Stationary cycling exergame use among inactive children in the family home: A randomized trial

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Abstract

Exergames may be one way to increase child physical activity, but long term adherence has seen little research attention. The primary objective of this study was to evaluate the usage of an exergame bike in comparison to a stationary bike in front of a TV across three-months within a family home environment among children aged 10-14 years old. Seventy-three inactive children were recruited through advertisements and randomized to either the exergame condition (n = 39) or the standard bike condition (n = 34). Weekly bike use was recorded in a log-book. Both groups declined in bike use over time ($t = 3.921$, $p < .01$). Although the exergame group reported higher use ($t = 2.0045$, $p < .05$), this was most prominent during the first week. Overall, these results do not support exergames as a standalone physical activity intervention, and suggest that short duration examinations of exergames may be misleading.

Key Words: Physical Activity, Enjoyment, Intervention, Family, Motivation

The importance of fostering physical activity (PA) patterns in youth is difficult to overstate. PA and high physical fitness protect against high blood pressure, high blood cholesterol, metabolic syndrome, low bone density, depression, and obesity (Janssen & LeBlanc, 2010). Furthermore, childhood PA forms the behavioral patterns necessary for health benefits across the life course such as the reduction of several health conditions including breast cancer, colorectal cancer, cardiovascular disease, stroke, type 2 diabetes, osteoporosis, and mood disorders (Warburton, Charlesworth, Ivey, Nettlefold, & Bredin, 2010). Unfortunately, few children in developed countries are sufficiently active to reap these benefits (Colley et al., 2011; Troiano et al., 2008), suggesting that promotion efforts are paramount for public health. The family home offers an ideal setting to promote children's PA (Kaushal & Rhodes, 2014; Maitland, Stratton, Foster, Braham, & Rosenberg, 2013), yet home-based PA interventions are limited and have resulted in negligible to modest changes in PA (Brown et al., 2016; Rhodes & Quinlan, 2014). Innovations in the types of interventions employed may help improve child PA in the family home.

One area of home-based child PA that has seen recent attention is exergames. Exergames such as those played on the Gamebike system, the Nintendo Wii™ and the Microsoft Kinect are games where players interact physically (using leg, arm, or whole-body movement) in response to some on-screen virtual activity. These games have extensive reach into the homes of children. The Wii has sold over 101.63 million units since its introduction and has contributed to a 73% increase in net Nintendo sales with Wii sports as their highest selling product (Nintendo Co. Ltd, 2017). The Microsoft Kinect was the fastest selling consumer electronics device of all time, selling over 8 million units in 60 days (BBC News, 2011) and exergames for the system continue to dominate many of the top sales figures since its release (Statistica, 2017). From a PA participation standpoint, exergames also have viability. They potentially offer an inexpensive, safe and controlled experience in the family home that can alleviate the fears that many parents have, whether real or imagined, about outdoor neighborhood play (Valentine & McKendrk, 1997). They can also overcome some of the barriers of inclement weather that see typical declines in child PA because exergames are played indoors (Carson & Spence, 2010) and can offer indoor PA in places where land density limits outdoor opportunities. Finally, motivation for exergame play behavior is predicated on affective expectations or judgments (expected pleasure, enjoyment, intrinsic regulation). Affective judgments are a central construct – in some form - in many popular health behavior models (e.g., self-determination theory, theory of planned behaviour, social cognitive theory) and show a clear link to child PA (Nasuti & Rhodes, 2013). Thus, if exergames can be developed to ensure that requisite PA is enjoyable and engaging, as well as being performed in a safe environment, it stands to reason that they may be useful additions to child PA promotion.

Exergaming is a relatively unexplored topic, but early interest and commentary have generated as many reviews as experimental trials (e.g., Baranowski, Buday, Thompson, & Baranowski, 2008; Barnett, Cerin, & Baranowski, 2011; Biddiss & Irwin, 2010; Foley & Maddison, 2010; Kaushal & Rhodes, 2014; LeBlanc et al., 2013; Maitland et al., 2013; Mark, Rhodes, Warburton, & Bredin, 2008; Peng, Crouse, & Lin, 2012; Primack et al., 2012). Overall, the emerging evidence suggests that these games can significantly increase energy expenditure similar to moderate intensity PA and these can translate into health-related fitness improvements. It is noteworthy, however, that there is considerable range in energy expenditure based on the types of games and game system employed. For example, Wii Bowling provides rather low average energy expenditure (< 3 METs) while Wii Boxing produces expenditure within the moderate-to-vigorous intensity range (>6 METs) (Barnett et al., 2011). Not surprisingly, the most consistent moderate and vigorous intensity play time is associated with traditional stationary exercise bikes adapted to interact with racing or driving videogames (Warburton et al., 2007; Warburton et al., 2009).

Despite results that exergames can provide a dose of PA that meets health guidelines, limited and mixed research is available supporting their long-term adherence. Of the nine home trials we located in our literature search (Baranowski et al., 2012; Chin A Paw, Jacobs, Vaessen, Titze, & van Mechelen, 2008; Graves, Ridgers, Atkinson, & Stratton, 2010; Maddison et al., 2011; Maloney et al., 2008; Mark & Rhodes, 2013; Ni Mhurchu et al., 2008; Owens, Garner, Loftin, Van Blerk, & Ermin, 2011), seven of these showed high use of exergames over a short duration (e.g., first few weeks), but significant declines in the first six weeks (Chin A Paw et al., 2008; Graves et al., 2010; Maloney et al., 2008; Mark & Rhodes, 2013; Ni Mhurchu et al., 2008; Owens et al., 2011), one study showed continued exergame use across 24 weeks (Maddison et al., 2011), and one study showed no effect of exergames (Baranowski et al., 2012). This suggests that continued exergame research is needed, preferably with durations longer than six weeks to understand the full trajectory of exergame play.

The primary objective of this randomized trial was to evaluate the use of an exergame bike in comparison to a stationary bike in front of a TV among children aged 10-14 years old across three-months within a family home environment. This trial extends a pilot study by Mark and Rhodes (2013), who showed that exergame bikes had higher use over six weeks than bikes in front of the TV with young children aged 4-10. That study, however, had a small and motivated sample, short duration, and young age group who had complaints that the bike did not fit their size. The authors suggested using a longer study duration, more diverse sample, and targeting slightly older children. Thus, the present study continued this line of inquiry by employing exergame bikes with established potential for delivering a moderate-vigorous intensity bout of PA (Warburton et al., 2007), as well as a comparison group that also had a viable exercise modality (stationary bike) with a distraction condition (ordinary TV) within the same context as the exergame (home) rather than a “no treatment” control (LeBlanc et al., 2013). The present study also advances prior research by including an extended trial duration to three months in order to examine a trajectory of exergame use and by shifting to a new age range of participants (tweens compared to children) to help deepen the research evidence base for this type of exergame across different age groups. Based on the pilot work, we hypothesized that bike use would be higher for the exergame condition in comparison to the comparison condition, but may wane across three months.

Methods

We followed the consolidated standards of reporting trials statement for this study (Schulz, Altman, Moher, & CONSORT Group, 2010). Furthermore, this trial was registered prior to data collection (clinicaltrials.gov #NCT01373762).

Design

A two-arm parallel design single blinded randomized controlled trial was conducted where participants were randomized using an online program, Research Randomizer (Urbaniak & Plous, 2015). This program provided a simple computer randomization that allowed for allocation of participants to one of two groups 1) exergame bike; or 2) stationary bike in front of TV- condition for three months duration at a 1:1 allocation ratio. Participants were aware of their group allocation, but assessors and initial recruiters were blinded to treatment allocation as this was concealed by a study coordinator (who performed the randomization) via opaque envelopes.

Participants

Participants were recruited via advertisements placed through recreation centres, health care centres, children's recreation classes, shopping malls, schools and online interest sites.

Inclusion criteria**.** Participants were children aged 10-14 years from single or dual parent families. Children were included in the study if they also participated in PA below Canadian recommended guidelines (Tremblay et al., 2011) of 60 min per day. The initial screening involved defining Canadian physical activity guidelines and then asking parents whether their children met this 60 min criterion. Finally, parents needed to consent to the placement of the stationary bike (exergame or standard) in front of their television in a common room for the duration of the trial.

Study settings. Participants were recruited in either greater Victoria, British Columbia or Greater Halifax, Nova Scotia regions.

Intervention

Participants in the Exergame group received a Hoggan Health® interactive video gaming system linked to a Sony Playstation3® and a television monitor. The Hoggan Health®interactive video gaming system reads the participant's speed (measured by cycling cadence) and steering, which in combination with a full function handlebar-mounted game controller that allows each participant the opportunity to play a variety of Sony Playstation3® video games. Thus participants move the avatar of the game through pedaling and steer the avatar with handlebars on the cycle ergometer. Participants received five of these video games (including Smuggler's run, ATV Offroad Fury, Gran Turismo 3, Nascar Heat, and Need for Speed) and were asked to select among these during bike use.

The comparison group received the Hoggan Health stationary bike without the videogame component and was instructed to exercise during each training session while watching TV. No instructions were provided on what TV programs to watch.

The recommended exercise training regime for both conditions was activity of moderate intensity exercise (i.e., 60 to 75% of heart rate reserve), 3 d/wk for 30 min/d (see Warburton et al., 2007). Participants were provided written and verbal instructions on the ratings of perceived exertion (RPE) associated with the recommended training intensity and received heart rate monitors to support participant fidelity to the target intensity (see supplemental Appendix A and B).

Outcomes

The primary outcome of the study was minutes of equipment usage tracked in a log and recorded by the date, time and duration of usage, and any comments about their experience using the machine. This log was based on the prior study by Mark and Rhodes (2013), who demonstrated a difference in bike use over a six week duration and was completed by children of an even younger age than the participants in this study. Parents were asked to monitor the usage log and to prompt their children to complete the times when the bikes were used. The record log is similar to daily diary or accelerometer record logs as an in-situ self-report capture method. Daily diary and record logs have shown validity and reliability in prior physical activity research with teens (Bratteby, Sandhagen, Fan, & Samuelson, 1997).

The secondary outcome was frequency of weekly use of the bikes. Our primary endpoint for both outcomes was the full three months. Given the documented reduction in exergame use over very short terms, we also examined the first week of exergaming use as a secondary endpoint.

Procedures

Our study followed the procedures of the prior pilot study (Mark & Rhodes, 2013) as a guide for recruitment, study protocol, assessment and measurement procedures. To ensure treatment fidelity across the two sites, the lead trial coordinators consulted on the study protocol before the study began and all research assistants were present during a series of phone-based conference calls to ensure the protocol was standardized. The lead site trial coordinators also had monthly conference calls to overview study recruitment details and troubleshoot any questions.

This study was advertised as a family-based intervention, where both parents and children were invited to join and use the bikes, although child PA was considered the critical outcome of interest across the study data collection and during advertisement. Only the child outcomes are reported in this paper. After interested parents contacted the researcher and were determined to be eligible to participate in the study, a researcher visited the respective families' homes and asked parents and children to complete informed consent. Parents were asked to complete a questionnaire on brief demographics, and PA with the Godin Leisure-Time Exercise Questionnaire (Godin & Shephard, 1985) while children were asked to complete the Physical Activity Questionnaire for Older Children (Crocker, Bailey, Faulkner, Kowalski, & McGrath, 1997). Measures derived from both instruments have demonstrated sound reliability and validity for adult (Jacobs, Ainsworth, Hartman, & Leon, 1993) and teen (Chinapaw, Mokkink, Poppel, van Mechelen, & Terwee, 2010; Saint-Maurice, Welk, Beyler, Bartee, & Heelan, 2014) populations, respectively.

On completion of baseline assessment, participants were randomized to one of the two conditions. Following randomization, the researcher scheduled an orientation session with the family. Families in the comparison condition received the stationary bike to place in front of the television, and the intervention group received the exergame bike linked into the family's television via a Sony PlayStation 3. At the orientation session, the equipment was brought to the home and set-up, and all family members including the children were given the opportunity to use the equipment. The usage log was given to the family and children. Families in both conditions were provided with Health Canada's Family Guide to Physical Activity (Public Health Agency of Canada, 2002). A discussion of intensity and perceived exertion using the Borg scale/heart-rate monitors (American College of Sports Medicine, 2000) followed. Children were instructed (verbally and with a hand-out) to use the bike to help achieve their physical activity. As an incentive for participation, participants were informed that they would be entered into a draw for a one-year family membership pass (end of study) to local aquatic center (pool). There was a follow-up check with all families (in both conditions) at six weeks to answer any questions about the trial or equipment, but no other contact over the three months was made between the research assistant and the participants.

At three months, children were asked to participate in a brief end-of-trial qualitative interview to evaluate the impact of the intervention delivered by a research assistant. These interviews were conducted at participants' homes. While their parents were present during the interview, questions were directed to the child participant and not via parent proxy answers. These interviews discussed usage, barriers and enjoyment in regards to the exercise game bike or stationary bike and also gave participants the opportunity to discuss anything about their experience that was not covered in the interview (see supplementary Appendix C). Interview questions were framed in accordance with Ajzen's (1991) theory of planned behavior. We chose this frame for consistency with our prior pilot trial (Mark & Rhodes, 2013) and the established protocol for the interview. Further, the theory of planned behavior elicitation questions are similar in scope to most social cognition theories (i.e., benefits and barriers) and should be applicable to other researchers and readers who may wish to interpret this information through the lens of social cognitive theory, the transtheoretical model, or other similar approaches (Fishbein et al., 2001).

Compliance with Ethical Standards

The study was approved by the University of Victoria Human Research Ethics Board and the authors had no conflicts of interest to disclose. All participants provided informed consent to participate in the study.

Statistical Analysis

Given the hierarchical nature of the data (i.e., repeated assessments nested within the individual), hierarchical linear modeling (HLM) was used. This approach is particularly useful with unbalanced designs (i.e., due to missing data created by attrition over the 13 weeks of the study) because it includes all participants that have available data points along the trajectory using maximum likelihood estimation (Allison, 2002; Raudenbush & Bryk, 2002). Power analysis (.80) of a trend with 13 repeated assessments, one-between group factor, an estimated medium effect size based on prior exergame research (Peng et al., 2012), with an alpha of .05 suggested that a sample size of 70 could detect the primary hypothesis (Faul, Erdfelder, Lang, & Buchner, 2007). In terms of the weekly minutes of activity, a random intercept (i.e., to allow the week1 values to vary across participants) was entered into the model at Level-1 in addition to a fixed slope for the linear trend, which was centered at the mid-point of the study (e.g., -6 = baseline, 0 = Week 7, 6 = Week 13, etc…). Next, to determine if entering a fixed quadratic trend improved model fit, the deviance statistic (i.e., a measure of model fit) of the linear trend model (i.e., model #1) was compared against the quadratic trend model (i.e., model #2) using the likelihood ratio test. A significant decrease in the deviance statistic is an indication of improved model fit. The same procedure was used for the cubic trend (Raudenbush & Bryk, 2002). Once the Level-1 slopes were finalized, condition (0 = experimental group; 1 = control group) at Level-2 (i.e., the participant level) was entered into the model to predict the intercept, linear and potential quadratic and cubic trends. The same analytical approach was then used for the weekly frequency dependent variable (secondary outcome).

End of study Process Interviews

All end-of-study interviews were transcribed verbatim. During this process, any identifying characteristics were removed from the transcripts. Once transcribed, irrelevant information was removed to reduce the data and each relevant statement was coded. First order themes were created based on categorizing coded data into common themes (Patton, 1990). This same process was performed with the first order themes to organize the data into second order themes framed using Ajzen's (1991) theory of planned behavior as a framework for understanding and organizing the findings. Total frequency of the themes and the percentage of endorsement were also calculated as an estimate of commonality across interviews.

Results

Participant Flow

One hundred and seventy three parents contacted our research coordinator about participating in the study. Of these, 100 children were deemed ineligible for participation because their PA was over 60 min per day over the last month. The 73 participants who met the study inclusion criteria and completed the baseline questionnaire package were randomly assigned to one of the two conditions (Figure 1) and rolling recruitment began in May 2012 and continued until December 2013. Almost half of our sample (49.3%) was recruited during the

Canadian winter, and nearly a third joined the trial in the spring (31.5%) with the remainder mixed between the summer (13.7%) and fall (5.5%) and recruitment was equivalent across conditions. The distribution between Halifax (n = 31) and Victoria (n = 42) sites was relatively equal and the comparison bike group included 34 children while the exergame bike group included 39 children, all from different family home environments. Of these, 30 (Victoria n = 17; Halifax n = 15) control participants and 37 (Victoria n = 22; Halifax n = 14) experimental group participants completed the study to the three-month endpoint. The reasons for drop-out included long-term illness (n = 2), lost bike log (n = 2) and requests to have the bike removed early (n = 2). These attrition numbers were not significantly different ($p > .05$) across the groups and amounted to an overall attrition rate of eight percent. Only 31 of the children in the comparison condition and 28 children in the experimental group, however, participated in the end of study interviews, which concluded in February, 2014. All parents cited time conflicts for their children as reasons for declining to participate. No participants cited harms associated with the study.

Baseline Characteristics of Respondents

Baseline characteristics of the participants can be found in Table 1. Children had an average age of 11.5 yrs, with an equal representation of boys and girls, mainly white, and over two-thirds were regular videogame players who watched about two hours of TV per day. On average the children reported doing less than 1-2 bouts of physical activity over the past week at baseline. BMI scores were all above the 50^{th} but lower than the 85^{th} percentile for age and sex (Kuczmarski, 2002).

Handling Skewed and Kurtosis Data

With respect to normality, various weekly frequency and minute variables had kurtosis values > 2.0. Given that each variable had only one or two outliers ($z > 3.29$), however, the values were removed prior to the HLM analysis.

Primary Outcome: Minutes of Bike Usage

In terms of the weekly minutes of activity, the initial model showed that the linear trend was significant. Further, the model fit improved when the quadratic trend (Δ deviance = 42.15, $p < .01$) and subsequent cubic trend (Δ deviance = 22.43, $p < .01$) was entered. Therefore, all three trends were entered into the final model. Table 2 shows that there was a significant cubic trend ($t = -3.921$, $p < .01$; CI -.240 / -.079), which was significantly moderated by condition ($t = 2.0045$, $p < .05$; CI .005 / .209). As can be seen from Figure 2, the gamebike participants averaged 74.35 min of use in week one, whereas the control group averaged 41.61 minutes ($d = .52$). The control group then appeared to have a steady decline until the study ended. However, for the gamebike participants, the weekly minutes appeared to level off during weeks three to nine (ave. min = 19.69 exergame vs. 14.85 min control; $d = .30$), after which they began to decline until the study end (ave. min = 7.82 exergame vs. 6.37 min control; $d = .08$).

Secondary Outcome: Frequency of Bike Usage

For weekly frequency of activity, the initial model showed that the linear trend was significant. Further, the model fit improved when the quadratic trend (Δ deviance = 34.37, $p < .01$) and subsequent cubic trend (Δ deviance = 14.37, $p < .01$) was entered. Therefore, the final model included the linear, quadratic and cubic trends. As can be seen from Table 3, results showed that there was a significant cubic trend ($t = -3.487$, $p < .01$; CI -.006 / -.002), however, the condition effect was non-significant. The frequency of using either bike steadily declined in the first few weeks and then leveled off until approximately weeks nine and 10, after which their use declined.

End of Trial Process Evaluation

Results of the end-of-trial interviews are summarized in Table 4. For the exergame condition, over half (57%) of children reported that the exergame was enjoyable or fun while 17% of participants reported that the bike felt like a chore or was tiring. The majority of children also suggested that the bike was a good way to get their exercise, and useful to have in the house. Still, two thirds of participants did report bike related barriers for gameplay including a lack of appealing games (21%), discomfort with the bike (18%) and general exergame operation problems (28%).

For the comparison bike condition, 45% of children reported that the bike was enjoyable or fun while 23% felt the bike was boring and an additional 13% of participants reported that the bike felt like a chore or was tiring. The majority of children suggested that the bike was a good way to get their exercise, and useful to have in the house, but almost half of the participants reported that the bike was uncomfortable and also cited preferences for doing other things.

Discussion

Overall, the findings from this trial provided mixed support for our hypothesis. Importantly and correspondent with most prior exergame trials (Chin A Paw et al., 2008; Graves et al., 2010; Maddison et al., 2011; Maloney et al., 2008; Mark & Rhodes, 2013; Ni Mhurchu et al., 2008; Owens et al., 2011), there was evidence of significant use of the exergame in the initial week compared to our comparison group. The potential advancement of this study over past designs, however, was that the comparison group represented a viable exercise modality (stationary bike) with a distraction condition (ordinary TV) within the same context as the exergame (home). Thus, the exergame condition was compared to another novel form of physical activity introduced to the children, rather than the more commonplace “no treatment” control group (LeBlanc et al., 2013). Our results showed that introducing this condition also had considerable use (average of 43 min), but exergame use was meaningfully higher within the medium effect size range (Cohen, 1992).

The applied value of this finding supports the potential of exergames to intrigue children enough to use the games within their homes, and that this effect is superior to the mere novelty of introducing exercise equipment into the home. Unfortunately, like most prior trials on exergames with children (Chin A Paw et al., 2008; Graves et al., 2010; Maloney et al., 2008; Mark & Rhodes, 2013; Ni Mhurchu et al., 2008; Owens et al., 2011), bike use waned over the first six weeks. Our results showed an interesting cubic trend however, where bike use dropped among both conditions quickly, was still significantly higher for the exergame condition over the mid-point of the trial, and then dropped again by the last few weeks of the trial to levels of play that would likely have no public health impact.

The results show that exergames may hold promise only if those initial weeks of use can be maintained. The longer design employed in this trial compared to some other experimental work with exergames (Baranowski et al., 2008; Barnett et al., 2011; Kaushal & Rhodes, 2014; LeBlanc et al., 2013; Peng et al., 2012) demonstrates how early reception to the intervention may be biased. Lab-based single-play experiments or very short-term trials are not recommended in the study of exergames. Future studies on exergames may benefit from a better understanding of the psychology of videogames (Madigan, 2016). One of the faulty assumptions in this initial phase of exergame research may be that videogames sustain playing behavior generally. Sedentary videogames, similar to these initial exergame results, show decline in playing frequency and time as games become familiar and the novelty wears (Koster, 2004). Follow-up interviews provided some evidence that at least a fifth of the participants waned in interest in the games. To sustain videogame play, manufacturers continually develop new games, and new editions of the same games. It would stand to reason that exergames would require the same approach as ordinary video games for behavioral maintenance.

Another aspect for future research may be the more natural merging of serious/coached games with affective games in this child/tween exergaming literature. Coached games employ behavior change strategies to increase a given behavior (e.g., Wii fit), while affective games are more aligned with traditional video games where the primary purpose of the game is fun and enjoyment (Lyons & Eysenbach, 2013). Our post-trial assessment clearly demonstrated that most children knew the bikes were present to increase their health and fitness. The exergame condition, commensurate with theory (Rhodes, Warburton, & Bredin, 2009), merely had more comments that it was an enjoyable (12% difference) and less boring (22.5% difference) experience than the ordinary stationary bike. Thus, a blend of affective and coached games may prove to be extremely useful for improving maintenance.

Despite the novel findings in our study and the strong methods employed, there are noteworthy limitations. First, the frequency and duration of play was obtained through log-books which could introduce biases. Log-books are still likely a more accurate measure of play than retrospective self-report (e.g., over the past week), and the use of self-report would not alter the findings between groups given the equalization of procedures but objective assessment of play time is more desirable. Furthermore, these log-books did not include intensity of play and it would be useful to measure intensity in any future assessment. Second, these families reported high education and incomes, and were mainly White. Thus, it remains uncertain how well these results may generalize to lower socio-economic status families and different ethnic backgrounds. We also had a significantly higher proportion of parents who smoked in the exergame condition compared to the control condition and do not know if this is an indicator of any other lifestyle health behaviors in the family that could affect exergame play. Finally, it should be acknowledged that research in exergames and technology do not progress at the same pace and this may have an impact on both the efficacy of the trial and the applied aspects of the findings. The time-intensive process of gathering pilot data to secure funding, to then running the actual trial means a marked delay in the technology being offered within these exergames to what is present within the consumer marketplace at the time of the trial. Future research in exergames would certainly benefit from working in tandem with video game companies in order to improve the match between research trials and marketplace technology.

Overall, our results showed evidence that exergames in the form of a stationary bike that interacts with driving-based video games were played for more duration but not frequency within the first week and mid-point of the intervention compared to a stationary bike set-up in front of the TV. Both types of equipment, however, dropped rapidly in use across the first few weeks and later weeks of the intervention. The exergame was generally viewed as more enjoyable and less boring than the ordinary stationary bike. The results show that exergames may have some potential to add to child physical activity but only if ways to sustain initial play are developed. The findings also highlight that short exposures to exergames are not a valid means of assessing their utility in changing PA, due to their steep drop in use. Future research employing games with more attention to gamer psychology (narratives, gamification, mutli-player social aspects) and a blend of coached and affect game components may help overcome the steep decline from initial exergame use.

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Figure Captions

Figure 1: Participant Flow

Figure 2: Cubic trend for weekly minutes of bike use over the 13-week intervention period by condition

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Table1

Baseline Demographic, Family and Parental Physical Activity Profile

Characteristic	Standard Bike (n = 34)	Exergame Bike (n = 39)	p-Level
Parent Demographic Profile			
Age Mean (SD)	43.50 (5.39)	43.67 (6.58)	.89
% Female	61.82	58.70	.75
% White	82.35	92.68	.17
% Completed University	81.48	69.23	.30
Mean Income (SD) $CND	87,208 (46882)	76,718 (33131)	.30
% Currently Employed	58.80	77.78	.53
% Smoker	2.63	19.15	.02
Child Profile			
Age	11.56 (1.40)	11.46 (1.23)	.75
%Female	52.94	46.15	.56
BMI	20.42 (4.72)	19.92 (3.93)	.63
% Regular Video game Players	68.42	74.47	.54
Physical Activity (PAC-C) Mean (SD)	1.53 (1.24)	1.31 (0.93)	.42
Hours of daily TV Viewing	2.32 (1.51)	2.24 (1.44)	.81

Table 2
Results from the HLM analysis for the weekly minutes of using a bike by condition

Fixed Effect	Coefficient	Standard Error	T-Ratio	95% CI
Intercept	7.200	3.043	2.365**	1.235 / 13.164
Condition (1 = Control)	6.088	4.653	1.308	-3.032 / 15.208
Linear Trend	.808	1.068	.757	-1.285 / 2.901
Condition	-1.752	1.350	-1.297	-4.398 / .894
Quadratic Trend	.746	.141	5.304**	.469 / 1.022
Condition	-.548	.164	-3.346**	-.869 / -.227
Cubic Trend	-.160	.041	-3.921**	-.240 / -.079
Condition	.107	.052	2.045*	.005 / .209

Variance Estimation

Random Effect	Variance	Chi-square
Intercept	284.527	392.623**

Note. *p < .01; **p < .01; CI = 95% confidence interval.

Table 3
Results from the HLM analysis for the weekly frequency of using a bike by condition

Fixed Effect	Coefficient	Standard Error	T-Ratio	95% CI
Intercept	.321	.098	3.269*	.128 / .513
Condition (1 = Control)	.211	.171	1.237	-.124 / .546
Linear Trend	.024	.033	.737	-.041 / .089
Condition	-.085	.044	-1.937	-.171 / .001
Quadratic Trend	.018	.004	4.400*	.010 / .026
Condition	-.009	.005	-1.854	-.019 / .001
Cubic Trend	-.004	.001	-3.487*	-.006 / -.002
Condition	.003	.002	1.843	-.001 / .007

Variance Estimation

Random Effect	Variance	Chi-square
Intercept	.337	473.121*

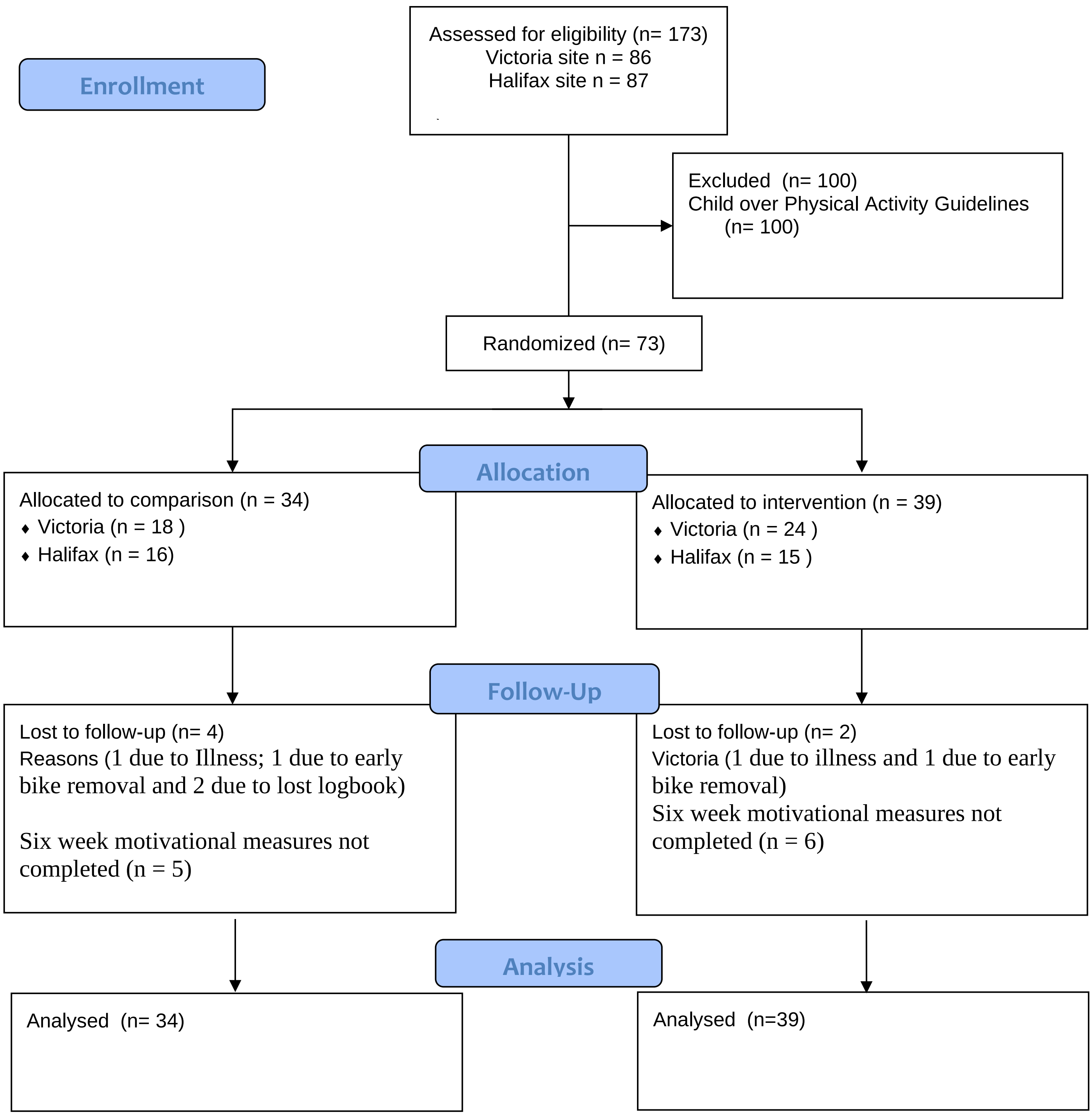
Note. *p < .01. CI = 95% confidence interval.

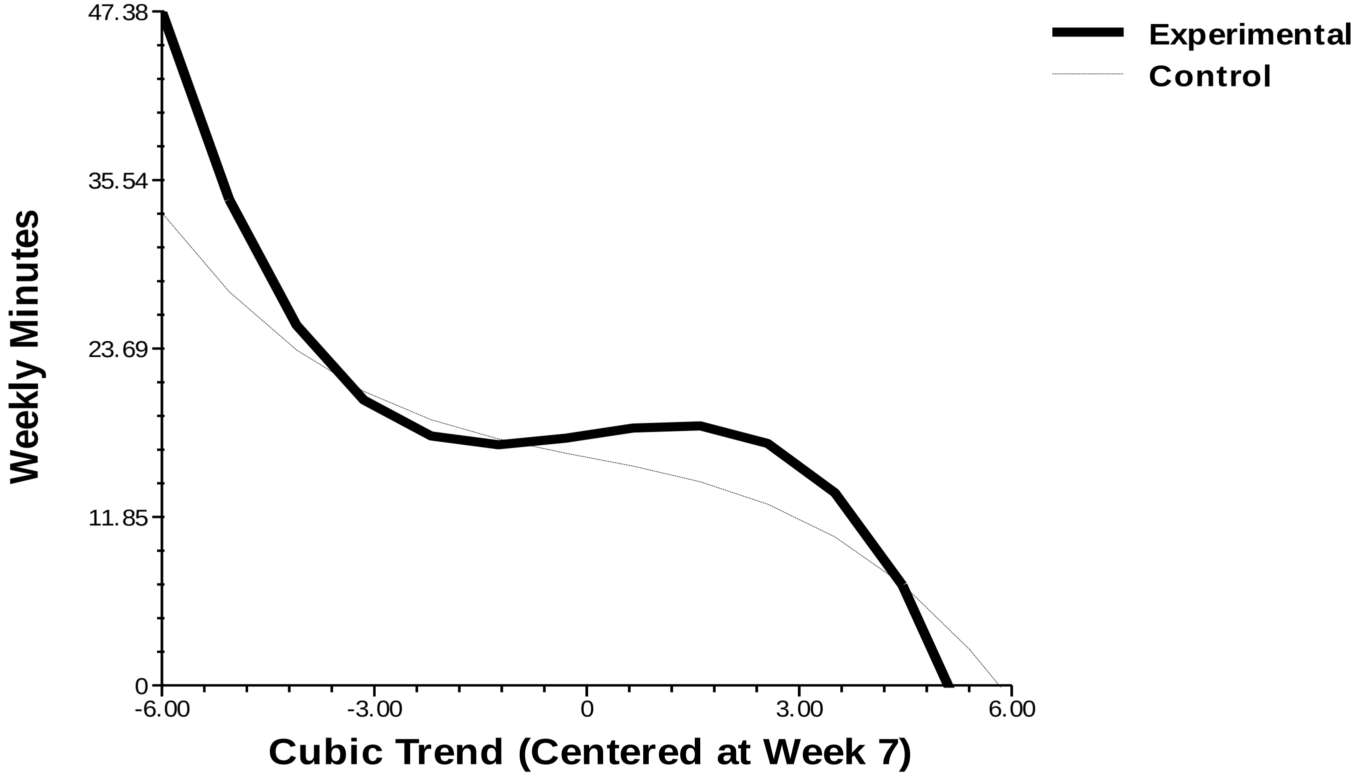
Table 4. Elicited themes by exergame (n = 28) and standard cycle (n = 31) groups

Theme	Subtheme	Elicited belief	Frequency	Percentage
		Exergame		
Attitude	Positive Affect	Fun/Enjoyable	16	57.14
		Standard		
		Enjoyable/Fun	14	45.16
		Exergame		
	Negative Affect	Tiring	3	10.71
		Felt like a chore/work	2	7.14
		Standard		
		Not enjoyable/Boring	7	22.58
		Felt like a chore/work	2	6.45
		Tiring	2	6.45
		Exergame		
	Instrumental Attitude	Valuable piece of equipment	9	32.14
		Able to get more exercise	7	25.00
		Improves fitness/health	5	17.86
		Gets intensity up	2	7.14
		Standard		
		Valuable piece of equipment	13	41.94
		Opportunity to be active	7	22.58
		Improve fitness/health	7	22.58
		Makes a sedentary activity active	5	16.13
		Feel good	4	12.90
		Have more energy	2	6.45

PBC	General Exercise Barriers	**Exergame**		
		Time/Other Commitments	5	17.86
		Standard		
		Time/Other Commitments	7	22.58
		Too tired to use bike	3	9.68
		Prefer other activities	3	9.68
		Rather watch TV	2	6.45
		Not interested/motivated	2	6.45
		Bad location in the house	2	6.45
	Equipment-Related Barriers	**Exergame**	6	21.43
		Did not find the games appealing	5	17.86
		Issues with the bike (e.g., not comfortable)	4	14.29
		Issues with the gaming equipment (e.g., controller)	2	7.14
		Issues with the game features (e.g., game tempo)	2	7.14
		Games were difficult to play		
		Standard		
		Issues with bike (e.g., not comfortable)	14	45.16
	Facilitator	**Exergame**		
		Games had goals	2	7.14
		Standard		
		Convenient	2	6.45

Abbreviations: PBC = perceived behavioural control.


Enrollment
Assessed for eligibility (n= 173)
Victoria site n = 86
Halifax site n = 87
Excluded (n= 100)
Child over Physical Activity Guidelines
(n= 100)
Randomized (n= 73)
Allocation
Allocated to comparison (n = 34)
Victoria (n = 18)
Halifax (n = 16)
Allocated to intervention (n = 39)
Victoria (n = 24)
Halifax (n = 15)
Follow-Up
Lost to follow-up (n= 4)
Reasons (1 due to Illness; 1 due to early bike removal and 2 due to lost logbook)
Six week motivational measures not completed (n = 5)
Lost to follow-up (n= 2)
Victoria (1 due to illness and 1 due to early bike removal)
Six week motivational measures not completed (n = 6)
Analysis
Analysed (n= 34)
Analysed (n=39)


Experimental
Control
Weekly Minutes
47.38
35.54
23.69
11.85
0
-6.00
-3.00
0
3.00
6.00
Cubic Trend (Centered at Week 7)