Association of number of siblings, birth order, and thinness in 3- to 12-year-old children: a population-based cross-sectional study in Shanghai, China

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Abstract

Background: To evaluate the associations among number of siblings, birth order, and childhood thinness as well as the effect of number of younger or older siblings on childhood thinness.

Methods: In this study, we performed a population-based cross-sectional study among 84075 3- to 12-year-old children in Shanghai using multistage stratified cluster random sampling. We defined grade 1, 2, and 3 thinness according to the body mass index cutoff points set by the International Obesity Task Force, and used multivariable logistic regression models to estimate the odds ratio (OR) and 95% confidence interval (95% CI).

Results: Compared with only children, sibling children were more likely to be thin: one sibling (OR = 1.21, 95% CI 1.11, 1.31) and two or more siblings (OR = 1.10 95% CI 1.02, 1.19); Middle children (OR = 1.14, 95% CI 1.04, 1.26) and youngest children (OR = 1.38, 95% CI 1.23, 1.55) had significantly increased ORs for childhood thinness. There was no statistically significant relationship, however, between a larger number of younger or older siblings and childhood thinness.

Conclusions: Having either siblings or a higher birth order was positively associated with childhood thinness. The present study suggests that future interventions to prevent childhood thinness should consider family background as an important factor, especially in multi-child families.

Background

Preschool- and school-age years are critical periods for a child’s growth and development. During these stages, children experience rapid but inadequate physical and psychological development, causing them to be the most vulnerable group in the population. Thus, children require more attention and support from family and society [1, 2]. The impact of
childhood obesity on health has been well documented in several studies, many of which show that obesity in early life has adverse impacts on growth and development, as well as social and academic performance [3]. Recently, increasing attention has been paid to childhood thinness, which is an indicator of recent malnutrition and eating disorders, which are often associated with physical, mental, and intellectual development problems, as well as a higher risk of metabolic disease in adulthood [4-6]. In 2010, China had a thinness rate of 9.0% among children aged 6 to 17 years old, including 10.4% for boys and 7.3% for girls [7]. In Shanghai, the prevalence of thinness was 13.92% for boys and 18.45% for girls aged 3 to 12 years old [8]. Moreover, the childhood thinness rate gradually increased in both mega-cities and poorer rural areas, and has therefore become one of the most significant public health problems requiring timely and effective intervention.

As a result of the implementation of the one-child policy in the 1980s, China became the country with the largest population of only children in the world (about 224.6 million), including 193.9 million urban residents and 30.7 million rural residents [9]. To ease the burden on population aging, China enacted its two-child policy in 2016, which resulted in changes to the structure of Chinese families, family scale, and personal relationships. Families play a vital role in the intervention of children with malnutrition, and studies have reported that family structure has affected childhood physical development [10-12]. In one-child families, parents and grandparents pay all their attention to their single child or grandchild. Excessive doting by supporters has resulted in childhood overweight and obesity [13]. In multi-child families, however, with the expansion of the number of siblings, parents’ time, energy, and financial resources are diluted among their children [14]. Studies have found that birth orders and number of siblings are important predictors of childhood malnutrition [12, 15-21]. Most studies have supported the finding that sibling
children and older children have a lower risk of being overweight or obese [12, 15–18]. However, results illustrating the effects of the number of siblings and birth order on childhood thinness were inconsistent. Some studies found that a child’s risk of malnutrition was higher as the birth order or number of siblings increased [19–22]. A previous study reported that a larger number of siblings increased the odds ratio (OR) for malnutrition for girls but not for boys [23]. By contrast, one study showed no relationship between the number of siblings or birth order and thinness [24].

With the implementation of China’s two-child policy, sibling structure and relationships will become increasingly complicated and will have an unpredictable effect on childhood health. Therefore, we conducted this study to identify the relationship between number of siblings and birth order and childhood thinness, and to discern the impact of the number of younger or older siblings on childhood thinness.

Methods

Study design and participants

This investigation was based on a large school-based cross-sectional study, which was part of a population survey of autism spectrum disorders led by the government. Relevant sampling methods have been described in a previous study [8], and are briefly stated as follows. This study was conducted using multistage, stratified cluster random sampling among children ages 3 to 12 years old in Shanghai, China, in June 2014. We randomly selected three urban districts and four suburban districts from a total of seventeen districts across Shanghai. In total, 134 of 949 (14.12%) kindergarten schools, as well as 70 of 436 (16.06%) primary schools, were randomly sampled from a set of schools located in the selected districts. In total, 84,075 of 576,621 (14.58%) children were recruited from these selected schools according to the proportion of students in each district to all of the
sampled districts. The child’s family, social environment and growth questionnaires were administered to teachers, who accepted uniform training on completing, distributing, and collecting the questionnaires. Teachers informed their students to take the questionnaire home, and then the students’ parents were asked to complete the questionnaire to collect multilevel information on the child’s characteristics (e.g., age, sex, weight, height, number of siblings, birth order, birth weight, feeding pattern, workday TV time, Internet use time, and snacking frequency) and family structure (e.g., parents’ age, parents’ weight status, parents’ education level, family income, residential area). Then, the completed questionnaires were collected by the teachers and returned to the investigators. Questionnaires with key information missing, including height, weight, number of siblings, or birth order, were excluded in the final analysis.

Measurement

Body mass index (BMI, kg/m$^2$) was calculated as weight (kg) divided by height (m) squared. Thinness, overweight, and obesity were defined according to the International Obesity Task Force recommended age- and sex-specific cutoff points for children aged 2 to 18 years old. The BMI cutoffs for grades 1, 2, and 3 were <18.5, <17.0, and <16.0 kg/m$^2$, respectively, while the cutoff for overweight was >25.0 kg/m$^2$. The cutoff for obesity was >30.0 kg/m$^2$, and the cutoff for severe obesity was >35.0 kg/m$^2$ [25, 26]. For adults, the weight status was categorized by BMI into underweight (<18.5kg/m$^2$), normal weight (18.5–25.0 kg/m$^2$), and overweight (25.0 kg/m$^2$) classes, which included obesity and severe obesity as defined by the World Health Organization standards [27]. According to a previous relevant study [16], we divided the number of siblings into three groups as follows: none (only child), one, or two or more siblings. We categorized birth
order into four groups as follows: only child, oldest child, youngest child, or middle child. The number of younger or older siblings were included in three groups: none (only child), one, or two or more siblings. For birth order, the middle child represented children who have younger sibling(s) and older sibling(s). For the number of younger siblings, the one-sibling group or the two-or-more-siblings group represented the children who were the oldest child and who had either one or two or more younger siblings. For the number of older siblings, one or two or more siblings represented children who were the youngest child and who had either one or two or more older siblings.

Child-related indicators included age (in years), sex (boy, girl), birth weight (<2500, 2500–4000, or ≥4000 g), feeding pattern (breast-feeding, formulary-feeding, mixed-feeding), workday TV time (<1, 1–3, or >3 hours/day), Internet use time (<2, 2–4, or >4 hours/day), and snacking frequency (0, 1–3, or >3 times/day). Family-related indicators included parents’ ages (<25, 25–34, or >35 years old) and parents’ education level, which was divided into low (illiterate, primary school, or junior high school), middle (senior high school, technical school, or college), and high (undergraduate or above). Family income was categorized into three groups as follows: low (<10,000, 10,000–30,000, or 30,000–50,000 Chinese yuan), middle (50,000–100,000, 100,000–150,000, or 150,000–200,000 Chinese yuan), and high (200,000–300,000, 300,000–1,000,000, and >1,000,000 Chinese yuan), according to a social science definition [28]. Residential type was defined as urban or suburban residents according to the participants’ living district.

Statistical analysis

We used EpiData 3.1 (EpiData Association, Odense, Denmark) for data entry and applied a logic error check. To ensure the reliability, consistency, and correctness of inputted data, we randomly sampled 15% questionnaires for repeat data entry. We obtained verbal consent from all participants and their parents before investigation. This study was
approved by the Institutional Review Boards of the Shanghai Municipal Commission of Health and Family Planning.

We used the chi-square test to compare the distribution of child- and family-related factors, as well as thinness frequency among the groups for different number of siblings, birth order, number of younger siblings, and number of older siblings. We used logistic regression models to calculate the OR and 95% confidence interval (95% CI) of number of siblings, birth order, number of younger siblings, and number of older siblings for grades 1, 2, and 3 thinness. We made additional adjustments for the multivariate regression models, including model I: unadjusted; model II: adjusted for child-related factors; and model III: adjusted for family-related factors based on model II. We conducted statistical analysis using the software package IBM SPSS Statistics (version 24.0) and found the p-value to be statistically significant (<0.05).

Results

A total of 84,075 questionnaires were distributed to participants aged 3 to 12 years old, and 81,384 completed questionnaires were collected with a response rate of 96.80%. In total, 13,810 children (16.97%) were excluded, among which 8,949 (11.00%) had incomplete height or weight data, and 4,861 (5.97%) had no data on number of siblings and birth order. We included 67,574 children in our final analysis, including 35,835 boys (53.03%) and 31,739 girls (46.97%).

Table 1 shows the characteristics of study participants arranged by the number of siblings. Overall, the number of children with no siblings (only child), one sibling, and two or more siblings were 49,097 (72.66%), 6,852 (10.14%), and 11,625 (17.20%), respectively. The average age (mean ± SD, standard deviations) of only children, those with one sibling, and those with two or more siblings was 7.03 ± 2.30, 6.99 ± 2.25, and 7.41 ± 2.19 years, respectively (not shown in the table). The proportion of boys in each number of siblings
group was higher than that of girls, especially in the one child category ($p < 0.001$). Low birth weight ($p = 0.029$) and breast-feeding ($p < 0.001$) were more common in the two-or-more-siblings group. Workday TV time ($p < 0.001$), Internet use time ($p < 0.001$), and snacking frequency ($p < 0.001$) were statistically different in the groups with different numbers of siblings.

Family characteristics according to the number of siblings are shown in Table 2. In the two-or-more-siblings group, the proportion of fathers ($p < 0.001$) or mothers aged ($p < 0.001$) younger than 25 years old was higher than parent ages for the only-child and one-sibling group. In the only-child group, more children had fathers ($p < 0.001$) and mothers ($p < 0.001$) who were underweight and more children were from urban residential families ($p < 0.001$). Most of the only children had a highly educated father ($p < 0.001$) or mother ($p < 0.001$), and had higher family income ($p < 0.001$) than that of the children with siblings.

We calculated the prevalence of thinness in relation to the number of siblings, birth order, and number of younger or older siblings (the distribution is shown in Table 3). In general, the prevalence of thinness of only children (14.96%) was lower than that of children with siblings (one sibling: 18.18%; two or more siblings: 17.45%). In the only-, oldest-, middle-, and youngest-child groups, the prevalence of thinness increased as birth order increased (14.96%, 17.73%, 17.11%, and 19.51%, respectively). In the groups with different numbers of younger or older siblings, thinness was more common in the oldest child with two or more younger siblings (18.31%) or in the youngest child with one older sibling (17.53%).

In the only-child, one-sibling, and two-or-more-siblings groups of boys (Figure 1), the prevalence of grade 2 thinness (2.54%, 3.24%, 3.40%, respectively) and grade 3 thinness (1.76%, 2.66%, 3.57%, respectively) was highest in the two-or-more-siblings group, and
the prevalence of grade 1 thinness (8.71%, 9.78%, 8.31%, respectively) was highest in the one-sibling group. As for girls (Figure 2), the prevalence of grade 1 thinness (11.38%, 13.14%, 11.20%, respectively) and grade 3 thinness (2.33%, 3.30%, 4.70%, respectively) was highest in the one-sibling and two-or-more-siblings group, respectively, but not in the only-child group. This was similar to the prevalence for boys, except that the prevalence of grade 2 thinness (3.52%, 4.30%, 3.89%, respectively) was highest for boys in the one-sibling group. Overall, girls were more likely to be thin than boys.

Crude and adjusted ORs of the number of siblings, birth order, and number of younger or older siblings for thinness are presented in Table 4. In model III, sibling children were more likely to suffer from thinness (OR and 95% CI): one sibling (OR = 1.21, 95% CI 1.11, 1.31) and two or more siblings (OR = 1.10, 95% CI 1.02, 1.19). Children with a higher birth order faced a higher risk of thinness: middle child (OR = 1.14, 95% CI 1.04, 1.26) and youngest child (OR = 1.38, 95% CI 1.23, 1.55). Although there was no significant relationship of thinness with a larger number of younger or older siblings, in two-child families, the younger child had a higher OR for thinness (OR = 1.40, 95% CI 1.25, 1.58).

Discussion

In the present study, children with siblings had higher ORs of thinness compared with only children. Furthermore, children who had a higher birth order had a higher risk of thinness. These results did not change significantly after adjustment, suggesting that other factors may explain the relationship between number of siblings and birth order and childhood thinness.

Our results showed that sibling children had a higher OR for thinness compared with only children. Few studies have reported that many siblings are a risk factor for thinness. However, some studies have found that having siblings increased ORs for childhood malnutrition [29, 30], especially when a malnourished sibling is living within the
household [31]. Other studies indicated that having a larger number of siblings was associated with a more significant decrease in BMI [17, 32]. One study, however, reported that there was no association between the number of siblings and thinness [24], whereas another study found that thinness was more common in girls than in boys [23]. One possible explanation is the effect of behavior and interaction between family members. On the one hand, upbringing and available resources for nutrition are different for children with different numbers of siblings, which may affect childhood weight status. A previous study reported that children with siblings faced a higher malnutrition risk [33]. Moreover, the nutritive value of diets for each child in small families was higher than that in large families, and children with siblings had significantly lower protein intake than only children [22]. It has also been reported that higher protein intake is associated with a lower risk of thinness [34]. On the other hand, additional sibling(s) enhanced interactions between children. Previous studies identified a relationship between physical activity and siblings [35]. Moreover, sibling children spent more time engaged in after-school sports or household chores than only children [17]. In this study, when we adjusted sedentary behavior, including workday TV time and Internet use time, the positive effect of the number of siblings on childhood thinness remained. Future studies should include physical activity as an investigated variable.

Regarding birth order, a higher birth order has been reported to significantly increase ORs for malnutrition [19–21, 36], which is consistent with our results. In contrast, some studies have not found a relationship between BMI or thinness and birth order [24, 32]. Thus, the effect of birth order on childhood thinness remains unclear; however, differences in fetal nutrition and changes in some factors related to growth development in early life may explain this outcome. With increasing pregnancies and the expansion of household size, child- and family-related factors may have changed, such as birth weight and prenatal
weight. The relationship between birth order and thinness, however, remained after adjusting for these factors. Thus, factors other than variates in the present study could be associated with the relationship between birth order and thinness. In addition, one study reported that firstborn children had lower birth weights than their younger siblings, yet tended to be more sensitive to factors that could encourage growth [37].

In our study, there was no relationship between a greater number of younger or older siblings and thinness. In two-child families, however, younger children face a higher risk of thinness, which may have been the result of being at a competitive disadvantage compared with their older siblings. Additionally, these children appear to have more physical activity time as a result of imitating the behaviors of their older siblings [38].

The strengths of our study are as follows. First, we evaluated the relationship between the number of siblings and birth order and childhood thinness. To our knowledge, no related study has been carried out in China. Second, the large sample size and multistage cluster random sampling employed ensured representative data, and therefore we had the ability to examine the influence of number of siblings and birth order on childhood thinness.

Finally, we examined the effect of the number of older or younger siblings on thinness, which has previously not been studied. This study also had some limitations. Shanghai has a high social economics level; thus, samples from this study cannot represent China as a whole. In addition, the implementation of the two-child policy may change the median birth interval of Chinese children, and the length of the birth interval has an impact on the status of a child’s weight [31]. We note that this information was not available for our study. Although we did not consider physical activity and diet patterns in the final analysis, we did include workday TV time, Internet use time, and snacking frequency as confounding factors. In fact, a recent study reported that the engagement level of family members was positively associated with a child’s diet quality [39]. Additionally, the
collection of height and weight data of children by self-reporting may have affected the
definition of weight status to some extent. Our findings may apply only to children
between 3 and 12 years of age, and therefore we cannot discern if the number of siblings
or birth order will have lasting effects on a child’s later health.

Conclusions

In general, as the number of siblings and birth order increased, a child’s risk of thinness
also increased. In two-child families, the youngest child was more likely to be thin. In
addition to helping researchers better identify children at risk of thinness, our findings
also provide a future reference for the implementation and social policy formulation of
child thinness intervention. At the family level, parents play an important role in sibling
relationships and thus can facilitate sibling interactions related to healthy eating and
physical activity. Socially, decisions should be made to improve the multi-child family
environment in order to address public health concerns associated with childhood
thinness.

Abbreviations

BMI, body mass index; SD, standard deviations; OR, odds ratio; CI, confidence interval

Declarations

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Availability of data and materials

The datasets used and/or analysed during the current study available from the
corresponding author on reasonable request.

Authors’ contributions

T. Y. and C. C. contributed equally to this work. X. J., Z. J., and S. L. designed the study;
Z. J., Y. Y., Y. J., L. H., X. Y., H. H., H. M. and F. J. performed the research; T. Y., C. C. and
S. L. performed data analyses, interpreted the results, and drafted the manuscript; H. H.
and S. L. were major contributors in revising the manuscript; and S. L. had primary
responsibility for the final content. All authors read and approved the final manuscript.

Ethics approval and consent to participate

This study was conducted according to the guidelines in the World Medical
Association (2000) Declaration of Helsinki: Ethical Principles for Medical Research
Involving Human Subjects (http://www.wma.net/en/30publications/ 10policies/b3/) and the
Guidelines for the Ethical Conduct of Medical Research Involving Children, revised in 2000
by the Royal College of Pediatrics and Child Health: Ethics Advisory Committee (Arch Dis
Child 2000, 82, 177-182). And all procedures involving human subjects were approved by the Institutional Review Boards of the Shanghai Municipal Commission of Health and Family Planning. Verbal informed consent was obtained from all participants, and witnessed and formally recorded.

Consent for publication

Not applicable.

Competing Interests

The authors declare that they have no competing interests.

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Tables

Table 1 Characteristics of study participants by the number of siblings

| Variables          | None (only child) | One | Two or more | Total |
|--------------------|-------------------|-----|-------------|-------|
|                    | N     | %    | N     | %    | N     | %    | N     | %    |
| Sex                |       |      |       |      |       |      |       |      |
| Boy                | 26351  | 53.67 | 3457  | 50.45 | 6027  | 51.85 | 35835  | 53.03 |
| Girl               | 22746  | 46.33 | 3395  | 49.55 | 5598  | 48.15 | 31739  | 46.97 |
| Total              | 49097  | 100.00 | 6852  | 100.00 | 11625 | 100.00 | 67574  | 100.00 |
| Birth weight (g)   |       |      |       |      |       |      |       |      |
| <2500              | 1631  | 3.32 | 417  | 6.09 | 939  | 8.08 | 2987  | 4.42 |
| 2500-4000          | 41584 | 84.70 | 5532 | 80.74 | 8712 | 74.94 | 55828 | 82.62 |
| ≥4000              | 4883  | 9.95 | 722  | 10.54 | 1393 | 11.98 | 6998  | 10.36 |
| Missing |
|---------|
| 999     |
| 2.03    |
| 181     |
| 2.64    |
| 581     |
| 5.00    |
| 1761    |
| 2.61    |
| Total   |
| 49097   |
| 100.00  |
| 6852    |
| 100.00  |
| 11625   |
| 100.00  |
| 67574   |
| 100.00  |

| Feeding Patterns                  |
|-----------------------------------|
| Breast Feeding                    |
| 21893                            |
| 44.59                            |
| 3546                             |
| 51.75                            |
| 7411                             |
| 63.75                            |
| 32850                            |
| 48.61                            |
| Formulary Feeding                |
| 7957                             |
| 16.21                            |
| 1054                             |
| 15.38                            |
| 1674                             |
| 14.40                            |
| 10685                            |
| 15.81                            |
| Mixed Feeding                     |
| 18965                            |
| 38.63                            |
| 2194                             |
| 32.02                            |
| 2391                             |
| 20.57                            |
| 23550                            |
| 34.85                            |
| Missing                           |
| 282                              |
| 0.57                             |
| 58                               |
| 0.85                             |
| 149                              |
| 1.28                             |
| 489                              |
| 0.72                             |
| Total                             |
| 49097                            |
| 100.00                           |
| 6852                             |
| 100.00                           |
| 11625                            |
| 100.00                           |
| 67574                            |
| 100.00                           |

| Workday TV time (hour/day)        |
|-----------------------------------|
| <1                                |
| 29037                            |
| 59.14                            |
| 3762                             |
| 54.90                            |
| 5484                             |
| 47.17                            |
| 38283                            |
| 56.65                            |
| 1-3                               |
| 18353                            |
| 37.38                            |
| 2843                             |
| 41.49                            |
| 5534                             |
| 47.60                            |
| 26730                            |
| 39.56                            |
| >3                                |
| 990                              |
| 2.02                             |
| 135                              |
| 1.97                             |
| 303                              |
| 2.61                             |
| 1428                             |
| 2.11                             |
| Missing                           |
| 717                              |
| 1.46                             |
| 112                              |
| 1.63                             |
| 304                              |
| 2.62                             |
| 1133                             |
| 1.68                             |
| Total                             |
| 49097                            |
| 100.00                           |
| 6852                             |
| 100.00                           |
| 11625                            |
| 100.00                           |
| 67574                            |
| 100.00                           |

| Internet using time (hour/week)   |
|-----------------------------------|
| <2                                |
| 30086                            |
| 61.28                            |
| 4518                             |
| 65.94                            |
| 7930                             |
| 68.22                            |
| 42534                            |
| 62.94                            |
| 2-4                               |
| 11235                            |
| 22.88                            |
| 1346                             |
| 19.64                            |
| 1742                             |
| 14.98                            |
| 14323                            |
| 21.20                            |
| ≥4                                |
| 6301                             |
| 12.83                            |
| 717                              |
| 10.46                            |
| 769                              |
| 6.62                             |
| 7787                             |
| 11.52                            |
| Missing                           |
| 1475                             |
| 3.00                             |
| 271                              |
| 3.96                             |
| 1184                             |
| 10.18                            |
| 2930                             |
| 4.34                             |
| Total                             |
| 49097                            |
| 100.00                           |
| 6852                             |
| 100.00                           |
| 11625                            |
| 100.00                           |
| 67574                            |
| 100.00                           |

| Snacking frequency (times/day)    |
|-----------------------------------|
| 0                                 |
| 14854                            |
| 30.25                            |
| 1951                             |
| 28.47                            |
| 2716                             |
| 23.36                            |
| 19521                            |
| 28.89                            |
| 1-3                               |
| 30643                            |
| 62.41                            |
| 4355                             |
| 63.56                            |
| 7724                             |
| 66.44                            |
| 42722                            |
| 63.22                            |
| >3                                |
| 2994                             |
| 6.10                             |
| 458                              |
| 6.68                             |
| 846                              |
| 7.28                             |
| 4298                             |
| 6.36                             |
| Missing                           |
| 606                              |
| 1.23                             |
| 88                               |
| 1.28                             |
| 339                              |
| 2.92                             |
| 1033                             |
| 1.53                             |
| Total                             |
| 49097                            |
| 100.00                           |
| 6852                             |
| 100.00                           |
| 11625                            |
| 100.00                           |
| 67574                            |
| 100.00                           |

P Value from Chi-squared test

| Table 2 Family characteristics of study participants by the number of siblings |
|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| Variables                    | None (only child)             | One                          | Two or more                  | Total                        | χ²                           |
|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| Father’s Age (years)         | N                             | %                             | N                             | %                             | N                             | %                             |
| 976.                          | 20                            | 976                           | 20                            | 976                           | 20                            | 976                           |

a P Value from Chi-squared test
| Age Group | Father's Weight Status | Mother's Age (years) | Mother's Weight Status | Mother's Education Level | Family Income |
|-----------|------------------------|----------------------|------------------------|-------------------------|---------------|
| <25       | 7217 14.70 1119 16.33 2263 19.47 10599 15.69 | 15672 31.92 2092 30.53 3872 33.31 21636 32.02 | 5260 10.71 579 8.45 726 6.25 6565 9.72 | 9842 20.05 2691 39.27 8306 71.45 20839 30.84 | 10257 20.89 1828 26.68 5368 46.18 17453 25.83 |
| 25-34     | 33800 68.84 4078 59.52 6264 53.88 44142 65.32 | 30882 62.90 3985 58.16 5933 51.04 42682 63.16 | 35611 72.53 4982 72.71 3137 70.48 48786 72.20 | 22742 46.32 2511 36.65 2475 21.29 27728 41.03 | 29251 59.58 3322 48.48 4862 41.82 37435 55.40 |
| ≥35       | 4918 10.02 1142 16.67 1902 16.36 7962 11.78 | 18292 37.26 2023 29.52 1162 10.00 42682 63.16 | 16450 33.51 1632 23.82 823 7.08 18905 27.98 | 16450 33.51 1632 23.82 823 7.08 18905 27.98 | 9563 19.48 1694 24.72 1388 11.94 12645 18.71 |
| Missing   | 3162 6.44 513 7.49 1196 10.29 4871 7.21 | 3901 7.95 508 7.41 997 8.58 5406 8.00 | 3162 6.44 513 7.49 1196 10.29 4871 7.21 | 3162 6.44 513 7.49 1196 10.29 4871 7.21 | 26 0.05 8 0.12 7 0.06 41 0.06 |
| Total     | 49097 100.00 6852 100.00 11625 100.00 67574 100.00 | 49097 100.00 6852 100.00 11625 100.00 67574 100.00 | 49097 100.00 6852 100.00 11625 100.00 67574 100.00 | 49097 100.00 6852 100.00 11625 100.00 67574 100.00 | 49097 100.00 6852 100.00 11625 100.00 67574 100.00 |
| Variables                         | Total sample | Grade 1 thinness | Grade 2 thinness | Grade 3 thinness |
|----------------------------------|--------------|------------------|------------------|------------------|
|                                  | N            | N                | N                | N                |
| Number of siblings               |              |                  |                  |                  |
| None (only child)                | 49097        | 4884             | 1469             | 993              |
| One                              | 6852         | 784              | 258              | 204              |
| Two or more                      | 11625        | 1128             | 423              | 478              |
| Total                            | 67574        | 6796             | 2150             | 1675             |
| Birth order<sup>a</sup>          |              |                  |                  |                  |
| only child                       | 49097        | 4884             | 1469             | 993              |
| oldest child                     | 7941         | 855              | 285              | 268              |
| middle                           | 6696         | 638              | 240              | 268              |
| youngest child                   | 3162         | 359              | 142              | 116              |
| Missing                          | 678          | 60               | 14               | 30               |
| Total                            | 67574        | 6796             | 2150             | 1675             |
| Number of younger siblings       |              |                  |                  |                  |
| None (only child)                | 49097        | 4884             | 1469             | 993              |
| One (oldest child)               | 3691         | 421              | 119              | 90               |
| Two or more (oldest child)       | 4250         | 434              | 166              | 178              |
| Total                            | 57038        | 5739             | 1754             | 1261             |
| Number of older siblings<sup>c</sup> |          |                  |                  |                  |
| None (only child)                | 49097        | 4884             | 1469             | 993              |
| One (youngest child)             | 2968         | 342              | 134              | 107              |
| Two or more (youngest child)     | 194          | 17               | 8                | 9                |
| Total                            | 52259        | 5243             | 1611             | 1109             |

*P Value from Chi-squared test*
### Variables

|                          | Total N | Grade 1 thinness |   |   |   |
|--------------------------|---------|------------------|---|---|---|
|                          |         | Model I<sup>a</sup> | Model II<sup>b</sup> | Model III<sup>c</sup> |   |
| **Number of siblings**   |         | 1.00 (Ref)        | 1.00 (Ref)            | 1.00 (Ref)            |   |
| None (only child)        | 49097   | 1.00 (Ref)        | 1.00 (Ref)            | 1.00 (Ref)            |   |
| One                     | 6852    | 1.17 (1.08, 1.28) | 1.14 (1.05, 1.24)    | 1.17 (1.06, 1.28)    | 1.29 (   |
| Two or more             | 11625   | 1.01 (0.95, 1.09) | 0.96 (0.89, 1.04)    | 0.97 (0.89, 1.07)    | 1.26 (   |
| **Birth order**         |         |                  |   |   |   |
| Only child              | 49097   | 1.00 (Ref)        | 1.00 (Ref)            | 1.00 (Ref)            | 1.29 |
| Oldest child            | 7941    | 1.08 (1.00, 1.17) | 1.03 (0.95, 1.12)    | 1.01 (0.92, 1.11)    | 1.20 |
| Middle child            | 6696    | 1.01 (0.93, 1.11) | 0.95 (0.86, 1.06)    | 1.02 (0.91, 1.16)    | 1.27 |
| Youngest child          | 3162    | 1.21 (1.08, 1.36) | 1.21 (1.07, 1.37)    | 1.30 (1.13, 1.49)    | 1.60 |
| **Number of younger siblings** |         | 1.00 (Ref)        | 1.00 (Ref)            | 1.00 (Ref)            |   |
| None (only child)        | 49097   | 1.00 (Ref)        | 1.00 (Ref)            | 1.00 (Ref)            |   |
| One (oldest child)      | 3691    | 1.13 (1.02, 1.26) | 1.08 (0.96, 1.21)    | 1.08 (0.96, 1.22)    | 1.06 |
| Two or more (oldest child) | 4250   | 1.04 (0.93, 1.15) | 0.99 (0.88, 1.11)    | 0.94 (0.82, 1.07)    | 1.32 |
| **Number of older siblings** |         | 1.00 (Ref)        | 1.00 (Ref)            | 1.00 (Ref)            |   |
| None (only child)        | 49097   | 1.00 (Ref)        | 1.00 (Ref)            | 1.00 (Ref)            |   |
| One (youngest child)     | 2968    | 1.23 (1.09, 1.39) | 1.21 (1.07, 1.38)    | 1.30 (1.13, 1.50)    | 1.60 |
| Two or more (youngest child) | 194    | 0.95 (0.57, 1.58) | 1.19 (0.70, 2.00)    | 1.27 (0.71, 2.27)    | 1.49 |

95% CI (OR): 95% confidence interval (Odds Ratio); Ref: reference category

<sup>a</sup> Model I: unadjusted

<sup>b</sup> Model II: adjusted for child-related factors, including age, sex, birth weight, feeding patterns, workday TV time, internet use time, snacking frequency

<sup>c</sup> Model III: adjusted for family-related factors, including parents’ age, parents’ weight status, parents’ educational level, family income and residential area based on model II

<sup>*</sup><i>p < 0.05</i>

**Figures**
Figure 1

Distribution of the prevalence of grades 1, 2, and 3 thinness in boys *Statistically significant difference in prevalence between 0 (only child) and 1 sibling ($\chi^2$ test): p < 0.05; #Statistically significant difference in prevalence between 1 and ≥2 siblings ($\chi^2$ test): p < 0.05; $Statistically significant difference in prevalence between 0 (only child) and ≥2 siblings ($\chi^2$ test): p < 0.05.
Figure 2

Distribution of the prevalence of grades 1, 2, and 3 thinness in girls *Statistically significant difference in prevalence between 0 (only child) and 1 sibling ($\chi^2$ test): $p < 0.05$; #Statistically significant difference in prevalence between 1 and $\geq 2$ siblings ($\chi^2$ test): $p < 0.05$; $\$Statistically significant difference in prevalence between 0 (only child) and $\geq 2$ siblings ($\chi^2$ test): $p < 0.05$. 

![Bar graph showing prevalence of grades 1, 2, and 3 thinness across different numbers of siblings.](image)