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# Comparison of Physical Intensity between Interactive Video Game Cycling and Conventional Stationary Cycling in Adolescents with High Functioning Autism Spectrum Disorder

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Comparison of Physical Intensity between Interactive Video Game Cycling and Conventional Stationary Cycling in Adolescents with High Functioning Autism Spectrum Disorder

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## Abstract

**Background:** Obesity has become a serious health concern in adolescents with autism spectrum disorder (ASD). Researchers have indicated that sedentary behaviors, especially technological activities, such as video games and other forms of screen-based activities is the main barrier to participate in physical activities. Active video games have demonstrated the efficacy in increasing physical activity and reducing body weight in children and adolescents with disabilities.

**Purpose:** The purpose of the study was to examine the exercise intensity and enjoyment level of interactive video game cycling (IVGC) in comparison with conventional stationary cycling (CSC) during matched number of sessions utilizing the same bicycle at the same resistance.

**Method:** Three adolescents with high functioning autism HFA (two males and one female) participated in an alternating treatment single-case design study. Two Game Rider bicycles that included gym mode and interactive video game mode were utilized in this study. In a random order, participants completed five cycling sessions engaging in conventional stationary cycling and five sessions carrying out the interactive video game cycling. Cycling method alternated every day with each participant receiving one treatment a day, and each session lasted 15 minutes. Measurements evaluated throughout the study were average HR, minutes spent in THRR, distance pedaled, and enjoyment level.

**Results:** Tau-U effect size and percentage of non-overlapping data (PND) were computed to analyze the significant differences between the two cycling methods. The results indicated that there were no statistically significant differences between the two applied treatments in average heart rate, minutes in THRR, and distance pedaled. The average heart rate within the recommended THRR (70% and above of HRmax) was achieved by one participant in both cycling methods. Participants reported a high enjoyment level in terms of IVGC.

**Conclusion:** Interactive video game cycling may lead to higher intensity of physical activity in adolescents with HFA when applying some recommendations that can increase individual's motivation, such as offering variety of the latest video games cycling, administering token system, and organizing contests between students. One limitation of this study was the small sample size. Therefore, larger sample size and/or replication of the study is needed.

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## Introduction

According to the 5th edition of the Diagnostic and Statistical Manual of Mental disorders (DSM-5), autism spectrum disorder (ASD) is an impairment in the neurological development resulting in underdeveloped social interaction and social communication as well as repetitive pattern of behaviors (American Psychiatric Association, 2013). Along with diagnostic criteria, the DSM-5 outlines three levels of severity based on social communication impairments, limited, and repetitive types of behavior. At the severest level which designated as level 3, individuals require substantial support to conduct normal daily activities, while level 1 requires some level of support in their daily lives (American Psychiatric Association, 2013).

Researchers have been increasingly interested in ASD as the prevalence has increased since the late 1970s (Centers of Disease Control and Prevention, 2016). A deconstruction of available data indicates that while in 2000 one in 150 children were diagnosed with ASD, the prevalence had grown to one in 110 children in 2006. By 2008, one in 88 children were diagnosed with ASD, and the rate had increased to one in 68 children in 2012 (CDC, 2016). According to CDC (2016), one in every 42 males is diagnosed with ASD, while one in every 189 females is diagnosed with this disorder which means that 2.35% of male individuals are afflicted by ASD, and .53% of females are afflicted by the same disorder. Male individuals are 4.5 times more likely to have ASD than females.

Until recently, only people demonstrating severe symptoms have been diagnosed with autistic disorder under the category of Pervasive Developmental Delay (Volkmar et al., 2014). However, starting in the 1990s, Asperger syndrome was included as a spectrum disorder under the category of Pervasive Developmental Delay. Individuals with Asperger Syndrome have typical language development and average to above average intelligence. Today this is commonly referred to as high functioning autism (HFA) (Volkmar et al., 2014). During 2013, in the Diagnostic and Statistical Manual of Mental Disorders 5$^{th}$ edition (DSM-V), the American Psychiatric Association categorized autism-related disorders as autism spectrum disorder or ASD (Volkmar et al., 2014). According to Rubin and Lennon (2004), HFA represents individuals with ASD who fall under full-scale IQ of greater than 70 and do not manifest significant delays in language and intelligence. Attwood (2003) claims that the term HFA was first employed to describe people who have exhibited typical autism symptoms during their childhood, but they later attained a higher level of cognition gradually as they grew up and demonstrated greater adaptive behavior and social skills as compared to other children with ASD.

Obesity has become a major source of health risk for adolescents in the general population as a significant number of adolescents across the world are obese or overweight (CDC, 2017). In the United States, the rate of teen obesity between 12 and 19 years of age has more than quadrupled from 5% in 1980 to 20.5% currently (Center for Disease Control and Prevention, 2015; Ogden, Carroll, Fryar, & Flegal, 2015), and 34.5% of individuals in the same population are overweight (Ogden, Carroll, Kit, & Flegal, 2014). Overweight adolescents are more probable to be overweight or obese in adulthood (Anderson, 2011). Reilly and Kelly (2011) evaluated relevant literature and found that obesity in adolescents is related to morbidity linked diseases and increased mortality in adulthood. Adolescents with ASD have comparatively higher measures of body mass index (BMI) values than the general population and other populations with different forms of disabilities (Griebenauw, 2015). According to Must et al, (2017), the prevalence of obesity among individuals with ASD is equal higher when compared to the prevalence in their peers, and the possibility of being obese among individuals with ASD increases systematically between the ages of 10 and 17 years. A study by Rimmer, Yamaki, Lowry, Wang, &Vogel (2010) examined that 24.6% of adolescents with ASD had obesity as compared to 13% prevalence among non-disabled adolescents. They further suggested that a high rate (42%) of overweight is prevalent among adolescents with ASD while in the case of typically developing adolescents it was only 28.8%.

A study by Chen, Kim, Houtrow, and Newacheck (2010), found that 23.4% of adolescents with ASD were obese. However, the prevalence of obesity among adolescents with asthma was only 19.7%, among adolescents with hearing and visually impaired the prevalence stood at 18.4%, while among youths with learning disabilities obesity reached 19.3%. Research studies consistently link autism and obesity with unhealthy eating habits, lack of nutritious food, and sedentary behaviors with low level of exercise as the contributory factors that cause the high prevalence of obesity in the adolescent population with ASD (Curtin, Jojic, & Bandini, 2014; Must et al., 2014). Similarly, sleep disorders, the increase use of medications, and anxiety are causes that can lead to obesity (Curtin, et al., 2014; Wink, 2014; Dillon, 2007; Reynolds & Malow, 2011; Fox, Gross, Rudser, Foy, & Kelly, 2016). There are numerous health risks associated with the early onset of obesity in adolescents. Obesity causes the likelihood of health risks, such as heart diseases and stroke, type II diabetes, respiratory ailments, hypertension, musculoskeletal problems, certain forms of cancers, high blood sugar, high blood pressure, high triglycerides, greater waist fat deposits, or low HDL cholesterol (Aguilar et al., 2015; Daniels, 2009; Kelly et al., 2013; Nejat, Polotsky, & Pal, 2010).

Due to social and behavioral factors associated with ASD, adolescents with ASD have limited activity levels and lack physical patterns (Pan & Frey, 2006; Srinivasan et al., 2014). Current guidelines recommend that adolescents should accumulate 60 minutes or more of moderate to vigorous physical activities (MVPA) each day to obtain the health benefits of physical activities (Pan &Frey, 2006; Stanish et al., 2017; US Department of Health and Human Services, 2008). According to Pan et al. (2015), only 33% of students with ASD of high school age were able to meet the recommended guideline and engage in long sessions of constant physical activity. Studies revealed that adolescents with ASD spend less proportion of time in moderate to vigorous physical activities during PE when compared with their peers without the disorder (Downs, Fairclough, Knowles, & Boddy, 2016; Pan et al., 2015; Sorensen, & Zarrett, 2014; Srinivasan et al., 2014; Stanish et al., 2017; Tyler, MacDonald, & Menear, 2014). Interestingly, some findings have stated that younger adolescents are more likely to be more active than older adolescents. The decrease in MVPA levels is connected to a concomitant increase in sedentary behavior (Memari et al., 2013; MacDonald, Esposito, & Ulrich, 2011; Pan & Frey, 2005; Pan & Frey, 2006).

Some benefits of MVPA involve reducing the risk of high blood pressure, the risk of cardiovascular diseases, type II diabetes, cholesterol levels, the chance of long-term chronic health conditions, decreasing weight, enhancing liver health, the sensitivity of vascular insulin, strengthening muscles and bones, and improvement in social and psychological aspects (American Heart Association, 2015; Annan, 2013; Cerdá et al., 2016; Na & Oliynyk, 2011; Padilla, Olver, Thyfault, & Fadel, 2015; Reiner, Niermann, Jekauc, & Woll, 2013; Shephard & Johnson, 2015). In addition to the benefits of MVPA mentioned above, a wide range of physical activities and aerobics have direct and implied benefits for adolescents with ASD. Participating in MVPA improves motor proficiency, social interactions, self-regulation, sleep quality, decreases repetitive pattern behaviors and hyperactivity (Magnusson, Cobham, & McLeod, 2012; Pan, Tsai, & Hsieh, 2011; Sorensen, & Zarrett, 2014; Srinivasan et al., 2014; Wachob, & Lorenzi, 2015).

Several studies have analyzed the barriers to adolescents with ASD for engaging in moderate to vigorous physical exercises. Most of the studies have found that a sedentary lifestyle is the most significant among such barriers (Obrusnikova & Cavalier, 2011). The target population tend to spend most of their leisure by playing video games or watching TV as compared to their counterparts as well as youngsters who suffer from other disabilities (Kuo, Orsmond, Coster, & Cohn, 2014; Mazurek, Shattuck, Wagner, & Cooper, 2012; Mazurek, & Wenstrup, 2013; Stanish et al., 2015). In addition, adolescents with ASD remain isolated from MVPA engagement due to their lack of fundamental movement skills including deficiency in locomotion and inadequacy in motor coordination that significantly limit the choices of physical activities that they can practically engage in (Mccoy, Jakicic, & Gibbs, 2016; Obrusnikova & Cavalier, 2011). Another impediment against their participation in MVPA is their limited social communication skills. Adolescents with ASD characteristically demonstrate several impairments in social skills that reduce the person's engagement in collaborative activities, relation with peers, and difficult tasks or sports that require pairing with others (Hamm & Driver, 2015; Menear & Neumeier, 2015; Srinivasan et al., 2014). Moreover, parents, guardians or service providers may fear students with ASD will get injured or hurt while participating in MVPA. Their over-protective attitude is a barrier that may prevent adolescents with ASD from actively engaging in physical activities (Stanish et al., 2015).

Adolescents with ASD require targeted interventions to reduce their obesity and increase their engagement in physical activities (Mccoy et al., 2016). In this era of technological development, the use of electronic video games can be a creative approach as interventions to address the problem of obesity in adolescents with ASD (Strahan, Elder, 2015). Active video games (AVGs) or exergames rely on technology that links physical activity movements to video game control (LeBlanc et al., 2013). Studies have revealed the effectiveness of AVGs to expend energy and reduce weight in adolescents with disabilities including ASD (Chang, Chang, & Shih, 2016; Dickinson & Place, 2014; Kauhanen et al., 2014; Sandlund, Waterworth, & Hager, 2011; Strahan & Elder, 2015). Currently, there is no research that has evaluated whether the use of an interactive cycling video game can influence the intensity of physical activity in adolescents with ASD. However, video game cycling has been investigated to have the potential to improve adherence and increase energy expenditure more than the conventional stationary cycling, and to be more enjoyable in typically developing adolescents and adults (Monedero, Lyons, & O'Gorman, 2015; Rhodes, Warburton, & Bredin, 2009; Warburton et al., 2007).

**Purpose of the Study**

The purpose of the study was to compare the intensity of physical activity and enjoyment level of interactive video game cycling and conventional stationary cycling during an equal number of sessions using the same bike at the same workload.

**Research Questions**

1) Do adolescents with high functioning autism spectrum disorder have higher heart rates when cycling on a video cycling game or a conventional stationary bicycle?

2) Do adolescents with high functioning autism spectrum disorder have a higher number of minutes in the target heart rate range when cycling on a video cycling game or a conventional stationary bicycle?

3) Do adolescents with high functioning autism spectrum disorder have greater distance pedaled when cycling on a video cycling game or a conventional stationary bicycle?

4) Do adolescents with high functioning autism spectrum disorder prefer a video cycling game or a conventional stationary bicycle?

5) Do adolescents with high functioning autism spectrum disorder believe a video cycling game is an effective intervention?

**Delimitations**

1- The participants were adolescent students with high functioning autism at a Northwest Arkansas high school.

2- The study recruited adolescents aged 16-18 years.

**Limitations**

The limitation of this study was the small sample size (3).

## Definition of Terms

**Active Video Games (AVGs):** Video games that require the individual to engage in body movements to manipulate the game (LeBlanc et al., 2013).

**Alternating Treatments Design (ATD):** A model of subject design that treatments are alterable fast in a random or semi-random manner to determine how effective these multiple treatments can be (Herrera & Kratochwill, 2005).

**Autism Spectrum Disorders (ASD):** Impairments on the neurological development of an individual who suffers from underdeveloped social interaction and social communication besides limited repetitious pattern of behaviors (American Psychiatric Association, 2013).

**Heart Rate (HR):** The number of heart beats per minute (2018, American Heart Association), and it will be measured once a day for four days while participant is at rest before the study begins to determine resting heart rate, and after each cycling session will be calculated to determine the intensity of the exercise.

**High Functioning Autism (HFA):** represents individuals with ASD whose fall under full-scale IQ of greater than 70 and do not manifest significant delays in language and intelligence (Rubin & Lennon, 2004).

**Maximum Heart Rate (HRmax):** The maximal number of heart beats per minute when the heart is working at its extreme and can be calculated by subtracting age from 220 (CDC, 2015).

**Moderate to Vigorous Physical Activity (MVPA):** The targeted heart rate for moderate intensity PA for adolescents is between 50 and 70% of the maximum heart rate. Moderate PA may include water aerobics, brisk walking, tennis doubles, and ballroom dancing. However, the target for vigorous PA is between 70 and 85% of the same. Examples of vigorous PA activities include running, tennis singles, bicycling 10 mph or more, and swimming laps. Adolescents should accumulate 60 minutes or more of moderate to vigorous physical activities each day (American Heart Association, 2015; CDC, 2015: Stanish et al., 2017; US Department of Health and Human Services, 2008).

**Percentage of Non-overlapping Data:** A metric that computes the proportion of data values during intervention that exceed the ultimate values in the other treatment. The number of non-overlapping values is divided by the total number of data values (Scruggs, Mastropieri, Cook, & Escobar, 1986).

**Physical Activity (PA):** Body movements that entail contraction of skeletal muscle and promote the exhaustion of energy above certain basal level (Kotecki, 2016).

**Physical Activity Enjoyment Scale (PACES):** A questionnaire that measures the extent to which a person enjoys participating in physical activities (Motl et al., 2001).

**Social Validity:** A measurement that seeks to ensure that the aims of the intervention are important, acceptable, and significant (Wolf, 1978).

**Target Heart Rate Range (THRR):** A range that defines efficient and safe lower and higher limits of exercise intensity (Gilbert, 2005).

**Tau-U:** A nonparametric technique for measuring data values nonoverlap between two treatments (Parker, Vannest, Davis, & Sauber, 2011).

## Literature Review

This chapter introduces an overview of the diagnoses and severity levels of autism spectrum disorder. The prevalence of obesity, low levels of physical activity, and barriers to PA in adolescents with HFA are identified. The preference for video games among adolescents with ASD and the concept of utilizing such these games as motivations to enhance PA levels are discussed. In conclusion, the chapter presents a review of research studies that indicated the effectiveness of different types of stimuli in addition to interactive video games to increase PA levels in adolescents with disabilities involving HFA.

### Diagnosis of ASD

Leo Kanner (1943) is credited for the first attempt at defining and diagnosing autism as a developmental disorder. Kanner identified autism when he observed the social interactions of individuals having poor communication skills, limited social interactions, and other atypical behaviors. In his breakthrough publication, "Autistic Disturbances of Affective Contact", Kanner coined the phrase "early infantile autism" to describe eleven children who exhibited high intelligence levels, but socially inactive and underdeveloped as they shunned crowds and were obstinate on minimizing social contact. These characterizations were to later form the basis for diagnosing autism among children (Kanner, 1943).

The DSM-5 specifies five (A-E) diagnostic criteria for autism spectrum disorders. The first criterion (A) specifies persistent defects in social communication and interaction, within different contexts. These should be manifested by all of the following: (a) deficiency in social-emotional reciprocity, (b) inability in nonverbal communication during social interaction, and (c) deficit in the development, maintenance and appreciation of different relationships. The second criterion (B) indicates restricted, repetitive behavior patterns, interests or activities. These should be manifested by at least two of the following: (a) repetition of stereotyped use of objects, motor movements, or speech, (b) inflexible routine adherence, insistence on sameness, or ritualized behavior, (c) highly fixated or restrictive interests with abnormal intensity or (d) unusual, hyper or hypo reactivity to sensory aspects of the environment. The severity of the first two diagnoses depend on impairments on social communication and restrictive behavioral patterns. The third diagnostic criterion (C) defines symptoms that must be manifested in early period of the individual's development. The fourth criterion (D) specifies that symptoms must have caused clinically significant social, occupational impairment or impairment on other vital current functional areas. The last diagnostic criterion (E) determines that the symptoms and associated disturbances may not have been adequately explained by the occurrence of global developmental delays or other intellectual developmental disorders (Autism Speaks, 2017).

Diagnosis of autism has been possible at birth. Nevertheless, it is not easy to determine its symptoms at this stage as it is possible later in the child's life. Parents are able to notice certain symptoms of autism in their children even before they reach three years of age. Potential behavior indicative of autism that parents can notice in the children include flapping hands, avoiding direct eye contact with the parents, inattention during name-calling and rocking of bodies. According to recent studies, in up to 54% of children who are ultimately diagnosed with the disorder, their parents were able to notice autism symptoms before the end of their first year whereas in up to 80% of children ultimately diagnosed with the disorder, parents were able to notice the symptoms before the second birthday (CDC; Chawarska & Volkmar; Robins, Fein, Barton, & Green as cited in Anderson, 2011).

**Levels of Severity of ASD**

There are three levels of severity of ASD, and these levels are based on social communication impairments, limited, and repetitive types of behavior. The three levels of severity include:

- Level 1: Requires some level of support in various instances to mitigate the individuals' deficits in social communications. In addition, individuals ordinarily have difficulties commencing social interactions, and exhibit vivid lack of response to social advances by other people. Moreover, individuals exhibit characteristic rituals and repetitive behaviors (RRBs) that interfere with daily functioning. At this level, individuals are likely to resist any attempt to disrupt the RRBs or the fixated interests.
- Level 2: tends to require moderate support. Even with support in place, the individuals exhibit challenges in interacting with others in verbal and non-verbal communication. Additionally, individuals tend to be unable to initiate interactions with others choosing to periodically shift their attention to familiar objects to the detriment of their interactions. Their focus on other objects tend to affect their capacity to function normally. Any attempt at disrupting their focus distresses them and may result in an incident with the individual.
- Level 3: individuals require constant and significant support in their lives. Their verbal and nonverbal communication are almost nonexistent and they are unable to initiate or participate in social interactions. Once they settle into a routine tasks or activity, they tend to be hostile to any interruptions and may resort to violence outbursts if disturbed (American Psychiatric Association, 2013).

## Other Conditions Related to ASD

In addition to deficits in social development, limited interests, and a preference for repetitive mannerisms, autism is linked with other conditions due to its effect on neurological development. Additional conditions associated with ASD range from obesity and weight related conditions, depression, attention deficiency conditions, hyperactivity, tendency to avoid physical contact (Dewey, Cantell, & Crawford, 2007; Hammond & Hoffman, 2014; Riquelme, Hatem, & Montoya, 2016), and sensitivity to sounds (Lucker & Doman, 2015; Stiegler & Davis, 2010). In like manner, intellectual disabilities among individuals with ASD affects over 70% of them. While severe intellectual disabilities affecting one in five who have IQ levels below 35, autism should not be regarded as synonymous with mental impairment. At least one in ten individuals have average or above average IQ, while a rare minority have high IQ levels of above 145 (Charman et al., 2011; Tandon, 2004). Similarly, approximately 20 to 28% of individuals with ASD develop a seizure disorder (Canitano, 2007; Valvo et al., 2013). Moreover, individuals with ASD suffer from sleep deficiency and sleep-related conditions. (Baker & Richdale, 2015; Richdale & Schreck, 2009). Furthermore, individuals with ASD exhibit other conditions including self-injurious and stimulatory behaviors, such as finger tapping, rocking, swaying on the feet, chewing and smiling objects, and staring at lights. (Minshawi, 2008; Reed, Hirst, & Jenkins, 2012; Richards, Moss, Nelson, & Oliver, 2016).

## Prevalence of Obesity in the US

Obesity is an excessive body mass based on the standard body mass index (BMI) of an individual based on gender and age (Mitchell, Catenacci, Wyatt, & Hill, 2011). Body Mass Index (BMI) can be calculated as weight in kilograms divided by height in meters squared (Looney, Spence, & Raynor, 2011). According to the Centers for Disease Control and Prevention (2017), the interpretation of Body Mass Index (BMI) for adults older than 20 years is based upon standard weight categories. Men and women of different ages and body formations are placed in these categories. For children and youths aged 2-20 years, the interpretation of BMI is different although the same formula is used in the calculations of both BMIs for children and youths as in the calculations for adults. The measure for individuals aged 2-20 years is dependent both on age and sex. This is in the understanding that body fat is a function of age when an individual is still growing and developing. In addition, there is a marked difference between body fat in boys and girls, which influences the sex index. Consequently, the CDC BMI-for-age growth charts accounts for these differences in children and youths. Thus, the charts indicate the BMI in percentile rankings. For instance, BMI for the overweight category ranges from $85^{th}$ to less than $95^{th}$ percentile, while BMI for the obese category is placed in or above $95^{th}$ percentile.

As mentioned by Odgen et al. (2016), one in five school children ages 6-19 is obese. The rates of obesity for children between 2 years and 19 years have increased three-fold to 16.9% since 1980. In children between six years and 11 years, obesity has increased from 7% to 17.5% during the same period, while the percentage of teen obesity ages between 12 and 19 years has more than quadrupled from 5% in 1980 to 20.5% (Center for Disease Control and Prevention, 2015; Ogden, Carroll, Fryar, & Flegal, 2015). National Youth Risk Behavior Surveillance (YRBS) in 2015 revealed that one in seven high school students was obese (CDC, 2016). Approximately 31.8% of individuals aged between 2 and 19 years are overweight, and 34.5% of individuals aged between 12 and 19 have the same condition (Ogden et al., 2014). Adolescents are more likely to be overweight than children (Griebenauw, 2015). Overweight children and adolescents are more likely to be obese or overweight in adulthood (Anderson, 2011).

According to the Centers for Disease Control and Prevention (CDC, 2017), through 2013-2014, more than 36% of adult Americans were clinically obese, and more than 70% were overweight. The higher tendency in prevalence of adult obesity started in 1999 and resumed through 2014 (Skinner, Perrin, & Skelton, 2016). Regarding adult individuals aged between 20 to 40 years, 32% of the population are obese. Among individuals of the population aged between 40 and 60, at least 40% of them are obese, and 37% have the same condition among the elderly aged 60 years and above. (Ogden et al., 2014). According to a report by Behavioral Risk Factor Surveillance System (BRFSS) (2019), the prevalence rate of adult obesity in 2017 surpassed 35% in seven US states. In addition, the rate of adult obesity in 22 other states was reported as 30-35% and was between 25-30% in other 19 states (BRFSS, 2019).

**Prevalence of Obesity among Individuals with ASD**

As previously noted, weight related conditions affect individuals with ASD. Children and teens with ASD are predisposed to obesity and are expected to stay obese through adolescence than their typically developing individuals (Must et al., 2017). Egan, Dreyer, Odar, Beckwith, and Garrison (2013) noted that among toddlers with ASD aged 3-4 years their obesity rates were markedly above that national average for toddlers of comparative age. Using body mass index statistics, the researchers noted that over 17% of children had a body mass index (BMI) in a range that pediatricians regard as overweight for children, and over 21% of the children were found to have a BMI in the obese range. A comparative study in 2015 by Hill, Zuckerman, and Fombonne focusing on individuals with ASD aged between 2-17 years highlighted that over 33% of the individuals within the study were overweight while about 18% were obese compared to their peers. National data on the prevalence of autism indicates that 40% of individuals with ASD between the ages of 3 and 17 years were obese. This is in comparison to 23.6% of individuals without the disorder. The same data indicated that people with ASD are predisposed to obesity when compared to those without the disorder (Curtin, Anderson, Must, & Bandini, 2010). In adolescents with ASD, obesity is 40% more probable to occur, when compared to the prevalence in typically developing adolescents, and this prevalence is on the rise according to the report and may surpass incidences of obesity in the general population (Strahan & Elder, 2015). According to Must et al, (2017), the prevalence of obesity among individuals with ASD is even greater when compared to the prevalence in their peers, at 23.1% for children with ASD versus 14.1% for their counterparts. The possibility of becoming obese among individuals with ASD increases systematically between the ages of 10 and 17 years. Another study placed the prevalence of obesity among adolescents with ASD at 24.6% when compared to a 13% prevalence of obesity among adolescents without autism, and placed the prevalence of overweigh among adolescents with ASD at 42.5% when compared to 28.8% prevalence among typically developing adolescents (Rimmer et al., 2010).

Adolescents with ASD have comparatively higher measures of body mass index (BMI) values than the general population and other populations with different forms of disabilities (Griebenauw, 2015). Rimmer et al. (2010), reported an obesity prevalence of 24.6% in adolescents with ASD. On the other hand, 12.4% in adolescents with an intellectual disability, and a prevalence of 4.0% for adolescents with cerebral palsy, alongside an overweight prevalence of 42.5%, 27.2% and 18.8% within these groups (Rimmer et al., 2010). Comparatively, a study by Chen et al. (2010), reported an obesity prevalence of 23.4% among youths with ASD. Differently, the prevalence of obesity among youths with asthma stood at 19.7%, among adolescents with hearing and visually impaired was 18.4%, among youths with learning disabilities obesity reached 19.3%, and among children with ADHD, the prevalence was 18.9%.

### Causes of Obesity

Unlike most diseases and other health care challenges that may have a single or a few numbers of causes, obesity arises due to a myriad of interconnected factors (Rippe & Angelopoulous, 2012). Primarily, obesity may be perceived as a condition caused by energy imbalances within an individual that cause the body to store fats. While such energy imbalances may arise due to genetic (40-70% of non-syndromic obesity cases) or endocrine (Herrera, Keildson, & Lindgren, 2011), or medical conditions, whenever an individual's energy intake surpasses their energy output the excess energy is stored in form of fats which upon continued accumulation give rise to obesity (Rippe & Angelopoulous, 2012; Butler, 2016; Xu & Xue, 2015). Other environmental factors also play a role in the development of obesity include exposure to a diet heavy on fast foods, overeating, lack of physical activity, and sleep deficit (Allender et al., 2015; Blakemore & Buxton, 2014; Wright & Aronne, 2012). Additionally, the causative factors for obesity include low socio-economic and emotional factors. Socio-economic factors that may predispose one to obesity include unemployment, low income, low level of education, and receipt of food stamps. These factors may lead to poor psychological wellbeing. Emotionally, obesity may arise from anxiety, depression, feelings of negativity, low self-esteem, low self-belief, and feelings of social insecurity (Akil & Ahmad, 2011; Hemmingsson, 2014).

### Causes of Obesity Associated with ASD

While research continues into the linkage between autism and obesity, the existence of unhealthy nutrition habits among individuals with ASD in addition to sedentary life style with minimal exercise are major factors in the higher prevalence of obesity in individuals with ASD when compared to typically developing individuals (Curtin et al., 2014; Must et al., 2014). In addition to eating disorders among individuals with ASD, there is a noticeable preference for foods with high concentrations of energy and high fat content. According to Bandini (2010), children with ASD are more likely to refuse food offers when compared to typically developing children (41.7% for children with ASD as compared 18.9% of foods offered for children without autism). In like manner, up to 89% of individuals with ASD have demonstrated problematic eating behaviors and resistance to new foods. Their preference includes energy-dense and starchy foods, such as pizza and sweetened beverages when compared to fruits, high-fiber foods, vegetables, and lean protein (Seiverling, Williams, & Sturmey, 2010; Srinivasan et al., 2014). Such significant intakes of energy and fat dense substances results in increased energy imbalance in their bodies as they do not engage in a more active lifestyle to shed off the increased intake of energy and fats (Sardesai, 2011). Holcomb, Pufpaff, and McIntosh (2009) indicated that there is a possibility that 50% of adolescents with ASD are obese due to low levels of participating in physical activities and exercise and not because of poor dietary habits.

Similarly, disordered sleep patterns and their symptoms negatively affect daytime function and lack of physical exercise and engagement with peers result in increased sedentary lifestyle (Dillon, 2007; Reynolds & Malow, 2011). Likewise, the increased use of psychopharmacological treatment for individuals with ASD renders them more susceptible to obesity due to the composition of the pharmacological substances ingested. Individuals with ASD may need more than one medication aimed at proactively addressing their disorder (Curtin, et al., 2014; Wink, 2014). Furthermore, anxiety and depression, which are conditions most likely associated with adolescents with ASD, can increase the risk of obesity (Fox et al., 2016).

**Health Risks of Obesity**

Reilly and Kelly (2011) reviewed several studies that have revealed that adolescent obesity is linked to morbidity related diseases and increased mortality in adulthood (Reilly & Kelly, 2011). The early onsets of obesity in adolescents can cause various health risks. A high number of reports have described that in obese children as in adolescents and adults, cases of impaired endothelial function increase by up to 50% more when compared to non-obese individuals (Short, Blackett, Gardner, & Copeland, 2009). According to Aguilar, Bhuket, Torres, Liu, and Wong (2015), obesity causes the likelihood of health risks, such as metabolic syndrome which manifests as a product of the combination between at least three of the following conditions: high blood sugar, high blood pressure, high triglycerides, greater waist fat deposits, or low HDL cholesterol. The overall metabolic syndrome incidence in the US from 2003 to 2012 was 33% (Aguilar et al., 2015). likewise, obesity increases in the risks of heart diseases and stroke, type II diabetes, respiratory ailments, hypertension, certain forms of cancers, nonalcoholic fatty liver disease, insulin resistance, dyslipidemia, musculoskeletal problems, gallstones and diseases associated with the gallbladder, gout and osteoarthritis have been reported (Daniels, 2009; Kelly et al., 2013; Nejat et al., 2010; Özdemir, 2015). Correspondingly, obesity can lead to an assortment of breathing problems, such as sleep apnea, and asthma (Ahima & Lazar, 2013; Sutherland, 2014). Moreover, obesity can lead to emotional and psychological consequences in obese individuals. Besides difficulties in controlling their urges, children with obesity have problems regulating their emotions. This causes anxiety, depression, mood disorders, as well as problems with self-esteem, and to be socially withdrawn, and to display somatoform problems and isolation (Luppino, Wit, Bouvy, & Zitman, 2010; Puder & Munsch, 2010; Sanders, Han, Baker, & Cobley, 2015). In the same manner, a number of studies have indicated cases of bullying, teasing, stigmatization, symptoms of eating disorder and dissatisfaction with one's body among obese children and adolescents (Greenleaf, Petrie, & Martin, 2014; Puhl & King, 2013; Sanders, et al., 2015).

**Benefits of Physical Activities**

According to Sorensen and Zarrett (2014), studies have indicated that moderate to vigorous physical activity (MVPA), such as running is more beneficial to teens' functioning than less intense physical activity, such as walking or playing catch. According to the American College of Sports Medicine (2006) and the CDC (2015), the targeted heart rate for moderate intensity PA for adolescents is between 50 and 69% of the maximum heart rate, while the target for vigorous PA is between 70 and 85% of the same. The maximum heart rate is the maximal number of heart beats per minute when the heart is working at its extreme. Adolescents should accrue 60 minutes or more of moderate to vigorous physical activities each day to meet the recommended physical activity guidelines (Pan & Frey, 2006; Stanish et al., 2017; US Department of Health and Human Services, 2008). As reported by Kokkinos (2012), maintaining physical activity throughout the life exposes the health advantages of exercising.

Literature has indicated that moderate to vigorous physical activities (MVPA) have positive impacts on an individual. Health benefits of exercise include, but are not limited to lowering the risk of high blood pressure and the risk of cardiovascular diseases, decreasing type II diabetes, decreasing the chance of long-term chronic health conditions, enhancing liver health and the sensitivity of vascular insulin, preventing colon and breast cancer, and reducing of arthritis pain (Annan, 2013; Na & Oliynyk, 2011; Padilla et al., 2015; Reiner et al., 2013; Shephard & Johnson, 2015). Additionally, physical activities help qualify gut microbiota (Cerdá et al., 2016). In addition, individuals experience numerous physical benefits, such as weight reduction, and maintenance of a healthy weight for individuals. Similarly, physical activities improve breathing, strengthening bones and muscles, and improve flexibility, and physical fitness (American Heart Association, 2015; Larouche, Saunders, Faulkner, Colley, & Tremblay, 2014). Furthermore, physical activities offer several social and psychological advantages to individuals. Most significantly, the opportunities to socialize between individuals and build friendships with people who have similar interests, reduce stress, and develop important qualities, such as confidence, self-esteem, and self-concept that result in a release of endorphins that create a feeling of euphoria and happiness, and improved emotional well-being (Eime, Young, Harvey, Charity, & Payne, 2013; Poirel, 2017; Rasmussen & Laumann, 2013). Regarding intellectual advantages, moderate to vigorous physical activities improve creativity, sharpen thinking, judgment, and learning skills as people grow older. Outdoor activities can improve an individual's level of concentration (Davis et al., 2011; Lubans et al., 2016; Sims-Gould, Vazirian, Remick, & Khan, 2017). Other benefits of physical activities include offering inspiration to others to live a healthy lifestyle and recovery therapy from drug and alcohol addiction through de-prioritization of cravings (Biddle, 2016; Priebe, Atkinson, & Faulkner, 2017).

**Benefits of Physical Activity for Adolescents with ASD**

Together with the positive impacts of physical activities mentioned above, a wide range of physical activities and aerobics have direct and implied benefits for adolescents with ASD. Physical activities improve motor proficiency, such as body coordination, gait, and agility (Biscaldi et al., 2014; Sorensen & Zarrett, 2014; Sowa & Meulenbroek, 2012). Frequent engagement in moderate to vigorous physical activities by adolescents with ASD has optimistic impacts on psychological well-being involving positive implications on self-regulation, and these benefits contain demoting behaviors and/or tendencies to self-harm, such as aggression and injury, decreasing their propensity to repetitive pattern behaviors, lessening anxiety and depression, and improving attention span and quality of sleep (Magnusson et al., 2012; Sorensen & Zarrett, 2014; Wachob & Lorenzi, 2015). Moreover, physical activities considerably improve social initiation and peer-interaction skills, and reduce hyperactivity among adolescents with ASD, which have direct and indirect implications on the rate of aberrant behaviors and inappropriate tendencies to vocalize (Pan et al., 2011; Sorensen & Zarrett, 2014; Srinivasan et al., 2014).

**Physical Activity Levels among Adolescents with ASD**

Social and behavioral factors associated with ASD have predominant effects on the physical activity level of youth presenting with the disorder. Adolescents with ASD are particularly at an increased risk of inactivity (Pan & Frey, 2006). Because of impairments in their motor skills, sensory, social communication and behavioral skills, adolescents with ASD have limited activity levels and lacking physical patterns. Therefore, there is consensus among researchers that adolescents with ASD do not engage in long sessions of continual physical activity (Pan & Frey, 2006; Srinivasan et al., 2014). According to Pan et al. (2015), only 33% of students with ASD of high school age were able to meet the recommended guideline and engage in long sessions of constant physical activity. Adolescents with ASD engage more in introverted physical activities like swimming, biking, running, or walking rather than the different kinds of team sports (Srinivasan et al., 2014).

Several studies have highlighted the comparative inactivity of adolescents with ASD in moderate to vigorous physical activities (MVPA) when matched with their peers without the disorder, and these studies revealed that adolescents with ASD spend less time in moderate to vigorous physical activities during lunchtime, recess, or even during PE when compared to the typically developing students (Downs et al., 2016; Pan et al., 2015; Sorensen & Zarrett, 2014; Srinivasan et al., 2014; Stanish et al., 2017; Tyler et al., 2014). In a study by Stanish et al. (2017), adolescents with ASD participate an average 29 minutes per day in moderate to vigorous physical activity as compared to 50 minutes per day for their peers. Even fewer were able to meet the Physical Activity Guidelines for Americans when compared to other students (14% for adolescents with ASD and 29% for those without). In like manner, their school weekday activity level is higher than the weekends because no agitation exists to exercise (Stanish et al. (2017). Another interesting finding is that younger adolescents are more likely to be more active than older adolescents. The drop in their MVPA levels was linked to accompanying increase in sedentary behavior (Memari et al., 2013; MacDonald et al., 2011; Pan & Frey, 2005; Pan & Frey, 2006).

**Barriers to MVPA Involvement among Adolescents with ASD**

A number of challenges hinder the engagement of adolescents with ASD in MVPA. Researchers have identified interests in sedentary activities as being the greatest among these barriers (Obrusnikova & Cavalier, 2011). Research has revealed sedentary technological activities as a rampant after-school enjoyment for a high number of adolescent students with ASD. Adolescents with ASD enjoy watching the television, and video gaming more when compared to their non-disabled siblings (Stanish et al., 2015). Several current studies have ascertained that adolescent students with ASD spend the majority of their free time using sedentary technology than even students with other forms of disabilities, such as individuals with learning, intellectual and language impairments (Kuo et al., 2014; Mazurek et al., 2012; Mazurek & Wenstrup, 2013).

Another hindrance to MVPA engagement among adolescents with ASD is deficiencies in motor skills. According to previous empirical research, 50% or more of children and adolescent students diagnosed with ASD exhibit difficulties in movements on standardized motor tests (Green et al., 2009). Problems associated with fundamental movement skills, such as difficulties in locomotion, motor coordination, and stability among these subjects effectively limit the choice of activities that they may engage in (Mccoy et al., 2016; Obrusnikova & Cavalier, 2011).

Deficiency in social communication is another obstacle to participating in MVPA. Social communication impairments reduce the individual's engagement in group activities, interpersonal relationship with peers, and challenging activities and sports that require peer partnering (Menear & Neumeier, 2015; Srinivasan et al., 2014). Conditions linked to behavior or preferences affect their active engagement with peers. These adolescents characteristically display stereotypical, repetitive, and highly restricted behavior and interests, which may hinder their social inclusion among their peers (Hamm & Driver, 2015). In addition, they are likely to exhibit strict schedules and follow highly predictable patterns in undertaking their activities. These not only limit their range of social activity, which other adolescents may engage in, but also prevents other adolescents from involving them in their own MVPAs (Srinivasan et al., 2014).

Another barrier to participating in MVPAs is the fear by their parents, guardians or service providers that they may get hurt. This fear and the overprotection can partly attribute to the exclusion of adolescents with ASD from physical activity for safety reasons (Stanish et al., 2015). Moreover, lack of some factors, such as lack of family support, exercise partner, time, physical activity programs or locations, trained staff, equipment and resources, and lack of transport can prevent adolescents with ASD from participating in physical activities. Other studies revealed that adolescents with ASD might have expressed difficulties using the equipment, while others are disinterested (Obrusnikova & Cavalier, 2011; Obrusnikova & Miccinello, 2012).

## Effects of Video Games among Individuals with ASD

Encouraging children with special needs to exercise is a struggle and this difficulty is documented extensively in literature. Autism spectrum disorder (ASD) presents unique challenges for therapists and it requires customized, innovative approaches to meet the obesity challenge (Deforche, Haerens, & De Bourdeaudhuij, 2011; Strahan & Elder, 2015). Since studies have proved that adolescents with ASD deeply engage with technology including video games and other forms of screen-based media in their leisure time which limits their participation in physical activities, therapists and researchers have utilized video games as motivational implements to teach them new skills, reinforce desirable behaviors and reduce unacceptable behaviors. Studies have indicated that video games positively influence children with ASD in their vocabulary acquisition, speech reading and grammar (Ploog, Scharf, Nelson, & Brooks, 2013). Additionally, video games help enhance their emotional awareness and friendship (Gallup & Serianni, 2017). Similarly, exergames improve motor skills and static balance, while reducing repetitive behaviors (Anderson-Hanley, Tureck, & Schneiderman, 2011; Hilton et al., 2014; Hsu, 2016).

## Active Video Games as Motivators

Group-based interventions aimed at participating in PA lead to substantial stress in youths with ASD due to motor-skill impairment and social interaction limitations. Hence, it is important to find unique ways to facilitate their participation while inspiring them to reach a higher level of physical activity that may help increase overall well-being. Active video games (AVGs), such as the Nintendo Wii, Xbox Kinect and Play Station can be played individually. Play-based AVGs require the player to engage in whole-body movements within a virtual world, and can help increase the physical activity duration, raise energy expenditure and at the same time, be enjoyable and inspiring (Edwards, Jeffrey, May, Rinehart, & Barnett, 2017).

Interactive cycling video games are games that employ technology and need the individuals to engage physically in the game by way of pedaling to move objects on the screen. This kind of video games can encourage adolescents with ASD to increase the intensity of exercise. Multiple studies have found that cycling video games influence individuals in the general population to reach high levels of PA. Compared to conventional stationary bikes, biking video games help improve fitness and body composition, enhance energy expenditure rate, and increase physical activity intensity, and satisfaction in adolescents and adults in the general population (Monedero et al., 2015; Rhodes et al., 2009; Warburton et al., 2007). As reported by Monedero et al. (2015), interactive cycling video games help in achieving a satisfying experience while at the same time meeting international physical activity guidelines.

Several studies have applied various approaches to inspire adolescents with disabilities to promote PA levels, improve fitness, or reduce weight. Techniques ranged from implementing different types of auditory and visual stimuli while cycling conventional stationary bikes, such as video games, music, songs, television, and vibratory stimulation to utilizing varied active video games. Hernandez et al. (2012) explored how to design a gaming station permitting children with Cerebral Palsy (CP) to play active video games (exergames) entailing energetic physical activity in an expedient, pleasurable, and harmless way. This study specifically focused on the physical design of the exergaming station and the software interface of such station to games. The goal set for participants was to reach 64-74% of their maximum heart rate as recommended by American

College of Sports Medicine (ACSM) (Hernandez et al., 2012). The participants comprised eight children with cerebral palsy aged between 12 and 18 years. Three of the eight children were females. Three of these children had spastic triplegia, with five having spastic diplegia. One of the children was at Gross Motor Function Classification System (GMFCS) level IV, with seven being at GMFCS level III (Hernandez et al., 2012). The design challenges involved inventing a physical apparatus supporting exercise and designing the exergaming station to allow exercise that is adequately energetic to bring about health benefits that allow for interpretation of input from this gadget. Given these design constraints, the authors preferred a custom-made cycling-based exergaming system. Considering the availability of programming interfaces and price, the researchers selected the Xbox 360 game controller and the PC Gamer Bike Mini cycling Ergometer (Hernandez et al., 2012). The authors thereby embarked on resolving the control limitation of interpreting input from the ergometer and the restriction of guaranteeing that exercise meets American College of Sports Medicine (ACSM) guidelines along with physical constraint of incorporating these controllers into an exergaming exercise station appropriate for children with CP (Hernandez, et al., 2012).

The researchers adopted a participatory, iterative design strategy spanning six months. This design comprised: the eight participants, a doctor focusing on children with CP, computer scientists, a mechanical engineer, and a physiotherapist. Further, the researchers obtained offline counsel from a professional game designer and convened four design and assessment sessions with the eight participants and an experimental session with every child separately (Hernandez et al., 2012). During the four design sessions, the participants were permitted to try various alternative chair designs. The authors evaluated the effectiveness of every design using observation. The children expressed reservations with all four designs. To measure pedaling control, the authors performed a study to investigate the following smoothing algorithms: inchworm, tier, smooth, and direct drive (Hernandez et al., 2012). The researchers found that input supplied by an exercise ergometer should be converted prior to being relayed to a game to boost accurate and smooth control in an in-game avatar, and costume-designed hardware is needed, permitting not only stress-free entry and exit from a wheelchair or walker, but also steady support during gaming (Hernandez et al., 2012).

According to Hernandez et al. (2012), the authors suggested a highly successful design. The key findings indicated that seven of the participants were able to pedal unaided using the ultimate version. Seven reached the set heart rate range for moderate to vigorous intensity. The eight participants were able to hold and manipulate the controllers of the game, but with a high degree of restriction. Additionally, participants reported a high rate of enjoyment.

Gaouette and Reid (1985) noted that adults with severe intellectual disabilities are inactive when it comes to undertaking physical activities. Recognizing that individuals with intellectual disabilities are at an increased risk of suffering from conditions such as obesity, the authors sought to examine the efficacy of audio-visual stimulation on the performance of physical activities. A stationary bicycle ergometer was used in this study (Gaouette & Reid, 1985).

The participants included six male adults with severe intellectual disabilities recruited from a psychiatric hospital in Montreal. Their mean age was 25.7 years, while their mental age was three years. The study apparatus consisted of a stationary bicycle ergometer connected to a dynamo that could turn on five 75-watt colored floodlights as well as three strings of flashing Christmas lights. The visual stimulation system was designed in a way that ignited one of the floodlights if the participant pedaled at a rate of 100% of baseline. If the rate reached 120% of baseline, all the lights would be progressively activated including the Christmas lights. A tape recorder was used to manually provide auditory stimulation when the participant pedaled at 120% of baseline (Gaouette & Reid, 1985).

The participants were then divided into two groups where data were collected in baseline conditions; visual or auditory stimulation; simultaneous visual and auditory stimulation; and return to the baseline assessment. There were five sessions each week for seven weeks. Each session lasted about 15 minutes on the ergometer followed by a 3-minute rest. The first group (consisting of three subjects) received a baseline assessment followed by an auditory stimulation alone. Then, they received simultaneous auditory and visual stimulation which was succeeded by a return to the baseline. The other three participants were assessed under baseline conditions before receiving visual stimulation alone. This was followed by both auditory and visual stimulation and a return to the baseline (Gaouette & Reid, 1985).

Results indicated that for the participants who received visual stimulation alone, there was a substantial increase in work output for two of them. Higher performance was noted when both visual and auditory stimulation was applied. With regards to the second group, all three of them exhibited higher work output under auditory stimulation alone and a further increase during simultaneous subjection to both forms of stimulation. Therefore, the authors concluded that auditory stimulation coupled with visual effects could be used to motivate adults with severe intellectual disabilities to engage in physical activities (Gaouette & Reid, 1985).

Research has revealed that undertaking physical activities by people with severe and multiple disabilities can improve both their general condition and behavior. However, physical activity in some cases fails to have its desired effect due to its artificiality and monotony (Lancioni et al., 2004). These two factors affect an individual’s willingness to partake in the intended activity as well as account for lack of positive mood during the course of the exercise. Researchers have tried to investigate ways in which physical activity on people with disabilities may be stimulated and even enjoyed. One study sought to find out the impact of positive stimulation on the physical activity undertaken by two people with multiple disabilities. In particular, the researchers were interested in assessing the effect of automatic stimulation on both the mood and level of activity on the subjects (Lancioni et al., 2004).

The participants were two male students with multiple disabilities staying at a center for people with multiple disabilities. One of them was 15 years, while the other was 22. Both students were blind although they could hear normally. They were also intellectually disabled with their level of functioning determined to be in the range of profound disability. Furthermore, according to the Vineland Adaptive Behavior Scales, their daily living skills were equivalent to those of two and one half-year-olds. Nonetheless, the authors noted that they were able to understand some simple verbal commands, such as "come here" and "sit down" as well as carrying out simple tasks like assembling two-piece objects (Lancioni et al., 2004).

As the authors were concerned about the participants' level of physical fitness, they used some fairly manageable exercises including a stationary bicycle and a stair stepper. The authors noted that the bicycle had been used before by the said participants under staff assistance. An electronic control system was then connected to the stationary bicycle and the stair stepper which had been modified in such a way that the electronic control system was able to detect each step/foot contact and every half-pedaling cycle (Lancioni et al., 2004).

During the experiment, each step/foot contact and half cycle made the system activate one or more stimuli. These stimulus events included music, excited voices, vibratory stimulation and hand clapping. Sessions on the stepper lasted 5 minutes while those on the bicycle were 10 minutes long. The sessions were videotaped and then observed for happiness indices which were defined as including laughing, smiling, or emitting excited sounds. This whole study was carried out for seven months and included two to four sessions a day (Lancioni et al., 2004).

The study indicated that automatically induced stimulation had an overall positive effect on physical activity. Additionally, it improved the moods of the participants regarding happiness as determined by the happiness indices described above. The authors mentioned that the procedure is not only practical, but also affordable. Nonetheless, they urge caution in applying a blanket acceptance to their findings because only two participants were used during the study (Lancioni et al., 2004).

In another study, Griebenauw (2015) examined the effectiveness of combining screen time with stationary cycling on adolescents with ASD. This research was grounded on several research findings. First, it has been investigated that adolescents with ASD typically exhibit lower levels of physical activity than their peers. Second, their sedentary behavior has been indicated to be significantly higher compared to their developing peers. Third, youth with ASD are at an increased risk of obesity. In addition to these health problems, adolescents with ASD exhibit a higher level of secondary health  conditions. Accordingly, the author intended to devise a way in which adolescents with ASD may be encouraged to undertake physical activities (Griebenauw, 2015).

The participants involved three adolescent males with ASD. They were between 16 and 18 years. The eligibility criteria used by the author required that the participant be suffering from ASD, can follow simple instructions, was able to physically pedal a bicycle, and had exhibited a preference towards screen time (watching TV or DVDs) for leisure.

The research design involved a participant pedaling a stationary bicycle that was connected to microprocessor used to display information. The information was two fold: time pedaled (TP) and revolutions per minute (RPM). In addition to the bicycle, there was a DVD player (Griebenauw, 2015). The sessions lasted between 20-30 minutes each day for five days a week. The total period of study was five weeks. Total output per sessions was calculated based on the TP and RPM data. In addition, the author used a heart rate monitor and a wrist band monitor to record the participants' level of physical activity. A baseline assessment was then carried out. Here, watching the DVD was not based on any pedaling. This was followed by an intervention phase where DVD watching was contingent on active pedaling (Griebenauw, 2015).

The findings indicated that all the all three participants exhibited an increase in compliance both in RPM and HR values across treatment sessions. Two of them pedaled at a moderate PA level (40% to 70% heart rate reserve), while the third showed a slow and gradual but increased physical level as well. Additionally, it was indicated that the work output for all the participants went up from baseline to intervention period. The author deduced that the contingent use of screen time on physical activity compliance was efficacious (Griebenauw, 2015).

Moreover, a study was influenced by the fact that there has been an increase in the number of children diagnosed with ASD and the subsequent finding that children with ASD are more likely to become obese compared to their peers. The author in this study was interested in determining the effect of contingent reinforcement as juxtaposed against delayed reinforcement on intensity using a stationary recumbent bicycle. In other words, the author examined whether contengent or delayed reinforcement had a positive impact on children with ASD to pedal for a higher duration of time (Anderson, 2011).

The participants were nine students recruited from a center for children with ASD. They were aged between 6 and 11 years and included seven males and two females. The research design included a stationary bicycle, a television, and a heart rate monitor which was connected to the television through a computer control system. In the first phase (contingent reinforcement), the television would immediately turn on when the participant pedaled his/her target heart rate zone (THRZ). Further, so long as the participant stayed in their THRZ, the television would remain on. In the delayed reinforcement phase, the participants were instructed that they could watch television after pedaling in their THRZ. Research trends were analyzed and compared using the split-middle technique in both phases (Anderson, 2011).

Findings demonstrated a higher willingness to pedal during the contingent phase than in the delayed reinforcement phase. Seven out of the 9 participants increased their physical activity by pedaling for a longer period during the contingent phase compared to only two who increased their amount of time spent in pedaling during the delayed reinforcement phase. Additionally, the author reported a higher total time pedaled in the contingent reinforcement phase than in the delayed reinforcement phase (Anderson, 2011). As such, the researcher concluded that as far as an increase in physical activity is concerned, contingent reinforcement is a more effective method than delayed reinforcement (Anderson, 2011).

Dickinson and Place (2014) sought to examine the impact of computer-based activity programs on the physical health of children with ASD. The study investigated the effect of computer-based activity on performance in children with ASD. Specifically, the two authors wanted to find out whether additional physical activity stimulated through a computer game could improve the cardio-pulmonary fitness of children with ASD as well as impact positively on their body mass index (BMI) (Dickinson & Place, 2014).

The study used two groups of children with ASD in Britain. The first group (the intervention group) consisted of 50 children, and out of these, 33 were below 11 years. Thirty-nine were males, while 11 were females. The second group also consisted of 50 children with ASD with 34 of them being under the age of 11. The group included 40 males and 10 females. This was the control group against which the findings were compared (Dickinson & Place, 2014).

The procedure for the study involved testing the physical activity of children during their usual physical education (PE) lessons. Notably, in addition to the regular PE program, the intervention group utilized a Nintendo Wii and the computer software game Mario and Sonics at the Olympics. The game consisted of authentic Olympic events including athletics, swimming, gymnastics and shooting. As they participated in the games, the children's physical fitness was assessed using elements of the Eurofit physical fitness test battery which is made up of nine physical fitness tests covering four main areas including speed, strength, flexibility, and endurance. The study also utilized a multistage progressive shuttle run test (bleep test), which is normally used to measure cardiopulmonary function (Dickinson & Place, 2014).

Research findings suggested a significant improvement in every fitness measure other than flexibility within the intervention group. Cardiorespiratory fitness and the bleep test exhibited a significant improvement as did the broad jump and sit-up scores. In contrast, children in the control group exhibited little change in the sit-up and broad jump score as well as the bleep test. In fact, the authors noted a deterioration in their BMI (Dickinson & Place, 2014).

likewise, Sandlund et al. (2011) examined the viability of low-cost  interactive games (EyeToy) as a physical activity intervention for children with cerebral palsy. EyeToy is an interactive system which is based on a video technique that enables children to watch themselves on the screen and interact with the game without the need for technical equipment such as goggles. It involves whole body movements of avoiding or hitting objects as well as challenging the user's motor physical ability, such as balance, eye-hand coordination, and arm and leg coordination.

The study consisted of 14 children with cerebral palsy ranging from 6 to 16 years (six females and eight males). All of the children were able to comprehend and follow simple instructions. Each child was then given a PlayStation2 together with the EyeToy game. The latter included around 20 different games to be played at home for 4 weeks. It was recommended to the children that they practice with the EyeToy for at least 20 minutes per day (Sandlund et al., 2011).

Measurements were carried out using several methods. First, children with the assistance of their parents were required to fill gaming diaries. The diary indicated the amount of time spent playing each day and the person who took the playing initiative, whether it was the child, parents, or relatives. Second, a physical activity monitor was used to register a child's activity levels. This was accomplished by measuring the Total Energy Expenditure (TEE), time spent as physically active, and the number of steps. Third, the Movement Assessment Battery for Children-2 (mABC-2) was used to measure motor control aspect of the children, such as arm movements and jumping. Lastly, the sub-test 5:6 of Bruininks-Oseretsky Test of Motor Proficiency was utilized to test the coordination of upper-limbs (Sandlund et al., 2011).

The results of the study indicated that the children played for an average of 33 minutes a day, 5.5 sessions a week. Noticeably, 8 of the ten children included in the analysis (4 were excluded for lack of meeting the study measurement requirements) had their physical activity improve during the gaming weeks. As a result, there was a significant increase in TEE and the time spent on physical active. Furthermore, the authors noted a considerable increase in time spent at the vigorous stage (Sandlund et al., 2011).

A study was conducted on children with cancer. Kauhanen et al. (2014) mentioned that children with cancer often exhibit low levels of physical activity. In addition, weight gain and musculoskeletal morbidity are common problems with such children. Moreover, medical treatments such vinca-alkaloids contributes to a decline in a child's physical activity coupled with deficient motor skills and muscle weaknesses. Therefore, simple and affordable methods of promoting physical activity in children with cancer had become an important aspect of cancer treatment. In light of this information, Kauhanen et al. (2014) were interested in evaluating the effectiveness of active video games as a way of promoting physical activity in children with cancer. Their objective was securing a decrease in sedentary behavior (Kauhanen et al., 2014). It should be mentioned that this study is still ongoing.

The participants consisted of children and adolescents who had been diagnosed with cancer outside the central nervous system. The eligibility criteria were that a participant had to be between 3 and 16 years. The treatment regimen included vincristine, and were treated in one of two designated hospitals (Kauhanen et al., 2014).

According to the research design, the physical activity in the intervention consisted of playing Nintendo Wii games each day for a minimum of 30 minutes. This was done during hospitalization as well as at home for 8 weeks in total. Notably, the researchers restricted physical activity fever, nausea, and vomiting episodes as well as verifying the child's physical ability before undertaking any gaming activity. The intervention also included information and recommendation on the game to play and guidance on how to play them (Kauhanen et al., 2014).

As the study was still ongoing, the authors indicated that outcomes would be measured using several different measures, and these included the Fitbit Tracker which detects changes in movement. Physical activity was assessed using two questionnaires. The first one measured physical activity in metabolic equivalent (MET) hours (METh) weekly. The second one included questions related to sedentary behavior such as the amount of time spent in one screen-based activity that is sedentary in nature. Additionally, there was an activity diary which was completed for one week at each measurement point: at baseline, two months, six months, one year and 2 and half years after baseline. Other measures included motor performance which was measured using the Movement Assessment Battery for Children (M-ABC) test; and child fatigue, measured by a standardized PedsQL Multidimensional Fatigue Scale questionnaires (Kauhanen et al., 2014).

In their discussion, the authors pointed out that physical activity and exercise have shown to be beneficial to children with cancer. They also mentioned that active video games were one of the mechanisms that could be used to promote physical activity. Accordingly, they hoped that their study would provide further insight on the use of active video games to stimulate physical activity in children and adolescents with cancer (Kauhanen et al., 2014).

Furthermore, it was mentioned that obesity in adolescents has drastically increased over the last decades (Strahan & Elder, 2015). As a result, these adolescents have become vulnerable to serious health issues, such as diabetes, sleep apnea, depression, and cardiovascular disease. Similarly, they may be faced with a myriad of social challenges including stigma, discrimination, and isolation due to their obese condition. In particular, adolescents with ASD are at increased risk of obesity owing to their physical and behavioral complications arising from their disorder. The authors highlighted that although physical exercises may be useful in reducing the incidence of obesity among adolescents, it may not be widely practiced due to poor motor skills, lower muscle tone, postural instability, and uneven developmental milestone acquisition in adolescents with ASD. Therefore, they proposed the introduction of electronic video games as an intervention for obese adolescents with ASD (Strahan & Elder, 2015).

The study consisted of one 15-year-old Caucasian male ("JD") with mild-to-moderate ASD. In addition to obese, he was diagnosed with Attention Deficit/Hyperactivity Disorder (ADHD) and Obsessive Compulsive Disorder (OCD). JD was then provided with two games; an active and an inactive one. Before any gaming, the researchers obtained baseline data. In addition, they collected physiological and gaming data. While the former consisted of aspects, such as weight, height, triceps skinfold, BMI, and waist-to-hip ratio, the latter included playing time and activity steps. JD was also instructed to keep a daily food and activity log throughout the study weeks (Strahan & Elder, 2015).

The procedure involved JD playing the inactive game for a minimum of half an hour each day for 4 or more days a week for 6 weeks. JD then played the active game for the same amount of time as the inactive one for six weeks as well. During the duration of play, JD wore a Fitbit which is a wireless wristband that monitors the distance traveled, steps taken, active minutes, and calories burned. Weight, waist-to-hip, and BMI measurements were then collected once a week during both the inactive and active phases. The researchers also measured triceps skinfold weekly (Strahan & Elder, 2015).   Completion of both gaming phases was followed by JD’s mother filling a stress and anxiety surveys as well as a therapy attitude inventory (TAI) (Strahan & Elder, 2015).

The research findings demonstrated that among the four baseline assessments, JD gained weight every week other than the final one. In the inactive phase, the first two weeks were characterized by a steady increase of between 0.20 to 0.30 pounds, while in the third and fourth week, JD’s weight dropped by 2.20 and 2.30 pounds respectively. During the active gaming phase, the first two weeks were marked by an increase in 1.70 and 4.10 pounds respectively. However, the remaining weeks saw a loss of 0.90 pounds to 4.20 pounds. In thier conclusion, the authors stated that physically active video games could be considered as valid options for motivating weight loss. It was, however, mentioned that the findings were limited to the use of only a single participant (Strahan & Elder, 2015).

In addition to the previous studies, Chang et al. (2016) conducted a study to examine whether linking a target response with preferred stimulation could be used to encourage overweight people with intellectual disabilities (ID) to exercise. The study used an air mouse combined with preferred stimulation. The study was based on earlier findings by one of the co-authors (Change et al., 2016) which had indicated a positive correlation between participants' preferred stimulation and their willingness to perform physical activity.

The study used four participants from a special education school. The first participant was Shen. She was an 18-year-old female with severe ID, and she was obese. Lin was the second participant and was an 18-year-old overweight male with ASD and severe AD. Lee, the third participant, was a 10-year-old female who in addition to having moderate ID was categorized as overweight due to her BMI. The fourth participant was Hsieh, a 12-year-old male with moderate ID and categorized as overweight according to the children BMI chart (Chang et al., 2016).

During the study, three main research devices were used: an air mouse that detected walking, a flat panel display, and a control system. The air mouse was then attached to a participant's calf from where walking movements were detected.  The control system was an Eee Box minicomputer which continually checked and monitored the data being transmitted by the mouse. As soon as the data indicated effective walking, cartoon videos preferred by the participants would be displayed on the flat panel (this was used to encourage walking). The videos would then be immediately suspended when the participant stopped walking (Chang et al., 2016).

The researchers then carried out two baseline assessments. Here, the air mouse was attached to the participant's calves, but there was no preferred stimulation. The only motivation offered was verbal prompting by a research assistant. The baseline studies were followed by the intervention phase with the similar experimental setting but with the addition of the preferred stimulation. The stimulation was activated as soon as the participant begun to walk and terminated when the participant stopped (Chang et al., 2016).

The results exhibited a marked difference between the two baseline assessments on the one hand and the intervention phase on the other. During the former, the time duration of walking activity (TDWA) of the four participants Shen, Lin, Lee, and Hsieh was 10.50s, 17.87s, 72.00s, and 27.17s respectively during the first assessment. In the second, the authors recorded TDWAs of 10.77s, 23.36s, 88.43s, and 41.41s respectively. In contrast, during the first intervention phase, Shen’s level of performance increased to 99.43s. In the second, it was 98.71s. Lin’s TDWA was 145.57s and 156.43s. Lee also showed a significant increase 166.7s in the first intervention phase and 173.95 in the second. Hsieh's TDWA went up to 163.76s and 170.43s (Chang et al., 2016).

Clearly, the TDWA was low during the baseline phase but shot up once the walking was combined with preferred stimulation. The authors concluded that an air mouse could be used to motivate overweight and obese individuals with ID to undertake physical activity if the same was integrated with stimulation. Nonetheless, the study was limited in the sense that only four participants were used (chang et al., 2016).

**Summary**

A comprehensive review of the current literature informed the research paper regarding background of developing children diagnosed with ASD. This section primarily discussed the prevalence of obesity, lack of physical activity (PA), and barriers present to PA in the context of adolescents with ASD. In addition to the severity of ASD, there are other conditions that put them at more risk and compromised their health and quality of life outcomes.

Obesity has emerged as a pertinent topic for adolescents with ASD. The problem of overweight and obesity begins as early as during the toddler stage for this group, and is seen to be well above national average for the general toddler population. A review of studies signified that risk of obesity is more prevalent in case of individuals diagnosed with ASD, especially during the developing age of 10-17 years. The risk of obesity is higher in this group due to sedentary activities, low levels of physical activity, unhealthy nutrition habits, disordered sleep patterns, and use of different types of medications to treat and manage their condition.

Benefits of PA for adolescents with ASD is multifold, as it enhances proficiency of motor abilities; increases self-regulation; reduces tendency for negative behaviors, anxiety, depression; and has positive impact on quality of sleep. Additionally, PA improves social skills of children, and reduces hyperactivity among them. However, current literature shed light on the fact that despite these benefits, adolescents with ASD may lack motivation to take part in PA. Moreover, inactivity also exists in this group regarding moderate to vigorous physical activities (MVPA) compared to their peers.

Barriers to MVPA in adolescents with ASD were identified in the context of preference of children and adolescents diagnosed with ASD. Scholars found that these individuals enjoy watching television and playing video games as opposed to their non-disabled siblings. Impairment in motor and movement skills, and lack of social communication further limits participation in MVPA, whereas external factors, such as fear of parents also contributes to child’s lack of involvement in MVPA with peers.

As adolescents with ASD demonstrate high preference for engaging in video games or watching television as after-school leisure activities, some studies suggest that active video games can be used as motivational tools to increase PA. Studies that have evaluated the use of particular video games in individuals with ASD as interventions by researchers and the therapists indicated the effectiveness of utilizing video games as motivators for learning and modifying the behavior. Cycling along with use of video games has been used as a major intervention to promote PA in non-disabled individuals. Different types of visual and auditory based stimuli have been incorporated specifically in cycling based interventions that encourage PA in children and adolescents with special needs.

# Method

## Independent Variables

The treatments were interactive video game cycling and non-interactive (gym mode) cycling

## Dependent Variables

The four following dependent variables were examined throughout the study:

1- Average heart rate during cycling sessions

2- Number of minutes in target heart rate range THRR for each session

3- Distance pedaled for each session

4- Enjoyment level

## Participants

The study recruited three adolescents from a Northwest Arkansas high school who have met the criteria of having HFA. Table 1 displays participants' characteristics. This research involved adolescents with ASD because the studies associated with physical activity including adolescents with ASD are limited. The majority of the studies target children with ASD (Griebenauw, 2015; Khouzam, El-Gabalawi, Pirwani, & Priest, 2004; Lang et al., 2010; Sorensen & Zarrett, 2014; Sowa & Muelenbroek, 2012). In addition, prevalence of obesity among adolescents with ASD is higher than typically developing adolescents and even than children with ASD, and they tend to have lower physical activity levels (Downs et al., 2016; Griebenauw, 2015; Must et al., 2017; Pan et al., 2015). Participants were non-randomly selected from a similar sample of high functioning students by their teacher and asked to participate in the study. Parents or guardians of the participants identified via a modified questionnaire-based interview with the teacher that their children had a moderate preference for video games and had a low level of physical activity (Griebenauw, 2015) (Refer to Appendix A for parent questionnaire). Before the study started, students were asked to ride and be familiar with the bicycle's both modes: non-interactive and video game (interactive) modes.

Table 1. Participants' Characteristics.

| Characteristics | Participant 1 | Participant 2 | Participant 3 |
|---|---|---|---|
| Age | 17 | 16 | 16 |
| Gender | Male | Male | Female |
| Weight (lb) | 274 | 176 | 118 |
| Height (ft) | 6′ | 5′ 11″ | 5′ 1″ |

## Equipment and Measurements

### *Game Rider Bicycle (Gaming Bike and System)*

Two gaming bicycles model BGB300 with dimensions height 68.1 x length 51.1 x width 22 inches were used in this study. The bicycle included two modes: video game (interactive) mode and gym (non-interactive) mode. Game mode involved four preloaded racing video games. Only one video game was played during the testing. This mode required individuals to pedal the bike to control the speed of a racing motorcycle, while the swiveling handle bars of the bike controlled the motorcycle's direction right and left. This mode was wirelessly connected to a TV. The bicycle in the gym (non-interactive) mode was used as a conventional exercise bicycle. With both modes, an electronic monitor displayed functions, such as speed, time, and distance pedaled in miles. Duration of cycling lasted 15 minutes for each session. Distance pedaled in miles for each session was one dependent variable that was measured and displayed on the electronic monitor of the bicycle at the end of each session. Other features included an adjustable seat and 16 resistance levels.

***Heart Rate Monitoring***

Heart rate is an indicator for the level of exertion (CDC, 2015). A Polar wristband heart rate monitor was utilized to measure exercise intensity during sessions and to indicate the time spent in target heart rate range (THRR). A number of published studies have proved the validation of the Polar heart rate monitor (Osanai, 2011). The average heart rate throughout each cycling session for both non-interactive and video game modes was calculated using the Polar heart rate monitor.

For calculating THRR, Gellish et al. (2007) invented an equation for computing HRmax. The equation is recommended in situations where the accuracy of the calculation is paramount (Gellish et al., 2007). The equation was: HRmax = 206.9 – (0.67 x age in years).

As recommended by the American College of Sports Medicine (2006) and CDC (2015), the target heart rate range for moderate to vigorous intensity should be 70-85% of a person's maximum heart rate. In an instance where the participants exceeded the limit of 85% on maximum heart rate, then it was assumed that the range was set from 70 – 100%. During exercise sessions the Polar heart rate monitor calculated average heart rate and minutes in THRR.

THRR was calculated using the following formula:

HRmax (calculated above) × desired training intensity % = target intensity

Since there was no difference between the ages of the participants, the maximum heart rate was calculated and set at 196 bpm for all participants. Therefore, 70% of maximum heart rate was 137 bpm. It followed that depending on the calculation, the range of THRR was 137 bpm and above.

## Setting the Resistance Level on the Bicycle

One day before the study started, resistance levels were determined on the bicycle for each participant. The bicycle included 16 resistance levels. Participants were asked to begin cycling at a constant speed on the bike's level (1) resistance for three minutes. Following this, and while maintaining the same speed, the workload was increased every two minutes by increasing the bike's resistance up 1 level until the subject reached volitional fatigue. The determined resistance level for each participant was set during the sessions for both treatments (Adamo, Rutherford, & Goldfield, 2010).

## Study Design

This study adopted a single case alternating treatments design (ATD). The single case/subject design is a systematic approach preferred for the accurate measurement of intra-individual effects. Essentially, the subjects act as their own control as opposed to the use of other control groups or individuals (Gage & Lewis, 2014). The alternating treatments design (ATD) is a model of subject design first used in the late 1970s (Barlow & Hayes, 1979). As a type of single-subject design, the ATD is suitable in the determination of how effective multiple treatments can be. Because the reigning conditions in ATD are alterable fast in a random or semi-random manner, the effects of the alterations are analyzable through a visual inspection or by statistical means (Herrera & Kratochwill, 2005).

This research utilized the alternating treatments design for a number of reasons. First, the study's intensive focuses is on each participant's behavior. Secondly, the research recruited a small sample size (Price, 2012). Thirdly, internal validity can often be assured by an immediate, repeated, and random series of fluctuation between treatments. In effect, no other conditions than these fluctuations can affect the dependent variables (Manolov & Onghena, 2017). The fourth reason regards the promptness of obtaining results without baseline data. The alternating treatments design provides quick feedback regarding the treatment conditions without the need for baseline data (Herrera & Kratochwill, 2005; O'Neill, McDonnell, Billingsley, & Jenson, 2011). Finally, the design allows the researcher to infer reliable conclusions regarding factors that influence dependent variables (Lammers & Badia, 2005).

**Procedure**

Three participants engaged in a 17 days study. Each participant cycled once a day during school days, so the cycling sessions were performed for 13 days. Each cycling session lasted15 minutes. The study utilized two Game Rider bicycles that had both non-interactive (gym) and interactive video game modes. These two cycling modes formed the treatments in the study. With the non-interactive mode, participants operated the bicycle just like any conventional stationary bike. In the interactive video game mode, a video game was loaded on a television by wirelessly connecting the bike to the TV. The video game required the participant to physically pedal to move a racing motorcycle on a track. The swiveling handle bars of the bicycle controlled the direction of the movement right and left. The video game contained colorful images and afforded audio and visual response involving motorized sounds and music (Monedero et al., 2015).

Since a baseline phase is not required in an alternating treatments design, the study directly began with the treatment phase. To prevent sequence effects, ensure validity, and guarantee a powerful technique, participants were randomly assigned to start the first session with either non-interactive (gym) cycling treatment or interactive (video game) cycling treatment (Herrera & Kratochwill, 2005; Kazdin, 2011; Onghena & Edgington, 1994). Treatment alternated every day with each participant receiving one treatment a day. Accordingly, the participant who was assigned to engage in either treatment on the first day, experienced the other treatment in the second session. On the third day, treatment was alternated to the bicycle used on the first session. At the end of day 10, each participant engaged in an equal number of the two treatments (Kazdin, 2011; Kratochwill & Levin, 2010) and completed five repetitions of the alternating sequence to meet the design standards (Cautin & Lilienfeld, 2015; Kratochwill et al., 2010; Wendt & Miller, 2012).

The procedure involved a series of actions completed before, during and after each cycling session. Since the target heart rate range was the same for the participants, the low and high limits were already set before the first session using the Polar heart rate monitor. The participant was required to wear the monitor on the wrist. Additionally, the obtained resistance level and the seat were adjusted for each participant before starting cycling. During the interactive video game cycling intervention, the bicycle was wirelessly connected to the TV to display the video game. However, during the non-interactive intervention, the bike was not connected to the TV. The electronic monitor of the bicycle was turned on to display distance pedaled. It is worth noting that the display monitor was covered with a dark thick paper during sessions, so the data counter on the monitor would not serve as a distraction. Each participant received a verbal notification with the word (GO) to start pedaling. During each cycling session, the participant did not receive any kind of verbal or non-verbal praises or cues while pedaling. After completing 15 minutes of cycling, the participant was verbally notified with the word (STOP) to stop pedaling. After each cycling session, the following three dependent variables were recorded: average heart rate, minutes in THRR, and distance pedaled. The average heart rate and minutes in THRR were monitored during wearing the Polar heart rate monitor. The distance pedaled in miles was displayed on the electronic monitor on the bicycle at the end of each session (see Appendix C for detailed procedures).

**Visual Analysis**

Single case design strongly relies on visual inspection criteria to assess data (Manolov, Jamieson, Evans, & Sierra, 2015; Price, 2012). The experimental criterion compares performance during the intervention with the situation where no intervention has been implemented. Accordingly, the intent of the experimental criterion is to enable the researcher to determine whether any significant changes have been indicated and whether such changes can be attributed reliably to the intervention used (Kazdin, 2011). This required the data related to each participant to be plotted and carefully considered to draw appropriate conclusions relating to whether the independent variable had an impact on the dependent variables or not (Price, 2012; Stylianou et al., 2016). Thus, separate graphs were prepared on the impact of interactive and non-interactive cycling activities on the three identified dependent variables, which were heart rate, minutes in target heart rate range, and the distance covered on each occasion. Three separate graphs for each participant were created containing the data points that indicate the impact of the two interventions on each dependent variable. Each graph included one phase that contained vertical data values of the two treatments. The experimental criteria for determining the impacts of the treatments involved stability, trend, and variability of the data values within treatments. Additionally, experimental criteria included overlapping data values between treatments, rapidity of behavior change from one treatment to the other one, and the intervals between data paths of the two different treatments. An increase in trend of the data shows a treatment effect in each intervention. The greater the distance of data (data split or data lane) between interventions shows the difference in treatment effects (Cooper, Heron, & Heward, 2007; Graham, Karmarkar, & Ottenbacher, 2012; Stylianou et al., 2016).

**Tau-U Effect Size**

The Tau-U effect size was calculated to supplement the visual inspection. Tau-U is a procedure for measuring data values nonoverlap between two treatments. It is a nonparametric technique with a statistical power from 91% – 95% when data comply with parametric assumptions. However, the power of Tau-U can surpass the parametric methods and reach 115% when data do not meet the parametric assumptions, and it is ordinary in single- case studies. Therefore, this index is suitable for short phases (Parker et al., 2011). Tau-U pursues sampling distribution (S) like Kendall Rank Correlation does. Thus, values of confidence intervals and p value are available (Parker et al., 2011). The range of Tau-U is from -1 to 1. Data values of .93-1, .66-.92, and 0-.65 respectively represent strong/large, moderate, and small effects (Parker & Vannest, 2009). Tau-U was using the online Tau-U calculator at www.singlecaseresearch.org. The level of significance $P < .05$ was already set in the calculator (Vannest, Parker, Gonen, & Adiguzel, 2016).

**Percentage of Non-overlapping Data (PND)**

According to Scruggs, Mastropieri, and Casto (1987), the percentage of non-overlapping data (PND) is an outcome measure for summing up data across studies using single-subject experimental designs. Scruggs et al. (1986) stated that PND is a proper measure to evaluate within-phase data overlap. Notably, PND is the most extensively published, and it forms the basis at least ten meta-analyses (Scruggs & Mastropieri, 2001). Scruggs and Mastropieri (2001) described the calculation as a consequential index of the effectiveness of treatment. In this study, PND was determined by calculating the percentage of data values during IVGC sessions that exceeded the extreme values in the CSC sessions. The number of non-overlapping values was divided by the total number of data values (Scruggs et al., 1986). Since this study involved two treatments with five sessions of each treatment in each dependent variable, PND was computed by dividing the number of non-overlapping values by five. PND ranges from 0% to 100%. The following interpretation guideline was provided 90% + = strong effect, 70-90% = Moderate effect, 50-70% Minimum effect, and >50% = no effect (Scruggs & Mastropieri, 1998).

**Social Validity**

Social validity or social validation has been used as a way of guiding the processes of assessment as well as intervention (Foster & Mash, 1999; Kennedy, 2002). The concept of social validity further seeks to ensure that the strategies of interventions consider the issues of society and the users of interventions, such as participants, families, and teachers (Schwartz & Baer, 1991). Wolf (1978) mentioned that social validity envisages three significant notions about intervention including relevance of the goal of the intervention to everyday life, the acceptance of the intervention procedures to the consumers and the community, and the social significance of the effects of the intervention.

Social validity of the intervention was measured during the three days after the study ended (day 11, 12, and 13). In this context, two different approaches were adopted for measuring the social validity of the intervention. The first approach called post intervention subjective assessment of the outcomes, with a view to indicate the impact of the intervention, on increasing the results of the dependent variables (Kennedy, 1992). In this approach, participants were asked to perform three more sessions during the last three days choosing the preferred cycling method. One cycling session was performed a day, and each session lasted 15 minutes. A comparative analysis of the results after treatments and those during the treatments was conducted.

The second approach encompassed post intervention subjective evaluation of the procedures for assessing participants' satisfaction (Kennedy, 1992). Participants indicated whether they would like the interactive video game cycling. This assessment utilized the revised Physical Activity Enjoyment Scale (PACES) questionnaire proposed by Motl et al. (2001). On the last day (day 13) and after the participants performed on the preferred treatment, an interview was conducted by the teacher to identify the level of enjoyment in terms of IVGC among participants. The PACES questionnaire in its original form included 18 items scored on a 7-point bipolar scale. This scale has primarily sought to measure the extent to which a person enjoys participating in physical activities (Kendzierski & De Carlo, 1991). The revised PACES included 16 items that precede a stem "When I am physically active... " However, the stem was modified to suit this research to, "When I ride a video game bicycle…" In this context, the scale assessed the enjoyment on a scale of highest to lowest; such as I enjoy and it is very exciting to the lowest level, such as I do not like it and it frustrates me. The scale was a 5-point Likert-type for the purpose of collecting responses from the participants, where the levels for each item were as follows: 1 = Strongly Disagree to 5 = Strongly Agree. Responses were calculated to determine participants' level of enjoyment. Scoring the highest total points indicated that the participant enjoyed it at a higher level. (See Appendix B). It has been demonstrated that the revised PACES questionnaire is reliable and valid for measuring the level of enjoyment in physical activity (Carraro, Young, & Robazza, 2008; Moore et al., 2009; Roman, Pinillos, Martinez, & Rus, 2014).

# Results

## Visual Analysis

Visual analysis was conducted by employing line graphs to indicate the differences in the effect between the two types of cycling methods on the dependent variables. The visual representation of the data collected from the sessions of the three participants are presented through line graphs provided in sections below. In this chapter, differences within and between the two cycling methods were presented. Furthermore, the line graphs display the effect of engaging in CSC versus IVGC on the participants' average heart rates, minutes spent in THRR, and distance pedaled.

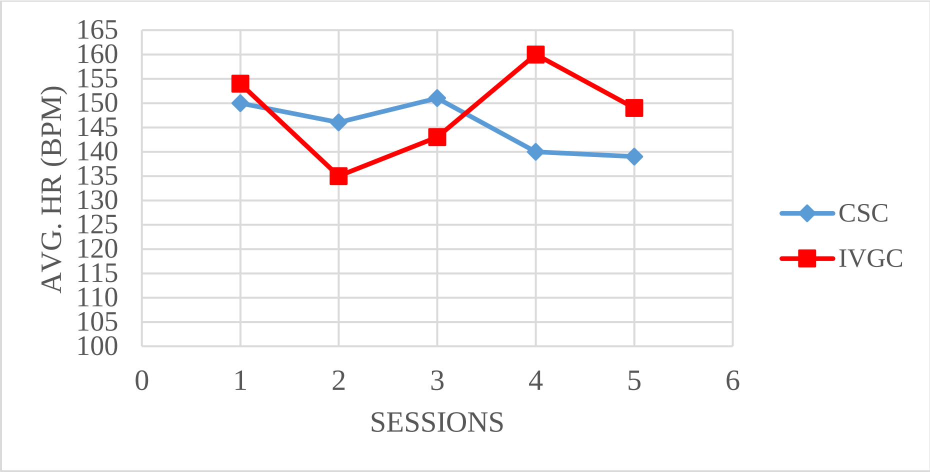
Figure 1 and Table 2 indicate the effects of the two methods on average heart rate for the three participants. The average heart rate for Participant 1 during the conventional stationary cycling (CSC) resulted in a value of 145 beats/minute, which accounted for 74% of maximum heart rate that falls in the recommended moderate to vigorous exercise intensity range. The range of the data values was observed as between 139 and 151 beats/minute. As such, the data collected for CSC method based on performance of Participant 1 formed a downward trend. In terms of engaging in interactive video game cycling (IVGC), the calculated average heart rate was 148 beats/minute, or 76% of maximum heart rate, which was classified under the suggested range of exercise intensity. The data points ranged from 135 to 160 beats/minute. The trend of the data from the collected recordings was upward.

The graph for Participant 1 indicates two overlapping data between the two modes of cycling. An overlap between the two data is noted during the second session with a range of 135 to 146 beats/minute. The other overlap in this case was observed during the third session between the two modes, ranging from 143 to 151 beats/minute. In regards of intervals between the cycling methods, the line graph displays that the first session had the smallest interval between selected cycling mode for Participant 1 in terms of average heart rate with a range from 150 and 154 beats/ minutes. However, the fourth session contained the largest interval between the cycling modes for Participant 1 in average heart rate, and ranged from 140 to 160 beats/minute, while in the last session, the range of the interval was between 139 and 149 beats/minute.

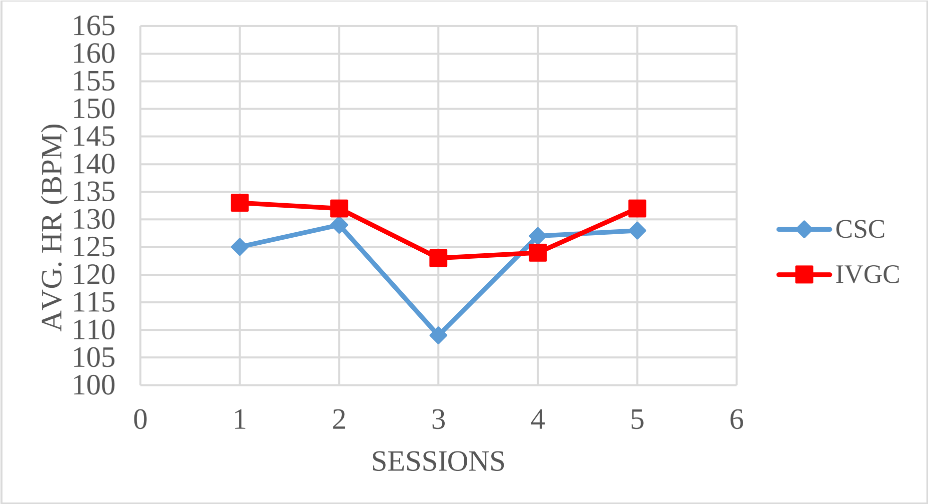
Regarding Participant 2, the calculated average heart rate for the five sessions of CSC was 124 beats/minute, or 63% of maximum heart rate, which was considered in the moderate range of exercise intensity. The obtained values fell between 109 and 129 beats/minute. The trend involved small variability in data. In case of IVGC, the average heart rate for the five sessions was 129 beats/minute, which equaled to 66% of maximum heart rate, indicating that this average was located within the moderate range of exercise intensity. The range of the recorded average heart rate was 123-133 beats/minute. The collected values formed a downward trend.

Participant 2's graph exhibits one data overlap between treatments. The data overlap occurred during session four with a small range from 127 to 124 beats/minute. Considering intervals between the treatments, session one included an interval that ranged from125 to 133 beats/minute. The second session contained the smallest interval between the two modes for Participant 2 with regard to average heart rate, and the values of the interval fell between 129 and 132 beats/minute. Another interval was noted in session three that ranged from 109 to 123 beats/minute. Finally, the fifth session included data interval with a range of 128 to 132 beats/minute.

**Participant 1**




**Participant 2**




**Participant 3**

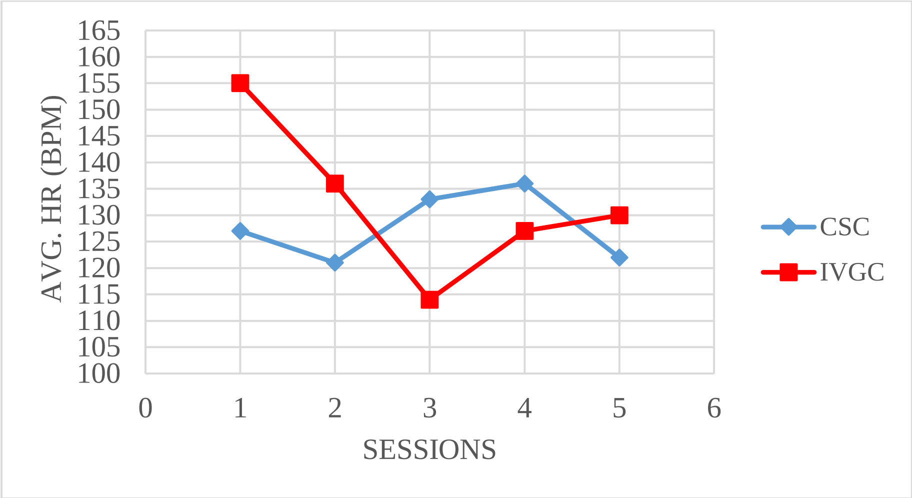



Figure 1. Effects of Treatments on Avg. HR.

The determined average heart rate for cycling using the conventional stationery bicycle for Participant 3 resulted in a value of 128 beats/minute, which represented 65% of maximum heart rate, indicating an exercise intensity of moderate range. The range of the data points was between 121 and 136 beats/minute. The data points generated a trend of small variability. In the case of IVGC, the third participant had an average heart rate of 133 beats/minute, or 68% of maximum heart rate. Accordingly, the classification of the average heart rate for Participant 3 was within moderate exercise intensity. The recorded average heart rate ranged from 114-155 beats/minute. The trend of the data values of (IVGC) demonstrated a downward slope.

Relating to overlapping data between the two cycling methods, two overlapping data are displayed on the line graph of Participant 3. Overlapping data were found during sessions three and four. The fourth cycling session contained data overlap between 133-114 beats/minute, and the other one ranged from 136-127 beats/minute. In terms of intervals between treatments, session one led to the largest interval between data for Participant 3 in terms of average heart rate with a range of 127-155 beats/minute. The interval between the treatments ranged from 121-136 beats/minute during session two and from 122-130 beats/minute during the fifth session.

Table 2: Means, Ranges, and Trends of treatments in Avg. HR.

| | Average Heart Rate (beat per minute) | |
|---|---|---|
| Participant 1 | CSC | IVGC |
| Mean | 145 | 148 |
| Range | 139–151 | 135–160 |
| Trend | Downward | Upward |
| Participant 2 | | |
| Mean | 124 | 129 |
| Range | 109–129 | 123–133 |
| Trend | Small Variability | Downward |
| Participant 3 | | |
| Mean | 128 | 133 |
| Range | 121–136 | 114–155 |
| Trend | Small Variability | Downward |

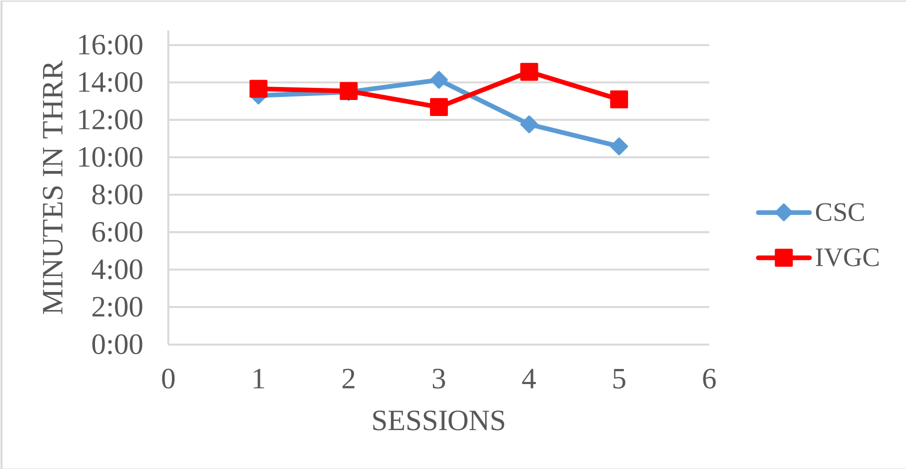
The values for the three participants with regards to minutes spent in target heart range comparing CSC and IVGC are exhibited in Figure 2 and Table 3. The mean value for minutes spent in THRR for Participant 1 in CSC was 12:40 minutes, or 84% of time with a range of 10:36 – 14:09 minutes. The collected data from CSC cycling sessions created a downward trend. Considering IVGC data values, the average minutes in THRR of the computed values reflected 13:32 minutes, or 90% of time with a range of 12:42 – 14:35 minutes. The scatter plots for THRR values created a stable trend.

In relation to overlapping data between sessions, it was noted that only session three included data overlap between treatments with a range of 14:09 and 12:42 minutes. Taking into account intervals between data treatments, the second session comprised the smallest interval between treatments for Participant 1 in terms of minutes in spent in THRR, and this ranged from 13:30-13:33 minutes. Another small interval ranged from 13:19-13:41 minutes, and was noted during the first session. The other intervals occurred during session four between 11:47-14:35 minutes, and during session five between 10:36- 13:07 minutes.

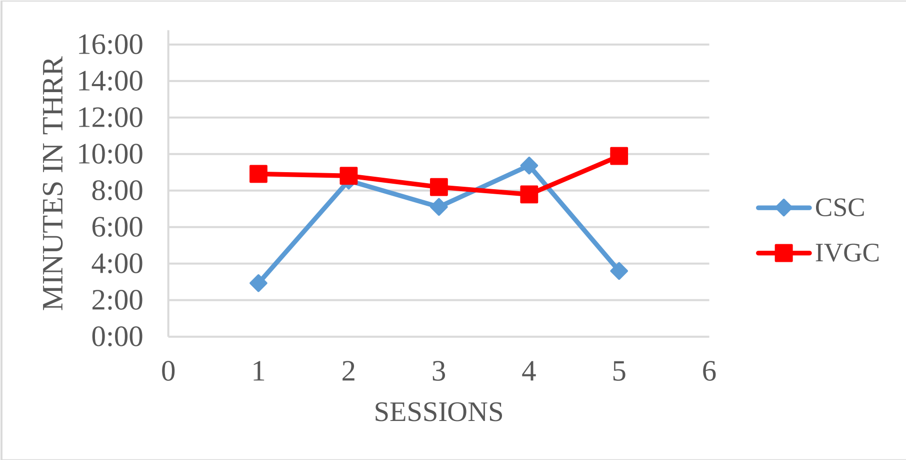
Regarding Participant 2, the mean of minutes spent in THRR for CSC was 6:19 minutes, which corresponded to 42% of time. The collected data ranged from 2:56 to 9:23 minutes. Data in CSC generated large variability. Comparatively, in case of IVGC, the calculated average of minutes spent in THRR was 8:44 minutes or 58% of time. The recorded values ranged from 7:48 – 9:54 minutes. The scatter plots of the values formed an upward trend, as displayed on Figure 2.

The graph of Participant 2 involved one overlapping data observed during session four between 9:23-7:48 minutes. Regarding the intervals between treatments, the first and fifth sessions contained large intervals between the two methods with a range of 2:56-8:55 and 3:36-9:54 minutes respectively. However, the second session had the smallest interval between 8:33 - 8:49 minutes. In session three, the interval between the methods was seen between 7:07 and 8:12 minutes.

**Participant 1**




**Participant 2**




**Participant 3**

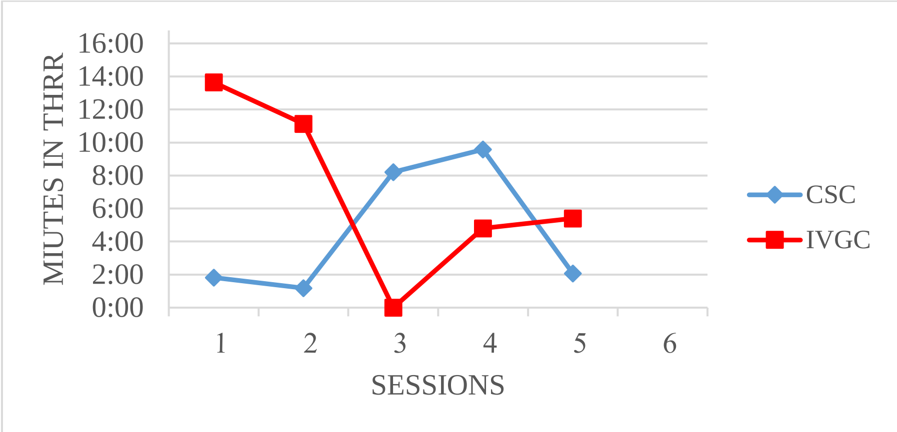



Figure 2. Effects of Treatments on Minutes in THRR.

The data collected from Participant 3 led to a calculated mean of 4:35 minutes, or 31% of time in CSC. The range here was 1.11 – 9.35 minutes with an upward trend. Related to IVGC, the determined mean of the five sessions was 7.00 minutes, or 47% of time with a range from zero - 13.39 minutes. A downward trend was produced as per the data.

Two overlapping data noted between treatments for Participant 3 have been indicated in Figure 2. Session three involved the largest overlapping data for Participant 3 in terms of minutes spent in THRR with a range of 8:13 minutes -Zero (00:00). The other data overlap occurred during the fourth session between 9:35- 4:48 minutes. In the matter of intervals between treatments, session one and session two consisted of two large intervals that ranged from 1:49 to 13:39 minutes and 1:11 to 11:08 minutes respectively. In regards of session five, the interval was between 2:05 and 5:24 minutes.

Table 3: Means, Ranges, and Trends of Treatments in Minutes in THRR.

| | Minutes in THRR | |
|---|---|---|
| Participant 1 | CSC | IVGC |
| Mean | 12:40 | 13:32 |
| range | 10:36–14:09 | 12:42 –14:35 |
| Trend | Downward | Stable |
| Participant 2 | | |
| Mean | 6:19 | 8:44 |
| Range | 2:56 –9.23 | 7:48–9:54 |
| Trend | Large Variability | Stable |
| Participant 3 | | |
| Mean | 4:35 | 7:00 |
| Range | 1:11– 9:35 | zero – 13:39 |
| Trend | Upward | Downward |

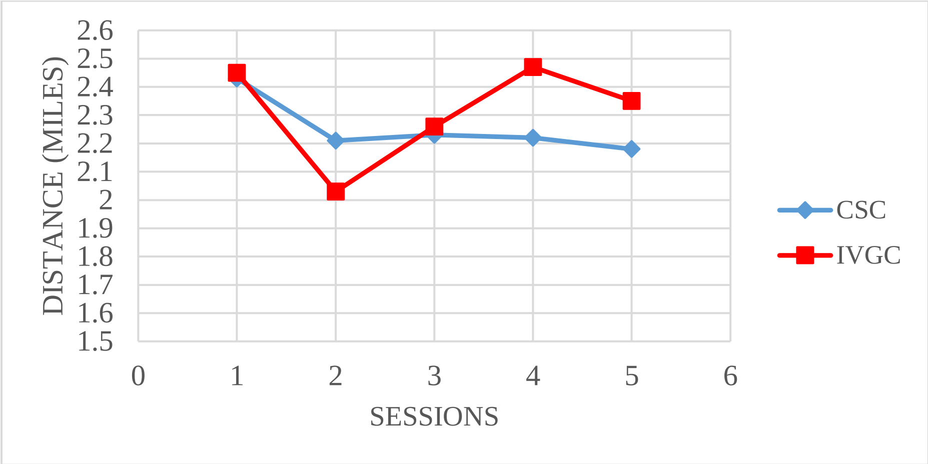
The last dependent variable of interest was the distance pedaled in miles. The results obtained after analyzing the variable of distance pedaled for the three participants are presented in Figure 3 and Table 4. In terms of the first participant, the data for CSC sessions reflected a mean value of 2.25 miles of distance pedaled. The range determined here was between 2.18 to 2.43 miles, which reflected a downward trend. Considering IVGC, the data obtained for the sessions led to a calculated mean of 2.31 miles. The range of the recorded data values was between 2.03-2.47 miles with an upward trend.

The visual analysis found that session two only had overlapping data between the two cycling methods with a range of 2.21-2.03 miles. Regarding the intervals between sessions, small intervals were indicated after sessions one and three that ranged from 2.43-2.45 miles, and 2.23-2.26 miles respectively. Session four for Participant 1 involved interval between treatments with a range of 2.22-2.47 miles, while for sessions five the range was recorded as 2.18-2.35 miles.

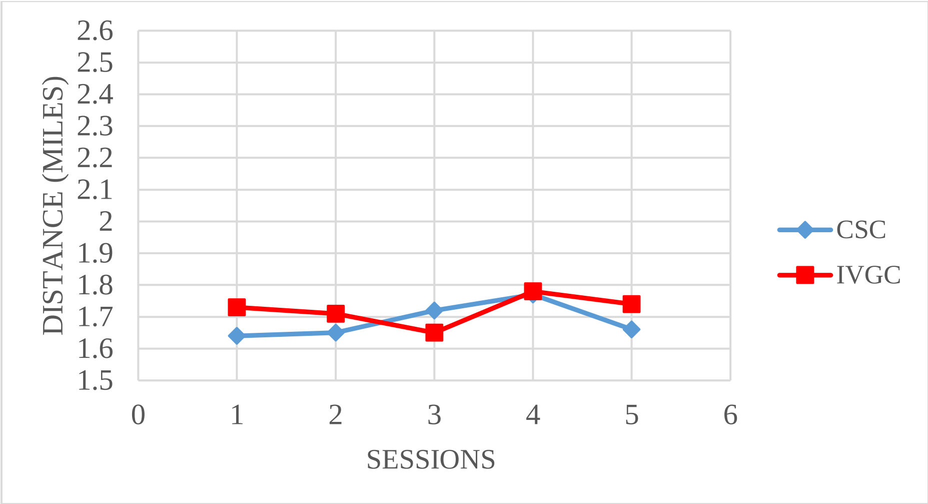
In case of Participant 2, the average mean of distance pedaled in CSC was 1.69 mile with a range during different sessions between 1.64 and 1.77 miles. The values in CSC formed an upward trend. In terms of IVGC, the calculated mean of the distance cycled was 1.72 mile. The recorded values ranged from 1.65-1.78 miles with a stable trend of data.

As regards Participant 2, results exhibited that the two types of cycling had only one data overlap, which was in session three with a range of 1.72 - 1.65 miles. Pertaining to intervals between the two methods, a very small interval occurred in session four while pedaling at 1.77 - 1.78 miles. Session one demonstrated the largest interval for Participant 2 in terms of distance pedaled with a range of 1.64 - 1.73 miles. The other intervals were found in sessions two, which ranged from 1.65 to 1.71 miles, and in session five between 1.66 and 1.74 miles.

**Participant 1**




**Participant 2**




**Participant 3**

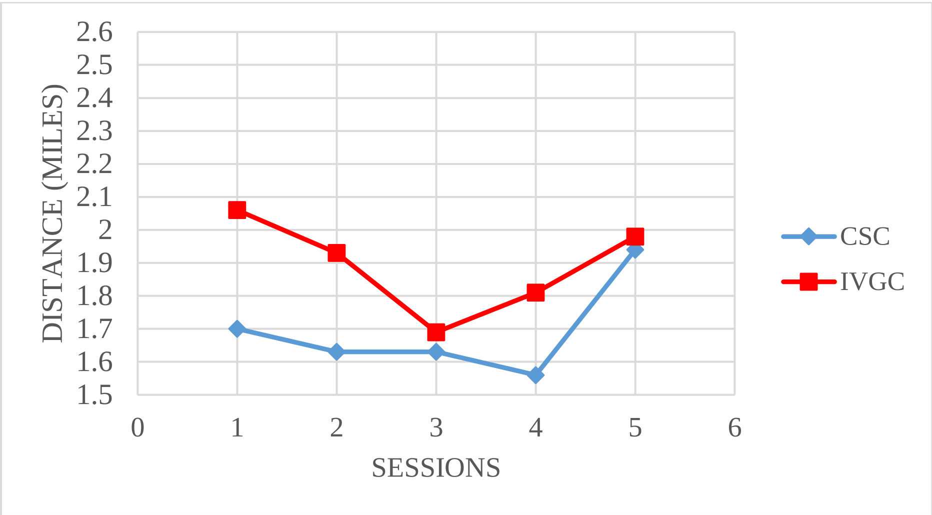



Figure 3. Effects of Treatments on Distance Pedaled.

In connection with Participant 3, the CSC sessions led to a mean of 1.69 mile with data values that ranged from 1.56 to 1.94 miles. The values on the graph formed an upward trend. In relation to IVGC sessions, the mean was calculated as 1.89 mile. The range contained data between 1.69-2.06 miles with a downward trend.

The visual analysis for Participant 3 revealed that the data values obtained for the two cycling modes did not involve any overlap. The values of the two cycling methods reflected intervals during all the sessions. An interval with a range of 1.70-2.06 miles was noted in the data obtained from Participant 3's performance during the first session, and this interval was the largest between the two methods while considering distance pedaled. However, the fifth session involved the smallest interval with a range of 1.94-1.98 miles. Another small interval was determined in session three between 1.63-1.69 miles. Regarding the other intervals between the two cycling modes, the second session had an interval with a range of 1.63-1.93 miles, while the interval in the fourth one ranged from 1.56-1.81 miles.

Table 4: Means, Ranges, and Trends of Treatments in Distance Pedaled.

| | Distance Pedaled (miles) | |
|---|---|---|
| Participant 1 | CSC | IVGC |
| Mean | 2.25 | 2.31 |
| Range | 2.18–2.43 | 2.03–2.47 |
| Trend | Downward | Upward |
| Participant 2 | | |
| Mean | 1.69 | 1.72 |
| Range | 1.64–1.77 | 1.65–1.78 |
| Trend | Upward | Stable |
| Participant 3 | | |
| Mean | 1.69 | 1.89 |
| Range | 1.56–1.94 | 1.69–2.06 |
| Trend | Upward | Downward |

The weighted mean was determined by calculating the means of the three participants. Table 5 exhibits the weighted mean for each dependent variable of interest in the study concerning both CSC and IVGC types of exercise. For average heart rate, the weighted mean in CSC was 132 beats/minutes, or 67% of maximum HR. In terms of the intensity of exercise, the weighted mean for averaged heart rate noted for CSC fell under the moderate range of intensity. In terms of IVGC, the result of the calculated weighted mean was 137 beats/minutes, or 70% of maximum HR. The percentage of the determined weighted mean was classified into moderate to vigorous intensity level of exercise. Considering minutes spent in THRR, the weighted mean for CSC was 7:51 minutes, or 52% of time, while for IVGC, the weighted mean was measured at 9:45 minutes, or 65% of time. For distance pedaled, the weighted mean for CSC was 1.88 mile, while the outcome reflected a weighted mean of 1.97 mile for the IVGC method.

Table 5: Weighted Mean of Dependent Variables for Both Treatments.

| Dependent Variables | CSC | IVGC |
|---|---|---|
| Avg. HR | 132 | 137 |
| Mins. in THRR | 7:51 | 9:45 |
| Distance Pedaled (miles) | 1.88 | 1.97 |

**Tau-U and Percentage of Non-overlapping Data**

Tau-U effect size for IVGC in average HR was small for all participants with a range of Tau-U values of .2 to .36 (Parker & Vannest, 2009). The calculated effect size for Participants 1 and 3 was .20. In case of Participant 2, the effect size for IVGC was slightly higher considering the average heart rate and extended to .36, which was included in the small range of effectiveness (Parker & Vannest, 2009).

With regards to percentage of non-overlapping data (PND) obtained for IVGC in average heart rate, the outcomes ranged between 20% and 60% of non-overlapping data between the two cycling methods. The determined percentage of non-overlapping data for Participant 1 was 40%, which indicated IVGC as a non-effective treatment (Scruggs & Mastropieri, 1998). The calculation of PND for Participant 2 resulted in a percentage of 60, which was the highest percentage noted in average HR. As stated by Scruggs and Mastropieri (1998), this outcome categorized IVGC as minimally effective. In contrast, for Participant 3, the observed value of PND was 20%, which was the lowest percentage recorded for the participants, thus demonstrating that IVGC had no effect on average HR (Scruggs & Mastropieri, 1998). Table 6 displays Tau-U (effect size) and percentage of non-overlapping data values for all three participants in terms of average HR.

Table 6: Tau-U and Percentage of Non-overlapping Data (PND) in Avg. HR.

| CSC condition vs. IVGC condition | | | | |
|---|---|---|---|---|
| | Tau-U | p | 85% CI | PND % |
| Participant 1 | .20 | .602 | -0.351< >0.751 | 40 |
| Participant 2 | .36 | .347 | -0.191< >0.911 | 60 |
| Participant 3 | .20 | .602 | -0.351< >0.751 | 20 |

The effect size (Tau-U) for IVGC in terms of minutes spent in THRR was small for each participant, reflecting similar results as that of average hear rate. The range of Tau-U values among participants was .28 to .52. The computed effect size for Participant 1 was small with a value of .36 (Parker & Vannest, 2009). Participant 2 had an effect size value of .52, which was the highest effect size considering minutes spent in THRR compared to other participants. However, this effect size also did not indicate a statistically significant effect size (Parker & Vannest, 2009). Furthermore, the estimated Tau-U as related with Participant 3 represented a small effect size with a value of .28 (Parker & Vannest, 2009), which was the lowest value among the three participants.

In the case of (PND) for IVGC regarding minutes spent in THRR, the percentages for the three participants ranged between 20% and 40% of non-overlapping data between the cycling sessions. The result of the evaluated PND for Participants 1 and 2 was 20%, which indicated a non-efficient result (Scruggs & Mastropieri, 1998). The outcome of the assessed PND for Participant 3 was also non-effective with a percentage of 40% (Scruggs & Mastropieri, 1998). Table 7 presents the results of Tau-U (effect size) and percentage of non-overlapping data values for all participants with regard to minutes spent in THRR.

Table 7: Tau-U and Percentage of Non-overlapping Data (PND) in Mins. in THRR.

| CSC condition vs. IVGC condition | | | | |
|---|---|---|---|---|
| | Tau-U | p | 85% CI | PND % |
| Participant 1 | .36 | .347 | -0.191< >0.911 | 20 |
| Participant 2 | .52 | .175 | -0.031<>1 | 20 |
| Participant 3 | .28 | .465 | -0.271< >0.831 | 40 |

Tau-U values obtained for IVGC cycling method with respect to distance pedaled indicates recorded values for participants that ranged from .40 to .68. Results involved two small effect size values of .44 and .40 for Participants 1 and 2 respectively (Parker & Vannest, 2009). In contrast, the computed Tau-U for Participant 3 revealed a moderate effect with a value of .68 (Parker & Vannest, 2009).

PND values calculated for the three participants related to distance pedaled indicated IVGC method as a non-effective treatment. Refer to Table 8 for results. The range of percentages determined was between 20% and 40%. The evaluated PND for Participants 1 and 3 was 40% with no effect (Scruggs & Mastropieri, 1998). Whereas, in case of Participant 2, the computed PND was 20% reflecting the absence of effectiveness of the IVGC method (Scruggs & Mastropieri, 1998).

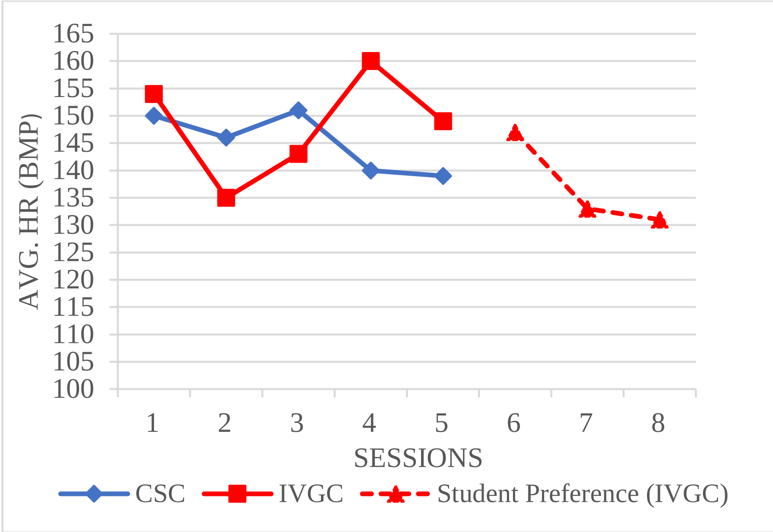
Table 8: Tau-U and Percentage of Non-overlapping Data (PND) in Distance Pedaled.

| CSC condition vs. IVGC condition | | | | |
|---|---|---|---|---|
| | Tau-U | p | 85% CI | PND % |
| Participant 1 | .44 | .251 | -0.111< >0.991 | 40 |
| Participant 2 | .40 | .296 | -0.151< >0.951 | 20 |
| Participant 3 | .68 | .076 | 0.129< >1 | 40 |

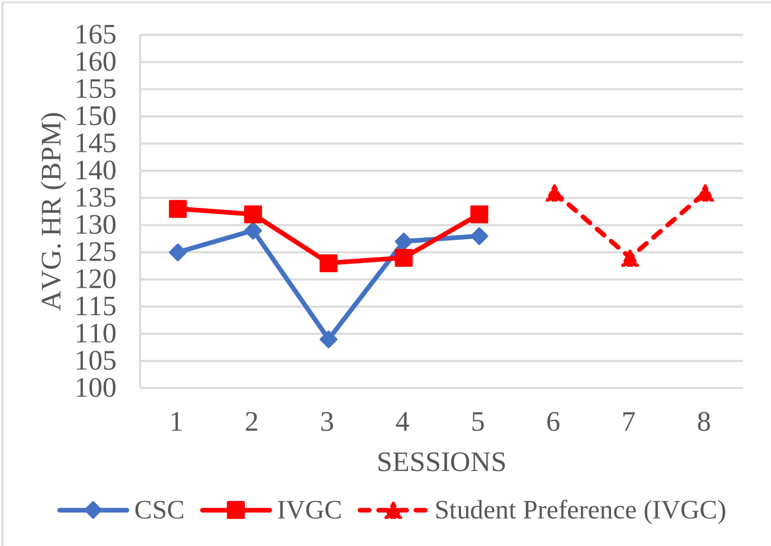
**Social Validity**

After engaging in ten sessions of cycling, the participants were required to cycle for three additional sessions using their preferred cycling method. All three students chose IVGC as their preferred method. To complete the additional sessions, participants cycled once a day for three days. The student preference of the first participant with regards to average heart rate was 137 beats/minute, or 70% of maximum heart rate indicating an exercise intensity of moderate to vigorous range.  Based on the data obtained from the first participant, the values ranged from 131 to 147 beats/ minute with a trend reflected a downward slope. For the second participant, the average HR during the preferred cycling method was 132 beats/minute, or 67% of maximum heart rate which was categorized under the range of moderate exercise intensity. The data of the additional sessions ranged from 124 and 136 beats/minute and formed a trend of small variability. Regarding Participant 3, the calculated average HR was 128 beats/minute, which accounted for 65% of maximum heart rate specifying that the average was located within the moderate range of exercise intensity. The range recorded was between 125 and 132 beats/minute with a trend of upward slope. Findings regarding participants' preferred cycling method in terms of average heart rate are presented in Figure 4 and Table 10.

**Participant 1**




**Participant 2**




**Participant 3**

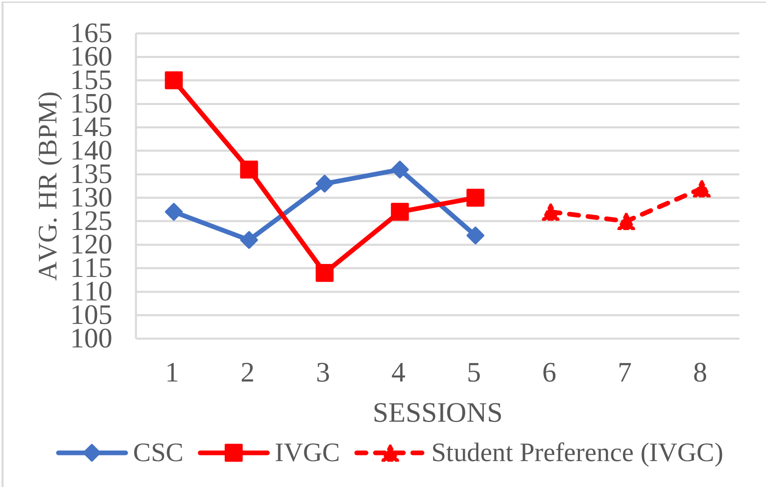


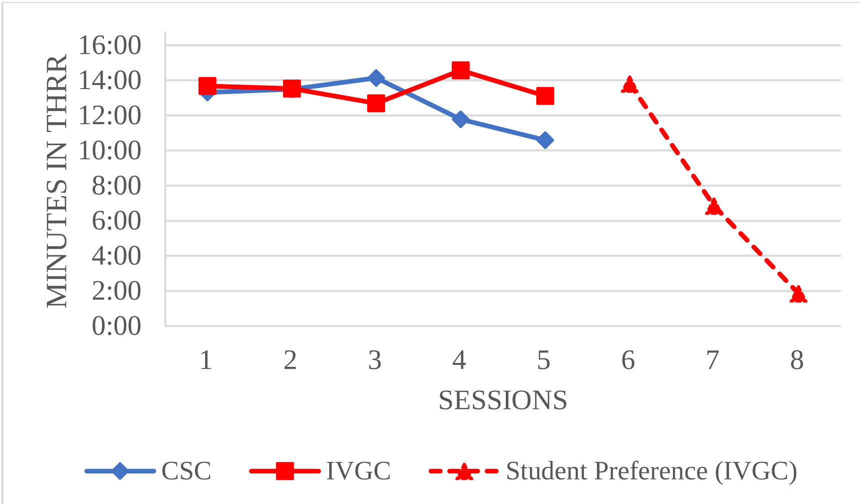

Figure 4. Effects of Student Preference on Avg. HR.

Table 9: Means, Ranges, and Trends of Student Preference in Avg. HR.

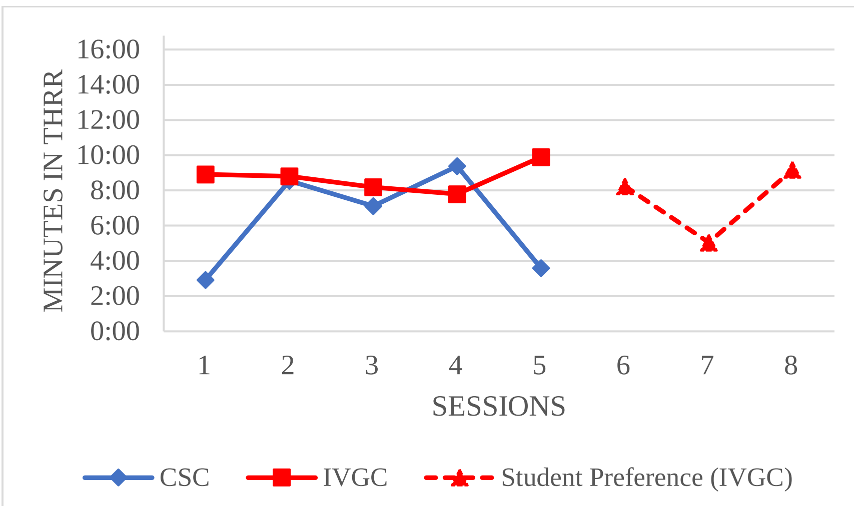
| | Student Preference (Avg. HR) | | |
|---|---|---|---|
| | Average | Range | Trend |
| Participant 1 | 137 | 131–147 | Downward |
| Participant 2 | 132 | 124–136 | Small Variability |
| Participant 3 | 128 | 125–132 | Upward |

The effect of student preference on minutes spent in THRR is presented in Figure 5 and Table 11. The student preference in minutes in THRR reflected an average of 7:31 minutes, or 50% of time for Participant 1. The data collected for the additional sessions indicated a range of 1:51 to 13:49 minutes with a downward trend. Similarly, Participant 2 finished the sessions with an average of 7:30 minutes, or 50% of time. The collected data ranged between 5:03 and 9:11 minutes. The direction of the scatter plot formed an upward trend. For Participant 3, the calculation of the three sessions resulted an average of 6:49 minutes, or 45% of time. The data ranged from 4:46 to 9:59 minutes, and the data reflected an upward trend as seen in case of Participant 2. Figure 5 and Table 11 present the effect of student preference on minutes spent in THRR.

**Participant 1**




**Participant 2**




**Participant 3**

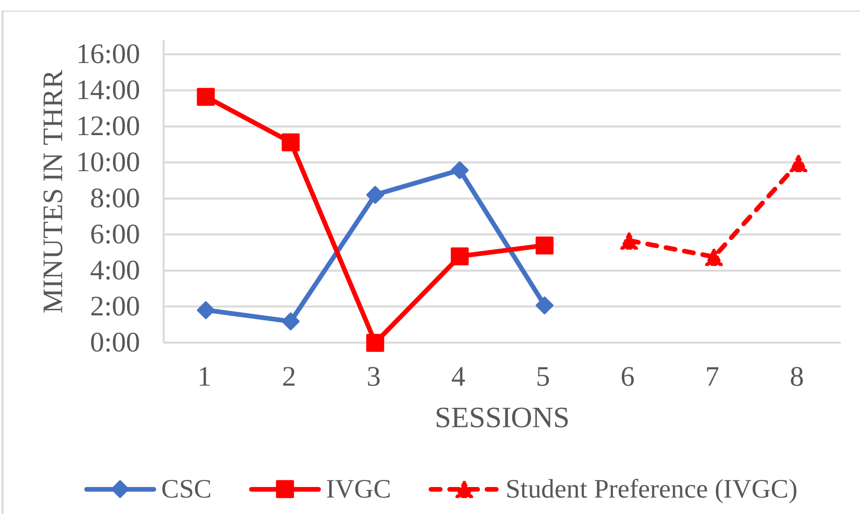


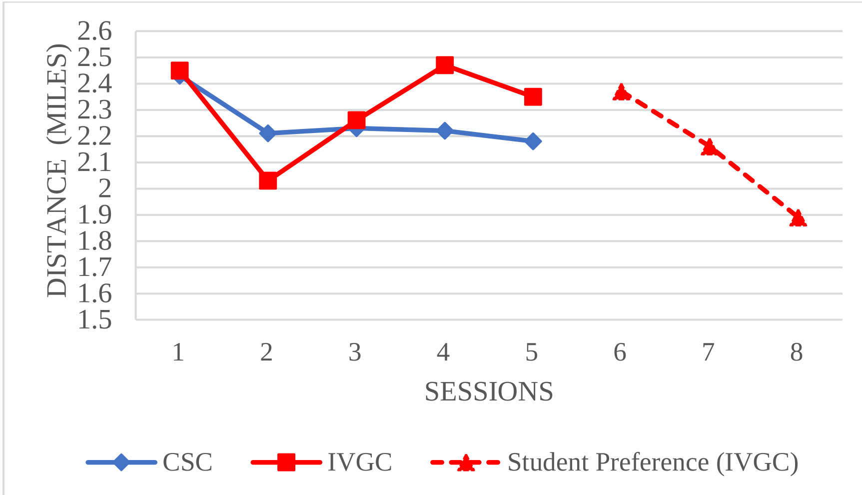

Figure 5. Effects of Student Preference on Minutes in THRR.

Table 10: Means, Ranges, and Trends of Student Preference in Minutes in THRR.

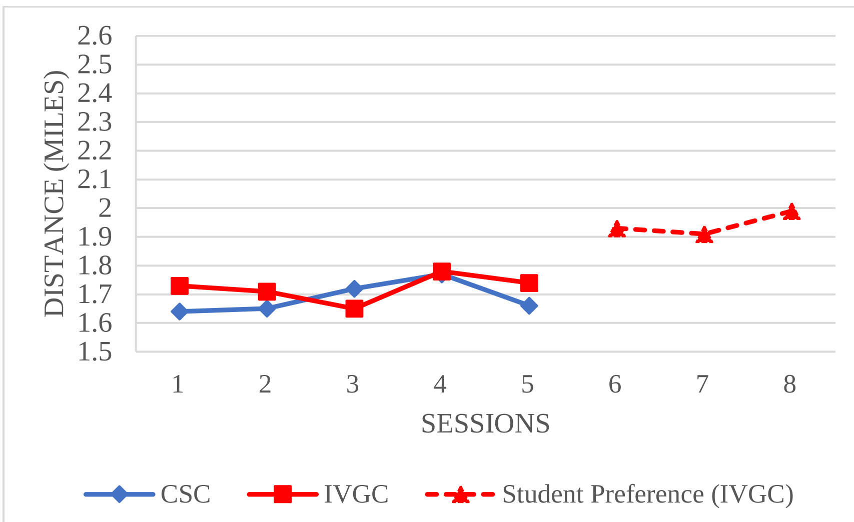
| Student Preference (Mins. in THRR) | | | |
|---|---|---|---|
| | Average | Range | Trend |
| Participant 1 | 7:31 | 1:51–13:49 | Downward |
| Participant 2 | 7:30 | 5:03–9:11 | Upward |
| Participant 3 | 6:49 | 4:46–9:59 | Upward |

Considering student preference regarding distance pedaled, the findings revealed that for Participant 1 the average distance pedaled was 2.14 miles between a range of 1.89 and 2.37 miles. As per data collected for the three sessions, a downward trend was recorded. Pertaining to the second participant, the average distance pedaled during the additional sessions was 1.94 miles between a range of 1.91 and 1.99 miles. Based on the data direction, an upward trend was produced for Participant 2. In case of Participant 3, the determined average was 1.96 miles. The data obtained for the three sessions ranged from 1.83 to 2.11 miles forming an upward trend. The effects of student preference on distance pedaled are displayed on Figure 6 and Table 12.

**Participant 1**




**Participant 2**




**Participant 3**

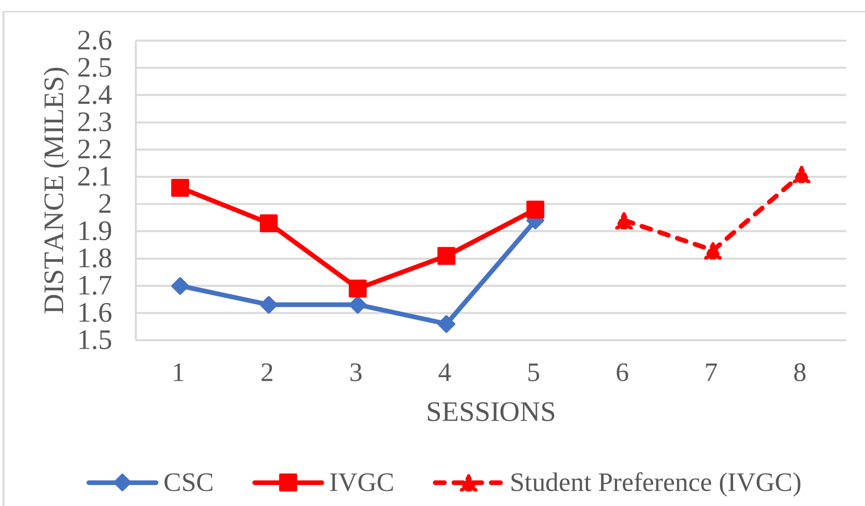



Figure 6. Effects of Student Preference on Distance Pedaled.

Table 11: Means, Ranges, and Trends of Student Preference in Distance Pedaled.

| Student Preference (Distance Pedaled in Miles) | | | |
|---|---|---|---|
| | Average | Range | Trend |
| Participant 1 | 2.14 | 1.89–2.37 | Downward |
| Participant 2 | 1.94 | 1.91–1.99 | Upward |
| Participant 3 | 1.96 | 1.83–2.11 | Upward |

The weighted mean has been calculated for the three dependent variables while also considering student preference. Refer to Table 13 that presents a summary of findings. The table demonstrates the generated weighted mean of Average HR based on student preference as 132 beats/minute. The weighted mean reflected a result of 7:17 minutes or 49% of time for minutes spent in THRR. Lastly, the recorded weighted mean for distance pedaled was 2.01 miles.

Table 12: Weighted Mean of Student Preference.

| Dependent Variables | Weighted Mean |
|---|---|
| Average HR (bpm) | 132 |
| Minutes in THRR | 7:17 |
| Distance Pedaled (mile) | 2.01 |

**Enjoyment Level**

The scaled scores of PACES presented evidence that participants experienced high level of enjoyment in case of IVGC type of cycling. As exhibited in Table 14, the score of PACES for Participant 1 was 4.19 with a range of answers between 1 and 5. As per Participant 2, IVGC had a higher level of enjoyment than Participants 1 and 3 with a score of 4.75 with a range of answers from 1 to 5. In case of the third participant, the computed score of mean responses was 3.81 with a range of responses between 1 and 5.

Table 13: Scores of PACES.

| Participants | Mean | Answer Range |
|---|---|---|
| Participant 1 | 4.19 | 1–5 |
| Participant 2 | 4.75 | 1–5 |
| Participant 3 | 3.81 | 1–5 |

## Discussion

Several researchers have presented conclusive evidence that interactive video game cycling is beneficial to the cardiorespiratory system of children and adolescents, as this type of integrated physical activity involves increased exercise intensity levels (Kraft et al., 2011; Monedero et al., 2015; Warburton et al., 2009). However, only few scholars have explored the cardiorespiratory effects that interactive video game cycling can have on populations with special needs (Barnett et al., 2011; Lyons et al., 2011), and moreover, existing literature does not focus on children or adolescents who experience (HFA). The fundamental aim of this inquiry was to investigate whether a cycling program that included interactive video game playing led to increased physical intensity and higher level of enjoyment when compared to cycling on a traditional stationary bicycle in case of adolescents with (HFA). The following sections provide an overview of the results of this study in terms of each dependent variable.

### Average HR

Results in regards to average HR indicated no statistically significant difference between the conventional stationary cycling and interactive video game cycling. Since the comparison of physical intensity between the applied cycling methods has not been done yet in terms of the special population, the findings of the current investigation were compared to other studies conducted on typically developing participants. Monedero et al. (2015) aimed to assess the impact of a trial of 30 minutes of interactive cycling on 34 typically developing youth participants. Consistent with this study, the authors reported non-significant results in terms of average heart rate between CSC and IVGC, as for the former heart rate was retained at 81.5% of participants' maximum heart rate, whereas for the latter, it was recorded at 82.5% (Monedero et al., 2015). Haddock, Siegel, and Wikin (2009) investigated the effects that physical activity during a 20 minutes stationary bicycle riding session had on typically developing children belonging to the age group of 7-14 years. The researchers conducted one test that excluded a video game, while another trial included a video game simulation where the speed of the bicycle would control the speed of a car within the game that the participant played. The study presented similar outcomes to the current one, such that there was no significant difference between the two trials in average heart rate. Haddock et al. revealed that cycling without playing a video game led to an average HR of 142.4 bmp, while with playing video game, the average HR was measured at 146 bmp. In like manner, a study by Glen, Eston, Loetscher, and Parfitt (2017) demonstrated that the average HR in the trial involving a video game was slightly increased, but not statistically significant when compared to the average HR of participants that cycled on the standard ergometer. This study engaged 20 adolescent and middle-aged participants who were between 18 to 40 years old. The participants exhibited exercise results of 4.4% more than the ventilator threshold (VT) when cycling the standard ergometer, whereas the results reflected 6.2% in case of the video game cycling (Glen et al., 2017).

In contrast, Warburton et al. (2009) conducted a study to evaluate the metabolic needs of participants engaged in interactive exercise that included video game as compared to those participants who exercised using stationary cycle with similar incremental workloads. The participants included 14 typically developing young adults with an average age (24.6 ± 4.2) who took part in two different exercise trials. The first session entailed stationary cycling on ergometer with five minutes of constant work load that involved an incremental pattern such as 25%, 50%, and 75% of the machine’s peak power output. The other session entailed cycling along with interactive video gaming that also administered a similar constant workload. The participants passed through three incremental stages of workload cycling, in which every stage had a duration of five minutes followed by a five-minute interval. The researchers recommended a training zone of 40-59% of HR reserve for these participants. After the training zone was completed, the researchers found that average HR for exercise with video game was statistically higher at workloads 25% and 50% of power output when compared to traditional cycling.

The differences in the findings of Warburton et al. (2009) can be understood through three major determinants. First, the authors employed a relatively shorter protocol, as participants were limited to just two cycling trials including one day with traditional ergometer cycling and the next day with interactive video game cycling. Another factor is that the participants were required to cycle at varied frequencies during the interactive video game session as part of contest (Warburton et al., 2009). It is possible that the challenges in the game paved the way for differences recorded in average HR (Monedero et al., 2015). Lastly, the game characters as well as overall design of the video game used in the case of Warburton et al. (2009) study may have also led to significant difference in average HR of participants during cycling trials.

The findings of calculated average HR for the three participants did not indicate a statistical difference when comparing both types of cycling. The average HR for first participant in IVGC was recorded at 148 beats/minute, which was considered in the range of moderate to vigorous exercise intensity. Comparatively, the value of the same dependent variable was 145 beats/minute in CSC, which was also classified in the same exercise intensity range. However, the obtained values for CSC in case of Participants 2 and 3 were 124 and 128 beats/minute, and for IVGC were 125 and 133 beats/minute respectively. In addition to the absence of statistical significance between the values from CSC and IVGC, the values for Participants 2 and 3 fell in the moderate range of physical intensity. The determined weighted mean of average HR during

CSC resulted in a value of 132 beats/minutes. The classification of this outcome was moderate intensity. However, the weighted mean of average HR during IVGC produced 137 beats/minute, which was categorized in the recommended moderate to vigorous intensity range. According to the study of Hernandez et al. (2012), seven of eight youths with cerebral palsy exhibited 64-76% of their maximum HR when they engaged in a cycling exergame. The participants took part in a total of five sessions. It transpires that the amount of sessions, as well as the results, demonstrates consistency with the current study, as three participants that displayed (HFA) took part in five sessions in terms of the interactive video game cycling, and reached a maximum HR of the same range as of the other participants. However, the study did not include comparing traditional stationary cycling for an assessment of the difference in the level of physical intensity considering the two distinctive cycling methods.

The computed values of Tau-U effect size for all three participants indicated a small effect for IVGC. The collected data ranged from .2 to .36 (Parker & Vannest, 2009). The small effect size for IVGC was caused by the small number generated from the comparison of pairwise data (#pos. – #neg.) due to the data overlaps between the two methods (Parker et al., 2011).

In the case of percentage of non-overlapping data (PND) for IVGC in average HR, the data ranged between 20% and 60% of non-overlapping data. The value for Participant 1 was 40%, which presented a non-effective treatment (Scruggs & Mastropieri, 1998). The deduction from this outcome indicated that two data values for IVGC in average HR exceeded the highest collected value of CSC (Scruggs et al., 1986). The outcome for Participant 2 reflected 60% of PND for IVGC indicating minimally efficient outcome (Scruggs & Mastropieri, 1998). The percentage for Participant 2 clarified that three observed data values for IVGC passed the highest value for CSC (Scruggs et al., 1986). For Participant 3, only one collected value of IVGC in this dependent variable exceeded the highest value for CSC, which resulted in a value of 20% with non-efficient treatment (Scruggs & Mastropieri, 1998; Scruggs et al., 1986).

**Minutes in THRR**

Participant 1 exhibited the highest mean of minutes spent in THRR in both cycling methods with observed data of 12:40 minutes in conventional stationary cycling, and 13:32 minutes in interactive video game cycling. In case of the second participant, THRR was recorded at 6:19 minutes in CSC, and 8:44 minutes in IVGC, while for Participant 3 THRR reflected 4:35 minutes in CSC and 7:00 minutes in IVGC. The recorded weighted mean presented no significant difference between the distinctive cycling methods in terms of minutes in THRR since the recorded value for CSC was 7:51 minutes, or 52% of time, whereas during IVGC the value was 9:45 minutes, or 65% of time pedaled.

The average of minutes spent in THRR related to IVGC presented in this study was higher than the average of the same dependent variable found by Knights et al. (2016) when the researchers examined the impact of an interactive online-platform based cycling game on the cardiovascular fitness of children and teenagers with cerebral palsy (CP). Participants for this study ranged from age 9 to 18, and had bilateral spastic CP measured at level III in terms of Gross Motor Functional Classification System (GMFCS). The researchers employed an exergame program lasting for a period of six weeks. It was determined that target HR was at 40–60% of heart rate reserve. Participants played for a minimum of half an hour every day for three days during each week. The researchers reported an average weekly playtime for participants at 202 minutes, in which 39% of playtime (79 minutes) was within the zone of targeted HR (Knights et al., 2016). This result indicated differences compared to the current study that reflected an average of time spent in THRR at 65%. Reduction in minutes spent in target heart rate zone for participants with CP can be caused by several factors. First, the study involved a small sample size. Second, Knights et al. (2016) administered a longer protocol, which could have potentially made the participants experience boredom considering regular exercise for a long period such a six weeks. Finally, the extent of severity in terms of disability for participants may have also been a factor contributing to reduced minutes of playtime spent in target HR zone. According to Mockford and Caulton (2008), children with CP display reduced ankle strength. The lower ankle strength can further impact intensity levels that participants engage in during exercise.

Considering the values of Tau-U, all the participants obtained small effect size values in case of IVGC, which ranged between .28 and .52 (Parker & Vannest, 2009). Interestingly, Participant 3 had a noticeable difference between cycling methods in minutes spent in THRR (4:35 minutes for CSC and 7:00 minutes for IVGC), but the computed Tau-U resulted in a value of .28 which indicated a small effect (Parker & Vannest, 2009). The justification for the obtained effect size for IVGC is the presence of the frequent data overlaps between methods that led to decrease in the effect size (Parker et al., 2011).

Regarding PND for IVGC in terms of minutes spent in THRR, data ranged from 20% to 40%. The calculated percentage for Participants 1 and 2 resulted in a value of 20% of non-overlapping data between methods, reflecting that IVGC had no effect considering THRR for the participants (Scruggs & Mastropieri, 1998). For Participant 3, the result also exhibited a non-effective treatment with a percentage of 40% (Scruggs & Mastropieri, 1998).

**Distance Pedaled**

Findings as per distance pedaled by the participants revealed that there were no significant differences in distance cycled between the two cycling methods. The collected values of average distance pedaled in case of Participant 1 in the two cycling methods reached the topmost values compared to other participants. The recorded value of distance pedaled in CSC was 2.25 miles, while in IVGC, the value reached 2.31 miles. Participants 2 and 3 obtained the same average of distance cycled in CSC, that is, 1.69 mile. For IVGC, Participant 2 achieved 1.72 mile, and the recorded value for Participant 3 was 1.89 mile. The computing weighted mean of CSC was 1.89 mile, while in case of IVGC the value was 1.97 mile, indicating that there were no statistical differences between the two methods in terms of average distance pedaled. Similar to the current investigation, Epstein, Beecher, Graf, and Roemmich (2007) reported that no statistically significant differences were recorded in miles cycled by typically developing children for two cycling methods including traditional stationary cycling that recorded .85 mile and interactive video game cycling that recorded 1.15 mile.

Related to Tau-U effect size, the effect for IVGC was small for Participants 1 and 2 with values of .44 and .40 respectively (Parker & Vannest, 2009). On the other hand, the effect size for Participant 3 was .68 representing moderate effect (Parker & Vannest, 2009) even though there was no significant difference between methods in regards to distance pedaled for Participant 3. The contraction of data overlaps between methods led to a moderate effect size (Parker & Vannest, 2009; Parker et al., 2011).

Regarding PND, the collected percentages ranged from 20% to 40%. The evaluated PND for Participants 1 and 3 was 40% of non-overlapping data between methods, which revealed that the IVGC had no effect (Scruggs & Mastropieri, 1998). Additionally, IVGC had absence of effectiveness in distance pedaled for Participant 2 with a percentage of 20% of non-overlapping data between both cycling methods (Scruggs & Mastropieri, 1998).

## Social Validity

All three participants cycled an additional three sessions of IVGC as their preferred cycling method. The average HR of the preferred cycling was measured at 137 beats/minute for Participant 1, which was the highest rate with a downward trend, followed by the second participant's HR of 132 beats/minute with a trend of small variability. The lowest rate was 128 beats/minutes recorded for Participant 3 with an upward trend. In terms of minutes in THRR, Participants 1 and 2 obtained the similar values of 7:31 minutes and 7:30 minutes, and their values created downward and upward trends respectively. The third participant reflected the lowest time spent in THRR as the recorded value was at 6:49 minutes, and the collected data involved upward trend. Considering the last dependent variable of distance cycled, Participant 1 pedaled the longest distance with an average of 2.14 miles and a downward trend, while Participant 2 and Participant 3 peddled 1.96 mile and 1.98 mile respectively, and their data contained upward trends.

In terms of weighted mean of the three dependent variables as per student preference, the result of average HR reflected 132 beats/minutes. Related to minutes in THRR, 7:17 minutes, or 49% of time, was the outcome of the weighted mean. The weighted mean for the last dependent variable revealed distance pedaled at 2.01 miles.

## Enjoyment Level

Based on the responses of participants, scores on the Physical Activity Enjoyment Scale (PACES) exhibited a high enjoyment level in case of IVGC. The determined weighted mean of PACES was 4.25. A number of studies have previously presented evidence regarding high levels of enjoyment that children with special needs as well as typically developing children and adolescents experience after engaging in IVGC (Glen et al., 2017; Hernandez et al., 2012;

Monedero et al., 2015; Rhodes et al., 2009). Thus, the results of this study are consistent with existing literature.

The indifferences noted between the two cycling methods in terms of the three established dependent variables can be understood from two major factors: 1) the video game selected for the interactive cycling sessions may not have served as a positive reinforcer for exercise. The type of the cycling video game used in the experiment was not considered as a modern or latest version video game, which may not have appealed to the tech-savvy adolescent participants. Perhaps the low-resolution images negatively affected the motivations of participants. 2) Students may have had access to video games outside the experiment location during the period of study. Engaging in video games during study days has the ability to decline motivation due to overstimulation from video games, and this can negatively impact their performance during the cycling sessions.

**Limitations of the Study**

The implementation of this study highlights a certain limitation which is the small sample size. This limitation may have reflected results of indifferences obtained after analyzing the two cycling methods. In order to generalize the results, it is imperative for the study to include a larger sample size that can appropriately represent the overall population. Thus, replication of the study is needed. Although the small sample size in this study was considered as a limitation, the study confirmed the findings of previous studies conducted on typically developing children and adolescents indicating that there are no significant differences between CSC and IVGC in terms of average heart rate and distance pedaled.

## Recommendations

### *Future Researchers*

1- For future research, recruiting a larger sample size is highly recommended. Additionally, replication of the study can be done with adaptations based upon these limitations. Given the heterogeneity in ASD, it is hard to find a large sample size. When using single case design to establish an evidence base, it is important for researchers to replicate studies and adapt studies based upon reported findings. Based upon the findings in this study, researchers should consider the type of equipment and the research design. An alternating treatment design was chosen to minimize carry over effects. Researchers could consider conducting a multiple probe baseline across subjects, as this design would minimize subjects time in baseline and possible minimize carry over effects.

2- Longer design in terms of number of pedaling sessions should be considered for further inquiry. Increasing the number of cycling sessions can be conducive to gain more insight and confirmation regarding inconclusive results.

3- The access to video games outside the experimental settings should be restricted during the period that students participate in the study.

4- The video game should be easy to control during play and not involve any complicated buttons or functions that may frustrate the participants. The video game adopted in this study only required the participants to pedal to move the object and use the handle bar to control the direction.

### *Physical Education Teachers*

1- Utilizing the latest video games that boast of high-quality images and sounds for interactive video game cycling can help reinforce participants to exercise at the recommended intensity.

Cycling video games that feature realistic images and sounds can play a more effective role in motivating individuals.

2- Offer a wide variety of cycling video games. Making use of a wide range of interesting cycling video games can keep participants occupied, increase motivation and prevent them from getting bored. This recommendation was taken in consideration when the values for Participant 1 demonstrated decline in the dependent variables although the student was taking part in student preference cycling as displayed on Figures 4, 5, and 6. Participant 1 is of particular interest as he was the only one who completed the three rounds of the applied video game several times during the experiment before students were provided the opportunity to engage in preferred cycling method. In addition to the downtrend of all dependent variables in student preference, Participant 1 exhibited decline in average values of the three dependent variables considering cycling mode with student preference compared with the average values for the former five sessions. It is speculated that frequent and similar images may have resulted in demotivation for the participant.

3- Teachers can administer reinforcement by implementing token system programs. Literature has indicated the efficacy of the token system in increasing physical activity and exercise among individuals with special needs. Bennett, Eisenman, French, Henderson, and Shultz (1989) examined the impact of the token program on physical activity as well as cardiorespiratory fitness levels of individuals diagnosed with Down syndrome while engaging in a 15-minute session on a cycle ergometer. The authors revealed that the token system could be highly beneficial in promoting exercise behavior and physical activity in this population (Bennett et al., 1989). Literature on this topic is laden with several studies that support use of token systems as an effective reinforcement strategy to promote physical activity in children and adults experiencing different disabilities including severe intellectual disabilities and cystic fibrosis (Bernard, Cohen, & Moffett, 2009; Croce, 1990; Krentz, Miltenberger, & Valbuena, 2016). Positive reinforcement and token economies are an evidence-based practices for people with ASD (Charlop-Christy & Haymes, 1998; Fiske et al., 2015; Souders, Freeman, DePaul, & Levy, 2002; Wong et al., 2015) and can easily be added to the bicycling routine.

4- Competition between students can lead to desired results in terms of exercise intensity. It was noticed that the trends of Participants 2 and 3 during the former five sessions were downward (refer to Figures 1, 2, and 3). However, the trends improved for these two participants during student preference cycling, leading to upward trends (except a small variability trend for Participant 2 in terms of average HR) (see Figures 4, 5, and 6). The underlying cause may have been the sense of competition or competitiveness with the first participant when the participant finished the three rounds in the former five sessions. In their study, Corbett, Barwood, Ouzounoglou, Thelwell, and Dicks (2012) found that when participants were engaged in head-to-head competition while exercising on a cycle ergometer, their performance was significantly increased. Similarly, Jensen et al. (2016) revealed that when individuals engaged in active video games entailing competitive play, their exercise intensity levels were elevated and were higher compared to single players. In addition, the authors concluded that competitive players were more likely to spend more time in the high intensity range (Jensen et al., 2016). Another reason identified for high intensity level of exercise during competitive play was that participants took more steps in such active video games when compared to solo play (Jensen et al., 2016). In the same manner, several studies have highlighted significant differences in terms of participants' exercise intensity level, enjoyment level, and motivation to engage in future play while competitively engaging in exergames as opposed to playing together cooperatively or solo play (Cruz et al., 2016; Peng & Crouse, 2013).

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## Appendices

APPENDIX A: Questionnaire to Parents for Collecting Medical and Style of Living Data Regarding Each Participant.

Child's Name: Date of Birth: Age:
Participant's Initial:

1. Does your child have other health or medical issues? (e.g., asthma, allergy, or other issues)
If yes, please list:

2. Does your child engage in organized sports and/or adapted physical activities?
If yes, please list: Frequency:

3. For how long does your child participate in moderate- to vigorous physical activity on average per day? (Examples of moderate activities are brisk walking, hiking, jumping on a trampoline, water aerobics, recreational roller skating, gymnastics, aerobic dancing, gardening and yard work, and other activities, and vigorous exercises are considered to be of high intensity and last for an extended time as compared to moderate activities.

a) Before and after school on weekdays:

| Min./ day | Physical Activity |
|---|---|
| Less than 10 | |
| 10 -19 | |
| 20 -29 | |
| 30 -39 | |
| More than 40 | |

b) Through weekend days:

| Min./ day | Physical Activity |
|---|---|
| Less than 10 | |
| 10 -19 | |
| 20 -29 | |
| 30 -39 | |
| More than 40 | |

4. What types of physical activity does your child prefer?

List:

5. How many hours does your child spend per day playing video games?

| Hrs./day | Video Game |
|---|---|
| Less than 1 | |
| 1- 2 | |
| 2- 3 | |
| 3- 4 | |
| More than 4 | Specify hours. ( ) |

6. What is the preferred device on which your child enjoys playing video games? (Consoles, PC internet, tablet, smart phone, or other devices).

List:

7. Does your child take part in active video games? (Explained as video games that require physical activity movements from player to control the game).

If yes, please list. Frequency:

8. What are your child's most favorite video game(s)?

Please list:

APPENDIX B: The Revised Physical Activity Enjoyment Scale (PACES) Questionnaire.

Stem: When I cycle a video game bicycle...

| Items / Responses | 1  Strongly disagree | 2  Disagree | 3  Neutral | 4  Agree | 5  Strongly agree |
|---|---|---|---|---|---|
| 1. I enjoy it | | | | | |
| 2. I feel bored | | | | | |
| 3. I dislike it | | | | | |
| 4. I find it Pleasurable | | | | | |
| 5. It is not fun at all | | | | | |
| 6. It gives me energy | | | | | |
| 7. It makes me sad | | | | | |
| 8. It is very pleasant | | | | | |
| 9. My body feels good | | | | | |
| 10. I get something out of it | | | | | |

(Appendix B continued)

| | | | | | |
|---|---|---|---|---|---|
| 11. It is very exciting | | | | | |
| 12. It frustrates me | | | | | |
| 13. It is not at all interesting | | | | | |
| 14. It gives me a strong feeling of success | | | | | |
| 15. It feels good | | | | | |
| 16. I feel as though I would rather be doing something else | | | | | |

## APPENDIX C: Study Procedures.

Warm-Up and stretching exercise for 5-7 minutes involved:

- Shoulder rotations and stretches
- Chest stretches
- Standing tall and reaching (Mountain pose) stretch
- Quadriceps stretch
- IT Band stretch
- Groin stretch
- Ankle circles and stretches

<u>Procedures for Non-Interactive Cycling Sessions:</u>

a. The participant wore the Polar heart rate monitor on the wrist.

b. The teacher adjusted the seat of the bicycle and set the resistance level.

c. A verbal notification was given to the participant by the teacher with the word (GO) and in the same time START button of the monitor was pressed to start pedaling.

d. When the teacher pressed the START button, the time and distance pedaled data counter displayed on the monitor. However, the monitor was covered with a dark paper, so the data counter on the monitor would not distract the participants.

e. While pedaling, the participant did not receive verbal or non-verbal praises or cues.

f. When the participant completed 15 minutes of cycling, the teacher verbally notified the participant with the word (STOP) and in the same time pressed the STOP button of the monitor of the bicycle.

(Appendix C continued)

g. Values of average heart rate and minutes in THRR were recorded by the teacher using the Polar heart rate monitor wristband.

h. The teacher removed the cover from the monitor to record the data of distance pedaled.

<u>Procedures for Interactive Cycling Sessions:</u>

a) The participant wore the Polar heart rate monitor wristband.

b) The seat of the bicycle was adjusted and the resistance level set by the teacher.

c) The teacher selected (Motor Storm) from the games menu, then selected the participant's preferred motorcycle color to play.

d) Before the race started, a traffic light was displayed on the TV screen in red, orange, and then green light in sequence to start the race. With the green light, the teacher gave a verbal notification to the participant with the word (GO) and in the same time pressed the START button of the monitor to start cycling.

e) When the race started, the time and distance pedaled data counter displayed on the bicycle's monitor. However, a dark paper covered the monitor to keep the participant's attention from the data counter.

f) The participant did not receive any form of verbal or non-verbal praises or cues while pedaling.

g) When the game was over, the teacher immediately selected the same game again and a color for the motorcycle and started a new game.

(Appendix C continued)

h) The teacher apprised the participant verbally with the word (STOP) after completing 15 minutes of pedaling and in the same time pressed STOP button of the monitor.

i) The teacher recorded the data of average heart rate and minutes in THRR.

j) The cover from the monitor was removed and the value of distance pedaled was recorded by the teacher.

Warm-Down for Seven Minutes:

- Heart rate monitor wristband was removed, and participant rested and took a few deep breath while sitting on the bicycle for two minutes.
- The participant concluded by participating in the same previous stretching exercises.
- Participant left to attend class.

Measuring Enjoyment Level:

- After completing 10 sessions (five sessions of each treatment), the participant chose the preferred treatment to cycle three additional sessions.
- At the end of the last session, the Physical Activity Enjoyment Scale (PACES) questionnaire was applied and scores were recorded by the teacher.

APPENDIX D: Protocol Approval Letter.

UNIVERSITY OF ARKANSAS

| | |
|---|---|
| **To:** | Dean Richard Gorman<br>HPER 0308W |
| **From:** | Douglas James Adams, Chair<br>IRB Committee |
| **Date:** | 05/21/2018 |
| **Action:** | **Expedited Approval** |
| **Action Date:** | 05/21/2018 |
| **Protocol #:** | 1804118462 |
| **Study Title:** | COMPARISON OF PHYSICAL INTENSITY BETWEEN INTERACTIVE VIDEO GAME CYCLING AND CONVENTIONAL STATIONARY CYCLING IN ADOLESCENTS WITH HIGH FUNCTIONING AUTISM SPECTRUM DISORDER |
| **Expiration Date:** | 04/26/2019 |
| **Last Approval Date:** | |

The above-referenced protocol has been approved following expedited review by the IRB Committee that oversees research with human subjects.

If the research involves collaboration with another institution then the research cannot commence until the Committee receives written notification of approval from the collaborating institution's IRB.

It is the Principal Investigator's responsibility to obtain review and continued approval before the expiration date.

Protocols are approved for a maximum period of one year. You may not continue any research activity beyond the expiration date without Committee approval. Please submit continuation requests early enough to allow sufficient time for review. Failure to receive approval for continuation before the expiration date will result in the automatic suspension of the approval of this protocol. Information collected following suspension is unapproved research and cannot be reported or published as research data. If you do not wish continued approval, please notify the Committee of the study closure.

Adverse Events: Any serious or unexpected adverse event must be reported to the IRB Committee within 48 hours. All other adverse events should be reported within 10 working days.

Amendments: If you wish to change any aspect of this study, such as the procedures, the consent forms, study personnel, or number of participants, please submit an amendment to the IRB. All changes must be approved by the IRB Committee before they can be initiated.

You must maintain a research file for at least 3 years after completion of the study. This file

should include all correspondence with the IRB Committee, original signed consent forms,

and study data. cc: Tariq Mohammed Alsoqairan, Investigator