[International Journal of Undergraduate Research and Creative Activities](https://digitalcommons.cwu.edu/ijurca)

Volume 5 | Issue 1 Article 1

October 2023

Physiological, psychological, and performance differences between Wii fitness gaming and traditional gym exercises

Mike R. Bumgarner
mike.bumgarner@drake.edu

David S. Senchina
dssenchina@drake.edu

Recommended Citation

Bumgarner, Mike R. and Senchina, David S. (2023) "Physiological, psychological, and performance differences between Wii fitness gaming and traditional gym exercises," *International Journal of Undergraduate Research and Creative Activities*: Vol. 5: Iss. 1, Article 1.
DOI: 10.7710/2168-0620.1007
Available at: https://digitalcommons.cwu.edu/ijurca/vol5/iss1/1

Physiological, psychological, and performance differences between Wii fitness gaming and traditional gym exercises

Peer Review
This work has undergone a double-blind review by a minimum of two faculty members from institutions of higher learning from around the world. The faculty reviewers have expertise in disciplines closely related to those represented by this work. If possible, the work was also reviewed by undergraduates in collaboration with the faculty reviewers.

Abstract
Video gaming systems market themselves as tools for promoting physical activity or physical therapy. In this investigation, we wanted to compare the Wii console system game EA Sports Active to traditional gym exercises using five activities: basketball passing, basketball shooting, biceps curls, body squats, and jogging. Our hypotheses were that: (1) physiological demand would be greater in the gym than on the Wii, (2) psychological measures of exertion would be greater in the gym than on the Wii, and (3) performance would be poorer in the gym than on the Wii. Ten young adults participated in the study, completing all five exercises in both settings. Heart rate recordings were higher for four of the five exercises when performed in the gym versus on the Wii, though estimations of caloric expenditure in the jogging exercise did not differ between the two settings. Ratings of perceived exertion and difficulty were higher in the gym versus on the Wii for half of the exercises but not different for the remaining ones. For the basketball exercises, accuracy was consistently lower in the gym versus on the Wii. These results support use of active video gaming to ameliorate inactivity or to help in physical therapy and rehabilitation, but point out important differences between the gym versus Wii exercise that are important in determining which may be better for general exercise, skill-building, promoting recovery.

Keywords
basketball, EA Sports Active, exercise, video games, video gaming, Wii

Acknowledgements
Thanks to all the subjects that participated in our study. Michael Ball facilitated use of the Fieldhouse for the gym exercises. The television, Wii console, and accessories were purchased through faculty start-up funds awarded to DSS previously from Drake University. The game and all the equipment needed for the gym exercises were purchased personally by DSS. Editor's Note: Dr. David S. Senchina, Associate Professor, Department of Biology, Drake University, served as faculty mentor for this work.

INTRODUCTION

Many video gaming systems market themselves as tools for promoting physical activity or physical therapy. Some labs have shown that playing Wii sports games can elicit heart rate increases similar to those seen in light to moderate exercise (Bosch et al. 2012; O'Donnovan & Hussey, 2012). Playing for 30 minutes may be sufficient to meet daily activity recommendations such as those provided by the American College of Sports Medicine for young adults (Douris et al. 2012; Garn et al. 2012) and may help prevent obesity (Lyons et al. 2012). Advantages of such games are that they appeal to young adults, can be social activities, and can be done in the home (living room or bedroom) making them more convenient.

Some researchers have shown the Wii can be used in rehabilitation ("Wiihab"; Daniel 2012; Taylor et al. 2011). Examples include improving leg muscle and function in older adults (Jorgensen et al. 2012), improving quality of life in cancer patients (Jahn et al. 2012), and recovery after stroke (Neil et al. 2012). Importantly, the latter study used a Sony PlayStation gaming system, suggesting that Nintendo Wii isn't the only system that might produce such benefits.

Many of the studies cited above examined single-sport or single-exercise games; however, many Wii fitness games present subjects with multiple cross-training exercises in a series such that subjects are switching exercise modes every 1-3 minutes. The purpose of this study was to examine how one such game, *EA Sports Active* for Nintendo Wii, influenced physiological, psychological, and performance outcomes in young adults, and to compare these parameters when subjects were playing the game versus when they were performing traditional equivalents in a gym setting.

Since *EA Sports Active* is a modular game, we elected to investigate five modalities: basketball passing, basketball shooting, biceps curls, body squats, and jogging. For physiological variables, our hypothesis was that heart rate and calories burned (during the run) would be higher when subjects performed the exercise in the gym versus on the Wii. For psychological variables, we hypothesized that subjects would report lower ratings of perceived exertion and difficulty on the Wii versus in the gym. For performance variables, we hypothesized that accuracy would be higher on the Wii versus in the gym for the basketball exercises.

MATERIALS AND METHODS

Human subject research approval was obtained through the Drake University Institutional Review Board prior to the study (2009-10092). Subjects gave signed informed consent prior to participating. Ten subjects participated and reported to the lab wearing a T-shirt, shorts, and athletic shoes like they would normally train in.

Gender, age, height, and weight were recorded for each subject (Table 1). Subjects were fitted with a radio-transmitter heart rate monitoring device (Polar Electro Oy). Subjects then completed a set of five exercises (basketball passing, basketball shooting, biceps curls, body squats, or jogging) on both the Nintendo Wii *EA Sports Active* video game and in the Drake Fieldhouse gymnasium. Gym vs. video game order was randomly determined.

	Female	Male
n	5	5
Age (yrs)	19.8 ± 1.8	19.8 ± 1.6
Height (cm)	167.6 ± 8.7	180.9 ± 4.7
Weight (kg)	54.5 ± 9.4	71.1 ± 6.8

Table 1. Subject characteristics. Values are given as means ± standard deviation.

Gym exercises were structured to mimic how the video game presented them so comparisons could be made between the two exercise modes. Figure 1 presents some examples.

For basketball passing on the Wii, subjects hold the Wiimote in one hand the nunchuk in the other, and the game presents them with 3 targets (left, middle, right) and prompts them to complete 30 passes by thrusting their arms towards the appropriate target (10 passes to each target). To emulate this in the gym, subjects were asked to complete 30 passes, 10 to each of 3 human targets positioned approximately 5 ft apart from each other and arranged in a row 25 ft away from the subject. These distances were chosen for the gym because they elicited magnitude and direction of arm thrusts similar to the Wii exercise during pilot studies.

Figure 1. Gym (left) versus Wii (right) exercises. Top: basketball shooting. Bottom: jogging.

For basketball shooting on the Wii, subjects again hold devices in both hands and are prompted to make 20 shots towards a single basket by jumping and thrusting their arms up and out. To emulate this in the gym, subjects were asked to make 20 shots onto a basket from the free throw line.

For biceps curls on the Wii, subjects again hold one device in each hand but also utilize a rubber resistance band provided with the game. The band is anchored underneath and between their feet (spaced shoulder width apart) with straps from the ends placed around each wrist. Subjects are prompted to perform 20 alternating biceps curls (10 for each arm). The amount of resistance the band provides is arbitrarily decided by each subject based on how much tension they put on the band. For the gym component, we provided subjects with dumbbells ranging in mass from 5-30 pounds and asked them to complete 20 alternating biceps curls.

For the body squats on the Wii, a holster is strapped to the upper right leg of the subject and the nunchuk placed inside it. Holding the Wiimote in the right hand, subjects are asked to perform 12 body squats. Body squats are like standing barbell back squats but using only body weight; thus, subjects start in a standing position, squat until their thighs are parallel to the floor, and the return to the upright position. During the squat they extend their arms forward on the down movement and keep their arms at their sides for the up movement. For the gym component, we asked subjects to complete 12 body squats using similar arm motions.

For the jogging component on the Wii, the subject again places the nunchuk in the holster and holds the Wiimote in the right hand. The subject is prompted to jog in place at a moderate speed until they reach the finish line (we selected the "long track" option which is ~90-100 seconds of jogging

DOI: http://dx.doi.org/10.7710/2168-0620.1007

depending on the subject's cadence). To emulate this in the gym, we asked subjects to run on a banked, indoor track for a fixed time of 100 seconds. Cadence was controlled for the jog but not for the other four exercises.

Multiple outcomes were measured. For physiological outcomes, heart rate (HR) was recorded at the start and end of each component for each set. Although the Wii provided estimated caloric expenditure after each exercise, estimating caloric expenditure in the gym is difficult. The American College of Sports Medicine provides validated equations for estimates of some common activities, but the only one that applied to our experiment was the equation for jogging. Therefore, the estimated caloric expenditure from the Wii (which also uses its own equations) was recorded and the distance ran on the track was recorded. From the fixed time of 100 seconds, the known distance jogged, and the known body mass of the subjects, metabolic equivalents for the run could be deduced using published tables (ACSM 2009) and caloric expenditure during the run could be estimated using the following equation:

$$\text{Kcal}\cdot\text{min}^{-1} = (\text{METs} \times 3.5 \times \text{BM}) / 200 \quad (1)$$

where BM is body mass in kg.

For psychological outcomes, rating of perceived exertion (RPE) was asked of the subjects at the end of each component in both sets. Subjects report a whole number numerical score of their perceived exertion ranging from 6 (no exertion) to 20 (maximal exertion) using a chart that gives anchor descriptions for alternating numbers. Our lab also produced our own "rating of perceived difficulty" (RPD) scale. To generate the RPD scale, the RPE scale was changed so that exertion terms were replaced with difficulty terms, but the same 6-20 value Likert system was used. Since we have not used this scale previously and were unsure of its efficacy, subjects were only asked to report RPD at the end of the basketball and running components of both components. While we fully acknowledge the homemade RPD scale is not validated, it provided us with a convenient tool for gauging whether subjects perceived selected exercises from the Wii as being of similar or differing difficulty compared to standard gym equivalents.

For performance outcomes, accuracy was recorded for both basketball passing (# of accurate passes/total attempts) and basketball shooting (# of baskets made/total attempts). As mentioned in a previous paragraph, distance was recorded for the jogging event in the gym and converted to caloric expenditure for comparison to the jogging component on the Wii.

ANOVA or paired samples T-tests were used to determine significant differences in outcomes by gender (female vs. male) or set (Wii vs. gym). Significance was defined as $p \leq 0.05$ whereas a trend for significance was defined as $0.05 \leq p \leq 0.1$. Linear regression equations were used to determine relationships between some selected outcomes.

RESULTS

Physiological Outcomes

Changes in HR from pre- to post-exercise (ΔHR) for all components of both sets are given in Table 2 (next page). Based on ANOVA, there were no significant differences by gender. ΔHR was significantly greater for gym versus Wii exercises for basketball passing ($p=0.01$), biceps curls ($p=0.02$), and jogging ($p=0.02$). ΔHR demonstrated a trend for being greater when shooting baskets in the gym than on the Wii ($p=0.1$).

https://digitalcommons.cwu.edu/ijurca/vol5/iss1/1
DOI: 10.7710/2168-0620.1007
DOI: http://dx.doi.org/10.7710/2168-0620.1007

	Gym	Wii
B-ball passing*	20.8 ± 17	1 ± 9.6
B-ball shooting†	23.3 ± 25.8	5.7 ± 9.5
Biceps curls*	17.7 ± 11.1	5 ± 4.4
Body squats	19.2 ± 13.6	14.7 ± 10.4
Jogging*	48.3 ± 28.3	32.8 ± 16.8

Table 2. Changes in heart rate (ΔHR) from pre- to post-exercise for all components of both sets, expressed as beats per minute. Values are given as means ± standard deviation. Asterisks (*) indicate significant differences between gym and Wii whereas daggers (†) indicate a trend towards a difference.

Caloric expenditure comparisons are possible only for the running component for reasons described earlier. Estimates of caloric expenditure were recorded from the Wii or calculated from the gym data, but there were no significant differences between the two by t-test (gym = 15.9 ± 3.4, Wii = 16.9 ± 2.7). Due to mass differences, males were estimated to have burned more calories than females (p=0.014). To better understand how well estimates between the Wii and the gym correlated, a linear regression equation was established from a scatterplot of the estimates (Figure 2). Correlations between the two were poor (R^2=0.153).

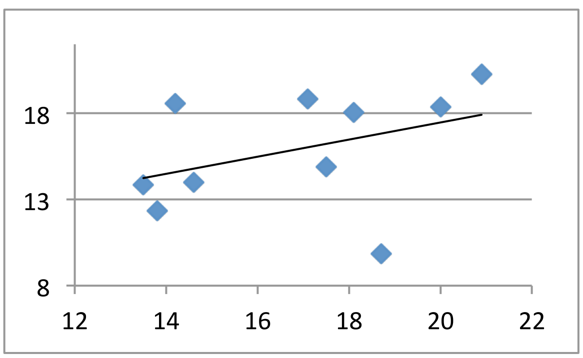

Figure 2. Lack of correlation (R^2=0.153) with jogging caloric expenditure estimates between the Wii (x-axis) and gym (y-axis) components.

Psychological Outcomes

RPE scores for all five components of both sets are provided in Table 3. RPE was significantly higher when in the gym versus on the Wii for basketball shooting (p=0.003) and biceps curls (p<0.001), and demonstrated a trend for being higher when jogging in the gym versus on the Wii (p=0.056), according to ANOVA. There were no significant differences by gender.

	Gym	Wii
B-ball passing	9.1 ± 2.5	8.1 ± 1.9
B-ball shooting*	10.9 ± 2.6	7.7 ± 1
Biceps curls*	11 ± 2.1	7.2 ± 1.3
Body squats	9.6 ± 2.4	9.3 ± 1.9
Jogging†	10.4 ± 3.4	9.6 ± 2.5

Table 3. RPE scores for all components of both sets. Values are given as means ± standard deviation. Asterisks (*) indicate significant differences between gym and Wii whereas daggers (†) indicate a trend towards a difference.

RPD scores for the basketball and jogging components are diagrammed in Figure 3. The only significant difference was for basketball shooting between the gym and the Wii (p=0.001) as determined from ANOVA. There were no significant differences by gender.

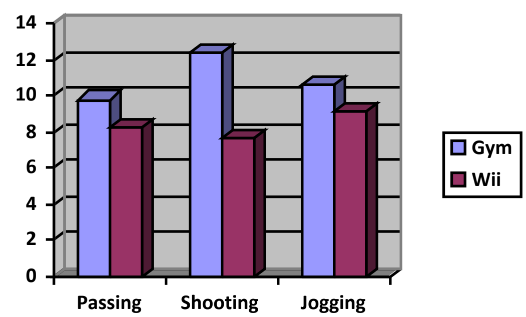

Figure 3. Mean RPD scores for basketball passing, basketball shooting, and jogging.

A linear regression equation was established from a scatterplot of the RPE data versus the RPD data (Figure 4) from the basketball and jogging exercises to better understand the utility of the new RPD scale in comparison to the widely-used and highly-validated RPE scale. Correlations

DOI: http://dx.doi.org/10.7710/2168-0620.1007

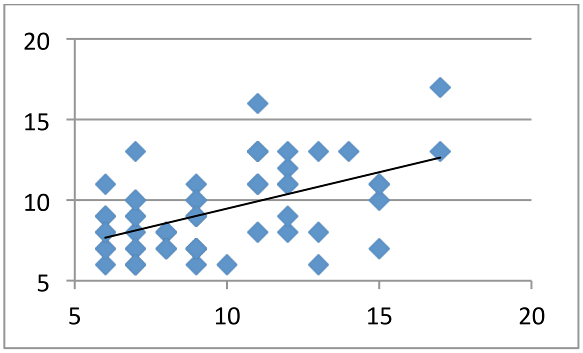

Figure 4. Lack of correlation (R^2=0.2692) with RPD (x-axis) versus RPE (y-axis) scales.

between the two were poor (R^2=0.2692). Interpretation of this finding will be provided in the discussion.

Performance Outcomes

Accuracy of basketball passing and shooting was determined between the two sets as is illustrated in Figure 5. ANOVA found that accuracy was lower in the gym versus on the Wii for both passing (p=0.007) and shooting (p<0.001). There were no significant differences by gender despite the fact that accuracy was greater in males than females for passing (85.3% vs. 69.4%) and slightly greater for shooting (26.7% vs. 20.7%). Estimates of caloric expenditure for jogging were presented earlier (Figure 2).

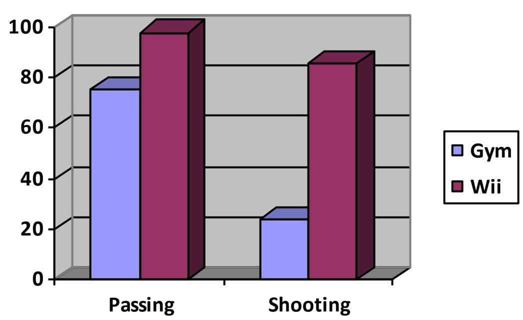

Figure 5. Accuracy (expressed as a percent—accurate passes or shots / total attempts) for both basketball passing and shooting for both

DISCUSSION

To the best of our knowledge, this is the first report of a physical activity comparison between the Nintendo Wii game *EA Sports Active* and traditional equivalents. We employed 3 comparisons: physiological, psychological, and performance.

Physiological Outcomes

Our first hypothesis was that HR would be higher for all exercises when performed in the gym versus on the Wii. An additional aspect of this hypothesis was that calories burned during the jog would also be higher in the gym versus on the Wii. The data support the first part of the hypothesis but not the second.

HR and ΔHR were significantly higher for four of the five exercises when done in the gym versus on the Wii (Table 2); the one that did not fit this pattern was the body squats, which perhaps isn't surprising considering that the two exercises are virtually identical between the two settings. HR results for the Wii data are congruent with some previous studies but incongruent with others. Our results agree with one study (Graves et al. 2010) done with similarly-aged subjects as ours. By contrast, our results disagree with other studies that demonstrate HR, maximal heart rate (HR_{max}), and rate pressure product are higher when playing Wii Fit versus exercising on a treadmill (Douris et al. 2012; Penko & Barkley 2010); however, these studies used a sedentary youth or young adult population whereas all of our participants were university athletes or regularly recreationally active. Other studies less directly comparable to ours state that 30 minutes of Wii boxing elicits ~75% of the participants' HR_{max} (as determined from a previous treadmill test; Bosch et al. 2012), and report HR_{max} for four Wii activities, but did not compare them to non-

DOI: http://dx.doi.org/10.7710/2168-0620.1007

Wii equivalents (O'Donovan & Hussey, 2012).

In contrast to our HR data, we found no differences in caloric expenditure between jogging in the two modes, and no correlation between the two (Figure 2). Both ourselves and the Wii used metabolic equations to infer caloric expenditure, even though our equations took factors such as body weight into account (which the Wii did not), instead of a metabolic cart. Additionally, the jog lasted only approximately 100 seconds, which may not be enough time to make an accurate estimate of caloric expenditure. Other researchers have explored energy expenditure in the context of video gaming using various methodologies including metabolic equations, VO_2 sampling, metabolic chambers, or accelerometers. Their results are difficult to compare directly to ours because subject characteristics and metrics differed.

Similar to what we found, an early study stated that active video game play similar to ours resulted in energy expenditure comparable to moderate intensity walking in pre-adolescent children (Graf et al. 2009). In another study examining younger and older adults comparatively, energy expenditure when playing Wii was less than for traditional treadmill exercise but higher than sedentary gaming (Graves et al. 2008, 2010). Different from what we found, a study of pre-adolescent boys showed multiple Wii activities elicited similar energy expenditure, which was higher than walking (White et al. 2011). Separately but importantly, one study showed that caloric expenditure was higher in older adults playing Wii versus a control group of seated exercise controls (Daniel 2012) and another reported that both children and adults who played Wii had higher caloric expenditure or VO_2 than when they played more traditional (sedentary) video games or passively watched television (Lanningham-Foster et al. 2009; Penko & Barkley 2010). Separate studies have reported METs for various activities, but did not compare them to non-Wii equivalents and utilized older adult populations (Hurkmans et al. 2011; Miyachi et al. 2010; O'Donovan & Hussey, 2012).

Psychological Outcomes

Our second hypothesis was that ratings of perceived exertion and difficulty would be lower on the Wii versus in the gym. Findings from this study lend some support to both aspects of the hypothesis.

RPE scores were significantly higher for 3 of the 5 exercises but not different for the other 2 (Table 3), and RPD scores were significantly higher for 1 of the 3 exercises we used the scale with (Figure 3). Our RPD scale is not validated, and it did not correlate well with the RPE scale (Figure 4). There are two possible interpretations for the lack of correlation. If one assumes that perceived difficulty and perceived exertion directly relate to one another, then the lack of correlation suggests our new RPD scale was a poor tool since it did not correlate with the established RPE scale. Alternatively, if one assumes that perceived difficulty and perceived exertion do not relate to one another, then the lack of correlation may suggest the RPD scale is a useful counterpart to the RPE scale. Since it is logical that perceived difficulty and perceived exertion should directly relate to one another, we are opting for the former interpretation. In retrospect, we wish we would have used a visual analogue scale (Mills et al. 2010) instead to ascertain perceived difficulty.

Fewer studies have examined psychological responses to Wii exercise compared to those that investigated physiological parameters. Whereas we found RPE was higher with gym vs. Wii, another study showed RPE scores when

DOI: http://dx.doi.org/10.7710/2168-0620.1007

playing Wii were higher compared to brisk walking on the treadmill, but that their sense of positive well-being decreased from pre- to post-exercise on the Wii but did not change on the treadmill (Douris et al. 2012). It could be that sense of well-being impacted on RPE scores in our subjects. Some other studies have reported psychological metrics (Graves et al. 2010; Penko & Barkley 2010) but differ enough from our own study that a comparison of results is not meaningful. Much more research needs to be done to better ascertain the psychological response to Wii gaming versus traditional exercise.

Performance Outcomes

Our third hypothesis was that accuracy would be higher on the Wii versus in the gym for the basketball exercises. Data from both the basketball passing and shooting components (Figure 5) fully supported the hypothesis as performance was always poorer in the gym versus on the Wii (in terms of accuracy). We also expected that we might see a significant gender difference in the results, and means suggest there may be one, but our sample size was too low to confirm such a possibility.

We could not locate any studies that examined accuracy differences between active video gaming and traditional equivalents. Thus, to the best of our knowledge, our accuracy results represent the most novel aspect of this study and may be the first report of its kind.

Conclusions & Future Directions

Two of our three hypotheses were partially supported and one was fully supported by our data. We conclude that when comparing exercise using Wii *EA Sports Active* to traditional gym exercises: (1) basketball accuracy scores on the video game are much higher than in the gym, suggesting that while the Wii may simulate the movement it does not accurately represent it; (2) HR in the video game is usually lower than when exercising in the gym, though this varies by exercise; and (3) subjects responded heterogeneously regarding their perceptions of exertion and difficulty between the two environments. Generally, our results support the notion of using active video gaming to ameliorate inactivity or to help in physical therapy rehabilitation.

Limitations of our study included the small sample size, the fact that our population was more active than the average college population, the short duration of each activity, and the small number of metrics used for physiological, psychological, and performance measurements.

Directions for future research are many. The most obvious recommendation from this research is more accuracy studies are needed. Such research will help exercise scientists and health professionals better understand how the two modes of exercise compare to each other in terms of demand and skill-building. More research needs to be conducted regarding psychological responses to Wii exercise compared to traditional exercise, especially in the areas of motivation and exertion. Most studies have used single, acute exercise bouts; in real life, the desire is for players to use the game routinely to improve daily physical activity levels. A better understanding of psychological responses to active video games (particularly pleasure and novelty) will inform whether or not video games are a good long-term solution for inactivity. Energy expenditure has been relatively well-studied, but demographic and methodological differences between studies make it difficult to compare them. A better grasp of reasons for variability would help scientists better understand physiological responses to active video gaming.

https://digitalcommons.cwu.edu/ijurca/vol5/iss1/1
DOI: 10.7710/2168-0620.1007

DOI: http://dx.doi.org/10.7710/2168-0620.1007

REFERENCES

American College of Sports Medicine (2009). *ACSM's resource manual for guidelines for exercise testing and prescription*. Baltimore, MD, USA: Lippincott, Williams, & Wilkins.

Bosch, P. R., J. Poloni, A. Thornton, & J. V. Lynskey. The heart rate response to Nintendo Wii boxing in young adults. *Cardiopulmonary Physical Therapy Journal* 23(2), 13-29.

Daniel, K. (2012). Wii-hab for pre-frail older adults. *Rehabilitative Nursing* 37(4),195-201. DOI:http://dx.doi.org/10.1002/rnj.25

Douris, P. C., B. McDonald, F. Vespi, N. C. Kelley, L. Herman. (2012). Comparison between Nintendo Wii Fit aerobic and traditional aerobic exercise in sedentary young adults. *Journal of Strength and Conditioning Research* 26 (4), 1052-1057. DOI:http://dx.doi.org/10.1519/JSC.0b013e31822e5967

Garn, A. C., B. L. Baker, E. K. Beasley, & M. A. Solmon. (2012). What are the benefits of a commercial exergaming platform for college students? Examining physical activity, enjoyment, and future interactions. *Journal of Physical Activity & Health* 9 (2), 311-318.

Graf, D. L., L. V. Pratt, C. N. Hester, K. R. Short (2009). Playing active video games increases energy expenditure in children. *Pediatrics* 124 (2), 534-540. DOI:http://dx.doi.org/10.1542/peds.2008-2851

Graves, L. E., N. D. Ridgers, G. Stratton (2008).The contribution of upper limb and total body movement to adolescents' energy expenditure whilst playing Nintendo Wii. *European Journal of Applied Physiology* 104 (4), 617-623. DOI:http://dx.doi.org/10.1007/s00421-008-0813-8

Graves, L. E., N. D. Ridgers, K. Williams, G. Stratton, G. Atkinson, N. T. Cable. (2010). The physiological cost and enjoyment of Wii Fit in adolescents, young adults, and older adults. *Journal of Physical Activity & Health* 7 (3), 393-401.

Guderian, B., L. A. Borreson, L. E. Sletten, K. Cable, T. P. Stecker, M. A. Probst, L. C. Dalleck. (2010). The cardiovascular and metabolic responses to Wii Fit video game playing in middle-aged or older adults. *Journal of Sports Medicine & Physical Fitness* 50 (4), 436-442.

Hurkmans, H. L., G. M. Ribbers, M. F. Streur-Kranenburg, H. J. Stam, R. J. van den Berg-Emons. (2011). Energy expenditure in chronic stroke patients playing Wii Sports: a pilot study. *Journal of Neuroengineering & Rehabilitation* 14 (8), 38. DOI:http://dx.doi.org/10.1186/1743-0003-8-38

Jahn, P., N. Lakowa, M. Landenberger, D. Vordermark, O. Stoll. (2012). InterACTIV: an exploratory study of the use of a game console to promote physical activation of hospitalized adult patients with cancer. *Oncology Nursing Forum* 39 (2), E84-E90. DOI:http://dx.doi.org/10.1188/12.ONF.E84-E90

Jorgensen, M. G., U. Laessoe, C. Hendriksen, O. B. Nielsen, P. Aagaard. (2012). Efficacy of Nintendo Wii training on mechanical leg muscle function and postural balance in community-dwelling older adults: a randomized controlled trial. *Journal of Gerontology A: Biological Sciences and Medical Sciences* [e-pub ahead of print.]

DOI: http://dx.doi.org/10.7710/2168-0620.1007

DOI:http://dx.doi.org/10.1093/gerona/gls222

Lanningham-Foster, L., R. C. Foster, S. K. McCrady, T. B. Jensen, N. Mitre, J. A. Levine. (2009). Activity-promoting video games and increased energy expenditure. *Journal of Pediatrics* 154 (6),819-823. DOI:http://dx.doi.org/10.1016/j.jpeds.2009.01.009

Lyons, E. J., D. F. Tate, S. E. Komoski, P. M. Carr, D. S. Ward. (2012). Novel approaches to obesity prevention: effects of video game enjoyment and game type on energy expenditure in active video games. *Journal of Diabetes Science & Technology* 6 (4), 839-848.

Mills, K., P. Blanch, B. Vicenzio (2010). Identifying clinically meaningful tools for measuring comfort perception of footwear. *Medicine & Science in Sports & Exercise* 42 (11), 1966-1971. DOI:http://dx.doi.org/10.1249/MSS.0b013e3181dbacc8

Miyachi, M., K. Yamamoto, K. Ohkawara, S. Tanaka (2010). METs in adults while playing video games: a metabolic chamber study. *Medicine & Science in Sports & Exercise* 42 (6), 1149-1153.

Neil, A., S. Ens, R. Pelletier, T. Jarus, D. Rand. (2012). Sony PlayStation EyeToy elicits higher levels of movement than the Nintendo Wii: implications for stroke rehabilitation. *European Journal of Physical and Rehabilitative Medicine* [e-pub ahead of print].

O'Donnovan, C., & J. Hussey (2012). Active video games as a form of exercise and the effect of gaming experience: a preliminary study in healthy young adults. *Physiotherapy* 98 (3),205-210. DOI:http://dx.doi.org/10.1016/j.physio.2012.05.001

Penko, A. L., J. E. Barkley. (2010). Motivation and physiologic responses of playing a physically interactive video game relative to a sedentary alternative in children. *Annals of Behavioral Medicine* 39 (2), 162-169. DOI:http://dx.doi.org/10.1007/s12160-010-9164-x

Taylor, M. J., D. McCormick, T. Shawis, R. Impson, & M. Griffin. (2011). Activity-promoting gaming systems in exercise and rehabilitation. *Journal of Rehabilitation Research & Development* 48 (10), 1171-1186. DOI:http://dx.doi.org/10.1682/JRRD.2010.09.0171

White, K., G. Schofield, A. E. Kilding. (2011). Energy expended by boys playing active video games. *Journal of Science & Medicine in Sports* 14 (2), 130-134. DOI:http://dx.doi.org/10.1016/j.jsams.2010.07.005

DOI: http://dx.doi.org/10.7710/2168-0620.1007