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An evaluation of the effectiveness of the National Aeronautics and Space Administration (NASA) Mission-X child health promotion program in the United States

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Abstract

Purpose: To examine the effects of the National Aeronautics and Space Administration Mission-X: Train Like an Astronaut program (MX) on children's the health-related knowledge and behaviors of a sample of United States participants.

Design: A nonexperimental pilot intervention study in five cities with a pre-post comparison of children's health-related knowledge and behaviors in the U.S in 2014 and 2015.

Sample: Children (n=409) with mean age (SD) 10.1 (1.7).

Measures: Children answered pre- and post-intervention questionnaires. We measured the differences in children's health knowledge on nutrition and physical fitness and behaviors on diet and physical activity as scores.

Intervention: A 6-week web- and school-based intervention for a healthier lifestyle by introducing physical fitness and science activities based on actual astronaut training under a teacher's supervision.

Analysis: Non-parametric analysis and logistic regression models.

Results: Participants significantly improved both of their health behaviors on physical activity ($p<.001$) and diet ($p=0.06$) and their health knowledge regarding nutrition ($p<.001$) and physical fitness ($p<.001$) after the intervention. The improvement of children's behaviors ($p<.001$),

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Conflict of interest

No conflict of interest was declared.

knowledge ($p<.001$) and the total score ($p<.001$) after intervention did not significantly vary by sex or age, after adjusting for year of participation and state of residency.

Discussion: The MX seems effective in improving health behaviors and health knowledge of participating children, which may serve as a model for sustainable global child health promotion program. Further research is needed to test its long-term effects on child health.

Keywords

intervention; childhood obesity; physical activity; nutrition; knowledge

Purpose

The World Health Organization recently has called on nations to take actions to fight the childhood obesity epidemic¹. Although the causes of childhood obesity are complex, dietary habits and physical activity (PA) level directly related to energy intake and expenditure are crucial factors to examine^{2,3}. In addition, children's lack of health knowledge may hinder their attempts to change their lifestyles, despite their awareness of their obesity problem⁴.

Although some of the school-based childhood obesity intervention studies have resulted in moderate improvements in children's weight status^{5,6}, education programs for children are faced with challenges to apply interactive communication techniques to maintain children's interests and challenges in healthy lifestyle⁴.

Recognizing the significant health risks arising from childhood obesity, the National Aeronautics and Space Administration (NASA) established the Mission-X: Train Like an Astronaut (MX) program, aiming to promote healthy and active lifestyles among all children, beginning at an early age^{7, 8} based on the astronauts' real-life training to prepare for exploring space. The present study examined the effects of the combined web- and school-based MX program on US children's health knowledge and health behaviors, based on pooled data collected in 2014 and 2015.

Methods

Design

Considering the strong correlations between unhealthy childhood diet, poor adolescent fitness and the onset of chronic disease during adulthood and the knowledge gap in the field regarding programs to address the related problems, the NASA Human Research Program Education and Outreach Project developed the MX child health promotion program in 2009 to encourage proper exercise and nutrition at an early age by teaching young people to live healthy as space explorers do⁷. Since 2011, the program has targeted elementary school aged children and has successfully expanded to cover a wider age range and covered the US and other 30 countries in 2015⁸. In 2017, the program has reached 38 countries across several continents.

The NASA team introduced MX program via educator presentations at conferences and outreach events in Texas and nearby states and the 'Shape America' newsletters, which were

distributed all across the US. Also detailed information of the MX program was announced over social media. After partnering sites indicated their interests by e-mail or phone call to the MX team, the MX coordinators contacted them and arranged for Skype sessions to answer their questions and for training. Once schools and teachers agreed to and approved participation, children were able to join the MX 6-week program, represented as Team USA from January to March. The program was facilitated under a teacher's supervision as part of the standard physical education class offered by the school cooperation.

Sample

In total, 418 children completed the pre- and post-survey questionnaires in 2014 (n=233) and 2015 (n=185) from 5 sites (Stanfield, AZ; St. Louis & Urbana, MO; Plant City, FL; and Houston, TX), respectively in the US. The present analysis was based on data from 409 children after excluding nine students' 2015 data who also had 2014 data, which were used.

This study was approved by the Institutional Review Boards of NASA (No. Protocol 0283). All participants had a signed informed consent from their parents or guardians and all personally identifiable information was removed for data analysis.

Intervention

The MX program aims to increase and promote opportunities for children to become more physically and mentally active⁷ with the excitement of space exploration and astronaut training. This is achieved by demonstrating the value of PA and nutrition needed by astronauts to train for and execute space flight missions. In 2014 and 2015, MX included 18 modules which aimed to improve childhood fitness regarding muscle strength, coordination, cardiovascular and muscular endurance, agility, speed, understanding specific nutritional needs, formulating balanced meal, etc. (see more details in MX homepage: www.trainlikeanastronaut.org). The modules were developed collaboratively with the European Space Agency (ESA), scientists, and fitness professionals who work directly with astronauts⁸. Each activity was completed in about 30–50 minutes per class time, and the participants could repeat the activities with the teacher two times or more within a week. Student and teacher handouts, related instructional videos and other educational guide materials were provided via the MX website. Teachers could select specific modules and customize the materials to fit the specific needs of participating students representing diverse geographic areas.

MX promoted individual personal improvement while also developing team-building collaborative work to ensure successful completion of the goal of Astro Charlie's walk to the moon. This was achieved through reporting their points on a periodic basis and posting to the blog site.

Measures

Changes in students' self-reported obesity-related behaviors and health knowledge were assessed by pre- and post-intervention questionnaires under their teachers' guidance in the classroom. The teachers first explained to the children that the NASA MX survey was neither a test nor would it affect their grades and administered the survey. Pre-intervention

data were collected at least one month before implementing the MX project and post-intervention data were collected within two months following participation.

This survey was designed with experienced primary school educators to investigate grade 3–5 children's 1) demographic characteristics, 2) health knowledge on nutrition and physical fitness, which could be learned from the MX activities, and 3) health behaviors (see Appendix 1).

Sub-total scores were computed for health behaviors (range: 7 to 34) and knowledge (range: 0 to 9) and summed as the total score (range: 7 to 43). Higher scores indicated preferable health behaviors or better health knowledge.

Analysis

First, we compared the pre- and post- intervention scores using the Wilcoxon signed rank test due to the non-normal distributions of scores and examined differences in health behaviors and knowledge as a function of gender and age by Mann-Whitney U tests.

Then we investigated the effects of age and gender on the odds of improvement in health behaviors and health knowledge from the MX intervention program using multivariate logistic regression models, after adjusting for year of participation and state of residency. Individual improvement in health behaviors and health knowledge subscores and total scores following intervention was defined as the sum of differences between post- and pre-scores > 0 . No difference or negative results between pre- and post-scores were defined as 'not improved' after MX program. All analyses were conducted using SAS 9.3 (SAS Institute, Cary, NC).

Results

Among the 409 participants, 47.7% were boys; their age ranged from 6 to 13 years, the average age was 10.1 (standard deviation: 1.7) years. Participants were from the states of Florida (40.4%), Missouri (33.0%), Texas (21.0%) and Arizona (5.6%; see Supplemental Table 1).

As shown in Table 1, student's health behaviors (mean (standard error): post- 25.3 (0.2) vs. pre- 24.3 (0.2), $p<0.001$), health knowledge (4.4 (0.1) vs. 3.5 (0.1), $p<0.001$) and total scores (29.8 (0.3) vs. 27.8 (0.2), $p<0.001$) significantly improved after participating in the 6-week MX program. In particular, children's knowledge of physical fitness (3.6 (0.1) vs. 2.9 (0.1), $p<0.001$) and nutrition (0.9 (0.0) vs. 0.6 (0.0), $p<0.001$) as well as their behavioral change on PA (7.3 (0.1) vs. 6.7 (0.1), $p<0.001$) increased. The change in children's dietary habits from pre- to post-intervention was marginally significant (18.0 (0.2) vs. 17.6 (0.2), $p=0.06$).

Stratification analysis on score changes between pre- and post- intervention by participant's demographic characteristics showed that all of the boys, girls, children aged 6 to 9, and children aged 10 to 13 showed significant increases in health behaviors (average score changes= 0.99) and health knowledge (0.93), as well as total score after intervention (2.02, $p<0.01$). The amount of change on sub-scores of children's health behaviors, health knowledge, and total scores did not significantly vary by child gender or age (younger vs.

older) (Figure 1). However dietary habits were not significantly improved for either boys ($p=0.15$), girls ($p=0.24$), younger ($p=0.27$) or older children ($p=0.14$). In addition, older children demonstrated greater improvements in health behavior scores on PA than did younger children (pre- and post- intervention difference: 0.82 vs. 0.46, $p=0.04$).

More than half of the participants showed improvements in subtotal scores of health behaviors (55.9%), health knowledge (56.0%), and total scores (68.3%) after intervention, based on our definition of improvement (sum of differences between the pre- and post-scores > 0 ; 25.4% children showed no change in health knowledge). However, neither children's gender nor age were significantly associated with the odds of improvement in health behaviors (boy vs. girl: OR(95% CI)=0.98 (0.63–1.50); > 9 years vs. ≤ 9 years: 0.87 (0.51–1.49), health knowledge (boy vs. girl: 1.20 (0.81–1.80); > 9 years vs. ≤ 9 years: 1.25 (0.77–2.01) and overall change (boy vs. girl: 1.17 (0.74–1.86); > 9 years vs. ≤ 9 years: 1.48 (0.83–2.66), based on logistic regression analyses adjusting for year of participation and state of residency.

Discussion

Although we recognized the global epidemic trend of childhood obesity^{1,2}, children in the US are still reported to have adverse dietary habits^{9–11} and a lack of PA¹². This study demonstrates the effectiveness of the NASA MX program on children's obesity-related health behaviors and health knowledge among US participants. Our results indicated significant increases in children's PA and health knowledge regarding physical fitness and nutrition respectively, in both gender and age groups, following program participation.

Educational interventions could be a key strategy in the health promotion of children, since children's lack of knowledge about nutrition and physical fitness may be hindering their attempts to change their health behaviors⁴. Review papers supported the evidence that education interventions enhanced children's knowledge, dietary behaviors and PA (e.g., choosing healthful snacks and reduce sedentary time)^{5,6,13–16} after participating the programs. However, education programs for children had challenges for having interactive communication techniques for children to maintain their interest in a healthy lifestyle⁴. Programs directed towards promotion of childhood health need to be interesting and engaging to their participants.

MX uses a fitness challenge format and provides inspiration through human space exploration to promote improvement in daily PA and making nutritional food choices⁷. The space flight connection is believed to add interest to encourage participation in the challenge format to improve health¹⁷. Children train to be healthy by participating in the same activities as astronauts use to prepare for their missions. The project 'Astro Charlie' is dependent upon multisite involvement to obtain a sufficient number of points to achieve the goal of walking to the moon, so additional teamwork and group effort is encouraged in the MX activities. Through MX website activities and blogs, participants communicate with others in different regions and with astronauts, which may strongly promote participants' self-motivation⁸.

We found marginally significant improvement in children's dietary habits following MX program participation. One possible explanation for this finding is that the 6-week intervention program might not be long enough to make significant children's dietary habit changes, although it did appear long enough to improve children's health knowledge on nutrition and physical fitness and PA behaviors.

This study has several limitations, including using self-reported data, no anthropometric measurements, and the lack of a control group. The NASA MX program has faced challenges to involve more children, mainly due to the lack of interest and manpower from schools to participate. This is the first program in the US that has applied space exploration-related physical challenges as the main theme of a child health promotion program, interactive web-based communication techniques with other participants in different locations, real astronauts, and real-time animated feedback based on participant data. These components were included to promote children's self-motivation for adopting a healthy lifestyle and ultimately prevent obesity. The present study is the first to examine the effectiveness of the MX program in the US.

In conclusion, the NASA Mission-X program was shown to improve children's health knowledge and physical activity in the US. Further research is needed to test its long-term effects on child BMI and other health outcomes and to assess its efficacy by ethnicity, socio-economic status and child's weight status. The NASA MX may serve as a model of sustainable global child health promotion programs.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Appendix 1. Pre- and post- survey questionnaires of 2014–2015 NASA Mission-X program and scoring matrix

1. I participate in physical activity such as sports, playing in the playground, and exercise out of school.
 - a. Never
 - b. Sometimes in a month
 - c. Once or two times per week
 - d. Three to five times per week
 - e. Every day

2. I eat fruits (for example, oranges, apples, bananas, etc.).
 - a. Never
 - b. Sometimes in a month
 - c. Once or two times per week
 - d. Three to five times per week
 - e. Every day
3. I eat vegetables (for example, spinach, carrots, broccoli, etc.).
 - a. Never
 - b. Sometimes in a month
 - c. Once or two times per week
 - d. Three to five times per week
 - e. Every day
4. I drink sugary drinks (for example, soft drinks, fruit juices, milkshakes, sport drinks etc.).
 - a. Never
 - b. Sometimes in a month
 - c. Once or two times per week
 - d. Three to five times per week
 - e. Every day
5. I have breakfast.
 - a. Never
 - b. Sometimes in a month
 - c. Once or two times per week
 - d. Three to five times per week
 - e. Every day
6. I eat greasy foods (for example, pizzas, sausages, fried foods, etc.).
 - a. Never
 - b. Sometimes in a month
 - c. Once or two times per week
 - d. Three to five times per week
 - e. Every day
7. Every day, I watch TV and/or play on the computer, and/or play videogames.

- a. Less than 1 hour
- b. Between 1–2 hours
- c. Between 3–4 hours
- d. More than 4 hours
8. When astronauts live and work in space, they _____.
- a. lose memory
- b. lose bone mass
- c. lose height
- d. lose lung capacity
- e. I don't know
9. The most important purpose of jump training and exercises that use your own body weight is to strengthen muscles and _____.
- a. brain
- b. coordination
- c. eyes
- d. bones
- e. I don't know
10. Physical activities that best improve my _____ and _____ are endurance exercises such as running, swimming, cycling, playing basketball, etc.
- a. heart and lungs
- b. lungs and kidneys
- c. heart and liver
- d. hair and eyes
- e. I don't know
11. What happens to the heart rate when doing exercises?
- a. stays the same
- b. decreases
- c. jumps a beat
- d. increases
- e. I don't know
12. In order to maintain a correct posture, it is very important to work on strengthening _____ muscles.
- a. arm

- b.** leg
- c.** core
- d.** neck
- e.** I don't know
- 13.** The food we eat converts into energy. Energy from food is measured in _____.
- a.** carbohydrates
- b.** meters
- c.** calories
- d.** nutrition
- e.** I don't know
- 14.** Aerobic exercises use _____ to produce energy.
- a.** blood
- b.** muscles
- c.** proteins
- d.** oxygen
- e.** I don't know
- 15.** Astronauts require assistance from a mechanical vehicle when exploring the surface of planets. In case of a mechanical problem, astronauts must be physically capable of a walk-back to the base-station. For that reason, it is necessary for astronauts to have a good level of _____.
- a.** coordination
- b.** speed
- c.** flexibility
- d.** endurance
- e.** I don't know
- 16.** For healthy and strong bones it is important to take enough _____ from food.
- a.** Calcium and Vitamin D
- b.** Zinc and Vitamin B
- c.** Calcium and Vitamin E
- d.** Iron and Vitamin D
- e.** I don't know

[Scoring matrix]

Scores measuring child behaviors were coded as from one to five according to preferable frequency presented as 5-level Likert scale, while their answers to knowledge related questions were coded as 1 for correct answers and 0 for wrong answers or for “I don’t know”.

*Q4, Q6 and Q7 were reversely coded.

Subtotal of behavior score= sum of seven questions of MX survey Q1~ Q7

Subtotal of behavior score on PA= sum of two questions of MX survey Q1 and Q7

Subtotal of behavior score on dietary habits= sum of five questions of MX survey Q2~ Q6

Subtotal of knowledge score= sum of nine questions of MX survey Q8~ Q16

Subtotal of knowledge score on physical fitness= sum of seven questions of MX survey Q8~ Q12 and Q14~Q15

Subtotal of knowledge score on nutrition= sum of two questions of MX survey Q13 and Q16

Total score= sum of sixteen questions of MX survey Q1~ Q16

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SO WHAT? Implication for health promotion practitioners and researchers**What is already known on this topic?**

Childhood obesity has become an epidemic around world. However, child health education programs are faced with challenges to apply interactive communication techniques to maintain children's interests and challenges in healthy lifestyle.

What does this article add?

As a pilot study, the NASA MX program has applied space exploration-related physical challenges as the main theme of a child health promotion program and a sample of US children in 2014 and 2015 showed significant improvement on children's health knowledge and health behaviors.

What are the implications for health promotion practice or research?

The space exploration theme and related interactive web technology of the NASA MX program can be an effective means of improving children's health knowledge about nutrition and physical fitness, as well as health related behaviors. The school-based and web-interactive NASA MX program may serve as a model for global child health promotion programs.

Figure 1.

Changes in children's behavior and knowledge scores between pre- and post- intervention of the 2014–2015 NASA MX program in the US, by sex and age (n=409)

a) Boys vs. Girls

Wilcoxon signed rank sum test was used to compare the distribution of scores between pre- and post- intervention within same sex group due to the non-normal distributions of scores.

*p<0.01.

There was no sex difference in pre & post changes in Mann-Whitney U test.

b) 6-9 years old vs. 10-13 years old

Wilcoxon signed rank sum test was used to compare the distribution of scores between pre- and post- intervention within same age group due to the non-normal distributions of scores.

*p<0.01.

Mann-Whitney U test was used to find significant difference in pre and post changes between age groups. [†]p<0.05.

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Table 1.

Changes in children's behavior and knowledge scores between pre- and post- intervention of the 2014 – 2015 NASA MX Program in the United States.^{a,b}

	Baseline		Post-intervention		Mean Change	p value ^c
	Mean (SE)		Mean (SE)			
Subtotal of behavior score	24.30	(0.20)	25.29	(0.22)	0.99	<.001
<i>On physical activity</i>	6.67	(0.08)	7.33	(0.10)	0.66	<.001
<i>On dietary habits</i>	17.62	(0.16)	17.95	(0.17)	0.33	0.06
Subtotal of knowledge score	3.51	(0.09)	4.44	(0.11)	0.93	<.001
<i>On physical fitness</i>	2.87	(0.08)	3.59	(0.09)	0.72	<.001
<i>On nutrition</i>	0.64	(0.03)	0.85	(0.04)	0.21	<.001
Total score	27.80	(0.23)	29.82	(0.26)	2.02	<.001

Abbreviations: NASA MX, National Aeronautics and Space Administration Mission-X: Train Like an Astronaut; SE: Standard error.

^an=409.

^bThe Sample sizes were: 2014–2015 (n=409), 2014 (n=233), and 2015 (n=176).

Subtotal of behavior score was defined as sum of seven questions of MX survey for children's behaviors (PA: 2, dietary habits: 5); subtotal of knowledge score was defined as sum nine questions for their knowledge (physical fitness: 7, nutrition: 2). Score ranges: subtotal of behavior (7~ 34), behavior on PA (2~ 9), behavior on dietary habits (5~25), subtotal of knowledge (0~ 9), knowledge on physical fitness (0~ 7), knowledge on nutrition (0~ 2), total (7~ 43).

^cWilcoxon signed rank sum test was used to compare the distribution of scores between pre- and post- intervention due to the non-normal distributions of scores.