

Rehabilita-fun: A Comparison of Active Gaming and Traditional Conditioning Exercises

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## **Abstract**

Active games, which include the Wii, Microsoft Kinect, and the Cateye Bike, are a modern approach to the incorporation of video games into a less sedentary lifestyle. These technology-driven activities require participants to move their bodies in order to play. Although research is limited, recent studies performed on active gaming in physical therapy settings have aimed to employ the positively reinforcing aspects of video games to intrigue users, while also promoting exercise. This study examined children's preference for either active games or traditional rehabilitative exercises. An additional purpose was to determine the effect of each activity on participants' heart rates. It was predicted that active gaming would receive more favorable ratings on social validity surveys, lower ratings on the OMNI scale, and more positive feedback, while producing heart rates comparable to those attained by traditional exercise.

**Methods:** Five children (not in rehabilitation), ages 8-10 years, participated in a mixed methods pilot study involving three active games and three traditional exercises over three 90-120 minute sessions. Data from social validity surveys, OMNI scales, interview questions, and heart rate monitors was collected. **Results:** Data suggests children do not have a preference between active games and traditional conditioning exercises. The heart rate data demonstrates increases over resting heart rates at 55.45% for active games and 45.72% for traditional exercises. **Conclusions:** The results suggest that children prefer a variety of activities over repeating one activity. The heart rate data suggests participation in active games is an appropriate means of physical rehabilitation.

## **Introduction**

In the past decade, children have been spending increasing amounts of time partaking in technology-based activities. In fact, 24.9% of students were found to engage in video or computer games for three or more hours per day in 2007, up from 22.1% in 2005 (Eaton, Kann, Kinchen, Shanklin, Ross, Hawkins, Harris, Lowry, McManus, Chyen, Lim, Brener, & Wechsler, 2008). Unfortunately these screen based activities are considered sedentary, therefore engagement in video games is occupying time that children could otherwise use to be physically active. Physical inactivity is known to be a risk factor for a myriad of health issues, including obesity (Blair, Sallis, Hutber, & Archer, 2012).

It has been estimated that patients with body mass indices greater than 40 spend double the amount that normal weight patients spend on outpatient health-related services, which include physical therapy. Moreover, rising costs linked to obesity are not restricted to bariatric patients, but are inflicting encumbrance on the health care system as a whole due to increased expenditure on health care services that counteract obesity (Andreyeva, Sturm, & Ringel, 2004).

A modern approach to the incorporation of video game play into more active lifestyles is the use of active games. Unlike their sedentary counterparts, active video games require players to move their bodies in order to participate. There are two main types of active games, exergames and interactive fitness games. While both require full body involvement in order to play, exergames are screen-based activities, whereas interactive fitness games may be centered around an assortment of devices, including pressure-sensitive technologies that perceive the movement of players. Drawn from an article published in *Strategies*, Figure 1 on the following page elucidates the two major categories of active gaming, noting their subtypes and several examples (Mears & Hansen, 2009).

**Figure 1: Categories and Types of Active Games**

<b>Types of Exergames</b>	<b>Description</b>
<b>Rhythmic Step Sequence Games, (e.g. Dance Dance Revolution)</b>	These games utilize a dance pad that requires the player to move his or her feet to a set pattern that matches the general rhythm of a song. Players stand on the “dance pad” and follow a sequence of scrolling arrows stepping in the direction (i.e., up, back, right, and left) as indicated.
<b>Virtual Bicycle Ergometers, e.g. Cateye Game Bikes (Cateye, 2009)</b>	These games utilize cycling ergometers as game controllers which resemble traditional exercise cycles. These controllers allow players to control on-screen actions, including steering, speed, turns, firing mechanisms and other game components. An upper body ergometer controller is also available as an option for most games.
<b>Balance Board Simulation Games, e.g. XrBoards (Itech Fitness, 2009)</b>	These games use some type of balance board as a controller which the user stands upon as they play the game. Most games simulate various outdoor recreational activities such as snowboarding, skiing or skateboarding, or various games requiring static or dynamic balance.
<b>Sport Simulation Games, e.g. Xavix (XaviX, 2007), Wii (Nintendo, 2009)</b>	These games simulate individual and team sports with common games consisting of racquet sports, bowling, boxing, baseball and others. For these games, the controllers serve as implements that simulate a bat, racquet, or paddle during game play.
<b>Interactive Fitness Games</b>	<b>Description</b>
<b>Martial Arts Simulators, e.g. 3 Kick Interactive (Interactive, 2009)</b>	These games are designed with multiple towers that can be punched, kicked, or tapped with hands and/or feet. A light and audible tone indicates which portion of the tower is to be contacted which goes off when the player correctly strikes the target. The game assigns a score based upon speed of contact and more points are allocated the faster reaction time.
<b>Sport wall (XerGames, 2009)</b>	Sport walls contain embedded lights that illuminate randomly. When a light comes on, the player contacts the light with a bare hand, glove, striking implement, or thrown ball in order to score points.
<b>Hopsports (Hopsports, 2009)</b>	Hopsports is a system that is used in a class or group environment that allows participants to follow an on screen instructor leading an activity. The on-screen instructor is often a known professional athlete or celebrity. All activities are designed as part of a lesson plan in order to develop a particular skill of fitness component.

Recent studies show that active games appear to have the potential to be effective and sustainable means of reducing sedentary activity in children. This was reflected in a focus group study conducted with the input of parents and children, both of whom reported positive feedback pertaining to the ability of active games to elevate physical activity and fitness (Dixon, Maddison, Ni Mhurchu, Meagher-Lundberg, & Widdowson, 2010). An article published in the *International Journal of Hypertension* methodically evaluated thirty-four studies that each aimed to investigate the physical benefits of children’s participation in active video games. The evidence in favor of active gaming as a contributor to the fulfillment of daily exercise recommendations was seen across the appraised studies. It was concluded that video games that incorporate physical activity override the stigma associated with conventional video games and have the potential to reduce childhood obesity (Guy, Ratzki-Leewing, & Gwadry-Sridhar, 2011).

Parents have cited the cost of active games as reason to doubt their sustainability as exercise programs (Dixon, et.al., 2010). However, as stated before, studies have shown that bariatric populations may ultimately face extended hospital stays, incur higher health care costs, and require more physical therapy long-term due to complications associated with obesity (Slayton, Williams, & Newman, 2012). Investment into active games as a preventative measure against obesity may be highly profitable when considering the potential costs of complications due to obesity. It is therefore of great importance to investigate active gaming as an effective and sustainable means of exercise in various settings.

There are many applications of active gaming technology. Active games have been utilized by physical education programs in schools, health facilities, waiting rooms in doctors' offices, as well as rehabilitation departments of hospitals where physical therapy is administered. This study focused on active games as applied to rehabilitation science. Although limited, there have been various studies performed to investigate the effects and benefits of active gaming in the physical therapy setting. Recent studies have aimed to employ the positively reinforcing and popular aspects of video games to intrigue and motivate users, while also promoting exercise.

Active gaming has been indicated to be effective in promoting health-related behavior through numerous studies. An article published in the American Journal of Preventative Medicine compiled twenty-seven articles about the effectiveness of twenty-five different active games in bolstering healthy behaviors, including attention, retention, motivation, and self-control. This collection and investigation of several studies showed that properly designed active games are generally successful in improving these aspects of overall health (Baranowski, Thompson, & Baranowski, 2008). The effectiveness of many physical therapy regimes also relies on these same characteristics, especially motivation. If a child is not interested in the

exercise that is required for progress, patient compliance may be compromised. Supporting this notion, a study printed in the *International Journal of Pediatrics* showed that, given an hour of time to devote to either sedentary or active video games, children chose to spend approximately 95% of their time participating in active games rather than computer screen-based games. It also found that the children were significantly more active while playing active games as opposed to sedentary counterparts (Sit, Lam, & McKenzie, 2010).

Recent research shows the potential effects of supplementing physical therapy with active gaming, but there is little means of comparison among such studies, as each investigates the effects of active gaming on a particular ailment. For example, a research team at the University of Medicine and Dentistry of New Jersey conducted a case study of a 13-year old patient with spastic diplegic cerebral palsy. They found that, despite his low score on an IQ scale and reports of a short attention span, he made improvements when exposed to the various active games for the Wii console. He enhanced his visual-perceptual processing skills, ambulation distance, and postural stability while participating in the physical therapy program designed around the Wii (Deutsch, Borbely, Filler, Huhn, & Guarrera-Bowlby, 2008).

Another study published in the *Journal of Neuroengineering and Rehabilitation* explored the potential benefits of active gaming among chronic stroke victims. The study explored METs, or metabolic equivalents, for participants playing Wii tennis. METs may range from 0.9 to 18, with the lowest value comparable to sleeping and the highest correlated with high intensity running. All participants but one succeeded in attaining METs of  $\geq 3$ , and the study suggests that the Wii provides a basis for subjects to achieve enough physical movement to improve their overall health (Hurkmans, Ribbers, Streur-Kranenburg, Stam, & Van Den Berg-Emons, 2011).

With regard to burn victims, a recent survey showed that occupational and physical therapists generally support the safety of the use of the Wii in therapy, the potential of the Wii to be therapeutic during rehabilitation, and the benefits of the Wii's application in trauma populations, particularly those affected by burns. The survey lists numerous prospective advantages to the use of video games in therapy, including distraction from pain and increasing motivation (Fung, So, Park, Ho, Shaffer, Chan, & Gomez, 2010).

The majority of research to date relating physical therapy and active gaming explores active gaming used as a rehabilitative method for patients with cerebral palsy, patients who suffer from chronic strokes, and burn victims. Few studies, however, have investigated the preference between active gaming and traditional rehabilitative practice when applied to typically developing children. Such a study is beneficial in that further research on active gaming in populations of children who regularly attend physical therapy could be tied together by comparison to preference of typically developing children. Because the determination of the effectiveness of the physical therapy itself would require several weeks of training by a licensed physical therapist engaging in two to three sessions per week with the participants, a preference evaluation and a comparison of heart rate was conducted to ascertain the potential of the exercise programs. The data obtained on preference of typical children for either active gaming or traditional conditioning exercises that can be used in physical therapy serves as a baseline for additional investigations into the potentially increased motivation generated by active gaming for many different kinds of patients seeking physical rehabilitation. This study focused on the motivation-related aspect of therapy, distinguishing either traditional conditioning exercises accompanied by music or modern active gaming techniques as potentially better suited for patient compliance.

## **Purpose**

The purpose of this study was to determine children's preference for either active games or traditional conditioning exercises that may be used in a physical therapy setting. An additional purpose was to determine the effect of the activities on participants' heart rates in order to ascertain and compare the immediate physical benefits of each activity. Due to the aerobic nature of the activities being examined, heart rate was an appropriate measure to utilize in order to compare the benefits of limited interaction generated by the exercises (Keytel, Goedecke, Noakes, Hiiloskorpi, Laukkanen, van der Merwe, & Lambert, 2005). It was predicted that active gaming would receive more favorable ratings on social validity surveys, lower ratings on the OMNI Scale of Perceived Exertion, and more positive feedback during interviews, while producing heart rate comparable to those attained by traditional exercise.

## **Methods**

Pamela Versage, PT for Shriners Hospital for Children, agreed to serve as a committee member in order to provide common exercises used in physical therapy that mirror the exercises required to participate in various active games housed in the University of South Florida's Active Gaming Lab. The three active games were chosen from the gaming lab upon discussion with Mrs. Versage based on similarity of movement required by the active game to a traditional conditioning exercise. One game employed a stationary bike that, when pedaled, reflected the speed of a dirt bike being raced on a screen displayed in front of the gamer. The conditioning exercise counterpart to this game was pedaling on a stationary bike. The Light Space gaming system is a large screen that displays moving light targets for players to hit with rubber balls in order to receive points. This exercise was mirrored by the throwing and catching of a ball between the subject and a researcher. The Gamercize Stepper for Xbox 360, which powers the controller needed to play an Xbox game as the player steps, was utilized in comparison to conventional stepping on a step box. During each of the traditional conditioning exercises, music was played to mimic the traditional motivational techniques commonly used in physical therapy during conventional exercises (Naylor, Kingsnorth, Lamont, McKeever, & Macarther, 2010).

Five children, ages 8-10 years and not receiving physical therapy, participated in the mixed methods pilot study. Measures included social validity surveys, an OMNI Scale of Perceived Exertion, interview questions, and data attained by heart rate monitors. Participants were drawn from a local elementary school upon submission of parental consent and verification of physical health forms. Data was collected over three 90-120 minute sessions. The first session involved five minute introductions to each of the activities followed by completion of social validity surveys. The second session entailed preference assessment between each active game

and traditional exercise pair, and ten minute periods of activity duration and a second round of social validity surveys. The final session was comprised of an interview session and assessment of preference for the activities. Resting periods followed each activity, and were either a minimum of five minutes or until participants' heart rates reached their resting rates.

Participants were recruited from a local after school program at an elementary school on the University of South Florida's campus. The program is known as H.O.S.T., an acronym for the Hillsborough County Public Schools Out-of-School Program. Participants were escorted from the elementary school to the active gaming lab by a H.O.S.T. employee. The gaming lab was a five to ten minute walk along a sidewalk, and the after-school program employee stayed for the duration of the participants' time in the lab before accompanying them back to the school.

The social validity surveys consisted of ten questions designed to ascertain the sustainability of each exercise. Each statement was accompanied by a Likert scale to which they could provide responses ranging from "strongly agree" to "strongly disagree," with "agree," "neutral," and "disagree" options in between. Later, each of these varying degrees of responses was assigned a number for quantitative analysis. For example, "strongly agree" was assigned a numerical value of 5, and "strongly disagree" was assigned 1, with values 4 through 2 assigned to the remaining gradient of responses. The social validity surveys administered to participants can be found in Appendix A, Figure 1.

The OMNI Scale of Perceived Exertion was designed to provide children with a graphical representation of their fatigue post-exercise and enable them to characterize how tired they felt in a concise manner (Robertson, Goss, Boer, Peoples, Foreman, Dabayebbeh, Millich, Balaksekaran, Riechman, Gallagher, & Thompkins, 2000). Participants were presented with the OMNI Scale following each activity and asked to pick a number based on how they were feeling

in comparison to the pictures of the bicycler on the scale. The OMNI Scale can be found in Appendix A, Figure 2.

The preference assessments aimed to ascertain participants' predilection for either active games or traditional exercise by presenting the pairs of two similar activities and then inquiring about which they enjoyed playing more. The first preference assessment took place in phase 2, and the selection was followed by participants' playing the activities. The second assessment took place during phase 3. In this preference assessment, each participant was presented with the three pairings of exergames and traditional exercises and asked to identify which they prefer.

The interview questions were utilized to enable participants to give reactions to the activities in a way that was more tailored to their personal experience. One at a time, each participant was escorted to a separate room and asked a series of nine questions pertaining to their experience in the gaming lab. This method investigated why participants liked certain activities more than others. The interview questions are listed in Appendix A, Figure 3.

Heart rate has been shown to be an accurate predictor of energy expenditure during moderate physical activity (Keytel, Goedecke, Noakes, Hiiloskorpi, Laukkanen, van der Merwe, & Lambert, 2005). Due to this relationship and the aerobic nature of the activities performed in this study, heart rate was utilized as a quantitative comparison of the active games and their corresponding traditional exercises. Polar RS400 heart rate monitors were assigned to each participant, and participants wore the same heart rate monitor throughout the study. Heart rate values were collected during the first and second sessions in order to document heart rate achieved during each activity. The heart rate displayed on each participant's monitor was recorded immediately after completion of the activities.

## Results

The data suggests that children do not have a preference between active games and traditional conditioning exercises. The social validity responses were not significantly different between pairs of active games and traditional exercise, nor among all activities. All social validity values are given out of a possible 5 points, and higher scores indicate greater social validity and potential greater likelihood of compliance. Overall, there was a 3% difference between the 4.33 average rating of active games, and the 4.19 rating for traditional exercises. For the Lightspace and catch with music pair, the average social validity values were 4.32 and 4.54 respectively with a percent difference of 4.97%. For the Motocross and bike with music pair, the average social validity values were 4.62 and 4 respectively, generating a percent difference of 14.39%. For the Gamercize and stepping with music pair, the average social validity values were 4.06 and 4.04 respectively, with a percent difference of only 0.49%. A graphical representation of these results is shown in Appendix B, Figure 1.

The OMNI Scale feedback was generally low and invariable across all activities. There were slightly higher OMNI Scale ratings for active games over traditional exercises, at averages of 3.07 and 2.70 respectively, a mere 12.72% difference. These values were out of a possible score of ten, with ten being the top of the scale accompanied by a depiction of a very tired bicyclist and a description of “very, very tired.” The OMNI Scale results are shown in Appendix B, Figure 2.

The preference assessment resulted in highly variable data. There was not a distinct preference for either active games or traditional exercises as a group. Each pairing was presented to participants during phase 2 and again during phase 3. Of the ten total preference assessments conducted for Lightspace and catch with music, catch was chosen 60% of the time and

Lightspace was chosen 40%. Preference for the Motocross and bike with music pairing was 80% and 20%, respectively. For the Gamercize and stepping with music pair, Gamercize and stepping were chosen 50% each. Visual representations of this data is found in Appendix B, Figure 3.

With regard to interview responses, some participants had difficulty choosing only one favorite activity, and among those who were able to identify a favorite, their selections were variable. Four of the five participants listed either the Gamercize stepper or stepping with music as their least favorite activity, with reasoning typically attributed to “frustration” and level of difficulty associated with multitasking. When asked if they would prefer to play an activity involving video games, or an activity involving exercise and music, responses were highly variable. One participant responded, “I don’t know, I can’t pick.” Similarly, another participant replied, “Both, because I love playing games with music and I like playing [active] games. They’re both really fun and cool.” In contrast, one partaker remarked, “Video games. In case you wanted to outside and exercise but it was too cold, you could play an active game and get exercise all at the same time.” Still, another participant responded, “Exercise with music because when I have the music, it doesn’t make me feel like I have to work as hard as I did with the actual games.”

The heart rate data demonstrated increases over resting heart rates for both active games and traditional exercises. There was an average increase of 55.45% for active games, and an average increase of 45.72% for traditional exercises. For all participants but one, the active games generated higher heart rates than their traditional exercise counterparts. Appendix B, Figure 4 shows a graphical representation of the heart rate data.

## **Discussion**

The results suggest that children prefer a variety of activities over repeating one activity. While active gaming did receive more favorable ratings on social validity surveys, the difference was not significant. Coupled with the positive feedback for all activities during the interview sessions, that data indicates that a variety of activities may be better suited for the child's fulfillment of the exercise rather than selecting one activity that the participant particularly enjoys.

Active games received higher ratings on the OMNI Scale of Perceived Exertion, but this did not appear to influence or be correlated with diminished enjoyment of the activity. Initially it was thought that activities which generated greater feelings of physical exertion might lead to less enjoyment during exercise. This was not the case according to the data, as the OMNI Scale responses were not strongly correlated with lower social validity responses or preference. The social validity responses were approximately eighty percent correlated with preference. While this correlation is not statistically significant, it is worth noting that the social validity data did reflect participants' overall preference to a substantial degree. There is a possibility that more participants in a future study would produce a significant correlation of these values.

With regard to preference, no distinct preference for either active games or traditional exercises as groups was found. Preference was highly variable among participants, and even among separate preference assessments of individuals. Two participants selected different activities within a pairing during phases 2 and 3, citing reasons like, "I like Lightspace and catch equally," and "It depends on the day." This volatility in preference from day to day further supports the notion that assortments of exercises are preferred over favorite activities performed repeatedly.

The heart rate data suggests participation in active games is a comparable means of physical rehabilitation when evaluated next to their traditional exercise counterparts, as heart rate increases over resting were 9.72% higher for active games over traditional exercises. Based on the Karvonen method of calculating target heart rate, which has been proven to be correlated with observed maximal heart rate, the heart rates achieved by participants while playing both active games and traditional exercise activities were below target heart rates (Camarda, Tebexreni, Pafaro, Sasai, Tambeiro, Juliano, & Barros Neto, 2008). The target heart rates for participants ranged from 171.05 to 176.1 beats per minute, or bpm. The highest heart rate recorded immediately after an activity was 171 bpm for a five minute exposure to playing catch. It is important to note, however, that heart rate values were recorded at the conclusion of the activity rather than throughout. Maximum heart rate may have been achieved during the beginning or middle of the exercise, therefore a study that focuses on heart rate throughout the duration of the session could produce different findings. The main finding of this study with regard to heart rate was that the pairings of each active game and traditional exercise produced similar increases in heart rate, with active gaming producing a slightly greater elevation.

Many active games, including the Gamercize stepper evaluated by this study, can be purchased for personal use and played at home, thus conferring convenience of use. A study published in *Physical Therapy* investigated home-based therapy for patients with acute ankle sprains in the hopes that patient adherence to therapy would be increased by the recommendation of a significant component of therapy to be performed at home. The study found that post-treatment ankle function was comparable among those receiving therapy at the clinic or at home, and that those who underwent the home intervention attended their clinic appointments significantly more often than the clinic group. The home intervention group also had a higher

completion rate for their physical therapy programs (Bassett & Prapavessis, 2007). While certain patients may need close monitoring and assistance during therapy and would therefore not be able to participate in home interventions, those with ailments that can be addressed by home intervention may benefit from active gaming and find it to be conducive to intervention adherence. Not only do the findings of this study alone show that active gaming is a reinforcing physical activity for children, but in conjunction with the notion of home-based therapy, they indicate that greater patient compliance may be achieved through the convenience of active games as in-home exercise stations.

The findings of this study also bear implications for preventative measures against health issues and the avoidance of non-communicable chronic diseases, or NCDs, which include cardiovascular disease, diabetes, and cancer. Risk factors for such diseases include obesity, physical inactivity, and hypertension, all of which are reduced by the type of aerobic activity supplied by the active games in this study. With NCD's already causing sixty-five percent of deaths worldwide and expected to account for three fourths of all deaths over the next two decades, it is important to find ways to effectively intervene and ameliorate lifestyles that lead to NCDs (Blair, Sallis, Hutber, & Archer, 2012). The positive feedback and elevated heart rates produced by active games and reflected in the findings of the study are promising indicators of active gaming's ability to aid in the reduction of risk factors, namely physical inactivity and obesity, specifically in children. Active games may be able to help children avoid the need for physical therapy due to NCDs by assisting in prevention of such diseases altogether, and they may become an integral part of therapy for those already affected by NCDs.

## **Limitations**

There are several limitations to this study, and further studies may take certain measures to reduce the impact of these confines. This was a pilot study, and the type of data collected required a limited number of participants. Heart rate data would be more valid if there were more participants, therefore it is advisable that more participants are involved in further research. It would also be beneficial to analyze heart rate data collected throughout the duration of each session rather than at the conclusion in order to obtain a more representative view of heart rate fluctuations during the different exercises.

It was noticed that age of participant may have been an influence on responses to social validity surveys. It may better serve future studies to reduce the age difference between youngest and oldest participants, or to utilize different social validity surveys dependent on the age of the participant in order to tailor the surveys to each age level.

With regard to the OMNI Scale of Perceived Exertion, it may be more effective to isolate each participant before presenting them with the scale and inquiring about how hard they felt they worked. Secluding participants during OMNI Scale data collection may reduce the influence of their peers and increase the accuracy of the measure by providing a confidential environment.

A final recommendation is isolation for participants exercising to music. The music for this study was played in a manner that minimized overhearing by participants who were playing exergames. The music was played at a low volume so that it was easily audible to those intended to hear it, but not loud enough to interfere with those who were engaged in exergaming. A more controlled environment would be generated through the use of a separate room for traditional exercising so that strictly those who were exercising to music could hear the exercise music.

## **Implications**

The data obtained may be compared to future investigations into activities that generate the most motivation for many different kinds of patients seeking physical rehabilitation. Future research might also look into a potential influence of age on preference for either active games or traditional exercise, as only eight to ten-year olds' preferences were evaluated in this study. It is important to note that many participants had not played active games before, therefore it is of interest to determine if the enjoyment of active gaming was due to novelty or more sustainable factors. This study, and potential studies that aim to replicate and amplify these findings, provide a baseline for comparison. Data suggests that active games are an enjoyable and comparable means of physical activity to traditional exercises that may be used in physical therapy settings, and it is consequently worthwhile to investigate preference of patients with diverse needs for either active games or traditional conditioning exercises.

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## Appendix A: Data Collection Methods

**Figure 1: Social Validity Surveys**

Participant: \_\_\_\_\_ Pre/Post: \_\_\_\_\_

### Social Validity Scale

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. I like playing the motocross game.					
2. I would play the motocross game again.					
3. I would play motocross game at home.					
4. I would recommend the motocross game to a friend.					
5. I could feel my heart rate change while playing the motocross game.					
6. The motocross game was difficult to play.					
7. While playing the motocross game, I was completely focused on what I was doing.					
8. I felt like I was working hard while playing the motocross game.					
9. It was hard for me to breath/I was out of breath while playing the motocross game.					
10. I felt tired after playing the motocross game.					

Participant: \_\_\_\_\_

Pre/Post: \_\_\_\_\_

**Social Validity Scale**

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. I like playing the bike with music.					
2. I would play the bike with music again.					
3. I would play the bike with music at home.					
4. I would recommend the bike with music to a friend.					
5. I could feel my heart rate change while playing the bike with music.					
6. The bike with music was difficult to play.					
7. While playing the bike with music, I was completely focused on what I was doing.					
8. I felt like I was working hard while playing the bike with music.					
9. It was hard for me to breath/I was out of breath while playing the bike with music.					
10. I felt tired after playing the bike with music.					

Participant: \_\_\_\_\_

Pre/Post: \_\_\_\_\_

**Social Validity Scale**

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. I like playing catch with music.					
2. I would play catch with music again.					
3. I would play catch with music at home.					
4. I would recommend playing catch with music to a friend.					
5. I could feel my heart rate change while playing catch with music.					
6. Catch with music playing was difficult to play.					
7. While playing catch with music, I was completely focused on what I was doing.					
8. I felt like I was working hard while playing catch with music.					
9. It was hard for me to breath/I was out of breath while playing catch with music.					
10. I felt tired after playing catch with music.					

Participant: \_\_\_\_\_

Pre/Post: \_\_\_\_\_

**Social Validity Scale**

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. I like playing Light Space.					
2. I would play Light Space again.					
3. I would play Light Space at home.					
4. I would recommend Light Space to a friend.					
5. I could feel my heart rate change while playing Light Space.					
6. Light Space was difficult to play.					
7. While playing Light Space, I was completely focused on what I was doing.					
8. I felt like I was working hard while playing Light Space.					
9. It was hard for me to breath/I was out of breath while playing Light Space.					
10. I felt tired after playing Light Space.					

Participant: \_\_\_\_\_

Pre/Post: \_\_\_\_\_

**Social Validity Scale**

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. I like playing Gamercize Stepper.					
2. I would play Gamercize Stepper again.					
3. I would play Gamercize Stepper at home.					
4. I would recommend Gamercize Stepper to a friend.					
5. I could feel my heart rate change while playing Gamercize Stepper.					
6. Gamercize Stepper was difficult to play.					
7. While playing Gamercize Stepper, I was completely focused on what I was doing.					
8. I felt like I was working hard while playing Gamercize Stepper.					
9. It was hard for me to breath/I was out of breath while playing Gamercize Stepper.					
10. I felt tired after playing Gamercize Stepper.					

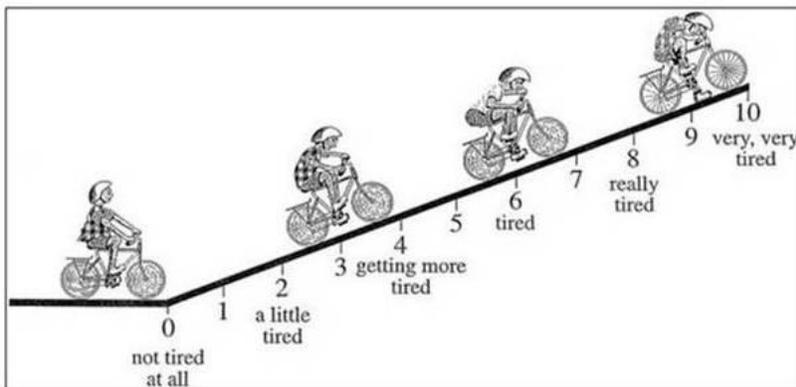
Participant: \_\_\_\_\_

Pre/Post: \_\_\_\_\_

**Social Validity Scale**

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. I like playing step-up with music.					
2. I would play step-up with music again.					
3. I would play step-up with music at home.					
4. I would recommend step-up with music to a friend.					
5. I could feel my heart rate change while playing step-up with music.					
6. Step-up with music was difficult to play.					
7. While playing step-up with music, I was completely focused on what I was doing.					
8. I felt like I was working hard while playing step-up with music.					
9. It was hard for me to breath/I was out of breath while playing step-up with music.					
10. I felt tired after playing step-up with music.					

**Figure 2: OMNI Scale of Perceived Exertion**



Children's OMNI Scale of Perceived Exertion: mixed gender and race validation.  
 ROBERTSON, ROBERT; GOSS, FREDRIC; BOER, NICHOLAS; PEOPLES, JENNIFER; FOREMAN, ALJAY; DABAYEBEH, IBRAHIM; MILLICH, NANCY; BALASEKARAN, G; RIECHMAN, STEVEN; GALLAGHER, JERE; THOMPSON, TAYLOR  
 Medicine & Science in Sports & Exercise 32(2):452, February 2000.

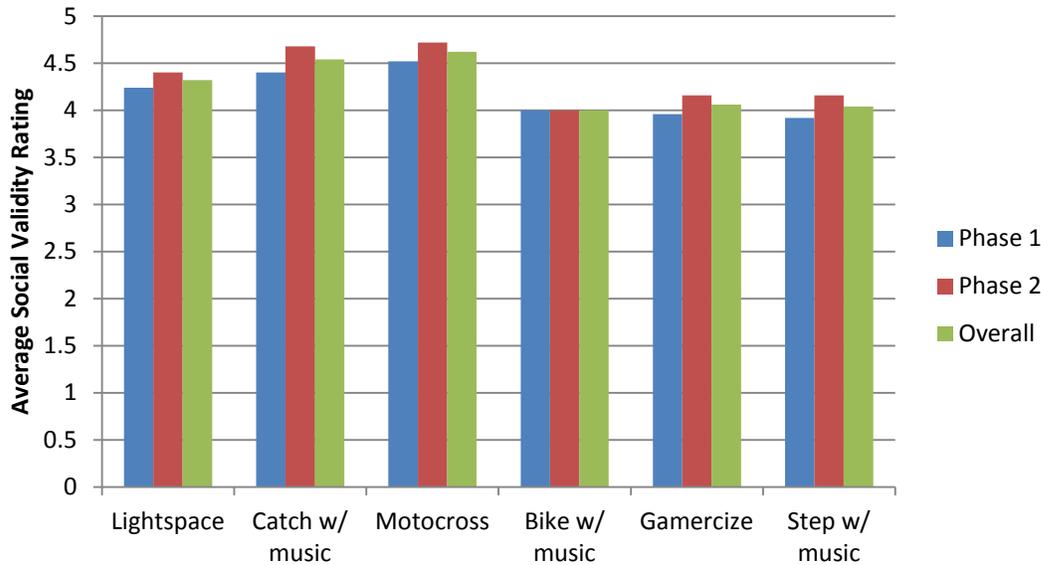
Figure1. Children's OMNI Scale of Perceived Exertion

### **Figure 3: Interview Questions**

1. Please discuss your feelings about the activities involving video games.
2. Please tell me what you liked and/or disliked about any of the activities.
3. If given the choice, would you choose an activity involving video games, or an activity involving exercise and music? Please tell me why.
4. Please discuss your feelings about \_\_\_\_\_. (The researcher asked this question about each activity.)
5. What was your favorite activity?
6. What was your least favorite activity?
7. How often would you play your favorite activity if you had it at home?
8. Do you think you would enjoy any of the activities more if you were playing with someone else, and why?
9. Would you like to tell me anything else?

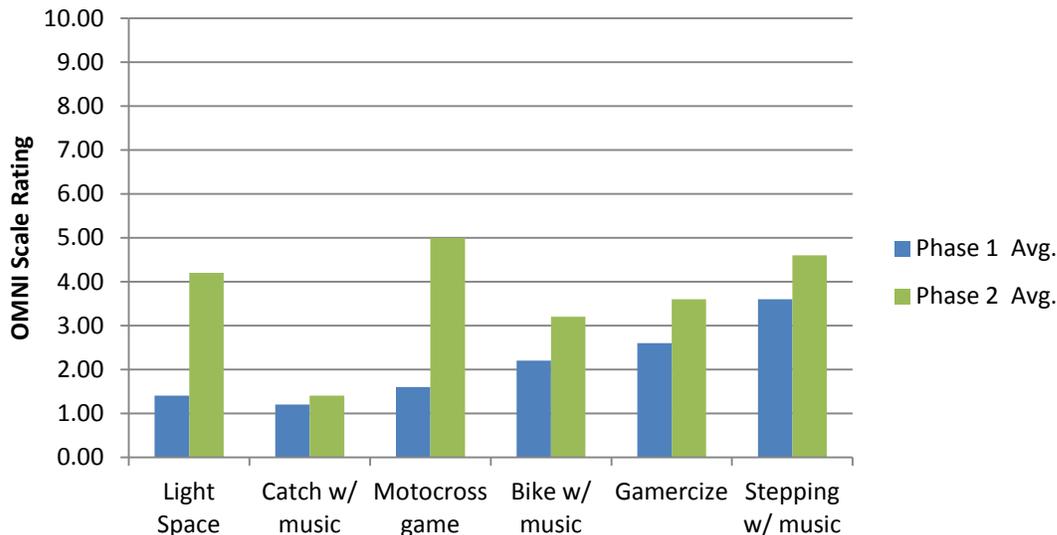
## Appendix B: Graphical Representations of Results

### Average Social Validity Ratings



**Figure 1: Average Social Validity Ratings.** This figure displays the mean social validity ratings among all participants for each activity. Ratings were given out of a possible five units. Phase 1 values are shown in blue, Phase 2 values are shown in red, and overall averages are depicted in green.

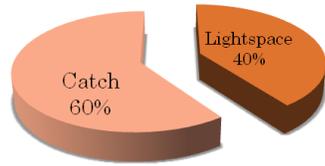
### OMNI Scale Ratings during Phase 1 and Phase 2



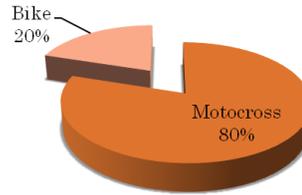
**Figure 2: OMNI Scale Ratings during Phase 1 and Phase 2.** This figure displays the average OMNI Scale ratings among all participants for each activity. Ratings were given out of a possible 10 units, with 10 indicative of feeling “very, very tired,” and 0 indicative of feeling “not tired at all.” Phase 1 values are shown in blue, Phase 2 values are shown in green.

### Preference Assessment

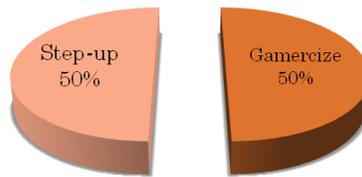
#### Catch v. Lightspace



#### Bike v. Motocross

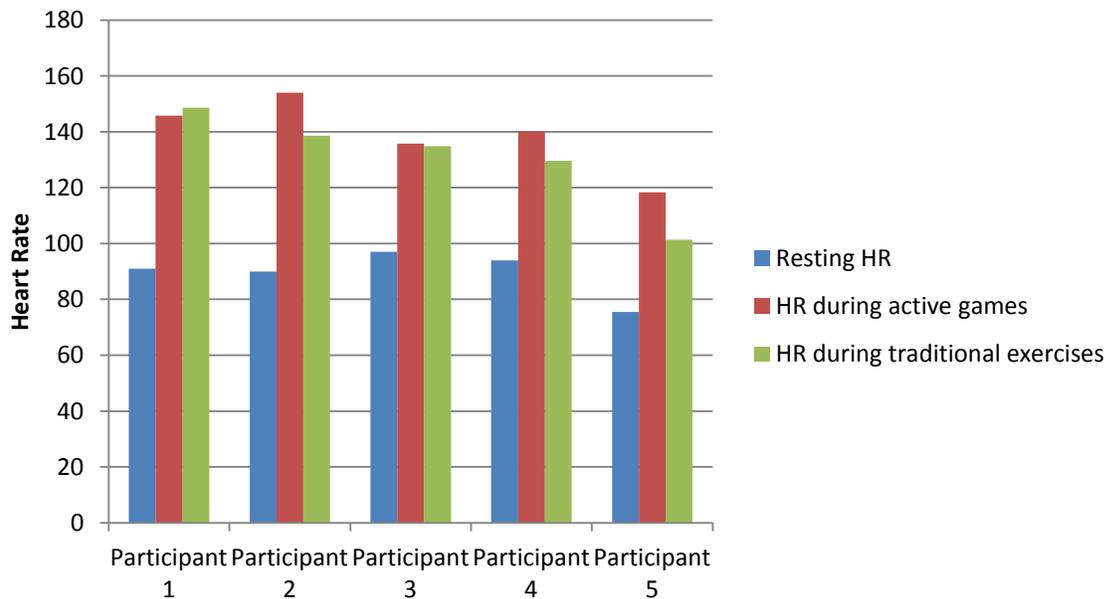


#### Step-up v. Gamercize



**Figure 3: Preference Assessment for Active Games or Traditional Exercises.** This figure displays the percentage that each game was chosen when presented with each pairing of active game and traditional exercise. The light orange represents traditional exercises, and the dark orange denotes active games.

### Heart Rates (HR) for Participants



**Figure 4: Heart Rates for Participants.** This figure displays the heart rates collected for each participant at rest, during active games, and during traditional exercises. Resting heart rate is shown in blue, average heart rate achieved by active gaming is shown in red, and average heart rate attained during traditional exercise is shown in green.