Effects of energy expenditure while playing the Nintendo Wii against a human and computer opponent

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Abstract

Playing a physically active video game increases energy expenditure above that associated with sedentary video game play, and anecdotal report suggest that people play even harder when playing against friends or family members. The purpose of this study was to determine if there is a difference in energy expenditure while playing Nintendo Wii boxing against a Human or Computer opponent. Methods. Twenty college-aged adults (10 males:10 females) were measured for body composition and maximal aerobic capacity (VO_2max) before playing, in a randomized manner, Nintendo Wii boxing for 15 minutes against a human or computer opponent while heart rate, oxygen consumption, and energy expenditure were measured. Results. Heart rate, oxygen consumption, and energy expenditure were all higher ($P<0.05$) at VO_2max than any other condition. Heart rates while playing the video game were higher ($P<0.05$) for both the Human (103.8 $\pm$ 4.31) and Computer (104.6 $\pm$ 4.58) opponent than at rest (75.4 $\pm$ 2.90), with no differences between gender or video game opponent. Oxygen consumption while playing the video game was higher ($P<0.05$) for both the Human (14.6 $\pm$ 1.80) and Computer (14.4 $\pm$ 1.66) opponent than at rest (4.4 + 0.51), with no differences between gender or video game opponent. Discussion. The present data supports previous investigations indicating that playing a physically active video game increase heart rate, oxygen consumption, and energy expenditure, but the magnitude of increases is not sufficient to classify physically active video game play as even moderate intensity exercise. The present data further suggest that playing against a computer or human

opponent does not alter the magnitude of increase in energy expenditure associated with physically active video game play.

Introduction

There are 58 million individuals that live in the United States that are overweight and 40 million individuals that are considered as being obese (8). The causes for the incidence of increasing obesity are due to overconsumption of food and insufficient physical activity (6). Results from the 2003 National College Health Assessment showed that 32%- 47% of college students are considered physically inactive (15). One factor that contributes to the reduction in the amount of physical activity is excessive time spent in sedentary behaviors, such as watching television, playing games on the computer, and playing video games (11).

Playing video games is a way for a person to relax and do something they enjoy without much physical activity. However, the Nintendo Wii is advertised as a physically active video gaming system that allows a person to interact with the game by performing intricate movements that are fast paced involving a certain skill. The Nintendo Wii gaming systems allow a person to be more physically active than if they were to play a regular video game on such systems as the Xbox 360 or Playstation (7, 12). Not only can increases in physical activity be beneficial, but there are other physical advantages to playing active video games such as an increase in motor control and musculo-skeletal health (16).

Previous investigations of the energy costs of using physically active video games have evaluated the effects when the participants play against the video game

system, and not a human opponent (18). However, one of the attractive aspects of the Nintendo Wii is the ability to play sports games, such as boxing or baseball, against other people as the opponent rather than playing against the programmed opponents in the video game system. Anecdotally, people have stated that they put much more effort into playing video games against their friend than when playing against the game system. However, there have been no previous investigations into the energy cost of playing physically active video games against a human rather than a computer opponent. Therefore, the purpose of this investigation was to evaluate the energy cost of playing Nintendo Wii boxing against a human and a computer opponent.

Methods

Overview. In order to assess the energy expenditure in response to physically active video game playing when competing against a computer or human opponent, twenty healthy adults (10 males and 10 females) were recruited as study participants. The participants were first evaluated for aerobic fitness and body composition. On a different day after an overnight fast, the subjects were to report to the UNK Human Performance Laboratory for the measurement of energy expenditure while playing a physically active video game (Wii Boxing) for 15 minutes against a computer opponent and 15 minutes against a human opponent with the order of game lay against an opponent occurring in a randomized manner. Heart rate, oxygen consumption, and energy expenditure were measured continuously during the game play.

Subjects. For this research there were 20 subjects; 10 males and 10 females. Subjects were between the ages of 19-25 years old. All subjects had to be free from contraindications to exercise (1) as assessed by a written medical history. Prior to

participation in this project, approved by the Institutional Review Board at the University of Nebraska at Kearney, all subjects signed a document of informed consent, written medical history, and lifestyle evaluation.

Body Composition Assessment. Body mass was measured to the nearest 0.1 kg using a digital scale (Befour Inc, Saukville, WI) and height was measured to the nearest 0.5 cm using a stadiometer (Model 707, Seca, Hamburg, Germany). Body composition was measured using Dual-Energy X-Ray Absorptiometry (DEXA; DPX-IQ, Lunar Corp, Madison WI). During the DXA scan, the subjects were asked to wear comfortable clothing with minimal metal snaps, buttons, or zippers and to remove all jewelry.

Aerobic Fitness Assessment. In order to assess maximal oxygen uptake (VO_2 max), the subjects underwent a treadmill Bruce Ramp Protocol (1, 20). Before they began graded exercise test the subject's sat quietly and relaxed for five minutes while attached to a metabolic cart in order to measure their resting VO_2. Oxygen consumption was measured using a metabolic cart (True One, Parvomedics, Sandy, UT) and heart rate was measured with a heart rate monitor (610, Polar Electro, Oy, Finland) throughout the fitness test with the data averaged over 15 second intervals.

Physically Active Video Gaming. The active video game that was chosen to be played was *Nintendo Wii Sports* boxing. On a separate day from the fitness assessment and after an overnight fast, the subjects reported to the Human Performance Laboratory for the measurement of energy expenditure as a response to playing a physically active video game. Upon reporting to the Human Performance Laboratory, each participant was connected to a metabolic cart and heart rate monitor (as described under Aerobic Fitness Assessment). All subjects used the same game system character (called a Mii) and

started at the same skill during game play and the Human opponent was one of the researchers. The subjects played 15 minutes against a human opponent and 15 minutes against a computer opponent, with the opponents being chosen at random. There was a five minute rest period after the first opponent was played in order to bring the heart rate back to rest.

Calculations and Statistics. Heart rate, oxygen consumption, and energy expenditure were analyzed using a 2 way (gender by intervention [pre-aerobic fitness test, post aerobic fitness test, pre computer opponent, post computer opponent, pre human opponent, and post human opponent) repeated measures of analysis of variance with a p value of 0.05 (Sigma Stat 10, SPSS Inc, Chicago, IL). Significant main effects or interaction effects were identified using a student Newman-Keuls posthoc comparison. Data are presented as means ± SEM.

Results

Subjects. The subjects completed all aspects of this investigation with no deleterious effects. The male subjects in this investigation were older than the female subjects (Table 1: $P < 0.05$), had a higher body mass ($P<0.05$), were taller, had less body fat, and a higher VO_2 max than the females ($P<0.05$). There were no differences between the males and females regarding BMI.

Heart Rate. There were no gender related differences in heart rate in any of the conditions, so the data are presented as pooled data from both genders. The maximal heart rates measured during the treadmill assessment of VO_2 max were higher ($P < 0.05$) than the heart rate measured at any other time (Figure 1). Heart rates while playing

Nintendo Wii boxing were higher than at rest ($P<0.05$), with no difference due to whether the subject's played against a human or computer opponent.

Oxygen consumption. The males had a higher VO_2max than the females (Table 1; $P < 0.05$). There were no gender related differences in oxygen consumption in any of the conditions, so the data are presented as pooled data from both genders. The oxygen consumption during the treadmill assessment of the VO_2 maximal test was higher than at any other time (Figure 2; $P<0.05$). Oxygen consumption while playing the Nintendo Wii was higher ($P<0.05$) than at rest, with no difference due to whether the subject's played against a human or computer opponent.

Energy Expenditure. Males had a higher ($P<0.05$) energy expenditure at VO_2max and at rest than did the females (Table 2). The energy expenditure in both genders was higher ($P<0.05$) at VO_2max than in any other condition. Energy Expenditure while playing the Nintendo Wii boxing was higher ($P<0.05$) than at rest, with no difference due to whether the subject's played against a human or computer opponent (Table 2).

Discussion

The main findings of the present investigation indicate that there were no differences in heart rate, oxygen consumption, or energy expenditure while playing a physically active video game against a human or computer opponent. These findings are surprising given the anecdotal reports of people trying much harder when playing against their friends or family members than when playing against the game system. Furthermore, two cases have reported persons becoming injured while playing Nintendo Wii against their friends and family (5, 14) highlighting the level of exertion that can occur while playing physically active video games.

Heart rate measurements showed that there were no gender differences in any of the conditions. The presently observed increases in heart rate due to playing a physically active video game were similar to those observed previously (10, 15, 16). In comparison, Straker and Abbott (16) observed no change in heart rate when playing a traditional, sedentary video game. Similar to Sell et al. (15) and Maddison et al. (10) the present investigation did not detect a gender related difference in the heart rate response to physically active video gaming. It is important to note that in the previous investigations (10, 15, 16) the participants were playing a physically active video game against the computer system, not a human opponent. The present data add to these findings by indicating that the opponent, whether human or computer, does not alter the heart rate response to physically active video gaming.

In the present investigation, oxygen consumption was increased by ~2.5 fold above resting when playing a physically active video game. The magnitude of the presently observed increases in oxygen consumption due to playing a physically active video game are similar to those observed by Straker and Abbott (16). Although the subjects in the present investigation were standing while playing a physically active video game, the increases in oxygen consumption are larger than would be expected simply due to standing (19). Therefore, it appears that playing a physically active video game increases oxygen consumption substantially above resting levels and more than simply due to postural changes. It is interesting to note that in spite of anecdotal reports of "trying harder" when playing against friends or family members, in the present investigation there were no differences in the oxygen consumption between playing a physically active video game against a computer or human opponent.

The measurement of energy expenditure showed that there was a significant gender difference between the subject's as well as during the VO_2 max fitness test. The male subjects had a higher VO_2 max than the females (Table 2). The presently observed increases in energy expenditure due to playing physically active video games were similar to those observed by Buckworth and Nigg (4). Playing physically active video games is associated with increased energy expenditure that is similar to light to moderate physical activity, such as walking and aerobic dance. It can also be compared to brisk walking, skipping, and stair walking (10). The results of a study by Straker and Abbott (16) showed that energy expenditure more than doubled when participants were playing active video games than when they were playing inactive video games due to the constant movement required in order to play. The present data adds to the findings by indicating that the opponent, whether human or computer, does alter energy expenditure response to physically active video gaming.

There was a gender difference when measuring VO_2 max and energy expenditure. The male subject's had a higher VO_2 max than the female subjects. This is mainly due to men having more muscle mass and overall greater body size than females. Women have higher amounts of body fat than males causing their VO_2 max to be lower. The male subject's had a higher energy expenditure than the female subject's. The slight increase in energy expenditure is not similar to previous studies. This could be due to the participant's not trying very hard while playing Wii boxing, the environment in which they played, their experience level of playing Nintendo Wii, or that they were connected to a metabolic cart making it harder for them to breathe. Most of the previous studies that have been compared to this one measured VO_2 and energy expenditure using a

metabolic cart. These studies showed a greater increase in VO_2 and energy expenditure, they also used a metabolic cart.

There was an increase in energy expenditure due to physically active video gaming compared to inactive video gaming. VO_2 more than doubled and energy expenditure more than tripled when individuals were playing physically active video games than when they were playing inactive video games, as they were connected to a metabolic cart (16). The amount of energy that was expended was equivalent to casual dancing or walking (2). Our data shows an increase in energy expenditure greater than at rest.

In summary, the present data suggests that the physiologic stimulus presented by a human or computer opponent is not different when playing Nintendo Wii boxing. Furthermore, our overall data suggests that playing a physically active video game, such as the Nintendo Wii (boxing), is not considered vigorous or moderate intensity exercise so it is unlikely that a person will experience optimal exercise induced adaptations if using a physically active video game as a source of exercise. Therefore, the term "exergaming", which is sometimes applied to physically active video games, may be misleading. However, it is beneficial to play active video games as a means of exercise rather than not participating in any exercise. Participating in no exercise causes a person to be inactive and increases their chances of becoming obese.

Overall, the present data indicates that playing a physically active video game results in an increase in heart rate, oxygen consumption, and energy expenditure. The level of increase in heart rate, oxygen consumption, and energy expenditure while playing a physically active video game is similar to that of slow dancing or casual

walking (2). It can also be compared to aerobic dance or a walk/jog which is considered submaximal exercise (13). However, the relatively small magnitude of increase in heart rate, oxygen consumption, and energy expenditure while playing a physically active video game is below the suggested threshold required to enhance health and fitness in adults (1). Conversely, for persons who are very sedentary or have impaired function that limits their exercise tolerance (3, 9, 17) a physically active video game may be a beginning step towards a more physically active lifestyle.

References

1. American College of Sports Medicine. ACSM's Guidelines for Exercise Testing and Prescription. Philadelphia: Lippincott, Williams, & Wilkins, 2000.

2. Ainsworth BE, Haskell WL, Whitt MC, Irwin ML, Swartz AM, Strath SJ, O'Brien WL, Bassett DR, Jr., Schmitz KH, Emplaincourt PO, Jacobs DR, Jr. and Leon AS. Compendium of physical activities: an update of activity codes and MET intensities. Med Sci Sports Exerc 32: S498-S504, 2000

3. Bassuk SS and Manson JE. Physical activity and cardiovascular disease prevention in women: how much is good enough? Exerc Sport Sci Rev 31: 176-181, 2003.

4. Buckworth J, Nigg C. Physical activity, exercise, and sedentary behavior in college students. J Amer Coll Health 53: 28-34, 2004.

5. Cowley AD and Minnaar G. New generation computer games: Watch out for Wii shoulder. BMJ 336: 110, 2008.; Robinson RJ, Barron DA, Grainger AJ and Venkatesh R. Wii knee. Emerg Radiol 2008

6. Eckel RH, York DA, Rossner S, Hubbard V, Caterson I, St Jeor ST, Hayman LL, Mullis RM and Blair SN. Prevention Conference VII: Obesity, a worldwide epidemic related to heart disease and stroke: executive summary. Circulation 110: 2968-2975, 2004.

7. Graves L, Stratton G, Ridgers ND and Cable NT. Comparison of energy expenditure in adolescents when playing new generation and sedentary computer games: cross sectional study. BMJ 335: 1282-1284, 2007.

8. Hedley AA, Ogden CL, Johnson CL, Carroll MD, Curtin LR and Flegal KM. Prevalence of overweight and obesity among US children, adolescents, and adults, 1999-2002. JAMA 291: 2847-2850, 2004.

9. Koezuka N, Koo M, Allison KR, Adlaf EM, Dwyer JJ, Faulkner G and Goodman J. The relationship between sedentary activities and physical inactivity among adolescents: results from the Canadian Community Health Survey. J Adolesc Health 39: 515-522, 2006.

10. Maddison R, Mhurchu CN, Jull A, Jiang Y, Prapavessis H and Rodgers A. Energy expended playing video console games: an opportunity to increase children's physical activity? Pediatr Exerc Sci 19: 334-343, 2007.

11. Marshall SJ, Biddle SJ, Gorely T, Cameron N and Murdey I. Relationships between media use, body fatness and physical activity in children and youth: a meta-analysis. Int J Obes Relat Metab Disord 28: 1238-1246, 2004.

12. Mhurchu CN, Maddison R, Jiang Y, Jull A, Prapavessis H and Rodgers A. Couch potatoes to jumping beans: A pilot study of the effect of active video games on physical activity in children. Int J Behav Nutr Phys Act 5: 8, 2008.

13. Olson MS, Williford HN, Blessing DL, Wilson GD. A test to estimate VO2 max in females using aerobic dance, heart rate, BMI, and age. J Sports Med Phys Fitness 35: 159-168, 1995.

14. Robinson RJ, Barron DA, Grainger AJ, Venkatesh R. Wii knee. Emerg Radiol 2008.

15. Sell K, Lillie T, Taylor J. Energy expenditure during physically interactive video game playing in male college students with different playing experience. J Amer Coll Health 56: 505-511, 2008.

16. Straker L, Abbott R. Effects of screen-based media on energy expenditure and heart rate in 9-to 12- year- old children. Pediatr Exerc Sci 19: 459-471, 2007.

17. Swartz AM, Strath SJ, Bassett DR, Moore JB, Redwine BA, Groer M and Thompson DL. Increasing daily walking improves glucose tolerance in overweight women. Prev Med 37: 356-362, 2003.

18. Unnithan VB, Houser W and Fernhall B. Evaluation of the energy cost of playing a dance simulation video game in overweight and non-overweight children and adolescents. Int J Sports Med 27: 804-809, 2006.

19. Wang X and Perry AC. Metabolic and physiologic responses to video game play in 7- to 10-year-old boys. Arch Pediatr Adolesc Med 160: 411-415, 2006.

20. Will PM and Walter JD. Exercise testing: improving performance with a ramped Bruce protocol. *Am Heart J* 138: 1033-1037, 1999.

Figure Legends

Figure 1. Heart rate in 10 males and 10 females (presented as pooled data as there were no gender differences) when measured at rest, while playing Nintendo Wii boxing vs. human opponent, and while playing Nintendo Wii boxing vs. computer opponent. † Indicates heart rate while playing Nintendo Wii boxing in both conditions higher than at rest ($P<0.05$).

Figure 2. Oxygen Consumption in 10 males and 10 females (presented as pooled data as there were no gender differences) when measured at rest, while playing Nintendo Wii boxing vs. human opponent, and while playing Nintendo Wii boxing vs. computer opponent. * Indicates oxygen consumption while playing Nintendo Wii boxing in both conditions higher than at rest ($P<0.05$).

Tables

Table 1: Subject Descriptive Data

	Males (n=10)	Females (n=10)	
Age (y)	22.5 ± 0.5	21.0 ± 0.4	*
Body Height (cm)	180.9 ± 2.8	167.2 ± 1.3	*
Body Mass (kg)	79.7 ± 4.9	64.5 ± 2.9	*
Body Mass Index (kg/m^2)	24.3 ± 0.9	23.1 ± 1.1	
Percent Body Fat	16.5 ± 2.4	30.5 ± 2.3	*
VO_2max	46.5 ± 4.2	37.6 ± 2.4	*

Data are means ± SEM. * indicates different between gender ($P < 0.05$)

Table 2. Energy Expenditure in 10 males and 10 females when measured at rest, while playing Nintendo Wii boxing vs. a human opponent, and while playing Nintendo Wii boxing vs. a computer opponent.

	Males (n=10)	Females (n=10)	
Energy Expenditure at rest (kcal/min)	1.3 ± 0.2	0.8 ± 0.2	*
Energy Expenditure at VO_2 max (kcal/min)	17.9 ± 0.7	12.3 ± 0.9	*
Energy Expenditure while playing human opponent (kcal/min)	2.9 ± 0.4	3.6 ± 0.7	†
Energy Expenditure while playing computer opponent (kcal/min)	3.1 ± 0.3	3.3 ± 0.6	†

Data are means ± SEM. * indicates difference between gender ($P<0.05$). † indicates energy expenditure while playing Nintendo Wii boxing higher than at rest ($P<0.05$).

Figures

Figure 1.

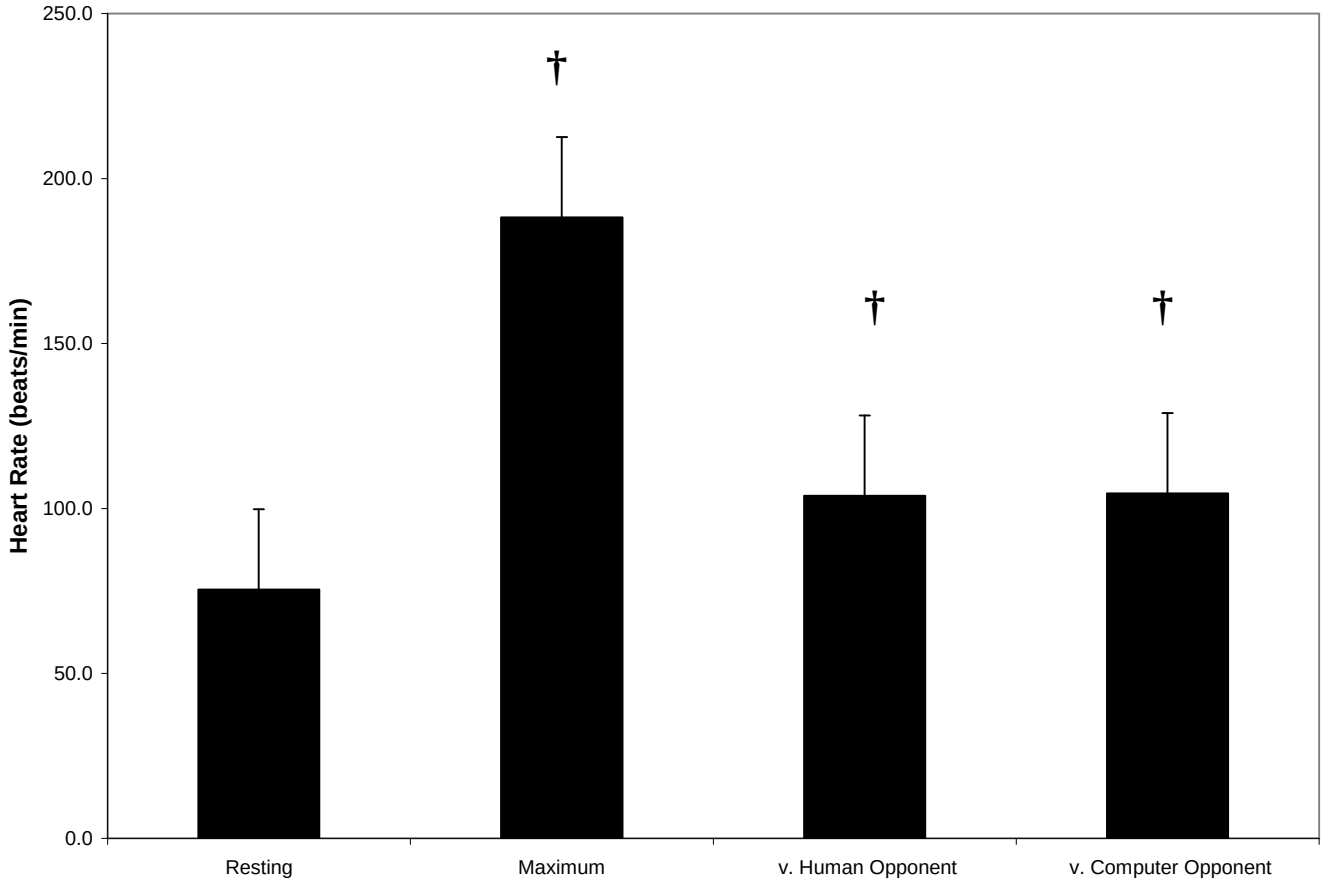
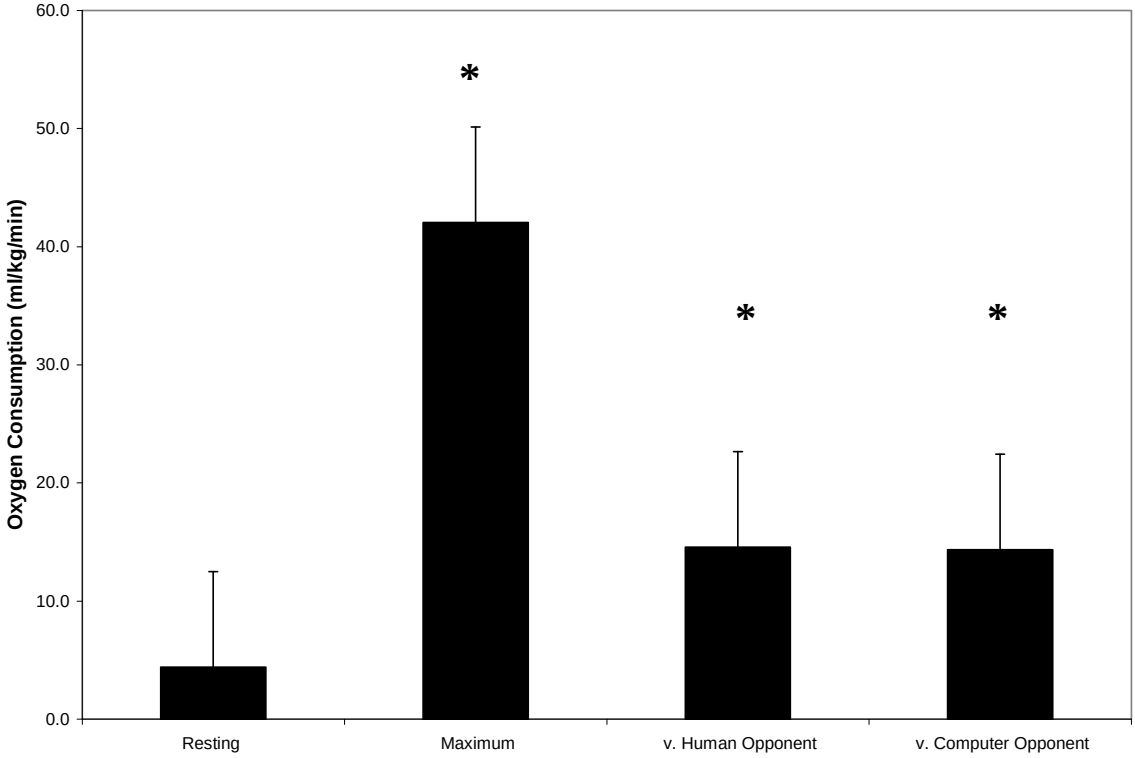


Figure 2.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Oxygen Consumption (ml/kg/min)
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