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Heart Rate and Liking During "Kinect Boxing" Versus "Wii Boxing": The Potential for Enjoyable Vigorous Physical Activity Videogames

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Abstract

Objective: Nintendo® (Kyoto, Japan) "Wii™ Sports Boxing" ("Wii Boxing") and Xbox® (Microsoft, Redmond, WA) "Kinect® Sports Boxing" ("Kinect Boxing") are both boxing simulation videogames that are available for two different active videogame (AVG) systems. Although these AVGs are similar, the style of gameplay required is different (i.e., upper body only versus total body movements) and may alter physical activity intensity and one's preference for playing one game over the other. AVGs that elicit the greatest physiologic challenge and are preferred by users should be identified in an effort to enhance the efficacy of physical activity interventions and programs that include AVGs.

Materials and Methods: The mean heart rate (HR_{mean}) and peak heart rate (HR_{peak}) for 27 adults (22.7 ± 4.2 years old) were recorded during four 10-minute conditions: seated rest, treadmill walking at 3 miles/hour, "Wii Boxing," and "Kinect Boxing." Upon completion of all four conditions, participants indicated which condition they preferred, and HR_{mean} and HR_{peak} were calculated as a percentage of age-predicted maximum heart rate to classify physical activity intensity for the three activity conditions (treadmill, "Wii Boxing," and "Kinect Boxing").

Results: "Kinect Boxing" significantly ($P < 0.001$) increased percentage HR_{mean} (64.1 ± 1.6 percent of age-predicted maximum) and percentage HR_{peak} (76.5 ± 1.9 percent) above all other conditions: Wii HR_{mean}, 53.0 ± 1.2 percent; Wii HR_{peak}, 61.8 ± 1.5 percent; treadmill HR_{mean}, 52.4 ± 1.2 percent; treadmill HR_{peak}, 55.2 ± 2.2 percent. Percentage HR_{peak} for "Kinect Boxing" was great enough to be considered a vigorous-intensity physical activity. There was no difference ($P = 0.55$) in percentage HR_{mean} between "Wii Boxing" and treadmill walking. Participants also preferred "Kinect Boxing" ($P < 0.001$; $n = 26$) to all other conditions ("Wii Boxing," $n = 1$; treadmill $n = 0$).

Conclusions: "Kinect Boxing" was the most preferred and the only condition that was physiologically challenging enough to be classified as a vigorous-intensity physical activity.

Introduction

Traditionally, videogames have been considered a sedentary screen-based activity; however, videogame technology has evolved, and some games are now physically interactive, requiring physical movement for successful gameplay. The term "active videogame" (AVG) has been developed to describe these physically interactive videogames, and several studies have examined the ability of AVG systems (e.g., Nintendo® [Kyoto, Japan] Wii™, Xbox® [Microsoft, Redmond, WA] Kinect®) to increase physiologic responses (i.e., heart rate, oxygen consumption, caloric expenditure) to a greater extent than playing videogames on a traditional sedentary gaming systems (e.g., any Sony [Tokyo, Japan] Playstation® or Xbox gaming systems without the motion control pieces).[1–9] These AVG systems are used in recreational settings, childcare facilities, and rehabilitation and senior centers, among others, to increase and promote physical activity.[10–12] Because of the variable uses of AVGs in individuals of all ages, a better understanding is needed as to which AVGs and systems are the most liked while simultaneously eliciting the greatest physiologic challenge. This information will be helpful for the development of more effective interventions and

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recommendations that include the best AVG for maximizing physical activity.[13]

Indeed, AVGs, such as ''Wii Sports Boxing'' (''Wii Boxing''), do appear to increase physical activity intensity to a greater extent than sedentary videogames, especially when they are played per the manufacturer's recommendations, in a standing position.[2–4,7] Many studies agree that participants can achieve a moderate (3.0–5.9 metabolic equivalents) physical activity intensity when playing AVGs like ''Wii Boxing'' and ''Kinect Sports Boxing'' (''Kinect Boxing'').[1–3,5,6] These two AVGs also meet the recommendations put forth by a panel at the American Heart Association's Getting Active Summit, which stated that AVGs may be more effective when they are easy to play and simple to master.[13] Although ''Wii Boxing'' has been rigorously studied,[2, 5–9,14] ''Kinect Boxing'' has been less well examined.

A potential drawback of the Wii is that successful gameplay only requires upper body movements, which opens the door for ''cheating'' or playing a Wii game in a seated position. The concept of ''cheating'' when playing the Wii has also been suggested by Lange et al.,[15] who described cheating as performing minimal wrist movements as opposed to full arm swings, and should be considered as a limitation in previous Wii research. Additionally, Sanders et al.[7] previously reported that 23 percent of participants studied reported that they preferred to play ''Wii Boxing'' in a seated position, suggesting that not all individuals will play AVG's for the Wii as recommended (standing). Playing these games in a seated, relative to standing, position reduces physical activity intensity when playing AVGs.[7] A potential method to reduce the likelihood of cheating when playing AVGs is to play similar games for the Kinect. The Kinect requires total body (upper and lower limb) movements for successful gameplay and may be a better choice when playing AVGs than games for the Wii as this would limit the user's ability to ''cheat'' during play.[7]

However, other factors such as liking of and preference for a specific game may also contribute to an individual's intensity and overall experience while playing AVGs. Research is warranted to evaluate AVGs, AVG systems, and their potential to alter physical activity intensity, in addition to assessing how much individuals like these games and if they prefer a specific game over others.

Liking and preference for an activity can be useful information to predict an individual's behavior, in this case, physical activity behavior.[16,17] The more an individual likes and prefers an activity suggests that he or she may be more likely to choose that activity over other less liked activities. This is true for physical activity behavior, as greater liking of physical activity has been positively associated with greater participation in moderate to vigorous physical activity.[16] Therefore, liking of a given AVG may also be predictive of game use. As such, liking may also be an important variable to assess when evaluating the potential merits of AVGs as physical activity. If an AVG is simultaneously well liked and physiologically challenging, it may be a viable option for researchers and practitioners to consider when designing physical activity interventions. Currently, there are no studies that have directly compared physical activity intensity, liking, and preference for playing ''Wii Boxing'' with ''Kinect Boxing'' or that have compared both games with a well-established moderate-intensity physical activity such as treadmill walking.[18] Comparing physical activity intensity between these AVGs with a treadmill walking condition can better highlight how a common form of activity compares with ''Kinect Boxing'' and ''Wii Boxing'' and how playing these games may be a more enjoyable and interactive form of physical activity than walking on a treadmill.

The purpose of the study was to assess heart rate, liking, and preference of the following three conditions: playing ''Wii Boxing'' and ''Kinect Boxing'' and moderate-intensity treadmill walking (3.0 miles/hour).[18] It was hypothesized that, because of the total body movement needed for successful gameplay, ''Kinect Boxing'' would increase heart rate and liking and that participants would prefer to play ''Kinect Boxing'' because the Kinect movements are more physically interactive, as opposed to ''Wii Boxing,'' which requires only upper body movement.

Materials and Methods

Participants

In total, 27 ($n = 14$ females, $n = 13$ males) college students with no contraindications to physical activity or exercise volunteered to participate in the study. College students were recruited as a convenience sample for the study using flyers that were posted around a large, public Southeastern American university campus and e-mail announcements. Prior to participation, college students read and then signed an informed consent form that included information regarding the methods of the study and their right to withdraw at any time. The study was approved by the University Institutional Review Board.

Protocol

Each participant came to the Human Performance Laboratory for a single visit. Upon arriving to the laboratory, each participant's height (cm) and weight (kg) were measured by two trained research personnel using a stadiometer and balance beam scale (Detecto®, Webb City, MO), respectively. After anthropometrics were obtained, participants were instructed on how to play each AVG, and they were given the opportunity to sample each game for 5 minutes. Following the familiarization period, participants rested in a seated position for 10 minutes (this allowed their heart rate to return to a baseline value) prior to completing the following 10-minute conditions:

- *Resting:* Participants rested in a seated position.
- *Treadmill:* Participants walked on a treadmill at 3.0 miles/ hour.
- *''Wii Boxing'':* Participants played ''Wii Boxing'' against a computer opponent while standing.
- *''Kinect Boxing'':* Participants played ''Kinect Boxing'' against a computer opponent while standing.

Five-minute familiarization periods were consistent with previous research[1,8] and deemed adequate because of the low level of gaming skill (i.e., simple punching movements and the lack of coordinated movements with additional button presses) required for successful gameplay of ''Wii Boxing'' and ''Kinect Boxing.'' All participants expressed an understanding of gameplay after this period.

For each participant, the resting condition was completed first, and the order of the two AVG and walking conditions

was randomized across all participants. Prior to beginning the resting condition, participants were fitted with a validated heart rate monitor (Polar®, Kempele, Finland).[19] Mean heart rate (HR_{mean}) and peak heart rate (HR_{peak}) were recorded as beats/minute for each 10-minute condition. The heart rate monitor device sampled and calculated heart rate every 5 seconds for a total of 10 minutes. After each 10-minute condition was completed, the heart rate monitor device calculated and recorded the participant's average heart rate and HR_{peak}. HR_{mean} was used as an indicator of physiologic stress throughout each condition, whereas HR_{peak} was recorded as an indicator of potential maximum physiologic stress for each 10-minute condition. The Centers for Disease Control and Prevention classifies physical activity intensity according to the individual's age-predicted maximum heart rate.[20] Moderate physical activity intensities are classified as 50–70 percent of an individual's age-predicted maximum heart rate (220 – age in years), whereas vigorous physical activity intensities are classified as 70–85 percent of their age-predicted maximum heart rate.[20] After completion of the study, HR_{mean} and HR_{peak} were used to calculate percentage of age-predicted maximum heart rate ($[HR_{peak}/(220 - age)] \times 100 =$ percentage HR_{peak}) (percentage HR_{mean}, percentage HR_{peak}) to assess physical activity intensity.

Upon completion of each activity condition, participants were asked to indicate their how difficult their 10-minute activity was by reporting their ratings of perceived exertion (RPE) using a validated Borg scale[21] and their liking of each activity condition using a validated visual analog scale by making a mark on a horizontal line that is anchored by the term "Do not like it at all" on the left and "Like it very much" on the right.[16] Liking and RPE were assessed for each activity condition, but they were not assessed during the resting condition. Lastly, after all four conditions were completed, participants were asked to indicate which condition they preferred.

The two different AVG systems (Nintendo Wii and Xbox Kinect) were selected for the study because of their popularity and the fact both systems have a similar physically interactive boxing simulation game ("Wii Boxing" and "Kinect Boxing," respectively). Also, indirect calorimetry to measure oxygen consumption was excluded from the study. Using the stationary metabolic cart to measure oxygen consumption would have restricted free movement when playing "Kinect Boxing," and this may have altered the results. Lastly, treadmill walking at 3.0 miles/hour was selecting because the American College of Sports Medicine states that walking at 3.0 miles/hour is equivalent to a moderate-intense physical activity[18] and it is similar to other studies[2,5] that used treadmill walking as a mode of activity to compare levels of physical activity intensity.

Statistical analysis

Descriptive statistics (means and standard deviations) were calculated for all physical characteristics (age, height, weight, and body mass index), and differences between males and females were analyzed using independent-samples *t* tests.

Four four-condition (rest, treadmill, "Wii Boxing," "Kinect Boxing") repeated-measures analyses of variance were used to examine differences in HR_{mean}, HR_{peak}, percentage HR_{mean}, and percentage HR_{peak}. Then two three-condition (treadmill, "Wii Boxing," "Kinect Boxing") repeated-measures analyses of variance were used to examine differences in liking and RPE. *Post hoc* analyses using paired-samples *t* tests with the Benjamini and Hochberg False Discovery Rate correction for multiple comparisons were completed to further assess significant any main effects of condition.[22] Sex (male, female) was initially included as an independent variable in all analysis of variance models; however, there were no significant ($P \geq 0.11$) main or interaction effects of sex for any of the dependent variables. Therefore sex was ultimately excluded.

A chi-squared analysis was used to assess any differences in the number of participants who preferred one of the four conditions. All statistical analyses were conducted using IBM SPSS for Windows software (version 21.0; IBM Inc., Armonk, NY).

Results

Physical characteristics

Males were significantly ($P \leq 0.02$) older, weighed more, and were taller than females (Table 1).

Heart rate

There was a significant main effect of condition ($P < 0.001$) for HR_{mean} and HR_{peak} (Table 2). *Post hoc* analysis revealed that HR_{mean} and HR_{peak} for "Kinect Boxing" were significantly greater ($P < 0.001$) than for rest, treadmill walking, and "Wii Boxing." There was a significant ($P \leq 0.01$) stepwise increase in HR_{peak} from rest to treadmill walking, then from treadmill walking to "Wii Boxing," and then another increase from "Wii Boxing" to "Kinect Boxing." HR_{mean} values for "Wii Boxing" and treadmill walking were significantly greater ($P < 0.001$) than the resting condition, but not from each other ($P = 0.56$).

Percentage heart rate maximum

There was a significant main effect of condition ($P < 0.001$) (Table 3) for percentage HR_{mean} and percentage HR_{peak}. Percentage HR_{mean} and percentage HR_{peak} for "Kinect Boxing" were significantly greater ($P < 0.001$) than for the treadmill walking and "Wii Boxing" conditions. Percentage HR_{peak} was significantly ($P = 0.01$) greater for "Wii Boxing" than the treadmill condition; however, there was no difference in percentage HR_{mean} between treadmill walking and "Wii Boxing" ($P = 0.55$).

RPE

There was a significant ($P < 0.001$) main effect of condition for RPE (Table 2). RPE during the "Kinect Boxing"

Table 1. Physical Characteristics of the Participants

	Male (n = *13*)	*Female* (n = *14*)
Age (years)	24.8 ± 5.3[a]	20.8 ± 1.1
Height (cm)	179.0 ± 5.4[a]	168.0 ± 7.3
Weight (kg)	87.5 ± 25.2[a]	69.3 ± 12.1

Data are mean ± standard deviation values. $P \leq 0.023$ for all.
[a]Significantly greater than females.

Table 2. Participants' Mean Heart Rate, Peak Heart Rate, Liking, and Ratings of Perceived Exertion for Each Condition

	Rest	*Treadmill*	*''Wii Boxing''*	*''Kinect Boxing''*
HR_{mean} (bpm)	73.4 ± 1.8	103.3 ± 2.0[b]	104.5 ± 2.2[b]	126.4 ± 3.0[b–d]
HR_{peak} (bpm)	86.1 ± 1.8	108.8 ± 4.2[b]	121.8 ± 2.7[bc]	150.7 ± 3.5[b–d]
Liking (cm)	[a]	4.1 ± 0.4	6.2 ± 0.3[c]	8.2 ± 0.2[cd]
RPE	[a]	9.6 ± 0.3	10.0 ± 0.4	12.6 ± 0.4[cd]

Data are mean ± standard error of the mean values. $P \leq 0.013$ for all.
[a]Liking and ratings of perceived exertion (RPE) were not measured during rest.
[b]Significantly greater than value at rest.
[c]Significantly greater than treadmill value.
[d]Significantly greater than ''Wii Boxing'' value.
bpm, beats/minute; HR_{mean}, mean heart rate; HR_{peak}, peak heart rate.

condition was significantly greater than for ''Wii Boxing'' and the treadmill walking conditions. There was no significant ($P = 0.36$) difference in RPE between ''Wii Boxing'' and treadmill walking.

Liking

There was a significant main effect of condition for liking ($P < 0.001$) (Table 2). Participants reported greater ($P < 0.001$) liking for ''Kinect Boxing'' than ''Wii Boxing'' and treadmill walking. Additionally, ''Wii Boxing'' was better liked than treadmill walking.

Preference

Chi-squared analysis revealed that a significantly ($P < 0.001$) greater number of participants preferred ''Kinect Boxing'' ($n = 26$), relative to ''Wii Boxing'' ($n = 1$) and treadmill walking at 3 miles/hour ($n = 0$).

Discussion

This is the first study to our knowledge to assess physiologic effort (i.e., heart rate), liking, and preference for playing two similar AVGs (''Wii Boxing'' and ''Kinect Boxing'') across two different AVG systems (Nintendo Wii and Xbox Kinect) while comparing each game with resting and treadmill walking conditions. The results demonstrate that playing ''Kinect Boxing'' was the most physiologically challenging, most liked, and most preferred over all other conditions. Additionally, ''Kinect Boxing'' was the only condition in which participants achieved a physiologic intensity that would be considered vigorous (e.g., an $HR_{mean} \geq 70$ percent of age-predicted maximum).

Table 3. Participants' Percentage Mean Heart Rate and Percentage Peak Heart Rate for Each Activity Condition

	Participants' (n = 27)
Treadmill (percent)	
HR_{mean}	52.4 ± 1.2
HR_{peak}	55.2 ± 2.2
''Wii Boxing'' (percent)	
HR_{mean}	53.0 ± 1.2
HR_{peak}	61.8 ± 1.5[a]
''Kinect Boxing'' (percent)	
HR_{mean}	64.1 ± 1.6[bc]
HR_{peak}	76.5 ± 1.9[ad]

Data are mean ± standard error of the mean values. $P \leq 0.012$ for all.
[a]Significantly greater than peak heart rate (HR_{peak}) for the treadmill condition.
[b]Significantly greater than mean heart rate (HR_{mean}) for the treadmill condition.
[c]Significantly greater than HR_{mean} for the ''Wii Boxing'' condition.
[d]Significantly greater than HR_{peak} for the ''Wii Boxing'' condition.

According to the Centers for Disease Control and Prevention's physical activity intensity classification,[20] participants averaged a moderate-intensity physical activity while walking on a treadmill and playing ''Wii Boxing'' and ''Kinect Boxing.'' These results coincide with previous research that suggests playing ''Wii Boxing'' and ''Kinect Boxing'' could be considered a moderate-intensity physical activity.[1–3,5,6] It is interesting that, based on percentage HR_{peak}, participants in the current study achieved a vigorous intensity while playing ''Kinect Boxing'' (76.5 percent) but not ''Wii Boxing'' (61.8 percent) or treadmill walking (55.2 percent). Although HR_{peak} indicates a participant's maximum heart rate for a particular condition, it is reasonable to suggest that these high intensities were achieved more than once throughout a 10-minute condition because of the intermittent burst of activity (i.e., boxing movements, then a brief rest between fighting rounds) needed to play a boxing game.

It is likely that two key factors contributed to participants achieving a vigorous intensity while playing ''Kinect Boxing.'' The first factor was the total body movements that are required for successful Kinect gameplay. The second factor was the use of a heart rate monitor, and not a metabolic cart, to measure physical activity. Using a heart rate monitor allowed the participants to play ''Wii Boxing'' and ''Kinect Boxing'' without limiting their upper and or lower body movements. In contrast, using metabolic carts to measure AVG physical activity reduces the amount of space available for physical movement and may have altered or lessened physiologic responses in previous studies that used such methods when assessing the Wii.[2,5,6,9] Collectively, the total body movements and the lack of physically restricted movements while playing ''Kinect Boxing'' may have allowed participants to move more vigorously during gameplay, which would elicit a more pronounced physiologic response and also likely mimics a real-world playing environment.

Currently, preference and liking were assessed for each activity condition because previous research suggests that liking and preference can be predictors of an individual's behavior.[16,17] The fact that participants preferred and better liked ''Kinect Boxing,'' which also elicited a moderate to vigorous physical activity response, implies that AVGs for the Kinect may be a better, more enjoyable physical activity option than playing similar AVGs for the Wii or walking on a treadmill. Furthermore, playing the Kinect potentially reduces the opportunity for one to ''cheat'' or sit while playing AVGs because it requires total body movements for successful gameplay. The simplistic (i.e., no button to press, only total body movements) style of gameplay for the Kinect, and more specifically ''Kinect Boxing,'' fits the American Heart Association's recommendation[13] that AVGs for the use of afterschool programs and community centers should be easy and simple to master. Therefore, ''Kinect Boxing'' and similar games for the Xbox Kinect should be strongly considered by researchers and practitioners when creating interventions that include AVGs and are designed to increase physical activity behavior.

Although the current study provides promising implications for the use of AVGs such as ''Kinect Boxing'' and its potential to elicit greater physical activity intensities, it is not without limitations. First, each condition was 10 minutes in length, and physical activity intensity may be altered when gaming for longer durations in a laboratory setting and in real-world environments (i.e., playing at home or with a friend). However, engaging in moderate to vigorous exercise for 10 minutes at a time has been shown to have a favorable effect on weight management,[18] blood pressure,[23] and self-efficacy.[24] Therefore, playing ''Kinect Boxing'' for 10 minutes at a time may be advisable for individuals who play AVGs to achieve greater physical activity intensities than what the Wii or treadmill walking elicits. Another limitation to the study is that only college-aged adults participated. It is possible that older adults and children may physiologically and behaviorally respond differently to the AVGs that were assessed. Although the AVGs that were used in this study could be considered easy and simple to master, these games need to be assessed in senior centers and child care centers alike. If older adults and children better like, prefer, and physiologically respond to other Kinect games in a similar manner as college adults, then these games for the Kinect should be recommended for children, adults, and older adults to increase their physical activity intensities and enjoyment when playing AVGs. Lastly, the number of times participants achieved HR_{peak} throughout each condition was not recorded. Anecdotally, it is reasonable to suggest that HR_{peak} intensities were achieved more than once during each condition. However, these results were not recorded and may be useful information in future studies.

In conclusion, playing ''Kinect Boxing'' can elicit a vigorous intense physical activity response. Although participants perceived ''Kinect Boxing'' as being more physically difficult, they reported a greater liking for and a preference for playing ''Kinect Boxing,'' relative to ''Wii Boxing'' and walking on a treadmill. ''Kinect Boxing'' and similar AVGs for the Kinect may be a better option to increase physical activity intensity than ''Wii Boxing'' and other activities (e.g., walking on a treadmill). Lastly, because of the total body movements required, playing AVGs for the Kinect may reduce one's ability to ''cheat'' or play in a seated position and may serve as a strong option for physical activity researchers and practitioners when developing enjoyable and effective physical activity interventions that include AVGs. Although additional research is needed to assess other simple-to-play AVGs for the Xbox Kinect and their potential impact on sustainable gameplay in real-world environments, these initial results support the ability of this game to elicit enjoyable physical activity of moderate to vigorous intensity.

Author Disclosure Statement

No competing financial interests exist.

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