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The impact of active gaming on adherence to a cycling program: An exploratory study.

Melanie R. Keats[1,2], Abby Jakob[1], and Ryan E. Rhodes[3]

Abstract

Background: A major factor influencing adherence to physical activity is the level of enjoyment derived from participating in the activity. Given the mass appeal of video games, technology that combines video games with physical activity (i.e., active gaming) is gaining popularity. Despite the large scale commercial growth however, few studies have examined the impact of active gaming on activity levels and fitness outcomes.

Purpose: Using the Theory of Planned Behaviour (TPB) as the guiding theoretical framework, the purpose of this study was to examine the effect of active gaming on activity enjoyment, adherence and fitness outcomes in postsecondary youth.

Methods: Participants (N = 19) were randomly assigned to experimental (n = 11) or comparison (n = 8) conditions. Participants were asked to cycle on the Exerbike Pro® for 30 minutes, twice a week for six weeks. Participants in the experimental condition exercised using an active gaming system that was linked to a Sony Playstation 2®. Participants in the comparison condition exercised using an interactive cycling training DVD. Pre and post intervention assessments included measures of TPB, physical activity behaviour, adherence, training intensity, and fitness. *Results:* Activity enjoyment ($p < 0.001$), intention ($p = 0.03$), adherence ($p = 0.01$), and exercise response (i.e., maximal aerobic power (VO_2max)) favoured the experimental condition ($p = 0.01$). *Conclusions:* This study provides additional support to the notion that active gaming may play an important role in supporting sustainable, active lifestyles. **Health & Fitness Journal of Canada 2011;4(4):20-30.**

Keywords: active gaming; stationary cycling; adherence; affective judgments; young adult

From the [1]School of Health and Human Performance, Dalhousie University, Halifax, Nova Scotia; [2]School of Physiotherapy, Dalhousie University, Halifax, Nova Scotia; [3]Department of Exercise Science, Physical and Health Education, University of Victoria, Victoria, British Columbia. Email: Melanie.Keats@Dal.Ca

Introduction

Given the convincing evidence that regular physical activity is associated with a decreased risk for several chronic health conditions and early mortality, encouraging regular physical activity has become a public health priority (Warburton, et al., 2006). Importantly, we know that as children progress through adolescence and transition to young adulthood, physical activity intensity and frequency tends to experience a steep decline (Biddle et al., 2004; Bray and Born, 2004). As many health habits are initiated, learned, and established during these transitional years, and as these behaviours will continue to influence health throughout the lifespan, these early years are vital for the adoption and sustainability of healthy lifestyle behaviours such as physical activity (Biddle et al., 2004; Fish and Nies, 1996; Sparling and Snow, 2002; Williams et al., 2002). These findings highlight the need for additional innovative intervention strategies to increase regular physical activity in this group (Wengreen and Moncur, 2009).

Optimizing Behavioural Change

Although the benefits of physical activity have been clearly established, there remains a considerable gap in our understanding of how to best promote and facilitate an active lifestyle (Hillsdon et al., 2005). Traditionally, self-efficacy has been cited as the most important physical activity correlate (Trost et al., 2002) however, a recent meta-analysis found affective judgments or the feeling states (i.e., pleasure, liking, fun) associated with engaging in physical activity to be a comparably strong correlate ($r = 0.42$) (Rhodes et al., 2009a). As enjoyment appears to be an important predictor of physical activity adoption and adherence, it seems prudent to explore novel interventions that foster positive affective expectations and responses (Rhodes et al., 2009a). One such intervention is the use of active video games or "active gaming". Harnessing the fascination and draw of video games, active gaming has the potential to provide an immersive, interactive, and intrinsically motivating (i.e., fun) way to attract those who shy away from what may be perceived as less appealing, traditional activities (Graf et al., 2009). While emerging evidence suggests that active gaming may foster positive attitudes (e.g., greater enjoyment) leading to enhanced exercise adherence, increased energy expenditure, and associated changes in health there remains a paucity of evidence and a need to further explore the motivational properties of active gaming (Rhodes et al., 2009b; Rhodes et al., 2008; Warburton et al., 2009; Warburton et al., 2007).

Accordingly, using the multi-component model of the Theory of Planned Behaviour (TPB; Ajzen, 1991) as the guiding theoretical framework, the primary purpose of the current study was to examine the effect of active gaming on physical activity attitudes/affective judgements, intentions, and activity adherence. Secondary objectives included examining the impact of the cycling intervention on levels of aerobic fitness. In alignment with the recent work and findings of Warburton (2007; 2009) and Rhodes (2008; 2009a; 2009b) it was hypothesized that the active gaming participants would report higher affective attitudes (i.e., activity enjoyment) and intentions compared to the participants who engaged in a comparison condition of stationary cycling with a non-gaming, media component. Further, we hypothesized that these differences would result in increased program adherence and fitness benefits.

Methods

Settings and Participants

This trial was conducted at Dalhousie University's School of Health and Human Performance. The study was reviewed and received ethical clearance from the school's internal ethics review board. Eligible participants were between the ages of 18 and 25 years and were English speaking. Participants were excluded from the trial if they were a varsity athlete or if they had any significant medical history that would have precluded the safe participation in the bi-weekly training sessions. A total of 19 undergraduate students consented to participate and were enrolled into the study. All 19 participants completed the six-week study.

Study Design, Procedures, and Recruitment

The overall study design follows that of the recent work of Warburton and colleagues (2007; 2009) and Rhodes et al. (2008; 2009b). This study was a six-week, randomized controlled cycling intervention comparing active gaming versus a DVD-based stationary cycling program. Participants were identified through advertisements containing a description of the media-based cycling intervention and inclusion and exclusion criteria. Details of the nature of the media (i.e., active gaming vs. DVD) were not specifically used in recruitment. All participants were fully informed of the nature and possible risks associated with the trial prior to providing written consent. Program attendance and workout intensity was monitored throughout the six-week intervention. Behavioural and fitness measures were assessed at baseline as well as after the six-week intervention.

Randomization and Blinding

Participants were randomly assigned to either the active gaming group (n = 11) or DVD cycling group (n = 8) using the fishbowl technique.

Training Regime

Sessions for each group were completed on alternating weekdays, twice a week. In an effort to minimize scheduling conflicts as a barrier to participation, activity sessions were booked based on each individual's availability. Participants were asked to perform a 5-minute cycling warm-up before performing 30 minutes of cycling with or without active gaming. All participants wore a Polar heart rate monitor and were encouraged to train at 60-80% of their maximum heart rate. Attendance, rating of perceived exertion (RPE; Borg, 1982) and heart rate were monitored at every training session.

Experimental Conditions

The experimental conditions involved subjects cycling on Exerbike Pro® along with a selection of compatible PlayStation2 videogames. Subjects in the control condition used the Exerbike Pro®, but cycled with the guidance of an instructive DVD containing video footage from on-bike cameras (RealRides, Penticton, BC, Canada). Subjects were not informed about the details of the other intervention in an effort to minimize variability in attendance and motivation.

Measures

Demographics

Baseline demographics included age, gender, degree, and year of program.

Physical Activity

Physical activity behaviour was assessed with the modified version of the Godin Leisure-Time Exercise Questionnaire (Courneya et al., 2004; Godin et al., 1985; 1986). The GLTEQ is used to assess average frequency and duration of exercise at three levels of intensity: mild (minimal effort, no perspiration), moderate (not exhausting, light perspiration), and strenuous (heart beats rapidly, sweating). Mild minutes were not included in the final calculations, but the category was included in the survey to ensure that participants did not report mild activities in the moderate category (Courneya et al., 2004). Our focus on only moderate and vigorous exercise minutes is based on public health recommendations that suggest that moderate-to-vigorous intensity activity lead to greater health benefits (Warburton et al., 2010). The GLTEQ is considered one of the most reliable measures of self-reported exercise. An independent evaluation of this measure found it to be easily administered, brief, reliable, and possess concurrent validity based on various criteria including objective activity monitors and fitness indices (Jacobs et al., 1993).

Adherence

Adherence to the intervention was documented with attendance logs (recorded as the number of sessions attended over the six-week trial).

Training Intensity and Fitness

Training intensity was assessed by RPE (Borg, 1982) and polar heart rate monitors. RPE and heart rate were assessed and recorded every 10 minutes. Average RPE and heart rate was recorded for each training session. Aerobic fitness was measured using the Astrand sub-maximal aerobic cycling test, a predictor of maximal aerobic power (VO_2max) (Astrand and Rodahl, 2003).

Guiding Theoretical Framework

Social cognitive correlates of behaviour were assessed within the theoretical framework provided by the TPB (Ajzen, 1991). These measures followed the recommendations of Ajzen and included measures of attitude, perceived behavioural control (PBC), subjective norm and intentions. Affective attitude was assessed using six items: unenjoyable-enjoyable, uninteresting-interesting, chore-fun, dull-stimulating, obligation-treat, inconvenient-convenient (baseline $\alpha = 0.81$; post-test $\alpha = 0.93$). Likewise, instrumental attitude was assessed using six items: useless-useful, harmful-beneficial, bad idea-good idea, negative-positive, unhealthy-healthy, not worthwhile-worthwhile (baseline $\alpha = 0.77$; post-test $\alpha = 0.91$). Each item was preceded by "For me to participate in a twice (2x) a week stationary cycling program for 30-minutes/session for 6 weeks would be…", and was rated on a 7-point, bipolar scale. The verbal descriptors were extremely (points 1 and 7), quite (points 2 and 6), and slightly (points 3 and 5). PBC was measured with the following 4 items: (1) "If you were really motivated, how confident are you that you are capable of participating in a twice (2x) a week stationary cycling program for 30-minutes/session over the next 6 weeks?" (1 = not at all confident to 7 = extremely confident), (2) "If you were really motivated, participating in a twice (2x) a week stationary cycling program for 30-minutes/session over the next 6 weeks would be (1 = extremely difficult to 7 = extremely easy), (3) "If you were really motivated, how much control do you feel you have over participating in a twice (2x) a week stationary cycling program for 30-minutes/session over the next 6 weeks?" (1 = very little control to 7 = complete control), and (4) "Participating in a twice (2x) a week stationary cycling program for 30-minutes/session over the next 6 weeks is entirely up to me" (1 = strongly disagree to 7 = strongly agree) (baseline $\alpha = 0.70$; post-test $\alpha = 0.72$). Subjective norm was assessed by four items rated on a 7-point scale, ranging from 1 (strongly disagree) to 7 (strongly agree). The four items read: (1) "Most people who are important to me would (a) approve, (b) encourage, (c), support me if I were to participate in a twice (2x) a week stationary cycling program for 30-minutes/session over the next 6 weeks (baseline $\alpha = 0.68$; post-test $\alpha = 0.87$). Finally, behavioural intention was assessed using two items: (1) "Over the next 6 weeks, I intend to participate in stationary cycling program for 30-minutes/session ____ times per week" and (2) "I intend to participate in a twice (2x) a week stationary cycling program for 30-

minutes/session over the next 6 weeks" (1 = strongly disagree to 7 = strongly agree).

Data Analysis

The statistical analysis of the data was carried out using SPSS version 15 for Windows. Descriptive statistics are reported for both groups, including age, gender, baseline fitness and physical activity levels, and social cognitive correlates of physical activity. Differences in program adherence were assessed using an independent t-test. Differences in self-reported physical activity as well as aerobic fitness between groups were assessed using independent t-tests. Differences in physical activity and aerobic fitness within groups were assessed using paired t-tests. The Pearson product moment correlation was used to explore the relationships between program adherence and the social cognitive correlates of behaviour. Differences between pre- and post-intervention affective attitudes within and between groups were assessed using a mixed between-within groups ANOVA analysis. Significance was set at $p < 0.05$ across all tests.

Results

Baseline

Participants had a mean age of 20.2 ± 2.0 years, and 58% were female. Participant year of study ranged from first year to fifth, with the majority in either their first (42%) or fourth (37%) year of undergraduate studies. At baseline, participants had an average VO_2max of 40.7 ± 10.2 mL/kg/min and a weekly average of 21.5 ± 16.4 MET hours of physical activity. No significant differences between baseline VO_2max, weekly MET hours, affective attitudes, instrumental attitudes, PBC, subjective norms, and intentions were found (Table 1).

Table 1: Comparison of experimental conditions on demographic, aerobic fitness, and Theory of Planned Behaviour constructs at baseline (mean ± SD).

	Overall (N = 19)	DVD (*n* = 8)	Active gaming (*n* = 11)	*p*-value
Demographic profile				
Age	20.2 ± 2.0	21.5 ± 1.3	19.3 ± 2.0	0.01
Female	58%	50%	64%	0.90
Fitness profile				
VO_2max	40.7 ± 10.2	44.2 ± 10.2	38.2 ± 9.9	0.22
MET hours	21.5 ± 16.4	25.9 ± 22.3	18.2 ± 10.4	0.32
Social cognitive items				
Affective attitude	5.4 ± 0.7	5.5 ± 0.8	5.3 ± 0.6	0.58
Instrumental attitude	6.2 ± 0.4	6.2 ± 0.5	6.2 ± 0.3	0.80
PBC	6.8 ± 0.2	6.9 ± 0.2	6.8 ± 0.3	0.24
Subjective norms	5.8 ± 0.8	6.2 ± 0.7	5.6 ± 0.8	0.10
Intention	10.6 ± 1.2	10.5 ± 1.3	10.6 ± 1.1	0.82

Post-Intervention

A statistically significant difference was found in both post-intervention affective attitudes (active gaming M = 5.9 ± 0.7 and DVD M = 4.5 ± 0.8, $t_{17} = -3.9$ $p <$

Table 2: Comparison of experimental conditions on Theory of Planned Behaviour constructs post-intervention (mean ± SD).

	Overall (N = 19)	DVD (*n* = 8)	Active gaming (*n* = 11)	*p*-value
Affective attitude	5.3 ± 1.0	4.5 ± 0.8	5.9 ± 0.7	0.00
Instrumental attitude	6.3 ± 0.6	6.1 ± 0.8	6.5 ± 0.4	0.18
PBC	6.6 ± 0.4	6.4 ± 0.5	6.7 ± 0.4	0.12
Subjective norms	5.8 ± 1.0	6.3 ± 0.7	5.5 ± 1.0	0.01
Intention	10.7 ± 0.7	10.3 ± 0.9	11.0 ± 0.0	0.03

0.001), and intentions between groups (active gaming M = 11.0 ± 0.0 and DVD M = 10.3 ± 0.9, t_{17} = -2.4, p = 0.03) (Table 2).

For the test of the intervention condition on adherence, the active gaming group (91%; M = 10.0 ± 1.0) produced higher attendance than the DVD group (73%; M = 8.0 ± 2.0) (t_{17} = -2.8, p = 0.01). The effect represents a large effect size (eta squared 0.32) (Cohen, 1998).

There was a statistically significant increase in total physical activity (MET hours/week) from Time 1 to Time 2 for both the active gaming group (Time 1, M = 18.2 ± 10.4; Time 2, M = 31.9 ± 15.8, t_{10} = -2.4, p = 0.04) and the DVD group (Time 1, M = 25.9 ± 22.3; Time 2, M = 39.6 ± 33.5, t_7 = -2.5, p = 0.04). Although there was no increase in $VO_{2\ max}$ for the DVD group, there was a statistically significant increase in $VO_{2\ max}$ in the active gaming group (Time 1, M = 38.2 ± 9.9; Time 2, M=44.1 ± 10.7, t_{10} = -3.0, p = 0.01) over the six-week intervention. Further analysis revealed that while perceived exertion was the same for both groups across the intervention (active gaming M = 6.1 ± 0.5 and DVD M = 6.0 ± 0.7, t_{17} = -0.43, p = 0.67), the active gaming group trained at a noticeably higher heart rate and approached significance (active gaming M = 150.8 ± 10.8 and DVD M = 139.2 ± 13.9, t_{17} = -2.1 p = 0.06).

Finally, a mixed between-within groups ANOVA was conducted to examine the impact of affective attitude on adherence. The results yielded a statistically significant interaction effect (change in attitude over time for both conditions) (F = 20.5, df = 1.0, $p < 0.001$) for affective attitude, and approached statistical significance for a total main effect (F = 4.0, df = 1.0, p = 0.06) with a large effect (partial eta squared = 0.19). Change scores and relationships between attendance, attitudes, perceived behavioural control, subjective norms, and intentions for both experimental conditions across the six-week intervention are presented in Tables 3 and 4.

Discussion

The aim of this study was to determine whether active gaming could increase adherence to a cycling program compared to DVD-based stationary cycling. The role of social cognitive constructs were also examined to help explain any differences. As hypothesized, adherence was greater in the active gaming group as seen by a 91% attendance rate, compared to a 73% attendance rate in the DVD group. Likewise, the active gaming group reported experiencing more enjoyment than did the DVD group.

According to the TPB, the key construct of affective attitude is postulated to influence behaviour

Table 3: Means, standard deviations, and mean change scores of the Theory of Planned Behaviour constructs by condition (mean ± SD).

Outcome	Group	Baseline	Post-intervention	Mean change	*p*-value	Effect (eta squared)
Affective attitude	Active gaming	5.3 ± 0.6	5.9 ± 0.7	0.6 ± 0.6	<0.00	0.55
	DVD	5.5 ± 0.8	4.5 ± 0.8	-0.9 ± 1.0		
Instrumental attitude	Active gaming	6.2 ± 0.3	6.5 ± 0.4	0.3 ± 0.4	0.01	0.15
	DVD	6.2 ± 0.5	6.1 ± 0.8	-0.1 ± 0.6		
PBC	Active gaming	6.8 ± 0.3	6.7 ± 0.4	-0.1 ± 0.3	0.03	0.01
	DVD	6.9 ± 0.2	6.4 ± 0.5	-0.5 ± 0.5		
Subjective norm	Active gaming	5.6 ± 0.8	5.5 ± 1.0	-0.1 ± 0.7	0.77	0.25
	DVD	6.2 ± 0.7	6.3 ± 0.7	0.1 ± 0.8		
Intention	Active gaming	10.6 ± 1.1	11.0 ± 0.0	0.4 ± 1.1	0.43	0.04
	DVD	10.5 ± 1.3	10.3 ± 0.9	-0.3 ± 1.8		

indirectly through intention. However, several studies examining the effects of affective attitude on behaviour have suggested that this construct may have a greater influence than once theorized (Lawton et al, 2007). In fact, Lawton et al., (2007) found that affective attitude was more important than cognition in the role of predicting intentions and behaviour. Specifically, in their study examining the importance of affective attitude across two health risk behaviours (speeding while driving and smoking), although participants were aware of the risks associated with the behaviours, their affective attitudes superseded their instrumental beliefs (Lawton et al., 2007). These findings can be paralleled with physical activity, or lack thereof, as most individuals are aware of the importance of physical activity for health and wellbeing (i.e., instrumental beliefs), but they often do not participate due to lack of enjoyment (i.e., affective beliefs). Furthermore, a meta-analysis examining the relationship between affective judgment and behaviour highlighted the significant positive correlation between affective judgment and physical activity (Rhodes et al., 2009a). Rhodes et al. (2009b) suggest that the reason for the increased affective attitudes seen in participants cycling with active gaming may be due to the interactions and challenges it promotes. Similarly, Kraft et al. (2005) explored the roles of PBC compared to the roles of affective attitude when predicting intention and behaviour and found that PBC was not as strong a predictor of intention as affective attitude. Therefore, the roles of PBC may be overestimated and the roles of affective attitude may be underestimated (Kraft, 2005). The results of the current study support these reports, as affective attitude demonstrated a direct, strong correlation with adherence (i.e., attendance). These findings suggests that enjoyment may be a critical factor in deciding whether or not to participate in physical activity. Future researchers should further investigate the enjoyment factor that active gaming provides, as well as explore affective attitudes associated to other types of physical activity.

Training Regime and Fitness Outcomes

While all participants were encouraged to participate in physical activity outside of the intervention, it was not compulsory for the study. Similarly, although participants were encouraged to cycle at 60%-80% of their maximum heart rates during their scheduled sessions, as we were interested in evaluating intrinsic motivation, again it was not enforced. Of note, while there were no group differences in perceived exertions throughout the cycling program, the active gaming group cycled at a noticeably higher training heart rate than the DVD group (active gaming M = 150.8 ± 10.8 and DVD M = 139.2 13.98, t_{17} = -2.06 p = 0.06); suggesting that perhaps the videogames acted as a distraction from the physical exertion associated with the task. These findings support those of Annesi and Mazas (1997) and Warburton et al. (2009) who reported that virtual reality-enhanced equipment may promote an interesting and challenging environment that effectively masks feelings of discomfort and boredom.

As the current Canadian guidelines recommend at least 150 minutes of moderate-to-vigorous aerobic physical activity per week (CSEP, 2011), it was acknowledged that cycling twice a week for thirty minutes over a short duration (i.e., 6-weeks) may not have been sufficient to gain fitness benefits. Despite this limitation and the non-prescriptive training recommendations, participants in the active gaming group demonstrated a substantial increase in VO_2max over the six-week intervention. Although, the small sample precluded detailed analyses, it was anticipated that the increase in VO_2max could be partially attributed to both the increased attendance as well as the higher training intensity. These findings support those of Warburton et al. (2009) who also found that interactive gaming resulted in enhanced fitness benefits over standard cycling.

While this is only the second study to examine social cognitive variables on adherence to an active gaming activity (Rhodes et al., 2009b), there is preliminary evidence that active gaming may have the potential to increase

Table 4: Correlations between attendance, attitudes, perceived behavioural control, subjective norms, and intentions for combined experimental conditions.

Variable	2	3	4	5	6	7	8	9	10	11
1. Attendance	0.26	0.64**	0.38	0.64**	-0.19	0.58**	-0.09	-0.11	0.52*	0.37
2. Affective Attitude Pre	1	0.27	0.60*)	0.43	-0.16	-0.02	0.42	0.22	0.43	-0.06
3. Affective Attitude Post	-	1	-0.02	0.51*	-0.34	0.43	0.02	-0.05	0.40	0.41
4. Instrumental Attitude Pre	-	-	1	0.44	0.20	0.29	0.13	0.24	0.41	0.23
5. Instrumental Attitude Post	-	-	-	1	0.12	0.58**	0.24	0.22	0.47*	0.17
6. PBC Pre	-	-	-	-	1	0.18	0.18	0.60**	0.12	-0.24
7. PBC Post	-	-	-	-	-	1	-0.07	<0.00	0.23	0.60*
8 Subjective Norms Pre	-	-	-	-	-	-	1	0.70**	-0.07	-0.08
9 Subjective Norms Post	-	-	-	-	-	-	-	1	0.18	-0.08
10. Intention Pre	-	-	-	-	-	-	-	-	1	-0.15
11. Intention Post	-	-	-	-	-	-	-	-	-	1

Note: ** Correlation is significant at the 0.01 level; * correlation is significant at the <0.05 level.

physical activity attitudes, intentions, and behaviours. In contrast to the Rhodes et al. (2009b) study however, it did not appear that the novelty of the active gaming activity wore off. In fact, the active gaming group demonstrated a significant improvement in both affective (Time 1, M = 5.3 ± 0.6; Time 2, M=5.9 ± 0.7; $t_{10} = -3.72$, $p < 0.00$) and instrumental (Time 1, M = 6.3 ± 0.8; Time 1, M = 6.5 ± 0.4; $t_{10} = -2.39$, $p = 0.04$) attitude over the six week intervention. Likewise, while Rhodes et al. (2009b) found intentions to decrease across time, the current study demonstrated stable intentions over time (Table 3).

The differences in affective attitudes between groups exhibit strong implications for long-term adherence to physical activity, as when an activity is perceived as enjoyable, an individual is more likely to continue to participate - regardless of the potential benefits or harms that activity may have on the individual (Lawton et al., 2007). The current findings suggest that active gaming may be an important tool in fostering greater motivation to be physically active. Interestingly, although this study did not explicitly explore the capacity of active gaming to encourage or promote physical activity outside of the active gaming intervention, the potential that it may stimulate additional activity merits further exploration. For example, in the current study, one participant reported that "It [active gaming] also prompted me to get back to the gym and start working on my health. I thoroughly enjoyed myself. I am glad that I participated."

Limitations

While this study makes an important contribution to the literature, it is important to acknowledge that our small sample represented a healthy, educated, and moderately active group with positive intentions to exercise at baseline. The results therefore may not generalize to other populations. Likewise, the short study duration (i.e., 6-weeks) and frequency (i.e., two sessions per week) limits the ability to predict the impact of active gaming on long-term adherence and fitness outcomes.

Conclusions

In summary, active gaming may have the potential to promote adherence to physical activity through enhanced enjoyment, which can ultimately lead to improved health and well-being. Future research is warranted to explore the utility of active gaming in promoting sustainable, physically active lifestyles across diverse populations.

Author Qualifications

The author qualifications are as follows: Melanie Keats, PhD; Abby Jacob, BSc; Ryan Rhodes, PhD.

References

Annesi, J., and Mazas, J. (1997). Effects of virtual reality-enhanced exercise equipment on adherence and exercise-induced feeling states. *Perceptual and Motor Skills, 85*, 835-844. URL: http://www.ncbi.nlm.nih.gov/pubmed/9399288.

Astrand, P., and Rodahl, K. (2003). *Textbook of work physiology: physiological basis of exercise* (*4th ed).* Champaign, IL: Human Kinetics.

Ajzen, I. (1991). The theory of planned behaviour. *Organizational Behavior and Human Decision Processes, 50*, 178-211.

Biddle, S., Gorley, T., and Stensel, D. (2004). Health-enhancing physical activity and sedentary behaviour in children and adolescents. *Journal of Sports Sciences, 22*,679-701. URL: http://www.ncbi.nlm.nih.gov/pubmed/15370482.

Borg, G. (1982). Psychophysical bases of perceived exertion. *Medicine and Science Sports and Exercise, 14,* 377-381. URL: http://www.ncbi.nlm.nih.gov/pubmed/7154893.

Bray, S.R., and Born, H.A. (2004). Physical activity and transition to university: implications for health and psychological well-being. *Journal of American College of Health, 52*, 181-188. URL: http://www.ncbi.nlm.nih.gov/pubmed/15018429.

Canadian Fitness and Lifestyle Research Institute. Physical activity levels among Canadian adults. http://cflri.ca/eng/levels/adult_levels.php. Accessed August 4, 2010.

Canadian Society for Exercise Physiology (CSEP). (2011). Canada's physical activity guide for adults. 18-64 years. Retrieved December 20, 2011, from http://www.csep.ca/CMFiles/Guidelines/CSEP-InfoSheets-adults-ENG.pdf
Canada.

Cohen, J. (1988). *Statistical power for the behavioural sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.

Courneya, K.S., Jones, L.W., Rhodes, R.E., and Blanchard, C.M. (2004). Effects of different combinations of intensity categories on self-reported exercise. *Research Quarterly for Exercise and Sport, 75*(4),429-433. URL: http://www.ncbi.nlm.nih.gov/pubmed/15673042.

Fish, C., and Nies, M. (1996). Health promotion needs of students in a college environment. *Public Health Nursing, 13*,104-111. URL: http://www.ncbi.nlm.nih.gov/pubmed/8936243.

Godin, G., Jobin, J., and Bouillon, J. (1986). Assessment of leisure time exercise behaviour by self-report: concurrent validity study. *Canadian Journal of Public Health, 77*, 359-362. URL: http://www.ncbi.nlm.nih.gov/pubmed/3791117.

Godin, G., and Sheppard, R. (1985). A simple method to assess exercise behaviour in the community. *Canadian Journal of Applied Sport Science, 10*, 141-146. URL: http://www.ncbi.nlm.nih.gov/pubmed/4053261.

Graf, D., Pratt, L., Hester, C., and Short, K. (2009). Playing active video games increases energy expenditure in children. *Pediatrics, 124*, 534-540. URL: http://www.ncbi.nlm.nih.gov/pubmed/19596737.

Jacobs, D., Ainsworth, B., Hartman, T., and Leon, A. A simultaneous evaluation of ten commonly used physical activity questionnaires. *Medicine and Science in Sports and Exercise*, *25*, 81-91. URL: http://www.ncbi.nlm.nih.gov/pubmed/8423759.

Keating, X.D., Guan, J., Pinero, J.C., and Bridges, D.M. (2005). A meta-analysis of college students' physical activity behaviours. *Journal of American College of Health, 54*(2), 116-125. URL: http://www.ncbi.nlm.nih.gov/pubmed/16255324.

Kraft, P., Rise, J., Sutton, S., and Roysamb, E. (2005). Perceived difficulty in the theory of planned behaviour: perceived behavioural control or affective attitude? *British Journal of Social Psychology, 44*, 479-496. URL: http://www.ncbi.nlm.nih.gov/pubmed/16238850.

Hillsdon, M., Foster, C., and Thorogood, M. (2005). Interventions for promoting physical activity. *Cochrane Database Syst Rev, 25*(1),CD003180.

Lawton, R., Conner, M., and Parker, D. (2007). Beyond cognition: predicting health risk behaviours from instrumental and affective beliefs. *Health Psychology, 26*, 259-267. URL: http://www.ncbi.nlm.nih.gov/pubmed/17500612.

Leslie, E., Sparling, P.B., and Owen, N. (2001). University campus settings and the promotion of physical activity in young adults: lessons from research in Australia and the US. *Health Education*, *101*, 116-125.

Rhodes, R., Fiala, B., and Conner, M. (2009a). A review and meta-analysis of affective judgments and physical activity in adult populations. *Annals of Behavioral Medicine, 38*, 180-204. URL: http://www.ncbi.nlm.nih.gov/pubmed/20082164.

Rhodes, R., Warburton, D., and Bredin, S. (2009b). Predicting the effect of interactive video bikes on exercise adherence: An efficacy trial. *Psychology, Health and Medicine, 14*,631-640. URL: http://www.ncbi.nlm.nih.gov/pubmed/20183536.

Rhodes, R., Warburton, D., and Coble, J. (2008). Effect of interactive video bikes on exercise adherence and social cognitive expectancies in young men: A pilot study. *Annals of Behavioral Medicine, 3*, S62*.*

Sparling, P.B., and Snow, T.K. (2002). Physical activity patterns in recent college alumni. *Research Quarterly for Exercise and Sport, 73*,200-205. URL: http://www.ncbi.nlm.nih.gov/pubmed/12092895.

Trost, S.G., Owen, N., Bauman, A., Sallis, J.F., and Brown, W. (2002). Correlates of adult's participation in physical activity: review and update. *Medicine and Science in Sports and Exercise, 34*, 1996-2001. URL: http://www.ncbi.nlm.nih.gov/pubmed/12471307.

Warburton, D., Bredin, S.S.D., Horita, L.T.L., Zbogar, D., Scott, J.M., Esch, B.T.A., and Rhodes, R.E. (2007). The health benefits of interactive video game exercise. *Applied Physiology Nutrition and Metabolism, 32,* 655-663.

Warburton, D., Charlesworth, S., Ivey, A., Nettlefold, L., and Bredin, S. (2010). A systematic review of the evidence for Canada's Physical Activity Guidelines for Adults. *International Journal of Behavioral Nutrition and Physical Activity, 7,* 39. URL: http://www.ncbi.nlm.nih.gov/pubmed/20459783.

Warburton, D., Sarkanv, D., Johnson, M., Rhodes, R., Whitfor, W., Esch, B., Scott, J., Wong, S., and Bredin, S. (2009). Metabolic requirements of interactive video game cycling. *Medicine and Science in Sports and Exercise*, *41*,920-926. URL: http://www.ncbi.nlm.nih.gov/pubmed/19276840.

Warburton, D., Nicol, C., and Bredin, S. (2006). Health benefits of physical activity: the evidence. *Canadian Medical Association Journal, 174*(6),801-809. URL: http://www.ncbi.nlm.nih.gov/pubmed/16534088.

Wengreen, H., and Moncur, C. (2009). Change in diet, physical activity, and bodyweight among young-adults during the transition from high school to college. *Nutrition Journal*, *8*, 32. URL: http://www.ncbi.nlm.nih.gov/pubmed/19624820.

Williams, P., Holmbeck, G., and Greenley, R. (2002). Adolescent health psychology. *Journal of Consulting and Clinical Psychology, 70*(3), 828-842. URL: http://www.ncbi.nlm.nih.gov/pubmed/12090386.