupations, n (%)             |                    |
| Father                                  |                    |
| Administrative                          | 785 (23.27)        |
| Technician                              | 839 (24.87)        |
| Clerk                                   | 1048 (31.07)       |
| Other occupation                        | 623 (18.47)        |
| Data missing                            | 78 (2.31)          |
| Mother                                  |                    |
| Administrative                          | 652 (19.33)        |
| Technician                              | 746 (22.12)        |
| Clerk                                   | 1245 (36.91)       |
| Other occupation                        | 639 (18.94)        |
| Data missing                            | 91 (2.70)          |
| Parents’ weight status, n (%)           |                    |
| Father                                  |                    |
| Underweight or normal weight            | 1276 (37.83)       |
| Overweight                              | 1394 (41.33)       |
| Obesity                                 | 548 (16.25)        |
| Data missing                            | 155 (4.60)         |
| Mother                                  |                    |
| Underweight or normal weight            | 2646 (78.45)       |
| Overweight                              | 507 (15.03)        |
### Characteristics

| Characteristics  | Statistics  |
|------------------|-------------|
| Obesity          | 93 (2.76)   |
| Data missing     | 127 (3.77)  |

Abbreviations: SD: standard deviation; BMI: body mass index; $M (Q1, Q2)$: median (25th and 75th percentiles).

Note: Missing data exists.

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**Table 2. Consumption Proportions and Frequencies of Food and Beverage Groups ($N = 3373$)**
| Food and beverage groups | Consumption proportions with 95% CIs (%) | Consumption frequencies, n (%) | Data missing |
|-------------------------|----------------------------------------|--------------------------------|-------------|
|                         | Less than once a week | Once a week | Twice to four times a week | Five to six times a week | Seven times a week | More than seven times a week |
| **Fruits**              |                         |                |                              |                            |                       |                               |
| Fruits                  | 99.91 (99.74, 99.98)    | 6 (0.18)       | 13 (0.39)                    | 125 (3.71)                 | 282 (8.36)            | 491 (14.56)                 | 2417 (71.66) | 36 (1.07) |
| Vegetables              | 99.85 (99.65, 99.95)    | 17 (0.50)      | 49 (1.45)                    | 269 (7.98)                 | 360 (10.67)           | 520 (15.42)                | 2075 (61.52) | 78 (2.31) |
| Dark-green vegetables   | 99.50 (99.19, 99.71)    | 113 (3.35)     | 276 (8.18)                   | 1085 (32.17)               | 687 (20.37)           | 391 (11.59)                | 691 (20.49) | 113 (3.35) |
| Other dark-color vegetables | 99.70 (99.46, 99.86) | 52 (1.54)     | 230 (6.82)                   | 1000 (29.65)               | 775 (22.98)           | 471 (13.96)                | 771 (22.86) | 64 (1.90) |
| Fresh fruit/vegetable juice | 84.73 (83.47, 85.93) | 1061 (31.46)  | 691 (20.49)                  | 695 (20.60)                | 151 (4.48)            | 87 (2.58)                   | 116 (3.44) | 57 (1.69) |
| Soybean milk            | 68.84 (67.25, 70.40)    | 1166 (34.57)   | 599 (17.76)                  | 372 (11.03)                | 59 (1.75)             | 29 (0.86)                   | 46 (1.36) | 51 (1.51) |
| **Milk**                |                         |                |                              |                            |                       |                               |
| Milk                    | 97.48 (96.89, 97.98)    | 119 (3.53)     | 135 (4.00)                   | 471 (13.96)                | 389 (11.53)           | 483 (14.32)                | 1680 (49.81) | 11 (0.33) |
| Yogurt or other dairy products | 98.55 (98.08, 98.92) | 112 (3.32)    | 170 (5.04)                   | 774 (22.95)                | 620 (18.38)           | 594 (17.61)                | 1037 (30.74) | 17 (0.50) |
| **Flavored milk drinks** |                         |                |                              |                            |                       |                               |
| Flavored milk drinks    | 54.52 (52.82, 56.21)    | 944 (27.99)    | 320 (9.49)                   | 299 (8.86)                 | 88 (2.61)             | 58 (1.72)                   | 66 (1.96) | 64 (1.90) |
| Carbonated drinks       | 26.50 (25.02, 28.03)    | 608 (18.03)    | 142 (4.21)                   | 79 (2.34)                  | 22 (0.65)             | 5 (0.15)                    | 10 (0.30) | 28 (0.83) |
| **Flavored fruit/vegetable drinks** | 53.16 (51.46, 54.85) | 1172 (34.75)  | 343 (10.17)                  | 196 (5.81)                 | 26 (0.77)             | 19 (0.56)                   | 17 (0.50) | 20 (0.59) |
| Energy drinks or sports drinks | 16.34 (15.10, 17.63) | 389 (11.53)   | 84 (2.49)                    | 34 (1.01)                  | 10 (0.30)             | 4 (0.12)                    | 4 (0.12) | 26 (0.77) |
| Tea drinks              | 20.49 (19.14, 21.89)    | 453 (13.43)    | 112 (3.32)                   | 58 (1.72)                  | 7 (0.21)              | 5 (0.15)                    | 11 (0.33) | 45 (1.33) |
| Plant-protein drinks    | 44.41 (42.73, 46.11)    | 1081 (32.05)   | 246 (7.29)                   | 97 (2.88)                  | 24 (0.71)             | 9 (0.27)                    | 11 (0.33) | 30 (0.89) |
| **Coffee drinks**       | 3.11 (2.55, 3.76)       | 53 (1.57)      | 5 (0.15)                     | 4 (0.12)                   | 7 (0.21)              | 2 (0.06)                    | 3 (0.09) | 31 (0.92) |
| Sweets                  | 96.74 (96.08, 97.31)    | 673 (19.95)    | 704 (20.87)                  | 1244 (36.88)               | 338 (10.02)           | 142 (4.21)                  | 145 (4.30) | 17 (0.50) |
| Food and beverage groups | Consumption proportions with 95% CIs (%) | Consumption frequencies, $n$ (%) | Data missing |
|--------------------------|----------------------------------------|---------------------------------|--------------|
|                          | Less than once a week | Once a week | Twice to four times a week | Five to six times a week | Seven times a week | More than seven times a week |
| Pastries                 | 97.51 (96.93, 98.01) | 757 (22.44) | 939 (27.84) | 1188 (35.22) | 251 (7.44) | 77 (2.28) | 49 (1.45) | 28 (0.83) |
| Puffed foods             | 71.51 (69.95, 73.03) | 1491 (44.20) | 552 (16.37) | 291 (8.63) | 25 (0.74) | 13 (0.39) | 6 (0.18) | 34 (1.01) |
| Fried foods              | 79.63 (78.23, 80.98) | 1729 (51.26) | 667 (19.77) | 227 (6.73) | 19 (0.56) | 8 (0.24) | 4 (0.12) | 32 (0.95) |
| Western fast foods       | 83.04 (81.73, 84.29) | 1951 (57.84) | 602 (17.85) | 175 (5.19) | 19 (0.56) | 10 (0.30) | 8 (0.24) | 36 (1.07) |
| Nuts                     | 95.14 (94.36, 95.84) | 721 (21.38) | 819 (24.28) | 1086 (32.20) | 325 (9.64) | 110 (3.26) | 119 (3.53) | 29 (0.86) |
| Wheat or wheat foods     | 86.87 (85.68, 87.99) | 1052 (31.19) | 898 (26.62) | 667 (19.77) | 165 (4.89) | 64 (1.90) | 50 (1.48) | 34 (1.01) |
| Meat or poultry          | 99.58 (99.30, 99.77) | 59 (1.75) | 120 (3.56) | 676 (20.04) | 714 (21.17) | 619 (18.35) | 1142 (33.86) | 29 (0.86) |
| Fishery products         | 98.49 (98.02, 98.87) | 271 (8.03) | 715 (21.20) | 1417 (42.01) | 486 (14.41) | 205 (6.08) | 196 (5.81) | 32 (0.95) |
| Other protein-rich foods | 99.58 (99.30, 99.77) | 48 (1.42) | 181 (5.37) | 822 (24.37) | 704 (20.87) | 661 (19.60) | 921 (27.31) | 22 (0.65) |

Abbreviation: CI: confidence interval.

Table 3. Factor Loadings after Orthogonal Rotation on Identified Dietary Patterns of Food and Beverage Groups$^{a,b}$ ($N = 3373$)
| Food and beverage groups<sup>c</sup> | “Sugar-sweetened beverage and snack” pattern | “Chinese traditional” pattern | “Health conscious” pattern | “Snack” pattern |
|-----------------------------------|--------------------------------------------|-------------------------------|----------------------------|-----------------|
| Fruits                            | 0.67                                       |                               |                            |                 |
| Vegetables                        | 0.77                                       |                               |                            |                 |
| Dark-green vegetables             | 0.68                                       |                               |                            |                 |
| Other dark-color vegetables       | 0.66                                       |                               |                            |                 |
| Fresh fruit/vegetable juice       | 0.39                                       | 0.45                          |                            |                 |
| Soybean milk                      | 0.48                                       | 0.44                          |                            |                 |
| Milk                              |                                            | 0.42                          |                            |                 |
| Yogurt or other dairy products    |                                            | 0.36                          |                            |                 |
| Flavored milk drinks              | 0.58                                       |                               |                            |                 |
| Carbonated drinks                 | 0.63                                       |                               |                            |                 |
| Flavored fruit/vegetable drinks   | 0.66                                       |                               |                            |                 |
| Tea drinks                        | 0.64                                       |                               |                            |                 |
| Plant-protein drinks              | 0.63                                       |                               |                            |                 |
| Sweets                            |                                            | 0.70                          |                            |                 |
| Pastries                          |                                            | 0.32                          | 0.63                       |                 |
| Puffed foods                      | 0.41                                       |                               |                            | 0.63           |
| Fried foods                       | 0.43                                       |                               |                            | 0.62           |
| Western fast foods                | 0.37                                       |                               |                            | 0.47           |
| Nuts                              |                                            | 0.56                          |                            |                 |
| Wheat or wheat foods              |                                            | 0.65                          |                            |                 |
| Meat or poultry                   |                                            | 0.46                          |                            |                 |
| Fishery products                  |                                            |                               |                            | 0.53           |
| Other protein-rich foods          | 0.42                                       | 0.42                          |                            |                 |
| Food and beverage groups<sup>c</sup> | “Sugar-sweetened beverage and snack” pattern | “Chinese traditional” pattern | “Health conscious” pattern | “Snack” pattern |
|------------------------------------|-----------------------------------------------|---------------------------------|--------------------------|-----------------|
| Percentages of variation (%)       | 12.89                                         | 11.03                           | 9.70                     | 9.60            |

Notes: <sup>a</sup>Blanks represent factor loadings with absolute values less than 0.3; <sup>b</sup>Data imputation was applied by using modes to replace missing data for each food and beverage group; <sup>c</sup>Coffee drinks and energy drinks or sports drinks were eliminated.

Table 4. Differences in Participants’ Characteristics and Consumption Proportions of Food and Beverage Groups by Predominant Dietary Patterns (N = 3373)
| Variables                        | “Sugar-sweetened beverage and snack” pattern | “Chinese traditional” pattern | “Health conscious” pattern | “Snack” pattern | F values/Chi-square values<sup>a</sup> | P values |
|---------------------------------|--------------------------------------------|--------------------------------|---------------------------|-----------------|---------------------------------------|----------|
| **Participants’ characteristics** |                                            |                                |                           |                 |                                       |          |
| Children’s age (years), mean (SD) | 4.34 (0.64)                                | 4.21 (0.68)                    | 4.18 (0.66)               | 4.23 (0.69)     | 8.894                                 | < 0.001  |
| Children’s gender, n (%)       |                                            |                                |                           |                 |                                       |          |
| Boy                             | 377 (53.17)                                | 504 (53.79)                    | 455 (54.17)               | 429 (48.37)     |                                       |          |
| Girl                            | 332 (46.83)                                | 433 (46.21)                    | 385 (45.83)               | 458 (51.63)     |                                       |          |
| Children’s BMI (kg/m<sup>2</sup>), M (Q1, Q2) | 15.44 (14.54, 16.47) | 15.26 (14.48, 16.22)           | 15.23 (14.43, 16.12)      | 15.42 (14.56, 16.29) | 13.156                                | 0.004    |
| Children’s weight status, n (%) |                                            |                                |                           |                 |                                       |          |
| Underweight or normal-weight    | 625 (88.15)                                | 873 (93.17)                    | 783 (93.21)               | 816 (92.00)     |                                       | < 0.001  |
| Overweight                      | 54 (7.62)                                  | 39 (4.16)                      | 35 (4.17)                 | 51 (5.75)       |                                       |          |
| Obesity                         | 30 (4.23)                                  | 25 (2.67)                      | 22 (2.62)                 | 20 (2.25)       |                                       |          |
| **Parents’ SES scores<sup>b</sup>, M (Q1, Q2)** |                                      |                                |                           |                 |                                       |          |
| Father                          | 63.7 (59.3, 69.3)                          | 67.7 (62.5, 69.5)              | 67.7 (62.5, 69.3)         | 66.7 (62.1, 69.3) | 44.921                                | < 0.001  |
| Mother                          | 64.6 (61.4, 69.8)                          | 69.5 (64.6, 71.4)              | 69.5 (64.6, 71.4)         | 69.5 (64.6, 71.4) | 53.407                                | < 0.001  |
| **Parents’ weight status, n (%)** |                                        |                                |                           |                 |                                       |          |
| Father                          |                                            |                                |                           |                 |                                       |          |
| Underweight or normal weight    | 259 (36.53)                                | 368 (39.27)                    | 322 (38.33)               | 327 (36.87)     |                                       |          |
| Overweight                      | 287 (40.48)                                | 384 (40.98)                    | 376 (44.76)               | 347 (39.12)     |                                       |          |
| Obesity                         | 122 (17.21)                                | 147 (15.69)                    | 107 (12.74)               | 172 (19.39)     |                                       |          |
|                          |        |        |        |        |
|--------------------------|--------|--------|--------|--------|
| Data missing             | 41 (5.78) | 38 (4.06) | 35 (4.17) | 41 (4.62) |
| Mother                   |         |         |         | 14.862 |
| Underweight or normal weight | 527 (74.33) | 732 (78.12) | 695 (82.74) | 692 (78.02) |
| Overweight               | 122 (17.21) | 149 (15.90) | 104 (12.38) | 132 (14.88) |
| Obesity                  | 29 (4.09) | 21 (2.24) | 16 (1.90) | 27 (3.04) |
| Data missing             | 31 (4.37) | 35 (3.74) | 25 (2.98) | 36 (4.06) |

Consumption proportions of food and beverage groups\(^b\), \(n(\%)

|                      |        |        |        |        |
|----------------------|--------|--------|--------|--------|
| Fruits               | 708 (99.86) | 937 (100.00) | 839 (99.88) | 886 (99.89) |
| Vegetables           | 709 (100.00) | 937 (100.00) | 838 (99.76) | 884 (99.66) |
| Dark-green vegetables| 706 (99.58) | 937 (100.00) | 834 (99.29) | 879 (99.10) |
| Other dark-color vegetables | 709 (100.00) | 937 (100.00) | 840 (100.00) | 877 (98.87) |
| Fresh fruit/vegetable juice | 646 (91.11) | 751 (80.15) | 764 (90.95) | 697 (78.58) |
| Soybean milk         | 586 (82.65) | 610 (65.10) | 668 (79.52) | 458 (51.63) |
| Milk                 | 687 (96.90) | 911 (97.23) | 835 (99.40) | 855 (96.39) |
| Yogurt or other dairy products | 694 (97.88) | 921 (98.29) | 835 (99.40) | 874 (98.53) |
| Flavored milk drinks | 579 (81.66) | 398 (42.48) | 367 (43.69) | 495 (55.81) |
| Carbonated drinks     | 404 (56.98) | 173 (18.46) | 95 (11.31) | 222 (25.03) |
| Flavored fruit/vegetable drinks | 565 (79.69) | 390 (41.62) | 315 (37.50) | 523 (58.96) |
| Tea drinks            | 344 (48.52) | 113 (12.06) | 68 (8.10) | 166 (18.71) |
| Plant-protein drinks  | 513 (72.36) | 279 (29.78) | 365 (43.45) | 341 (38.44) |
| Sweets                | 686 (96.76) | 886 (94.56) | 808 (96.19) | 883 (96.02) |
Table 5. Associations between Predominant Dietary Patterns and Overweight/Obesity\(^a, b, c\) (N = 3373)

|          | Median (25th and 75th percentiles) | p-value |
|----------|-----------------------------------|---------|
| Pastries | 680 (95.91) 898 (95.84) 828 (98.57) 883 (99.55) | 0.001   |
|          | 37.337 < 0.001                             |
| Puffed foods | 596 (84.06) 563 (60.09) 474 (56.43) 779 (87.82) | 0.001   |
|          | 327.716 < 0.001                             |
| Fried foods | 631 (89.00) 667 (71.18) 566 (67.38) 822 (92.67) | 0.001   |
|          | 248.043 < 0.001                             |
| Western fast foods | 622 (87.73) 719 (76.73) 660 (78.57) 800 (90.19) | 0.001   |
|          | 82.033 < 0.001                             |
| Nuts     | 668 (94.22) 874 (93.28) 830 (98.81) 837 (94.36) | 0.001   |
|          | 34.076 < 0.001                             |
| Wheat or wheat foods | 609 (85.90) 770 (82.18) 821 (97.74) 730 (82.30) | 0.001   |
|          | 121.404 < 0.001                             |
| Meat or poultry | 700 (98.73) 936 (99.89) 837 (99.64) 886 (99.89) | 0.001   |
|          | 16.662 < 0.001                             |
| Fishery products | 686 (96.76) 927 (98.93) 833 (99.17) 876 (98.76) | 0.001   |
|          | 18.684 < 0.001                             |
| Other protein-rich foods | 703 (99.15) 936 (99.89) 840 (100.00) 880 (99.21) | 0.008   |
|          | 11.891 0.008                               |

Abbreviations: SD: standard deviation; BMI: body mass index; M(Q1, Q2): median (25th and 75th percentiles); SES: socioeconomic status.

Notes: \(^a\)Chi-square values of the Kruskal-Wallis tests for children’s body mass index and weight status, and parents’ socioeconomic status scores were adjusted for ties; \(^b\)Missing data exists.
| Predominant dietary patterns\(^d\) | ORs with 95% CIs/Variance with 95% CIs | Robust SEs | Z values | P values |
|----------------------------------|---------------------------------------|------------|----------|---------|
| **Fixed parts**                  |                                       |            |          |         |
| “Sugar-sweetened beverage and snack” pattern |                                       |            |          |         |
| Model 1                          | 1.76 (1.21, 2.58)                     | 0.34       | 2.934    | 0.003   |
| Model 2                          | 1.67 (1.15, 2.43)                     | 0.32       | 2.689    | 0.007   |
| Model 3                          | 1.66 (1.14, 2.42)                     | 0.32       | 2.662    | 0.008   |
| Model 4                          | 1.61 (1.09, 2.38)                     | 0.32       | 2.385    | 0.017   |
| “Health conscious” pattern       |                                       |            |          |         |
| Model 1                          | 1.00 (0.70, 1.43)                     | 0.18       | -0.014   | 0.988   |
| Model 2                          | 1.04 (0.72, 1.51)                     | 0.20       | 0.226    | 0.821   |
| Model 3                          | 1.05 (0.73, 1.51)                     | 0.20       | 0.247    | 0.805   |
| Model 4                          | 1.13 (0.78, 1.65)                     | 0.22       | 0.646    | 0.518   |
| “Snack” pattern                  |                                       |            |          |         |
| Model 1                          | 1.16 (0.82, 1.63)                     | 0.20       | 0.838    | 0.402   |
| Model 2                          | 1.22 (0.86, 1.72)                     | 0.22       | 1.102    | 0.271   |
| Model 3                          | 1.17 (0.83, 1.65)                     | 0.20       | 0.921    | 0.357   |
| Model 4                          | 1.13 (0.79, 1.61)                     | 0.20       | 0.680    | 0.497   |
| **Random parts**                 |                                       |            |          |         |
| Intercepts at class level        |                                       |            |          |         |
| Model 1                          | 0.35 (0.18, 0.67)                     | 0.12       |          |         |
| Model 2                          | 0.00 (0.00, 0.00)                     | 0.00       |          |         |
| Model 3                          | 0.00 (0.00, 0.00)                     | 0.00       |          |         |
| Model 4                          | 0.02 (0.00, 487.47)                   | 0.08       |          |         |

Abbreviations: OR: odds ratio; CI: confidence interval; SE: standard error.

Notes: \(^a\)Dependent variable: overweight/obesity; \(^b\)Model 1 only included predominant dietary patterns; model 2 included adjustment for children's age and gender; model 3 included further adjustment for children's daily average time of moderate-to-vigorous physical activities and daily average sedentary time, on weekdays and on weekends respectively; model 4 included further adjustment for parents' socioeconomic status scores and body mass index; \(^c\)Data imputation was applied by using modes to replace missing data in children's daily average time of moderate-to-vigorous physical activities and daily average sedentary time, and medians in parents' socioeconomic status scores and body mass index; \(^d\)Reference: the “Chinese traditional” pattern.
Figure 1

Sampling and Survey Procedures of the Study

Supplementary Files

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- Additionalfile1.docx
- Additionalfile2.docx
- Additionalfile3.docx
- Additionalfile4.docx