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Effects of Yogurt Supplementation on the Growth of Preschool Children in Beijing Suburbs

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Objective To investigate the effect of yogurt supplementation on the growth of preschool children in Beijing suburbs. **Methods** Four hundred and two preschool children (217 males, 185 females), aged 3-5 years, whose height for age and/or weight for age were less than the reference level, were selected as subjects from 7 kindergartens in Beijing Fangshan District. The subjects were divided randomly into control group (CG, 201) and yogurt supplemented group (YG, 201). Each subject in YG was given one serving of yogurt (125 g) for 5 days a week from March to December in 2001, while nothing additional was provided to CG. All subjects kept their usual diet during the study. Anthropometry (body height and weight and upper-arm circumference) and the bone mineral density (BMD) of forearm were measured every 3 months. Disease status and dietary intake were also recorded and assessed. **Results** The intake of calcium, zinc, and vitamin B_2 in YG was significantly higher than that in CG. The incidence and duration of upper-respiratory infection and diarrhea of children in YG were significantly less than those in CG. The height gain of children in YG was significantly higher than that in CG after yogurt was supplemented for 3, 6, and 9 months ($P<0.05$) (1.90±0.49 cm vs 1.77±0.54 cm, 3.83±0.57cm vs 3.64±0.66 cm and 5.43±0.69 cm vs 5.24±0.76 cm, respectively). The weight gain of children in YG was significantly higher than that in CG after yogurt was supplemented for 3, 6, and 9 months ($P<0.05$) (0.70±0.43 kg vs 0.49±0.35 kg, 0.98±0.62 kg vs 0.80±0.60 kg and 1.42±0.76 kg vs 1.20±0.67 kg, respectively). The BMD of children in YG was significantly higher than that in CG after yogurt was supplemented for 9 months ($P<0.05$) (0.415±0.058 g/cm^2 vs 0.400±0.065 g/cm^2). **Conclusion** Yogurt is beneficial to the improvement of calcium, zinc, and vitamin B_2 intake, the decreasing of the incidence and duration of upper-respiratory infection and diarrhea, and the promotion of the health and the growth and development of preschool children.

Key words: Yogurt; Preschool children; Growth and development

INTRODUCTION

Milk intake is important for the health of people, especially for children. In the Third National Nutrition Survey of China in 1992[1], the average milk intake of children was only 7.2 g/d at the country level, and it was even less in the suburb (4.2 g/d). There was still a significant difference between city and suburbs in the height and weight of children under 7 years of age, and their average height for age and weight for age was less than the reference level recommended by the World Health Organization (WHO)[2].

Yogurt is rich in nutrients with high bioavailability, such as high quality protein, calcium, and vitamin B_2. Yogurt can also help maintain a balanced flora in the colon[3-4], decrease the incidence of diarrhea[5-6] and lactose intolerance. Nevertheless, the effect of yogurt on children's growth and development has not been focused by investigators.

The aim of this study was to investigate the effect of 9-month yogurt supplementation on the growth and development of preschool children in Beijing suburbs.

SUBJECTS AND METHODS

Subject

Of 1 870 3-5 year-old children from 7 kindergartens in Beijing suburbs, 402 children (217 males, 185 females) were selected as subjects, who were satisfied by their health status, and whose height for age and/or weight for age were less than the reference level and birth weights were higher than 2.5 kg. Those children with obesity or overweight, congenital disease or chronic infectious disease, a history of gastro-intestinal operation, taking antibiotics for more than 1 week, growth retardation in womb, disliking yogurt, or without consents by their parents

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were excluded from this study.

Subjects were randomly allocated to either the control group (CG, 201) or the yogurt group (YG 201), stratified by gender and the height, weight, age at baseline.

The study was approved by the Ethical Review Committee of the Institute of Nutrition and Food Safety, Chinese Center for Disease Control and Prevention. Informed consents were obtained from the parents.

Yogurt and Supplementation

Yogurt (125 g/cup) was gotten from market. The fermented bacteria were thermophilus streptococci, Bulgaria lactobacilli and bifidum bacteria at the level $>10^7$ cuf/g. The major nutrients supplied were: protein 3.8 g, calcium 150 mg, vitamin B_2 0.19 mg in a serving of yogurt.

Each subject in YG was given one cup of yogurt from Monday to Friday during April to December in 2001 (9 months). Nothing additional was supplied to children in CG. All subjects kept their usual diet offered by the kindergartens during the study.

Protocol and Methods

Antropometry was conducted at the baseline level and at the time of 3, 6, and 9 months of the study. The standing height of subjects on barefoot was recorded to the nearest 0.1 cm and the body weight in underwear was recorded to the nearest 0.1 kg by using a digital electronic scale. Upper-arm circumference was measured to the nearest 0.1 cm by using a soft ruler at the middle point of upper-arm.

Bone mineral density (BMD) of forearm was measured at baseline, during 3, 6, and 9 months of the study, respectively. The BMD was scanned at the upper one third of forearm by a single photon absorptiometer (BMD400 absorptionmeter, made by the Chinese Institute of Atomic Energy, Beijing).

Dietary intake was assessed before and after supplementation by using a 72-hour food record method. The intake of nutrients was computed with SAS 6.12 based on the data in the "Food Composition Table of China".

The occurrence of diseases, such as upper-respiratory infection and diarrhea, was recorded every month.

Statistical Analysis

Descriptive statistics were reported as $\bar{x}\pm s$ or frequency for all variables, unless otherwise stated. Statistical analysis was performed by SAS 6.12 on *t*-test, χ^2 and the sum of rank.

RESULTS

Characteristics of Subjects

The basic information of subjects and their parents are shown in Table 1. There was no significant difference between the groups except for the total family income and mother's height. But food expenditure was almost the same in the two groups, and 1 cm difference in mother's height would exert little influence on the growth of preschool children.

TABLE 1

General Information of the Subjects ($\bar{x}\pm s$)

	CG	YG	*P*
Children			
Male, *n* (%)	111(55.2%)	106 (52.7%)	
Female, *n* (%)	90 (44.8%)	95 (47.3%)	
Age (m)	50.3±8.5	50.9±7.7	0.449
Birth Weight (kg)	3.2±0.5	3.33±0.5	0.122
Height (cm)	100.8±5.3	101.0±4.6	0.773
Weight (kg)	15.6±1.7	15.3±1.4	0.112
Parents			
Mother's Height (cm)	158.9±4.3	159.9±3.9	0.011
Mother's Weight (kg)	56.3±9.1	55.8±7.5	0.318
Mother's BMI	22.3±3.3	21.8±2.8	0.131
Father's Height (cm)	171.1±4.5	171.8±3.9	0.096
Father's Weight (kg)	70.9±10.6	71.5±9.1	0.830
Father's BMI	24.2±3.4	24.2±2.9	0.960
Economy			
Total Family Income (RMB/m)	1910.4±834.2	2089.9±718.6	0.022
Expenditure on Food (RMB/m)	640.7±287.8	647.8±286.0	0.807

The type of exercise and the length of time under sunshine in all subjects were collected and analyzed. No significant difference was found between the two groups (YG 128 min/d vs CG 130 min/d).

Dietary Intake

The energy and protein intake before and during the study was not significantly different between the two groups, and virtually met the "Chinese Dietary Reference Intakes" (Chinese DRIs). The intake of calcium, zinc, and vitamin B_2 before the study was similar in the two groups, which was only about 38.8%-43.5%, 64.3%-68.4%, 77.3%-84.7% of DRIs, respectively. After the supplementation of 125 g yogurt, the intake of these nutrients in YG increased significantly to 52.4%, 70.0%, and 95.4% of Chinese DRIs, respectively (Table 2).

Anthropometrics

Height Table 3 shows the increase of height and HAZ at 3, 6, and 9 months of study. The increase of height and HAZ of children in YG was significantly higher than the reference level recommended by WHO for children aged 50 months, and also higher than those in CG.

Table 4 presents more detailed analysis about height increase by being stratified with gender and HAZ during the 9 months of study. Yogurt supplementation could significantly improve the height gain of girls and the subjects with -1<HAZ<0.

TABLE 2

Dietary Nutrients Intake of Children in CG and YG ($\bar{x}$±s)

Group			Energy (kJ)	Protein (g)	Vitamin B_2 (mg)	Vitamin A (μg)	Calcium (mg)	Zinc (mg)
CG	0 m	Intake	5491.33±980.35	43.80±9.00	0.62±0.16	259.24±85.97	310.55±20.22	6.43±0.87
		DRIs %	93.75±16.74	97.32±20.02	77.33±20.40	51.84±17.19	38.82±12.53	64.31±8.71
	9 m	Intake	5307.53±891.90	41.97±8.42	0.67±0.27	310.40±37.89	334.80±136.56	6.33±1.24
		DRIs %	90.61±15.22	93.27±18.71	83.19±34.36	62.08±14.75	41.84±17.07	63.31±12.42
YG	0 m	Intake	5477.78±961.36	45.84±7.70	0.68±0.22	257.51±75.45	348.30±42.18	6.83±1.25
		DRIs %	93.51±16.41	101.86±17.11	84.69±28.0	51.50±15.09	43.54±17.77	68.37±12.59
	9 m	Intake	5517.32±1293.02	45.30±12.00	0.76±0.19[b]	356.54±43.03	419.2±135.73[b]	7.00±1.78[a]
		DRIs %	94.19±22.07	100.66±26.67	95.41±24.16[b]	71.31±18.60	52.40±16.97[b]	70.00±17.76[a]

Note. [a]P<0.05. [b]P<0.01 compare with CG.

TABLE 3

Increase of Height and Change of HAZ at 3, 6, and 9 Months of Study ($\bar{x}$±s)

Group	Increase of Height (cm)			Change of HAZ		
	3 m	6 m	9 m	3 m	6 m	9 m
CG	1.77±0.54	3.64±0.66	5.24±0.76	0.009±0.125	0.048±0.155	0.077±0.175
YG	1.90±0.49[a]	3.83±0.57[b]	5.43±0.69[a]	0.038±0.121[a]	0.098±0.144[b]	0.123±0.168[b]
WHO Reference	1.7-1.8	3.4-3.5	5.0-5.2			

Note. [a]P<0.05. [b]P<0.01 compare with the control group.

TABLE 4

Increase of Height in Subjects Stratified by Gender and HAZ (cm, $\bar{x}$±s)

Group	Total	Gender		Range of HAZ		
		Male	Female	HAZ≤-1	-1<HAZ<0	HAZ≥0
CG	5.24±0.76 (169)	5.27±0.64 (92)	5.20±0.89 (77)	5.13±0.80 (43)	5.24±0.74 (108)	5.48±0.78 (18)
YG	5.43±0.69 (179)[a]	5.38±0.73 (97)	5.49±0.63 (82)[a]	5.11±0.52 (46)	5.46±0.67 (110)[a]	5.95±0.72 (23)

Note. [a]P<0.05 compared with the control group. ( ): the number of subjects.

Weight The weight gain and WAZ at 3, 6, and 9 months of study in YG were significantly higher than those in CG. The weight gain in CG was less than the WHO reference level, while the weight gain in YG was the same as the WHO reference (Table 5).

Table 6 shows analyses in detail about the weight gain stratified by gender and WAZ during the 9 months of yogurt supplementation. The weight gain of girls and the children with WAZ<0 in YG was significantly higher than that in CG.

Upper-arm Circumference

The upper-arm circumference of children in YG at baseline level was lower than that in CG, and it was close to CG after yogurt supplementation (Table 7).

Bone Mineral Density (BMD)

The forearm BMD of children was comparable before the study in the two groups. After yogurt supplementation for 9 months, the results showed that the BMD of children in YG was significantly higher than that in CG. The increase rate of BMD in YG was also higher than that in CG (Table 8).

TABLE 5

Weight Gain and Change of HAZ at 3, 6, and 9 Months of Study ($\bar{x}\pm s$)

Group	Increase of Weight (kg)			Change of WAZ		
	3 m	6 m	9 m	3 m	6 m	9 m
CG	0.49±0.35	0.80±0.60	1.20±0.67	0.031±0.184	-0.047±0.281	-0.043±0.301
YG	0.70±0.43[a]	0.98±0.62[a]	1.42±0.76[a]	0.139±0.228[a]	0.058±0.306[a]	0.078±0.365[a]
WHO Reference	0.5	0.9-1.0	1.3-1.5			

Note. [a]P<0.01 compare with CG.

TABLE 6

Weight Gain of Subjects Stratified by Gender and WAZ (kg, $\bar{x}\pm s$)

Group	Total	Gender		Range of WAZ		
		Male	Female	WAZ≤-1	-1<WAZ<0	WAZ≥0
CG	1.20±0.67(169)	1.26±0.76(92)	1.14±0.55(77)	1.05±0.48(43)	1.16±0.58(99)	1.59±1.01(27)
YG	1.42±0.76(179)[a]	1.35±0.83(97)	1.51±0.66(82)[a]	1.32±0.59(62)[a]	1.50±0.85(105)[a]	1.35±0.66(12)

Note. [a] P<0.01 compare with the control group. ( ): the number of subjects.

TABLE 7

Upper-arm Circumference (cm, $\bar{x}\pm s$)

	0 m	3 m	6 m	9 m
CG	16.39±0.97	16.21±0.90	16.42±1.02	16.55±1.08
YG	15.87±0.83	16.12±0.98	16.23±0.98	16.47±1.08
P	0.000	0.401	0.077	0.504

TABLE 8

BMD of Forearm (g/cm^2, $\bar{x}\pm s$)

Group	0 m	3 m	6 m	9 m	Total Increase (%)
CG	0.394±0.056(145)	0.391±0.042(161)	0.402±0.044(159)	0.400±0.065(160)	1.52
YG	0.383±0.055(171)	0.383±0.047(170)	0.401±0.052(176)	0.415±0.058(175)	8.36
P	0.076	0.113	0.873	0.028	

Suffering From Diseases

The upper-respiratory infection and diarrhea were the diseases most frequent in preschool children. The incidence of these diseases in YG was much less than that in CG (Table 9). The duration of upper-respiratory infection and diarrhea during the 9 months study in YG was much less than those in CG (Table 10).

TABLE 9

Incidence of Upper-respiratory Infection and Diarrhea (%)

Group	Upper-respiratory Infection				Diarrhea			
	0-3 m	3-6 m	6-9 m	Total	0-3 m	3-6 m	6-9 m	Total
CG	20.51	6.71	12.43	13.21	1.30	3.39	2.60	2.43
YG	11.73	4.28	6.52	7.51	1.53	1.31	0.87	1.23
P^a	0.001	0.085	0.001	0.001	0.785	0.043	0.050	0.023

Note. [a]by χ^2 test.

TABLE 10

Duration of Upper-respiratory Infection and Diarrhea (d, $\bar{x}$±(Q3-Q1))

Group	Upper-respiratory Infection				Diarrhea			
	0-3 m	3-6 m	6-9 m	Total	0-3 m	3-6 m	6-9 m	Total
CG	4.0±4.0	7.0±5.0	4.3±5.0	4.8±4.0	2.0±0.8	3.0±2.5	2.0±1.0	2.8±1.0
YG	3.0±3.0	3.0±2.0	3.0±3.0	3.4±2.5	2.0±0.8	2.0±1.0	2.0±0.5	2.0±0.5
P^a	0.284	0.047	0.096	0.012	0.406	0.009	0.573	0.012

Note. [a]by non-parameter statistical test.

DISCUSSION

The effects of yogurt on colon flora[3-4], diarrhea[5-6], and immunology[7] have been reported by many investigators, but the effect of yogurt on children's growth was seldom reported.

The result of our longitudinal study showed that the intake of calcium, zinc and vitamin B_2, the gain of height and weight, the bone mineral density (BMD) of forearm were all significantly improved after yogurt supplementation, and the incidence and duration of upper-respiratory infection and diarrhea were decreased at the same time. The better growth rate and the lower incidence of infectious diseases in YG may be the result of getting more nutrients from yogurt.

The gain of height and weight of girls in YG was especially higher than that in CG. Girls may obtain more benefit from yogurt. The increase of BMD in YG during the study period of 6-9m was much higher than that in CG. It was just the autumn of Beijing when the sunshine and sport time were dropped. The increase of BMD in YG may be the compensation effect of more calcium and protein from yogurt.

There were reports about dairy supplementation during puberty or pre-puberty. Studies on dairy intervention for preschool children were not found. Merrilees M. J.[8] reported that milk supplementation on girls during their puberty for 2 years had no significant effect on the gain of height and weight, whereas there was a positive effect on BMD. The difference of results between Merrilees and our study might come from the following respects:

· Yogurt keeps almost all nutrients of milk and the absorption of yogurt is easier than milk[9].

· Yogurt could improve the flora in colon tract[3-4].

· Yogurt could modulate the immunity[7] and decrease the incidence of diseases, such as diarrhea[5-6].

· Preschool children eat less than the children during the age of puberty. The quantity of yogurt on 125 g per day is more suitable for preschool children than the amount of regular milk for the children in puberty.

It is generally accepted that yogurt is beneficial to preventing diarrhea[5-6]. While few reports are available on the effect of yogurt on upper-respiratory infection, our study demonstrated that yogurt was beneficial not only to the prevention of diarrhea but also of upper-respiratory infection. The health effect of yogurt on upper-respiratory infection might be related to immunity modulation, by stimulating the activities of B and T cells and natural killer cells[10].

In conclusion, yogurt supplementation can significantly improve the growth and increase the density of bone minerals of 3-5 years old preschool children by increasing calcium, zinc, and vitamin B_2 intake and decreasing the incidence of diarrhea and upper-respiratory infection.

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