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Activity promoting games and increased energy expenditure

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Abstract

Objectives—Children and adults spend large portions of their days in front of screens. Our hypothesis was that both children and adults would expend more calories and move more while playing activity-promoting video games compared to sedentary video games.

Study Design—In this single-group study, twenty-two healthy children (12 ± 2 years, 11 M, 11 F) and 20 adults (34 ± 11 years, 10 M, 10 F) were recruited. Energy expenditure and physical activity were measured while participants were resting, standing, watching television seated, sitting and playing a traditional sedentary video game, and while playing an activity-promoting video game (Nintendo® Wii™ Boxing). Physical activity was measured using accelerometers and energy expenditure was measured using an indirect calorimeter.

Results—Energy expenditure increased significantly above all activities when children or adults played Nintendo® Wii™ (mean increase over resting, 189 ± 63 kcal/hr, $p < 0.001$, and 148 ± 71 kcal/hr, $p < 0.001$, respectively). Upon examination of movement using accelerometry, children moved significantly more than adults (55 ± 5 AAU and 23 ± 2 AAU, respectively, $p < 0.001$) while playing Nintendo® Wii™.

Conclusions—Activity-promoting video games have the potential to increase movement and energy expenditure in children and adults.

Keywords

physical activity; obesity; indirect calorimetry; video games; accelerometer

Introduction

Sedentariness and excess caloric intake (energy imbalance) are associated with obesity in both children and adults. There have been many efforts in the school, workplace, and home to improve food choices and increase daily physical activity, all with the goal of improving health through weight management [1–4]. There is wide variation in the success of these programs, most likely due to the complexity of obesity and its comorbidities. Perhaps new approaches to being more physically active and therefore impacting energy balance on a daily basis are needed not only for children, but for families. In today's technology driven society, children and their families are spending large portions of their days in front of screens for televisions, computers

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and video games [5–9]. If this sedentary screen time can be converted into active screen time, children and families could burn more calories while at the same time engaging in fun activities in the safety and comfort of their homes. There is also evidence that it may be important to focus behavior modification efforts on parents who in turn can model healthy behaviors for their children [10, 11].

Recently, we along with others have explored the potential for burning extra calories with a variety of activity-promoting games and systems: EyeToy™, Sony Computer Entertainment Inc. [12], 13, Dance Dance Revolution [12, 14–16], and more recently Nintendo® Wii [17]. Thus far, these studies have focused on children or young college students. In the current study, our objective was to examine energy expenditure and physical movement while lean and overweight or obese children and adults play sedentary video games and the activity-promoting game system Nintendo Wii. Our hypothesis was that both children and adults would expend more calories and move more while playing activity-promoting video games compared to sedentary video games. Gathering this information is an important first step in the development of potential obesity intervention and/or prevention programs for both children and parents.

Participants and Methods

Participants

Twenty-two healthy children (11 males, 11 females) and 20 adults (10 males, 10 females) of varying height and weight were recruited from the Rochester, MN community (Table 1). Advertisements were placed in the Mayo Clinic Research Study Classifieds in order to recruit potential participants. Our goal was to recruit equal numbers of lean and obese adults and to recruit equal numbers of normal weight and overweight or obese children. Eight children (4 males, 4 females) who were overweight or obese (85^{th} percentile ≤ Body Mass Index (BMI) ≤ 99^{th} percentile) were recruited. The remaining children (7 males, 7 females) were normal weight (5^{th} percentile ≤ BMI ≤ 85^{th} percentile). Ten adults (5 males, 5 females) were obese (BMI ≥ 30 kg/m^2) and the remaining 10 adults (5 males, 5 females) were lean (18.5 kg/m^2 ≤ BMI ≤ 24.9 kg/m^2). Each participant's weight and height were measured using a calibrated digital scale (Seca 644 hand-rail scale, Seca Corp., Hanover, MD) and electronic stadiometer (Seca 245 measuring rod, Seca Corp.) Participants' video game experience was not considered in the recruitment process. The study was approved by the Mayo Clinic's Pediatric and Adolescent Medicine Research Committee and the Institutional Review Board. Informed written assent was obtained from the child and informed written consent was obtained from the parent(s) or adult.

Procedures

Video Game Systems and Games—The two video game systems were PlayStation®2, Sony Computer Entertainment Inc., San Mateo, CA and Nintendo® Wii. The PlayStation®2 system uses a hand-held controller that is connected to the system with a wire. The Wii system uses one or two (depending on the game) wireless remote controllers. Two video games were used; one sedentary game (PlayStation®2) and one game which was played on the activity-promoting system (Nintendo® Wii). The sedentary video game was called Disney's Extreme Skate Adventure by Activision® Inc., Los Angeles, CA. The activity-promoting video game was Wii Sports, and the specific game was Wii Sports Boxing. Both of the games were rated "E™" for "Everyone" by the Entertainment Software Rating Board (ESRB). During the study protocol, all participants played the same video games with the same game settings.

Physical Activity Monitoring—Physical activity was measured using a Physical Activity Measurement System (PAMS) which we developed and validated in our laboratory in children and adults [18–20]. We combined inclinometers (Model CXTA02, Crossbow Technology Inc., San Jose, CA), and triaxial accelerometers (Model CXL02LF3-R, Crossbow Technology Inc.) and data loggers (Ready DAQ AD2000, Valitec, Dayton, OH) to continuously detect body posture and motion. PAMS included six sensors; four inclinometers and two accelerometers. The sensors were fixed onto Lycra® shorts and shirt using Velcro® straps. Two of the four inclinometers were positioned over the lower-thigh (right and left) and the other two inclinometers were positioned on the trunk, approximately 6 inches below the underarm (right and left). Two triaxial accelerometers were attached to the shorts at the participant's lower back. The output from these accelerometers allowed body motion to be quantified for any given body position. All participants wore the same PAMS throughout the protocol.

Energy Expenditure—Energy expenditure was measured using a high precision flow-over indirect calorimeter (Columbus Instruments, Columbus, OH). Expired air was collected using a dilution facemask that covered the entire face. A primary gas standard (0.50 % CO_2, 20.5 % O_2, balanced N_2) was used for gas calibrations prior to each measurement.

Protocol

Participants were instructed to fast (water allowed) for at least 6 hours before arriving at the Clinical Research Unit. The study was explained to the participant as, “we would like to understand what happens to your movement and the number of calories that you burn when you play a traditional video game and when you play the new Nintendo Wii.” The study hypothesis was not specifically stated to the participant. After explanation of the study, informed consent was obtained. The participant's height and weight was measured. The study investigator helped the participant to put on the PAMS, which was worn underneath their clothing. The participant rested in a dimly-lit room for 30 minutes. Resting energy expenditure (REE) was then measured for 20 minutes using indirect calorimetry as described above. Children were given a small snack after the resting energy expenditure measurement. Participants watched an age-appropriate video while sitting and standing. The content of the videos was not standardized, but the selection was limited. Energy expenditure was measured for 10 minutes each while sitting and then standing. The participant was allowed to play the sedentary video game (Disney's Extreme Skate Adventure) for approximately three minutes to familiarize him or herself with the game. Energy expenditure was then measured for 10 minutes while playing the traditional video game while seated. Participants were allowed to rest for 5 minutes between video game systems. The participant was then allowed to play the activity-promoting video game (Wii Sports Boxing) for three minutes for familiarization. Energy expenditure was then measured for 10 minutes while playing the activity-promoting video game while standing. For each of the video games, the participants were encouraged to play the game as best to their ability and/or desire. If participants stopped playing the game before the end of the measurement period, he or she was asked to resume play in order to capture the energy expenditure and movement data. However, all participants were informed at the beginning of the study that they could choose to stop the study at any time. Participants were allowed to drink water in the rest period.

Data Analysis

Values are expressed as mean ± Standard Deviation (SD). Height, weight, age, sex, BMI, movement and energy expenditure were calculated for each participant. Data from the accelerometers worn by participants were analyzed through standard kinematic equations ($\Sigma\Delta A/\Delta t$ over a 0.1 second epoch). We have used and described these methods previously [26]. To address our hypothesis that energy expenditure and movement are significantly greater when children and adults play activity-promoting video games compared to sedentary video games; we numerically compared energy expenditures determined using indirect calorimetry and movement determined using PAMS while participants were at rest, sitting, standing and playing the two video games. To compare changes in energy expenditure and movement, ANOVA with *post hoc* paired t-tests (Tukey/Kramer) were used. Statistical analyses were conducted using StatView v. 5.0 (SAS Institute, Cary, N.C.).

Results

Characteristics of the participants are listed in Table 1. For the entire group, the children (9−15 years, 11 M, 11 F) were of varying height (142−181 cm), weight (34−86 kg) and BMI (15−28 kg/m^2). The adults (18−56 years, 10 M, 10 F) were also of varying height (157−199 cm), weight (50−117 kg), and BMI (19−36 kg/m^2).

Energy Expenditure

Values for the REE and energy expenditure during the various activities (adjusted for body weight) are shown in Table 1. As expected, energy expenditure at rest and during the various activities was significantly higher for children than for adults ($p < 0.001$, Figure 1) [22–24]. Regardless of this difference in energy expenditure relative to pubertal stage, there were significant increases in energy expenditure for the various activities above REE for both groups. For children, there were significant increases in energy expenditure over REE (1.22 ± 31 (kcal/hr)/kg body weight) for all activities (sitting: 1.62 ± 0.33 (kcal/hr)/kg body weight, standing: 1.78 ± 0.41 (kcal/hr)/kg body weight, traditional video game: 1.67 ± 0.37 (kcal/hr)/kg body weight, Nintendo® Wii: 5.14 ± 1.71 (kcal/hr)/kg body weight $p < 0.001$). There were no significant differences between energy expenditure of sitting, standing or playing the traditional sedentary video game. Energy expenditure increased significantly above all activities when children played Nintendo® Wii ($p < 0.001$). When children played Nintendo® Wii, the mean increase in energy expenditure above REE was 189 ± 63 kcal/hr.

For adults, there were significant increases in energy expenditure over REE (0.85 ± 0.15 (kcal/hr)/kg body weight) for standing (1.07 ± 0.24 (kcal/hr)/kg body weight), playing the traditional video game (1.03 ± 0.20 (kcal/hr)/kg body weight), and playing Nintendo® Wii (2.67 ± 0.95 (kcal/hr)/kg body weight)($p < 0.001$). There were no significant differences in REE and sitting energy expenditure for adults. Energy expenditure increased significantly above all activities when adults played Nintendo® Wii ($p < 0.003$). When adults played Nintendo® Wii, the mean increase in energy expenditure above REE was 148 ± 71 kcal/hr. There were no significant differences in energy expenditure based upon gender for both children and adults. Although there were significant differences in energy expenditure between children and adults for REE and the activities, there were no significant differences in energy expenditure within the child and adult groups relative to age, sex, or BMI status.

Movement

We examined movement at the back, trunk, and thighs during video game play for both children and adults (Table 2). For both children and adults, movement was significantly greater when they played Nintendo® Wii compared to all other activities, ($p < 0.0001$). There were no significant differences in movement for the other activities.

When we compared back movement between children and adults, we found that children moved (51 ± 22 Arbitrary Acceleration Units (AAU)) significantly more than adults moved (23 ± 10 AAU) when playing Nintendo® Wii, $p < 0.001$, Table 2. Children moved significantly more at the thighs (left and right) and trunk (left and right) compared to adults for sitting and watching television ($p < 0.01$) and playing the sedentary game ($p < 0.05$). Children moved significantly more at the right trunk when playing Nintendo® Wii ($p < 0.005$). However, there was no significant difference in left trunk movement when playing Nintendo® Wii between children and adults. For the group, 21 children and 19 adults were right hand dominant. There were no significant differences in movement between sitting and standing for children or adults.

There were no significant differences in movement within the child and adult groups relative to age, sex, or BMI status.

Discussion

One factor that is thought to be important in obesity pathogenesis is low physical activity levels or low non-exercise activity thermogensis (NEAT) [20, 25, 26]. Screen time may be an area for researchers to focus efforts on decreasing sedentariness or increasing NEAT in children and adults. The objective of this study was to examine the energetic implications of converting sedentary video gaming to activity-promoting video gaming. When children or adults played activity-promoting video games, energy expenditure more than doubled compared to the sedentary equivalent.

Vandewater et. al., observed a relationship between weight status and the amount of time spent playing video games [27]. Our question was as to whether activity-promoting screen-time substantially increases energy expenditure as this might precipitate studies to examine these modalities for weight loss. The results are clear that children will burn more calories when playing the activity-promoting games. If a child plays 8 hours of video games a week[9], for weekly video gaming energy expenditure alone, he or she could burn 652 calories playing a sedentary video game or 1990 calories (average of 284 calories each day) playing the activity-promoting Nintendo® Wii Boxing. We previously examined other forms of activity-promoting video gaming and walking in similarly aged children. If children participated in 8 hours a week of other activities such as Dance Dance Revolution, EyeToy™, or walking on a treadmill at 1.5 mph, they could burn on average 189 calories/day, 144 calories/day, and 166 calories/day, respectively[12].

Similarly, if adults participated in only half of the time that children do for weekly video gaming, an adult could burn an average of 124 calories each day playing the activity-promoting Nintendo® Wii Boxing. This is similar to the number of calories that adults might burn if they walked on a treadmill at 2 mph for this same period of time (146 calories/day, unpublished observation). One important advantage of adult participation in activity-promoting video games is that it may provide positive behavior modelling for children. It is also important to note that there is evidence that the sustained use of activity-promoting video games is difficult, but more likely to be achieved if children play in the company of others [14,28].

Although our data clearly demonstrate that activity-promoting video games markedly increase energy expenditure in children and adults, the study has limitations. First, the experiments were conducted in the laboratory rather than the home. We do not think that a home-based study would have substantially altered our primary finding that activity-promoting video gaming doubles energy expenditure compared to sedentary video gaming. Because this was a laboratory-based study, energy expenditure was measured for 10-minute periods. This period is unlikely to capture the variability in energy expenditure if the participants were engaged in free video game play at home. Second, this was not a weight loss intervention study. However, our goal here was to evaluate the energetic potential of converting sedentary to activity promoting video gaming. We think that these data are sufficiently robust to warrant prospective, randomized studies in this area. We did not randomize the order of the study protocol between study participants. Randomization of the protocol activities would have extended the length of the study protocol from 2.5 hours to 5 hours, making it more difficult for young children to participate in a lengthy study. The children received a small snack which might have increased energy expenditure above resting by approximately 5 percent. This was ethically mandatory to prevent the children from feeling excessively hungry. We did not assess the extent to which children or adults found the games to be fun or enjoyable. We did not receive any comments to indicate dissatisfaction with playing the games, but future studies to address overall satisfaction would be important especially for sustainability of the activity. In general the study sample was small and not ethnically diverse. Despite the limitations, it is clear that activity-promoting video games can increase energy expenditure 2−3 times compared to sedentary video games.

Projections are that video gaming in children and adults is likely to continue to increase rather than decline. Even at the current level of weekly video gaming, activity-promoting video games have the potential to substantially increase daily energy expenditure. Despite the fact that activity-promoting video gaming allows children and adults to burn more calories than when they play sedentary video games, playing video games as a substitution for real sports or free play needs to be evaluated further. There are likely components of free play and sports that are beneficial beyond the increased energy expenditure and movement associated with activity-promoting video games.

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Abbreviations

AAU, Arbitrary Acceleration Units; BMI, Body Mass Index; ESRB, Entertainment Software Rating Board; NEAT, Non-Exercise Activity Thermogenesis; PAMS, Physical Activity Measurement System; REE, Resting Energy Expenditure.

References

1. Beers EA, Roemmich JN, Epstein LH, Horvath PJ. Increasing passive energy expenditure during clerical work. Eur J Appl Physiol 2008;103:353–60. [PubMed: 18351381]
2. Epstein LH, Roemmich JN, Robinson JL, Paluch PA, Winiewicz DD, Fuerch JH, et al. A randomized trial of the effects of reducing television viewing and computer use on body mass index in young children. Arch Pediatr Adolesc Med 2008;162:239–45. [PubMed: 18316661]
3. Spurrier NJ, Magarey AA, Golley R, Curnow F, Sawyer MG. Relationships between the home environment and physical activity and dietary patterns of preschool children: a cross-sectional study. Int J Behav Nutr Phys Act 2008;5:31. [PubMed: 18513416]
4. Foster GD, Sherman S, Borradaile KE, Grundy KM, Vander Veur SS, Nachmani J, et al. A policy-based school intervention to prevent overweight and obesity. Pediatrics 2008;121:e794–802. [PubMed: 18381508]
5. Company ACN. 2001−2002 U.S. Television Household Estimates Report. 2002.
6. Crespo CJ, Smit E, Troiano RP, Bartlett SJ, Macera CA, Andersen RE. Television watching, energy intake, and obesity in US children: results from the third National Health and Nutrition Examination Survey, 1988−1994. Arch Pediatr Adolesc Med 2001;155:360–5. [PubMed: 11231802]
7. Foundation, KF.; Generation, M. Media Use in the Lives of 8−18 Year-Olds. 2005.
8. Hu FB, Li TY, Colditz GA, Willett WC, Manson JE. Television watching and other sedentary behaviors in relation to risk of obesity and type 2 diabetes mellitus in women. JAMA 2003;289:1785–91. [PubMed: 12684356]
9. Cummings HM, Vandewater EA. Relation of adolescent video game play to time spent in other activities. Arch Pediatr Adolesc Med 2007;161:684–9. [PubMed: 17606832]
10. Golan M, Crow S. Targeting parents exclusively in the treatment of childhood obesity: long-term results. Obes Res 2004;12:357–61. [PubMed: 14981230]
11. Golan M, Kaufman V, Shahar DR. Childhood obesity treatment: targeting parents exclusively v. parents and children. Br J Nutr 2006;95:1008–15. [PubMed: 16611394]

12. Lanningham-Foster L, Jensen TB, Foster RC, Redmond AB, Walker BA, Heinz D, et al. Energy expenditure of sedentary screen time compared with active screen time for children. Pediatrics 2006;118:e1831–5. [PubMed: 17142504]
13. Ni Mhurchu C, Maddison R, Jiang Y, Jull A, Prapavessis H, 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 2008;5:8. [PubMed: 18257911]
14. Chin APMJ, Jacobs WM, Vaessen EP, Titze S, van Mechelen W. The motivation of children to play an active video game. J Sci Med Sport 2008;11:163–6. [PubMed: 17706461]
15. Sell K, Lillie T, Taylor J. Energy expenditure during physically interactive video game playing in male college students with different playing experience. J Am Coll Health 2008;56:505–11. [PubMed: 18400662]
16. Unnithan VB, Houser W, 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 2006;27:804–9. [PubMed: 17006803]
17. Graves L, Stratton G, Ridgers ND, Cable NT. Comparison of energy expenditure in adolescents when playing new generation and sedentary computer games: cross sectional study. BMJ 2007;335:1282–4. [PubMed: 18156227]
18. Harris AM, Lanningham-Foster LM, McCrady SK, Levine JA. Nonexercise movement in elderly compared with young people. Am J Physiol Endocrinol Metab 2007;292:E1207–12. [PubMed: 17401138]
19. Lanningham-Foster LM, Jensen TB, McCrady SK, Nysse LJ, Foster RC, Levine JA. Laboratory measurement of posture allocation and physical activity in children. Med Sci Sports Exerc 2005;37:1800–5. [PubMed: 16260984]
20. Levine JA, Lanningham-Foster LM, McCrady SK, Krizan AC, Olson LR, Kane PH, et al. Interindividual variation in posture allocation: possible role in human obesity. Science 2005;307:584–6. [PubMed: 15681386]
21. Foster RC, Lanningham-Foster LM, Levine JA. Optimization of accelerometers for measuring walking. Journal of Sports Engineering and Technology. 2008In press
22. Harrell JS, McMurray RG, Baggett CD, Pennell ML, Pearce PF, Bangdiwala SI. Energy costs of physical activities in children and adolescents. Med Sci Sports Exerc 2005;37:329–36. [PubMed: 15692331]
23. Bitar A, Vernet J, Coudert J, Vermorel M. Longitudinal changes in body composition, physical capacities and energy expenditure in boys and girls during the onset of puberty. Eur J Nutr 2000;39:157–63. [PubMed: 11079735]
24. Molnar D, Schutz Y. The effect of obesity, age, puberty and gender on resting metabolic rate in children and adolescents. Eur J Pediatr 1997;156:376–81. [PubMed: 9177980]
25. Fruhbeck G. Does a NEAT difference in energy expenditure lead to obesity? Lancet 2005;366:615–6. [PubMed: 16112286]
26. Laurson KR, Eisenmann JC, Welk GJ, Wickel EE, Gentile DA, Walsh DA. Combined influence of physical activity and screen time recommendations on childhood overweight. J Pediatrics 2008;153:209–14.
27. Vandewater EA, Shim MS, Caplovitz AG. Linking obesity and activity level with children's television and video game use. J Adolesc 2004;27:71–85. [PubMed: 15013261]
28. Madsen KA, Yen S, Wlasiuk L, Newman TB, Lustig R. Feasibility of a dance videogame to promote weight loss among overweight children and adolescents. Arch Ped Adol Med 2007;161:105–107.

Table 1

Characteristics of study participants and mean energy expenditure during each activity. Data are expressed as mean ± SD. For all activities, percent increase above resting values is shown in parentheses. Values with different letters indicate a significant difference in energy expenditure. Values with the same letter were not significantly different.

	Children (n=22)	**Adults (n=20)**
Age (yrs)	12.1 ± 1.7	33.5 ± 10.7
Height (cm)	157.1 ± 10.8	172.1 ± 10.7
Sex (Male:Female)	11:11	10:10
Weight (kg)	50.5 ± 12.8	82.7 ± 20.5
BMI (kg/m^2)	20.2 ± 3.3	27.7 ± 5.5
BMI Percentile	65.6 ± 26.8	N/A
Energy Expenditure ($kcal*hr^{-1}$/kg body weight) Resting Energy Expenditure	1.22 ± 0.31[a]	0.85 ± 0.15[d]
Sit Watch Television	1.62 ± 0.33[b] (36%)	0.93 ± 0.17[d] (9%)
Stand Watch Television	1.78 ± 0.41[b] (48%)	1.07 ± 0.24[e] (25%)
Sedentary Video Game Extreme Skate Adventure	1.67 ± 0.37[b] (40%)	1.03 ± 0.20[e] (23%)
Activity-promoting Video Game Nintendo Wii Sports	5.14 ± 1.71[c] (329%)	2.67 ± 0.95[f] (214%)

[b]Significantly greater than child REE or same task in adult, $p < 0.0001$

[c]Significantly greater than child REE or same task in adult, $p < 0.0001$

[d]Significantly less than child REE, $p < 0.0001$

[e]Significantly greater than adult REE or sitting, significantly less than same task in child, $p < 0.001$

[f]Significantly greater than adult REE and tasks, significantly less than same task in child, $p < 0.003$

Table 2

Movement in arbitrary acceleration units (AAU) on the left and right side during sitting and watching television, sitting and playing the sedentary video game, and standing and playing the activity-promoting video game. Data are expressed as mean ± SD. For both children and adults, movement was significantly greater when they played Nintendo® Wii compared to all other activities, ($p < 0.0001$).

	Children (n=22)	Adults (n=20)
Back		
Left sit	1.41 ± 0.55	1.05 ± 0.74
Right sit	1.28 ± 0.67	1.10 ± 0.69
Left Sedentary Game	2.38 ± 5.09	0.58 ± 0.28
Right Sedentary Game	2.38 ± 4.87	0.65 ± 0.26
Left Activity-Promoting Game	51.58 ± 22.31*	22.69 ± 9.66
Right Activity-Promoting Game	50.74 ± 22.32*	22.36 ± 9.61
Thigh		
Left sit	0.87 ± 0.46**	0.47 ± 0.39
Right sit	0.89 ± 0.65**	0.60 ± 0.41
Left Sedentary Game	1.56 ± 2.58**	0.48 ± 0.26
Right Sedentary Game	1.22 ± 1.56**	0.44 ± 0.25
Left Activity-Promoting Game	20.53 ± 11.06**	7.41 ± 5.17
Right Activity-Promoting Game	20.69 ± 11.62**	6.75 ± 4.98
Trunk		
Left sit	2.01 ± 1.06***	0.79 ± 0.42
Right sit	1.85 ± 1.21***	0.78 ± 0.46
Left Sedentary Game	2.47 ± 2.28***	0.91 ± 0.32
Right Sedentary Game	2.17 ± 1.98***	0.80 ± 0.30
Left Activity-Promoting Game	29.97 ± 10.31	23.12 ± 15348
Right Activity-Promoting Game	37.66 ± 13.28****	21.82 ± 11.76

* Significantly greater compared to adult, $p < 0.0001$

** Significantly greater compared to adult, $p < 0.001$

*** Significantly greater compared to adult, $p < 0.05$

**** Significantly greater compared to adult, $p < 0.0005$