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Direct Observation of Children's Preferences and Activity Levels During Interactive and Online Electronic Games

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Background: Interactive electronic games have recently been popularized and are believed to help promote children's physical activity (PA). The purpose of the study was to examine preferences and PA levels during interactive and online electronic games among overweight and nonoverweight boys and girls. ***Methods:*** Using a modification of the SOFIT, we systematically observed 70 Hong Kong Chinese children (35 boys, 35 girls; 50 nonoverweight, 20 overweight), age 9 to 12 years, during 2 60-minute recreation sessions and recorded their game mode choices and PA levels. During Session One children could play either an interactive or an online electronic bowling game and during Session Two they could play an interactive or an online electronic running game. ***Results:*** Children chose to play the games during 94% of session time and split this time between interactive (52%) and online (48%) versions. They engaged in significantly more moderate-to-vigorous physical activity (MVPA) during interactive games than their online electronic versions (70% vs. 2% of game time). Boys and nonoverweight children expended relatively more energy during the interactive games than girls and overweight children, respectively. ***Conclusions:*** New-generation interactive games can facilitate physical activity in children, and given the opportunity children may select them over sedentary versions.

Keywords: physical activity, moderate-to-vigorous physical activity, electronic games, obesity, exercise

With the immediate and long term effects of physical activity becoming more clear[1] there is recent worldwide concern about children's reduced physical activity levels and increased sedentary lifestyles.[2–5] Being overweight in childhood not only has its own physical and psychological health problems, but overweight children are likely to become overweight or obese in adulthood and to be at increased risk for cardiovascular disease, diabetes, and cancer. Reviews of the scientific literature show that physical activity reduces the risk of overweight and Type 2 diabetes in children and aids in their treatment, and current health guidelines recommended that children engage in at least 60-minutes of moderate-to-vigorous physical activity (MVPA) daily.[1,6,7]

Direct observation exceeds other measures of physical activity in providing contextually-rich data on the environment,[8,9] and observations of cohorts of children in their homes in Hong Kong[10] and the US[11,12] have shown that children spend most of their leisure time indoors and in sedentary pursuits. Children's use of media at home has been correlated with both the time they spend indoors and being inactive,[11,12] and there is widespread concern that electronic media, such as computer and video games, contribute to sedentary living and childhood obesity problems.[13,14] While most electronic media are sedentary in nature, a series of new-generation electronic games have been developed and are being promoted as being effective ways to motivate children to be physically active. Preliminary studies have shown that new-generation interactive, wireless, electronic games can significantly contribute to children's activity levels,[15] including increasing children's energy expenditure over seated electronic games by 51%.[16] Playing interactive games which involve upper body movements and dancing have been shown to increase children's energy expenditure over resting values by 108% and 172%, respectively.[17]

A few interventions aimed at decreasing sedentary behavior have resulted in increased physical activity and reduced body mass index.[18,19] Some studies have assessed engagement in interactive games by gender and weight status. Boys have been shown to be more physically active during interactive games than girls,[16] but often gender differences are not found.[17,20] As well, nonoverweight children have been shown to be more willing to play an interactive dance game than their overweight counterparts.[21] Additional information is needed to make a determination on the potential role of interactive games in facilitating children's active behavior.

Previous studies of electronic games have typically assessed children's activity levels during short time periods (eg, 15 minutes per game segment), and without participants having a choice of interactive or seated versions of the same game. The present investigation goes beyond the typical protocol to study children's behavior during

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extended time periods (ie, 1 hour) and under conditions where they have a choice to be sedentary or physically active. In this study, interactive games are defined as electronic media that permit a child to actively interface with the game by stepping on or physically manipulating sports-like equipment. The purpose of the study was to examine the role that interactive and online electronic games can play in promoting physical activity in children. We hypothesized 1) that given a choice, children would choose interactive electronic games over their sedentary versions, and 2) that they would be relatively more physically active during the interactive games than during the online games. We also hypothesized there would be significant differences in game use between boys and girls and between overweight and nonoverweight children.

Methods

Participants

Seventy primary school children (35 boys; 35 girls), ranging in age from 9 to 12 (mean = 10.87, SD = 0.88) were recruited from grades 4 to 6 in 2 schools using a stratified random sampling method from territory-based lists (ie, Hong Kong Island, Kowloon) of coeducation schools provided by the Hong Kong Education Bureau. Participating children were free from medical conditions that would limit their physical activity, and according to the International Obesity Task Force (IOTF) definitions of child obesity,[22] 16 (13 boys; 3 girls) were overweight and 4 (all boys) were obese. Both children and their parents provided written consent to participate in the study which was approved by the university faculty ethics committee.

Procedures

Each child participated alone in 2 60-minute sessions in a controlled laboratory setting where he or she was permitted to play either an interactive electronic game or a similarly themed online game. The child was allowed to choose the game mode (interactive or online) and was free to stop playing at any time or to switch between modes. During session one, the child engaged in bowling-type games (ie, XAviX bowling) and during session two, running-type games (ie, Aerostep), both developed by Shiseido Co. of Japan. After the second session, the child was asked to express his/her feelings about the games and to rank them during a short interview. All sessions were video-taped.

Before session one, each child was familiarized with the laboratory, the procedures, and the interactive and online electronic versions of the games and was assessed on anthropometric measures by a certified technician. Height and weight were measured to the nearest 0.1 cm and 0.1 kg, respectively, using a freestanding Seca stadiometer (Seca AG, Reinach, Switzerland). Body composition (fat mass in kg, fat free mass in kg, and body fat percentage) was assessed using bioimpedance (TBF-401, Tanita Co., Japan). All data were collected in 2006 and were analyzed in 2007–2008.

Observation System

Trained assessors used a modification of the SOFIT (System for Observing Fitness Instruction Time) instrument[23] to record each child's physical activity levels and the amount of time he/she spent on each game mode during the 2 60-min sessions. Throughout each session, the child's activity level was scored every 20 seconds by entering 1 of 5 codes: lying down (code 1), sitting (code 2), standing (code 3), walking (code 4), or vigorous (code 5). These codes have been validated using heart rate monitoring and accelerometry[24–26] and have been widely used for measuring children's physical activity levels at home[11,12] and during physical education[27,28] and recess[29] at school.

The second author served as the primary data collector and the first author completed the reliability measures. They were trained using the standardized SOFIT protocol,[8] which included memorizing coding definitions and conventions, viewing videotaped segments, and surpassing the interobserver agreement (IOA) of 85% on videotaped assessments before beginning data collection. The first author was responsible for reliability checks (20% of the total data) and the IOA for child activity levels exceeded 98%.

Data Analysis

Dependent variables were mean minutes children spent in each game mode and in different physical activity levels. Child physical activity variables were expressed as both minutes per session and as the proportion of observed intervals or session time. The Walking and Vigorous categories were summed to form Moderate to Vigorous Physical Activity (MVPA), a description often used in health-related literature. In addition, a summary score for activity intensity, Energy Expenditure Rate (EER), was obtained using the following standard calculation based on heart rate monitoring:[30] proportion of time lying down × 0.029 kcal/kg per minute + proportion of time sitting × 0.047 kcal/kg per minute + proportion of time standing × 0.051 kcal/kg per minute + proportion of time walking × 0.096 kcal/kg per minute + proportion of time vigorous × 0.144 kcal/kg per minute. Total Energy Expenditure (TEE) (kcal/kg) for each game activity was also obtained using the following calculation: EER (kcal/kg per minute) × session length in minutes. Independent variables were gender and body weight classifications based on age and gender using the work of Cole et al.[22]

Data were analyzed using SPSS 15.0, and descriptive statistics, including means, standard deviations, frequencies, and percentages were obtained for all variables. Chi-square analysis was used to identify the frequency distribution of body weight by gender. One-way ANOVAs were conducted to test for significant gender and body weight differences for game modes (ie, mean minutes for each game mode) and physical activity variables (ie, the 5 codes, plus MVPA, EER, and TEE). Alpha level was set at $P < .05$ for all statistical tests.

Results

Physical Characteristics of Participants

Table 1 shows that boys had significantly greater body weight, body mass index, fat mass, and body fat percent than girls and that those classified as overweight exceeded nonoverweight children on all 6 listed variables. A substantially greater proportion of the boys were overweight or obese than the girls (N = 70, $\chi = 13.72$, $P = .001$).

Time Spent in Different Game Modes

Overall, children spent an average of only 3.5 min of the 1-hour session times not playing games. They engaged in game play 96.2% of the time during bowling game sessions and 92.2% of the time during running game sessions, splitting their times between the interactive and online electronic versions of games (bowling games = 49.9% interactive vs. 46.3% of session time online; running games = 48% interactive vs. 44.2% of session time online).

Children spent the largest amount of time playing the interactive bowling game (mean = 29.9 min, SD = 9.9), followed by the interactive running game (mean = 28.8 min, SD = 6.9), online bowling game (mean = 27.8 min, SD = 9.6), and online running game (mean = 26.5 min, SD = 7.0). Figure 1 shows the mean minutes spent in

Table 1 Physical Characteristics of Participants (Mean and SD)

		Gender		Body weight	
Variables	Total (N = 70)	Boys (n = 35)	Girls (n = 35)	Nonoverweight (n = 50)	Overweight (n = 20)
Height (cm)[b]	145.4 ± 7.1	145.0 ± 7.2	145.9 ± 7.1	144.2 ± 6.2	148.7 ± 8.3
Weight (kg)[a,c]	40.1 ± 10.8	43.1 ± 12.5	37.1 ± 8.0	35.0 ± 5.7	53.0 ± 10.0
BMI (kg/m^2)[a,c]	18.7 ± 3.9	20.2 ± 4.5	17.3 ± 2.4	16.8 ± 1.9	23.7 ± 2.8
Fat mass (kg)[a,c]	8.9 ± 5.7	10.8 ± 6.7	7.1 ± 3.8	6.2 ± 2.6	15.9 ± 5.5
Fat free mass (kg)[c]	31.2 ± 5.9	32.4 ± 7.0	30.0 ± 4.4	28.9 ± 3.6	37.1 ± 6.6
Percent body fat[a,c]	20.6 ± 7.8	23.2 ± 8.8	18.1 ± 5.5	17.0 ± 4.6	29.6 ± 6.6

Abbreviations: BMI, body mass index

[a] Differences between gender groups ($P \leq .01$).

[b] Differences between nonoverweight and overweight groups ($P < .05$).

[c] Differences between nonoverweight and overweight groups ($P < .001$).

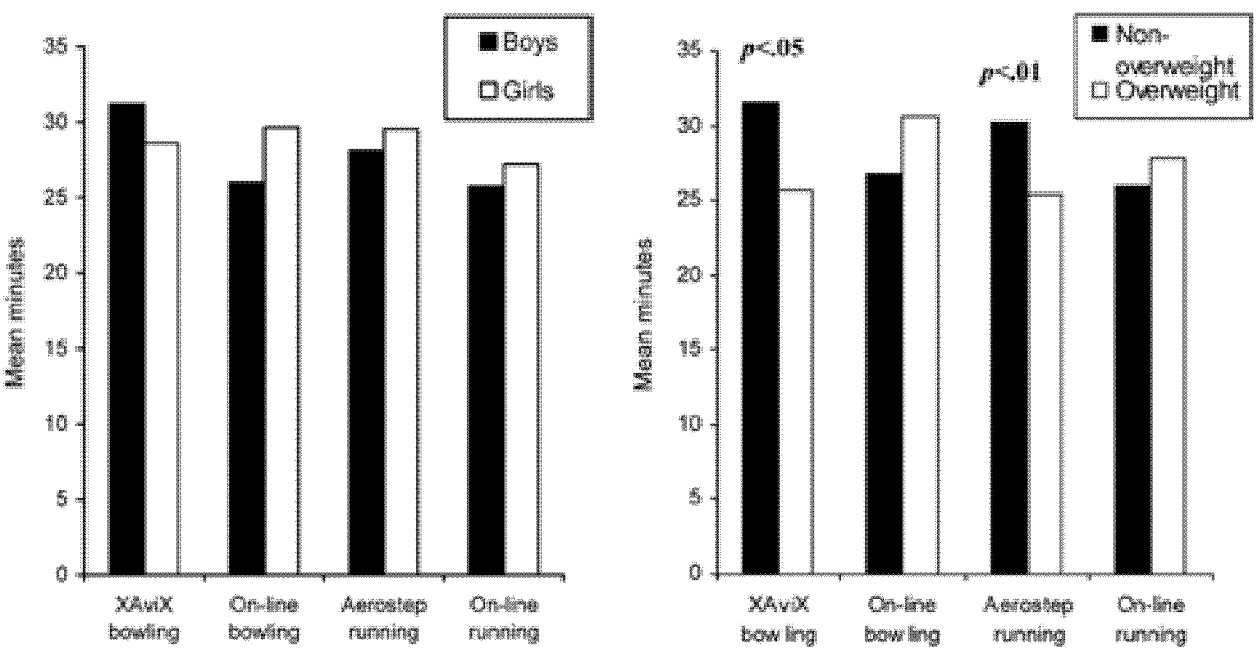

Figure 1 — Mean minutes spent in each game mode by gender and body weight classification.

each game mode by gender and body weight classification. There were no significant gender differences on how much time was spent on the 4 games (all $P > .05$). Nonoverweight children, however, spent more time on the interactive versions of both the bowling ($P < .05$) and running games ($P < .01$) than their overweight counterparts.

Physical Activity During Sessions

Table 2 shows children's overall activity levels during the 1-hour bowling and running game sessions. Children were substantially more physically active during sessions that offered running games rather than bowling games. Overall, the time spent in MVPA during each session was 52.7% (equivalent to 29.1 minutes) and 38.9% (equivalent to 22.4 minutes) for running and bowling games, respectively. During bowling games, boys had higher MVPA% ($P \leq .01$), EER ($P < .0001$), and TEE ($P \leq .01$) than girls, but during running games the only significant difference was for EER ($P < .0001$). Nonoverweight children had a greater MVPA% ($P < .0001$) and TEE ($P < .0001$) during running game sessions than overweight children.

Figure 2 shows MVPA percent in each game mode by gender and body weight groups. Overall children engaged in greater MVPA percent during interactive games than their online electronic versions, with the interactive running game producing the highest MVPA percent. During interactive bowling boys engaged in greater MVPA percent (82.3% vs. 60.2%, $P < .0001$) than girls. No significant differences in the 4 game modes were found for body weight status.

Table 2 Children's Overall Activity Levels Throughout Entire 60-Minute Bowling Game and Running Game Sessions

	Bowling game mean min. = 57.7			Running game mean min. = 55.3		
Group	**MVPA % (min)**	**EER (mean)**	**TEE (mean)**	**MVPA % (min)**	**EER (mean)**	**TEE (mean)**
Overall	38.9 (22.4)	0.13	3.90	52.7 (29.1)	0.18	5.20
Boys	46.9 (27.1)[a]	0.14[b]	4.13[a]	51.2 (28.3)	0.19[b]	5.09
Girls	30.9 (17.8)	0.13	3.68	54.1 (29.9)	0.18	5.31
Nonoverweight	40.5 (23.4)	0.13	3.98	55.1 (30.5)[c]	0.18	5.36[c]
Overweight	34.8 (20.1)	0.13	3.72	46.6 (25.8)	0.18	4.80

Abbreviations: MVPA, moderate to vigorous physical activity (walking + vigorous); EER, energy expenditure rate ($kcal \cdot kg^{-1} \cdot min^{-1}$); TEE, total energy expenditure ($kcal \cdot kg^{-1}$).

[a] Differences between gender groups ($P \leq .01$).

[b] Differences between gender groups ($P < .0001$).

[c] Differences between nonoverweight and overweight groups ($P < .0001$).

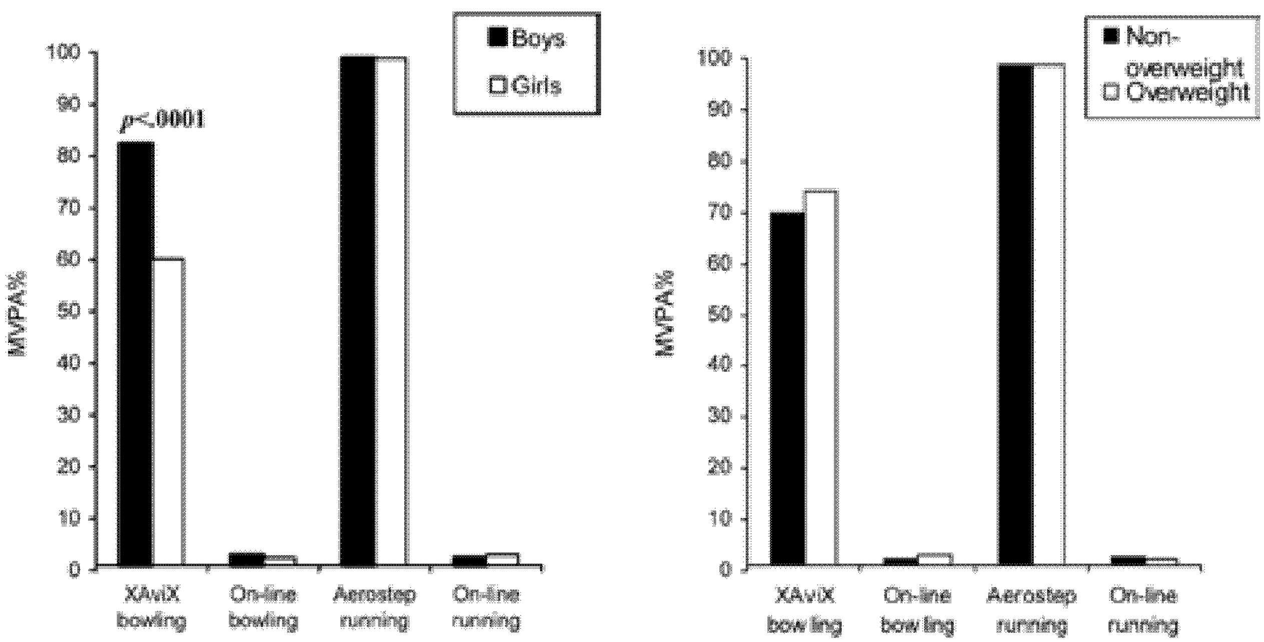

Figure 2 — Proportion of time spent in MVPA during game modes by gender and body weight classification. MVPA = moderate to vigorous physical activity (walking + vigorous).

Discussion

Children were given a choice of how to spend their time during 2 1-hour sessions, and they spent 94% of it playing games, splitting their games between interactive (52%) and online electronic versions (48%). The children were much more physically active during interactive versions of games, and engaged in MVPA 99% of the time they engaged in the interactive running game and 70% of the time they played the interactive bowling game. These results are congruent with previous findings,[15–17,21] providing further indication that interactive games involve substantial amounts of physical activity and when given an opportunity children may choose them.

While children spent approximately half their time on the 2 different game modes, during interviews many indicated that they strongly preferred the interactive versions. They frequently indicated they changed to online versions only when they became tired and that they switched back when they had recovered. Overall they were more positive about the interactive games than the online versions, and they ranked the Aerostep running game as their favorite. This game was particularly attractive for the Hong Kong children because they could mimic "Jackie Chan" and "travel" through the streets of Hong Kong while using walking, running, jumping, and side-stepping actions on a mat. The children periodically encountered potential combatants during their travels, and they avoided them and made them disappear by quickly stepping on places on a mat. That game also provided a performance grade, ranging from A+ to F, at the end of each 5-minute workout to indicate children's progress, thus serving to reinforce doing more trials, playing longer, and exerting more effort. The interactive bowling game was much less vigorous than the interactive running game, but it nonetheless actively engaged children in bowling simulations that involved walking and moving the arms and torso.

Adolescent girls are typically less active than boys in leisure time settings,[6] and it is important to be able to provide venues for them to engage in MVPA and vigorous physical activity. Previous work reported no gender differences in use of interactive games by children.[17,20] In the current study boys were much more physically active than girls during interactive bowling game, but in the interactive running game girls were at least as active (and sometimes more) than boys.

Nonoverweight children spent more time playing the interactive versions of games than those who were overweight (31.6 vs. 25.7 minutes during XAviX bowling; 30.2 vs. 25.4 minutes during Aerostep running game). In contrast, overweight children spent more time playing the online versions. Nonoverweight children also had a higher MVPA% and greater TEE during the entire running game session than their overweight counterparts, but not during the entire bowling session. These findings were consistent with a study by Epstein et al[21] which reported that nonoverweight children were more active and responsive to interactive games.

The current study supports the tenets of behavioral choice theory and provides further evidence that making interactive games available may reduce the time children spend in sedentary pursuits.[19,31,32] Given that children often prefer electronic games to physical activity and that parents are frequently challenged to limit the use of sedentary electronic media,[33] the provision of active versions of popular electronic games appear to be a viable and appealing way to promote physical activity. While these games may increase children's activity levels, the amount might not be enough to contribute substantially to the recommended amount of daily activity.[16] In this controlled environment, however, access to interactive versions of games reduced sedentary screen-time to about half of each 60-min session, and children accrued from 22.4 to 29.1 minutes of MVPA each hour.

Children are primarily sedentary when observed at home[11,12] and the opportunity to participate in interactive games might also increase physical activity in that location. Parents are the main purchasers of the toys their children use, and they typically have a choice in both the content (eg, bowling or running games) and mode (ie, interactive or online) of the games they buy. If a child had access to the Aerostep running game at home and played it for a half hour each day rather than being sedentary, he/she would be half way toward the 60 minutes per day recommendation for physical activity accrual. Changes of this type are especially crucial to overweight children who tend to adopt sedentary lifestyles. Interactive games might work exceptionally well in smaller homes or apartment buildings where ample play space is not available, such as in Hong Kong. It should be noted, however, that the Jackie Chan Aerostep running game may have less appeal to children outside of Hong Kong, and it may be necessary to have interactive electronic games tailored for specific countries or regions.

To conclude, the results of this study suggest that interactive electronic games have potential to encourage children to engage in physical activity while decreasing the time they spend in sedentary screen-time. It is not our intention to encourage children to participate in interactive electronic games instead of other forms of physical activity such as organized sport or outdoor play. However, participating in interactive games is a better choice of that participating in the sedentary versions of the games. Over time, engaging in physical activity during interactive games may improve children's fitness and movement skills and encourage them to be active in nonelectronic environments (eg, free play, sports) and subsequently play a role in reducing childhood obesity. Limitations of the study include the assessment of children's physical activity levels in a controlled setting and the examination of only 2 paired interactive and online electronic games. Future research could be extended to using other objective measures of physical activity and to assessing the long term outcomes of an interactive games intervention on children's levels of physical activity over time (eg, assess for maintenance of physical activity and levels of boredom with games). Observations of the effects of interactive games in natural settings, such as at home and during leisure time at school are also recommended.

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