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NASA Mission X Program for Healthy Eating and Active Living among Taiwanese Elementary School Students

Yu-Chun Lin [a], Hsin-Jen Chen [a], Youfa Wang [b], Jungwon Min [b], Hui-Chao Wu [c], Nubia A. Carvajal [d], Hsing-Yu Yang, DrPH, RN [c,*]

[a] Institute of Public Health, National Yang-Ming University, Taipei, Taiwan
[b] Fisher Institute of Health and Well-being, Department of Nutrition and Health Sciences, College of Health, Ball State University, Muncie, IN, USA
[c] Department of Nursing, Mackay Medical College, New Taipei City, Taiwan
[d] MORI Associates, NASA Communications, Outreach, Multimedia and Information Technology (COMIT) Contract, TX, USA

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ABSTRACT

Purpose: This study assessed the effects of an intervention program adapted from the NASA Mission X (MX) program on children's Healthy Eating Active Living (HEAL) knowledge and behaviors and anthropometry.
Methods: This clustered randomized control trial recruited 8 elementary schools in remote rural areas of Northern Taiwan. The intervention was the 8-week MX program. All the 3rd and 4th graders were invited to the study ($n = 245$). Children's weight, height, HEAL knowledge and behaviors were measured pre- and post-intervention.
Results: The intervention group had significantly more improvements than control group in physical activity knowledge score (+0.91 vs. +0.25, $p = 0.002$), diet knowledge score (+0.62 vs. +0.17, $p = 0.044$), and score of interests in NASA and space exploration (+0.34 vs. −0.07, $p < 0.0001$). BMI increased from 18.4 to 18.6 ($p < 0.05$) for the control group but did not change for the intervention group. The changes in BMI between groups did not differ significantly.
Conclusion and practice implications: This randomized controlled trial showed that the NASA MX program was feasible and acceptable among children in Taiwan, and improved children's HEAL knowledge.
(ClinicalTrials.gov registration: NCT03355131)

Introduction

Childhood obesity is a major global public health issue (Lobstein et al., 2015; Wang & Lobstein, 2006). The World Health Organization (WHO) considers the prevention of childhood obesity the basic issue of global obesity prevention (WHO, 2015). Like other developed countries, the prevalence of overweight and obesity among elementary school boys increased three-fold from 4.9% in 1993–1996 to 14.7% in 2001–2002, and that among girls increased from 6.9% to 9.1% in Taiwan (Pan, Lee, Chuang, Lin, & Fu, 2008). In addition, Taiwan has higher prevalence of childhood obesity in rural areas than that in urban areas, which is similar to the findings in other countries (Davis, Bennett, Befort, & Nollen, 2011; Johnson 3rd & Johnson, 2015; Li, Xue, Wen, Wang, & Wang, 2017; Liou, Yang, Wang, & Huang, 2015; Lutfiyya, Lipsky, Wisdom-Behounek, & Inpanbutr-Martinkus, 2007). These statistics demonstrate the value of effective approaches to preventing and controlling the higher prevalence of childhood obesity in rural areas.

Most children spend a large part of daytime in school, learning and developing healthy behaviors. Children's healthy behaviors have been associated with the school environment, including the availability of water fountain, time and facilities for physical activities, and social norms toward healthy behaviors (Chen & Wang, 2013; Chen, Xue, Kumanyika, & Wang, 2017; Haddad, Ullah, Bell, Leslie, & Magarey, 2017; Heelan, Bartee, Nihiser, & Sherry, 2015; Ip et al., 2017; Jia et al., 2017; Smit, de Leeuw, Bevelander, Burk, & Buijzen, 2016; Wang, Xue, Chen, & Igusa, 2014). Therefore, school-based intervention for obesity prevention has been a public health focus worldwide. The literature regarding school-based interventions on childhood obesity shows moderately strong evidence of benefits (Wang et al., 2015).

School nurses play pivotal roles in school health promotion and disease prevention. Literature has shown that school nurses are interested in and support obesity prevention in school settings (Kubik, Story, & Davey, 2007). There are successes in school nurse-led interventions for obese adolescents' weight management (Pbert et al., 2013). However, for school-wide obesity prevention, in practice, school nurses would face barriers to conduct obesity prevention programs, including

* Corresponding author at: Assistant professor of Department of Nursing, Mackay Medical College, No.46, Sec. 3, Zhongzheng Rd., Sanzhi Dist., New Taipei City 252, Taiwan.
E-mail address: hyyang@mmc.edu.tw (H.-Y. Yang).

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time constraints, limited staffing and resources (Quelly, 2014). A handy toolkit for promoting healthy eating and active living (HEAL) would be essential for successful obesity prevention in school. Most importantly, fun and engaging activities is critical to interest children to continually practice HEAL (Council on Sports Medicine and Fitness and Council on School Health., 2006).

The Mission X (MX) Train Like an Astronaut Challenge is an international fitness challenge, which was developed in 2011 by the National Aeronautics and Space Administration (NASA). MX aims to improve children's fitness and nutrition by encouraging children around the world to "train like an astronaut" and by letting children know how and why astronauts implement their healthy lifestyle (Lloyd, 2012). The images of astronauts in space would stimulate children's curiosity and motivate children's HEAL practices. In addition, MX provides curricular materials that are accessible online and in 19 languages for children aged 8–12 years old. These course activities were designed to incorporate the context of astronauts living in microgravity, and the materials can be easily applied for school health promotion programs and incorporated into existing math, science, reading classes. Currently, participants from 38 countries, with 104,709 participants and 1641 teams (National Aeronautics and Space Administration have been recruited into the MX program (NASA, 2017)). Nevertheless, rare evidence has shown the program's impact on children's health status.

Recently published research reported the feasibility of the MX programs in the US and South Korea (Lim et al., 2016; Min et al., 2018b). However, in these two intervention studies, there was no control group to compare with the children who participated in the program, and they did not collect children's changes in weight and height either. To provide evidence of the effect of the MX program, the present study aimed to adapt the MX program in Taiwan, particularly in children of rural areas, and to test its effect on children's body mass index, healthy diet and physical activity using a clustered-randomized controlled trial.

Methods

Study design

This study was a cluster randomized control trial and school was the unit of randomization. While the 8-week MX program was delivered in the intervention group, the control group did not receive any intervention. We proposed to the control group having the same program after the intervention group completed the intervention (Fig. 1). The entire intervention took place in the fall semester of 2016 school year. The current study compared the outcome measures before and after the intervention program between the intervention and control groups in order to examine the effect of the intervention.

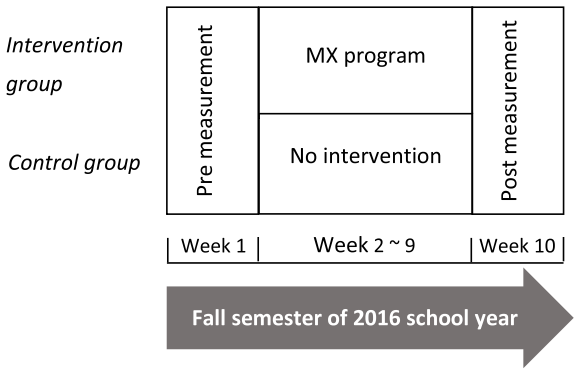

Fig. 1. The timeframe of the clustered randomized control trial.

Study subjects

The 13 public elementary schools in Tamsui, Sanzhi and Shimen Districts, New Taipei City, Taiwan, composed the target population. Schools that were within 30 min distance by car from Mackay Medical College were approached. Eight of the schools agreed to participate and were randomized into intervention and control (4 schools in each arm), using a blocked and stratified randomization procedure. All the 3rd and 4th graders of the participating schools were invited to the study, and written informed consent from the children and the children's guardians was obtained. In total, 201 children (92 in the intervention group and 109 in the control group) were enrolled (Fig. 2). The study was reviewed by the McKay Internal Review Board. (ClinicalTrials.gov registration: NCT03355131).

Intervention

The MX: Train Like an Astronaut Program consists of 24 challenges for children aged 8–12 of years, which are available on http://trainlikeanastronaut.org/. For the present study, eight challenges were selected for the intervention (Appendix 1) according to the schools' capacity and resources to implement the program. These challenges were arranged to be delivered in 8 sessions. Four sessions aimed to train students with exercises like crab walk, bear crawl, squat, pushup, rope-jumping, and running across cones. Two other sessions aimed to improve students' water drinking in school, and their knowledge of food groups and balanced diet. The two other sessions were circuit trainings.

The 8 sessions were delivered in a 40-min class every week for eight consecutive weeks by the research group. Before each session, we introduced astronauts' activities in space in order to associate the curriculum with the context of living and working in space station. The sessions were operated by the researchers to assure the consistency. In addition to the 8-week education, a 1000 c.c. water bottle and a "space log" were distributed to motivate the children to keep training and recording their physical activities and diet at school and at home.

Outcome measurements

Outcomes of interest were measured for both groups before and after the intervention group received the 8-week MX program. The questions were developed and expanded from the MX's routine questionnaire. The questions were translated into Chinese for children's comprehension. A pilot survey in another school showed that elementary school students' were able to comprehend the questions and to self-administer the questionnaire.

Children's interest in the intervention

MX was created to interest children in HEAL by associating with the image of astronauts living in space. Therefore, the influence of MX should be mediated by children's interests and curiosity of space. Children's interests in NASA and space exploration were assessed by two questions that have been listed in MX routine questionnaire, *"Are you interested in exploring space?"* and *"Are you interested in getting to know what exactly NASA is doing?"* The answer *"yes"* got one point while *"no"* and *"I don't know"* or *"I have no idea what NASA is doing"* was recorded as zero. Children's satisfaction with the MX program was measured as well. Further, the children rated their satisfaction on the eight sessions based on a 5-point Likert scale. Form teachers and/or physical education teachers were invited to evaluate the sessions in terms of the appropriateness of the program content, the program's relevance to space exploration, and their willingness to apply the program in their class, after the teachers observed the program sessions.

Knowledge and HEAL behaviors

The MX routine questionnaire included questions related to HEAL behaviors. These questions were kept in this study. In addition, we

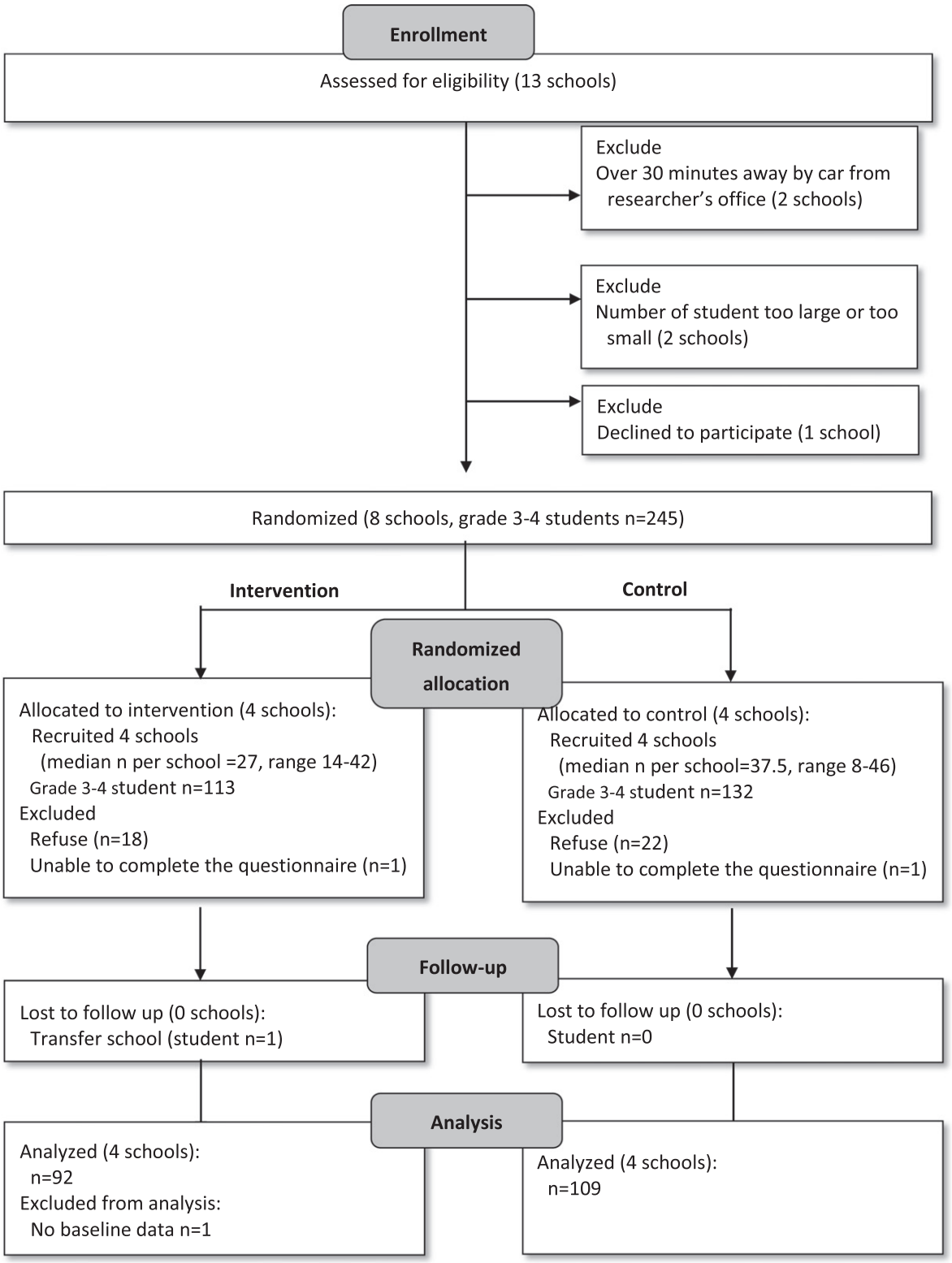

Fig. 2. The flow chart of schools and participants, with school as cluster unit.

expanded the questionnaire to assess children's HEAL knowledge and HEAL behaviors via a self-administered questionnaire.

Physical activity knowledge was assessed using six multiple-choice questions. The answers to these knowledge questions were coded as correct/incorrect. Every correct answer to a question was worth one point. Hence, the total score for physical activity knowledge ranged from 0 to 6, with higher scores indicating better physical activity knowledge. Healthy diet knowledge was assessed by eight multiple-choice questions that tested children's knowledge of food groups; the total score ranged from 0 to 8, with higher scores indicating better healthy diet knowledge.

The children's HEAL behaviors in the week preceding the interview were assessed via self-administered questionnaire as well. Physical activities were assessed by 5 items: 1) *"Do you take part in physical*

activities (e.g. exercise, playing on the playground, extracurricular activities)? Never, several times a month, 1-2 times/week, 3-5 times/week, every day (1-5 points)"; 2) "How many days a week do you work out to the point that includes heavy breathing, sweat, and a 20-minute long heart rate increase? None, 1-2 days/week, 3-4 days/week, 5-7 days/week (1-4 points)"; 3) "How many days a week do you train or work out with your family? None, 1-4 days/week, 4-7 days/week (1-3 points)"; 4) "How much time do you spend watching TV on school days? None, 1 hour/day, 2 hours/day, 3-4 hours/day, >4 hours/day (1-5 points)"; and 5) "On school days, how much time do you spend playing video games, computer games, or doing something unrelated to homework on your computer (e.g. Xbox, PlayStation, smart phone, iPad, YouTube, Facebook, and surfing the internet)? None, 1 hour/day, 2 hours/day, 3-4 hours/day, >4 hours/day (1-5 points)". The total score ranged from 5 to 22. Dietary behaviors were assessed by the frequency of eating the food groups in the past 7 days (i.e. *"In the past 7 days, how many times did you drink soda, sport's drink, or anything besides water or milk?", "have green vegetables?", "other vegetables?", "eat fruits?", "go to a fast-food restaurant?", "eat breakfast?", "drink milk or goat milk?", "drink from the drinking fountain?" and "drink water before exercising?"*) The higher score meant more frequent healthy dietary practices and unhealthy ones were reversely coded (fast food restaurants and sport drinks). The total score ranged from 9 to 44.

Anthropometric measures

School nurses in every school measured children's height and weight in school health centers at baseline and in the 9th week. Body mass index (BMI) was calculated based on their weight and height. Children's weight statuses were divided into four groups as healthy weight, overweight, obesity and thinness, based on the International Obesity Task Force (IOTF) cut-offs (World Obesity Federation., 2012). In addition, sex- and age-specific height-for-age Z score and BMI-for-age Z score were derived based on the US Centers for Disease Control and Prevention (CDC) Growth Charts (CDC National Center for Health Statistics, 2009).

Statistical analysis

All statistical analyses were performed using SAS/STAT® software ver. 9.4, and we set the significance level of 0.05. Descriptive analysis examined whether baseline differences existed between the intervention and control groups, using *t*-test for continuous variables and Chi-square tests for categorical variables. Next, the effects of the intervention were tested by the mixed-effect modeling, using intention-to-treat analysis. The mixed models dealt with the intra-individual clustering of repeated measurements, and the inter-individual clustering of school. The mixed-effect model equation could be expressed as: $Y_{jit} = \beta_0 + \beta_1 intervention + \beta_2 time + \beta_3 intervention * time + u_j + u_{ji}$, where u_i and u_{ji} were random effect terms at school and children levels to control for clustering among the observations. The term of intervention*time (intervention: intervention vs. control group; time: post-test vs. pre-test) tested the significance of the difference in outcome changes between intervention and control groups. Significant interaction term suggested significant effect of MX on the outcome.

Because baseline weight status differed between the intervention and control group, we conducted sensitivity analysis that adjusted for baseline BMI value. In addition, the moderation effect of children's baseline interest in space exploration on the intervention effects was also tested.

Results

Baseline characteristics of participants

The age (mean ± SD) was 8.99 ± 0.56 years for the intervention group and 9.12 ± 0.57 years for the control group. 57.6% (n = 53) boys in the intervention group and 51.4% (n = 56) in the control group. The proportion of 3rd graders was higher in the intervention group than in the control group. Regarding anthropometry, the mean body weight (35.68 ± 10.81 kg), height z-score (0.11 ± 1.02), and BMI (19.51 ± 4.37 kg/m^2) for the intervention group were significantly higher than that for the control group (weight: 32.83 ± 8.15 kg, height z-score: −0.20 ± 0.95, BMI: 18.41 ± 3.34 kg/m^2). About half of students in the intervention group and a third of students in the control group were overweight or obese (Table 1).

Effect of intervention: healthy eating (Table 2)

The nutrition knowledge score increased from 6.42 to 7.04 for the intervention group, and from 6.41 to 6.58 for the control group. Compared to the control group, the intervention group had significant increases in the healthy diet knowledge score (+0.62 vs. +0.17, $p = 0.044$). However, there was no significant effect on children's healthy eating behaviors.

Effect of intervention: active lifestyle (Table 2)

The active lifestyle knowledge score increased from 2.72 to 3.63 for the intervention group, and from 2.56 to 2.81 in the control group. Compared to the control group, the intervention group had significant increases in the active lifestyle knowledge score (+0.91 vs. +0.25, $p = 0.002$). Active lifestyle behaviors increased in both intervention and control groups, but the difference between two groups was not statistically significant.

Effect of intervention: anthropometry (Table 2)

The intervention did not show significant beneficial effects on the body weight outcomes. Mean BMI-for-age Z score did not change pre- and post-intervention in the intervention group (from 0.72 to 0.71), but increased in the control group (from 0.54 to 0.60). The prevalence of overweight and obesity decreased from 52% to 49% in the intervention group, but increased slightly from 34% to 35% in the control group. We further examined the intervention effect on BMI-for-age Z score by children's baseline weight status, but there were no significant findings.

Children's interests in MX program

In the intervention group, the prevalence of participants answering positively to the question "*Are you interested in exploring space?*" increased from 54% at baseline to 64% after the 8-week intervention. The prevalence of positive answer to the question "*Are you interested*

Table 1
Baseline characteristics of students enrolled in the study (n = 201).

Characteristics	Intervention group (n = 92)		Control group (n = 109)		
	Mean	(SD)	Mean	(SD)	
Age (years)	8.99	(0.56)	9.12	(0.57)	
Weight (kg)	35.68	(10.81)	32.83	(8.15)	*
Height (cm)	134.19	(7.14)	132.86	(6.76)	
Height Z-score	0.11	(1.02)	−0.20	(0.95)	*
BMI (kg/m^2)	19.51	(4.37)	18.41	(3.34)	*
BMI Z-score	0.72	(1.39)	0.54	(1.09)	
	n	(%)	*n*	(%)	
Gender					
Male	53	(57.6)	56	(51.4)	
Female	39	(42.4)	53	(48.6)	
Grade					
3rd	51	(55.4)	53	(48.6)	
4th	41	(44.6)	56	(51.4)	
Prevalence (%) of overweight/obesity-IOTF[a]	48	(52.2)	37	(33.9)	**

[a] IOTF = International Obesity Task Force.
* p < 0.05, testing for difference between two groups (*t*-test).
** p < 0.01, testing for difference between two groups (*t*-test).

Table 2
Intervention effects on physical activity, healthy eating, and anthropometry: comparison between intervention and control groups.

	Intervention group, *n*, *mean* (*SD*)							Control group, *n*, *mean* (*SD*)							Testing for	
	Pre (n = 92)			Post (n = 90)			Test for change[c]	Pre (n = 109)			Post (n = 107)			Test for change[c]	Baseline difference[a]	Effect[b]
	n	mean	(SD)	n	mean	(SD)		n	mean	(SD)	n	mean	(SD)		*	
Anthropometry																
Weight (kg)	92	35.68	(10.82)	90	36.50	(11.08)	***	109	32.83	(8.15)	107	33.91	(8.15)	***	*	
Height (cm)	92	134.19	(7.14)	90	135.55	(7.31)	***	109	132.86	(6.76)	107	134.29	(6.69)	***		
Height Z-Score	92	0.11	(0.11)	90	0.18	(1.04)	***	109	−0.20	(0.95)	107	−0.09	(0.96)	***	*	
BMI (kg/m^2)	92	19.51	(4.37)	90	19.54	(4.32)		109	18.41	(3.34)	107	18.62	(3.26)	*	*	
BMI Z-score	92	0.72	(1.39)	90	0.71	(1.31)		109	0.54	(1.09)	107	0.60	(1.04)			
Physical activity																
Physical activity knowledge score (Range:0–6)	92	2.72	(1.22)	90	3.63	(1.64)	***	109	2.56	(1.13)	107	2.81	(1.21)	*		**
Physical activity behaviors score (Range:5–22)	92	16.54	(3.21)	90	16.90	(3.14)		109	15.87	(3.27)	107	16.62	(3.72)	*		
Healthy eating																
Healthy diet knowledge score (Range:0–8)	90	6.42	(1.69)	90	7.04	(1.28)	**	109	6.41	(1.63)	107	6.58	(1.55)			*
Healthy diet behaviors score (Range:9–44)	92	28.12	(4.96)	90	30.77	(5.63)	***	109	28.81	(4.40)	107	31.13	(5.30)	***		
Interests in NASA and space exploration (Range:0–2)	91	0.84	(0.81)	89	1.18	(0.87)	**	108	0.97	(0.79)	106	0.90	(0.87)			***

[a] Testing for baseline differences between intervention and control groups. Comparing the baseline outcomes between the intervention group and the control group by *t*-test.
[b] Testing for the effect of intervention, comparing the pre-post change between two groups by mixed effect model.
[c] Testing for change of the outcome variables in each group by paired *t*-test.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.0001$.

in getting to know what exactly NASA is doing?" also increased from 29% to 53%. At the end of the intervention, 90% of students were happy participating in MX program. Students evaluated the eight sessions at the end of the program. Testing for the interaction between children's baseline interest in space exploration and the intervention effect showed no significant results, suggesting children's interest in the space topic did not moderate the effect of HEAL knowledge and behaviors and weight status.

Discussion

This study evaluated the effects of an 8-week school-based intervention program that aims to promote healthy weight and healthy lifestyle of Taiwanese children. The results showed that HEAL knowledge was significantly improved more in the intervention group compared to those in the control group. The changes of anthropometric variables were not significantly different between the two groups, however.

The present study showed the success of MX in promoting children's health knowledge. This is similar to many other intervention studies. Previous studies found that 6 weeks of MX training improved Korean preschoolers' nutrition knowledge (Lim et al., 2016) and physical activity level (Min et al., 2018a). Another pre-post comparison on US children ages of 6–13 years showed increments in physical activity and nutrition knowledge as well (Min et al., 2018b). Our controlled intervention provides further evidence of the effect of the MX program on children's HEAL knowledge. Our study suggests that children's physical activity knowledge score can be significantly improved in 8 weeks by 33.5% and healthy diet knowledge score improved by 10.0%.

With regard to the practices of HEAL, the healthy eating score improved significantly in the intervention group, similar with what was observed in other studies applying MX. In the US, children's physical activity and healthy diet scores were improved after a 6-week program (Min et al., 2018b). The Korean study found that preschoolers' vitamin B1 intake decreased while folate intake increased after the program completed (Lim et al., 2016). However, the present study suggested that the healthy eating score improved in the control group as well. After comparing to the control group, the intervention group's behavioral improvement was not able to attributable to the intervention.

In addition, the previous two studies in South Korea and the US did not evaluate the impact of the MX program on body weight outcomes (Lim et al., 2016; Min et al., 2018b). The present study measured the students' weight and height, but did not detect significant beneficial effects of the 8-week MX program on BMI and overweight/obesity rate. This is likely due to the short intervention duration and modest sample size. Nevertheless, some other school-based interventions showed significant effects on children's weight status; and they can lead to improvement in blood pressure and blood lipid profile even if some of the interventions could not prevent obesity (Cai et al., 2014; Cai, Wu, Cheskin, Wilson, & Wang, 2014; Wang et al., 2015). Unfortunately, the present study did not measure health outcomes other than weight and height. Future inquiries need to take measures on other health parameters.

Despite the non-significant findings on HEAL behaviors, children who participated in the intervention had increased interests in the program. It has been advocated that obesity prevention strategies should be "attractive, exciting, and enjoyable" so to encourage children to improve their active lifestyles (Council on Sports Medicine and Fitness and Council on School Health., 2006, p.1839). Examples include obesity prevention via extracurricular activities (Branscum & Sharma, 2012) and games (McGaffey, Abatemarco, Jewell, Fidler, & Hughes, 2011). The MX program increases children's interest in participation by driving their curiosity and excitement with space exploration. After completing the program, the intervention group had improved interest in NASA and space exploration. It was observed that children identified with and were able to associate themselves with the mascot Astro Charlie. Meanwhile, they were satisfied with the activities introduced in the program. These suggested that the novel program was engaging for children in rural schools in Taiwan.

There are several strengths in this study. First, this is a randomized controlled intervention, and the effect of intervention can be revealed. This is also the first study testing the effect of the MX program on children's HEAL knowledge, behaviors and growth outcomes with a randomized control group for comparison (Lim et al., 2016; Min et al., 2018b). Second, the school-based randomization of the intervention can minimize the issue of contamination of the intervention across two groups. Third, at the end of the intervention, most of the children

had positive satisfaction with the sessions, and teachers evaluated the sessions positively. Finally, after the intervention phase was completed, we provided the MX program to the control group. This could prevent the ethical issue that children in the control group did not receive the program that was supposed to be beneficial. Moreover, this design could minimize the control group's attempt to do similar interventions on their own since they could expect to receive the same intervention later on. Fourth, lost to follow-up rate was small.

Despite of the strengths, this study has several limitations. First, the intervention was not blinded. Nonetheless, as the schools in the control group expected to receive the intervention later, they would be less likely to execute the program on their own while waiting for their intervention. Therefore, the concern of drop-in could be slightly eliminated. Second, the small number of schools for randomization could cause imbalanced distribution of basic characteristics, including sex, age, and BMI, between the intervention group and the control group. Future study based on a larger number of schools could minimize this issue. Third, the questions for HEAL knowledge and behaviors were not validated, although they were adapted from the MX routine questionnaire. Before applying the questionnaire, we conducted a pilot survey to test elementary school students' ability to understand and to complete the questionnaire. Fourth, refusal rate was 16.3%, and the sample may not be representative of the population. Fifth, the intervention period was relatively short. Thus, the changes in anthropometric variables did not differ between intervention and control groups. However, the 8-week period may be effective to improve children's HEAL knowledge. To achieve significant effects on health outcomes, a longer term of intervention may be needed. Sixth, the delivery of the program was conducted by the research team in this study. Therefore, the impact of MX in Taiwan when it will be delivered by school staff and faculty is unknown and needs future exploration. Lastly, the school nurses did not receive standardized training for the height and weight measurements taken for this study, but they were registered nurses who were experienced in measuring children's height and weight regularly. Nonetheless, there could have been variations in the height and weight measurements across the schools because of the different instruments used by the schools. We applied mixed effect models to adjust for the systematic variations between the schools. However, any measurement errors could have underestimated the association between the intervention and the anthropometric outcomes.

Practice implications

This study showed that as few as 8 weeks of the MX program could improve the HEAL knowledge of Taiwanese children in rural schools. The images associated with space exploration would encourage the children to participate in the MX activities. For school nurses who may have limited resources for health promotion programs in schools, the free online MX materials are useful for engaging children and teaching them how to achieve healthy eating and active lifestyles.

Conclusions

In conclusion, our study demonstrated the beneficial effect of the adapted MX program in improving children's knowledge of healthy eating and active living in rural schools in Taiwan. The present study also demonstrated the feasibility and acceptability in Taiwan children population. MX website provides materials in different languages, which are convenient tools for school teachers and staff to apply for HEAL promotion. Future research may prolong the intervention period and increase sample size to reach the aims of health outcomes improvements.

Credit taxonomy

Yu-Chun Lin: Investigation; Formal analysis; Writing - Original draft writing. **Hsin-Jen Chen:** Conceptualization; Data curation; Methodology; Investigation ; Formal analysis; Writing - review & editing. **Youfa Wang:** Resources; Conceptualization; Methodology; Writing - review & editing. **Jungwon Min:** Writing - review & editing. **Hui-Chao Wu:** Investigation; Project administration. **Nubia Carvaljal:** Resources; Writing - review & editing. **Hsing-Yu Yang:** Conceptualization; Data curation; Methodology; Funding acquisition; Investigation; Resources; Writing - review & editing.

Declaration of Competing Interest

The authors declare no conflicts of interest.

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Author contribution: The authors contributed to the study and manuscript preparation: Study design (HYY, HJC), adaptation of MX materials (HYY, HJC, and HCW), participant recruitment and data collection (HHY, HCW, YCL), implementation of intervention (HHY, HCW, YCL, HJC), data analysis and drafting the manuscript (YCL, HJC, HHY, YW), and the international coordination (YW, JM, NC). All the authors participated in manuscript preparation and approved the final version.

Appendix 1. Mission X program selected for the intervention[a]

Session	Theme	Activities	Goals
1	Hydration station	Learning how to tell one's hydration level by spotting the colors of simulated urine	Students understand the importance of hydration, and the signs of dehydration
2	Crew strength training	Doing body weight squats and push-ups correctly	Students know the importance of muscle strength and how to perform the moves correctly
3	Do a spacewalk!	Competition of bear crawl and crab walk	Students know the importance of muscle strength and coordination, and how to improve them
4	Energy of an astronaut	Learning the food groups of Taiwan Health Promotion Administration's Daily Dietary Guideline	Students can correctly categorize foods into food groups
5	Building an astronaut core	Doing crunch and plank correctly	Students understand the importance of core muscles and can train them correctly
6	Jump for the moon and Agility astro-course	Rope-jumping and running for a predetermined distance	Students understand the importance of bone strength, muscle endurance, agility, coordination, and speed in space.
7	Shipping foods to the space	Team competition: By running between two points, student takes a food card at one point (the Earth), runs to the other point (the space station)	Students correctly categorize foods into food groups, and move in speed to complete the task in team work. Students are reminded the

(continued on next page)

(*continued*)

Session	Theme	Activities	Goals
		where the student puts the food cards in the correct food group.	importance of keeping hydrated.
8	Base station walk-back and circuit training	Individual competition: Running around playground and doing the exercises that were introduced in the previous sessions.	Students pass the endurance competition successfully and have fun.

[a] The intervention program was implemented for 8 weeks in the 1st semester of 2016 school year, and each session was offered in 30 to 40 min.

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