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Cardiovascular and Affective Outcomes of Active Gaming: Using the Nintendo Wii as a Cardiovascular Training Tool

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Abstract

Naugle, KE, Naugle, KM, and Wikstrom, EA. Cardiovascular and affective outcomes of active gaming: Using the Nintendo Wii as a cardiovascular training tool. *J Strength Cond Res* 28(2): 443–451, 2014–Active-video gaming is purported to produce similar cardiovascular responses as aerobic fitness activities. This study compared the emotional and cardiovascular effects of Wii games with those of traditional exercise in college-aged adults with different exercise backgrounds. Specifically, the percentage of heart rate reserve, rate of perceived exertion (RPE), level of enjoyment, and Positive and Negative Affect Schedule scores were compared between subjects who reported exercising frequently at high intensities (high-intensity exerciser group: age = 20.18 years [0.87]; Height = 165.23 cm [9.97]; Mass = 62.37 kg [11.61]), $N = 11$ and those who exercise more often at lower intensities (low-intensity exercisers group: age = 20.72 years [1.19]; Height = 164.39 cm [8.05]; Mass = 68.04 kg [10.71]), $N = 11$. The subjects completed six 20-minute exercises sessions: treadmill walking, stationary cycling, and Wii's Tennis, Boxing, Cycling, and Step. The low-intensity exerciser group achieved a greater percentage of heart rate reserve (a) during traditional exercise compared with that during Wii boxing, (b) playing Wii boxing compared with that for Wii tennis, and (c) playing Wii boxing compared with that when the high-intensity exercisers group played any Wii games ($p < 0.05$). The RPE was greater for boxing and cycling compared with that for tennis and step ($p < 0.05$). Ratings of enjoyment and the increase in positive emotion were greater for boxing and for tennis compared with those for traditional exercises ($p < 0.05$). Results suggest that Wii boxing shows the greatest potential as a cardiovascular fitness tool among the Wii games, particularly for individuals who typically exercise at lower intensities.

Keywords

exercise; affect; RPE; video games; activity

Introduction

In the past few decades, the United States has experienced a significant rise in the sedentary lifestyle. For example, approximately 40% of adults engage in no leisure-time physical

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activity. Even more alarming is that the majority of adults do not engage in even the minimum amount of recommended physical activity (moderately intense physical activity for 30 min · d^{-1}, 5 d · wk^{-1}) (27). One of the most significant factors promoting this sedentary lifestyle includes the dramatic increase in total screen time, including time spent in front of television, computers, and video games (6,23). Consequently, physical activity is no longer a natural part of many people's lifestyle and must be intentionally supplemented if we are to promote proper health and fitness. Interestingly, one of the most significant problems for the rise of the sedentary lifestyle (video games) may be a possible solution.

Video gaming has undergone a radical change in the past 10 years. A new era of video game systems now allows the participant to be physically active during game play. This new genre has been called Exergaming or Active gaming and includes games where the user specifically moves in coordination with the video system. Active gaming has become a trendy fitness tool to improve or maintain cardiovascular fitness, balance, and strength and thus may be a viable mechanism to combat the increase in sedentary lifestyle because of increases in total screen time. To date, the current research has produced mixed results regarding the benefits of active gaming in these avenues. Several studies suggest that active gaming can produce cardiovascular responses greater than sedentary video games (10,17,21,22) equal to or greater than traditional physical activity (3,10,21,22,37), and within the recommended ranges of the American College of Sports Medicine (ACSM) for cardiovascular fitness training (28). For example, Douris et al. (3) recently revealed that sedentary adults playing Wii Fit's “Free Run” program at a self-selected intensity achieved a greater heart rate (HR) than brisk walking on a treadmill (17). However, substantial research also indicates that gaming systems do not produce energy expenditure and fitness benefits comparable with what can be found with moderate intensity physical activity (11,24,25). Indeed, Miyachi et al. (25) studied adults playing the Wii and found that MET values (i.e., energy cost of physical activities) for the Wii sport were not equal to the actual sport, and only 22 of the 63 activities tested could even reach moderate intensity. Clearly, the use of active gaming as a cardiovascular training tool remains in question.

Evidence suggests that the decision to engage in exercise behavior is influenced by affective variables, such as whether the previous exercise experience was perceived as enjoyable or produced positive affective responses (5,20,29,36). Importantly, active gaming combines entertainment with aerobic fitness, potentially increasing motives for continued physical activity involvement. However, evaluations of enjoyment and affective responses to active gaming are limited and have produced contrasting results (1,3,13). For example, Graves et al. (13) found that adolescents, young, and older adult populations rated balance and aerobic Wii Fit games as being more enjoyable than treadmill walking or jogging. Conversely, Douris et al. (3) found that positive well-being decreased in sedentary young adults when playing Wii Fit compared with walking on the treadmill. Interestingly, prior research in exercise psychology has shown that previous exercise experience influences affective responses to acute exercise (2,26); however, no research has considered this factor when examining affective responses to active gaming.

Although active gaming appears to hold potential as a means of cardiovascular exercise, the discrepancies in the literature highlight the importance of identifying the subset of individuals who will experience the greatest benefits from active gaming, both psychologically and cardiovascularly. This knowledge could encourage the development of individually tailored exercise interventions, which use the active gaming exercise experience (5). Thus, the objectives of this study were threefold. The first objective was to determine whether playing Wii games at a self-selected intensity could equal the cardiovascular outcomes of traditional physical activity performed at a moderate intensity. The second objective was to determine how playing Wii games at a self-selected intensity influenced emotional responses (i.e., enjoyment, changes in positive and negative affect) compared with traditional physical activity performed at a moderate intensity. Finally, the third objective was to determine whether previous exercise behavior influenced the self-selected intensity at which the Wii games were played and the emotional responses to the Wii games. We hypothesized that (a) the Wii games played at a self-selected intensity would produce equal cardiovascular outcomes as moderate intensity exercise performed on the treadmill and stationary bike, (b) the Wii games would produce high levels of enjoyment and an increase in positive emotions, and (c) positive emotional responses to the Wii games would be greater for individuals who report typically exercising at a lower intensity compared with those who report exercising more often at a high intensity.

Methods

Experimental Approach to the Problem

A cross-sectional, repeated measures design was used to examine the cardiovascular and emotional responses to playing 4 Nintendo Wii games at a self-selected intensity compared with traditional exercises completed at a perceived moderate intensity. We also compared responses between participants who reported frequently exercising at high-intensity levels to those who typically exercise at lower intensities. The participants first completed a session involving treadmill walking and running and stationary cycling. During subsequent sessions, the participants played active games through the Nintendo Wii. During the sessions, each subject wore an HR monitor and used the Borg RPE scale to determine levels of exercise intensity for each activity. Levels of enjoyment and emotional responses to each exercise activity were also recorded at the end of each session.

Subjects

All the participants, recruited from the university campus, were college-aged recreationally active volunteers. A total of 22 participants completed the study. All the participants read and signed the informed consent form, which was approved by the University's Institutional Review Board. During the initial visit, the participants were screened with the Physical Activity Readiness Questionnaire for any potential health conditions that would prohibit them from participating in physical activity (30).

Levels of physical activity were measured with the Godin Leisure-Time Exercise Questionnaire (GLTEQ) (8). The GLTEQ consists of 2 parts that measure physical activity. Part I assesses the frequency of strenuous, moderate, and mild intensity exercise occurring in a regular 7-day period. The participants report the times per week they participate in each type of exercise for >.15 minutes. Part II consists of a single question assessing the frequency in which a subject engages in exercise activity long enough to work up a sweat and rapid heartbeat during a typical 7 d·wk^{-1}, answer choices include *Often, Sometimes, or Never/Rarely*. The participants were divided into high-intensity exercisers (HIE group: 3 men, 8 women) and low-intensity exercisers (LIE group: 4 men, 7 women) based on answers to the Leisure-Time Exercise Questionnaire. The participants had to meet 2 criteria to be categorized as an HIE: (a) report that they "often" engage in physical activity long enough to work up a sweat (Part II) and (b) report participation in strenuous exercise (Part I) 3 or more times per week. This question has been shown to be strongly associated with objective measurements of physical activity and physical fitness (9). Furthermore, the ACSM states that engaging in at least 3 days of vigorous aerobic exercise promotes health and fitness benefits (15). Conversely, the participants who reported that they "sometimes" or "never" engage in physical activity long enough to work up a sweat (Part II) and reported participating in strenuous activity <3 times per week (Part I) were included in the LIE group. Prior work has demonstrated that the GLTEQ is reliable and a valid self-report measure of physical activity (16). Demographics for the 22 participants who completed the study are given in Table 1.

Procedures

The participants completed 3 exercise sessions, with 2 exercise activities performed during each session for 20 minutes each. The sessions took place at approximately the same time each day, and the participants were instructed not to exercise on the days of testing before each session. At the beginning of each session, the participants were instructed on how to wear the Polar HR monitor (FT7) (Polar Electro OY, Kempele, Finland), which collected the HR at rest (sitting) and during activity. Resting HR and blood pressure were measured before initiation of exercise. During session 1, the participants exercised on a Stairmaster 2100 LC treadmill (Stairmaster Inc., Vancouver, WA, USA) and a Cybex 700 exercise bike (Cybex International Inc., Medway, MA, USA) at a light to moderate pace. Specifically, the participants were asked to walk and jog or pedal at a Rate of Perceived Exertion (RPE) that was equivalent to 11–13 on the Borg RPE scale (i.e., moderate pace). Rate of perceived exertion was measured during each activity using the 15-point Borg RPE scale, a valid measure of exercise intensity (4). The order of 2 activities was counterbalanced across the participants. The traditional exercise was performed on a separate day from the Wii games to prevent possible fatigue resulting from this exercise influencing the intensity at which the participants chose to play the Wii games. During sessions 2 and 3, the participants performed a total of 4 Nintendo (Redmond, WA, USA) Wii and Wii Fit games including Wii Sport's Tennis and Boxing, and Wii Fit's Island Cycling and Aerobic Step. Table 2 presents a brief description of each Wii game. For the Wii gaming activities, the participants' instructions were as follows: please play the game as you see fit. No specific instructions about how to play the games were given to reduce tester biases and to emulate how the participants would naturally play in their home environment. Thus, the subjects exercised at a self-selected pace, and we operationally define this as "the ability of the subjects to play the Wii game as they wanted to, or similarly to what they would play if they were playing the game at their home and at their convenience." Anecdotally, the researchers noted that performance ranged from moderate whole-body physical activity to simple wrist movements. The order of the Wii games was randomized and counterbalanced across the 2 sessions. During each 20-minute activity, RPE and HR measures were taken every 5 minutes. Upon completion of each activity, the participants were asked to complete a 10-point visual analog scale (35) indicating their level of enjoyment while completing the exercise, with 0 indicating no enjoyment and 10 indicating the most enjoyment one could experience. Additionally, after each activity, the participant was allowed to rest until the resting HR was achieved. Each activity day was separated by at least 48 hours to prevent fatigue effects.

Percentage of HR reserve (HRR) determined exercise intensity, which has been shown to equate to oxygen uptake reserve (14,31). We determined the average percentage of HRR (HHR%) that each participant achieved while performing each exercise activity by using the Karvonen formula. The Karvonen formula is related to the percent of age-predicted maximal HR but allows for differences in resting HR (RHR) (18). Heart rate reserve equals age-predicted maximal HR (220 – age) minus resting HR. Percentage of HRR was calculated with the following formula:

$$\left[\frac{(\text{Average HR during exercise activity} - \text{RHR})}{\text{HRR}}\right] \times 100.$$

Emotional response to exercise was measured with the Positive and Negative Affect Schedule (PANAS) (34). The PANAS is a questionnaire containing 10 positive (e.g., excited, interested, strong, and alert) and 10 negative items (e.g., distressed, irritable, nervous, and jittery). The participants rated the degree to which they felt each emotion at that moment with reference to a 5-point Likert scale ranging from *very slightly or not at all* = 1, to *very much* = 5. A score for each scale (Positive affect, Negative affect) was obtained by adding item scores. The PANAS scales have good convergent, construct, and discriminant validity (34). The participants completed the PANAS before and after each exercise activity.

Statistical Analyses

Descriptive characteristics were calculated for age, height, body mass, and the total and subscale totals of the Leisure-Time Exercise Questionnaire. Average HRR%, average RPE, average level of enjoyment, average PANAS-Positive score (PANAS-P), and average PANAS-Negative score (PANAS-N) were calculated for each exercise activity. Enjoyment was analyzed with a 2 (Group: Low, High) × 6 (Activity: Stationary Biking, Treadmill walking, Wii Tennis, Wii Boxing, Wii Step, Wii Cycling) analysis of variance (ANOVA) with repeated measures on the second factor. The PANAS data were analyzed with a 2(Group: Low, High) × 6(Activity: Stationary Biking, Treadmill walking, Wii Tennis, Wii Boxing, Wii Step, Wii Cycling) × 2(Time: pre, post) ANOVA with repeated measures on the last 2 factors. If the sphericity assumption was violated, then Greenhouse-Geisser degrees of freedom corrections were applied to obtain the critical *p* value. The average HRR% and RPE were analyzed with a 2(Group: Low, High) × 6(Activity: Stationary Biking, Treadmill walking, Wii Tennis, Wii Boxing, Wii Step, and Wii Cycling) multivariate analysis of variance (MANOVA) with repeated measures on the second factor, to control for type I error. Separate 2-way univariate ANOVAs were performed for follow-up testing when appropriate. Post hoc analyses were conducted using Tukey Honestly Significant Difference procedure and simple effect tests for significant main effects and interactions, respectively. For all analyses, the probability value was set at $p \leq 0.05$.

Results

Exercise Intensity Outcomes

The MANOVA revealed a significant main effect of Activity, *Wilks' Lambda* = 0.008, $F(10, 198) = 17.38$, $p < 0.001$, and a significant Activity × Group interaction, *Wilks' Lambda* = 0.758, $F(10, 198) = 2.94$, $p = 0.002$. The Group main effect was not significant, $p = 0.446$. Table 3 presents the 95% Confidence Intervals for all the outcome measures by group and activity.

Percentage of Heart Rate Reserve—As demonstrated in Figure 1, the HRR% data indicate that the LIE group exercised at a moderate intensity (40–60% of HRR) on the treadmill and stationary bike, while the HIE group exercised at a moderate to high intensity during the traditional exercises (50–70% of HRR). However, in regards to the Wii games, only the LIE group when playing Wii boxing reached an average a moderate intensity level of >40% HRR. The follow-up univariate ANOVAs revealed a significant effect of Activity on average HRR%, $F(5, 100) = 45.68$, $p < 0.001$. However, the main effect was superseded by a significant Activity × Group interaction, $F(5, 100) = 5.75$, $p < 0.001$. In the LIE group, HRR% was significantly greater when (a) exercising on a treadmill and stationary bike compared with playing Wii tennis, Wii step, and Wii cycling, and (b) playing Wii boxing compared with Wii tennis. However, in the HIE group, a greater HRR% was achieved when exercising on the treadmill and stationary bike compared with all the Wii games. Also, the LIE group reached a greater HRR% when playing Wii boxing compared with the HIE group. The main effect of Group was not significant ($p = 0.235$).

Rate of Perceived Exertion—The participants were instructed to exercise on the treadmill and stationary bike at a moderate RPE (“Fairly light” to “somewhat hard”: 11–13 on Borg's RPE scale) and the data indicate that this was achieved by both groups (Figure 1). However, participants' average perceived exercise intensity when playing the Wii games was somewhat lower ranging from 9 to 10.5. The follow-up univariate ANOVAs for RPE revealed a significant effect of Activity, $F(5, 100) = 19.98$, $p < 0.001$. Similar to the HRR% results, the RPE was greater on the treadmill and stationary bike compared with that in all the Wii games. The RPE was also greater for Wii boxing and Wii cycling compared with that for Wii tennis and Wii step. The main effect of Group ($p = 0.194$) and the Group × Activity interaction ($p = 0.331$) were not significant.

Psychological and Emotion-Related Outcomes

Enjoyment—The analyses demonstrated a significant effect of Activity for level of enjoyment, $F(5, 100) = 5.92$, $p < 0.001$. Follow-up tests indicated that the participants enjoyed playing Wii tennis significantly more than they did all the other exercise activities except for Wii boxing. The participants also enjoyed playing Wii boxing significantly more than they did exercising on the treadmill and stationary bike. The Group main effect ($p =$

0.067) and Group × Activity interaction ($p = 0.063$) were not significant. Figure 2 presents the enjoyment data for each exercise activity.

Positive and Negative Affect Schedule-Positive Affect Scores—The 3-way ANOVA showed a significant activity × time interaction, $F(2.63, 55.34) = 2.76$, $p = 0.047$. The post hoc tests showed that positive affect significantly (a) decreased after walking and running on the treadmill, and (b) increased after playing Wii tennis and Wii boxing. All other interactions and main effects were not significant (ps > 0.05). Figure 3 presents the pre and post PANAS-P scores for each exercise activity.

Positive and Negative Affect Schedule-Negative Affect Scores—The analysis showed a significant effect of time ($p = 0.024$), with negative affect decreasing from preassessment to postassessment. All other main effects and interactions were not significant (ps > 0.05).

Discussion

Three important contributions emerged from the current data: (a) the Wii games, when played at a self-selected intensity, produced a reduced cardiovascular response compared to the traditional forms of physical activity performed at a moderate intensity, with Wii boxing showing the greatest potential for use as a cardiovascular fitness tool among the Wii games, (b) the exercise background of the participants influenced the self-selected intensity at which the Wii games were played, and (c) Wii boxing and Wii tennis elicited the highest levels of enjoyment and produced an increase in positive emotions after game play.

Contrary to our hypothesis, the Wii games did not produce similar increases in the percentage of HRR or RPE compared with moderate intensity treadmill walking and stationary biking. As instructed to do so, both groups of participants exercised on the treadmill and stationary bike at a moderate intensity based on the RPE scale, averaging approximately 12 (somewhat hard). However, the HRR% data indicate that the participants actually exercised at a moderate to vigorous intensity ranging between 45 and 75% of HRR (28). To mimic real life settings, the participants played the Wii games at a self-selected intensity that ranged from “very light” when playing Wii tennis to “somewhat hard” when playing Wii boxing. Interestingly, the exercise background of the participants influenced the intensity that was achieved when playing the Wii games. Specifically, individuals who typically exercise at lower intensities played Wii boxing at a higher intensity than those who exercise more often at a high intensity. The LIE group achieved an HRR% that reached moderate intensity at approximately 44% of HRR while playing Wii boxing, whereas the participants in the HIE group failed to achieve an HRR% >40 for any of the Wii games.

The results from this study are in line with those of other studies investigating cardiovascular responses to active gaming. For example, Jordan et al. (17) found that Wii boxing elicited a mean percentage of approximately 65% HRmax over a 12-minute time frame that was greater than when walking at 5.6 km•h^{-1} but less than when running at 9.6 km•h^{-1}. Additionally, the active gaming literature has indicated that several active games played at a self-selected intensity are comparable with moderate intensity physical activity, including

CatEyeGB300 and Dance Dance Revolution (19), Wii Fit Aerobics (13), and Wii Fit Free Run (3). American College of Sports Medicine recommends that adults should do at least 150 minutes of moderate intensity (40–59% HRR) aerobic activity to obtain substantial health benefits. Furthermore, exercise intensities between 40 and 50% to 85% HRR are needed to achieve cardiovascular fitness, with low fit individuals experiencing improvements at intensities as low as 40–49% of HRR (28). Therefore, among the tested Wii games in this study, Wii boxing was the most effective as a form of moderate intensity exercise, whereas Wii tennis, step, and cycling appear to be insufficient activities for maintaining or improving cardiovascular fitness when the subject self-selects the intensity at which they play the game. Collectively, the extant evidence suggests that selection of active game is integral when using the Nintendo Wii as a means of cardiovascular exercise.

Several reasons could account for the reduced cardiovascular response in the current sample of participants while playing the Wii games. First, the participants were not given specific instructions on what intensity levels to the play the Wii games; thus, the amount of physical activity during each game spanned a broad range among the participants. During testing, for example, some participants engrossed themselves in the games moving their whole body vigorously; others played the games by simply moving the wrists or ankles. Second, the Wii games were played at their lowest level. Higher levels of the games likely require greater physical exertion and thus may produce a greater increase in RPE and HR. In support of this theory, Worley et al. (37) demonstrated that Wii step elicited a greater $\%Vo_2max$ and energy expenditure at higher vs. lower levels of the game because higher game levels require an increased rate of speed at which steps must be performed. As such, Worley et al. (37) suggested that users should play games at an intermediate level to improve fitness levels. Third, a limitation of the Wii games compared with treadmill walking and stationary biking is the unavoidable short periods of inactivity when pauses in the game or levels of the game are completed and new levels of the game are loaded into view. These periods of inactivity likely caused the HR to lower and should be addressed by game designers in the future.

Partially supporting our second hypothesis, Wii tennis produced the greatest level of enjoyment compared with all exercise activities (expect for boxing) and boxing elicited greater enjoyment than the traditional exercise activities. Furthermore, positive emotions increased after Wii tennis and boxing, whereas they decreased after walking on the treadmill. Prior work has also shown negative shifts in affect after an acute bout of moderate to vigorous intensity stationary cycling in sedentary older and young adults (7). Similar to this study, Graves et al. (13) found that young and older adults reported greater enjoyment when playing Wii Fit balance and aerobic games compared with treadmill walking or jogging. Positive emotional responses to acute exercise have been shown to predict future exercise participation (36). As such, enjoyment in an activity can promote attendance or continued adherence to said activity (5). Importantly, Warburton et al. (33) found that those participating in active gaming and cycling program compared with a stationary cycling only training program attended exercises sessions 30% more frequently. Increases in attendance adds to the amount of physical activity being performed and thus a possible increase in fitness levels and health benefits.

To our knowledge, this is the first study to explore the impact of typical exercise behavior on cardiovascular and emotion-related responses to Wii games. Contrary to our hypothesis, no significant differences existed between the HIE and LIE in the emotions elicited by the different exercise activities. However, typical exercise behavior did impact the self-selected intensity at which the participants performed the exercise activities, with only the LIE group self-selecting an intensity when playing Wii boxing that falls within the range recommended for maintenance and development of cardiovascular fitness. These group differences could be explained by potential fitness differences between the 2 groups or differences in how the games were played, and thus, the HIE are not getting the increase in cardiac outcomes that the LIE group experience. Future research could explore this possibility by using accelerometers to measure upper, lower, and whole-body movements during game play (12). Nevertheless, the current data in combination with others show that selective active games, such as Wii boxing, are capable of eliciting an exercise intensity between 40 and 50% of HRR, and therefore appear to be more suitable for less intense exercisers and deconditioned individuals.

Several methodological issues should be considered when interpreting the results. First, the enjoyment and affective comparisons between the traditional exercises and the Wii games may have been confounded by the differences in exercise intensity and the nature of the instructions given to participants (i.e., prescribed exercise intensity vs. self-selected intensity). The self-selected intensity protocol for the Wii games could have provided increased perceptions of autonomy, which have been shown to result in more positive affective experiences (32). Second, the order of activities was not truly randomized with the traditional activities always performed on the same and first day. This occurred to prevent potential fatigue after completion of the traditional moderately intense activities influencing the self-selected intensity of the Wii games. Third, this study examined cardiovascular and emotional responses to a single session of each activity. Caution must be exercised when extrapolating these findings to the use of Wii as a tool to maintain cardiovascular fitness. Longitudinal studies are needed to determine cardiovascular and emotional responses to the repeated use of active games. Fourth, we did not control for variables such as sleep, nutrition, hydration, and menstrual phase. These, variables might impact emotional and cardiovascular responses to exercise. Finally, individuals using active gaming as a training tool may behave differently than individuals naturally playing active games for other reasons and future research should investigate these potential differences.

Practical Applications

The use of active gaming as a fitness tool is novel and has to continue to evolve with fitness goals. The ability for fitness professionals to incorporate active gaming as a means to burn calories and increase activity levels would provide an enjoyable and trendy tool in their arsenal of fitness equipment. Specifically to this study, Wii Boxing has shown to provide an enjoyable active game that can increase HR and provides an RPE that is at levels needed for ACSM promoted health benefits, particularly for individuals who typically exercise at a low to moderate intensity. With scientific based research, personal trainers and fitness professionals can substitute active gaming as a way to achieve health and fitness related improvements instead of more traditional and maybe less enjoyable exercises. This will also open up an avenue for clients with different fitness backgrounds to have a way to achieve the recommended ACSM guidelines.

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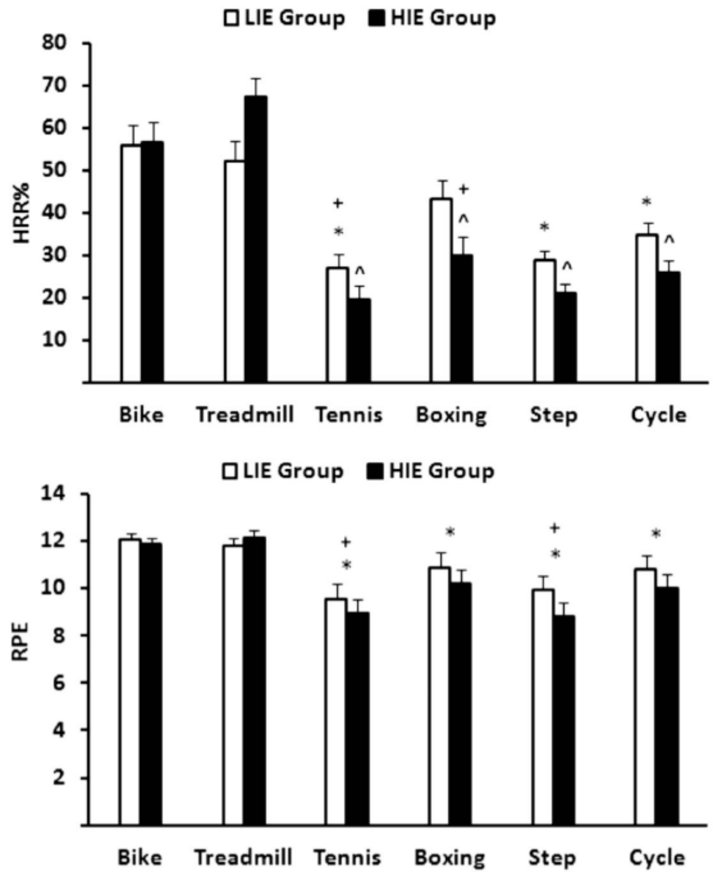

Figure 1.

Top: Mean percentage of the heart rate reserve (HRR) achieved for the low-intensity exercise (LIE) group and the high-intensity exercise (HIE) group for each exercise activity. *Significantly different from the LIE group on the treadmill and bike. ˆSignificantly different from the HIE group on the treadmill and bike. +Significantly different from the LIE group playing boxing. Bottom: Mean RPE for the LIE group and the HIE group for each exercise activity. *Significantly different from the bike and treadmill for both groups. +Significantly different from the boxing and cycling for both groups.

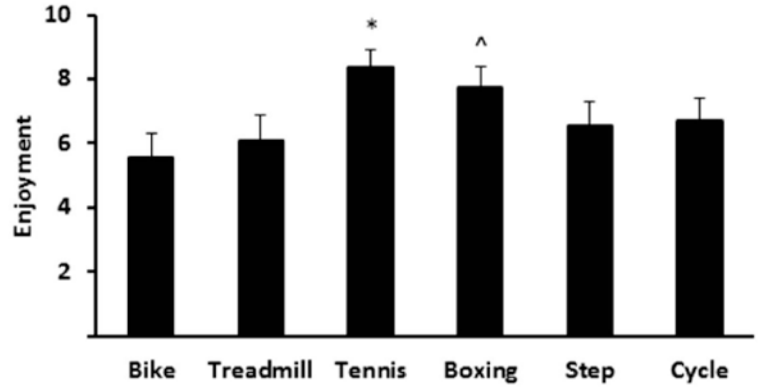

Figure 2.
Mean level of enjoyment reported for each exercise activity. *Significantly different from treadmill, bike, step, and cycling. ˆSignificantly different from the treadmill and bike.

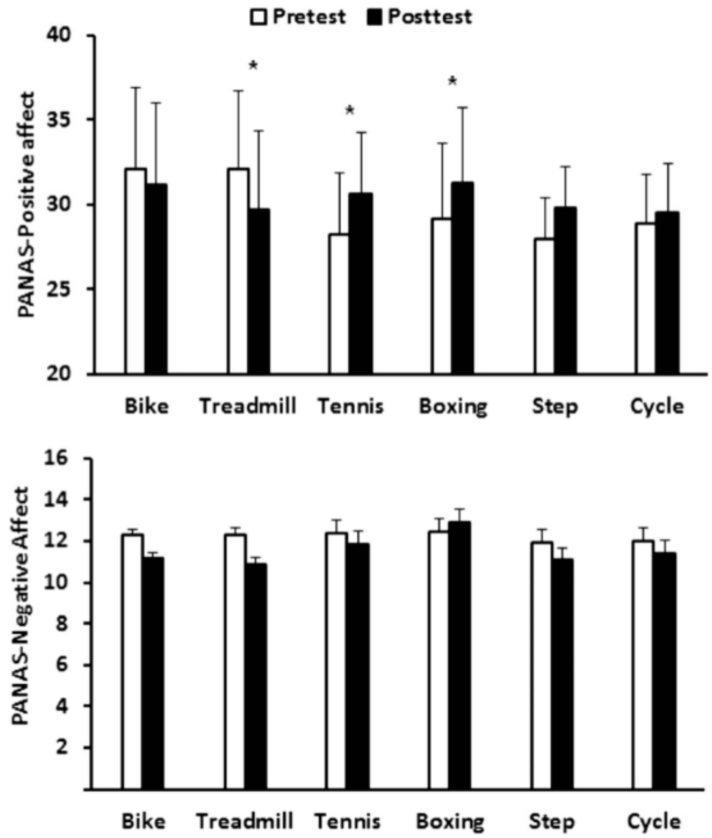

Figure 3.
Top: Mean scores for the Positive and Negative Affect Schedule (PANAS)–Positive scale for each exercise activity. *Significant difference between pretest and posttest. Bottom: Mean scores for the PANAS– Negative scale for each exercise activity.

Table 1

Participant characteristics.*

	LIE group Mean (*SD*)	**HIE group Mean (*SD*)**
Age (y)	20.72 (1.19)	20.18 (0.87)
Height (cm)	164.39 (8.05)	165.23 (9.97)
Weight (kg)	68.04 (10.71)	62.37 (11.61)
LTEQ–strenuous	1.42 (0.76)	3.50 (1.14)
LTEQ–total	41.72 (21.02)	58.91 (17.88)

*LIE = low-intensity exerciser; HIE = high-intensity exercise; LTEQ = Leisure-Time Exercise Questionnaire.

Table 2

Games used during Wii data collection.

Game	Description
Boxing	Wii Sports upper extremity game, which uses both upper extremities to mimic boxing movements
Cycling	Wii Fit lower extremity game that uses jogging in place to mimic cycling on a bike to collect flags within the context of the game
Tennis	Wii Sports upper extremity game, which uses both upper extremities to mimic tennis movements
Aerobic step	Wii Fit lower extremity game that uses step rhythmic stepping to simulate a cardio step class

Table 3

The 95% confidence intervals of the outcome measures for each activity.*

	Treadmill	Stationary bike	Wii tennis	Wii boxing	Wii step	Wii cycling
%HRR all subjects	52.54–66.23	49.13–63.44	18.52–29.19	30.74–43.88	21.92–29.13	26.55–35.13
LIE group	41.91–61.26	46.01–66.30	20.75–35.84	35.44–54.01	25.00–35.19	29.67–41.81
HIE group	57.51–76.87	46.27–66.51	11.86–26.96	20.61–39.19	15.86–26.05	19.86–31.99
RPE all subjects	11.39–12.40	11.58–12.36	8.39–10.32	9.62–11.52	8.59–10.37	9.53–11.34
LIE group	10.97–12.40	11.54–12.62	8.41–11.09	9.61–12.30	8.90–11.42	9.59–12.14
HIE group	11.40–12.82	11.32–12.41	7.57–10.25	8.84–11.53	7.54–10.05	8.72–11.28
Enjoyment all subjects	4.46–6.69	4.88–7.24	7.62–9.16	6.77–8.67	5.50–7.63	5.64–7.74
LIE group	4.30–7.65	4.27–7.42	7.99–10.17	6.56–9.26	6.77–9.77	5.92–8.89
HIE group	4.48–7.82	3.73–6.88	6.60–8.78	6.18–8.87	3.35–6.35	4.48–7.45
PANAS-P pretest all subjects	29.72–34.41	29.72–34.41	24.54–31.91	25.58–32.77	24.47–31.40	24.59–32.28
LIE group	28.25–34.75	28.26–34.75	22.00–32.17	23.20–33.14	21.63–31.21	22.80–32.20
HIE group	29.25–36.03	29.25–36.02	24.05–34.68	24.99–35.37	24.45–34.46	25.37–35.18
PANAS-P posttest all subjects	27.66–34.70	26.04–33.29	26.79–34.48	27.08–35.34	26.00–33.53	25.07–33.92
LIE group	24.13–33.87	23.24–33.26	25.68–36.32	25.08–36.59	23.97–34.37	20.97–33.20
HIE group	28.28–38.45	25.85–38.44	24.72–35.82	25.63–37.65	24.93–35.80	25.52–38.30
PANAS-N pretest all subjects	11.05–13.60	11.05–13.60	10.48–14.29	10.59–14.36	10.23–13.64	10.34–13.71
LIE group	11.52–15.28	11.52–15.28	09.29–14.91	09.92–15.48	9.18–14.22	9.81–17.79
HIE group	09.53–12.97	09.53–12.97	10.10–15.23	09.71–14.79	9.87–14.47	9.48–14.02
PANAS-N posttest all subjects	10.34–11.96	09.51–12.24	10.23–13.54	10.36–15.37	10.13–12.00	10.40–12.45
LIE group	10.10–12.50	09.48–13.52	09.65–14.55	8.70–16.10	9.92–12.68	10.59–13.61
HIE group	09.91–12.10	08.41–12.09	09.41–13.90	9.96–16.71	9.57–12.10	9.40–12.13

*HRR = heart rate reserve; LIE = low-intensity exerciser; HIE = high-intensity exercise; RPE = rate of perceived exertion; PANAS = positive and negative affect schedule.