

# Caregivers' Feeding Behavior, Children's Eating Behavior, and Weight Status among Children of Preschool Age in China

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## Research

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# Abstract

**Background** Childhood overweight and obesity have become significant public health challenges worldwide. This study aimed to explore whether caregivers' feeding behavior and children's eating behavior were associated with the weight status of preschool children in China.

**Methods** A cross-sectional questionnaire was administered to 912 caregivers of preschool children from April to July 2016. Caregivers' feeding behaviors were assessed by the Chinese Preschooler's Caregiver Feeding Behavior Scale (CPCFBS). Children's eating behaviors were evaluated using the Chinese Preschooler's Eating Behavior Questionnaire (CPEBQ). After controlling for demographic characteristics, multiple linear regression and logistic regression analyses were performed to evaluate the relationship between caregivers' feeding behavior, children's eating behavior, and children's body mass index (BMI).

**Results** The results showed that weight concerns on the part of caregivers ( $\beta=0.53$ ) and food responsiveness on the part of children ( $\beta=0.93$ ) were positively correlated with children's BMI, whereas caregivers' responsibility for feeding ( $\beta=-0.68$ ) and children's external eating ( $\beta=-0.53$ ) were negatively correlated with BMI. Among caregiver feeding behaviors, weight concerns ( $OR=4.54, P<0.001$ ) and behavior-restricted feeding ( $OR=0.29, P<0.001$ ) were positively correlated with children's BMI. A child's food responsiveness ( $OR=4.04, P<0.001$ ) was also positively correlated with his/her BMI, while the child's satiety responsiveness ( $OR=0.42, P<0.001$ ) and emotional eating habits ( $OR=0.56, P<0.001$ ) were negatively correlated with overweight/obesity status.

**Conclusions** Our study demonstrated that children's eating behavior and caregivers' feeding behavior were associated with weight status among preschool children in China. Behavior interventions on caregivers as well as their children may prevent or reduce weight problems in preschool children.

**Trial registration** This study was not a clinical experiment.

## Introduction

Overweight and obesity have become serious public health challenges worldwide in recent years [1-5]. A systematic analysis reported that the rates of overweight/obesity in developing and developed countries were 13% and 24%, respectively, in 2013 [4]. The Nutrition and Chronic Diseases of Chinese Residents Report (2015) showed that the prevalence of overweight and obesity in children < 6 years of age was 8.4% and 3.1%, respectively, and these rates are increasing [2, 6]. Childhood overweight and obesity are closely related to the occurrence of chronic diseases such as hypertension, diabetes, and coronary heart disease [3, 5] and also have a negative association with mental health, intellectual and learning abilities, personality development, and psychosocial well-being [1].

Recent increases in the rates of childhood obesity and associated health risks have drawn the attention of scientists [4, 7-9]. Ek *et al.* showed that the occurrence of overweight and obesity was closely correlated with both feeding practices and eating behaviors [10]. Moreover, previous evidence showed

that the age range of 3–6 years is a critical period for the maturation of healthy eating behaviors and the prevention of childhood obesity [11, 12]. At these ages, children begin to develop their eating habits [13], which are strongly affected by the caregivers' feeding behavior[11, 12]. Caregivers control children's food intake by establishing routines for when, what, and how their children eat and drink, and how the food and drinks are served[14]. Some studies have confirmed that inappropriate feeding practices lead to the development of unhealthy eating patterns in children, such as partial eclipse, picky eaters, and anorexia, resulting in increased rates of childhood overweight and obesity [15-17]. Caregivers' feeding can play a significant role in influencing the development of unhealthy eating patterns, but we also know that eating/weight (and even caregivers' feeding behavior) results from a complex interaction of multiple factors within and external to the feeding relationship. A more holistic lens for understanding contributors of child eating/weight development needs to be acknowledged. Furthermore, preschool years (3–6 years old) are a critical period for the prevention of childhood obesity [13, 18, 19]. The identification of promising intervention strategies requires a thorough understanding of the modifiable factors contributing to overweight and obesity in children.

At present, most studies have reported on associations between caregivers' feeding behavior, children's eating behavior, and body weight based on samples from European<sup>12</sup>[20] and North American populations[21, 22], and food-related caregivers' feeding behavior, children's eating behavior have shown great variations according to demographic characteristics[19, 23]. The association among caregivers' feeding behavior, their children's eating behavior and body weight might be different in China and other countries, and this association, particularly in Chinese children of preschool age preschooler, has not been well studied in China. Thus, our study aims to explore whether caregivers' feeding practices and children's eating behaviors are correlated with weight status in preschool children. Our results may support the development of early interventions for obesity prevention in children.

## **1. Materials And Methods**

### **1.1 Subjects**

The experimental protocol was approved by the Research Ethics Committee of the Fourth Military Medical University (November 16, 2018) and all procedures were performed in accordance with the relevant regulations and guidelines. A total of 912 preschool children (3–6 years old) and their primary caregivers were recruited from five kindergartens in the urban and suburban areas of Xi'an and Jinan City in China, during the period from April to July 2016 using a stratified sampling method at each kindergarten. The primary caregiver was defined as the person who was responsible for the majority of care/feeding(activity, diet, sleep, etc.) at home. This person maybe was the children's parent, grandparent, or nanny. Each recruited caregiver gave written informed consent before data were collected. All data were collected anonymously.

The inclusion criteria were: (1) children at the age of 3–6 years; (2) caregiver agreed to participate and answer the questionnaire. The exclusion criteria were: (1) children with a history of constipation, chronic

gastritis, or other chronic diseases that might influence his/her eating behavior over the last 2 months; (2) caregiver unwilling to participate in this study or unable to communicate.

## 1.2 Study instruments

Caregivers' feeding behaviors were assessed using the Chinese Preschooler's Caregivers' Feeding Behavior Scale (CPCFBS) [24]. The CPCFBS comprises 7 dimensions and 35 items. Dimension 1 – Responsibility Feeding (RF) reflects the feeding behaviors caused by caregivers' responsibility to maintain a healthy diet during feeding. Dimension 2 – Weight Concerns (WEC) evaluates the association between parental worry on children's weight and their daily feeding behaviors. Dimension 3 – Encourage Healthy Feeding (EHF) describes behaviors that encourage healthy eating. Dimension 4 – Content Restricted Feeding (CTRF) and dimension 5 – Behavior Restricted Feeding (BHRF) assesses the limits set by the caregiver on food composition and eating behaviors. Dimension 6 – Forced Feeding (FOF) measures the association between mandatory feeding practices and the children's healthy eating behaviors. Dimension 7 – Supervise Eating (SE) evaluates the association between caregiver monitoring and children's unhealthy eating patterns. Test-retest reliability was 0.85, and Cronbach's  $\alpha$  coefficient for the total scale was 0.91. The construct validity of the scale was evaluated by factor analysis. The seven dimensions of this scale explained 58.6% of total variance in caregivers' feeding behavior.

Children's eating behaviors were evaluated with the Chinese Preschoolers' Eating Behavior Questionnaire (CPEBQ), which consists of 7 dimensions and 38 items. [25]. Dimension 1 – Food Fussiness (FF) examines whether the child refuses food because of its taste, appearance, smell, or texture. Dimension 2 – Food Responsiveness (FR) assesses the child's desire to eat. Dimension 3 – Eating Habits (EH) detects unhealthy eating habits, such as watching television or playing with toys while waiting a long time for meals. Dimension 4 – Satiety Responsiveness (SR) evaluates satiety sensitivity. Dimension 5 – Exogenous Eating (EXE) evaluates the child's response to external factors that might affect his/her eating. Dimension 6 – Emotional Eating (EE) assesses eating status when the child experiences negative emotions. Dimension 7 – Initiative Eating (IE) evaluates whether the child is able to eat independently. The CPEBQ has been shown to have good reliability and validity in Chinese children of preschool age [25]. The test-retest reliability was 0.72. The Cronbach's  $\alpha$  coefficient for the entire scale was 0.92. The construct validity of the CPEBQ was evaluated by factor analysis. The seven dimensions of this questionnaire explained 57.0% of the total variance in children's eating behavior.

The items in both scales evaluated feeding practices or eating behaviors that occurred over the 3 months leading up to the study. There were 5 options available for each item: never, rarely, sometimes, often, and always, which were assigned scores of 1, 2, 3, 4, and 5, respectively. The average score for each dimension was calculated as the sum of the scores for each item divided by the number of items included in that dimension. Overall, higher scores indicated more engaged eating or feeding behaviors.

Demographic data including caregivers' age and educational level, total monthly household income, children's gender, children's age, and the nature of the child-caregiver relationship were also collected. The

height and weight of both caregivers and children were measured by an investigator at the kindergarten with standardized anthropometric protocols. BMI was calculated as:  $BMI = \text{weight (kg)} / \text{height (m}^2\text{)}$ . All enrolled children were classified into 4 groups according to the BMI standards published by the Centre for Disease Control of China [26]: underweight (sex- and age-specific BMI <15th percentile), normal weight (sex- and age-specific BMI between the 15th and 85th percentiles), overweight (sex- and age-specific BMI between the 85th and 95th percentiles), and obese (sex- and age-specific BMI >95th percentile). Caregivers were categorized into 4 groups: underweight (BMI <20), normal weight (BMI between 20 and 24), overweight (BMI between 24 and 28), and obese (BMI >28) [27]. The educational level of caregivers was classified as junior high school or below, senior high school, or college/university and above. The 25<sup>th</sup> percentile ( $P_{25}$ ), 50<sup>th</sup> percentile ( $P_{50}$ ), and 75<sup>th</sup> percentile ( $P_{75}$ ) values for scores on the CPCFBS and CPEBQ were calculated, and the scores of all dimensions in these two scales were converted into 4 grades, by quartile ( $P_{25}$ ,  $P_{50}$ ,  $P_{75}$ ).

## 1.3 Investigation and quality control

Caregivers recruited from each kindergarten were congregated in a single classroom. An investigator explained the aims and detailed requirements of the study to the caregivers. Then the questionnaires were distributed to all caregivers. The completed questionnaires were collected by the investigator.

All questionnaires were administered by five pediatricians who had at least five years of experience in pediatric practice. All investigators were trained before the study to ensure that they fully understood the purpose, significance, and requirements of the questionnaire, the meaning of all items in each subscale, and the physical examination methods. All completed questionnaires were carefully reviewed by the primary investigator. If the questionnaire was not complete, telephone interviews were conducted to collect missing information. A database was established using EpiData software (version 3.1, EpiData Association, Odense, Denmark). To ensure data accuracy, a logic error-check was performed and a double-entry mode was used.

## 1.4 Statistical analysis

Statistical analyses were performed using IBM SPSS software (version 21, SPSS Inc., Chicago, USA). A  $P$ -value <0.05 was considered significant. Qualitative data are expressed as frequencies and percentages. Quantitative data are shown as mean  $\pm$  standard deviation. Multiple linear stepwise regression was used to investigate the Influencing factors for abnormal BMI. Demographic characteristics and CPCFBS and CPEBQ scores were defined as independent variables ( $X$ ). The child's BMI was defined as the dependent variable ( $Y$ ) (see Table 1). Progressive advance logistic regression analysis was used to screen for Influencing factors for overweight/obesity status in children. The demographic characteristics and CPCFBS and CPEBQ scores in 7 dimensions were defined as the independent variables ( $X$ ). The child's weight status (overweight or obese) was defined as the dependent variable ( $Y$ ) (see Table 2). The

inclusion criterion for the two regression analyses was  $P$ -values  $<0.05$ . The rejection criterion was  $P$ -value  $>0.10$ . The degree of interpretation of the independent variables in the model was determined by the model's determination coefficient,  $R^2$ . The larger the  $R^2$  value, the better the model fit.

Table 1  
Multiple Linear Stepwise Regression Analysis

| Independent variables        | Classification and assignment  |
|------------------------------|--|
| Child sex                    | Male=0 Female=1 Female as the reference  |
| Child age (years)            | Processing by continuous variables   |
| Caregiver age (years)        | Set the dummy variable, CgAge2={30-40 years old=1, the rest=0}, CgAge3={40-50 years old=1, the rest=0}, CgAge4={50 years old or above=1, the rest=0}, 20-30 years old as the reference |
| Child-caregiver relationship | Parents = 0, grandparents and others = 1 (parents as the reference)  |
| Caregiver education          | Set the dummy variable, CgEdu2={senior high school=1, the rest=0}, CgEdu3={college/university or above=1, the rest=0}, junior high school or below as the reference                    |
| Family monthly Income        | Set the dummy variable, FamInc2={\$750-\$1500=1, the rest=0}, FamInc3={\$1500 or more=1, the rest=0}, \$750 or below as the reference  |
| CPCFBS                       | 7 dimension scores are processed as continuous variables   |
| CPEBQ                        | 7 dimension scores are processed as continuous variables   |

Table 2  
Logistic Regression Analysis

| Independent variables                 | Classification and assignment  |
|---------------------------------------|--|
| Child sex                             | Male=0 Female=1 Female as the reference  |
| Child age (years)                     | Processing by continuous variables   |
| Caregiver age (years)                 | Set the dummy variable, CgAge2={30-40 years old=1, the rest=0}, CgAge3={40-50 years old=1, the rest=0}, CgAge4={50 years old or above=1, the rest=0}, 20-30 years old as the reference |
| Child-caregiver relationship          | Parents = 0, grandparents and others = 1 ( parents as the reference)   |
| Caregiver education                   | Set the dummy variable, CgEdu2={senior high school=1, the rest=0}, CgEdu3={college/university or above=1, the rest=0}, junior high school or below as the reference                    |
| Family monthly Income                 | Set the dummy variable, FamInc2={\$750-\$1500=1, the rest=0}, amlnc3={\$1500 or more=1, the rest=0}, \$750 or below as the reference   |
| CPCFBS                                | Convert each dimension score to four levels based on the 25th ( $P_{25}$ ), 50th ( $P_{50}$ ), and 75th ( $P_{75}$ ) percentiles for each dimension score                              |
| Responsibility for Feeding (RF)       | $RF < P_{25} = 1$ RF $P_{25} - P_{50} = 2$ RF $P_{50} - P_{75} = 3$ RF $> P_{75} = 4$  |
| Weight Concerns (WEC)                 | $WEC < P_{25} = 1$ WEC $P_{25} - P_{50} = 2$ WEC $P_{50} - P_{75} = 3$ WEC $> P_{75} = 4$  |
| Encouragement of Healthy Eating (EHE) | $EHE < P_{25} = 1$ EHE $P_{25} - P_{50} = 2$ EHE $P_{50} - P_{75} = 3$ EHE $> P_{75} = 4$  |
| Content Restricted Feeding (CTRF)     | $CTRF < P_{25} = 1$ CTRF $P_{25} - P_{50} = 2$ CTRF $P_{50} - P_{75} = 3$ CTRF $> P_{75} = 4$  |
| Behavior Restricted Feeding (BHRF)    | $BHRF < P_{25} = 1$ BHRF $P_{25} - P_{50} = 2$ BHRF $P_{50} - P_{75} = 3$ BHRF $> P_{75} = 4$  |
| Forced Feeding (FOF)                  | $FOF < P_{25} = 1$ FOF $P_{25} - P_{50} = 2$ FOF $P_{50} - P_{75} = 3$ FOF $> P_{75} = 4$  |
| Supervise Eating (SE)                 | $SE < P_{25} = 1$ SE $P_{25} - P_{50} = 2$ SE $P_{50} - P_{75} = 3$ SE $> P_{75} = 4$  |
| <b>CPEBQ</b>                          | Convert each dimension score to four levels based on the 25th ( $P_{25}$ ), 50th ( $P_{50}$ ), and 75th ( $P_{75}$ ) percentiles for each dimension score                              |
| Food Fussiness (FF)                   | $FF < P_{25} = 1$ FF $P_{25} - P_{50} = 2$ FF $P_{50} - P_{75} = 3$ FF $> P_{75} = 4$  |
| Food Responsiveness (FR)              | $FR < P_{25} = 1$ FR $P_{25} - P_{50} = 2$ FR $P_{50} - P_{75} = 3$ FR $> P_{75} = 4$  |

| Independent variables      | Classification and assignment   |
|----------------------------|---|
| Eating Habit (EH)          | EH <P <sub>25</sub> =1 EH P <sub>25</sub> -P <sub>50</sub> =2 EH P <sub>50</sub> -P <sub>75</sub> =3 EH >P <sub>75</sub> =4     |
| Satiety Responsiveness(SR) | SR <P <sub>25</sub> =1 SR P <sub>25</sub> -P <sub>50</sub> =2 SR P <sub>50</sub> -P <sub>75</sub> =3 SR >P <sub>75</sub> =4     |
| External Eating (EXE)      | EXE <P <sub>25</sub> =1 EXE P <sub>25</sub> -P <sub>50</sub> =2 EXE P <sub>50</sub> -P <sub>75</sub> =3 EXE >P <sub>75</sub> =4 |
| Emotional Eating (EE)      | EE <P <sub>25</sub> =1 EE P <sub>25</sub> -P <sub>50</sub> =2 EE P <sub>50</sub> -P <sub>75</sub> =3 EE >P <sub>75</sub> =4     |
| Initiative Eating (IE)     | IE <P <sub>25</sub> =1 IE P <sub>25</sub> -P <sub>50</sub> =2 IE P <sub>50</sub> -P <sub>75</sub> =3 IE >P <sub>75</sub> =4     |

## 2. Results

### 2.1 Characteristics of the children included in the study and their caregivers

Among 912 primary caregivers, valid questionnaires were collected from 768 participants (response rate = 84.2%). The characteristics of the children and caregivers are shown in Table 3. The mean age of the recruited children was 4.9±0.9 years. Among them, 52.0% resided in urban areas, and 53.4% were boys. The majority of these children (66.8%) had normal weight status. The rates of underweight, overweight, and obesity among these children were 10.0%, 12.5%, and 10.7%, respectively. The prevalence rates of underweight, overweight, and obesity were higher in children who lived in urban areas, compared to those residing in rural areas ( $\chi^2=25.506$ ,  $P=0.013$ ). Gender differences were found in the weight status of children ( $\chi^2=15.595$ ,  $P<0.001$ ).

Table 3  
Demographic characteristics of the children and their caregivers

|                                 |       | Weight status of childrene ( <i>n</i> =768) |                           |                         |                      |          |
|---------------------------------|-------|---|---------------------------|-------------------------|----------------------|----------|
|                                 |       | Underweight <sup>a</sup>                    | Normalweight <sup>b</sup> | Overweight <sup>c</sup> | Obesity <sup>d</sup> |          |
| Group                           | Total | <i>n</i> =77                                | <i>n</i> =513             | <i>n</i> =96            | <i>n</i> =82         | <i>P</i> |
| Urban/Rural(%)                  |       |   |                           |                         |                      |          |
| Urban                           | 52.0  | 55.8  | 61.4                      | 63.5                    | 54.9                 | 0.013    |
| Rural                           | 48.0  | 44.2  | 38.6                      | 36.5                    | 45.1                 |          |
| Child sex                       |       |   |                           |                         |                      |          |
| Male                            | 53.4  | 44.2  | 50.5                      | 67.7                    | 63.4                 | <0.001   |
| Female                          | 46.6  | 55.8  | 49.5                      | 32.3                    | 36.6                 |          |
| Child age (years)<br>(%)        |       |   |                           |                         |                      |          |
| 3-                              | 31.5  | 23.4  | 29.0                      | 40.6                    | 64.6                 | <0.001   |
| 4-                              | 33.5  | 26.0  | 36.7                      | 21.9                    | 26.9                 |          |
| >5                              | 35.0  | 50.6  | 34.3                      | 37.5                    | 8.5                  |          |
| Child-caregiver relationship(%) |       |   |                           |                         |                      |          |
| Parent                          | 76.2  | 85.7  | 77.6                      | 77.1                    | 57.3                 | <0.001   |
| Grandparent and others          | 23.8  | 14.3  | 22.4                      | 22.9                    | 42.7                 |          |
| Caregiver age (years) (%)       |       |   |                           |                         |                      |          |
| 20-                             | 11.5  | 18.2  | 11.3                      | 8.3                     | 9.8                  | 0.005    |
| 30-                             | 62.2  | 55.8  | 65.3                      | 63.5                    | 47.6                 |          |
| 40-                             | 7.4   | 13.0  | 5.9                       | 8.3                     | 10.9                 |          |
| >50                             | 18.9  | 13.0  | 17.5                      | 19.8                    | 31.7                 |          |
| Caregiver weight status(%)      |       |   |                           |                         |                      | 0.028    |
| Underweight <sup>e</sup>        | 8.7   | 15.6  | 7.6                       | 5.2                     | 13.4                 |          |
| Normal weight <sup>f</sup>      | 45.1  | 36.4  | 47.6                      | 48.9                    | 32.9                 |          |
| Overweight <sup>g</sup>         | 35.5  | 41.5  | 34.3                      | 31.3                    | 42.7                 |          |

|                             |      |      |      |      |      |        |
|-----------------------------|------|------|------|------|------|--------|
| Obesity <sup>h</sup>        | 10.7 | 6.5  | 10.5 | 14.6 | 11.0 |        |
| Caregiver education(%)      |      |      |      |      |      | <0.001 |
| Junior high school or below | 27.6 | 28.6 | 26.5 | 27.1 | 34.2 |        |
| Senior high school          | 25.4 | 28.6 | 22.2 | 18.7 | 50.0 |        |
| College/university or above | 47.0 | 42.8 | 51.3 | 54.2 | 15.8 |        |
| Family monthly Income(%)    |      |      |      |      |      | 0.002  |
| <\$750                      | 45.6 | 63.6 | 45.6 | 33.3 | 43.9 |        |
| \$750~\$1500                | 43.8 | 27.3 | 43.1 | 53.2 | 51.2 |        |
| >\$1500                     | 10.7 | 9.1  | 11.3 | 13.5 | 4.9  |        |
|                             |      |      |      |      |      |        |

Note: <sup>a</sup> Sex- and age-specific BMI <15th percentile; <sup>b</sup> Sex- and age-specific BMI between the 15th and 85th percentiles; <sup>c</sup> Sex- and age-specific BMI between the 85th and 95th percentiles; <sup>d</sup> Sex- and age-specific BMI >95th percentile. <sup>e</sup> BMI <18.5; <sup>f</sup>BMI between 18.5 and 24; <sup>g</sup> BMI between 24 and 28; <sup>h</sup> BMI >28.

## 2.2 CPCFBS and CPEBQ scores

The mean scores on each dimension of the CPCFBS and CPEBQ are presented in Table 4. For the CPCFBS, scores were highest on the Supervised Eating dimension, followed by Responsibility Feeding and Encouraging Healthy Feeding. These results suggested that most caregivers performed their responsibilities during the feeding process. For the CPEBQ, scores were highest on the Initiative Eating and External Eating dimensions.

Except for Forced Feeding ( $P<0.05$ ), average scores on various dimensions of the CPCFBS differed significantly among children with different weight status. Scores on the Weight Concerns dimension increased with overweight/obesity status, whereas the results for Responsibility Feeding and Encouraging Healthy Feeding showed the opposite trend. For the CPEBQ, average scores on the Food Responsiveness, Food Fussiness, Eating Habits, Emotional Eating, and Initiative Eating dimensions were significantly different among children who differed in terms of weight status ( $P<0.05$ ). Scores on the Food Responsiveness, Eating Habits, and Emotional Eating dimensions increased in association with overweight.

Table 4

Average scores on each dimension of the CPCFBS and CPEBQ in children, stratified by weight status

| behaviors                                 | Underweight              | Normal                   | Overweight               | Obesity                    | total     |
|---|--------------------------|--------------------------|--------------------------|----------------------------|-----------|
| Responsibility Feeding( $X_{RF}$ )        | 4.00±0.57                | 3.92±0.67                | 3.72±0.69 <sup>a,b</sup> | 3.47±0.77 <sup>a,b,c</sup> | 3.85±0.69 |
| Weight Concerns( $X_{WEC}$ )              | 1.73±0.84 <sup>b,c</sup> | 2.12±0.92 <sup>a,c</sup> | 2.49±0.94 <sup>a,b</sup> | 2.56±0.73 <sup>a,b</sup>   | 2.17±0.93 |
| Encourage Healthy Feeding( $X_{EHF}$ )    | 3.90±0.56 <sup>c</sup>   | 3.87±0.62 <sup>c</sup>   | 3.63±0.68 <sup>a,b</sup> | 3.36±0.69 <sup>a,b,c</sup> | 3.79±0.65 |
| Content-Restricted Feeding( $X_{CTRF}$ )  | 3.50±0.89                | 3.66±0.81 <sup>c</sup>   | 3.47±0.86 <sup>b</sup>   | 3.45±0.68 <sup>b</sup>     | 3.59±0.81 |
| Behavior-Restricted Feeding( $X_{BHRF}$ ) | 3.63±0.85                | 3.72±0.75                | 3.50±0.74 <sup>b</sup>   | 3.31±0.68 <sup>a,b</sup>   | 3.64±0.76 |
| Forced Feeding( $X_{FOF}$ )               | 3.40±0.83                | 3.55±0.83                | 3.43±0.70                | 3.48±0.65                  | 3.51±0.82 |
| Supervise Eating( $X_{SE}$ )              | 3.97±0.82                | 3.99±0.77                | 3.81±0.79                | 3.63±0.80 <sup>a,b</sup>   | 3.92±0.82 |
| Food Fussiness( $X_{FF}$ )                | 2.48±0.55 <sup>c</sup>   | 2.56±0.55                | 2.68±0.47 <sup>a</sup>   | 2.69±0.48 <sup>a,b</sup>   | 2.58±0.54 |
| Food Responsiveness( $Y_{FR}$ )           | 2.20±0.53 <sup>b,c</sup> | 2.38±0.63 <sup>a,c</sup> | 2.53±0.57 <sup>a,b</sup> | 2.77±0.68 <sup>a,b,c</sup> | 2.43±0.65 |
| Eating Habit( $X_{EH}$ )                  | 2.29±0.68 <sup>c</sup>   | 2.37±0.66 <sup>c</sup>   | 2.54±0.63 <sup>a,b</sup> | 2.71±0.59 <sup>a,b</sup>   | 2.42±0.67 |
| Satiety Responsiveness( $X_{SR}$ )        | 2.69±0.54                | 2.70±0.53                | 2.67±0.50                | 2.81±0.53                  | 2.71±0.54 |
| External Eating( $X_{EXE}$ )              | 2.82±0.64                | 2.95±0.65                | 2.90±0.67                | 2.87±0.60                  | 2.92±0.65 |
| Emotional Eating( $X_{EE}$ )              | 1.80±0.67                | 1.95±0.75                | 2.28±0.87 <sup>a,b</sup> | 2.47±0.80 <sup>a,b</sup>   | 2.03±0.79 |
| Initiative Eating( $X_{IE}$ )             | 3.90±0.75 <sup>c</sup>   | 3.76±0.68                | 3.64±0.69 <sup>a</sup>   | 3.50±0.61 <sup>a,b</sup>   | 3.73±0.69 |

Note: <sup>a</sup> $P \leq 0.05$  vs. underweight; <sup>b</sup> $P \leq 0.05$  vs. normal weight; <sup>c</sup> $P \leq 0.05$  vs. overweight.

## 2.3 Association among feeding behaviors, eating behaviors, and children's BMI

The results of multivariate linear stepwise regression analysis using BMI as the dependent variable ( $Y$ ), the demographic characteristics (children's gender, children's age, caregivers' age, child-caregiver relationship, caregivers' educational level, monthly household income), and scores on the CPCFBS and CPEBQ as independent variables ( $X$ ) are shown in Table 5. According to Model 1, in which demographic

characteristics were independent variables, the Influencing factors for abnormal BMI were the child's gender ( $\beta=1.01$ ), the child's age ( $\beta=-1.29$ ), the caregivers' educational level ( $\beta=-1.45$ ), and monthly household income ( $\beta=0.72$ ) ( $F=25.04$ ,  $P<0.001$ ). The model determination coefficient  $R^2$  was 0.371. In Model 2, the demographic characteristics and caregivers' feeding behaviors were used as independent variables. The Influencing factors for BMI included child's gender ( $\beta=1.07$ ), child's age ( $\beta=-1.08$ ), caregivers' educational level ( $\beta=-1.11$ ), monthly household income ( $\beta=0.65$ ), Responsibility for Feeding ( $\beta=-0.87$ ), and Weight Concerns ( $\beta=0.69$ ) on the CPCFBS ( $F=24.46$ ,  $P<0.001$ ). The model determination coefficient ( $R^2$ ) was 0.422. In Model 3, the demographic characteristics, caregivers' feeding behaviors, and children's eating behaviors were used as independent variables. The results showed that the Influencing factors for BMI were child's gender ( $\beta=1.06$ ), child's age ( $\beta=-1.01$ ), caregivers' educational level ( $\beta=-1.12$ ), monthly household income ( $\beta=0.68$ ), Responsibility for Feeding ( $\beta=-0.68$ ), and Weight Concerns ( $\beta=0.53$ ) on the CPCFBS, and Food Responsiveness ( $\beta=0.93$ ) and External Eating ( $\beta=-0.53$ ) on the CPEBQ ( $F=21.18$ ,  $P<0.001$ ). The model determination coefficient ( $R^2$ ) was 0.601. Moreover, BMI was higher among boys, compared to girls ( $P\leq 0.001$ ). Family monthly income and scores on the Weight Concerns and Food Responsiveness dimensions were positively correlated with children's BMI ( $P<0.05$ ). Children's age, caregivers' educational level, Responsibility for Feeding score on the CPCFBS, and External Eating behavior in children were negatively correlated with children's BMI ( $P<0.05$ ). A lower BMI was observed in younger children, in caregivers with higher educational levels, and in subjects with higher scores on the Responsibility for Feeding and External Eating subscales.

Table 5

The association between caregivers' feeding behavior, children's eating behavior, and children's BMI.

| Model                       | Partial regression coefficient $\beta$ | Standardized partial regression coefficient | 95% CI      |             | P Value      | $R^2$        |
|-----------------------------|--|---|-------------|-------------|--------------|--------------|
|                             |  |   | Lower limit | Upper limit |              |              |
| <b>Model 1</b>              |  |   |             |             | <b>0.000</b> | <b>0.371</b> |
| Child sex                   | 1.01                                   | 0.12  | 1.02        | 1.57        | 0.001        |              |
| Child age (years)           | -1.29                                  | -0.30                                       | -1.58       | -1.01       | 0.000        |              |
| Caregivers' Education       |  |   |             |             |              |              |
| Senior high school          | 0.02                                   | 0.02  | -           | -           | 0.579        |              |
| College/university or above | -1.45                                  | -0.17                                       | -2.03       | -0.86       | 0.000        |              |
| Family monthly Income       |  |   |             |             |              |              |
| \$750~\$1500                | 0.72                                   | 0.09  | 0.02        | 0.12        | 0.019        |              |
| >\$1500                     | 0.06                                   | 0.05  | -           | -           | 0.148        |              |
| <b>Model 2</b>              |  |   |             |             | <b>0.000</b> | <b>0.484</b> |
| Child sex                   | 1.07                                   | 0.13  | 1.02        | 1.61        | 0.000        |              |
| Child age (years)           | -1.08                                  | -0.25                                       | -1.37       | -0.79       | 0.000        |              |
| Caregivers' Education       |  |   |             |             |              |              |
| Senior high school          | 0.04                                   | 0.02  | -           | -           | 0.36         |              |
| College/university or above | -1.11                                  | -0.13                                       | 1.02        | 1.61        | 0.000        |              |
| Family monthly Income       |  |   |             |             |              |              |
| \$750~\$1500                | 0.65                                   | 0.12  | 0.02        | 0.17        | 0.042        |              |
| >\$1500                     | 0.06                                   | 0.05  | -           | -           | 0.148        |              |
| RF                          | -0.87                                  | -0.14                                       | -1.27       | -0.47       | 0.000        |              |
| WEC                         | 0.69                                   | 0.15  | 0.39        | 0.99        | 0.001        |              |
| <b>Model 3</b>              |  |   |             |             | <b>0.000</b> | <b>0.601</b> |
| Child sex                   | 1.06                                   | 0.27  | 1.05        | 1.60        | 0.000        |              |

|                             |       |       |       |       |       |
|-----------------------------|-------|-------|-------|-------|-------|
| Child age (years)           | -1.01 | 0.23  | -1.31 | -0.72 | 0.000 |
| Caregivers' Education       |       |       |       |       |       |
| Senior high school          | -0.05 | 0.07  | -     | -     | 0.196 |
| College/university or above | -1.12 | -0.13 | -1.65 | -0.58 | 0.000 |
| Family monthly Income       |       |       |       |       |       |
| \$750~\$1500                | 0.68  | 0.12  | 0.06  | 0.13  | 0.033 |
| >\$1500                     | 0.08  | 0.11  | -     | -     | 0.108 |
| RF                          | -0.68 | -0.11 | -1.08 | -0.27 | 0.003 |
| WEC                         | 0.53  | 0.12  | 0.22  | 0.84  | 0.001 |
| FR                          | 0.93  | 0.15  | 1.04  | 1.41  | 0.000 |
| EXE                         | -0.53 | -0.08 | -0.97 | -0.09 | 0.001 |

Note: (1) Model 1 used demographic characteristics as independent variables; Model 2 used demographic characteristics and CPCFBS scores as independent variables; Model 3 used demographic characteristics, CPCFBS scores, and CPEBQ scores as independent variables; (2) For classification variables, gender of the child, educational level of the caregiver, and monthly family income were analyzed based on “female”, “junior high school or below”, and “under \$750”, respectively; (3) Data were analyzed using the multivariate stepwise linear regression method.

## 2.4 Association among feeding behaviors, eating behaviors, and children's weight status

In the binary logistic regression analysis, abnormal weight status (overweight/obesity) was used as the dependent variable ( $Y$ ). The demographic characteristics (child gender, age, caregiver age, relationship with child, caregiver education, family monthly total income) and scores on the CPCFBS and CPEBQ were independent variables ( $X$ ) (see Table 6). According to Model 1, in which demographic characteristics were the independent variables, the Influencing factors for overweight/obesity included caregivers' educational level ( $OR=0.49$ ,  $P<0.001$ ), monthly family income ( $OR=3.01$ ,  $P<0.001$ ), and children's age ( $OR=0.42$ ,  $P<0.001$ ) ( $\chi^2=68.29$ ,  $df=6$ ,  $P<0.001$ ). In Model 2, demographic characteristics and caregivers' feeding behaviors were the independent variables. The Influencing factors for overweight/obesity were family monthly income ( $OR=2.02$ ,  $P<0.001$ ), Responsibility for Feeding ( $OR=0.44$ ,  $P<0.001$ ), Weight Concerns ( $OR=5.36$ ,  $P<0.001$ ), Behavior-Restricted Feeding ( $OR=0.53$ ,  $P<0.001$ ), and Supervised Eating ( $OR=0.52$ ,  $P<0.001$ ) on the CPCFBS ( $\chi^2=218.76$ ,  $df=13$ ,  $P<0.001$ ). According to Model 3, in which demographic

characteristics, caregivers' feeding behaviors, and children's eating behaviors were the independent variables, the Influencing factors for overweight/obesity were monthly family income ( $OR=1.76, P<0.001$ ), Weight Concerns ( $OR=4.54, P<0.001$ ), Behavior-Restricted Feeding ( $OR=0.29, P<0.001$ ) on the CPCFBS, and Food Responsiveness ( $OR=4.04, P<0.001$ ), Satiety Responsiveness ( $OR=0.42, P<0.001$ ), and Emotional Eating ( $OR=0.56, P<0.001$ ) on the CPEBQ ( $\chi^2=244.96, df=17, P<0.001$ ). The model determination coefficient ( $R^2$ ) was 0.666. Furthermore, family monthly income, and scores on the Weight Concerns, Behavior-Restricted Feeding, and Food Responsiveness dimensions were positively correlated with overweight/obesity status in children ( $P<0.05$ ). The higher the score on a given dimension, the higher the risk for overweight/obesity in children. Scores on the Satiety Responsiveness and Emotional Eating subscales were negatively correlated with abnormal weight status in children ( $P<0.05$ ). A higher likelihood of overweight/obesity was observed in participants with more monthly family income, with higher scores on the Weight Concerns and Behavior-Restricted Feeding subscales on the CPCFBS, as well as higher scores on the Food Responsiveness subscale on the CPEBQ. A higher likelihood of overweight/obesity was also observed in participants with lower scores on the Satiety Responsiveness and Emotional Eating subscale on the CPEBQ ( $P<0.05$ ).

Table 6

The association between caregivers' feeding behavior, children's eating behavior, and children's overweight/obesity status.

| Model                       | Regression coefficient $\beta$ | OR   | OR 95% CI   |             | P Value      | $R^2$        |
|-----------------------------|--------------------------------|------|-------------|-------------|--------------|--------------|
|                             |                                |      | Lower limit | Upper limit |              |              |
| <b>Model 1</b>              |                                |      |             |             | 0.000        | 0.314        |
| Caregivers' Education       |                                |      |             |             | 0.001        |              |
| junior high school or below | -                              | -    | -           | -           | -            |              |
| Senior high school          | -0.06                          | 0.94 | 0.62        | 1.43        | 0.783        |              |
| College/university or above | -0.71                          | 0.49 | 0.33        | 0.75        | 0.001        |              |
| Family monthly Income       |                                |      |             |             | 0.000        |              |
| $\leq \$750$                | -                              | -    | -           | -           | -            |              |
| $\$750 \sim \leq \$1500$    | 1.10                           | 3.01 | 2.09        | 4.33        | 0.001        |              |
| $> \$1500$                  | 0.66                           | 1.94 | 1.12        | 3.36        | 0.018        |              |
| Child age (years)           |                                |      |             |             | 0.000        |              |
| 3~                          | -                              | -    | -           | -           | -            |              |
| 4~                          | -0.62                          | 0.54 | 0.37        | 0.77        | 0.001        |              |
| 5~6                         | -0.86                          | 0.42 | 0.29        | 0.61        | 0.000        |              |
| <b>Model 2</b>              |                                |      |             |             | <b>0.000</b> | <b>0.432</b> |
| Family monthly Income       |                                |      |             |             | 0.001        |              |
| $\leq \$750$                | -                              | -    | -           | -           | -            |              |
| $\$750 \sim \leq \$1500$    | 0.71                           | 2.02 | 1.42        | 2.89        | 0.000        |              |
| $> \$1500$                  | 0.36                           | 1.44 | 0.82        | 2.53        | 0.010        |              |
| RF                          |                                |      |             |             | 0.005        |              |
| $P_{25}$                    | -                              | -    | -           | -           | -            |              |
| $P_{25} \sim$               | -0.42                          | 0.65 | 0.40        | 1.07        | 0.092        |              |
| $P_{50} \sim$               | -0.82                          | 0.44 | 0.27        | 0.73        | 0.002        |              |
| $\geq P_{75}$               | -0.89                          | 0.41 | 0.23        | 0.72        | 0.002        |              |

| Model                          | Regression coefficient $\beta$ | OR   | OR 95% CI   |             | P Value      | $R^2$        |
|--------------------------------|--------------------------------|------|-------------|-------------|--------------|--------------|
|                                |                                |      | Lower limit | Upper limit |              |              |
| WEC                            |                                |      |             |             | 0.000        |              |
| $\square P_{25}$               | -                              | -    | -           | -           | -            |              |
| $P_{25}\sim$                   | 0.57                           | 1.71 | 1.01        | 3.12        | 0.048        |              |
| $P_{50}\sim$                   | 1.68                           | 5.36 | 3.30        | 8.72        | 0.000        |              |
| $\geq P_{75}$                  | 2.15                           | 8.54 | 4.69        | 15.54       | 0.000        |              |
| BHRF                           |                                |      |             |             | 0.001        |              |
| $\square P_{25}$               | -                              | -    | -           | -           | -            |              |
| $P_{25}\sim$                   | -0.57                          | 0.95 | 0.57        | 1.55        | 0.023        |              |
| $P_{50}\sim$                   | -0.63                          | 0.53 | 0.33        | 0.86        | 0.010        |              |
| $\geq P_{75}$                  | -0.98                          | 0.38 | 0.22        | 0.64        | 0.000        |              |
| SE                             |                                |      |             |             | 0.041        |              |
| $\square P_{25}$               | -                              | -    | -           | -           | -            |              |
| $P_{25}\sim$                   | -0.28                          | 0.76 | 0.48        | 1.19        | 0.228        |              |
| $P_{50}\sim$                   | -0.65                          | 0.52 | 0.29        | 0.93        | 0.027        |              |
| $\geq P_{75}$                  | 0.13                           | 1.14 | 0.65        | 1.99        | 0.042        |              |
| <b>Model 3</b>                 |                                |      |             |             | <b>0.000</b> | <b>0.666</b> |
| Family monthly Income          |                                |      |             |             | 0.012        |              |
| $\leq \$750$                   | -                              | -    | -           | -           | -            |              |
| $\square \$750\sim\leq \$1500$ | 0.56                           | 1.76 | 1.21        | 2.56        | 0.003        |              |
| $> \$1500$                     | 0.24                           | 1.28 | 0.70        | 2.31        | 0.023        |              |
| WEC                            |                                |      |             |             | 0.000        |              |
| $\square P_{25}$               | -                              | -    | -           | -           | -            |              |
| $P_{25}\sim$                   | 0.61                           | 1.84 | 1.03        | 3.29        | 0.040        |              |
| $P_{50}\sim$                   | 1.51                           | 4.54 | 2.73        | 7.55        | 0.000        |              |

| Model            | Regression coefficient $\beta$ | OR   | OR 95% CI   |             | P Value | $R^2$ |
|------------------|--------------------------------|------|-------------|-------------|---------|-------|
|                  |                                |      | Lower limit | Upper limit |         |       |
| $\geq P_{75}$    | 1.79                           | 5.97 | 3.20        | 11.12       | 0.000   |       |
| BHRF             |                                |      |             |             | 0.000   |       |
| $\square P_{25}$ | -                              | -    | -           | -           | -       |       |
| $P_{25}\sim$     | -0.20                          | 0.98 | 0.58        | 1.64        | 0.039   |       |
| $P_{50}\sim$     | -0.71                          | 0.49 | 0.31        | 0.78        | 0.003   |       |
| $\geq P_{75}$    | -1.25                          | 0.29 | 0.17        | 0.47        | 0.000   |       |
| FR               |                                |      |             |             | 0.000   |       |
| $\square P_{25}$ | -                              | -    | -           | -           | -       |       |
| $P_{25}\sim$     | 0.14                           | 1.15 | 0.72        | 1.82        | 0.559   |       |
| $P_{50}\sim$     | 1.39                           | 4.04 | 2.05        | 7.97        | 0.000   |       |
| $\geq P_{75}$    | 1.52                           | 1.69 | 1.02        | 2.81        | 0.044   |       |
| SR               |                                |      |             |             | 0.025   |       |
| $\square P_{25}$ | -                              | -    | -           | -           | -       |       |
| $P_{25}\sim$     | -0.37                          | 0.69 | 0.44        | 1.07        | 0.099   |       |
| $P_{50}\sim$     | -0.53                          | 0.59 | 0.36        | 0.97        | 0.036   |       |
| $\geq P_{75}$    | -0.88                          | 0.42 | 0.23        | 0.76        | 0.004   |       |
| EE               |                                |      |             |             | 0.000   |       |
| $\square P_{25}$ | -                              | -    | -           | -           | -       |       |
| $P_{25}\sim$     | -0.58                          | 0.56 | 0.34        | 0.91        | 0.019   |       |
| $P_{50}\sim$     | -0.18                          | 1.19 | 2.04        | 0.69        | 0.014   |       |
| $\geq P_{75}$    | -0.65                          | 1.91 | 3.62        | 1.01        | 0.048   |       |

Note: (1) Model 1 used demographic characteristics as independent variables; Model 2 used demographic characteristics and CPCFBS scores as independent variables; Model 3 used demographic characteristics, as well as CPCFBS scores and CPEBQ scores, as independent variables; (2) For

classification variables, child's age, caregiver's level of education, and family monthly income were analyzed based on "3–4 years old", "junior high school or below", and "under \$750", respectively; (3) Data were analyzed by logistic regression.

### 3. Discussion

The identification of factors associated with weight status can optimize early intervention strategies to prevent childhood obesity. Recent studies have reported that demographic characteristics, such as children's age [28], family environment [29], caregivers' feeding behavior [12, 13, 30-33], and children's eating behavior [10] are closely related to children's weight status. Furthermore, parental feeding practices are partially responsible for the relationship between children's eating behaviors and their BMI. On the other hand, children's eating behaviors explain part of the association between parental feeding behaviors and children's BMI [13]. Our multiple linear regression and binary logistic regression analyses consistently showed that children's weight status was associated with family demographic characteristics, children's eating behavior, and caregivers' feeding behavior.

#### 3.1 Association between family demographic characteristics and children's weight status

Nowicka *et al.* examined the psychometric properties of the Child Feeding Questionnaire (CFQ) [34] and explored the relationship between parenting practices and children's weight status in Sweden [35]. The results showed that children's BMI and parents' foreign origin had a direct impact on restriction, and the pressure to eat was also affected by parental educational level. In 2014, Moreira *et al.*[29] confirmed the association between children's gender, children's age, child-caregiver relationship, family economic status, and children's weight status by analyzing the data collected from the CFQ and the OCCS(Overt and Covert Control Scale) using linear regression analysis. They reported that family environment and maternal socioeconomic factors were associated with the pressure to eat and perceived monitoring, while maternal health behavioral characteristics were associated with restriction. Rodenburg *et al.* also found that sociodemographic variables, such as the child's ethnicity and the primary caregivers' educational level, were correlated with psychological control and the child's BMI [36]. Using the Child Eating Behaviour Questionnaire (CEBQ), Alshammary *et al.* found that obesogenic-eating behaviors were associated with excess weight in both children and parents [19].

In this study, the linear regression model showed that a child's gender, his or her age, his or her caregivers' educational level, and monthly household income were the main factors associated with BMI in children. BMI was higher in boys than girls. Higher caregiver educational level was associated with lower BMI values in children. These findings indicate that Chinese caregivers with lower monthly household incomes and higher educational levels are more likely to be concerned about childhood obesity. Their feeding practices were not associated with high BMI, indicating that these behaviors may reduce the risk of childhood obesity.

## 3.2 The association between caregivers' feeding behavior and children's weight status

Childhood overweight/obesity has become a common concern in recent years. However, Branch *et al.* found that concerns were rarely translated into healthier family meal characteristics or feeding behaviors. Maternal concerns alone may not be sufficient to motivate actions to reduce the risks of childhood obesity [21]. In 2010, Webber *et al.* used CFQ to confirm the impact of maternal perceptions and concerns on the weight status of their children [20]. Also, Ma *et al.*[37] developed a Young Child Feeding Questionnaire (YCSQ) for 18-month-old infants and young children. The results obtained with use of this questionnaire showed that parental concerns about infants' weight status were positively correlated with BMI-for-age z-scores ( $\beta=0.293$ ,  $P=0.029$ ). Consistently, we found that caregivers' concerns about children's weight status during feeding led to increased BMI, suggesting that these feeding behaviors may increase risk for childhood obesity.

In 2012, Cheah *et al.* conducted a CFQ survey on Chinese and Korean caregivers of children (3–8 years of age) in the United States. The results demonstrated the impact of feeding responsibility on a child's weight status [38]. The authors found that caregivers' feeding responsibility correlated negatively with children's weight status and the occurrence of overweight/obesity. The stronger the caregivers' sense of responsibility, the higher the chance that he/she would have healthy feeding behaviors, which may decrease a child's BMI and reduce the risk of obesity.

## 3.3 Associations among caregivers' feeding behavior, children's eating behavior, and children's weight status

To organize various potentially overlapping constructs in the literature, Rodgers *et al.* conducted a principal components analysis in a sample of 2-year-old children to clarify a set of core independent constructs representing maternal feeding styles [18]. The authors found that weight-based restriction, encouragement to eat, emotional feeding, and restriction were positively correlated with the development of children's obesogenic eating behaviors, including food approach behaviors (such as good appetite and enjoyment of food), tendency to overeat, and emotional eating. Moreover, Sleddens *et al.* stated that the use of snacks as a reward may increase the number of external factors related to eating for the child, and may affect the child's eating behaviors by increasing exposure to unhealthy snacks, leading to overeating and obesity in children [39]. Therefore, the authors advised parents not to use food to regulate children's behavior or mood, and to encourage children's interest and curiosity in tasting different kinds of food. In the current study, the linear regression model showed a negative correlation between External Eating and BMI in children. The binary logistic regression also showed that children's Emotional Eating was negatively correlated with the occurrence of overweight/obesity, indicating that stimulate children's interest in tasting and eating different foods may promote the development of healthy eating behaviors in children, thereby reducing children's weight and decreasing the risk of obesity.

Stunkard *et al.*[40] used a three-factor dietary behavior scale (TFEQ) as a measurement tool and found that food response had a strong positive correlation with children's BMI. Wu *et al.* used the Dutch version of the Adult Dietary Behavior Scale (DEBQ) in 1171 middle school students and reached the same conclusion [41]. Jansen *et al.* performed a cross-sectional study using the CEBQ and CFQ, and found that higher levels of parental restriction, children's food responsiveness and enjoyment of food were associated with higher BMI values, independent of measured confounders [13]. Consistent with their findings, our results showed that children's responsiveness to food was positively correlated with excessive dietary intake, which may lead to an increase in BMI and a higher risk of obesity.

Viana *et al.*[42] and Sleddens *et al.* [43] used CEBQ to evaluate the dietary behavior of a pediatric population (3–13 years of age) in Portugal and another pediatric population (6–7 years of age) in the Netherlands. The results obtained showed a strong negative correlation between children's satiety response and their BMI. Jansen *et al.* also confirmed that children's fussiness, children's satiety responsiveness, and parents' pressure to eat were negatively correlated with children's BMI [13]. Our linear regression model did not incorporate Satiety Responsiveness. However, the binary logistic regression showed that children's Satiety Responsiveness had a significant negative correlation with overweight/obesity, indicating that children with greater satiety responsiveness had better capacity to regulate food consumption, which may prevent an excessive increase in BMI and reduce the incidence of overweight/obesity.

Previous evidence has shown that not only insufficient parental control [44] but also parental over-control [45] contribute to children's overweight/obesity status, as children are likely tempted to overeat in the obesogenic environment. Poor parental restriction [46-48] and monitoring [46] of children's food intake were positively correlated with higher BMI values. Birch *et al.* stated that caregivers' restriction of feeding may lead to unhealthy eating behaviors in children (Birch, 2008). Elford *et al.* used an adapted version of the CFQ to explore the impact of other key care providers on the weight and eating habits of children [49]. The results showed that a controlling maternal child-feeding style (e.g. restriction of certain food, the use of pressure to eat) was associated with fussy eating, overconsumption, and abnormal weight. Conversely, a responsive child-feeding style, whereby children were encouraged to eat different kinds of food, encouraged to try new tastes, and allowed to regulate their food intake, was associated with healthy eating styles and normal weight. Our results were not consistent with theirs. In the binary logistic regression model, Restriction Feeding was negatively correlated with the occurrence of overweight/obesity, indicating that a child showed healthy eating behaviors when a caregiver restricted his/her food consumption, and thus the risk of overweight/obesity was decreased.

We did not identify a relationship among caregiver feeding behaviors (e.g., Content-Restricted Feeding, Forced Feeding, Supervised Eating), children's eating behaviors (e.g., Eating Habits, Initiative Eating), and children's BMI or overweight/obesity status. The influencing factors are complex, as dietary culture and feeding habits vary among regions, ethnicities, and family social environments. Another source of complexity is the diversity of caregivers' feeding practices and children's eating behaviors.

## 3.4 Limitations

This study had some limitations. First, the study participants may not have been representative of the entire population of preschool children in China, as we only recruited subjects from Jinan and Xi'an City. Secondly, the sample size was small. Thirdly, the current study was limited by its cross-sectional design. Longitudinal studies are necessary to determine the direction of causality. Also, the information pertaining to children's eating behaviors was collected based on the subjective opinions of caregivers, which may have been confounded by reporting bias. Future investigations on other potential confounding factors will be needed.

## 3.5 Conclusions

In summary, this study comprehensively evaluates the relationships among demographic characteristics, caregivers' feeding behavior, children's eating behavior, and children's weight status using regression analyses. Our results show that caregivers' feeding behaviors and children's eating behaviors are associated with children's weight status and the occurrence of overweight/obesity in China, suggesting that the prevention of unhealthy overweight/obesity status among children may require behavioral changes on the parts of children as well as their caregivers. These findings provide reference information for the development of healthy feeding habits and the optimization of prevention and intervention strategies for the management of childhood obesity.

## Declarations

### Ethical approval and consent to participate

This study was approved by the Research Ethics Committee of the Fourth Military Medical University. All caregivers recruited provided written informed consent prior to the collection of any information.

### Consent for publication

All caregivers understood and agreed that their information could be published in any journal.

### Availability of data and materials

All data and materials were available.

### Competing interests

The authors have declared that no competing interests exist.

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## Author Contributions:

Lei Shang, Jiang Xun conceived the study and led the writing of the manuscript. All authors designed the study and reviewed versions of the protocol. Jing Yuan, Tongyu Zhu, Yuhai Zhang and Yue Wang organized and supervised the data collection phase of the study. Jing Yuan, Tongyu Zhu, Yuhai Zhang, Xianjun Yang conducted the data analysis and also participated in writing the manuscript. Lei Shang, Xun Jiang and Yuhai Zhang analyzed and interpreted the results and led the writing of the manuscript. All authors critically reviewed the manuscript and provided comments for revision. All authors read and approved the final version of the manuscript.

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