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Child health promotion program in South Korea in collaboration with US National Aeronautics and Space Administration: Improvement in dietary and nutrition knowledge of young children

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BACKGROUND/OBJECTIVES: Childhood obesity has become a global epidemic. Development of effective and sustainable programs to promote healthy behaviors from a young age is important. This study developed and tested an intervention program designed to promote healthy eating and physical activity among young children in South Korea by adaptation of the US National Aeronautics and Space Administration (NASA) Mission X (MX) Program.
SUBJECTS/METHODS: The intervention program consisted of 4 weeks of fitness and 2 weeks of nutrition education. A sample of 104 subjects completed pre- and post- surveys on the Children's Nutrition Acknowledgement Test (NAT). Parents were asked for their children's characteristics and two 24-hour dietary records, the Nutrition Quotient (NQ) at baseline and a 6-week follow-up. Child weight status was assessed using Korean body mass index (BMI) percentiles.
RESULTS: At baseline, 16.4% (boy: 15.4%; girl: 19.2%) of subjects were overweight or obese (based on BMI≥85%tile). Fat consumption significantly decreased in normal BMI children (48.6 ± 16.8 g at baseline to 41.9 ± 18.1 g after intervention, $P < 0.05$); total NQ score significantly increased from 66.4 to 67.9 ($P < 0.05$); total NAT score significantly improved in normal BMI children (74.3 at baseline to 81.9 after the program), children being underweight (from 71.0 to 77.0), and overweight children (77.1 at baseline vs. 88.2 after intervention, $P < 0.001$).
CONCLUSIONS: The 6-week South Korean NASA MX project is feasible and shows favorable changes in eating behaviors and nutritional knowledge among young children.

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INTRODUCTION

Childhood obesity is a major public health concern worldwide [1]. An estimated 42 million pre-school children under the age of 5 years are overweight [2]. Childhood obesity is the main cause of physical and psychosocial health problems, such as hypertension, diabetes, cardiovascular disease, asthma, depression, and low self-esteem [3]. Early childhood is a critical period for developing healthy eating habits and food preferences [4,5], which collectively affect a child's lifelong health [6]. Childhood obesity increases the risk of becoming overweight and obese throughout adolescence and beyond [7]. To prevent and manage the condition, a multifactorial system that encompasses diet, fitness, and behavior is needed [8].

Interactive learning and targeted and tailored healthy eating and physical activity programs are needed for successful childhood obesity intervention [9]. Few obesity intervention programs have targeted preschool-aged children or offered health-related information in the form of flyers, booklets, or homework [10-12]. However, these interventions have shown significant improvement in children's eating and exercise habits as well as perceived competence [9].

The World Health Organization (WHO), national governments, and local communities have created taskforces and programs to tackle the global childhood obesity epidemic. In 2011, the US National Aeronautics and Space Administration (NASA) launched the NASA Mission X: Train like an Astronaut (TLA) Project. Mission X (MX) is an international education challenge

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that has grown to encompass 28 countries, with over 800 teams comprised of more than 39,000 children. Exercising, eating healthy, and learning about the challenges of living in space are the central education components of the MX project [13]. The MX program is a US NASA-supported project. We adopted the main theme of the astronaut's challenge for maintaining good health during space exploration in MX in order to address the positive energy balance issue of obesity.

Until now, no studies have attempted to encourage behavioral changes by teaching children the importance of fitness and nutrition in preschool settings in South Korea. This study aimed to evaluate implementation of the adapted MX project for young children in South Korea. This paper examined how effective the MX project was in improving eating behaviors and nutrition knowledge among the study population. To improve eating behaviors, especially, this study examined the effects of nutrition education sessions regarding 'maintaining a balanced diet' and 'how to snack healthfully' in Korean preschoolers. In a separate paper, we assessed changes in their physical activity.

SUBJECTS AND METHODS

Study design, setting, and subjects

The NASA MX project was originally designed as a school-based intervention study for children aged 8-12 years. We aimed to test the feasibility and effectiveness of this project among children in kindergarten in order to promote early prevention of childhood obesity. The Korea Institute of Child Care and Education (KICCE) selected three kindergartens in the cities of Seoul, O-san, and Yong-in and eight lead teachers to participate in this program.

The intervention was initiated in late October 2014 and was completed in early December 2014. At baseline, 212 children were enrolled with parental consent. A total of 104 children completed the Nutrition Acknowledgement Test (NAT), which is a survey delivered pre- and post-intervention. Parents were asked to describe their child's characteristics, report four 24-hour dietary records (two at baseline and two at follow-up), the Nutrition Quotient (NQ) at baseline and a 6-week follow-up.

All participants (children' legal guardians) provided written informed consent, and the study was approved by the Institutional Review Board of Kyung Hee University, Yongin, South Korea (# KHU IRB 2014-G20).

Six-week intervention program

The Korean program adapted the original NASA MX project for 5-year-old children. The original MX project consisted of 18 modules (14 physical activities and 4 nutrition education sessions) for children aged 8-12 years. NASA provided a translation of the modules for this study, and we modified it for young children in South Korea. MX was designed to give educators the ability to modify the contents and select modules that fit their participants' needs and unique program goals.

Korea's curriculum included six modules: four physical activities and two nutrition education sessions (see Appendix A). Each module included comprehensive weekly lesson plans and activities for use in the classroom and at home. The nutrition education part of the program followed Korean Ministry of Health & Welfare and Korean Ministry of Education guidelines for preschool children with an advisory committee. The NASA MX teaching materials were translated into Korean. The teacher's guidebook provided aims and detailed directions for guiding children through the program. All teachers participated in training before the intervention and quality control monitoring throughout the program.

Each weekly session was about 40-60 minutes and was taught by a teacher and a nutrition specialist. The two nutrition sessions took place in individual classrooms or an auditorium with around 30 (or less) children participating. The program was focused on how to maintain a balanced diet and eat healthy snacks by explaining what astronauts' consume while aboard the International Space Station. For the two nutrition education sessions, e.g. energy of an astronaut and reduced gravity-low fat, we developed educational materials such as movie clips, food balance wheels (i.e. food pyramid), food models, wearable fat vest, and a healthy vs. unhealthy snack board. The first nutrition session focused on the functions of nutrients, our body's nutritional needs, and how to maintain a balanced diet by using the food balance wheels and food models. During the education sessions, children participated in food arranging activities, educational games, and questions and answers to demonstrate what they learned. Next, healthy and unhealthy snacks were identified by assessing unhealthy snacks, e.g. fat and sugar contents, fast food, and sweetened beverages. Children were then able to experience what it would feel like to add that fat to their body, by wearing a fat vest during the session.

Teachers uploaded the achieved points of each module and photos and comments about each week's activity to the MX interactive website, http://trainlikeanastronaut.org/content/74966/south-korea. Then, the points were converted to steps for the MX icon, Astro Charlie, to travel from the Earth to the Moon.

Assessment and measures

A set of measures was collected at baseline and post-intervention from children and their parents, including the children's baseline anthropometric characteristics (height, weight, birth length, birth weight, and gestational age), diet history (breast feeding, age of introducing weaning, food related allergy, and picky eating), two 24-hour dietary recalls, children's nutrition knowledge [14], dietary quality and habits [15], and physical activity levels [16].

Children's weight and height at baseline were reported by parents after measuring the children at home. The children answered survey questionnaires pertaining to nutrition knowledge, with assistance from their teachers when needed. Other assessments were collected from survey questionnaires, which were completed by their parents. Pre-intervention data collection began 2 weeks before the start of the program, and the post data collection was completed within 1 week of the program's end.

Baseline body mass index (BMI) status

We used sex-age-specific BMI percentiles from the Korean Children and Adolescents Growth Standard [17] to assess child weight status: $\geq$ 85th percentile for overweight, < 10th percentile for underweight, and those in-between the 10th and 85th percentiles for normal BMI.

Assessing dietary intake (Food records)

Each parent was informed of how to complete the food records using photos of appropriate portion sizes for 2 days (one weekday and one weekend) at baseline and follow-up. All completed records were evaluated for average daily nutrient intake using the Computer Aided Nutritional Analysis Program (CAN Pro, Version 4.0, The Korean Nutrition Society, 2010). Intakes of 15 different nutrients as well as total energy were compared with Dietary Reference Intakes for Koreans (KDRIs) [18].

Assessing eating behaviors (Nutrition quotient [NQ])

Children's dietary behavior was assessed using the NQ [15]. It was developed by the Korean Nutrition Society in 2012 based on the literature and the Korean National Health and Nutrition Examination Survey data. The NQ was designed to evaluate children's diet quality, eating attitudes, and behaviors. The NQ questionnaire consists of 19 items categorized into five factors: balance (mixed grains, vegetables, milk, legumes, eggs, and fruits), diversity (diverse side dishes, Kimchi, and vegetables), moderation (fast-food, instant noodles, late-night snack, street food, and sweets), regularity (meal regularity, eating breakfast, and screen time restrictions), and practice (checking nutrition labeling, chewing well, and washing hands before meals). The scores of all five factors were added, yielding the total NQ score ranging from 0 to 100. Five groups were assigned according to the total NQ score (Highest: 80.9-100, High: 73.8-80.8, Medium: 56.5-73.7, Low: 47.6-56.4, Lowest: 0-47.5).

Nutrition achievement test (NAT)

Children's nutrition knowledge was evaluated using the modified version of the NAT [14]. It was is a picture-questionnaire consisting of 10 items in two main categories: balanced meals and healthy snacking. This questionnaire was based on the intervention's nutrition sessions (Appendix A). Scores for each component: Six questions on balanced meals were scored on a scale ranging from 0 (poor) to 60 (excellent), and four questions on snacking were scored on a scale ranging from 0 (poor) to 40 (excellent). The two questions were summarized to achieve the total NAT score (ranging 0-100).

Statistical analysis

We compared the differences in dietary behaviors and nutrition knowledge by sex and weight status (underweight, normal weight, and overweight) using t-test, ANOVA (analysis of variance), and Chi-square test. Paired t-tests were used to assess changes in children's measurements between pre- and post-test.

All statistical analyses were performed using SAS Version 9.3 (SAS Institute, Cary, NC, USA). Statistical significance was set as $P < 0.05$.

RESULTS

Baseline characteristics of study subjects

Mean BMI was 15.5 ± 1.8 (boy: 15.8 ± 1.7; girl: 15.3 ± 1.9 kg/m^2); 16.4% were overweight while 19.2% were underweight. Approximately 60% of subjects were picky eaters while 50% took supplements regularly. There were no significant differences in health-related characteristics (birth weight, gestational age, breast feeding length, age of introduction to weaning, food allergy, picky eating, supplements, or physical activity) between boys and girls, except for their height and weight (see Table 1).

Changes in nutrients intake

Table 2 shows the nutrient intakes of the subjects. No significant differences in energy intake were observed between the pre- and post- tests in the whole scale. However, intakes of fat (48.6 ± 16.8 vs. 41.9 ± 18.1 g/day, $P < 0.05$) and vitamin A (922.3 ± 548.5 vs. 756.4 ± 390.3 μgRE/day, $P < 0.05$) decreased significantly after intervention in the normal weight group. Overall, intakes of vitamin B1 (1.2 ± 0.4 vs. 1.0 ± 0.3 mg/day, $P < 0.05$) and folate (360.7 ± 120.2 vs. 408.3 ± 141.2 μg/day, $P < 0.05$) were significantly changed. Compared to KDRIs, intakes of protein, phosphorus, iron, vitamin A, vitamin B_1, vitamin B_2, vitamin C, folate, and zinc were higher in all groups, except for calcium and vitamin D (less than 80%) (Data not shown).

Pre- and post- changes in children's dietary behaviors accessed using NQ score

Fig. 1 shows stratified NQ changes by sex and weight status. Total NQ score significantly increased (66.4 to 67.9, $P < 0.05$) after the intervention. Balance factor, which evaluates consumption of various food groups, significantly improved (57.3 to 62.9, $P < 0.001$) regardless of sex and weight status; however, score for regularity of meals only significantly improved in under-

Table 1. Baseline characteristics of 5-year-old children in South Korea participating in the study

Variable	Total (n = 104)	Boys (n = 52)	Girls (n = 52)
Anthropometric			
Height (cm)	117.5 ± 5.1[1)]	119.4 ± 5.1	115.7 ± 4.8***
Weight (kg)	21.5 ± 3.1	22.6 ± 3.2	20.6 ± 3.0**
Body mass index (kg/m^2)	15.5 ± 1.8	15.8 ± 1.7	15.3 ± 1.9
Weight status (%)[2)]			
Underweight to thin	19.2	17.3	21.2
Normal weight	64.4	67.3	61.5
Overweight	16.4	15.4	19.2
Birth-related			
Birth length (cm)	51.0 ± 5.3	51.4 ± 2.4	50.1 ± 1.6*
Birth weight (kg)	3.3 ± 0.4	3.3 ± 0.4	3.2 ± 0.4
Gestational age (weeks)	39.0 ± 1.5	38.9 ± 1.5	39.0 ± 1.7
Breast feeding (yes/ no, %)	90.4/ 9.6	90.4/ 9.6	90.4/ 9.6
Breast feeding period (month)	11.5 ± 7.5	12.2 ± 9.2	10.5 ± 5.9
Age of introducing weaning (month)	6.2 ± 1.4	6.4 ± 1.5	6.1 ± 1.5
Diet-related			
Food related allergy (yes/ no, %)	7.7 / 92.3	9.6 / 90.4	5.8 / 44.2
Picky eating (yes/ no, %)	58.7 / 41.3	59.6 / 40.4	57.7 / 42.3
Supplements (yes/ no, %)	51.0 / 49.0	48.1 / 51.9	3.8 / 46.2

[1)] Values were presented by mean ± SD.
[2)] Defined based on age- and sex-specific BMI percentiles from the 2007 Korea National Growth Chart; underweight (< 10th percentile); normal weight (10th percentile ≤ BMI < 85th percentile); overweight (≤ 85th percentile).
Significant differences were shown between boys and girls using Student t-test; * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

Table 2. Comparing pre- and post-intervention dietary intakes among 5-year-old South Korean children by their weight status

Variables	All (n = 104)			By weight status[1]								
				Underweight to thin (n = 20)			Normal weight (n = 67)			Overweight (n = 17)		
	Pre-	Post-	△	Pre-	Post-	△	Pre-	Post-	△	Pre-	Post-	△
Energy (kcal)	1,612.9 ± 348.1	1,539.5 ± 392.3		1,602.6 ± 379.2	1,456.1 ± 424.9		1627.8 ± 358.7	1545.1 ± 401.8		1,570.6 ± 274.9	1,615.7 ± 308.8	
Carbohydrate (g)	238.6 ± 52.7	231.9 ± 55.3		232.6 ± 51.5	211.5 ± 53.1		240.1 ± 56.8	237.4 ± 57.8		239.9 ± 36.6	234.6 ± 43.8	
Protein (g)	61.5 ± 20.4	59.5 ± 20.8		62.0 ± 17.6	57.5 ± 24.9		62.1 ± 22.5	59.5 ± 20.9		58.6 ± 14.8	61.7 ± 15.6	
Fat (g)	47.8 ± 17.9	43.6 ± 18.8		48.9 ± 22.3	44.4 ± 22.6		48.6 ± 16.8	41.9 ± 18.1	↓*	43.4 ± 16.7	49.8 ± 16.3	
Fiber (g)	16.9 ± 5.6	16.9 ± 5.5		17.1 ± 5.7	15.7 ± 5.4		17.3 ± 5.9	17.6 ± 5.8		15.5 ± 4.8	15.5 ± 4.3	
Iron (mg)	13.4 ± 5.7	12.0 ± 3.9		13.0 ± 4.3	11.1 ± 3.6		13.7 ± 5.8	12.4 ± 4.3		12.7 ± 6.7	11.7 ± 2.5	
Sodium (mg)	2,997.3 ± 1,124.1	3,106.2 ± 1,3478.2		3,287 ± 1,359.3	3,298.8 ± 1,368.7		3,102.3 ± 1,447.4	3,003.0 ± 968.8		2,532.3 ± 903.7	3,104.5 ± 960.2	
Vitamin A (μgRE)	831.3 ± 502.2	806.1 ± 588.1		674.6 ± 378.5	1,025.6 ± 1,098.0		922.3 ± 548.5	756.4 ± 390.3	↓*	656.6 ± 338.6	743.5 ± 302.3	
Vitamin B_1 (mg)	1.2 ± 0.4	1.0 ± 0.3	↓*	1.1 ± 0.5	0.9 ± 0.3		1.2 ± 0.4	1.1 ± 0.4		1.2 ± 0.4	1.1 ± 0.3	
Vitamin B_2 (mg)	1.3 ± 0.5	1.2 ± 0.4		1.3 ± 0.7	1.1 ± 0.6		1.3 ± 0.5	1.2 ± 0.5		1.2 ± 0.3	1.3 ± 0.2	
Vitamin C (mg)	117.05 ± 91.9	122.7 ± 69.6		98.2 ± 67.3	117.6 ± 83.6		126.1 ± 102.2	123.1 ± 68.1		106.0 ± 70.4	126.9 ± 60.8	
Vitamin D (mg)	3.7 ± 3.7	3.8 ± 3.8		3.1 ± 3.1	3.2 ± 3.2		3.3 ± 3.2	3.9 ± 4.2		5.9 ± 5.4	4.0 ± 2.9	
Folate (μg)	360.7 ± 120.2	408.3 ± 141.2	↑*	361.2 ± 120.2	395.8 ± 126.9		370.5 ± 126.0	422.8 ± 145.4	↑*	321.6 ± 91.2	365.3 ± 137.3	
Zn (g)	8.7 ± 3.1	8.3 ± 3.0		8.1 ± 2.3	7.9 ± 3.1		9.1 ± 3.5	8.3 ± 3.1		8.3 ± 2.4	8.7 ± 2.2	

△: change
[1] Values were presented by mean ± SD.
[2] Defined based on age- and sex-specific BMI percentiles from the 2007 Korea National Growth Chart; underweight (< 10th percentile); normal weight (10th percentile ≤ BMI < 85th percentile); overweight (≤ 85th percentile).
Significant differences were shown between pre- and post-intervention by paired t-test; *P< 0.05.
No statistically significant differences were detected at pre- and post-intervention among the three groups by weight status.

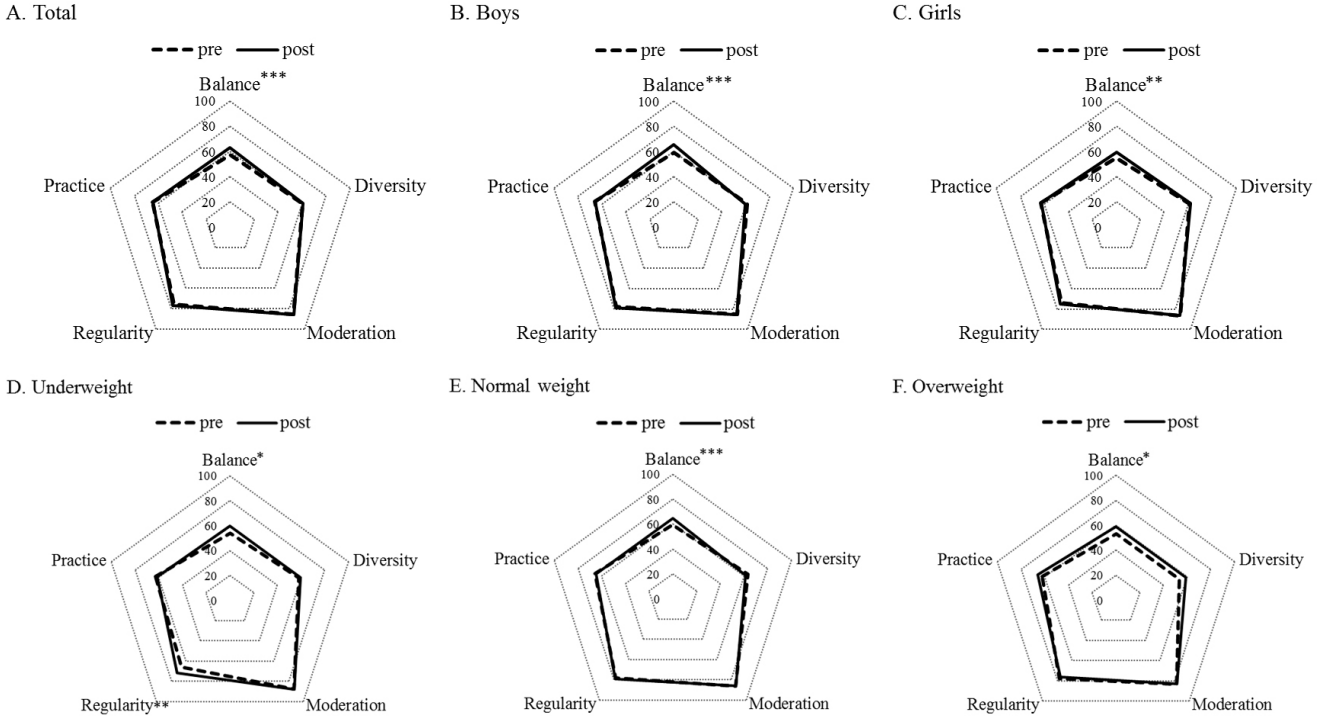

Fig. 1. Pre- and post-intervention measures of Nutrition Quotient (NQ) of 5-year-old South Korean children participating in the intervention program, by sex and weight status. [1] Defined based on age- and sex-specific BMI percentiles from the 2007 Korea National Growth Chart; underweight (< 10th percentile); normal weight (10th percentile ≤ BMI < 85th percentile); overweight (≤ 85th percentile). [2] Total NQ score (0 to 100 points) = sum of [checklist item score (0-100) × item weight within NQ] [3] NQ grade: Five dietary behavioral stages (Highest: 80.9-100, High: 73.8-80.8, Medium: 56.5-73.7, Low: 47.6-56.4, Lowest: 0-47.5) were assigned according to the total NQ score ranged from 0 to 100 points and a higher score indicated better dietary behaviors. Significant differences were shown between pre- and post-intervention by Paired t-test; * P< 0.05, ** P< 0.01, *** P< 0.001. No statistically significant differences were detected at pre- and post-intervention among the three groups by weight status.

weight children (66.2 vs. 71.7, P < 0.01). Normal weight children showed higher scores for balance, diversity, and practice factors than underweight and overweight groups.

Pre- and post- changes in nutrition knowledge using NAT

Table 3 shows NAT scores of the subjects by sex and weight status. Total NAT score was significantly higher (82.0 ± 15.2, P

Table 3. Changes in Nutrition Achievement Test (NAT) between pre- and post-intervention among 5-year-old Korean children by sex and weight status

	Total (n = 104)			By sex						By weight status[1]								
				Boys (n = 52)			Girls (n = 52)			Underweight to thin (n = 20)			Normal weight (n = 67)			Overweight (n = 17)		
	Pre-	Post-	△	Pre-	Post-	△	Pre-	Post-	△	Pre-	Post-	△	Pre-	Post-	△	Pre-	Post-	△
Total NAT score[3]	74.1 ± 14.5[2]	82.0 ± 15.2	↑***	73.3 ± 15.9	78.8 ± 18.0	↑*	75.0 ± 13.2	84.6 ± 13.2	↑***	71.0 ± 15.2	77.0 ± 15.3		74.3 ± 15.1	81.9 ± 16.1	↑***	77.1 ± 11.0	88.2 ± 8.8	↑***
Balanced meal (Q1-Q6)[4]	42.0 ± 11.3	48.2 ± 11.6	↑***	41.0 ± 11.8	45.2 ± 12.4	↑*	43.1 ± 10.8	51.2 ± 9.8	↑***	41.0 ± 11.7	45.5 ± 11.9		41.9 ± 11.7	47.8 ± 11.8	↑***	43.5 ± 9.3	52.9 ± 9.2	↑***
Healthy Snacking (Q7-Q10)[5]	32.1 ± 7.1	34.3 ± 7.3	↑*	32.3 ± 6.7	34.2 ± 7.0		31.9 ± 7.4	33.5 ± 7.6		30.0 ± 8.6	31.5 ± 7.5		32.4 ± 6.8	34.2 ± 7.6		33.5 ± 6.1	35.3 ± 5.1	

△: change
[1] Defined based on age and sex specific BMI percentiles from the 2007 Korea National Growth Chart; underweight (< 10th percentile); normal weight (10th percentile ≤ BMI < 85th percentile); overweight (≤ 85th percentile).
[2] Values were presented by mean ± SD.
[3] Total Nutrition Achievement Test were scored on this scale range from 0 (poor) to 100 (excellent)
[4] Six questions of balanced meal were scored on this scale range from 0 (poor) to 60 (excellent)
[5] Four questions of snacking were scored on this scale range from 0 (poor) to 40 (excellent)
Significant differences were shown between pre- and post-intervention by Paired t-test; *P< 0.05, **P< 0.01, ***P< 0.001.
No statistically significant differences were detected at pre- and post-intervention among the three groups by weight status.

< 0.001) than at baseline (74.1 ± 14.5) in all groups. Both the balanced meals (48.2 ± 11.6 to 42.0 ± 11.3, P < 0.001) and healthy snacking sections significantly improved after intervention (34.3 ± 7.3 to 32.1 ± 7.1, P < 0.05). There was no sex difference in NAT scores at baseline; however, total NAT score was significantly different by sex after the intervention (boys: 73.3 ± 15.9 to 78.8 ± 18.0, P < 0.05; girls: 75.0 ± 13.2 to 84.6 ± 13.2, P < 0.001).

DISCUSSION

The modified NASA MX project was a feasible and somewhat effective intervention for promoting healthy eating in young children in South Korea. Our 6-week intervention program resulted in several desirable changes in children's dietary behaviors, especially with regards to consumption of a more balanced diet and food groups, such as mixed grains, vegetables, legumes, white milk, eggs, and fruit. These changes in dietary behaviors differed by children's weight status but not by sex. Underweight children showed improved regularity of meal time, breakfast, and controlled screen time after the intervention. The intervention also improved nutrition knowledge among normal weight and overweight children.

Childhood is a critical period for formation of healthy eating habits, which is affected by knowledge, attitudes, preferences, and family economic status [19,20]. Caregivers and school teachers play a key role in teaching and encouraging healthy dietary behaviors in early childhood [21]. Behavioral change strategies incorporating dietary and physical activity should be used in intervention programs of children aged 4-6 years [9]. Systematic reviews and meta-analysis studies, including ours, have demonstrated the importance of lifestyle interventions such as diet management for childhood obesity prevention [22,23]. To achieve the major goal of food behavioral changes in order to prevent childhood obesity, we modified the original NASA MX project for young children in South Korea [24].

Childhood obesity is a public health concern due to its scale and spread into South Korea. According to a 2013 national report, the overweight proportion in 6-11 year-old children was 6.1% [25], although there is no national report on children under 6 years of age. According to previous studies, the rate of obesity for children aged 2-5 years has gradually increased in South Korea from 5.1% in 1997 [26] to 6.3% in 2007 and 9.6% in 2010 [27]. A previous study showed that children aged 3-6 years preferred unhealthy snacks with high fat and sugar contents, such as hamburgers, pizzas, fried foods, and sugar-sweetened beverages [28]; 69.1% of children, regardless of sex, possessed deviated food habits, and particularly 51.2% of children did not like eating vegetables [28]. Western-style meals may be a cause of the increasing obesity rate among young children in Korea.

Additionally, 14.6% of preschool children skipped breakfast, and 25% ate out once a day [25]. Our study participants showed undesirable dietary behaviors, especially balance factor. Children did not consume important food groups, such legumes, vegetables, or milk.

Only a small number of studies have tested the effects of obesity prevention programs among young children [29,30]. Eating behaviors of students in this program improved after the 6-week intervention. Nutrient-based meal balance and choosing healthy snacks were the focus of the nutrition education sessions. After intervention, children changed their dietary behaviors, regardless of sex and weight status. In addition, the post-test reported improvements in nutrition knowledge, balanced meal consumption, and healthy snacking. Intervention programs for young children are still uncommon due to difficulties in maintaining the program and evaluating intervention effects.

Assessing dietary intake among young children is still challenging. The total NQ score shows similar results with NQ equation modeling [31], which was performed among children aged 10-12 years in six metropolitan cities in South Korea. However, our children showed lower scores for balanced dietary factors at baseline, which is in accordance with a previous study [32]. This result indicates that sweets, fast food, street food, and late-night snacking were under control for this age group, whereas various food groups (vegetables and fruits, milk, mixed grains, beans, and eggs) were unbalanced in their diet. To assess nutrition knowledge, we applied NAT, a structured questionnaire consisting of pictures for young children [14]. After the program, most children underwent positive changes in balanced dietary factors and improvements in nutrition knowledge. Other prevention programs have shown similar results [8,11]. These results suggest that school-based nutrition education programs with a family component could be effective in the early childcare system.

In addition, we did not detect any significant changes in children's energy intake using 2-day food recalls collected from

their caregivers. Although not statistically significant, energy intake decreased in underweight children and increased in overweight children after the intervention program. This could be attributable to variations in sample size and/or reporting errors. Caregivers of underweight children may be more concerned with their child's weight status and therefore may be more likely to report their child's dietary intake as being insufficient, whereas it is the opposite for overweight children.

Over one-third (35%) of underweight and overweight subjects showed worsening dietary behaviors compared to normal weight children. In particular, underweight children scored lower in meal frequency, breakfast skipping, and regular screen time. There were no statistically significant changes in nutrition knowledge and dietary intakes after education in each group. In the future, more in-depth studies are necessary to reinforce the education contents and assessment indicators and improve behavioral changes according to the weight status of the child, especially underweight children.

The coexistence of stunting and overweight children has been found in both low-income and high-income countries [33]. For this reason, we approached childhood obesity with factual nutrition education for young children. A balanced diet has a key role in maintaining healthy weight and growth. In this study, 5.9% of overweight children had a higher grade of NQ, compared to 31.3% of normal weight children. In contrast, overweight children showed the highest improvement in nutrition knowledge. This highlights that overweight children may have learned the most from the program and could benefit more in the future. Caregiver, school, and policymaker efforts are needed to encourage the life-long health of young children.

Projects such as the NASA Mission X: Train Like an Astronaut program address difficulties associated with setting up and maintaining health and fitness intervention programs unique to individual school or community settings. Aspects that can make such projects difficult may include costs, lack of readily available age appropriate materials and activities, and school or community time limitations for implementation.

The project sustains the most costly components such as the website, the development and implementation of activities, and recommendations of educational materials at little or no cost. The project further targets a timely theme of human space exploration and addresses a global issue associated with health and fitness. Background knowledge, training on how to implement activities, training videos, and providing limited unique training sessions via Skype and Google Hangouts are all part of the global MX project. These components address some of the difficulties associated with programs like this.

MX is designed around a "challenge" format, which works around unique time limitations; however, simple modification may be selected to change to a non-challenge format. Two challenges are offered at present, allowing for organizations and schools to participate in MX from October to December or from January to April each year for free. The team can also participate in both challenges and keep their children engaged throughout the school year. Each team's approach to implementing the content in their setting can involve all MX activities and materials or only those they prefer. In addition, MX training materials outline the amount of time each activity may entail.

Lastly, large globally offered intervention programs such as the NASA MX can be a gateway to other participating countries, languages, customs, and cultures, allowing a fuller understanding of the world. For example, some participating countries/teams use MX to teach languages and to communicate with other students around the world, thus engaging in their new knowledge about nutrition and exercise with each other.

The present study has limitations, as its small sample size, weight, and height were not measured in the follow-up and the intervention was relatively short. The validation study has not been implemented for Korean children, even though the program has already been applied in several countries. Nevertheless, these young children showed improvements in nutrition knowledge and eating after participating in this program. The study results show the feasibility of adapting the MX program for young children through the early childcare and education systems in South Korea.

The MX program was originally designed to include science-based experimental components about the human body and diet-related health conditions, which are helpful to support full understanding of young children. To promote childhood obesity prevention, a school, family, and community-level integrating primary prevention approach that builds on right knowledge and skills to prevent obesity-related risk factors would be required based on socio-ecological and socio-cognitive theory.

In conclusion, it is feasible to carry out the modified NASA Mission X intervention program to promote healthy eating among young children in South Korea. The intervention has resulted in some desirable improvements in children's dietary intake, nutrition knowledge, attitudes, and their parents' attitudes. Further research is needed to test the long-term effects with more children. In collaboration with the basic concept of the MX program, age-targeted nutrition education will bring powerful effects to promote healthy life and eating habits in young children and their families.

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CONFLICT OF INTEREST

The authors declare no potential conflicts of interests.

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Appendix A. The South Korean adapted version of the National Aeronautics and Space Administration (NASA) Mission-X project intervention components for young children*

Week	Themes	Goals	Activities
1	Do a space walk!	muscle strength, coordination	bear crawl, crab walk
2	Jump for the moon	bone strength, muscle endurance	jump training with a rope
3	Agility astro-course	agility, coordination, speed	running a specific course
4	Energy of an astronaut	understanding specific nutritional needs	categorizing different food items
5	Reduced gravity, Low-fat	formulating balanced meal	discovering fat contents
6	Building an astronaut "core"	abdominal and back muscle strength	commander crunch, pilot plank

* The intervention program was implemented for 6 weeks in the fall of 2014 by advisory committee members of early child care and education, sports science and preventive medicine fields and current preschool teachers.