



Predictors of stationary cycling exergame use among inactive children in the family home

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ABSTRACT

Objectives: Exergames may be one viable way to increase child physical activity, but investigation of long term motivation, and prediction of adherence has seen little research attention. The purpose of this study was to compare the effect of an exergame intervention (exergame bike, standard bike) among children aged 10–14 years on motivational variables (self-determination theory, theory of planned behavior) and to explore whether these variables could predict use of the equipment across three months.

Design: Randomized controlled trial. **Method:** Seventy-three insufficiently active children were recruited through advertisements within the community/schools and randomized to either an exergame condition (n = 39) or a standard bike condition (n = 34). Weekly bike use was recorded in a log-book and motivational variables were assessed after a familiarization session and at six weeks.

Results: Exposure to exergames conferred higher affective and instrumental attitudes, perceived behavioral control, intention, and intrinsic motivation compared to the comparison condition, but this difference was not present by the six-week point of the trial. Children who had higher intention to use the bikes and extrinsic regulation were more likely to use the bikes from six weeks to three months, but no assessed psychological variable could account for use during the first six weeks.

Conclusions: Single-exposure research designs may not accurately reflect the motivations for longer term exergame play. Further, parent consumers of exercise equipment for the family home may benefit from considering how much their children would enjoy using the equipment after repeated exposures.

The benefits of regular physical activity (PA) in youth are well-established. 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 youth in developed countries are sufficiently active to reap these benefits (Hallal et al., 2012), suggesting that promotion efforts are paramount for public health.

Although school-based interventions are likely imperative to

promote PA in youth (Beauchamp, Rhodes, & Nigg, 2017), the family home also offers a critical setting for increasing PA (Kaushal & Rhodes, 2014; Maitland, Stratton, Foster, Braham, & Rosenberg, 2013). Compared to school-based PA, far less research attention has been spent on understanding home-based PA in youth (Brown et al., 2016; Kaushal & Rhodes, 2014; Maitland et al., 2013; Marsh, Foley, Wilks, & Maddison, 2014).

One area of home-based PA that has seen recent attention is in the use of 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. Evidence suggests that these games can significantly increase energy expenditure, although

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this is highly dependent on the type of game and console used (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). Exergames also have extensive reach into the homes of youth, suggesting massive potential with regard to intervention scalability. 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 promotion standpoint, exergames may also affect some of the key mediators of behavior. 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 & McKendrick, 1997). They can also overcome some of the barriers of inclement weather that see 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. Thus, exergames may promote a sense of control over PA participation. In support of this premise, the only two randomized controlled trials to investigate the effects of sustained exergame play on sense of control over PA, found positive increases over time compared to control groups (Staiano, Abraham, & Calvert, 2013; Staiano, Beyl, Hsia, Katzmarzyk, & Newton, 2017).

Perhaps more germane to exergames is their potential to impart motivation in the form of high 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 behavior, social cognitive theory) and show a clear link to child PA (Nasuti & Rhodes, 2013). The effect of exergames on affective judgments in youth also has strong validation, particularly under short-term exposures. Exergames are reliably established as more enjoyable than traditional forms of exercise (Epstein, Beecher, Graf, & Roemmich, 2007; Graves, Ridgers, Williams, et al., 2010; Penko & Barkley, 2010; Sun, 2012; Vernadakis, Zetou, Derri, Bebetos, & Filippou, 2014; Wadsworth, Brock, Daly, & Robinson, 2014), although the effect does appear to wane over time (Rhodes, Warburton, & Bredin, 2009; Sun, 2012).

While the effects of exergames on key potential mediators of youth PA is promising, there are limitations to the extant research. Most notable is the disconnect between studies that show short-term effects of exergames upon affective judgments, yet home-based behavioral trials show negligible sustained use. Indeed, of the 10 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; Rhodes et al., 2017), eight 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, Ridgers, Atkinson, et al., 2010; Maloney et al., 2008; Mark & Rhodes, 2013; Ni Mhurchu et al., 2008; Owens et al., 2011; Rhodes et al., 2017), one study showed continued exergame use across 24 weeks (Maddison et al., 2011), and one study showed no change in physical activity as a result of receiving exergames (Baranowski et al., 2012). None of these studies reported on the predictors of exergame play or employed mediation tests to explore the relationship between exergame use and its potential antecedents. Clearly these analyses are necessary to chart the mechanisms that may be responsible for use and its subsequent decline across time. Further, exergame research has thus far been scattershot in the application of the theory to understand its use. Our

literature review did not identify any research that has employed a psychological model in order to understand sustained adherence.

Thus, the purpose of this study was to follow-up on a previously published randomized controlled trial focused on exergame and traditional recumbent cycling among children aged 10–14 (Rhodes et al., 2017) to now examine its effects on 1) intermediary motivational variables and 2) predict use over time. Similar to many exergame trials, our trial showed the exergame group reported significantly higher use early (first week), though both conditions declined in bike use over time and had no significant differences across three months (Rhodes et al., 2017). Our present study used self-determination theory (Deci & Ryan, 2000) and the theory of planned behavior (Ajzen, 1991) as motivational frameworks. Neither model has been explored in relation to exergame use and youth, yet both models have shown predictive capability when explaining PA (McEachan, Conner, Taylor, & Lawton, 2011; Teixeira, Carraça, Markland, Silva, & Ryan, 2012). Briefly, self-determination theory suggests motivation lies on a continuum from amotivation (which involves an absence of motivation), followed by several forms of extrinsic regulation in ascending forms of self-determination (motivation for compliance, guilt, identification with benefits, and integration with other valued behaviors) through to intrinsic motivation (engagement due to enjoyment). The theory of planned behavior suggests that intentions are the primary cause of behavioral action with intention determined by affective (pleasure) and instrumental (utility) attitudes, subjective norm (perceived social pressure) and perceived control over enacting the behavior.

For the first purpose of our study, we hypothesized that participants in the exergame bike condition would report higher intrinsic motivation (from self-determination theory) and affective attitude, and intention (from the theory of planned behavior) compared to the stationary cycle condition, although these effects would wane over time. This hypothesis was aligned with previous findings of enhanced enjoyment (Epstein et al., 2007; Graves, Ridgers, Williams, et al., 2010; Penko & Barkley, 2010; Sun, 2012; Vernadakis et al., 2014; Wadsworth et al., 2014) following exergame play.

For our second purpose, we sought to explore the correlates of PA equipment use in both conditions across time, given there was no noteworthy difference in use across conditions but considerable variability in use between participants (Rhodes et al., 2017). The introduction of fitness equipment into the family home, whether equipped with videogame technology or not, may be useful to facilitate youth PA (Kaushal & Rhodes, 2014). The Sport and Fitness Industry Association reports that exercise equipment sales is a \$5 + billion business, with home fitness equipment exceeding 35% of that revenue (Sport and Fitness Industry Association, 2015). Thus, whether purchasing home equipment can help promote changes in youth PA is a practical research question for parents. We are unaware of any prior studies that have examined the predictors of home PA equipment use among youth; thus the results of this study will shed light on what motivational factors may contribute to the use of stationary cycling ergometers. Based on prior theory of planned behavior and self-determination theory research (Rhodes, Fiala, & Conner, 2009; Rhodes, Warburton, et al., 2009; Teixeira et al., 2012), we hypothesized that bike users would be more intrinsically motivated (self-determination theory) and have stronger intentions and affective attitudes (theory of planned behavior). Still, we also considered it possible that more extrinsic factors aligned with parental reinforcement to use the bikes (subjective norm, external/introjected regulation) could predict sustained bike use, given that parents are often instrumental in facilitating PA at this age (Gustafson & Rhodes, 2006).

1. Methods

Methods and primary outcomes from this study have been published in full elsewhere (Rhodes et al., 2017). We followed the consolidated standards of reporting trials statement for the study (Schulz, Altman,

Moher, & CONSORT Group, 2010) and the trial was registered prior to data collection (clinicaltrials.gov #NCT01373762).

1.1. Design

A two-arm parallel design single blinded randomized controlled trial was conducted where participants were randomized using an on-line 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.

1.2. Participants

Participants were recruited via advertisements placed through recreation centres, health care centres, children's recreation classes, shopping malls, schools and online interest sites. 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 and if their parents consented to the placement of the bike (exergame or standard) in front of their television in a common room for the trial.

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

1.3. 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 allows each participant the opportunity to play a variety of Sony Playstation3® video games. 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 programs of their choice.

The recommended exercise training regime for both conditions was activity of moderate intensity exercise (i.e., 60–75% 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.

1.4. Measures

Equipment usage was 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.

Predictor variables of bike use included social cognitive constructs from the theory of planned behavior (Ajzen, 1991) and motivational

regulations from self-determination theory (Deci & Ryan, 2000). The instrumentation used to assess the constructs of the theory of planned behavior has been previously validated for stationary bike exercise similar to those used in this study (Rhodes, Warburton, et al., 2009) and was initially created based on the suggestions of Ajzen (2006). Questions were framed in terms of expectations of bike use over the next six weeks. Bike use corresponded to the 3 days per week of 30 min recommended in the trial during the initial orientation session. *Affective attitude* (unenjoyable-enjoyable, unpleasant-pleasant, boring-exciting) and *instrumental attitude* (useless-useful, unwise-wise, harmful-beneficial) were measured with three semantic differential items on seven-point scales. *Subjective norm* was measured with three items comprising both the injunctive (most people who are important to me would want me to ..., most people whose opinions I value would expect me to ...) and descriptive (most people who are important to me will ...) components of the concept with seven-point response anchors from strongly disagree to strongly agree. *Perceived behavioral control* was measured with three items through the response options of seven-point scales between strongly disagree and strongly agree. Assessment of perceived behavioral control included both of its components of capability (confident I can ...) and autonomy (under my control, up to me ...), with a phrase to hold motivation constant (i.e., if I really wanted to) in order to reduce any confounded assessment of motivation (Williams & Rhodes, 2014, 2016). Finally, intention was measured with two items (I plan ..., I intend ...) using seven-point response anchors from strongly disagree to strongly agree. Measures of affective attitude (time 1 $\alpha = 0.85$; time 2 $\alpha = 0.83$), instrumental attitude (time 1 $\alpha = 0.76$; time 2 $\alpha = 0.82$), subjective norm (time 1 $\alpha = 0.65$; time 2 $\alpha = 0.77$), perceived behavioral control (time 1 $\alpha = 0.76$; time 2 $\alpha = 0.73$) and intention (time 1 $\alpha = 0.87$; time 2 $\alpha = 0.93$) all showed adequate internal consistency.

Assessments of motivational regulations in self-determination theory were measured using adapted questions from the Behavioral Regulation in Exercise Questionnaire 2 (BREQ-2; Markland & Tobin, 2004). The BREQ-2 has five subscales measuring *amotivation*, *external regulation*, *introjected regulation*, *identified regulation*, and *intrinsic motivation*. Each of the BREQ-2 items was reformatted to specifically address the bike use for this study and was rated on a five-point Likert scale (1 = strongly disagree, 5 = strongly agree). The aggregate scores for amotivation (time 1 $\alpha = 0.79$; time 2 $\alpha = 0.82$), external regulation (time 1 $\alpha = 0.88$; time 2 $\alpha = 0.88$), introjected regulation (time 1 $\alpha = 0.84$; time 2 $\alpha = 0.80$), identified regulation (time 1 $\alpha = 0.78$; time 2 $\alpha = 0.85$), and intrinsic motivation (time 1 $\alpha = 0.76$; time 2 $\alpha = 0.93$) all had acceptable scale reliabilities. Examples of revised BREQ-2 items for each subscale are as follows - external regulation: "I exercise on the bike because other people say I should"; introjected regulation: "I feel guilty when I don't exercise on the bike"; identified regulation: "I value the benefits of exercising on the bike"; intrinsic motivation: "I exercise on the bike because it is fun"; amotivation: "I don't see why I should have to exercise on the bike".

1.5. 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.

After interested parents contacted the researcher and children were determined to be eligible to participate in the study, 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

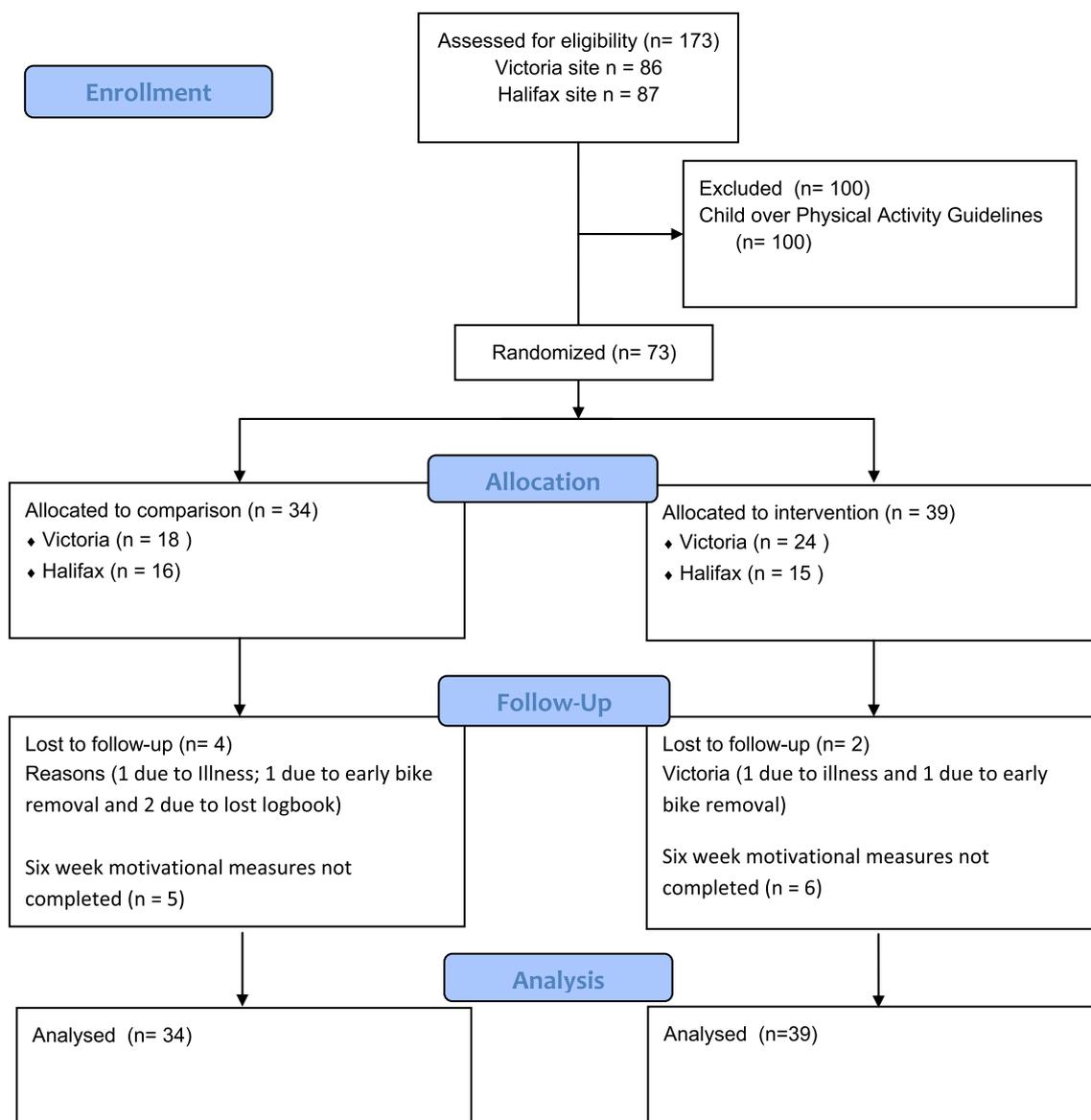


Fig. 1. Participant flow.

orientation session, the equipment was brought to the home and set-up, and all family members including parents were given the opportunity to use the equipment. The usage log was given to the family with specific sections for each member designated as a participant in the trial. 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. Participants were instructed (verbally and with a hand-out) to use the bike to help achieve their PA. At this time, participants were asked to complete the instrumentation from the theory of planned behavior and self-determination theory. These measures were administered immediately after the initial practice session use of the bike so that participants had an appropriate frame of reference with regard to equipment use (Rhodes, Warburton, et al., 2009). The same instrumentation was administered at the six-week point of the trial.

1.6. Compliance with ethical standards

The University of Victoria Human Research Ethics Board approved the study and the authors had no conflicts of interest to disclose. All

participants provided informed consent to participate in the study.

1.7. Statistical analysis

Data were analysed in SPSS 20 (SPSS Inc., Chicago, IL, USA). Missingness of bike use due to incomplete logs was inspected to determine the appropriate imputation procedures (Allison, 2002) and normality of all variables was checked to determine whether any transformations were required. The aggregate of one to six weeks and seven weeks to 13 weeks bike data were normally distributed. Four of the participants had missing bike data at one to six weeks and six participants had missing data at seven weeks to 13 weeks intervals. These data were found to be missing completely at random [Little's test (1) = 0.31; $p = .58$]. A more specific analysis of dummy coding "missingness" variables and testing for the association with various baseline variables and bike use showed no significant relationships ($p > .05$). This suggests a conservative missing at random estimation of these data is accurate and an imputation approach was conducted using the expectation-maximization algorithm (Allison, 2002, 2012).

Eleven (15% of the sample) participants had missing data on the theory of planned behavior and self-determination theory constructs at

the second assessment (seven week point). These data were also found to be missing completely at random [Little's test (37) = 40.15; $p = .33$] and a more specific analysis of dummy coding a "missingness" variable showed no association with baseline variables and bike use. Thus, similar to the bike use data, an imputation approach was conducted using the expectation-maximization algorithm.

Descriptives and bivariate correlations of all variables were then computed. Prediction of the frequency of bike use with the theory of planned behavior and self-determination theory concepts included the week one to week six and week seven to week 13 epochs (i.e., the total frequency of use across these time periods) of bike use. This approach directly aligned with the questionnaire phrasing that asked participants to think about use of the bikes over the next six weeks, as we assessed these concepts on the orientation day and then again at six weeks into the trial. Ordinary least squares regression analyses with path analysis were used to predict the effect of condition (exergame, stationary bike) on the constructs of the theory of planned behavior and self-determination theory and subsequently predict the effects of these constructs on bike use. Further, the PROCESS macro for SPSS (Hayes, 2013) was used (5000 bootstrapped samples) to investigate any mediation effects of the theoretical constructs between bike condition (standard, exergame) and bike use. An amalgamated theoretical approach was not considered because both theories have considerable conceptual overlap (Fishbein et al., 2001).

2. Results

2.1. Participant flow

Study flow of participants (see Fig. 1) has been presented previously (Rhodes et al., 2017). The 73 participants who met the study inclusion criteria were randomly assigned to one of the two conditions and rolling recruitment began in May 2012 and continued until December 2013. No two participants were from the same family. 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. 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. No participants cited harms associated with the study.

2.2. Baseline characteristics of respondents

Baseline characteristics of the participants have been reported in the prior publication (Rhodes et al., 2017). Children had a mean age of 11.5 years ($SD = 1.3$) with an equal representation of boys and girls, mainly white (87%), and over two-thirds were regular videogame players who watched an average of two hours of TV per day. On average, the children reported doing less than 1–2 bouts of PA over the past week at baseline. BMI scores were all above the 50th but lower than the 85th percentile for age and sex (Kuczmarski, 2002). Demographics were not different across the experimental and comparison condition ($p > .40$).

2.3. Associations with theory of planned behavior and self-determination theory

Descriptives and bivariate correlations among the theory of planned behavior and self-determination theory constructs with bike use can be found in Table 1 and Table 2, respectively. For the theory of planned behavior, participants scored modestly on all constructs after the initial bout with the bikes (means 4.85 to 5.86), showing no noticeable ceiling

effect. Constructs of instrumental attitude, affective attitude and perceived behavioral control were associated with intention to use the bike ($p < .05$) in the medium effect size range, but subjective norm was not. No theory of planned behavior construct was associated with actual bike use over the first six weeks ($p > .05$). Scores of all theory of planned behavior variables were modest at six weeks when asked of expectations about using the bike for the second half of the trial (Means ranged from 4.06 to 5.45). Instrumental attitude, affective attitude and subjective norm were associated with intention to use the bike from week seven to week 13 ($p < .05$), but perceived behavioral control was not. Bike use, however, was associated with instrumental attitude, perceived behavioral control, and intention ($p < .05$) in the medium effect size range.

Participants rated self-determination theory constructs of amotivation, external regulation and introjected regulation low (means < 1.08) after the initiation session with the bike, while identified regulation and intrinsic motivation to use the bike were modest (Means 2.68 to 2.75). None of these different motivations was associated with bike use over the first six weeks. A fairly similar pattern of low amotivation, external, and introjected regulation was reported concerning the bikes at the six week point of the trial (means < 1.12), yet identified regulation and intrinsic motivation remained modest (Means 2.27 to 2.34). External, introjected, and identified regulation, however, were all associated ($p < .05$) with bike use in weeks seven to 13 in the small to medium effect size range.

2.4. Path analyses of bike condition and use for the theory of planned behavior and self-determination theory

Fig. 2a details the path diagram for the theory of planned behavior predicting bike use during the first six weeks and Fig. 2b shows bike use during week seven to week 13. Condition was associated with affective ($\beta = 0.31$; $p < .01$) and instrumental ($\beta = 0.27$; $p = .02$) attitude as well as perceived behavioral control ($\beta = 0.28$; $p = .02$) but not subjective norm ($p = .97$) following the initiation session. Specifically, participants in the exergame bike condition rated expected use of the bikes as more favorable than participants in the standard bike condition and indicated they were more confident they could use the bikes. Interestingly, both affective ($\beta = 0.25$; $p = .03$) and instrumental ($\beta = 0.31$; $p = .01$) attitude constructs were independent predictors of intention, although subjective norm and perceived behavioral control were not ($p > .39$). Furthermore, mediation tests also suggested that the effect of condition on intention was mediated by these pathways of affective (standardized mediation coefficient = 0.09; 95% CI 0.01 to 0.22) and instrumental (standardized mediation coefficient = 0.09; 95% CI 0.01 to 0.25) attitude. There was no meaningful direct covariance between the bike condition and intention after controlling for these effects from the theory of planned behavior ($p = .05$; 95% CI -0.10 to 0.33). Despite this effect on intention, no theory of planned behavior constructs, or bike condition, predicted bike use over the first six weeks ($p > .29$).

By contrast, intention to use the bikes over the second half of the trial (i.e., theory of planned behavior measured at six weeks) predicted bike use ($\beta = 0.34$; $p < .01$) during the week seven to week 13 period (Fig. 2b). No other theory of planned behavior construct, or condition, had an independent significant effect on bike use ($p > .05$). Affective ($\beta = 0.31$; $p = .01$) and instrumental attitudes ($\beta = 0.35$; $p < .01$) significantly predicted intention, while subjective norm, perceived behavioral control and condition were not significant predictors ($p > .09$). Interestingly, affective attitude (standardized mediation coefficient = 0.19; 95% CI = 0.03 to 0.43) had an indirect effect on behavior through intention but not instrumental attitude (standardized mediation coefficient = 0.08; 95% CI = -0.07 to 0.27). Further, condition had no significant relationships with any of the theory of planned behavior constructs.

Fig. 3a details the path diagram for self-determination theory on

Table 1
Correlations among the theory of planned behavior constructs with bike use.

	2	3	4	5	6	7	8	9	10	11	12	M	SD
1. Instrumental Attitude T1	.41 (<i>< .01</i>)	.16 (.17)	.49 (<i>< .01</i>)	.47 (<i>< .01</i>)	.13 (.26)	.61 (<i>< .01</i>)	.42 (<i>< .01</i>)	.26 (.03)	.49 (<i>< .01</i>)	.42 (<i>< .01</i>)	.12 (.31)	5.86	0.90
2. Affective Attitude T1		.22 (.06)	.30 (.01)	.42 (<i>< .01</i>)	.01 (.93)	.20 (.09)	.32 (.01)	-.03 (.81)	.05 (.66)	.28 (.02)	-.05 (.70)	5.30	1.20
3. Subjective Norm T1			.23 (.05)	.20 (.08)	.19 (.12)	.08 (.51)	.41 (<i>< .01</i>)	.51 (<i>< .01</i>)	.05 (.66)	.12 (.31)	.13 (.27)	4.85	1.02
4. Perceived Control T1				.35 (<i>< .01</i>)	.14 (.22)	.37 (<i>< .01</i>)	.03 (.83)	.29 (.01)	.57 (<i>< .01</i>)	.07 (.56)	-.07 (.55)	5.57	1.11
5. Intention T1					.17 (.16)	.19 (.12)	.27 (.02)	.09 (.46)	.03 (.82)	.56 (<i>< .01</i>)	.04 (.74)	5.59	1.14
6. Bike Use Week 1 to Week 6						.50 (<i>< .01</i>)	.03 (.80)	.15 (.22)	.21 (.07)	.41 (<i>< .01</i>)	.49 (<i>< .01</i>)	169.38	162.27
7. Instrumental Attitude T2							.48 (<i>< .01</i>)	.31 (<i>< .01</i>)	.66 (<i>< .01</i>)	.54 (<i>< .01</i>)	.37 (<i>< .01</i>)	5.38	0.97
8. Affective Attitude T2								.31 (<i>< .01</i>)	.25 (.04)	.52 (<i>< .01</i>)	.19 (.14)	4.57	1.19
9. Subjective Norm T2									.23 (.06)	.37 (<i>< .01</i>)	.30 (.01)	4.06	1.06
10. Perceived Control T2										.18 (.13)	.16 (.17)	5.45	1.16
11. Intention T2											.36 (<i>< .01</i>)	5.09	1.20
12. Bike Use Week 7 to Week 13												97.04	148.47

Note: p levels are provided in parentheses below the correlation coefficients.

bike use during the first six weeks and Fig. 3b includes bike use during week seven to week 13. Similar to the bivariate correlations, no construct measured after the initiation session predicted bike use over the first six weeks. The condition variable, however, was associated with intrinsic motivation ($\beta = 0.30$; $p = .01$) measured after the initiation session, but not any of the other self-determination theory constructs. Thus, participants in the exergame condition rated these bikes as more intrinsically motivating than participants in the comparison condition. Condition was not related to bike use during the first six weeks either directly or indirectly through the self-determination theory constructs (all 95% confidence interval estimates passed through zero). Extrinsic regulation measured at six weeks ($\beta = 0.28$; $p = .04$) predicted bike use over the second six weeks of the trial, independent of condition and all other self-determination theory constructs, which were not significant

predictors of use (all $p > .37$). Condition was not associated with self-determination theory constructs (all $p > .07$) and had no indirect effect on bike use via these constructs (all 95% confidence interval estimates passed through zero).

3. Discussion

This study compared effects of an exergame intervention (exergame bike, standard bike) among children aged 10–14 on motivational variables (self-determination theory, theory of planned behavior) and explored whether these variables predicted use of the equipment. For the first objective of the study, we hypothesized that the exergame bike condition would report higher intrinsic motivation from self-determination theory and affective attitude and intention from theory of

Table 2
Correlations among the self-determination theory constructs and bike use.

	2	3	4	5	6	7	8	9	10	11	12	M	SD
1. Amotivation T1	.41 (<i>< .01</i>)	-.01 (.96)	-.15 (.20)	-.38 (<i>< .01</i>)	.16 (.19)	.40 (<i>< .01</i>)	.16 (.18)	.06 (.62)	-.21 (.07)	-.19 (.11)	.21 (.07)	0.59	0.85
2. External Regulation T1		.36 (<i>< .01</i>)	.21 (.08)	.00 (.98)	.03 (.83)	.26 (.03)	.60 (<i>< .01</i>)	.29 (.01)	.10 (.40)	.10 (.40)	.14 (.23)	0.97	1.01
3. Introjected Regulation T1			.56 (<i>< .01</i>)	.27 (.02)	.01 (.91)	-.09 (.44)	.20 (.09)	.61 (<i>< .01</i>)	.37 (<i>< .01</i>)	.29 (.01)	.08 (.48)	1.08	1.06
4. Identified Regulation T1				.61 (<i>< .01</i>)	.17 (.15)	-.18 (.12)	.30 (.01)	.56 (<i>< .01</i>)	.73 (<i>< .01</i>)	.61 (<i>< .01</i>)	.07 (.55)	2.75	1.02
5. Intrinsic Motivation T1					-.02 (.90)	-.45 (<i>< .01</i>)	.14 (.23)	.38 (<i>< .01</i>)	.65 (<i>< .01</i>)	.77 (<i>< .01</i>)	.00 (.98)	2.68	0.98
6. Bike Use Week 1 to Week 6						-.02 (.84)	.16 (.17)	.08 (.53)	.23 (.05)	-.03 (.81)	.49 (<i>< .01</i>)	169.38	162.27
7. Amotivation T2							.24 (.05)	-.25 (.03)	-.54 (<i>< .01</i>)	-.51 (<i>< .01</i>)	-.06 (.62)	0.78	0.82
8. External Regulation T2								.34 (<i>< .01</i>)	.23 (.05)	.19 (.10)	.33 (<i>< .01</i>)	1.12	0.99
9. Introjected Regulation T2									.70 (<i>< .01</i>)	.51 (<i>< .01</i>)	.26 (.03)	0.97	0.78
10. Identified Regulation T2										.79 (<i>< .01</i>)	.28 (.02)	2.34	0.93
11. Intrinsic Motivation T2											.20 (.09)	2.27	1.01
12. Bike Use Week 7 to Week 13												97.04	148.47

Note: p levels are provided in parentheses below the correlation coefficients.

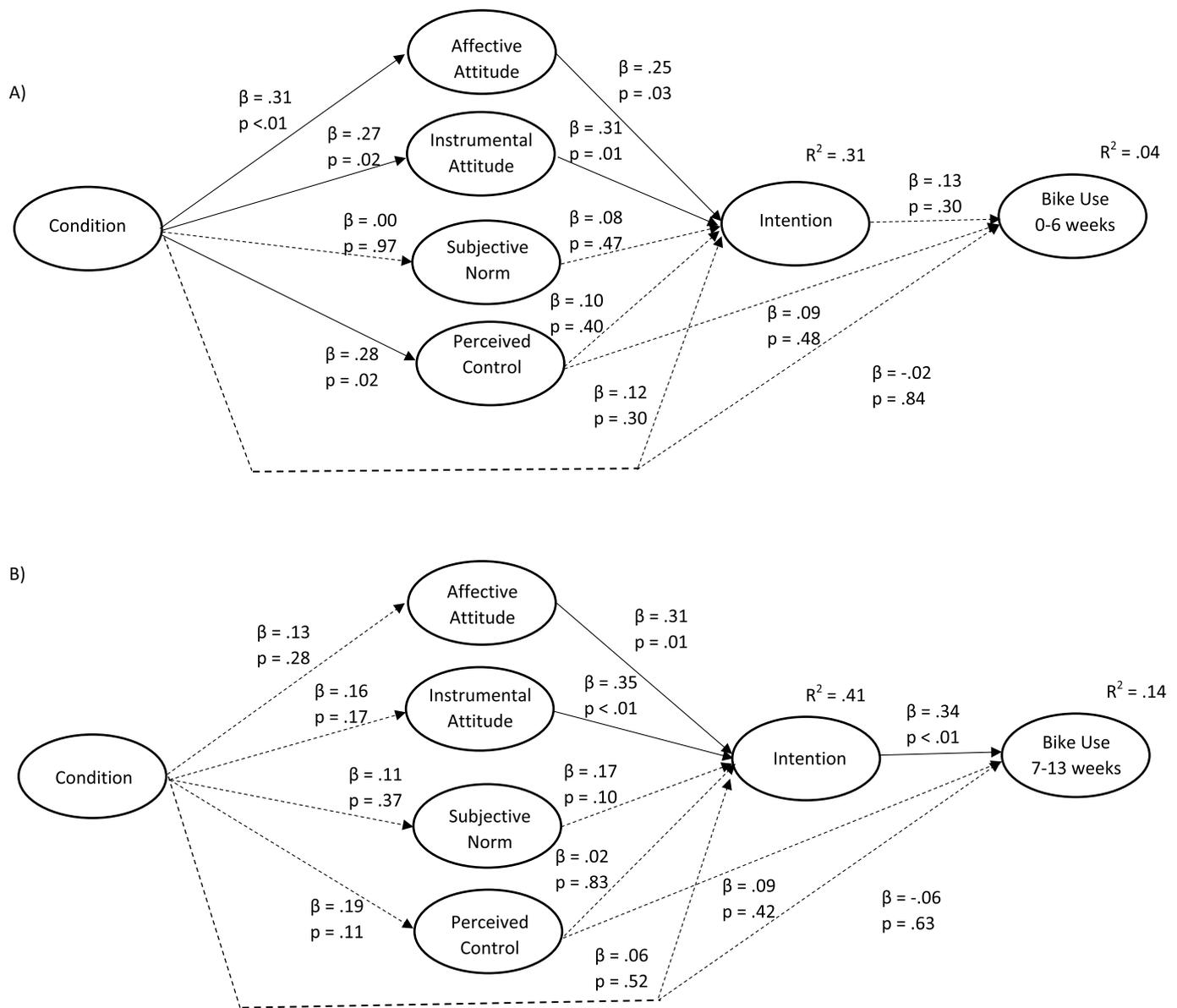


Fig. 2. Prediction of bike use with the theory of planned behavior at (A) baseline to six weeks and (B) seven weeks to three months. Note: slotted lines = $p > .05$; full lines = $p < .05$.

planned behavior based on previous findings of enhanced enjoyment (Epstein et al., 2007; Graves, Ridgers, Williams, et al., 2010; Penko & Barkley, 2010; Sun, 2012; Vernadakis et al., 2014; Wadsworth et al., 2014) following exergame play. This hypothesis was supported. After a familiarization session with the bikes, those participants who received the exergame bike reported higher affective and instrumental attitudes, perceived behavioral control, and intentions to play over the next six weeks. Further, the exergame participants also reported higher intrinsic motivation compared to participants in the standard bike condition. The findings thus extend a generally well-established result showing that exergames produce higher affective judgments among youth compared to ordinary exercise modalities and align with prior experiments using jogging (Graves, Ridgers, Williams, et al., 2010; Vernadakis et al., 2014), walking (Graves, Ridgers, Williams, et al., 2010; Penko & Barkley, 2010), and tennis (Wadsworth et al., 2014). It was interesting to note that the theory of planned behavior variables also showed a difference in instrumental attitude, as one could presume that the standard bike would be just as beneficial to use toward one's benefits from PA. Similarly, perceived control would likely be just as possible with the standard bike, given it is within the same context and is the

same equipment. The findings likely represent an overlap of some affect-based motivation in the measures. Specifically, enjoyment is beneficial and useful in itself, and perceived control is likely to have some measurement overlap with motivation (Williams & Rhodes, 2016). It may also represent some causal attribution bias, as prior studies support the notion that affective judgments can increase other cognitions about a behavior (Kiviniemi & Klasko-Foster, in press).

Despite these differences in motivation between the exergame and standard condition after the initial familiarization bout, our findings did not support any differences in theory of planned behavior or self-determination theory constructs at six weeks. We believe this finding is critical to the exergame literature as it helps bridge research that generally finds supportive motivational outcomes from single-bout experiences (Epstein et al., 2007; Graves, Ridgers, Williams, et al., 2010; Monedero, Murphy, & O'Gorman, 2017; Pasco, Roure, Kermarrec, Pope, & Gao, ; Wadsworth et al., 2014) and research trials that show low exergame use over time (Chin A Paw et al., 2008; Graves, Ridgers, Atkinson, et al., 2010; Maloney et al., 2008; Mark & Rhodes, 2013; Ni Mhurchu et al., 2008; Owens et al., 2011; Rhodes et al., 2017). Specifically, higher motivation for exergame use wanes over time, probably

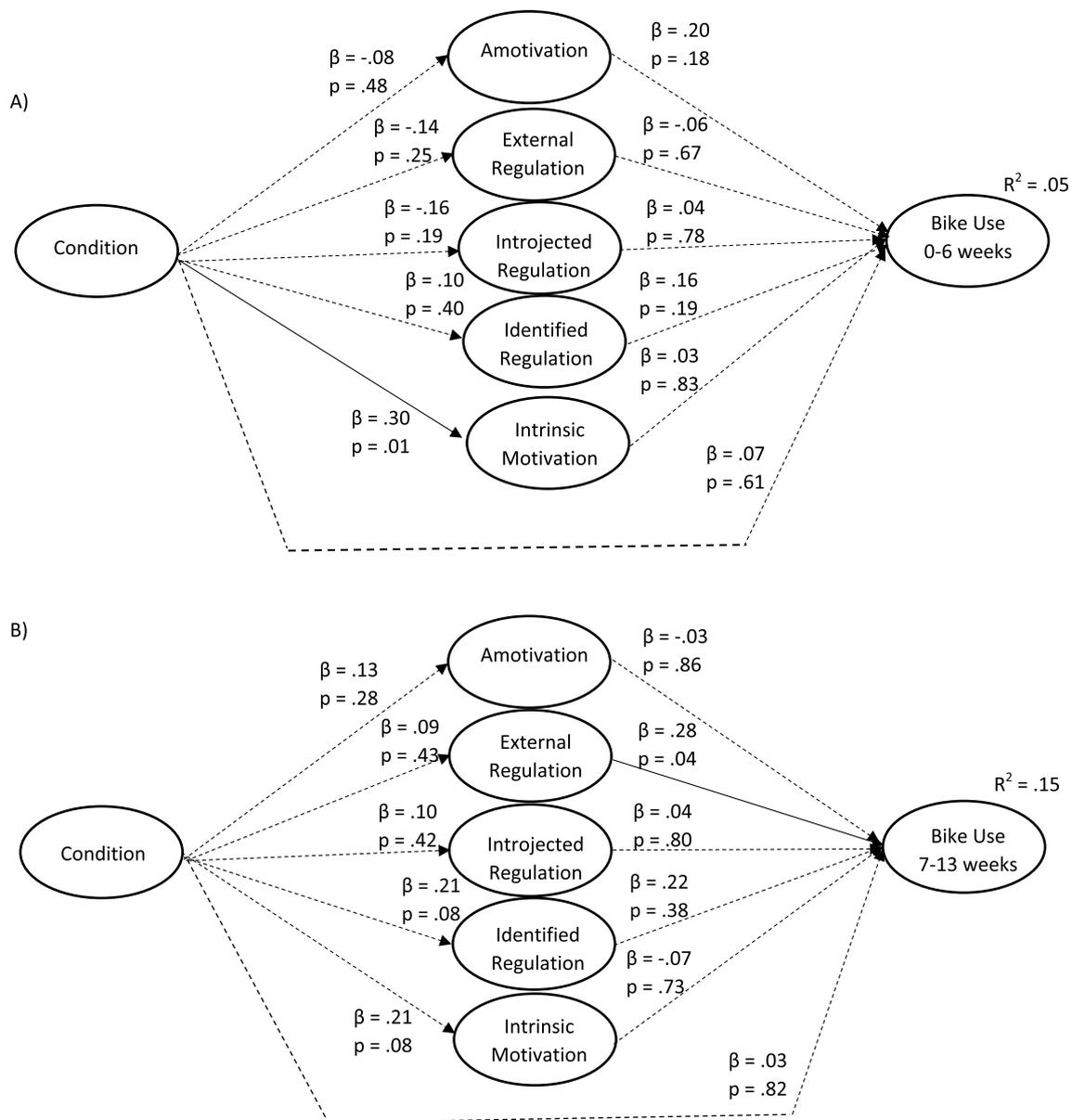


Fig. 3. Prediction of bike use with self-determination theory at (A) baseline to six weeks and (B) seven weeks to three months. Note: slotted lines = $p > .05$; full lines = $p < .05$.

due to the novelty of the activity wearing off (Barnett et al., 2011; Peng et al., 2012) but also potentially due to initial expectations about exercise equipment. For example, both conditions received instructions to use the bikes regularly and some of the initial effects of motivation may be from expectations to adhere to these instructions. The practical application of this finding suggests that single exposure exergame studies are not valid for understanding long-term exergame motivation or use. We recommend trials of at least six weeks duration to examine the longer term cognitions toward exergaming. Certainly there are some studies with exergames that do show long-term motivational benefits (Staiano et al., 2013, 2017), but only these types of long-term trials can address this important research question.

For our second purpose, we sought to explore the correlates of equipment use in both exergame conditions across time. We expected intrinsic motivation (self-determination theory) and intentions and affective attitudes (theory of planned behavior) to predict bike use. Still we also considered it possible that more extrinsic factors aligned with parental reinforcement to use the bikes (subjective norm, external/introjected regulation) could predict sustained bike use, given that

parents are often instrumental in facilitating PA at this age (Gustafson & Rhodes, 2006). Interestingly, neither theory of planned behavior or self-determination theory could explain bike use in the first six weeks. Affective and instrumental attitude did predict intention to use the bikes and even mediated the relationship between bike condition and intention, but this did not link to behavior. The intention-behavior gap is a fairly well-established limitation of the theory of planned behavior (Rhodes & de Bruijn, 2013; Sniehotta, Presseau, & Araújo-Soares, 2014), but the absolute lack of association between any motivational variable is atypical in PA research with either theory (McEachan et al., 2011; Teixeira et al., 2012).

By contrast, prediction of bike use fared better over the second six-week period of the trial. Affective and instrumental attitude predicted intention and intention predicted bike use in the medium sized range (Cohen, 1992), which is fairly standard predictive capability for the theory of planned behavior (McEachan et al., 2016) and aligned with our hypotheses. Those participants who found the bikes enjoyable and useful intended to use them more and subsequently engaged in more use. Interestingly, this did not have entirely commensurate support

using self-determination theory. Only external regulation was an independent predictor of bike use, although introjected and identified regulation were bivariate correlates of bike use. Subjective norm in the theory of planned behavior also had a significant bivariate correlation with bike use during the second six-weeks of the trial. Thus, taken together, the findings suggest that children who felt using the bike was important to their parents, were more likely to ride the bikes. This type of motivation is generally not a desired outcome for long term behavioral adherence or well-being (Ryan, Williams, Patrick, & Deci, 2009), but does make some sense within the family PA context as children are often regulated by their parents (Rhodes & Quinlan, 2014).

The differences in prediction from baseline to six weeks and six weeks to 13 weeks is an interesting finding. We believe this is likely from the differences in the accuracy of measurement of the theory of planned behavior and self-determination theory constructs over time. Specifically, it may have been that a single exposure to the bikes to draw conclusions about one's perceptions was simply not sufficiently informative to account for use over the initial six weeks, but the assessment of these perceptions at six weeks were better indicators of participant motives due to greater familiarity with the stimulus. This phenomenon of response shift due to a more fulsome understanding of task demands is a common limitation of measurement (Campbell, 1957).

The results yield some practical suggestions for parent consumers. First, having a sense of whether your child will like using the equipment may be critical to its use and this judgment is probably best made after repeated exposures. Thus having a child try similar equipment at a recreation centre/school before purchasing or ensuring a lengthy return policy with purchased equipment may be beneficial. It may also be useful to introduce new game experiences across time to maintain motivation (Kaos et al., 2018). Our study included the same games throughout the trial and this could have contributed to the lowered motivation over time. We saw some evidence that other motivations such as identified regulation or instrumental attitude were predictive of use, so education that the exercise equipment would be useful as a means of obtaining health benefits may aid as a motive for using exercise equipment. While some parental encouragement may also be helpful (subjective norm and extrinsic regulation were correlated with use), we caution the over-use of these strategies in this context and believe it is likely better for the parent to promote other types of PA in an autonomy supportive manner (Ryan et al., 2009).

Despite the novel findings in our study and the strong methods employed, there are noteworthy limitations. First, the frequency of bike use was obtained through log-books which could introduce biases. Log-books are still likely a more accurate measure of bike use than retrospective self-report (e.g., over the past week), but objective assessment of use is more desirable. Furthermore, these log-books did not include intensity of use and it would be useful to measure intensity in any future assessment. Second, families in this study 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.

Overall, our results showed evidence that initial exposure to exergames in the form of a stationary bike that interacts with driving-based video games conferred higher affective and instrumental attitudes, perceived behavioral control, intention, and intrinsic motivation compared to a stationary bike set-up in front of the TV, but this difference was not present by the six-week point of the trial. Children who had higher intention to use the bikes and extrinsic regulation were more likely to use the bikes. The results demonstrate that single-exposure research designs may not accurately reflect the motivations for longer term exergame use. Further, parent consumers of exercise equipment for the family home may benefit from considering how much their children would enjoy using the equipment after repeated exposures, while educating them about the benefits of regular PA.

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