Proper protein intake, adequate sleep and short screen time can promote physical growth and reduce the incidence of obesity in children aged 3~7 years

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Abstract

Background

With the rapid development of social economy in China, children's dietary behaviors and lifestyle has undergone great changes. Picking eating, inappropriate protein intake, inactive lifestyle may lead to children's poor physical growth. Especially for preschool children who are in the key period for the formation of dietary habits and lifestyle, early identification of problems in their diet and living habits and interventions will be the key procedure to improve the growth and health level of the whole population.

Methods

All subjects were from a cross-sectional survey in China, a total of 53172 preschool children were included. The anthropometric measurement was completed on site, and dietary behavior, physical activity, sleeping and screen time were collected by face-to-face interview using a self-made questionnaire.

Results

1) Among preschool children, 34.0% were picky eaters, the growth level of them was lower than non-picky eaters, the height SDS and weight SDS of picky eaters were 0.01 ± 1.00 and 0.10 ± 1.10 , and those of non-picky eaters were 0.17 ± 1.01 and 0.17 ± 1.15 . The differences were statistically significant ($P < 0.01$). 2) The growth level of children with high frequency of milk and eggs intake was higher than others: the height SDS and weight SDS of children ate more than 6 eggs per week were 0.26 ± 0.99 and 0.25 ± 1.13 , those who did not eat eggs were -0.12 ± 1.02 and -0.20 ± 1.10 ; the height SDS and weight SDS of children drank more than 6 bags of milk per week were 0.17 ± 1.01 and 0.14 ± 1.14 , and those did not drink milk were -0.14 ± 1.04 and -0.21 ± 1.15 . 3) Only 12.3% of children met all sleeping, physical activity and screen time requirements in guidelines, and they have higher HtSDS and lower WtSDS. 4) Multivariate analysis showed more protein intake, inadequate sleep were risk factors of overweight and obesity, while short screen time was a protective factor.

Conclusions

Appropriate protein intake, adequate sleep and shorter screen time are associated with healthy physical growth and reduced risk of obesity and obesity in preschool children.

Background

Firstly, diet and nutrition are the material basis of children's physical growth. Preschool children are in the key period for the formation of dietary habits [1], during this period children's self-care ability is improved,

their curiosity are enhanced and attention is easily distracted, so it's easy to form picky eating and other poor diet habits [2]. Secondly, reasonable physical activity and adequate sleep can not only improve children's physical growth and maximize the growth potential of children's height, but also are greatly significant for children's cardiopulmonary health, cognitive, emotional, social and psychological health and avoiding obesity [3, 4]. Meanwhile in recent years, with the popularity of intelligent electronic products, children's lifestyle has undergone great changes, and decreased physical activity, lack of sleeping time and increased screen time have become common social problems [5].

Unhealthy dietary behaviors and lifestyle may lead to two extremes of children's physical growth, on the one hand the overweight and obesity incidence increased significantly to 16.1% in 2020 [5, 6], and on the other hand the growth retardation and emaciation still exists. If not been intervened, these problems can last throughout the life and affect the health and quality of life in adulthood [7, 8]. Therefore, to improve the health level of the whole population, we should focus on the key period (preschool) of children's eating behavior and living habits formation. So, the World health organization (WHO) and many countries all established their diet and physical activity guidelines for preschool children[[1, 9]], in order to help them establishing and maintaining good behaviors and habits, and avoid the impact of adverse factors in the key period on children's whole life health.

Children's diet and lifestyle vary greatly in different countries, so based on this large sample survey in China, we described the status of diet behaviors, physical activity and sleeping time of preschool children, analyzed whether they have met the requirements of dietary and physical activity guidelines, and explored the influencing factors of physical growth in this large sample population. Meanwhile, considering the increasing incidence of overweight and obesity and its serious impact on health, we also analyzed the risk factors of overweight and obesity in dietary behaviors and lifestyle, aimed to provide evidence-based basis for targeted intervention on diet and living habits.

Subjects And Methods

Sample

All subjects were from the 5th National Survey on Physical Growth and Development of Children (NSPGDC) in nine cities of China carried out in 2015. Of the nine cities, Beijing and Shanghai are municipalities, the other seven cities are provincial capital cities including Harbin (Heilongjiang's provincial capital), Xi'an (Shaanxi), Nanjing (Jiangsu), Wuhan (Hubei), Guangzhou (Guangdong), Fuzhou (Fujian), and Kunming (Yunnan). The stratified cluster sampling method was used in each city, taking kindergartens as a unit to carry out cluster sampling on children aged three to seven years. Their age was calculated by the date of investigation and the birthdate. All children were divided into seven age groups: 3.0 years ~, 3.5years ~, 4.0 years~, 4.5 years ~, 5.0 years~, 5.5years ~ and 6.0-7.0 years. Each sex-age subgroup consisted of almost an equal sample size of 300 to 400 infants in each city. The children with premature birth or low birth weight, twins or multiple births, physical disability, acute and chronic diseases, fever or diarrhea in past two weeks and other diseases affecting children's growth and

development and daily diet were excluded. Finally, a total of 53172 children aged three to seven years were investigated in this survey.

Data collection

Children's height and weight were measured by trained staffs using uniformly equipped and regularly corrected tools. The dietary, physical activity and sleeping status were collected by self-made questionnaire and face-to-face interview with children's parents. The questionnaire items included: Picky or not. Picky eaters were defined as those children only eat their favorite kind of food, reject or almost don't eat the food they don't like in the past month. Common foods were divided into five categories (meat, eggs, fish, vegetables and fruits). Picky eaters were asked what category of food was their most and least preferred; Intake frequencies of eggs and milk: The intake of milk / yogurt was divided into never drink, 250-750ml/w(per week), 1000-1250ml/w and >1500ml/w in the past week. The intake of eggs was also divided into never eat, 1-2 eggs/w, 3-4 eggs/w and >6 eggs/w in the past week; Sleeping time: we investigated the night and daytime sleeping of each child by hours in the past week; Physical activity and screen time: We investigated children's average outdoor physical activity time each day and their average time spending on watching TV, computer and playing video games each day in past week by hours. Mother's educational background was also collected by questionnaires.

Evaluation of children's physical growth

Taking the growth standards of Chinese children aged 0 to seven years as standard [10], we calculated the standard deviation score (SDS) of children's height (HtSDS) and weight (WtSDS). HtSDS less than - 2.0 defined as children's growth level lower than normal, HtSDS between - 2.0 and 2.0 was normal, HtSDS larger than 2.0 defined as they higher than normal. Body mass index (BMI) = weight (kg) / height (m)². A BMI at the 85th-95th percentile was defined as overweight, and BMI above the 95th percentile as obesity. BMI below the 3rd percentile was defined as emaciation [11]

Divisions of outdoor physical activity, total sleeping and screen time

According to physical activity guideline for Chinese preschoolers aged three to six years [9], Outdoor physical activity time was divided into two groups: ≥ 2 hours was achieving the recommended amount and < 2 hours was not reaching the recommended amount; The total sleeping time was the sum of daytime and night sleeping, which was divided into two groups: ≥ 10 hours was achieving the recommended amount and < 10 hours was not; The screen time was also divided into two groups: < 1 hour was achieving the recommended amount and ≥ 1 hour was not.

Statistics

After three rounds of check, the data were input by digital scanning, then we sorted and checked all data, established the final database. Spss22.0 software (IBM, USA) was used to analyze the data. Continuous variable were described by $\bar{x} \pm SD$, the differences between different groups was performed by T-test or

analysis of variance (ANOVA); The Categorical variables were described by number of cases and the constituent ratio (n,%), the differences between different groups was performed by Chi square test (χ^2). $P < 0.05$ was statistically significant. Multivariate logistic regression analysis was used to analyze the risks of overweight and obesity. The inclusion criteria of independent variables were $p < 0.05$ and the exclusion criteria were $p > 0.01$. At the same time, the OR value of each independent variable on overweight / obesity was calculated, if $OR > 1$ the independent variables were the risk factors of overweight / obesity, and if $OR < 1$ they were the protective factors of overweight / obesity.

Results

Demographic characteristics of samples

A total of 53172 preschool children aged 3-7 years were investigated, with an average age of 4.8 ± 1.1 years, the HtSDS of the sample population was 0.12 ± 1.01 , WtSDS was 0.08 ± 1.14 , and other demographic characteristics were shown in Table 1.

Dietary behaviors of preschool children

Table 2 shows that 34.0% of preschool children were picky eaters. Among picky eaters, the proportion of those doesn't like vegetables most was 51.9%, and the proportion doesn't like meat was 20.8%. The consumption rate of milk in preschool children was above 96.0%, among which 54.3% drink about 200ml milk per day; the consumption rate of eggs was 96.2%, and 30.6% of them reached the recommended amount of dietary guidelines (6 eggs/w).

Effects of picky eating behaviors on children's growth

Comparing the differences of growth level between picky eaters and non picky eaters, Figure 1 shows the HtSDS and WtSDS of picky eaters were lower than non picky eaters, the mean HtSDS decreased from 0.17 to 0.01, and the WtSDS decreased more significantly than HtSDS, from 0.17 to -0.10. Among the picky eaters, the growth level of children who doesn't like meat and eggs were lower than other groups. The mean HtSDS was -0.16 and -0.01, and the mean WtSDS was -0.38 and -0.20. There were all significant differences among different groups ($p < 0.01$).

Effects of egg and milk intake on children's growth

Comparing the growth level of children with different intake frequency of milk and egg, Figure 2 shows the growth level of preschool children gradually decreased as the intake frequency of milk and eggs decreased. The HtSDS and WtSDS of children who ate more than 6 eggs/w were 0.26 ± 0.99 and 0.25 ± 1.13 , and they were -0.12 ± 1.02 and -0.20 ± 1.10 for children who never eat eggs. The HtSDS and WtSDS of children who drank more than 1500ml milk/w were 0.17 ± 1.01 and 0.14 ± 1.14 , and they were 0.14 ± 1.04 and -0.21 ± 1.15 for children who never drink milk. There were all significant differences in different categories ($p < 0.01$).

Effects of sleeping, physical activity and screen time on children's growth

Table 3 shows the mean total sleeping time of preschool children was 11.0 hours, the mean outdoor physical activity time was 2.0 hours, and the mean screen time was 1.4 hours. According to the latest physical activity guideline, 93.4% of children achieved the recommended sleeping time, 64.9% achieved the recommended physical activity time and 62.4% of them met the recommended screen time. Only 12.3% of preschool children's met all sleeping, physical activity and screen time demands in guidelines. Compared the growth level of children in different groups, we found those children with insufficient time have higher weight and those children with shorter screen time have higher height. Those children met all sleeping, physical activity and screen time demands were higher and lighter than others.

The risk factors on overweight and obesity

The prevalence of overweight and obesity in preschool children was 18.3%. Analyzing the influencing factors of overweight and obesity (Table 4), we can see that male, picky eaters like meat, eggs and fish, higher intake frequency of eggs and milk, and total sleeping time < 10 hours were risk factors of overweight and obesity, while screen time < 1 hour was the protective factor of overweight and obesity. In addition, the regression analysis showed that higher educational level of mothers was a risk factor of overweight and obesity (OR=1.14), which might be related to the distribution of educational level of mothers in this survey and have no practical value.

Discussion

Preschool children are in the key stage of cultivating their eating behaviors and habit which can influence the physical growth and health throughout their life. Therefore, to improve the health conditions of the whole population, we should focus on this key stage and cultivate preschool children's good eating behaviors. In this survey, the proportion of eggs and milk intake on preschool children was greater than 96.0%, which was significantly higher than that of the Chinese national survey in 2002 [12]. In general, the nutrition gap between children in developing and developed countries has disappeared [13]. Especially in China, as the rapid development of social economy in recent years, the food consumption pattern of the Chinese people has been changed, children's dietary structure also tended to be reasonable [14], and children's overall growth level has exceeded the WHO's children's growth standard [10]. However, picky eating behaviors and unreasonable dietary structure on preschool children still existed. 34.0% of children were picky eaters in this survey. A system review showed that the picky eating rate of children aged four months to 15 years in different countries varies from 5.5–70.1% [15]. Which partly due to parents' excessive anxiety on children's eating behaviors and reported higher picky eating rates than the actual incidence [16]. On the other hand, the picky eating rate is varied as children's age, the incidences of eating behavior problems increased after one year old, reach the peak around three years old and then gradually decrease after four years old [17].

Non picky eating and proper meats and eggs intake were associated with children's higher growth level. We can see both the HtSDS and WtSDS of picky eaters were lower than non-picky eaters and the weight

loss in picky eaters was more obvious, which confirmed picky behaviors had a significant impact on children's physical growth, especially on their weight. Other similar studies also showed that picky eaters have significantly lower BMI, lower body fat and higher probability of low weight [7, 18]. This mainly due to the relatively insufficient food intake in picky eaters, they may eat less fruits, less vegetables, less whole wheat and fish. Moreover, among all picky eaters, the HtSDS and WtSDS of children who's least favorite food were meat and eggs are lower than other children, suggesting the high-quality protein intake is very necessary for children's physical growth. At the same time, multivariate analysis found that like meat, egg and fish for picky eater is the risk factor of overweight and obesity. So we should actively help picky eaters to achieve a balanced intake of all kinds of food.

The milk and eggs intake can promote the height of preschool children. In this survey, the proportion of eggs and milk intake in preschool children was higher than children in rural areas [19], and the children with higher intake frequency of eggs and milk had higher HtSDS and WtSDS. The main reason is that milk is rich in protein, calcium and other micronutrients necessary for human body, and can promote boys' and girls' height growth in every age group [20]. Eggs are rich in high-quality protein and micronutrients, including various amino acids needed by human beings, and are easy to be digested. Studies on school-aged children also confirmed that high intake frequency of milk and eggs can reduce the incidence of growth retardation [21], which is consistent with the conclusions of our study. At the same time, multivariate analysis found the risk of overweight and obesity increased in children with more milk and eggs intake. Therefore, children who are not allergic to egg and milk should follow the dietary guidelines [8], eat one egg and drink 300-400ml dairy each day to promote their physical growth, meanwhile avoid excessive intake to inducing overweight and obesity.

In nine cities of China, 93.4% of preschool children archived the recommended sleeping time, but only 12.3% of them met all sleeping, physical activity and screen time requirements in guidelines. Those 12.3% of children have higher HtSDS and lower WtSDS, which confirmed the guideline's promoting effect on children' growth and the necessity of further promotion of the guideline. Otherwise insufficient sleeping time and long screen time increased the risk of overweight and obesity. Many studies have confirmed the screen time of preschool children is positively correlated with the incidences of overweight and obesity [22, 23]. In this study, 37.6% of children's screen time is more than 1 hour per day, and they have lower HtSDS and higher risk of overweight / obesity, so they should be the target population for lifestyle correction.

In addition, with the increasing rate of overweight and obesity in preschool children, diet and physical activity cannot fully explain this phenomenon. Some studies found insufficient sleeping time can lead to obesity [24], which is consistent with the increased risk of overweight and obesity in children with total sleeping time less than 10 hours in this study. The possible mechanisms are insufficient sleeping time leads to changes of appetite regulating neuropeptides such as gastrin and leptin, increases appetite and food intake [25]; Lack of sleep leads to individual fatigue, reduced physical activity, and more convenient and high-energy food in diet [26]; Sleep deprivation can also affect obesity incidence by activating inflammatory pathways [27]. We did not find the relationship between outdoor physical activity and

children's physical growth, which may due to the investigation method, we only investigated the physical activity time but not the activity intensity. Most preschool children's outdoor activities may not reach the medium intensity, so the promotion effect on height and weight is limited.

The strengths of this study were the large sample size and the two-sided approach looking at both poor growth and obesity, which can relative truly reflect the diet and lifestyle of preschool children and its correlation with their physical growth in China. There were also some limitations. This is a cross-sectional survey so the results can show associations but not causality. The sample are all from mine cities, cannot reflect the situation in rural areas. Besides, we should consider the risk of under-reporting of problems in face-to-face interviews.

Conclusions

Balanced diet, appropriate protein intake, proper physical activity and sleeping may improve the physical growth of children. Avoiding excessive protein intake, ensuring adequate sleep and reducing screen time can reduce the risk of overweight and obesity. Dietary and exercise guidelines should be further promoted to improve the physical growth and health level of preschool children.

Abbreviations

WHO, World health organization;

HtSDS, Height Standard Deviation Score;

WtSDS, Weight Standard Deviation Score;

Declarations

Ethics approval and consent to participate

The survey received ethical approval from the Ethical Review Committee of the Capital Institute of Pediatrics (SHERLL2015009). Participation was voluntary, and informed consent was sought from all of the respondents.

Consent for publication

Not applicable.

Availability of data and materials

If you are interested in the data of this survey, you can contact us. We can provide you with data suitable for public publication.

Competing interest

The authors have no conflict of interests to report.

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Author's contributions

H-HW was involved in data review, in charge of this paper's results interpretation and paper writing. HL was in charge of survey design, investigation and data review supervision, and involved in results interpretation and paper writing. Y-QZ was involved in investigation supervision, data review and analysis. X-NZ was involved in data review and analysis. All authors agreed with the data interpretation and approved of the final version of the manuscript.

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Tables

Table 1 The demographic characteristics of the subjects

	N	Percentage (%)
Gender		
Male	26651	50.1
Female	26521	49.9
Age groups		
3.0 years~	7603	14.3
3.5 years~	7627	14.3
4.0 years~	7564	14.2
4.5 years~	7596	14.3
5.0 years~	7585	14.3
5.5 years~	7578	14.3
6.0~7.0 years	7619	14.3
Mother's educational background		
University and above	28598	53.8
High school/technical secondary school	13651	25.7
Less than high school	10787	20.3
Height subgroups		
HtSDS<-2	940	1.8
normal	50525	95.0
HtSDS>2	1683	3.2
Weight subgroups		
underweight	1455	2.7
normal	42007	79.0
Overweight and obesity	9710	18.3

Table 2 The dietary behaviors of preschool children (N (%))

	Total	Male	Female	2
Picky or not				
non-picky	35063 (66.0)	17272 (64.8)	17791 (67.1)	30.846**
picky	18092 (34.0)	9372 (35.2)	8720 (32.9)	
The least favorite food for picky eaters				
meat	3749 (20.8)	1781 (19.1)	1968 (22.7)	53.347**
eggs	2212 (12.3)	1108 (11.9))	1104 (12.7)	
fishes	1868 (10.4)	1052 (11.3)	816 (9.4)	
vegetables	9335 (51.9)	4917 (52.8)	4418 (50.9)	
fruits	830 (4.6)	462 (5.0)	368 (4.2)	
The intake frequencies of eggs				
>6 eggs/w	16266 (30.6)	8625 (32.4)	7641 (28.8)	105.150**
3-4 eggs/w	16684 (31.4)	8335 (31.3)	8349 (31.5)	
1-2 eggs/w	18146 (34.1)	8625 (32.4)	9521 (35.9)	
never	2045 (3.8)	1052 (3.9)	993 (3.7)	
The intake frequencies of milk				
>1500ml/w	28722 (54.3)	14993 (56.6)	13729 (52.0)	127.170**
1000-1250ml/w	8435 (15.9)	4145 (15.6)	4290 (16.3)	
500-750ml/w	13606 (25.7)	6354 (24.0)	7252 (27.5)	
never	2127 (4.0)	1007 (3.8)	1120 (4.2)	

Note: ** is $p < 0.01$ for T-test or Chi square test.

Table 3 The sleeping, screen and activity time and their effects on physical growth

	n(%)	HtSDS()	WtSDS()
Total sleeping time (11.0±1.0h)			
<10h	3511(6.6)	0.13±1.00	0.16±1.18
≥10h	49567(93.4)	0.11±1.01	0.07±1.14
<i>t</i>		0.603	21.155**
Outdoor physical activity time (2.0±1.1h)			
<2h	18366(35.1)	0.11±1.00	0.07±1.14
≥2h	34449(64.9)	0.12±1.01	0.08±1.14
<i>t</i>		0.630	2.048
Screen time (1.4±1.0h)			
<1h	33,122(62.4)	0.13±1.01	0.07±1.12
≥1h	19,972(37.6)	0.09±1.02	0.09±1.17
<i>T</i>		29.622**	2.288
Sleeping≥10h , physical activity≥2h and screen time<1h			
Yes	6535(12.3)	0.15±1.01	0.04±1.09
No	46637(87.7)	0.11±1.01	0.08±1.14
<i>t</i>		3.073**	-2.922**

Note: *t* is the T-test of HtSDS and WtSDS between different groups. ** is $p<0.01$ for T-test

Table.4 The multivariate logistic regression analysis of children's obesity and overweight

	β	OR	95%CI	<i>P</i>
Constant	-2.27			0.000
Gender=female	0.48	1.61	1.48~1.75	0.000
Mother's educational background				
University and above	0.13	1.14	1.00~1.29	0.050
High school/technical secondary school	0.18	1.20	1.05~1.36	0.006
The favorite food for picky eaters				
Meat	0.97	2.63	2.28~3.04	0.000
Eggs	0.60	1.82	1.53~2.16	0.000
Fishes	0.39	1.47	1.22~1.78	0.000
The intake frequencies of milk				
>6 eggs/w	0.31	1.36	1.06~1.76	0.015
3-4 eggs/w	0.39	1.47	1.13~1.92	0.004
The intake frequencies of eggs				
>1500ml/w	0.38	1.46	1.18~1.81	0.001
1000-1250ml/w	0.23	1.26	1.02~1.56	0.035
Screen time <1h	-0.15	0.86	0.79~0.94	0.001
Total sleeping time <10h	0.24	1.26	1.09~1.46	0.002

Figures

Figure 1

The effect of picky eating behavior on children's physical growth Note: ** is p<0.01 for T-test or ANOVA.

Figure 2

The effects of egg and milk intake on physical growth of children Note: ** is p<0.01 for ANOVA .