Journal of Undergraduate Kinesiology Research

Official Research Journal of the Department of Kinesiology
University of Wisconsin – Eau Claire

Volume 3 Number 2 May 2008

PHYSIOLOGICAL RESPONSES WHILE PLAYING NINTENDO WII SPORTS

Lauri Bausch[1], Jason Beran[1], Sara Cahanes[1], Lucas Krug[1]

[1]Kinesiology Department, University of Wisconsin – Eau Claire, Eau Claire, WI, USA

ABSTRACT

Bausch LM, Beran JN, Cahanes SJ, Krug LD. Physiological Responses While Playing Nintendo Wii Sports. *Journal of Undergraduate Kinesiology Research* 2008;3(2):19-25. Active gaming has become a popular trend in today's society due to technological advances. The Wii may be a useful addition to the range of opportunities for physical activities that are available. **Purpose:** The objective of our study was to examine the physiological responses while playing the Nintendo Wii and compare these results to other common daily activities. **Methods:** 12 subjects participated in our study, 8 women and 4 men with a mean age of 22.1 ± 2.0 years. The mean height and weight of test subjects were 166.5 ± 9.1 cm and 69.5 ± 15.8 kg, respectively. The mean resting heart rate was 72.7 ± 11.6 bpm, and the mean resting blood pressure was 119.5 ± 10.7 mmHg systolic over 76.0 ± 8.2 mmHg diastolic. The mean HR_{max} and VO_{2max} were 194.9 ± 7.8 bpm and 51.9 ± 7.2 mL/kg/min, respectively. Relative intensity levels were established for two Nintendo Wii games by comparing oxygen uptake levels attained while playing Nintendo Wii to subjects' peak oxygen uptake reached during a maximal effort graded treadmill test. **Results:** We found relative intensities for Wii Boxing and Tennis at $\%VO_2R$ [41.7 vs. 23.9 %, $t(11)=6.879$]; at %HRR [48.1 vs. 28.1 %, $t(11)=3.944$], and an absolute intensity for Wii Boxing and Tennis in METs [5.2 vs. 3.2, $t(11)=6.692$]. The total energy expenditure for playing Nintendo Wii was 128.8 ± 46.3 Kcal/session. **Conclusion:** Playing Wii Boxing achieves an adequate intensity that provides cardiovascular benefits, and both games elicit energy expenditure levels that could contribute towards the ACSM minimal recommendation for weekly EE. By meeting energy expenditure guidelines, one could reduce their risk for chronic diseases and all-cause mortality.

Key Words: Video Games, Physical Activity, Screen Based Activities, Next Generation Video Games

INTRODUCTION

Video games have become a prevalent leisure activity that adolescents and adults participate in on a regular basis. A recent U.S. survey found children in grades 7 and 8 spend an average of 4.2 hours a

week playing video games (1). Television, computers, and video games have raised concerns regarding the health status of adolescents and young adults by promoting inactive behaviors (2).

According to American College of Sports Medicine (ACSM), the minimal recommendation of physical activity is 30 minutes a day of moderate intensity on most days of the week (3). Almost 40% of adults do not engage in regular physical activity (3). During the past decade, the number of overweight and obese individuals has increased dramatically; according to the National Health and Nutrition Examination Survey, approximately 65 percent of Americans are overweight and 31 percent are obese (3). In order to accommodate for individuals' interests and abilities, finding alternative forms of physical activity may aid individuals in meeting these recommendations. Active video games, such as the Nintendo Wii, may be a viable alternative to traditional exercise for individuals struggling to meet physical activity guidelines.

Active gaming has become a popular trend in today's society due to technological advances. Nintendo Wii, a new generation game console, differs from other video game consoles in that it requires active play rather than sedentary play. The Wii may be a useful addition to the range of opportunities for physical activities that are available (4).

Due to limited research on video games and health behaviors associated with them (5), the objective of our study was to examine the physiological responses while playing the Nintendo Wii and compare these results to other common daily activities. We hypothesized that playing the Nintendo Wii would elicit physiological responses that could contribute to physical activity recommendations and would be comparable to other traditional daily activities.

METHODS

Subjects

Twelve college participants (4 male and 8 female), aged 20-27, were recruited by online and verbal communication. Applicants were considered eligible after completing a Physical Activity Readiness Questionnaire and health history questionnaire, along with baseline assessments indicating they are at low or moderate risk according to ACSM's risk stratification guidelines (3). Our test population consisted of individuals with various levels of Nintendo Wii experience, ranging from first-time players to advanced players. Subjects were conveniently selected and happened to be highly fit individuals. Prior to participation, each subject consented to the study and was informed of pre-test guidelines. They were encouraged to avoid food, alcohol, caffeine, and tobacco 3 hours prior to testing. For better results, they were informed not to engage in strenuous exercise 24 hours prior to testing. Additional pre-test guidelines included: wear appropriate workout attire, sleep 6 to 8 hours prior to testing, and report to testing sessions normally hydrated. The study was approved by the Institutional Review Board of the University of Wisconsin – Eau Claire.

Procedures

Eligible participants reported to the exercise physiology lab for two separate sessions to complete baseline assessments, VO_{2max}, and Nintendo Wii familiarization and testing. The first session consisted of baseline assessments including height, weight, resting blood pressure, resting heart rate, and a VO_{2max} test. Height was measured to the nearest 1.0 cm using a Seca (Hamburg, Germany) stadiometer and weight measured to the nearest 1.0 kg using a Detecto Balance Scale (Webb City, MO). We rounded height and weight measurements to the nearest centimeter and kilogram because the metabolic equipment required whole units. Participants rested for five minutes before a resting blood pressure and heart rate were taken for comparison with test results to determine physiological responses to playing Nintendo Wii. We also asked them to avoid smoking and caffeine 3 hours before the blood pressure measurement was taken. The subject's blood pressure was taken while in a sitting position using the appropriate size cuff, a sphygmomanometer, and stethoscope. Resting heart rate was measured after a minimum of five minutes rest using a T31 heart rate monitor by Polar Electro Inc. (Woodbury, NY); prior to the VO_{2max} and Nintendo Wii testing.

The VO_{2max} test and Wii test was performed in a controlled environment using a $K4b^2$ portable metabolic analyzer by Cosmed Pulmonary Function Equipment (Rome, Italy). After baseline variables were recorded, a three minute warm-up led into the VO_{2max} testing protocol and was immediately followed by a 3 to 5 minute cool down. All subjects followed the Modified Balke using a Woodway treadmill (manufactured in Waukesha, WI) until a maximal effort was achieved (3). VO_{2max} was considered valid if the two of the following three criteria were achieved: 1) leveling of oxygen consumption despite an increase in work load (less than 150 ml/min); 2) respiratory exchange ratio (RER) = 1.1; and 3) HR within 15 beats of the age-predicted maximal HR (6).

The second session consisted of Nintendo Wii familiarization, a rest period of at least 5 minutes, followed by the actual Wii testing. The familiarization session allowed participants of various skill levels to get briefly accustomed to the specific games of tennis and boxing before testing for data collection. The Nintendo Wii protocol was designed based on an initial survey from students who had "Wii-experience" and was refined through pilot testing. A majority of surveys collected suggested that the typical playing sequence consisted of roughly 10-minute bouts. In order to accommodate for testing in both tennis and boxing as well as mimicking the suggested playing sequence, our final protocol consisted of: 3 minutes collecting resting data, 10 minutes playing boxing/tennis, 3 minutes recovery, 10 minutes playing boxing/tennis, and a 3 minute recovery period; see Table 1. The order in which the games played were randomly assigned to each subject. In each of the 3-minute resting/recovery periods, blood pressure measurements were taken.

Table 1. Wii Testing Protocol.

3 min Rest	10 min Boxing or Tennis	3 min Rest	10 min Boxing or Tennis	3 min Rest

Statistical Analyses

All analyses were performed using Statistical Package for the Social Sciences, Version 15.0 (SPSS, Inc, Chicago, IL). Measures of centrality and spread are presented as mean ± *SD*. Paired *t*-tests were performed to compare mean physiological responses between Wii tennis and boxing. The probability of making a Type I error was set at $p \leq 0.05$ for all statistical analyses.

RESULTS

Demographics for subjects who completed the study are shown in Table 2. Our final sample size (n=12) was reduced from a larger sample size due to portable metabolic analyzer malfunctions resulting in a loss of data. Comparisons of mean physiological responses showed significant

differences ($p < 0.05$) between Wii boxing and tennis for $\%VO_2R$ [41.7 vs. 23.9 %, $t(11)=6.879$]; %HRR [48.1 vs. 28.1 %, $t(11)=3.944$], and METs [5.2 vs. 3.2, $t(11)=6.692$]. The total energy expenditure for playing Nintendo Wii was 128.8 ± 46.3 Kcal/session. Mean ± SD for percent heart rate reserve and oxygen uptake reserve are presented in Figure 1.

Table 2. Descriptive characteristics of the participants

Parameter	Women (*N* = 8)	Men (*N* = 4)	Combined (N = 12)
Age (yrs)	22.1 ± 2.3	22.0 ± 1.4	22.1 ± 2.0
Height (cm)	161.9 ± 7.0	175.8 ± 4.6	166.5 ± 9.1
Weight (kg)	61.4 ± 9.1	85.8 ± 13.7	69.5 ± 15.8
RHR (beats/min)	70.3 ± 13.8	77.5 ± 1.9	72.7 ± 11.6
Resting Systolic BP	116.5 ± 5.9	125.5 ± 16.3	119.5 ± 10.7
Resting Diastolic BP	73.0 ± 8.1	82.0 ± 5.0	76.0 ± 8.2
HR max (beats/min)	193.9 ± 7.5	198.8 ± 8.0	194.9 ± 7.8
VO_2 max (mL/kg/min)	50.3 ± 6.4	55.2 ± 8.5	51.9 ± 7.2

Values are mean ± SD. (RHR, resting heart rate; BP, blood pressure; HR max, maximal heart rate; VO_{2max}, maximal oxygen uptake); Rest VO_2 assumed to be 3.5 mL/kg/min.

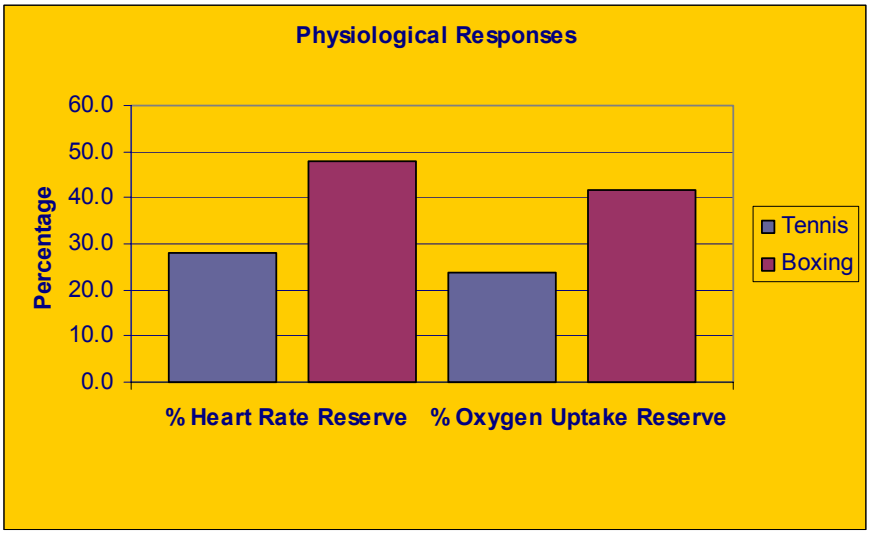

Figure 1. Physiological responses to Nintendo Wii Sports

DISCUSSION

The present study evaluated the physiological effects of playing Nintendo Wii Sports in people averaging 22.1 years of age. To our knowledge, there have been no previous studies examining Nintendo Wii Sports in college-aged populations. The main finding of our study was that we had a mean percent heart rate reserve (%HRR) of 48.1% and mean percent oxygen uptake reserve ($\%VO_2R$) of 41.7% for boxing. The ACSM recommends an intensity corresponding to 40-85% of VO_2R and HRR (3). These values for boxing meet the minimum intensity to increase or maintain cardiorespiratory fitness for lower fit individuals. Our subjects' VO_2R and HRR fell below 40 percent during Wii Tennis, which does not provide a significant cardiovascular benefit, however we believe the relative intensity levels was significantly impacted by our subjects' high cardiorespiratory fitness levels.

Less fit individuals (VO_{2max} below 40 ml/kg/min) could improve their VO_{2max} values and

experience other cardiovascular benefits at an intensity as low as 30% VO_2R (7). As displayed in Table 1, the mean VO_{2max} for our female subjects was 50.3 ml/kg/min and the mean VO_{2max} for our male subjects was 55.2 ml/kg/min. These values are classified as at or above the 90th percentile for the age range of 20-29 years (3). Since our subjects had VO_{2max} ratings that were well above average, the majority of the general population which lies within this age range will have lower cardiorespiratory fitness levels than our test subjects. While our subjects' attained 23.9% of their VO_2R on average, a sample from a more general population would be likely to attain a greater $\%VO_2R$. Due to this event, future research including a more general sample population may result in subjects' VO_2R exceeding the threshold of 30% which would suggest that Wii Tennis could provide cardiovascular benefits for lower fit subjects.

Our results indicated that playing Nintendo Wii Boxing provided a MET value of 5.2 and playing Nintendo Wii Tennis provided a MET value of 3.2. The ACSM states that an activity achieving 3-6 METs is considered moderate intensity while a 6+ MET activity is considered vigorous (3). The intensity of Wii Boxing is comparable to activities such as doubles tennis (5.0 METS) and mowing the lawn (5.5 METS). Physical activities that are similar in intensity to Wii Tennis are moderate walking at 3.0 MPH (3.3 METS), and mopping and vacuuming (3.5 METS) (8).

The total energy expenditure (EE) for playing Nintendo Wii was 128.8 Kcal/session, which included 20 minutes of actual playing time and 9 minutes of rest and recovery. Based on our testing protocol, we found a mean hourly rate of 258 Kcal, which would include game-time and rest. A recent study by Graves et al. found EE for Wii Sports Boxing to be 175 Kcal per hour and Wii Sports Tennis to be 180 Kcal per hour for adolescents ages 13-15 (4). The study performed by Graves presented an EE rate based solely on game-time; the rate presented in our study exceeded their findings. We found the energy cost of Nintendo Wii to be valuable because of the substantial amount of health outcomes that may be improved by an increase in physical activity and subsequent energy expenditure. The ACSM recommends an energy expenditure target range of 150 to 400 kcal from physical activity per day (3). The minimum caloric threshold of 1000 kcal/week is associated with a 20% to 30% reduction in risk of all-cause mortality, while an energy expenditure in excess of 2,000 kcal/wk have been successful for both short- and long-term weight control (3). Depending on the duration and frequency an individual plays Nintendo Wii, they may be able to meet or exceed the minimum weekly energy expenditure threshold. Increased physical activity leads to improvement in the lipoprotein profile and is related to a reduced risk of cardiovascular disease (9). Physical inactivity may result in central body fat, which is an independent risk factor for cardiovascular disease, type 2 diabetes mellitus, and hypertension; a dose-response relationship has been observed between weekly exercise and weight change in overweight individuals (10). Additionally, duration of physical activity significantly improves the response of insulin action to training (11). The sum of these findings support the importance of increasing physical activity levels and energy costs so an individual may achieve positive health outcomes.

One limitation to our study was that we used a convenience sample of higher fit individuals, which we believe to have created less generalizeable results. An assumption of our study is that each individual was honest, followed directions and gave a valid effort. While Nintendo Wii skill levels and experience may be considered a limitation, we believe that the various skill levels of participants may actually aid in generalizing the results because it takes into account the various levels of effort and mechanical efficiency. Depending on their level of enthusiasm, participants' performance ranged from minimal movement, such as flicking their wrist, to full body movements.

Wii Tennis – Full Body/High Enthusiasm
Wii Boxing

CONCLUSIONS

We had hypothesized that playing the Nintendo Wii would elicit physiological responses that would contribute to physical activity recommendations and would be comparable to other traditional daily activities. Our most important findings include that Wii Boxing attained a relative intensity that exceeded the threshold to provide cardiovascular benefits, and an energy expenditure that could contribute towards physical activity recommendations. However, Wii Tennis did not achieve an adequate intensity to meet this threshold but did indicate a rise in energy cost above resting levels. Both games revealed MET levels that are comparable to other daily activities that promote a healthy lifestyle. These findings are not generalizeable to the general public at this time, however we believe future research could produce more generalizeable findings. Our test results are most applicable towards college-aged, higher fit individuals because they would match our sample population. These individuals could expect to experience an intensity that could provide cardiovascular benefits while playing Wii Boxing, and expend energy in both games. Individuals that may be interested in our results include health and fitness professionals, parents, game enthusiasts, children, persons with disabilities, and anyone struggling to meet physical activity recommendations. Future research should include individuals of various fitness levels, skill levels, functional capacities, ages, other active games, and measuring health outcomes from a Nintendo Wii training study.

ACKNOWLEDGEMENTS

We would like to acknowledge the University of Wisconsin – Eau Claire's Kinesiology department for the use of their facilities, equipment, and faculty assistance including: Dr. Lance Dalleck and Dr. Don Bredle .

Address for correspondence: Bausch LM**,** BS, 8975 Fern Brook Rd., Fredonia, WI 53021, University of Wisconsin – Eau Claire, Eau Claire, WI 54703. (715).828.2825;bauschlm@uwec.edu

REFERENCES

1. Maddison, R., Mhurchu, C.N., Jull, A., Jiang, Y., Prapavessis, H. and Rodgers A. (2007) Energy expended playing video console games: an opportunity to increase children's physical activity?. *Pediatric Exercise Science* **19**, 334-343.
2. Leon, S. and Abbott, R. (2007) Effect of screen-based media on energy expenditure and heart rate in 9- to 12-year-old children. *Pediatric Exercise Science* **4**, 459-71.
3. American College of Sports Medicine. (2005) American College of Sports Medicine's Guidelines for Exercise Testing and Prescription. 7th ed. Philadelphia: Lippincott Williams and Wilkins, 3-6, 141-142, 216.
4. Graves, L., Stratton, G., Ridgers, N.D., and Cable, N.T. (2007) Energy expenditure in adolescents playing new generation computer games. *British Medical Journal* **335**, 1282-1284.
5. Bredin, S.S., Esch, B.T., Horita, L.T., Rhodes, R.E., Scott, J.M., Warburton and D.E., Zbogar, D. (2007) The health benefits of interactive video game exercise. *Applied Physiology, Nutrition, \and Metabolism* **32**, 655-663.
6. Cengiz, A., Robergs, R.A., and Kravitz, L. (2008) $VO2_{max}$ prediction during cycle ergometry. *Journal of Exercise Physiology Online* **11**, 1-17.
7. Swain, D.P., and Franklin, B.A. (2002) VO_2 reserve and the minimal intensity for improving cardiorespiratory fitness. *Medicine and Science in Sports and Exercise* **34**, 152–157.

8. Ainsworth, B.E., et al. (2000) Compendium of physical activities: an update of activity codes and MET intensities. *Medicine and Science in Sports and Exercise,* S498-S516.
9. Kraus W.E., et al. (2002) Effects of the amount and intensity of exercise on plasma lipoproteins. *New England Journal of Medicine* **347,**1483-92.
10. Slentz C.A., et al. (2004) Effects of the amount of exercise on body weight, body composition, and measures of central obesity: STRRIDE--a randomized controlled study. *Archives of Internal Medicine* **164**, 31-9.
11. Houmard J.A., et al. (2004) Effect of the volume and intensity of exercise training on insulin sensitivity. *Journal of Applied Physiology.* **96**, 101-6.

Disclaimer