Use of Active Video Games to Increase Physical Activity in Children: A (Virtual) Reality?

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There has been increased research interest in the use of active video games (in which players physically interact with images onscreen) as a means to promote physical activity in children. The aim of this review was to assess active video games as a means of increasing energy expenditure and physical activity behavior in children. Studies were obtained from computerised searches of multiple electronic bibliographic databases. The last search was conducted in December 2008. Eleven studies focused on the quantification of the energy cost associated with playing active video games, and eight studies focused on the utility of active video games as an intervention to increase physical activity in children. Compared with traditional nonactive video games, active video games elicited greater energy expenditure, which was similar in intensity to mild to moderate intensity physical activity. The intervention studies indicate that active video games may have the potential to increase free-living physical activity and improve body composition in children; however, methodological limitations prevent definitive conclusions. Future research should focus on larger, methodologically sound intervention trials to provide definitive answers as to whether this technology is effective in promoting long-term physical activity in children.

Childhood obesity has reached epidemic proportions in developed countries. In the United States, the prevalence of overweight for children increased by 182% between 1971–74 and 1999–2000 (11). Similar increases have been reported for Canada, Finland and China (13,15,39). In New Zealand, one third of children are currently overweight or obese (23). Obesity is associated with a myriad of negative health effects, including increased incidence of Type II diabetes and heightened risk of cardiovascular disease (5,29). This increase in obesity rates has been proposed to be related to changes in physical and social environments, which increasingly promote a high energy intake and sedentary behaviors (9). For example, in New Zealand, three in every ten children do little or no physical activity, which mimics world-wide trends (23).
Technological advancement has led to a dramatic increase in the time children spend in sedentary screen-based activities, such as watching television, playing video games, and using computers. These screen-based activities are thought to displace active behaviors and have been independently associated with obesity (31) and other adverse health outcomes such as hypertension (27). Television watching is also thought to increase exposure to food advertisements and consumption of energy dense snack foods. Screen-time accounts for the largest proportion of children’s sedentary time (4). Interventions aimed at decreasing screen-time have been largely unsuccessful because children value these activities (38). When developing interventions to decrease sedentary time and/or increase physical activity, Marshall et al. (20) recommended that the context of the preferred activity be maintained. Subsequently, population health researchers have begun to develop novel interventions that use technology as part of the solution rather than part of the problem.

One such intervention is the use of active video games. These are electronic games that allow players to physically interact (using arm, leg, or whole-body movement) with images onscreen in a variety of activities such as sports (e.g., football, boxing, martial arts) and other activities (dancing, washing windows etc). Games are dependent on player movement either through a camera (Sony EyeToy), infra-red sensor (Nintendo Wii and XaviX), laser (Lasersquash), pressure-sensitive mat/table (Dance Dance Revolution, XaviX J-mat and ApartGame) or modified ergometer (Xerbike or GameCycle). This active component replaces the largely sedentary hand controller of traditional video games whereby button pushing is used to control the game. Researchers have begun to examine the utility of active video games to replace sedentary video games as a means for increasing physical activity in children. The literature to date has focused primarily on two aspects: 1) quantification of the energy cost of playing active video games; and 2) determining whether active games can be successfully used as an intervention to increase free-living physical activity and improve physiological and/or body composition outcomes in children. The purpose of this review is to identify and review the extant literature for the use of active video games as a means to increase energy expenditure and promote physical activity in children.

Methods

Criteria for Considering Studies for This Review

Types of Studies. Randomized controlled trials (RCT’s), quasi-experimental studies and laboratory-based studies were included. Studies published before 2000 were not included, as active video game technology did not exist before this time.

Types of Participants. Participants (both males and females) aged 18 years or under were included in the review. Studies examining the use of active video games in college-age participants were excluded.

Types of Interventions. Studies that used active video games were included (see definition above). To meet the definition of active video game, it was required that physical interaction with the game was essential to play the game. For example, interventions in which participants pedalled a modified ergometer to keep a television on were not included, nor were studies where traditional hand-controller games were
played while standing instead of sitting. In addition, recreation and activity needed to be the main purpose of the video game; interventions in which virtual reality simulations were used to improve decision making or navigation were also excluded.

**Types of Outcome Measures.** Studies that measured physical activity, energy expenditure, cardiovascular fitness or body composition were included. Details regarding adverse events are presented where these were reported.

The following databases were searched for relevant articles: MedLine, PubMed, Embase, PsychInfo, Cinahl and Cochrane Controlled Trials Register. The reference lists of eligible articles were screened. Conference abstracts from relevant conferences were screened, and attempts were made to contact the authors of relevant dissertations to obtain copies. The last search was conducted in December 2008.

**Results**

Five hundred and fifty-three abstracts were identified and screened. Eleven studies were identified that quantified the energy cost of playing active video games using indirect calorimetry (Table 1). In addition, eight studies were identified that focused on the utility of active video games as an intervention to increase physical activity and/or improve body composition in children (Table 2).

**Energy Expenditure Studies**

Eleven studies were conducted which quantified the energy expended playing active video games, of which four used Metabolic Equivalents (METS) to describe the intensity of the activity. METs are multiples of resting metabolic rate, with values of $< 3 =$ light intensity; $3–6 =$ moderate intensity; and $> 6 =$ vigorous intensity activity (1). However, MET values were originally derived from adult data, and it may not be appropriate to apply these same values to children as this could result in over-estimation of the energy expenditure of the activity. For children, it has been recommended that child-specific METS are used by dividing activity VO$_2$ by resting VO$_2$ (35). However, only one (16) of the 11 studies presented child-specific METS.

A study of four different arcade-style active games (simulated driving, horse-racing, basketball and table hockey) showed that energy expenditure was significantly elevated above rest (32). More recent research examined a dance simulation game (Dance Dance Revolution) and found energy expenditure values equivalent to 7.0 METS (37). In this study, no adverse events were reported during 201 hr of play. Straker & Abbott (36) compared the Sony EyeToy with sedentary gaming and TV watching and found that energy expenditure was 224% higher during active gaming than during TV watching, and was significantly higher than sedentary gaming. Graves et al. (6,7), Maddison et al. (16) and Mellecker et al. (22; using the Nintendo Wii, Sony EyeToy and XaviX respectively) also compared active and sedentary gaming and found significantly greater energy expenditure in active games as compared with sedentary gaming and rest.

However, different types of active games have been shown to elicit varying energy expenditure values, with some more vigorous than others. Ridley et al. (32) found that energy expenditure ranged widely (from 2.2–7.6 METS) between the different arcade games. Similarly, Simons et al. (34) found that only four of six active games (Xerbike, Lasersquash, ApartGame and Dance Dance Revolution)
<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Design</th>
<th>Sample Description</th>
<th>Game Type</th>
<th>Measures</th>
<th>Result</th>
</tr>
</thead>
</table>
| Ridley (32)      | 2001 | Laboratory study  | $n = 10$
Males/females
Mean age = 12.5yr | Arcade games
(driving, table
hockey, horse-
racing, basketball)                                      | $\text{VO}_2$ (indirect calorimetry)
Heart rate
Accelerometer counts
(Caltrac)                                      | Energy expenditure = 0.16–0.57 kJ.kg$^{-1}$.min$^{-1}$
Heart rate = 112–169 bpm
Accelerometer counts = 0–1.3 counts. min$^{-1}$ |
| Tan (37)         | 2002 | Laboratory study  | $n = 40$
Males/females
Mean age = 17.5yr | Dance Dance Revolution | $\text{VO}_2$ (indirect calorimetry)
Heart rate                                      | Energy expenditure = 2.2–7.6
Energy expenditure = 480 watts
Heart rate = 137 bpm
METS = 7.0 |
| Lanningham-Foster (14) | 2006 | Laboratory study  | $n = 25$
Males/females
Age 8–12yr | Sony EyeToy, Dance Dance Revolution | $\text{VO}_2$ (indirect calorimetry)                      | Energy expenditure = 13.61–17.26 kJ.h$^{-1}$.kg$^{-1}$ |
| Unnithan (40)    | 2006 | Laboratory study  | $n = 22$
Males/females
Age 11–17yr | Dance Dance Revolution | $\text{VO}_2$ (indirect calorimetry)
Heart rate                                      | Energy expenditure = 2.9–4.6 kcal.min$^{-1}$
Heart rate = 126–127 bpm |
| Straker (36)     | 2007 | Laboratory study  | $n = 20$
Males/females
Age 9–12yr | Sony EyeToy | $\text{VO}_2$ (indirect calorimetry)
Heart rate                                      | Energy expenditure = 0.127 kcal.min$^{-1}$.kg$^{-1}$
Heart rate = 130 bpm |
| Maddison (16)    | 2007 | Laboratory study  | $n = 21$
Males/females
Age 10–14yr | Sony EyeToy | $\text{VO}_2$ (indirect calorimetry)
Heart rate
Accelerometer counts
(Actigraph)                                      | Energy expenditure = 2.9–6.5 kcal.min$^{-1}$
Heart rate = 110–142 bpm
Accelerometer counts = 122.9–2,132 counts. min$^{-1}$
METS = 2.3–5.0 | (continued)
<table>
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<tr>
<th>Author</th>
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<th>Sample</th>
<th>Game Type</th>
<th>Measures</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graves (6,7)</td>
<td>2007/2008</td>
<td>Laboratory study</td>
<td>n = 11 Males/females Age 13–15yr</td>
<td>Nintendo Wii</td>
<td>IDEAA counts</td>
<td>Energy expenditure = 190.6–202.5 kJ.kg⁻¹.min⁻¹</td>
</tr>
<tr>
<td>Mellecker (22)</td>
<td>2008</td>
<td>Laboratory study</td>
<td>n = 18 Males/females Age 6–12yr</td>
<td>XaviX</td>
<td>VO₂ (indirect calorimetry) Heart rate</td>
<td>Energy expenditure = 1.89–5.23 kcal.min⁻¹ Heart rate = 102–160 bpm</td>
</tr>
<tr>
<td>Simons (34)</td>
<td>2008</td>
<td>Laboratory study</td>
<td>n = 12 Males/females Age 7–13yr</td>
<td>Xerbike, Laser-squash, Apart-game, Dance Game, Dance Revolution, Sony EyeToy, Nintendo Wii</td>
<td>VO₂ (indirect calorimetry) Accelerometer counts (Actigraph)</td>
<td>METS = 4.4–9.8</td>
</tr>
<tr>
<td>Graves (8)</td>
<td>2008</td>
<td>Laboratory study</td>
<td>n = 13 Males/females Age 11–17yr</td>
<td>Nintendo Wii</td>
<td>VO₂ (indirect calorimetry) Heart rate (Actiheart) Accelerometer counts (Actigraph)</td>
<td>Energy expenditure = 182.1–267.2 J.kg⁻¹.min⁻¹ Heart rate = 103.2–136.7 bpm</td>
</tr>
</tbody>
</table>
## Table 2  Intervention Studies

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Design</th>
<th>Sample</th>
<th>Intervention Length &amp; Game Type</th>
<th>Measures</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maloney (19)</td>
<td>2008</td>
<td>2-arm RCT</td>
<td>$n = 60$ Males/females Age 7–8yr</td>
<td>10 weeks (28 week FU) Dance Dance Revolution</td>
<td>Physical activity (accelerometer) Physical activity (pedometer) Sedentary screen time Body Mass Index Blood pressure Pulse Active video game use</td>
<td>Sig. ↑ in vigorous PA in intervention group 0–10 weeks Sig. ↓ in sedentary screen time in intervention group compared with control group 0–10 weeks Mean game use 89 mins.week in intervention group 0–10 weeks No sig. changes in anthropometric measures 0–10 weeks</td>
</tr>
<tr>
<td>Ni Mhurchu (25)</td>
<td>2008</td>
<td>2-arm RCT</td>
<td>$n = 20$ Males/females Age 10–14yr</td>
<td>12 weeks Sony EyeToy</td>
<td>Physical activity (accelerometer) Physical activity (self-report) Active and nonactive video game use Body Mass Index Waist circumference</td>
<td>Sig ↓ in time spent playing nonactive video games in intervention group compared with control No sig. differences between groups for moderate-vigorous PA Sig. ↓ in waist circumference in intervention group compared with control group</td>
</tr>
<tr>
<td>Murphy (24)</td>
<td>2006</td>
<td>2-arm RCT</td>
<td>$n = 35$ Males/females Age 7–12yr Overweight</td>
<td>12 weeks Dance Dance Revolution</td>
<td>Physical activity (pedometer) Physical activity (self-report) Body Mass Index Waist/hip circumference Cardiovascular fitness Blood pressure Blood chemistry</td>
<td>No sig. differences between groups for physical activity Intervention group gained sig. less weight than control group Sig ↑ in cardiovascular fitness in intervention group compared with control group Sig ↓ in mean arterial pressure in intervention group compared with control group</td>
</tr>
</tbody>
</table>

(continued)
<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Design</th>
<th>Sample</th>
<th>Intervention Length &amp; Game Type</th>
<th>Measures</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palmeira</td>
<td>2008</td>
<td>2-arm intervention (nonrandomized)</td>
<td>n = 15</td>
<td>4 weeks Sony EyeToy</td>
<td>Physical activity (accelerometer)</td>
<td>Sig ↑ in moderate physical activity in intervention group compared with control group</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Males/females Mean age = 13.6yr Overweight</td>
<td></td>
<td></td>
<td>Sig ↓ in sedentary behavior in intervention group compared with control group</td>
</tr>
<tr>
<td>McDougall</td>
<td>2008</td>
<td>1-arm intervention (no control)</td>
<td>n = 12</td>
<td>1 week Sony EyeToy</td>
<td>Physical activity (pedometer) Heart rate Perceptions of active video games</td>
<td>Intervention group did average 1408 steps and 11 min of moderate-vigorous PA per active video game session on average During active video game play, heart rate was 148 bpm on average Children reported liking games and would use them in future Use of active video game not associated with change in BMI at 3 or 6 months</td>
</tr>
<tr>
<td>Madsen</td>
<td>2007</td>
<td>1-arm intervention (no control)</td>
<td>n = 30</td>
<td>24 weeks Dance Dance Revolution</td>
<td>Body Mass Index Active video game use</td>
<td>Sig ↑ in maximum work capability</td>
</tr>
<tr>
<td>Widman</td>
<td>2006</td>
<td>1-arm intervention (no control)</td>
<td>n = 8</td>
<td>16 weeks GameCycle</td>
<td>Maximum work capability</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Males/females Age 9–18yr Overweight</td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Spina bifida Mean age = 15.5yr (girls) 17.5yr (boys)</td>
<td></td>
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</tr>
<tr>
<td>Paw</td>
<td>2008</td>
<td>2-arm RCT</td>
<td>n = 27</td>
<td>12 weeks Dance simulation</td>
<td>Body Mass Index Cardiovascular fitness Skinfolds thickness Physical activity (self-report) Sedentary behavior (self-report) Active video game use</td>
<td>No sig. differences between groups for minutes playing active video games Sig. lower drop-out in multiplayer group compared with home group</td>
</tr>
</tbody>
</table>
were associated with energy expenditure of greater than 5 METS. Graves et al. (6,7) reported that energy expenditure was highest during Nintendo Wii virtual tennis, followed by boxing and bowling. Maddison et al. (16) reported child-specific METS ranging between 2.3 and 5.0 for Sony EyeToy games, with the most vigorous being Play2 Knockout (boxing) and HomeRun (baseball).

The amount of upper, lower and full-body involvement while playing is important in terms of the intensity and overall energy cost of the games and has been examined in three studies. Of these, Maddison et al. (16) concluded that Sony EyeToy games that required whole-body movement resulted in the greatest energy expenditure (4.8–5.0 METS) with upper-body dominant games resulting in light intensity movement (2.3–2.9 METS). These findings are supported by Lanningham-Foster et al. (14) who found that a dancing simulation game (Dance Dance Revolution) elicited significantly greater expenditure than a Sony EyeToy game that was predominantly upper-body movement based. More recently, research in this area examined the contribution of upper- and total-body movement to overall energy expenditure during active gaming (8), and found that while playing Nintendo Wii virtual boxing, bowling and tennis, energy expenditure was greatest when movement of both arms was required rather than one. Contrary to prior research by the same author, boxing elicited the greatest energy expenditure (3.2 METS), followed by tennis and bowling (8). However, the authors noted that playing the real sports expends substantially greater energy expenditure than the simulated games.

Research examining a differential energy cost associated with active gaming between overweight and nonoverweight children was equivocal. For walking and running, it has been found that overweight children expend more energy than normal weight children (12,18). However, this has been only partially supported in the small number of active video game studies examining this topic to date. Unnithan et al. (40) found that absolute VO₂ was greater in overweight children playing Dance Dance Revolution compared with nonoverweight children, though this disappeared when VO₂ was corrected for differences in fat-free mass. Similarly, Lanningham-Foster et al. (14) found that obese children had significantly greater absolute energy expenditure than nonobese children when playing Sony EyeToy and Dance Dance Revolution; however, this difference disappeared when corrected for body weight.

Several studies (6–8,16,32,36,37) have investigated whether gender differences exist in the energy expended during active video game play; however the evidence to date is equivocal in this regard. Five studies (6,7,32,36,37) found a trend for greater heart rate, oxygen consumption or energy expenditure in boys playing active games compared with girls, though few statistically significant differences existed. Conversely, one other study found that girls had a significantly higher heart rate than boys during active gaming (8), while another (16) found no differential effect by sex.

There is some disagreement as to whether these games are vigorous enough to cause appreciable change to body composition or cardio-respiratory fitness. Straker et al. (36) extrapolated their energy expenditure data and estimated that 15 min per day of active video game play would result in approximately 2.5kg loss of adipose tissue per year if energy balance remained constant. Maddison et al. (16) estimated that 30 min of video game play per day, five days per week would result in a child losing 1kg of adipose tissue in nine weeks (or nearly 6kg per year), if all other factors remained constant. Other studies (8,37,40) have examined whether active games met the American College of Sports Medicine (ACSM) guidelines (30) for
the development and maintenance of cardio-respiratory fitness. According to these guidelines, exercise must be at a minimum intensity of 60% of maximum heart rate (HR\text{max}), 50% of heart rate reserve (HRR) or 50% of VO\textsubscript{2} reserve, for a duration of at least 10 min. Tan et al. (37) found that the intensity of the games met the HR\text{max} and HRR guideline, but did not meet the minimum VO\textsubscript{2} reserve. Furthermore, the mean duration of play was 6 min, which was below the recommended duration. Unnithan et al. (40) also found that active video game playing met the HR\text{max} but did not meet the VO\textsubscript{2} reserve guideline for minimum exercise intensity. However, these guidelines were developed for adults and recent work suggests a higher intensity is required for the development of cardio-respiratory fitness in children (3). Graves (8) found that active video game playing met the HR\text{max} guideline, but concluded that this intensity was not sufficient to improve fitness in this population. Three other studies (16,34,36) presented data to determine whether playing active video games could contribute to children meeting existing physical activity recommendations. International guidelines recommend the accumulation of 60 min of moderate-vigorous physical activity per day for children (2). Straker et al. (36), Maddison et al. (16) and Simons et al. (34) concluded that active games were of sufficient intensity to contribute to daily physical activity, depending on the duration and frequency of play.

**Intervention Studies**

Eight intervention studies were identified. Findings from three studies (19,25,26) suggest active games can improve levels of physical activity in children. In the first study Ni Mhurchu et al. (25) conducted a randomized controlled pilot study to examine the effect of a 12-week Sony EyeToy intervention on physical activity levels. Twenty children were randomly assigned to either receive an upgrade of their existing PlayStation\textsuperscript{2}TM console, which permitted them to play EyeToy video games (n = 10), or no change (control; n = 10), in which they were told to continue with their usual video game play. Children who received the active games had significantly higher levels of accelerometer-measured physical activity at six and 12 weeks compared with those in the control condition. The intervention group also showed significant reductions in total self-reported video game play compared with the control group at six and twelve weeks. A smaller second study by Palmeira et al. (26) examined the effect of a four-week Sony EyeToy intervention on both sedentary and physical activity behavior in 15 overweight children. The intervention group (n = 10) significantly decreased sedentary activity and increased accelerometer-measured moderate physical activity compared with the control group (n = 5). However, there was no random assignment in this study. The most recent study by Maloney et al. (19) randomly assigned 60 children to either a 10-week Dance Dance Revolution intervention (n = 40) or wait-list control (n = 20). At 10 weeks, the control group were given the active games, with outcomes assessed at 10 and 28 weeks. Accelerometer-measured vigorous physical activity significantly increased within the intervention group from baseline to 10 weeks; however, no statistically significant differences were found between the groups for this variable at 10 weeks. There was a significant between-groups effect for hours per week of sedentary screen time. In the intervention group, screen time decreased significantly, whereas in the control group screen time increased.

One study examined the acute effects of an active video game intervention. McDougall et al. (21) used a mixed-methods approach to examine the effect of
a brief (one-week) school-based Sony EyeToy intervention on physical activity during lunch time (as measured by both pedometry and heart-rate monitoring) and perceptions of video games in 12 children. Acute effects were found with children accumulating an average of 1408 steps and 11 min of moderate-to-vigorous physical activity per video game session. Postintervention, children reported enjoying the games and felt they would continue to play them if given the opportunity. This study did not include a control group thus comparisons could not be made.

One other study found no effect on physical activity. Murphy et al. (24) randomly assigned 35 overweight children to either a 12-week Dance Dance Revolution intervention \((n = 23)\) or a wait-list control \((n = 12)\). No significant differences between groups in either weekly or total pedometer step counts were found at 12 weeks.

Intervention studies have also investigated the effect of active games on body composition and physiological markers related to obesity. Despite showing no statistically significant differences in physical activity levels, Murphy et al. (24) found that the intervention group had significantly increased cardiovascular fitness and decreased mean arterial pressure compared with control. While both groups gained weight during the course of the study, the intervention group gained significantly less. Ni Mhurchu et al. (25) found a significant decrease in waist circumference in children who received the active games compared with the control group. Madsen et al. (17) examined the effect of a Dance Dance Revolution intervention on body mass index (BMI) in 30 overweight children over six months (physical activity was not measured). Active video game use was not associated with change in BMI at either three or six months. In this study, there was no control as all participants received the intervention. One study was identified that examined a special population of adolescents with spinal cord dysfunction (41). Eight children underwent a four-month intervention using the GameCycle, a modified arm ergometer which allowed for traditional video games to be controlled with arm cranking. Compared with preintervention, there was a significant increase in maximum work capability; however there was no control group in this study.

Compliance with the active video game interventions generally appeared to be high in studies with shorter durations. Murphy et al. (24) measured compliance via self- and parent-report and found that 75% adhered to the prescribed protocol of 10–30 min play, five days per week. Ni Mhurchu et al. (25) found that children in the intervention group played on average, more minutes of active games per day than those in the control group \((41 \text{ vs. } 27 \text{ min/day})\), though there was no specific prescription given for amount of play. Interestingly, children in the intervention group tended to spend less time playing all types of video games than those in the control group. However, Madsen et al. (17) found very low levels of compliance, despite prescribing a similar protocol to Murphy et al. (24; 30 min, five days per week). Only 12 out of 30 children used the games at least twice per week in the first three months of the intervention, with this dropping to two children in the second three months of the intervention. Paw et al. (28) tested the effect of adding regular multiplayer sessions to a prescribed protocol of home-based individual use as a strategy to improve compliance. Children who were randomly assigned to play both multiplayer and individual sessions of a dancing simulation game \((n = 13)\) played for twice as many minutes during their individual sessions than those who were randomly assigned to play individual sessions only \((n = 14)\) over the 12-week intervention. Playing duration decreased over time in the individual group, but increased over time in the multiplayer group.
Discussion

Without exception, active video games have been shown to elicit greater energy expenditure compared with rest and traditional nonactive video games, as well as other common sedentary activities such as TV watching. The energy expenditure associated with playing active video games is comparable to mild to moderate intensity physical activity in children. Although these active games are more vigorous than traditional video games, it is not clear whether children would play these games with sufficient intensity, frequency and duration in a real-world situation to gain cardiovascular or health benefits. In the energy expenditure studies described, game play occurred continuously, and the measurement period was less than 10 min. However in a naturalistic setting, the nature of video game playing is intermittent, and therefore the energy expenditure is not uniform across the gaming session. It may be that active games hold promise as an intervention only if they displace nonactive video games and/or other sedentary activities (such as watching television) as opposed to vigorous activities (such as playing sports).

The large variation in energy expenditure values between different games has implications for the design of future active video games and suggests that active video games should be designed to maximize whole-body movement if they are to have a physiological health benefit. Further research is required to clarify if differences in energy expenditure exist between overweight and nonoverweight children during active gaming. This has implications for the potential target populations of future active video game interventions; in overweight children, the relatively higher exercise intensity may confer greater health benefits (40). Further clarification is also required of possible gender differences in energy expenditure during active gaming. While it appears that boys play active video games more vigorously than girls, this relationship may be confounded somewhat by playing experience. A study in a sample of college-age participants (excluded from this review due to the stated age criteria) found that experienced players worked at higher intensity during active gaming than those with less experience (33), and this may also be the case in children. As boys tend to be greater users of video game technology than girls (10), this may partially explain findings to date.

Encouraging findings exist from the small number of intervention studies conducted to date, which suggest that active games have the potential to increase free-living physical activity and improve body composition in children. Notwithstanding these positive findings, methodological limitations prevent definitive conclusions. All of the studies conducted to date have included small sample sizes (n ranging from 8 to 60) and were underpowered and of insufficient duration (12 weeks or less) to detect the small changes that are likely to occur to variables such as BMI. Several studies did not include a control group (17,21,41), and one other did not use randomisation (26). Furthermore, two trials (17,26) were conducted in a hospital setting, where participants were likely receiving other obesity interventions. There is also inconsistency between studies in the measurement of primary outcomes. For example, physical activity has been measured by self-report questionnaire, pedometer and accelerometer. Because active video gaming technology is relatively new, it may be that physical activity elicited during this type of gaming is poorly captured with traditional physical activity questionnaires. Furthermore, the type of movement generated during active gaming should be carefully considered when selecting a device to objectively measure physical activity. As evidenced in
the energy expenditure literature, active gaming involves both upper- and lower-body movement to different degrees depending on the type of game being played. Pedometers are therefore poorly suited to measuring the full spectrum of movement elicited during active video gaming. Accelerometers, while able to measure a greater range of movement, are still limited to capturing predominantly lower body movement when the traditional placement site of the hip is used. The strength of the relationship between activity counts from accelerometry and energy expenditure measured by indirect calorimetry during active gaming is somewhat tenuous; one study found a poor correlation (32), whereas another more recent study found a strong relationship (8). Graves et al. (8) tested several accelerometer placement sites and found that traditional hip placement was superior to wrist placement for assessment of energy expenditure during active gaming. The IDEAA (intelligent device for energy expenditure and activity) device has also been used to estimate energy expenditure during active gaming (6,7), though again is limited by an inability to detect arm movement well. The use of both subjective and objective measurement of physical activity in active video game trials should be considered.

A critical issue in the intervention research to date is whether the games are sufficiently attractive enough to children for consistent play to occur. The length of the intervention periods ranged from one week to six months; due to the critical nature of compliance with protocol future studies should have longer intervention and follow-up periods to examine long-term stability of game use.

In summary, future research should focus on larger, methodologically sound intervention trials to provide definitive answers as to whether this technology is effective in promoting long-term physical activity in children. A search of existing clinical trials databases identified one large trial (n = 330) currently in progress examining the effect of active video games on children’s body composition and physical activity. Gaming technology is continually evolving and refining to accommodate consumer demand for new gaming experiences. Interventions that use this technology should take advantage of this to provide an attractive intervention to the population of interest.

Conclusions
Active video games have the potential to displace what is traditionally a sedentary behavior with a more active one. Laboratory-based findings indicate that playing these games result in greater energy expenditure compared with nonactive video games, and are equivalent to mild to moderate-intensity physical activity. Preliminary active video game intervention research has shown encouraging results in terms of increasing children’s free-living physical activity levels.

References
Active Video Games to Increase Physical Activity


