



Web-Based Intervention to Promote Physical Activity in Taiwanese Children

Sheu-jen Huang^{a,*}, Wen-chi Hung^b, Meei-Ling Shyu^c, Kuo-chen Chang^d, Chun-Kai Chen^e

^a Department of Health Promotion & Health Education, National Taiwan Normal University, Taipei, Taiwan

^b Department of Oral Hygiene & Healthcare, Cardinal Tien Junior College of Healthcare and Management, New Taipei City, Taiwan

^c School of Nursing, Taipei Medical University, Taipei, Taiwan

^d Department of Geography, National Taiwan Normal University, Taipei, Taiwan

^e Disaster Prevention Technology Research Center, Sino Technology Company, Taipei City, Taiwan

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ABSTRACT

Purpose: This study investigated the effectiveness of a theory-based, technology-integrated website in promoting the physical activity of schoolchildren.

Design and methods: A website designed using a self-management strategy and supplemented with a geographical information system (GIS) mapping function was used to increase children's physical activity levels. A total of 524 students from six elementary schools in Taipei City completed surveys at three times during 2010 and were assigned to one of three groups: (1) a self-management group, using a website employing a goal-setting strategy and a storytelling schema based on a classical Chinese novel; (2) a knowledge-only group that was given only access to the website; or (3) a control group that was only given lectures and not allowed to access the website. **Results:** After adjustment for the effects of the pretest, the self-management and knowledge-only groups were found to be more physically active and have higher self-efficacy than the control group. Moreover, the self-management group had higher scores for these two variables than the knowledge-only group. Furthermore, the intervention was more effective for male students than female students.

Conclusion: Overall, the self-management website proved to be effective in promoting schoolchildren's physical activity. The positive correlation of self-efficacy with the ability to handle the difficulties inherent in physical activity continued for 3 months after the intervention was completed.

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Introduction

Childhood obesity has considerably increased over the last two decades in several affluent countries (De Onis, Blossner, & Borghi, 2010; Ogden, Carroll, Kit, & Flegal, 2014; Wang & Lim, 2012). The percentage of children in Taiwan who are overweight or obese (30.4%; Taiwan Health Promotion Administration, 2016) is consistent with the worldwide trend of weight gain, which is potentially caused by ingesting too many calories and insufficient physical activity. Despite its apparent benefits, physical activity levels among children and adolescents are critically low. A representative study from Taiwan reported that only 18.8% of elementary school children performed the minimum recommended amount of physical activity: 30 min, 3 days per week (Taiwan Sport Affairs Council, 2009). Additionally, data from the 2013/2014 Health Behavior of School Children survey indicated that only 23% of boys and 15% of girls met the World Health Organization guidelines of

150 min of physical activity per week (Inchley, Currie, Young, Samdal, & Torsheim, 2017). Similar results were reported using the same criteria in a review of Asian children and adolescents (Müller & Khoo, 2016).

Numerous programs have been conducted to help members of the younger generation live a more physically active life. However, in their review of 57 programs aimed at promoting physical activity among children (<12 years) and adolescents (≥12 years), Sluijs, McMinn, and Griffin (2007) concluded that there were few high-quality evaluations of these programs, which limits researchers' ability to draw conclusions about their effectiveness, especially regarding children. With the increasing burden caused by obesity and chronic diseases, new methods of making behavior-changing programs available to numerous people at a low cost are needed. The Internet, in particular, is an innovative medium for increasing physical activity in children and adolescents due to its wide reach, availability, and openness to interactive approaches (Norman et al., 2007). Additionally, it is suitable for these age groups because children and adolescents are sufficiently adept in using Internet technology and spend a considerable amount of time online (Müller & Khoo, 2016). In Taiwan, where information education is a required course in elementary schools, more than 1.96 million elementary-age schoolchildren

* Corresponding author.

E-mail addresses: huangsj@ntnu.edu.tw (S. Huang), meeiling@ntnu.edu.tw (M.-L. Shyu), kcchang@ntnu.edu.tw (K. Chang).

have access to the Internet. Schoolchildren spend 45.4 min on the Internet in class and 57.8 min online outside of class each day (Ko, 2016). One-hundred percent of Taiwanese schoolchildren have access broadband Internet (Taiwan Network Information Center, 2016). The Internet is therefore a promising channel for the promotion of regular physical activity in Taiwanese children, which could slow or even reverse the trend toward childhood obesity.

In a systematic review of 13 studies (Müller & Khoo, 2016), 5 were identified as reporting interventions that had significant effects on a number of physical activity domains. All the studies included were performed in Europe or the United States; thus, there is still a lack of research in other world regions, especially in Asia, where 50.2% of Internet users reside (Miniwatts Marketing Group, 2017). Efforts are needed to utilize this potential to promote healthy behavior, including physical activity, in children and adolescents. Experimental studies with samples drawn from ethnic groups in this region, such as in Taiwan, are thus warranted.

The present study was conducted in Taipei City, Taiwan. The constructs of self-efficacy, vicarious learning, and self-management from social cognitive theory, as well as Health Belief Model concepts such as perceived benefits of physical activity, were incorporated into a web-based intervention program, as were behavior change concepts. Bandura and Wood (1989) indicated that self-management means setting goals and monitoring (observing) oneself in order to achieve behavioral change. With the advent of the “e-health” age, increasing numbers of studies are exploring the use of Internet-mediated technology. Researchers (Delamater et al., 2013; Duan, Wienert, Hu, Si, & Lippke, 2017; McIntosh, Jay, Hadden, & Whittaker, 2017; Müller & Khoo, 2016) described the significantly positive effects of web-based interventions on physical activity improvement. One other study discovered that a cost-effective self-management intervention that was implemented through a telehealth device significantly improved older women’s physical activity levels after their bypass surgeries (Young, Zimmerman, Pozehl, Barnasn, & Wang, 2012). However, some meta-analyses of the effectiveness of Internet-delivered interventions that aimed to increase the physical activity level of adults concluded that these interventions had a positive but small effect (Davies, Spence, Vandelanotte, Caperchione, & Mummery, 2012; Rothert et al., 2006; Vandelanotte, Spathonis, Eakin, & Owen, 2007; Webb, Joseph, Yardley, & Michie, 2010). Nonetheless, it was discovered that intervention components such as a large sample size, screening for baseline physical activity levels, and the inclusion of educational components significantly increased the effectiveness of interventions (Davies et al., 2012). Certainly, keeping participants engaged with the intervention website also increases the effectiveness of the intervention (Glasgow, Boles, McKay, Feil, & Barrera, 2003; Leslie, Marshall, Owen, & Bauman, 2005). Furthermore, new and more innovative forms of intervention must be developed to increase the level of participants’ interest and engagement.

As an alternative to the traditional, unstructured teaching of physical education and gym classes, a geographical information system (GIS)-based website combined with a self-management strategy was investigated in this study to determine its effectiveness in increasing children’s physical activity levels. The Internet and associated screen time may be part of the problem of increasing sedentary lifestyles, which further increase the risk for disease incidence, morbidity, and hospitalization (Biswas et al., 2015; Costigan, Barnett, Plotnikoff, & Lubans, 2013; Saunders, Chaput, & Tremblay, 2014), however, in this instance it is being utilized to potentially increase activity through an interactive program.

Methods

Participants

This was a three-armed, quasi-experimental study in which a total of 617 fifth- and sixth-grade students from six schools in three districts in

Taipei City participated voluntarily in 2010. Two schools were selected in each district, with one serving as the experimental school and the other as the comparison school. The two schools were matched based on their demographic characteristics and then randomly assigned to the intervention or control group. Within the experimental school, there were self-management, knowledge-only, and control groups; within the comparison school, however, there was only the control group. The students who were assigned to the self-management group engaged in an 8-week web-based exercise program using a self-management strategy and applying knowledge regarding physical activity, which was communicated using an animated story. The students who were assigned to the knowledge-only group were supplied with the animated story. The control group did not have access to the website and was given lectures on generic health care topics. In the design of this study, there were inter- and intra-school comparison groups. Questionnaires were returned by 524 participants, indicating an 84.9% response rate. Informed parental consent forms were collected from the students’ primary guardians prior to their participation.

A flowchart presenting the design of this study is displayed in Fig. 1.

Instruments

Data were collected using a questionnaire that incorporated the following measures.

Physical activity

We employed a modified Chinese version (Wu & Pender, 2002) of the Child/Adolescent Activity Log (Garcia, George, Coviak, Antonakos, & Pender, 1997) to assess how frequently the students engaged in various forms of physical activity. Every participant was asked to recall the physical activities he or she had engaged in each day and the time (in minutes) that he or she spent doing 25 activities over a period of 3 days—2 weekend days and 1 weekday. The amount of physical activity performed was quantified using the energy consumed and was calculated using the following formula: energy consumption (MET · h / w) = MET × duration (minutes per bout) × frequency (bouts per week). An MET is a metabolic equivalent of task and was referenced from data reported by Harrel et al. (2005) for children of similar age groups (8–12 years old for boys, 8–11 year old for girls). We chose 11.0, 7.0, and 5.2 MET to correspond to vigorous, moderate, and light activity levels in our study, respectively. The total energy consumption was the sum of all energy consumed during light, moderate, and vigorous activities. The test–retest reliability was 0.58–0.80.

Exercise-related self-efficacy

A self-developed 5-item Exercise-Related-Self-Efficacy Scale (Liu & Huang, 1999) was used to measure participants’ confidence in their own ability to keep exercising in various situations such as a lack of facilities. Self-efficacy expectancies may vary in strength, and so each item can be answered based on a 4-point Likert scale of perceived coping: 1 (really sure I couldn’t), 2 (probably couldn’t), 3 (probably could), and 4 (really sure I could). The total score is derived by summing the scores for the 5 items, yielding a possible total score between 5 and 20. Higher scores reflect greater self-efficacy expectations. The Cronbach α for inter-item reliability was 0.78. The test–retest reliability of this scale was 0.69.

Perceived benefit of physical activity

A self-developed 7-item Perceived-Benefit-of-Exercise Scale (Liu, Huang, Hung, & Lie, 2005) was used to measure the benefit of regularly engaging in physical activities, as perceived by the participants. Response choices include 1 (strongly disagree), 2 (disagree), 3 (neither agree nor disagree), 4 (agree), and 5 (strongly agree). The scores for

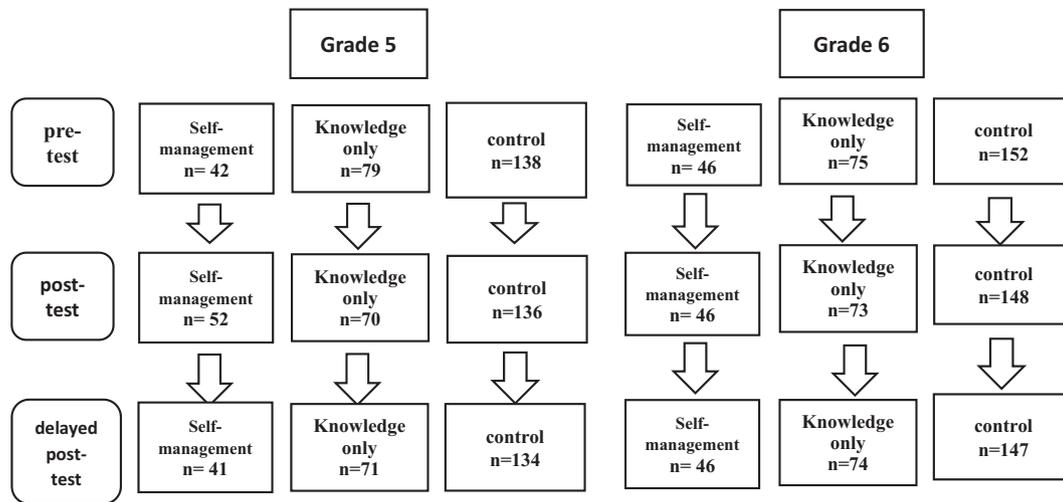


Fig. 1. Flowchart of the study's repeated-measures crossover design.

each participant were determined by computing the mean of a participant's item scores on each scale. Higher scores indicated a higher level of perceived benefits of physical activity. Perceived-Benefit Scale items were asked with the phrase "A major reason for being physically active or exercising for me is to ...". The Cronbach α for inter-item reliability was 0.89. The test–retest reliability was 0.51.

Sociodemographic variables

Data were gathered regarding student gender, student age, the socioeconomic status of students' family, and the students' school district. This sociodemographic information was supplied by the participants' parents.

Intervention implementation

Physical activity website

The researchers designed a website integrating a classical Chinese novel—*Journey to the West*, which has been well-known to the Chinese for over 500 years—into a real-life context and uses it to communicate the importance of an active lifestyle. A historical and cultural component was thus incorporated because it is something young Taiwanese students can readily find identity with it. This website designed to employ a self-management strategy and supplemented with a GIS was used. The website also employed a narrative format and animation based on the aforementioned classical Chinese novel *Journey to the West*, which describes the adventurous journey of Master Monk (Tung Monk) and his three disciples, namely a monkey, a pig, and a young monk named SaWu Ging; they go to the Western Sky (India) to find a Buddhist scripture, a difficult but ultimately successful quest. We chose to use cartoon illustrations as the presentation format, again because this appeals to young students and should be effective in conveying information to this demographic (in this context, see Delp & Jones, 2008). The Taipei Metropolitan Transit System (known as the MRT), including nine virtual stations, was used to symbolize this route. Each of the nine virtual stations represented a certain aspect of a physically active life and was based on some similarity between the area surrounding the station and a scene in the novel. For example, the four-member team would read the billboard at Taipei Main Station, which served as a general guide to all the upcoming physical activities. The team would then row a boat onto the Small Blue Pond located at another station, discussing sports safety, and then cross Flame Mountain to find Princess Iron Fan at New Beitou Station, which is famous for its hot springs. The story, already familiar to Taiwanese children, was told in an animated film, and by "following" the story, the students learned

about health and exercise. The story was told section by section over 8 weeks. The website's instructional content regarding physical activity was based on the information in two health and physical activity textbooks (Han Lin Publishing Co., Ltd., 2010; Kang Hsuan Educational Publishing Group, 2010). The Google map function on the website enabled users to map routes and measure the distance users traveled when moving around the school district for a given period of time.

Goal-setting was a crucial strategy used in this study. The participants defined an exercise goal for the subsequent week, such as how long they would exercise every day, on how many days they would exercise, or what strength of exercise they would perform. They recorded what goals had been met the next week, and comments popped up automatically after their total score was calculated. Problem-solving was also required through a set of multiple-choice questions about difficult situations that can arise for people who wish to have an active lifestyle and what action they would take. Scores were assigned corresponding to the actions selected, with more appropriate actions receiving higher scores. The total score appeared on the website immediately after the students had completed the multiple-choice questions. The GIS enabled the participants to record the routes they had walked so that they would be motivated to improve by comparing the goal they had set for themselves the previous week with their actual performance.

The students also marked the route they followed on their way home from school on the GIS map, quantifying the distance they had walked each day. The actual distance walked was compared with that from the previous week. Comments appeared on the website such as "Congratulations, you are making progress!" for those who walked more than the previous week and "You are losing! Go! Go!" for those whose performance had worsened. The website content layout is displayed in Fig. 2. The intervention used in this study thus included goal-setting, self-monitoring, and also self-evaluation because students had to compare their performance from one week to the next. Problem-solving was also required through a set of multiple-choice questions about difficult situations that can arise for people who wish to have an active lifestyle. To provide suitable examples for vicarious learning, stories about two elementary school students who were famous athletes were also used.

This design was based on the results of a needs assessment study that involved six focus groups and a large-scale survey. Seven graduate students were invited to develop the preliminary website content under the supervision of two health educators (Huang, Chang, Hung, Shyu, & Gou, 2010). The preliminary website was then modified based on the results of a preliminary evaluation that included an online end-user pretest (n = 50), three focus group interviews, and a review by two experts in sports physiology, one expert in physical



Fig. 2. Nine MRT stations on the “Exercise Journey to the West” website.

education, and one expert in educational psychology. The online survey focused on the content, design, and usefulness of the website and the degree of participant satisfaction, and it included an open-ended question that allowed the students to make their own suggestions. To prevent contamination, any students involved in the development and pretesting of the website did not participate in this study. The nine MRT stations used on the “Exercise Journey to the West” website are displayed in Fig. 2.

Implementation process and data collection

The 8-week intervention was part of computer education lessons at the participating schools, and a link to the website was placed on the front page of each school’s website. The students in the self-management group logged onto the self-management website, which included categories regarding goal-setting, self-monitoring, and problem-solving. They also kept a record of the routes they had walked in the previous week, completed GIS records, and continued to read the biweekly installments of *Journey to the West*. A flow-chart indicating how the website was used is presented in Fig. 3. Using the website in class took 40 min on each occasion. By contrast, students in the knowledge-only group spent only 15 min every other week reading the ongoing story of *Journey to the West*. A posttest was conducted immediately after the course had finished, and a delayed posttest was performed 3 months afterward to assess the long-term effects of the program.

Statistical analysis

Descriptive statistics (frequencies and means) were used to describe the distribution of demographic characteristics (age, parents’ occupation, and parents’ education level) and the time and distance that the research participants walked. To identify differences in physical activity levels and psychological determinants in the immediate and delayed posttests, analyses of covariance (ANCOVA), with the pretest score

used as a covariate, and repeated measures of ANCOVA were used, respectively.

Results

Baseline characteristics of the participants

The participants included in the data analysis were those who completed the questionnaire during the pretest, intermediate test, and delayed posttest. In total, the researchers analyzed data from 524 students, 51% of whom were boys and 49% were girls. The participants’ average age was 11.38 (standard deviation = 0.34). Of the 524 participants, 88 were in the self-management group, 146 in the knowledge-only group, and 290 in the control group. There were no significant differences regarding sociodemographic variables or physical activity levels among these groups: for grade level, $\chi^2(2, N=524) = 0.04, p = .98$; for gender, $\chi^2(2, N=519) = 1.13, p = .57$; for parents’ occupation, $\chi^2(2, N=486) = 15.81, p = .33$; for parents’ income, $\chi^2(2, N=485) = 13.55, p = .63$; for physical activity level, $F(2, 522) = 1.29, p = .28$. The pretest results for all groups are presented in Table 1.

Additionally, there was no significant differences between those students who remained in the study and those who dropped out regarding sociodemographic variables (for grade level, $\chi^2(2, N=524) = 1.29, p = .32$; for gender, $\chi^2(2, N=519) = 1.15, p = .33$) or psychological determinants (for perceived benefit of physical activity, $F(1,513) = 2.51, p = .11$; for self-efficacy, $F(1,502) = 1.58, p = .21$); for total amount of physical activity, $F(1,523) = 0.03, p = .87$.

Effect on physical activity

The posttest and delayed posttest revealed that students in both experimental groups were significantly more active than those in the control group. The total amount of physical activity at posttest reached a significant level. The effect size was 0.03, which is small according to Cohen (1992). Post hoc analysis demonstrated that both the self-

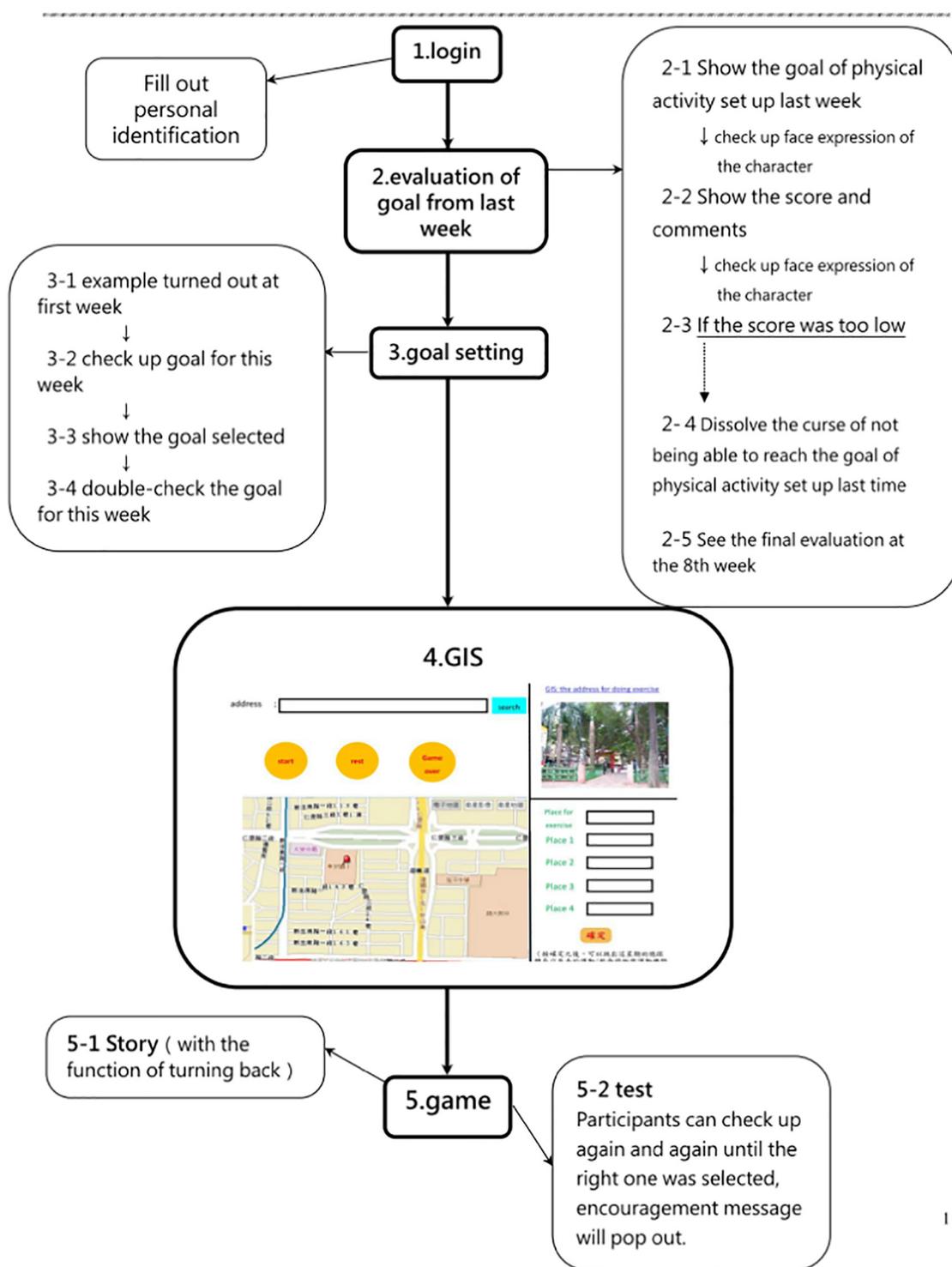


Fig. 3. Website usage flowchart.

management and knowledge-only groups had a higher level of total physical activity than the control group; in addition, the self-management group scored higher in this area than the knowledge-only group. The researchers concluded that the students who received website information, regardless of whether they used the self-management strategy, were more physically active than those who did not receive the intervention, and that the self-management strategy was more effective than the knowledge-only strategy. Thus, a significant difference existed between the groups with time (the interaction effect of group \times time) in terms of the total amount of physical activity,

according to the follow-up measurements made using repeated measures ANCOVA (interaction effect group \times time $F(2,479) = 11.59, p = .01$, effect size = 0.016). The self-management group was significantly more active than the knowledge-only and control groups.

Psychological determinants

After the 8-week intervention, a significantly higher level of perceived benefit ($F(2,502) = 3.84, p = .02$) and physical activity self-efficacy ($F(2,479) = 36.91, p = .00$) was discovered for the self-

Table 1
Background and physical activity levels at baseline of the participants in the three groups.

Variables	Self-management Group		Knowledge only Group		Control Group		χ^2
	n	%	n	%	n	%	
Grade							
5th Grade	42	47.73	71	48.63	138	47.59	$\chi^2 = 0.04$ p = .98
6th Grade	46	52.27	75	51.37	152	52.41	
Gender							
Female	38	44.19	75	51.37	141	49.13	$\chi^2 = 1.13$ p = .57
Male	48	55.81	71	48.63	146	50.87	
Occupation of head of household							
Executives, administrators, professionals	50	59.52	70	51.47	131	49.25	$\chi^2 = 15.81$
Assistant professionals, staff members	25	29.77	47	34.55	100	37.59	
Service workers, salesmen, technicians	9	10.71	19	13.98	35	13.16	
Monthly household income							
<NT\$20,000	2	2.38	6	4.29	7	2.68	$\chi^2 = 13.55$ p = .63
NT\$ 20,000-79,999	34	40.48	52	37.15	102	39.08	
NT\$ 80,000-159,999	37	44.04	68	48.57	116	44.45	
NT\$ 160,000 and above	11	13.10	14	10.00	36	13.79	
	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	ANOVA (F)
Amount of physical activity	88	4435.02 (3457.04)	146	3989.46 (3205.73)	290	3829.21 (2937.69)	F(1,523) = 1.29 p = .87

management group than for the knowledge-only and control groups, with the effect sizes being 0.015 and 0.135, respectively, which are small according to Cohen (1992). No significant difference, however, was identified in the delayed posttest between and among groups regarding perceived benefit; that is, any significant effect of perceived benefit was not present 3 months later. A delayed significant difference with regard to self-efficacy of physical activity ($F(2,479) = 32.38$, $p = .000$) was found. However, the corresponding effect size was small at only 0.019. Further analysis revealed significant differences between all groups. The power levels of perceived benefit and self-efficacy were 0.71 and 0.95, whereas that of the other variables was as high as 1.00. This revealed that the number of data was sufficiently large to detect differences. The results are listed in Table 2.

The influence of gender on the amount of physical activity was also explored. ANCOVA and repeated measures ANCOVA were used to control for the pretest because there was a difference in the pretest scores in both male and female groups. Post hoc analysis revealed that the male students in the self-management group achieved a significantly higher amount of physical activity than those in the control group. However, no difference was discovered among the groups' female students regarding the amount of physical activity at the posttest ($F = 7.50$, $p <$

.005) or delayed posttest ($F = 3.21$, $p < .001$). This demonstrated that the website intervention increased the amount of physical activity only in male students, with this increase sustained at 3 months later, but was not effective for the female students. The results are presented in Table 3.

Process evaluation

An evaluation of the website was conducted immediately after the 8-week intervention. When asked whether they were generally "satisfied with the website," 86% and 82% of the participants in the self-management and knowledge-only groups replied in the affirmative. On this point, no significant differences were identified between the two groups ($F = 2.80$, $p = .095$). More than 85% agreed with statements such as "I was attracted to the website," "the layout was clear," "the descriptions were understandable," and "surfing the website was easy and without a prolonged waiting time." However, there were significant differences between the self-management and knowledge-only groups regarding the following issues: "The content of this website helped me learn more about exercise" ($F = 18.22$, $p = .000$); and "I now better understand my own habits regarding physical activity" ($F = 30.22$, $p =$

Table 2
ANOVA and repeated measures statistics for physical activity, perceived benefit, and self-efficacy of 3 groups in immediate posttest and delayed posttest, with the pretest score used as the covariate.

Variable	Group			ANOVA F test	Repeated measurement F test
	1.Self-management Group	2.Knowledge-only Group	3.Control Group		
Perceived benefit					
Pre-test	16.51(3.17)	17.32(3.20)	16.99(3.54)	F = 3.35* P = .036 1 > 3	F = 1.79 Power = 0.55
Post-test	17.01(3.84)	16.03(4.42)	15.66(4.32)	Effect Size = 0.013 Power = 0.63	N.S.
Delayed Post-test	16.41(3.93)	16.53(4.32)	16.37(4.26)		
Self-efficacy					
Pre-test	33.39(10.11)	35.47(9.51)	31.88(9.92)	F = 39.61*** 1 > 2, 1 > 3, 2 > 3	F = 32.38*** 1 > 2, 1 > 3, 2 > 3
Post-test	37.35(7.63)	33.15(10.37)	28.55(7.89)	Effect Size = 0.135 Power = 1.00	Effect Size = 0.019 Power = 0.92
Delayed Post-test	35.62(11.64)	33.04(11.40)	31.42(10.05)		
Amount of Physical Activity					
Pre-test	4435.02(3457.04)	3989.46 (3205.73)	3829.21(2937.69)	F = 2.06 (N.S)	Delayed post-test > post-test 1 > 2, 1 > 3
Post-test	2039.92(1610.12)	1778.58(1486.42)	1687.73(1333.99)	Effect Size = 0.008 Power = 0.425	Effect Size = 0.016 Power = 0.91
Delayed Post-test	2036.47(1612.66)	1777.55(1392.92)	1689.68(1330.13)		

* $p < .05$.

*** $p < .001$.

Table 3

ANOVA and repeated measures statistics for physical activity, perceived benefit, and self-efficacy of 3 groups in immediate posttest and delayed posttest, with pretest score used as the covariate, by gender.

Variable	Group			ANOVA F test	Repeated measurement F test
	1.Self-management Group	2.Knowledge- only Group	3.Control Group		
Male (n = 265)	n = 48	n = 71	n = 146		
Amount of Physical Activity					
Pre-test	5540.79(3678.32)	4463.02(3548.82)	3543.58(2861.97)	F = 8.53**	F = 3.21***
Post-test	6004.28(4060.96)	4703.19(3852.05)	3664.11(3100.53)	1 > 3	1 > 3
Delayed Post-test	5999.54(4066.66)	4703.19(3852.05)	3664.11(3100.53)		
Female (n = 254)	n = 38	n = 75	n = 141		
Amount of Physical Activity					
Pre-test	3061.18(2698.96)	3541.15(2793.67)	4118.35(2939.27)	F = 2.06(N.S.)	F = 0.68 (N.S.)
Post-test	3226.51(2772.72)	3626.36(2993.80)	4217.38(3060.18)		
Delayed Post-test	3213.84(2776.62)	3621.68(2466.99)	4226.73(3040.39)		

** p < .005.

*** p < .001.

.000). On both of these points, the self-management group reported higher agreement than the knowledge-only group. Therefore, by using this interactive model, the self-management participants clearly acquired a more positive perception of physical activity and more fully appreciated the website. Male students were also discovered to be more fond of the website than female students ($t = 5.54, p < .05$).

Discussion

The findings of this study demonstrate that Internet-delivered interventions integrating a self-management strategy with a GIS mapping function are effective in producing small but significant increases in schoolchildren's self-efficacy and physical activity. This is consistent with the results of previous studies (Chen, Weiss, Heyman, & Lusting, 2010; Hu, Cheng, Lu, Zhu, & Chen, 2016; Huang, Hung, Chang, & Chang, 2009; Joseph, Durant, Benitez, & Pekmezi, 2013). Producing such changes across a large population can have a powerful effect even though the individual effects may be small. The effect size regarding the total amount of physical activity was 0.03. This magnitude corresponds with recent findings that Internet-delivered programs have a small but positive effect on physical activity ($d = 0.14$) (Davies et al., 2012). Capturing mediating processing constructs is also possible, because the present study included psychosocial as well as physical activity variables. The perceived benefit and the self-efficacy of regular physical activity might have partly affected the participants' physical activity levels, because the self-efficacy factor was always higher for the experimental groups than for the control group at the posttest and delayed posttest; it was also higher for the self-management group than for the knowledge-only group at the same tests.

In the present study, we also discovered that the intervention was more effective for male students than female students, which was partly because the design of the website was more appealing to male students than female students. The male students were more interested in the use of GIS mapping and because Journey to the West is essentially an adventure story, with such stories generally more popular with male students. Although there was an overall change with a small effect size, the change may only be attributed to boys and warrants further exploration of this situation. Also, in the future, before designing such a website, the differences between boys and girls may need to be taken more into consideration.

Digital multimedia is one of the most effective teaching instruments, catching the attention and increasing the interest of learners through the use of interactive content. Participants in the self-management group were eager to formally set goals for themselves and to make choices to remedy mistakes they had made in previous attempts, hopefully reaching their goal on the next occasion. Inducing positive feelings and seeking to eliminate negative feelings, the students underwent a recursive process of contemplating their set goal, performing, and experiencing a certain degree of self-efficacy (Bandura & Wood, 1989).

A hands-on experience enables students to reflect on what they are doing and enjoy the learning process for its own sake. In the present study, the use of interactive teaching aids—combining the plot and characters of a well-known classical story from the participants' own culture with GIS mapping and real-time physical activities—attracted and excited the young learners.

Strengths of the study

The present study is the first, according to a review of the literature, to investigate the effect of an Internet-based intervention on Asian children's physical activity. Previous studies on Internet-based physical activity interventions were mainly oriented toward white, middle-aged, and female individuals (Joseph et al., 2013), and there is a paucity of research regarding interventions for Asian children (Müller & Khoo, 2016). Consistent with the findings of other school-based intervention studies (Gao & Xiang, 2012; Joseph et al., 2013), our web-based intervention program was discovered to affect children's physical activity levels over time. Specifically, children participating in the 8-week web-based program at school demonstrated greater improvement in physical activity level than those in the control group. Additionally, the effect of the intervention lasted beyond the intervention period, with the effect of stronger self-efficacy mediating the increase in the amount of physical activity of fifth and sixth-grade children in the intervention group 3 months later. Other research suggested that school-based studies have been the most successful regarding the reporting of significantly positive physical activity outcomes. (McGoey, Root, Bruner, & Law, 2016) The findings of the current study provide empirical support for using web-based exercise interventions to improve children's physical activity levels in a school setting.

One of the reasons for the effectiveness of the interactive self-management strategy in this study was the appeal of the website itself, which combined various elements including a classical Chinese narrative and the modern act of riding the MRT in Taipei. The data suggest that the technological mode of intervention had strong motivational power because it was appealing to children (Sun, 2012). During the website design process, a needs assessment was performed by using focus group interviews and conducting surveys to identify the favorite characters and stories of Taipei's children. Additionally, target groups were invited to take part in the needs assessment process to craft the website and integrate the voices of children and adolescents, as has been suggested by other researchers (Müller & Khoo, 2016; Sjöberg, 2015).

Structuring study designs based on a theoretical framework has been argued to promote an understanding of causal mechanisms when studying complex behavior change such as regular participation in physical activity (DiClemente, Croby, & Kogler, 2009). In this study, which was based on social cognitive theory and the health belief model, the significance of potential mediating psychosocial variables

such as self-efficacy and perceived benefit informed us how the intervention affects physical activity behavior in children.

This study had a quasi-experimental design involving intra- and inter-school comparison groups. Classes in a school were randomly assigned to either the experimental or control group; thus, the researchers eliminated possible threats to the study's internal validity such as those involving selection, experimental contamination, maturity, pretesting effects, and instrumentation. Moreover, the intervention was integrated into a normal computer education course; hence, the students were participating while in a nonintrusive environment, avoiding the Hawthorne effect.

Many of this study's participants logged on to the intervention website after class because they were very interested in its *Journey to the West* story. The relative ease with which the students' website engagement was maintained was a crucial factor in the overall effectiveness of the study.

Possible limitations and implications for future research

This study has several limitations. We used self-reported data; participants needed to recall facts and past events when they completed the questionnaire, which introduced the possibility of recall bias. Baranowski (1988) indicated that the validity of children's recall is dependent on their age and cognitive development. Sallis and Owen (1999) reported that validity correlations are usually significant in fourth- and fifth-grade samples. Because the participants in our study were in the fifth or sixth grade, the threat of recall bias to the internal validity of the study was eliminated. Furthermore, the researchers carefully designed the questionnaire to minimize the possibility of recall bias. Focus groups and a pretest of target group members who did not attend the participating schools were performed to collect and discuss the questionnaire items in an effort to design the clearest and most valid questionnaire. Still, the psychometric value of the test-retest reliability of the Perceived-Benefit-of-Exercise Scale was 0.51, which was not sufficient (cf. Nunally and Bernstein (1994)) and should be addressed in further studies.

The generalizability of the results of the present study is limited because of the selective sample used. Not all schools worldwide could use mandatory computer education classes or take advantage of strong community engagement. Furthermore, McGoey et al. (2016) suggested in a review study that long-term follow-up measurements should be collected more than 6 months after intervention. The current study employed only a 3-month interval because of budget and time constraints, and this should be remedied.

Clinical implications

In addition to traditional methods, various media and network technology interventions can be applied to improve child healthcare. Pediatric nurses may teach sick children and their families to use the Internet to find and verify useful information. Moreover, the nurses may establish support systems for the family and sick children on the Internet. Furthermore, interactive web-based interventions should be utilized to a larger extent by sport and exercise medicine professionals to prescribe physical activity as a regimen for the cure and rehabilitation of diseases.

Web-based interventions for children should be carefully designed to match the unique needs and capabilities of this group. User involvement during development may ensure that the interventions are accessible, useful, and appropriate for the children of different health status.

At present, several websites offer information on children's diseases, and the structure and content of these websites are perfect. However, because of the websites are not in the native language of Taiwanese users, sick children and their families cannot receive help if they are connected to a foreign network support system. Therefore, if the content of domestic children's disease-related websites can be improved

and made comprehensive, then sick children and their families can receive assistance effectively.

Conclusion

In conclusion, Internet-delivered interventions integrating a self-management strategy and GIS are effective in producing a small but significant increase in the physical activity levels of schoolchildren. The self-efficacy derived from regular physical activity may be the mediating processing construct that explains the effectiveness of the intervention. Also, the intervention made a significant difference for the boys, not for the girls.

The website was made appealing through a mixture of modern life and a culture-based storyline, taken from a classical novel. This website involved interactive features to attract the participants. Goal-setting was another strategy used in this study. Using GIS, the participants were able to record and monitor the routes they had walked each day, which served as a reinforcement function.

Future research in this area should focus on which aspects of Internet-delivered interventions can increase the engagement and retention of experimental participants. Thus, researchers may need to better understand the elements that enhance the effectiveness of this type of intervention. Also, in the future, before designing such a website, the differences between boys and girls may need to be taken more into consideration.

For a research study such as the current study, tailoring the intervention to family needs and generating family support may also increase children's physical activity on weekends and after school. Delivering such interventions to diverse populations would also be a worthy goal.

Competing interests

The authors declare that they have no conflict of interest.

Ethics approval

All procedures were performed in compliance with the Declaration of Helsinki and National Science Council in Taiwan has approved the conduct of this research. Informed consent was collected from the parents of the participants. This study was supported by a grant from the National Science Council (grant number: NSC97-2410-H003-096-SS2).

CRedit authorship contribution statement

Sheu-jen Huang: Conceptualization, Funding acquisition, Methodology, Supervision, Validation, Writing - original draft, Writing - review & editing. **Wen-chi Hung:** Formal analysis, Methodology, Software, Project administration, Writing - original draft, Writing - review & editing. **Meei-Ling Shyu:** Investigation, Writing - review & editing. **Kuo-chen Chang:** Methodology, Resources, Writing - review & editing. **Chun-Kai Chen:** Investigation, Data curation, Visualization, Project administration, Writing - review & editing.

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