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Original Article

Dietary nutrient patterns among preschool children aged 3-6 and the correlation with being overweight and obese

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Abstract: Objective: To investigate the dietary nutrient patterns in preschool children aged 3-6 years old, and analyze the relationship between the dietary nutrients and being overweight or obese. Methods: A stratified cluster sampling method was used to select 19,529 preschool children aged 3-6 from 62 kindergartens in Jiashan County of Zhejiang Province. To evaluate the overweight and obesity rates in the included children, body mass index (BMI) of all the children were analyzed using the BMI-for-age method and the weight-for-height method recommended by the World Health Organization (WHO). The dietary nutrient patterns of the preschool children were obtained by survey of food frequency and dietary reviews. Results: The intake of meat from livestock and poultry among overweight and obese children increased significantly at different ages. Moreover, there were significant differences observed between normal-weight and overweight/obese children with regard to the consumption of grain, eggs, milk, vegetables, potatoes, livestock, poultry, fish and shrimp, legumes, fruits and oils (all $P<0.05$). Generally, children in the overweight or obese group consumed higher amounts of food than recommended, whereas normal-weight children tended to meet the recommended levels for protein, fat and carbohydrate intake. In addition, overweight and obese children tended to consume higher levels of various dietary nutrients compared to the normal-weight children, with statistical differences observed (all $P<0.05$). Children with a normal physique showed higher intake of milk and vegetables compared to the overweight/obese ones, with statistical differences observed between the two groups (all $P<0.05$). Meanwhile, overweight children tended to consume relatively high amounts of grains and fruits, although no statistical difference was identified. Obese children had a relatively high intake of eggs, fish and shrimp, with a statistical difference observed in egg intake between them and the normal-weight children ($P<0.05$). Conclusion: There is a correlation between the dietary nutrient patterns and being overweight and obese in preschool children aged 3-6.

Keywords: Children, obesity, overweight, nutrient pattern

Introduction

China's economic development has advanced in the context of economic globalization, leading to changes in the residents' dietary patterns. As a result, nutrient intake has improved, and the incidence rate of malnutrition-related diseases has decreased. Moreover, dietary patterns from other countries also have an impact on the dietary habits of Chinese residents. However, the rising obesity rate in China reflects the occurrence of obesity and being overweight accompanied by adequate nutrition [1]. It is worth mentioning that although the growth of children aged 3-6 is slower than that of infants, they are still in a phase of constant growing. In preschool children, the growth of 20 deciduous teeth have finished, which increased their chewing ability to approximately 40% of that of adults [2]. Therefore, at this stage, the dietary nutrient model can have a significant impact on the growth and development of children through their nutrient supply. Furthermore, the dietary habits and patterns developed during this period are vital factors affecting the physical health of children [3, 4].

According to the report released by the China Center for Disease Control and Prevention in 2019, the overweight and obesity rates of pre-

school children were 10.88% and 7.87%, respectively [5, 6]. Scholars found that higher intake of fat and carbohydrates in preschool children was associated with increased incidence of being overweight and obesity [7-9]. Moreover, the China Child Obesity Data Report (2017) suggested that without timely and effective intervention, the number of overweight and obese children in China may surpass 40 million by 2030 [10, 11]. As a chronic disease, obesity has long-lasting effects on the physiology and psychology of children from the time of onset. Physiologically, being overweight or obese can damage children's cardiovascular, respiratory and immune systems to some extent, and in severe cases, may even threaten their lives [12]. Psychologically, being overweight or obese can cause psychological trauma during their life due to social stigma and different social perspectives, which can have a negative impact on their mental health [13]. So far, research on dietary nutrient patterns in children in China is still at its early stages, with most studies focusing only on specific aspects such as dietary investigations or nutritional status assessments. Few studies have examined the detailed correlation of dietary nutrient patterns with overweight and obese children. Against this background, this study took Jiashan County of Zhejiang Province as an example to investigate the dietary nutrient patterns of 3-6-year-old preschool children and the correlation of dietary patterns with being overweight and obese. The findings of this study would serve as a foundation for proposing effective and evidence-based nutrition education methods, enhancing parental nutritional knowledge, and guiding children to adopt healthy dietary habits.

Methods

Subjects

This study included a total of 19,529 preschool children from senior class, middle class and junior class in 62 kindergartens in Jiashan County of Zhejiang Province, including 10,346 boys (52.98%) and 9,183 girls (47.02%).

The main caregivers were the parents, elders or other persons with capacity to provide care and be responsible for the children's daily food and drink. Inclusion criteria: (1) Children were 3-6 years old. (2) Children had no important organ diseases (lung, heart, liver, kidney, etc.) and endocrine diseases. (3) Children were well developed, without deformity and disability. (4) The guardians of the children supported the study and cooperated with the investigation. Exclusion criteria: (1) Children were unwilling to communicate or participate in the study. (2) Children were accompanied with serious organ diseases or endocrine diseases. (3) Children had chronic diseases, such as recent digestive diseases that affected their food intake. This research was approved by the Ethics Committee of Jiashan Maternal and Child Health Hospital (Ethics approval No. 202184).

Dietary pattern survey

According to the types of food that are commonly consumed by residents in Zhejiang Province, the food intake of children was categorized into four major groups: (1) Cereals, potatoes and legumes; (2) Vegetables, algae, fungi, and fruits; (3) Fish, eggs, meat (from livestock and poultry), and milk; (4) Soybeans and nuts. To specify, the dietary patterns of children in this study were analyzed based on the consumption of various food groups, including cereal crops, potato crops, vegetables, fruits, fish and seafood, leguminous plants, milk, meat, eggs, and edible oils. In addition, industrial processed food such as beverages, instant food, biscuits, canned food, frozen food, puffed food, candy, and cakes were also categorized according to the above food groups.

Before the formal investigation and research, a pre-investigation was conducted in 10 kindergartens by random sampling. After that, the questionnaire was improved and used for subsequent investigation, taking into account the actual situation. The investigators involved in this study were uniformly trained. The medical workers guided the class teachers and parents to fill in the questionnaire during both pre-investigation and formal investigation. The sixth edition of the Chinese Food Composition Table was used to calculate the average consumption frequency per capita per day and unit time, and the dietary reference intake (DRI) from the 2013 edition of the Chinese Dietary Nutrition Reference Intake revised by the Chinese Nutrition Society was used as a comparison baseline [14].

Table 1. Proportion of overweight and obesity in children

Age (years)	Number	Obese		Overweight	
		Numbers	Percentage (%)	Numbers	Percentage (%)
3~	4679	117	2.5	211	4.5
4~	4615	142	3.1	253	5.5
5~6.5	10235	420	4.1	763	7.5
Total	19529	679	3.48	1227	6.28

The assessment of being overweight and obese

The measurement recommended by WHO was used in this study for the evaluation of overweight and obese children aged 3 to 6 years. For children aged 3 to 5, the evaluation was conducted using the weight-for-height method recommended by WHO. This method compares the weight of children with the average weight standard from groups corresponding to their height. A weight value greater than or equal to 1 standard deviation was considered overweight, and a weight value greater than or equal to 2 standard deviations was considered obese. For children who were over 5 years old or taller than 120 cm, the BMI for-age method recommended by WHO was used for the assessment. This method compares the BMI of children with the average BMI standard from the group corresponding to their age. A BMI greater than or equal to 1 standard deviation was considered overweight, and a BMI greater than or equal to 2 standard deviation was considered obese. According to the assessment results, the children were divided into a normal-weight group, an overweight group and an obese group.

Statistical analysis

The age, sex, being overweight or obese and other basic information of the respondents were analyzed by descriptive statistical analysis. A computer dietary guidance service system (CDGSS30) was used for the nutrients analysis, and SPSS 20.0 software was used for data analysis. The measurement data were expressed as mean ± standard deviation, and the comparison between two groups was conducted by t test. The comparison among three groups or more was performed using one-way ANOVA followed by Bonferroni post hoc test. The count data were presented as percentages/cases. The comparison among groups was performed using χ^2 test. $P<0.05$ suggested statistically significant differences.

Results

The overweight and obesity rate in children

Among the 19,529 preschool children from 62 kindergartens, 679 children were obese, with an obese rate of 3.48%; 1,227 children were overweight, with an overweight rate of 7.5%. The details are shown in **Table 1**.

In the 3-year-old group, 117 children were evaluated to be obese and 211 to be overweight, accounting for 2.5% and 4.5%, respectively, in this group. In the 4-year-old group, 142 children were evaluated to be obese and 253 to be overweight, accounting for 3.1% and 5.5%, respectively, in this group. In the 5-6.5 years old group, 420 children were evaluated to be obese and 763 to be overweight, accounting for 4.1% and 7.5%, respectively, in this group.

Dietary patterns in the children

According to the categorization of children's dietary intake, the results of this survey showed that the intake of milk, eggs, meat of livestock and poultry, fish, shrimp, leguminous plants, vegetables, fruits and oils in 3-year-old children was lower than recommendation. The intake of cereal, milk, eggs, meat of livestock and poultry, fish and shrimp, leguminous plants, vegetables, fruits and oils in 4-year-old children was within the range recommended. The intake of grain, meat of livestock and poultry, fish, shrimp, vegetables and oils in 5-6.5-years-old children was significantly higher than the recommended amount. The details are shown in **Table 2**.

Energy and dietary nutrient intake

The average daily intake of energy and dietary nutrients in children are shown **Table 3**. There were 13 indexes of dietary nutrients, including 4 basic substances (energy, proteins, carbohydrate, and fat), 3 mineral substances (calcium, iron and zinc), and 6 vitamins (vitamin C, vitamin E, vitamin A, vitamin B1, vitamin B2, and nicotinic acid).

Table 2. The average daily intake in the children (g/standard man-day)

Type of food	The recommended amount	Age (years)		
		3~	4~	5~6.5
Cereal	100-150	88.3	143.5	177.2
Potato	-	34.1	59.6	73.3
Milks	350-500	288.6	435.1	467.8
Eggs	50	31.2	46.7	56.8
Livestock meat, poultry, fish and shrimp	50-75	43.4	61.1	82.7
Leguminous plants	15-20	12.6	17.2	18.7
Vegetables	150-300	137.6	233.8	324.1
Fruits	150-250	133.3	245.9	210.2
Oils	20-25	12.8	21.1	35.3

Table 3. The average daily intake of energy and dietary nutrients in the children and the RNI

Dietary nutrient	The recommended amount (Age 3/Age 4/Age 5~6.5)	Intakes (Age 3/Age 4/Age 5~6.5)	Percentage of RNI (%) (Age 3/Age 4/Age 5~6.5)
Energy/kcal	1250-1300/1300-1400/1450-1600	1048.97/1382.78/1608.16	80.69/98.77/100.51
Proteins/g	30/30/35	12.64/30.11/45.45	42.13/100.37/129.86
Carbohydrates/g	120/120/120	93.34/94.83/111.13	77.78/79.03/92.61
Fat/g	30/30/35	19.86/23.91/32.21	66.20/79.70/92.03
VA/μg	360/360/360	75.38/103.89/151.41	20.94/28.86/42.06
VB1/mg	0.8/0.8/0.8	0.68/0.64/0.75	85.00/80.00/93.75
VB2/mg	0.7/0.7/0.7	0.46/0.61/0.67	65.71/87.14/95.71
VC/mg	50/50/50	18.96/42.61/43.21	37.92/85.22/86.42
VE/mg	7/7/7	5.21/7.67/9.80	74.43/109.57/140.00
Ca/mg	800/800/800	500.78/631.04/711.68	62.60/78.88/88.96
Fe/mg	10/10/10	6.12/8.21/13.47	61.20/82.10/134.70
Zn/mg	5.5/5.5/5.5	1.59/2.75/3.19	28.91/50.00/58.00
Nicotinic acid/mg	8/8/8	3.42/3.48/4.43	42.75/43.50/55.38

Note: RNI: Recommended nutrient intake, VA: Vitamin A, VB1: Vitamin B1, VB2: Vitamin B2, Ca: Calcium, Fe: Ferrum, Zn: Zinc.

In the 3-year-old group, the intake of protein, vitamin A, vitamin C, nicotinic acid and zinc per capita was 60% lower than the recommended nutrient intake (RNI), while the intake of carbohydrates, vitamin B1, vitamin E and other dietary nutrients was basically in line with the recommendations.

In the 4-year-old group, the intake of vitamin A and Zn was 60% lower than the RNI. Whereas the intake of carbohydrate, fat, vitamin B1, vitamin B2, vitamin C, Ca and Fe was basically in line with the recommendations. However, the intake of protein and vitamin E was more than the RNI. The intake of overall dietary nutrients in this group needed to be improved as compared with that in the 3-year-old group.

In the 5-6.5-year-old group, the intake of vitamin A, nicotinic acid and zinc were 60% lower than the RNI. However, the intake of overall dietary nutrients was significantly increased as compared with that in the 3- and 4-year-old groups. Moreover, the intake of carbohydrates, fat, vitamin B1, vitamin B2, vitamin C, and Ca was basically in line with the recommendations, but the intake of protein, vitamin E, and Fe were more than the RNI.

Dietary nutrient intake in children with different BMIs

As seen in **Table 4**, the intake of energy, protein, carbohydrates, nicotinic acid, Ca, Fe and Zn in normal-weight children were lower than those in overweight-obese children, while the intake of vitamin C, vitamin E, vitamin A, vitamin B1, vitamin B2 in normal-weight children were more than those in overweight-obese children. Statistically significant differences were observed between the two groups (all $P<0.05$).

Table 4. Comparison of dietary nutrient intake between normal-weight children and overweight-obesity children

Dietary nutrients	The recommended amount	Normal-weight children	Overweight-obesity children
Energy/kcal	1250-1600	1123.08±50.17	1505.18±552.36
Protein/g	30-35	27.48±3.25	42.11±4.26
Carbohydrates/g	120	110.22±3.69	130.37±28.71
Fat/g	35	22.32±9.48	36.93±4.52
VA/μg	360	298.33±48.47	215.66±42.36
VB1/mg	0.8	0.53±0.23	0.49±0.21
VB2/mg	0.7	0.56±0.11	0.47±0.23
VC/mg	50	45.68±13.02	40.49±10.05
VE/mg	7	5.58±2.02	4.33±2.32
Ca/mg	800	722.12±69.74	817.16±75.03
Fe/mg	10	7.38±3.02	8.16±4.89
Zn/mg	5.5	3.01±1.25	5.45±1.76
Nicotinic acid/mg	8	6.37±1.05	8.86±2.27

Note: VA: Vitamin A, VB1: Vitamin B1, VB2: Vitamin B2, Ca: Calcium, Fe: Ferrum, Zn: Zinc.

Table 5. The proportions of calorie supply from three major nutrients in the children

Dietary nutrients	The recommended proportions of calorie supply (%)	Normal-weight children		Overweight-obesity children	
		Intakes (g)	Proportions of calorie supply (%)	Intakes (g)	Proportions of calorie supply (%)
Proteins	-	27.48±3.25	11.63	42.11±4.26	16.74
Carbohydrates	50-65	110.22±3.69	59.79	130.37±28.71	66.55
Fat	20-30	22.32±9.48	21.58	36.93±4.52	31.65

Table 6. The intake of various foods among children with types of constitution [M (P25, P75)]

Food variety	Eucrasia	Overweight	Obesity
Cereals	300 (200, 400)	550 (400, 600)	300 (160, 450)
Potato	50 (40, 60)	45 (5, 50)	53 (32, 64)
Milks	220 (150, 250)	185 (100, 225)	200 (100, 390)
Eggs	60 (50, 70)	60 (50, 70)	70 (40, 90)
Livestock meat, poultry, fish and shrimp	60 (50, 100)	90 (80, 100)	100 (55, 110)
Leguminous plants	50 (30, 60)	55 (50, 76)	50 (30, 75)
Vegetables	200 (175, 410)	150 (105, 160)	180 (150, 280)
Fruits	200 (140, 300)	280 (200, 300)	240 (150, 330)
Oils	40 (30, 45)	45 (23, 52)	50 (26, 73)

Energy supply from three major nutrients in dietary patterns

As shown in **Table 5**, it was recommended that children aged 3-6 years old should consume 20-30% of their diet as fat and 50-65% as carbohydrates. There is no reference value for the protein intake. However, the levels of the 3 major nutrients in the overweight-obese children in this study were much higher than the recommended amount, while the intake of protein, fat and carbohydrates in normal-weight children was in line with the recommendations.

Dietary pattern analysis among children with different types of constitutions

As shown in **Table 6**, the intake of milk and vegetables in eucrasia children was higher than that in overweight and obese children, and there was a statistical difference in the intake

Table 7. The amount of energy and dietary nutrient intake among children with different types of constitutions ($\bar{x} \pm s$)

Dietary nutrient	Eucrasia	Overweight	Obesity
Energy/kcal	1123.08±50.17	1521.18±252.36	1605.18±272.36
Protein/g	27.48±3.25	39.23±3.56	41.54±3.66
Carbohydrates/g	110.22±3.69	121.37±19.35	129.48±18.57
Fat/g	22.32±9.48	35.93±3.66	36.95±3.69
VA/μg	298.33±48.47	177.88±52.36	256.66±82.36
VB1/mg	0.53±0.23	0.42±0.19	0.51±0.22
VB2/mg	0.56±0.11	0.45±0.13	0.51±0.23
VC/mg	45.68±13.02	45.49±10.05	40.49±11.27
VE/mg	5.58±2.02	3.99±2.63	4.33±1.96
Ca/mg	722.12±69.74	758.84±62.11	822.16±65.03
Fe/mg	7.38±3.02	7.92±4.67	8.31±4.88
Zn/mg	3.01±1.25	4.68±1.22	5.57±1.64
Nicotinic acid/mg	6.37±1.05	7.81±2.34	9.01±1.88

Note: VA: Vitamin A, VB1: Vitamin B1, VB2: Vitamin B2, Ca: Calcium, Fe: Ferrum, Zn: Zinc.

of milk and vegetables between normal-weight children and obese children (all $P<0.05$). The intake of cereal and fruits in overweight children was relatively high, but there was no statistical difference in these indexes between normal-weight children and overweight children. The intake of eggs, meat of livestock and poultry, fish and shrimp in obese children were relatively high. Moreover, the intake of eggs in obese children was statistically different from that in normal-weight children.

Energy and dietary nutrient intake among children with different types of constitutions

As shown in **Table 7**, the intake of energy, protein, carbohydrates, fat, Ca, Fe, Zn and nicotinic acid in the overweight and obese children were significantly higher than those in normal-weight children, with significant differences observed (all $P<0.05$).

Discussion

In this survey, it was found that there were 679 obese children (3.48%) and 1,227 overweight children (7.5%) among the 19,529 preschool children, and the intake of energy and nutrients of the overweight and obese children was higher than those of the normal-weight children. It is indicated that the type and amount of diet were associated with the incidence of being overweight and obese. The fish, shrimp, vegetables, milk, fruit and other foods consumed by normal-weight children were relatively low, which caused some insufficiency in nutrients [15]. Our finding indicates that dietary nutrient patterns are positively correlated with the growth and development levels of children.

It was found that the children with low intake of vitamin A and vitamin C and high intake of energy had growth retardation, indicating that the lack of vitamin A and vitamin C was a risk factor for infection in preschool children [16]. Calcium is the main element of bones, and insufficient calcium intake inevitably leads to growth retardation [17, 18]. Another study showed the intake of vitamin B1 and B2 in overweight children was significantly higher than that in normal-weight children, while the intake of vitamin A, vitamin C, and Ga in overweight children were relatively low, leading to growth retardation. In addition, this survey found that the under-intake of calories, protein, fat and carbohydrates in the children was prominent, suggesting that normal, obese and overweight children may suffer from malnutrition. Plant proteins, are the main source of protein intake in children, mainly from rice flour and leguminous plants. The low content of lysine in the rice flour results in a low amino acid score of these foods. Due to the low absorption and utilization rate of proteins from the rice flour food, protein deficiency is common among children aged 3-6 years old. There are two primary sources of fat in the diet: animal fat and plant fat. In this study, it was found that animal fat

was the main source of fat for normal and overweight-obese children. Previous studies reported that the total fat intake of children with normal constitution was 36.16 g, including 20.17 g (55.77%) of animal fat and 15.99 g (44.22%) of vegetable fat, and the total fat intake in obese and overweight children was 52.93 g, including 37.18 g (70.24%) of animal fat and 15.75 g (29.76%) of vegetable fat [19]. Due to the different types and quantities of dietary nutrients consumed by children, there was a general lack of trace elements, mainly manifested in vitamin A, vitamin B, vitamin C and minerals (such as calcium, zinc, and selenium) [20].

The dietary nutrient patterns have obvious advantages over the dietary model. It can accurately reflect the interaction between nutrients, and systematically evaluate the role and impact of dietary nutrients on health. According to the analysis, researchers can know the impact of different dietary nutrients on different disease conditions. It is also considered that the dietary nutrient patterns of children should be changed and improved timely to reduce the risk of chronic diseases such as being overweight or obese in preschool children [21, 22]. According to the *Reference Intake of Dietary Nutrients for Chinese Residents,* the intake of calcium nutrition food, vegetables and fruits, such as dairy and bean products as well as green leafy vegetables, in the preschool children in this study should be increased. In addition, a certain amount of coarse grain is suggested to reduce the consumption of refined rice noodles. The intake of industrial processed food should be reduced to create balanced and comprehensive nutritious diet patterns, which can help preschool children to develop healthy eating habits.

In conclusion, the dietary nutrient patterns of preschool children aged 3-6 years old was associated with the incidence of being overweight and obese. The findings of this study provided some diet guidance for children. However, there are some limitations in this study because this is a single-center study with small sample size and no follow up data. Moreover, we did not carry out subgroup comparison and mechanism analyses. In the future, a multicenter controlled long-term follow-up study with large sample size is required for further confirmation.

Disclosure of conflict of interest

None.

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