Scholars LITERATURE

Journal of Womens Health Care and Management

Research Article

DOI: https://doi.org/10.47275/2692-0948-134
Volume 3 Issue 2

Get Fit with Ring-Fit Adventure™: Physiological Outcomes of a Novel Active Video Game Intervention among Women

Kameron B Suire[1]*, Katherine Spring[2], Chloe Jones[2], Darby Winkler[2], Alexandra Carroll[2], Monaye Merritt[2] and Danielle D Wadsworth[2]

[1]Division of Physical Activity and Weight Management, Department of Internal Medicine, University of Kansas Medical Center, Kansas City, Kansas, United States

[2]Exercise Adherence and Obesity Prevention Laboratory, School of Kinesiology, Auburn University, Auburn, Alabama, United States

Abstract

Introduction: The purpose of this study was to investigate the impact of the Nintendo Switch™ active video game, Ring Fit Adventure™, on body composition, muscular strength, and cardiorespiratory endurance in adult women.

Methods: 15 adult women participated in Ring Fit Adventure™ gameplay twice a week, for 45 minutes over eight weeks (total of 16 sessions). Body composition was measured by the iDexa, muscular strength was assessed by the handgrip test, and cardiorespiratory endurance was measured by the YMCA step test.

Results: Paired samples t-tests from pre-post revealed a significant increase in lean mass ($p = 0.02$), and bone mineral density ($p = 0.01$). There was a non-significant decrease in fat mass ($p = 0.35$). A significant increase was noted for dominant handgrip ($p < 0.001$), non-dominant handgrip strength ($p = 0.001$), and a significant increase in heart rate recovery ($p = 0.001$).

Conclusions: A short-term intervention utilizing Ring Fit Adventure™ resulted in significant body composition and fitness changes for adult women. Future studies would benefit from diversifying the sample and exploring the benefits of an at-home intervention.

Keywords: Exergames; Fitness; Body Composition; Women; Adult; Serious Games

Correspondence to: Kameron B Suire, Division of Physical Activity and Weight Management, Department of Internal Medicine, University of Kansas Medical Center, Kansas City, Kansas, United States; E-mail: kameronsuire@gmail.com

Citation: Suire KB, Spring K, Jones C, et al. (2022) Get Fit with Ring-Fit Adventure™: Physiological Outcomes of a Novel Active Video Game Intervention among Women. J Womens Health Care Manage, Volume 3:2. 134. DOI: https://doi.org/10.47275/2692-0948-134

Received: December 05, 2022; **Accepted:** December 21, 2022; **Published:** December 26, 2022

Introduction

Over the last decade, active video games (AVGs) have emerged as a unique opportunity to merge popular entertainment with potential health benefits. AVGs prompt physical activity or exercise through interactive gameplay [1]. As almost 277 million Americans play video games, and over 75% of adult gamers spend at least three hours a week playing video games in the United States [2], AVGs provide an opening for exercise within the home. Furthermore, AVGs may be more important as we see the effects of social distancing restrictions and loss of physical activity opportunities due to COVID-19 [3-7].

As to the effects of previous AVGs on physiological parameters, the literature is mixed. According to a meta-analysis, AVGs were effective in increasing light-to-moderate physical activity and were comparable to traditional physical activities among mostly young populations [8]. In contrast, another meta-analysis found that AVGs had little impact on weight among youth [9]. Another review among youth and young adults found that while AVGs are a healthier alternative to sedentary behavior, the case for large impacts on physical activity and body composition has not been substantiated [10]. It is also evident that adult populations are often ignored in the literature as very few studies exist outside of short-term measures of energy expenditure, neglecting changes in body composition, physical fitness, and physical activity over time [11,12].

Although the popularity of AVGs on home consoles appeared to peak with Wii Fit™ on the Nintendo Wii™ [13], a new AVG titled Ring Fit Adventure™ played on the Nintendo Switch™ is starting to challenge that narrative. The Nintendo Wii, Nintendo's previous best-selling home console, sold about 101 million units, with Wii Fit selling over 22 million units [13]. The Nintendo Switch™ has now surpassed the Nintendo Wii with 114.33 million units sold as of September 2022 [14]. Ring Fit Adventure™ is closing in on the total sales of Wii Fit with about 15 million units sold despite only being on the marketplace for 3 years [14]. Wii Fit was a cultural and video game sales phenomenon, and we are witnessing a similar occasion once again. Ring Fit Adventure™ is a unique game that uses a ring, similar to a Pilates ring, for resistance in numerous upper and lower body exercises. The intensity and difficulty of the exercises increase as the levels are surpassed. Throughout the gameplay, exercises are detailed in written and visual demonstrations. Only two studies have investigated the Ring Fit Adventure™. One

conducted among children found it to require higher levels of energy expenditure compared to the Nintendo Wii, dance mats, and Xbox Kinect [15]. The other study examined patients with chronic low back pain and found Ring Fit Adventure™ increased pain self-efficacy and reduced pain [16]. As minimal data exist on the physiological effects of Ring Fit Adventure™ on body composition and fitness parameters, further investigation is required. Therefore, the purpose of this intervention was to investigate the impact of Ring Fit Adventure™ on body composition, muscular strength, and heart rate recovery over an eight-week intervention. This intervention also had the goal of detailing physical activity during the gameplay sessions utilizing an accelerometer. Finally, while many feel video games are primarily played by young boys, the average age for a video game player is 31 years old and 45% of those who play games are female in the United States [2]. In addition to this, it appears obesity impacts females at a higher rate than males globally. It was estimated that 15% of all females were obese in 2016 compared with 11% of males [17]. One study also found that a staggering 87% of 151 countries included in analysis showed a higher female obesity prevalence compared with males [18]. However, 31.7% of women are inactive while 23.4% of men are inactive globally [19]. Therefore, we decided to purposely sample adult women.

Methods

This single-armed study was approved by the University Institutional Review Board for Research Involving Human Subjects and followed the standards set by the Declaration of Helsinki under protocol 21-001 MR 2101. Each participant read and signed a written informed consent and completed the Physical Activity Readiness Questionnaire (PAR-Q). Participants had to answer "no" to all questions on the PAR-Q to participate in the intervention.

Participants

Participants were recruited by word of mouth, e-mail, flyers, and social network blasts within the community with a three-week window to join the study. To be eligible for this study, participants had to be: female, low risk for medical complications from exercise (as determined by the PAR-Q), currently not exercising, and not pregnant. A total of 15 female subjects were screened, found to be eligible, and consented to participate in this study. Table 1 displays demographic information at baseline.

Procedure

Prior to the intervention, participants were assessed for height, weight, body composition, muscular strength, and heart rate recovery. After pre-testing, all participants selected a schedule to allow them to participate in the Ring Fit Adventure™ game twice a week over eight weeks at a university laboratory. Each appointment lasted approximately 45 minutes with the inclusion of a warm-up, gameplay, and cool-down. All aspects were led by the in-game Ring-Fit Adventure™ avatar. After the warm-up, participants were guided through a course requiring them to jog/run with the addition of physical challenges involving the use of the resistance ring throughout. In addition, they were presented with challenges mid-course consisting of upper-body, lower-body, and core exercises using the resistance ring. The workout gameplay was approximately 35 minutes for each session. After each workout, the cool-down was completed. The potential dose of the intervention was 720 minutes over 16 sessions (16 sessions X 45 minutes).

Table 1: Means (standard deviations) and percentages for demographic variables at baseline.

Variable	(*n* = 15)
Age (yrs)	45.93
BMI kg/m^2	31.88
% White	80%
% Black	13.3%
% Asian	6.7%

BMI = Body Mass Index

Body Composition

The iDexa was utilized to measure body composition in a fasted state (no nutritional intake for the prior eight hours) by trained personnel. The iDexa measures body composition and bone density by dual-energy X-ray absorptiometry which provides accurate data related to body composition in terms of body fat, lean mass, bone mineral density (BMD), and exact data from regions of the body if necessary [20,21]. Specifically, variables of interest for this study include lean mass (kg), fat mass (kg), and bone mineral density (g/cm ^{2}). According to previous studies, the precision error for total body mass was 0.9%, total body lean mass was 0.4-0.5%, total bone mineral content was 0.6%, fat mass was 0.7-0.8%, and percent body fat was 0.6-0.9%, which are all considered to be excellent [22-24].

Muscular Strength

To assess muscle strength, participants completed a handgrip strength test during pre- and post-testing [25]. The handgrip dynamometer is a non-invasive and portable device used to assess muscular strength measured as a force in kilograms. After being adjusted specifically for each participant's hand size, participants were instructed to squeeze the handgrip dynamometer using as much force as possible. In a standing position with both arms by their sides, the handgrip was measured three times in both the right and left hands in an alternating manner between the two sides. The highest force in kilograms for each hand was used for analysis.

Heart Rate Recovery

The YMCA step test was used to assess heart rate recovery. This test was conducted primarily due to social distancing requirements as this data was collected during Spring 2021 when social distancing was required by university mandates. The YMCA step test has been validated and recommended for situations where time or resources are limited [26]. Participants stepped on and off a 30.5 cm (12 inches) step 24 times per minute for 3 minutes. They were aided in this endeavor by an electronic metronome set at 96 beats per minute which they were to match with 96 steps (24 ascent-descent cycles) per minute. At one-minute intervals participants were told "you are doing well" and the time remaining was indicated. After the completion of the test, participants were instructed to sit down and relax for one minute. Then, the participant's heart rate was obtained with the polar heart rate monitor (Polar Electro, USA) [27].

Accelerometry

To determine physical activity levels during gameplay, participants wore an ActiGraph GT3X+ tri-axil accelerometer (ActiGraph corp, Pensacola, FL, USA) on their right hip. Physical activity was assessed for both sessions during weeks one, four, and eight for a total of six measurements. Data were downloaded in 60-second epochs and scored using adult cut points [28]. The researcher's analyzed time spent in light, moderately vigorous, and very vigorous activity during gameplay across the intervention.

Statistical Analysis

Data were analyzed with SPSS 26. Paired sample t-tests assessed differences in body composition, muscular strength, and heart rate recovery from pre- to post-test. Changes in physical activity during gameplay were assessed with repeated measures of ANOVA. Physical activity was measured at weeks one, four, and eight. G*power indicated a required sample size of 16 and was used to calculate post hoc power analysis for the paired t-test [29]. Probability values of $p < 0.05$ were considered significant.

Results

All 15 subjects were placed in the intervention after completing the informed consent process. One subject declined to attend post-testing. Therefore, the final analysis included 14 subjects. Participants attended an average of 15 out of 16 sessions. The minimum number of sessions attended was 13 while the maximum was 16.

Body Composition

Table 2 displays mean scores for pre- and post-testing body composition variables. A significant increase was noted for lean mass ($M = 0.70$ kgs, $t(13) = 2.64$, $p = 0.02$) and BMD ($M = 0.03$, $t(13) = 3.26$, $p = 0.01$). There was a non-significant decrease in fat mass ($M = -0.38$ kgs, $t(13) = -0.98$, $p = 0.35$). Observed power for body composition ranged from 0.24 to 0.92. Power was less than the recommended .80 for fat mass (.24) and BF% (.76).

Fitness

Table 2 displays mean scores for pre- and post-testing fitness variables. A significant increase was noted for dominant handgrip strength ($M = 2.31$ kg, $t(13) = 6.54$, $p < 0.001$), and (in non-dominant handgrip strength ($M = 1.75$ kg, $t(13) = 4.51$, $p = 0.001$). A significant increase was noted for heart rate recovery ($M = 9.86$, $t(13) = 4.10$, $p = 0.001$). Observed power for fitness measures ranged from 0.98 to 1.00.

Physical Activity

Accelerometer data reveled participants stayed primarily in light physical activity during sessions. Figure 1 displays mean physical activity levels during weeks one, four, and eight. Repeated measures ANOVA determined no significant changes in light (F (2, 26) =1.81, $p = 0.183$) or moderate (F (2, 26) = 0.716, $p = 0.498$) physical activity levels across eight weeks. As vigorous and very vigorous physical activity violated the assumption of sphericity, a Greenhouse-Geisser correction was used. Furthermore, repeated measures ANOVA with a Greenhouse-Geisser correction determined no significant changes in vigorous (F (1.996, 25.948) = 2.629, $p = 0.091$) or very vigorous (F (1.210, 15.736) = 1.515, $p = 0.242$) physical activity levels across eight weeks.

Figure displays A) Light, B) Moderate, C) Vigorous, and D) Very Vigorous physical activity levels across eight weeks.

Discussion

Body Composition

These results establish strong potential of Ring-Fit Adventure for various physiological outcomes among women, even after limited use. This intervention demonstrated a significant increase ($M = 0.70$ kgs, 1.61%) in lean mass, a significant decrease in body fat% ($M = 0.81\%$), and a non-significant decrease in fat mass ($M = -0.38$ kgs, -1.04%). Only three studies were identified that examined changes in body composition among adults playing AVGs. Bock BC, et al. (2019) [30], conducted a three-arm RCT, 12-week, 3 day/week with 50 minutes of game play among middle aged adults (79% females) and found a significant reduction in body fat% for AVG compared to a control group [30]. Although this study used the iDexa, comparisons are difficult as Bock utilized an adjustment model to calculate body composition differences, with no clear definition on what or how adjustments were made [30]. Owens SG, et al. (2011) [31], (9 adults, 3 months, at home use (no directive)) found a non-significant decrease (.2%) in body fat% utilizing bioelectrical impendence [31]. Warburton DE, et al. (2007) [32], conducted a six-week, three-day/week, 30 minutes per session AVG study among 14 ($n = 7$ AVG, $n = 7$ control) college males [32]. Utilizing bioelectrical impendence, the results showed a 1kg reduction in fat mass and no change in lean mass, resulting in no significant changes in body fat percentage. While it is difficult to draw conclusions based on these limited findings, our results indicate Ring Fit Adventure™ impacts body composition in a more positive manner compared to previous studies in the literature. As there is a direct link between fat

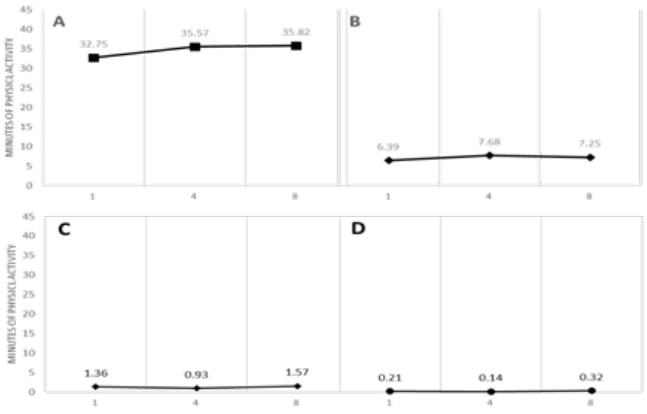

Figure 1: Physical activity levels across weeks one, four, and eight.

Table 2: Mean scores (standard deviations).

Variable	Pre	Post	*p*	*Effect size (Cohen's D)*	*Power*
Body Composition					
Fat Mass (kgs)	36.18 (18.43)	35.80 (18.79)	0.35	0.26	0.24
Lean Mass (kgs)	43.64 (9.14)	44.34 (9.24)	0.02*	0.71	0.81
BF%	43.47 (7.37)	42.66 (7.64)	0.03*	0.67	0.76
BMD	1.19 (.18)	1.22 (.18)	0.01*	0.87	0.92
Fitness Variables					
HR Recovery	126.79 (15.17)	116.93 (10.85)	0.001*	1.07	0.98
HG Dom	25.96 (6.53)	28.28 (6.96)	0.000**	1.75	1.00
HG Non-Dom	24.35 (5.81)	26.10 (6.01)	0.001*	1.21	0.99

*Denotes a significant change ($p < 0.05$). **Denotes value less than 0.001. BF=Body fat, BMD=Bone mineral density, HR=heart rate, HG=hand grip, Dom=dominant

mass, lean mass, and mortality [33], more research is needed on the impact of exergaming and Ring Fit Adventure™ on body composition.

Fitness

We could only identify two interventions that included various fitness measures after an AVG intervention [31,32]. One study found that after three months of at home use of Wii Fit, nine adults had no significant changes in pushups and peak VO_2 [31]. Warburton DE, et al. (2007) [32], conducted a three-day/six-week intervention utilizing interactive video gaming combined with stationary cycling among 14 college students in a randomized controlled trial [32]. There was a significant increase in VO_2max in the video game group, (11±5.1%), a non-significant increase of 2 kg in grip strength, and a significant increase in leg power and vertical jump. Our results found an increase (M = 2.31 kg, 8.9%) for dominant handgrip strength and non-dominant handgrip strength (M = 1.75 kg, 7.2%), as well as an increase in heart rate recovery (M = 9.07, 7.2%). These results point to Ring Fit Adventure™ having potential for fitness outcomes despite only encompassing 16 sessions over eight weeks.

Physical Activity

The literature is mixed when it comes to the potential of AVGs impact on physical activity. Based on the accelerometer data, participants in the current study participated in light physical activity for an average of 34.71 minutes during a 45-minute session. Furthermore, it is evident that physical activity levels did not significantly differ across eight weeks. The accelerometer findings from this study support the current literature which suggests that while AVGs are effective in promoting physical activity, they may not meet the intensity levels needed for health benefits [34-36]. It is possible that placing the accelerometer on the hip did not accurately estimate the intensity of the resistance exercise, particularly upper body exercises. This thought is present primarily due to the changes in body composition. Future studies should consider multiple placements of accelerometers and/or measuring energy expenditure via indirect calorimetry. This method has been utilized in previous studies among adults and may provide more information on the intensity of the Ring Fit Adventure™ game [11,37-39].

Limitations

The largest limitation with this intervention is the small sample size which confines the generalizations that can be made. In addition to this, with power lacking for fat mass (0.24), the sample size may have hindered our ability to detect a significant difference for this measure. The lack of a control group also limits the inferences that can be made regarding these results. In keeping accordance with social distancing guidelines, we were limited on the number of participants and thus experimental conditions. Future interventions would benefit by focusing on increasing sample size and randomly assigning participants to experimental conditions. Although purposefully, this intervention was made up entirely of a female sample, which also limits generalizations. Future interventions may focus on adding male participants, and perhaps participants across the age span. Another limitation was the lack of measurement for physical activity and nutrition outside of the intervention. While we asked the participants to maintain their current eating habits and physical activity levels outside of the study, it cannot be ruled out that potential changes in habit influenced the results.

Conclusion

Ring Fit Adventure™ demonstrated a significant impact in multiple body composition and fitness variables over eight weeks and 16 sessions. This may be applicable to health professionals looking for a recommendation for an at-home workout option. To support these findings, future studies should also focus on increasing and diversifying the sample, increasing the duration of the study, and conducting interventions within the home setting to determine adherence outside of a laboratory.

References

1. Mears D, Hansen L (2009) Active gaming: definitions, options and implementation. Article# 5 in a 6-part series. Strategies 23: 26-29.
2. Entertainment Software Association, Connect I (2021) Essential facts about the Video Game Industry.
3. Bhutani S, Cooper JA (2020) COVID-19 related home confinement in adults: Weight gain risks and opportunities. Obesity 28: 1576-1577. https://doi.org/10.1002/oby.22904
4. Ghosh A, Arora B, Gupta R, Anoop S, Misra A (2020) Effects of nationwide lockdown during COVID19 epidemic on lifestyle and other medical issues of patients with type 2 diabetes in north India. Diabetes Metab Syndr 14: 917-920. https://doi.org/10.1016/j.dsx.2020.05.044
5. He M, Xian Y, Lv X, He J, Ren Y (2020) Changes in body weight, physical activity, and lifestyle during the semi-lockdown period after the outbreak of covid-19 in china: an online survey. Disaster Med Public Health Prep 15: e23-e28. https://doi.org/10.1017/dmp.2020.237
6. Pellegrini M, Ponzo V, Rosato R, Scumaci E, Goitre I, et al. (2020) Changes in weight and nutritional habits in adults with obesity during the "lockdown" period caused by the COVID-19 virus emergency. Nutrients 12: 2016. https://doi.org/10.3390/nu12072016
7. Suire K (2021) Motivational interviewing for weight management among college students. [PhD Dissertation]. Auburn University.
8. Peng W, Lin JH, Crouse J (2011) Is playing exergames really exercising? A meta-analysis of energy expenditure in active video games. Cyberpsychol Behav Soc Netw 14: 681-688. https://doi.org/10.1089/cyber.2010.0578
9. Bochner RE, Sorensen KM, Belamarich PF (2015) The impact of active video gaming on weight in youth: A meta-analysis. Clin Pediatr 54: 620-628. https://doi.org/10.1177/0009922814545165
10. O'Loughlin EK, Dutczak H, Kakinami L, Consalvo M, McGrath JJ, et al. (2020) Exergaming in youth and young adults: a narrative overview. Games Health J 9: 314-338. https://doi.org/10.1089/g4h.2019.0008
11. Dutta N, Pereira MA (2015) Effects of active video games on energy expenditure in adults: a systematic literature review. J Phys Act Health 12: 890-899. https://doi.org/10.1123/jpah.2013-0168
12. Street TD, Lacey SJ, Langdon RR (2017) Gaming your way to health: a systematic review of exergaming programs to increase health and exercise behaviors in adults. Games Health J 6: 136-146. https://doi.org/10.1089/g4h.2016.0102
13. Nintendo (2021) Top selling title sales units Nintendo Wii.
14. Nintendo (2021) Top selling title sales units Nintendo Switch.
15. Comeras-Chueca C, Villalba-Heredia L, Pérez-Llera , Lozano-Berges G, Marín-Puyalto J, et al. (2020) Assessment of active video games' energy expenditure in children with overweight and obesity and differences by gender. Int J Environ Res Public Health 17: 6714. https://doi.org/10.3390/ijerph17186714
16. Sato T, Shimizu K, Shiko Y, Kawasaki Y, Orita S, et al. (2021) Effects of Nintendo Ring Fit Adventure exergame on pain and psychological factors in patients with chronic low back pain. Games Health J 10: 158-164. https://doi.org/10.1089/g4h.2020.0180
17. World Health Organization (2021) Obesity and overweight. Geneva, Switzerland.
18. Garawin F, Devries K, Thorogood N, Uauy R (2014) Global differences between women and men in the prevalence of obesity: is there an association with gender inequality? Eur J Clin Nutr 68: 1101-1106. https://doi.org/10.1038/ejcn.2014.86
19. Guthold R, Stevens GA, Riley LM, Bull FC (2018) Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1.9 million participants. Lancet Glob Health 6: 1077-1086. https://doi.org/10.1016/S2214-109X(18)30357-7
20. Svendsen OL, Haarbo J, Hassager C, Christiansen C (1993) Accuracy of measurements of body composition by dual-energy x-ray absorptiometry in vivo. Am J Clin Nutr 57: 605-608. https://doi.org/10.1093/ajcn/57.5.605

21. Visser M, Fuerst T, Lang T, Salamone L, Harris TB (1985) Validity of fan-beam dual-energy X-ray absorptiometry for measuring fat-free mass and leg muscle mass. J Appl Physiol 87: 1513-1520. https://doi.org/10.1152/jappl.1999.87.4.1513

22. Hind K, Oldroyd B, Truscott JG (2011) In vivo precision of the GE Lunar iDXA densitometer for the measurement of total body composition and fat distribution in adults. Eur J Clin Nutr 65: 140. https://doi.org/10.1038/ejcn.2010.190

23. Rezzi S, Ginty F, Beaumont M, Blondel-Lubrano A, Oguey-Araymon S, et al. (2009) Body composition precision with the Lunar iDXA. J Clin Densitom 12: 402. https://doi.org/10.1016/j.jocd.2009.03.006

24. Rothney MP, Martin FP, Xia Y, Beaumont M, Davis C, et al. (2012) Precision of GE Lunar iDXA for the measurement of total and regional body composition in nonobese adults. J Clin Densitom 15: 399-404. https://doi.org/10.1016/j.jocd.2012.02.009

25. Wind AE, Takken T, Helders PJ, Engelbert RH (2010) Is grip strength a predictor for total muscle strength in healthy children, adolescents, and young adults? Eur J Pediatr 169: 281-287. https://doi.org/10.1007/s00431-009-1010-4

26. Beutner F, Ubrich R, Zachariae S, Engel C, Sandri M, et al. (2015) Validation of a brief step-test protocol for estimation of peak oxygen uptake. Eur J Prev Cardiol 22: 503-512. https://doi.org/10.1177/2047487314533216

27. Goodie JL, Larkin KT, Schauss S (2000) Validation of polar heart rate monitor for assessing heart rate during physical and mental stress. J Psychophysiol 14: 159-164. https://doi.org/10.1027/0269-8803.14.3.159

28. Sasaki JE, John D, Freedson PS (2011) Validation and comparison of acti graph activity monitors. J Sci Med Sport 14: 411-416. https://doi.org/10.1016/j.jsams.2011.04.003

29. Faul F, Erdfelder E, Lang AG, Buchner A (2007) G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav Res Methods 39: 175-191. https://doi.org/10.3758/BF03193146

30. Bock BC, Dunsiger SI, Ciccolo JT, Serber ER, Wu WC, et al. (2019) Exercise videogames, physical activity, and health: wii heart fitness: a randomized clinical trial. Am J Prev Med 56: 501-511. https://doi.org/10.1016/j.amepre.2018.11.026

31. Owens SG, Garner III JC, Loftin JM, Van blerk N, Ermin K (2011) Changes in physical activity and fitness after 3 months of home Wii Fit™ use. J Strength Cond Res 25: 3191-3197. https://doi.org/10.1519/JSC.0b013e3182132d55

32. Warburton DE, Bredin SS, Horita LT, Zbogar D, Scott JM (2007) The health benefits of interactive video game exercise. Appl Physiol Nutr Metab 34: 655-663. https://doi.org/10.1139/H07-038

33. Lee DH, Keum N, Hu FB, Orav EJ, Rimm EB, et al. (2018) Predicted lean body mass, fat mass, and all cause and cause specific mortality in men: prospective US cohort study. BMJ 362: k2575. https://doi.org/10.1136/bmj.k2575

34. McWha JA, Horst S, Brown GA, Orav EJ, Rimm EB, et al. (2009) Metabolic changes associated with playing an active video game against a human and computer opponent. Afr J Phys Health Educ Recreat Dance 9: 219-228.

35. Miyachi M, Yamamoto K, Ohkawara K, Tanaka S (2010) METs in adults while playing active video games: a metabolic chamber study. Med Sci Sports Exerc 42: 1149-1153. https://doi.org/10.1249/MSS.0b013e3181c51c78

36. Scheer KS, Siebrant SM, Brown GA, Shaw BS, Shaw I (2014) Wii, Kinect, and Move. Heart rate, oxygen consumption, energy expenditure, and ventilation due to different physically active video game systems in college students. Int J Exerc Sci 7: 22-32.

37. Lyons EJ, Tate DF, Komoski SE, Carr PM, Ward DS (2012) Novel approaches to obesity prevention:effects of game enjoyment and game type on energy expenditure in active video games. J Diabetes Sci Technol 6: 839-848. https://doi.org/10.1177/193229681200600415

38. Lyons EJ, Tate DF, Ward DS, Bowling JM, Kalyanaraman S (2014) Engagement, enjoyment, and energy expenditure during active video game play. Health Psychol 33: 174-184. https://doi.org/10.1037/a0031947

39. Lyons EJ, Tate DF, Ward DS, Bowling JM, Kalyanaraman S (2011) Energy expenditure and enjoyment during video game play: differences by game type. Med Sci Sports Exerc 43: 1987-1993. https://doi.org/10.1249/MSS.0b013e318216ebf3