The Efficacy of Contingent Reinforcement on Compliance with a Stationary Cycling Activity by Adolescent Boys with Autism Spectrum Disorder

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By

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ABSTRACT

Studies have reported that youth with Autism Spectrum Disorder (ASD),when compared to typically developing children as well as youth with other disabilities had (a) higher levels of obesity (Broder-Fingert, Brazauskas, Lindgren, Iannuzzi, & Van Cleave, 2014; Curtin, Anderson, Must, & Bandini, 2010; Rimmer, Yamaki, Lowry, Wang, & Vogel, 2010), (b) lower levels of physical activity (PA) (MacDonald, Esposito, & Ulrich, 2011; Pan & Frey, 2005) and (c) higher levels of sedentary behavior (especially screen time [ST]) (Mazurek & Wenstrup, 2013; Shane & Albert, 2008). The short- and long-term disadvantages of these three conditions are well documented. However, the complex, heterogeneous nature of ASD, often coupled with other concurrent conditions, as well as particular individual idiosyncrasies has resulted in this population reportedly experiencing difficulty in motivation for and complying with physical activity (Lang et al., 2010; Sherrill, 2004).

The purpose of this study was to assess the efficacy of the contingent use of screen time (watching DVDs) on the compliance with a stationary cycling activity by three adolescent males (ages 17 to 18 years) with mild to moderate ASD for 5 days a week over a period of 5 weeks (20+ sessions). Participants pedaled a regular bicycle mounted on an indoor trainer connected to a microprocessor that displayed information on time pedaled (TP) and revolutions per minute (RPM) to the participants, as well as controlled the portable DVD player. These sessions were 20 to 30 minutes long in total. During each session, TP and RPM data collected were used to calculate total output per session (TOS) and percentage compliance. In addition, heart rate (HR) was monitored prior to, during, and after exercise using a wristband monitor. Phase A (baseline) required the participants to pedal the stationary bicycle for 15 minutes while the DVD (reinforcement) played continuously (thus non-contingent). Once predictability was established

for the dependent variables (TP and RPM), phase B (several brief learning/orienting task sessions) was implemented during which participants were afforded the opportunity to learn/understand the task (i.e., DVD paused when pedaling within 5 RPM outside the set RPM criterion zone, and shut off when pedaling > 5RPM outside the criterion zone). Phase C (treatment) was then introduced during which the DVD played normally (i.e., was made contingent on the participants' ability to pedal within a predetermined set RPM zone [range of 10 RPM] for a duration of 15 min).

Results indicated that all three participants pedaled the full 15 min throughout all treatment sessions. The participants all showed increased compliance in terms of RPM changes during each criterion change phase (whether the change was an increase or a decrease), as well as increased HR values across treatment sessions. Two of the subjects pedaled within their individualized HR levels equaling moderate PA (40% to 70% heart rate reserve [HRR]), while the third participant's data showed a slow and gradual, but definite upward slope. In addition, TOS (work output) for each participant increased from baseline to treatment, and within treatment. These results demonstrated the efficacy of the contingent use of screen time (watching a DVD) on the compliance of these three participants with a stationary cycling activity.

The discussion involved an interpretation of the findings with regard to the dependent variables, and incorporated the findings of additional measures (DVD actions taken, enjoyment ratings, body composition measures, and social validity).

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APPROVAL OF THE DISSERTATION

This dissertation, "The Efficacy of Contingent Reinforcement on Compliance with a Stationary Cycling Activity by Adolescent Boys with Autism Spectrum Disorder", has been approved by the Graduate Faculty of the Curry School of Education in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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DEDICATION

This manuscript is dedicated to my daughter. My liewe Liebe, baie, baie dankie vir nie net alles wat jy opgeoffer het nie, maar dat jy altyd daar was deur die jare – jou ondersteuning, bystand, hulp, skouer en oor was, en sal altyd dit wees wat my in die lewe dryf. Ek het jou innig lief…

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

Autism is a set of complex, heterogeneous, neurodevelopmental conditions, ranging from mild to severe, that includes the following diagnostic categories as defined by the fourth edition of the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed., text rev.; *DSM-IV-TR*; American Psychiatric Association, 2000): autistic disorder; Asperger's disorder (AS); childhood disintegrative disorder; and pervasive developmental disorder—not otherwise specified (PDD-NOS). It is characterized by impairments in social interaction and communication, as well as restricted, repetitive and stereotyped patterns of behavior (American Psychiatric Association, 2000). In the revised and recently published fifth edition of the *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.; *DSM-5*, 2013), the four diagnostic categories were collapsed into a single category of autism spectrum disorder (ASD), the social and communication domains were combined into a single domain, and three "functional levels" based on social communication impairments and restricted repetitive behavior now define severity ranging from requiring "very substantial support" (Level 3) to "requiring support" (Level 1) (American Psychiatric Association, 2013; Buxbaum & Caron-Cohen, 2013). *DSM-5* explicitly recognizes the "spectrum" nature of autism (Lai, Lombardo, & Baron-Cohen, 2013).

The reported prevalence of ASD has increased over recent decades, with numbers ranging from one in 88 (Autism and Developmental Disabilities Monitoring Network [ADDM] Surveillance Year 2008 Principal Investigators, 2012) to one in 50 children between the ages of 6 and 17 years (Blumberg et al., 2013). The ADDM (2012) reported a 78% increase in ASD prevalence between 2002 and 2008. Blumberg et al. (2013) also indicated that boys were more than four times more likely than girls to have ASD and that the magnitude of the increase was greatest for boys and for adolescents aged 14 to 17 years. Whether or not these increasing numbers were due to increases in the actual prevalence of ASD or due to increases in knowledge about ASD or the recognition of ASD being a spectrum disorder leading to an increase in diagnosis (Blumberg et al., 2013; Howlin, 2008), the fact remains that with these increasing numbers there is an increased need for individual and effective intervention strategies on multidisciplinary levels.

ASD, as part of its “make-up” and extreme heterogeneity, often comes with additional or coexisting conditions. It is estimated that more than 70% of individuals with ASD have concurrent medical, developmental, or psychiatric conditions (Lai et al., 2013). Some of these conditions include particular idiosyncrasies that may manifest in different ways or forms unique to the individual (Militerni, Bravaccio, Falco, Fico, & Palermo, 2002). Individually, or in combination, these conditions could impact not only the acquisition of physical activity skills, but also the motivation for and enjoyment of these activities.

The obesity and overweight epidemic among all youth is a well-recognized and well-documented problem, not only in the United States but worldwide (Odgen et al., 2006; Slyper, 1998). In the United States, the prevalence of overweight and obesity in children and adolescents has quadrupled since the mid-1960s, with a current estimated 17% of children and adolescents aged 2 to 19 years reported to be obese and 34.5% overweight (Odgen et al., 2014).

The childhood obesity epidemic poses a great threat to the long-term health of our youth, and its financial consequences were estimated at between $147 and $210 billion per year (Wang, Hsiao, Orleans, & Gortmaker, 2013). Obesity in youth is associated with considerable short- and long-term health risks with respect to physiological/medical and psychosocial well-being (Dietz & Robinson, 2005). Within the past 5 years, studies have reported on the prevalence of overweight and obesity among youth with ASD. Combined, they reported both overweight and obesity prevalence ranging between 11% and 43%, and when compared to the general populations in their studies, youth with ASD had significantly higher body mass index (BMI) values (Broder-Fingert, Brazauskas, Lindgren, Iannuzzi, & Van Cleave, 2014; Chen, Kim, Houtrow, & Newachek, 2010; Curtin, Bandini, Perrin, Tybor, & Must, 2005; Curtin, Anderson, Must, & Bandini, 2010; Rimmer, Yamaki, Lowry, Wang, & Vogel, 2010; Zuckerman, Hill, Guion, Voltolina, & Fombonne, 2014). It was also reported that youth with ASD had a higher prevalence of obesity than youth with other disabilities (Holcomb, Pufpaff, & McIntosh, 2009; Rimmer et al., 2010). The reasons for this high prevalence of overweight and obesity among youth with ASD are multifaceted and complex, but due to the wide variety of ASD's unique characteristics, several factors may impact the weight status of affected youth. The severity of ASD has been reported as being a risk factor for obesity (Broder-Fingert et al., 2014; Egan, Dreyer, Odar, Beckwith, & Garrison, 2013). In addition, problems with eating may adversely affect the quality of diet in this population and lead to obesity (Cermack, Curtin, & Bandini, 2010; Minihan, Fitch, & Must, 2007). Other comorbidities, such as poor sleep quality and gastrointestinal disturbances, as well as the effects of some medications, may also increase the possibility of developing obesity (Correll, 2007; Zuckerman et al., 2014). However, the most important contributors to obesity in all population groups (and ages) are diet and sedentary lifestyle—consuming too many calories and not being physically active (Centers for Disease Control and Prevention, 2013; Muth, 2013; Krebs et al., 2007). Interestingly, Holcomb et al.

(2009) noted that youth with ASD are not necessarily obese due to poor dietary habits, but possibly as a result of very low levels of physical activity (in about 50% of this population).

A vast majority of papers in the literature have reported that obesity among all youth was a result of low levels of physical activity (PA) and high levels of sedentary behavior (especially screen time) (Armstrong, Tomkinson, & Ekelund, 2011; Bauman et al., 2012; Hamilton, Healy, Dunstan, Zderic, & Owen, 2008; Jago, Fox, Page, Brockman, & Thompson, 2010; Laframboise & deGraauw, 2011; Prentice-Dunn & Prentice-Dunn, 2012; Villaire, 2001). There has been mounting evidence that physical fitness/activity during childhood impacts current or future health (Harris & Cale, 2006). An inverse relationship between physical fitness and obesity (strongly linked to several health risk factors) among youth has consistently been reported (Aires et al., 2010). In addition, research on youth who are sedentary and/or obese has also consistently reported low levels of cardiorespiratory fitness (CRF) (Ortega et al., 2010)—mainly because obesity is associated with reduced capacity for weight-bearing PA and increased health risk (Armstrong et al., 2011). Oppewal, Hilgenkamp, van Wijck, and Evenhuis (2013) conducted a review of CRF in individuals with intellectual disability (ID). Of the 13 studies that met their criteria, six investigated CRF in youth with ages ranging from 11 to 18 years. The authors reported low CRF among these youth as well as a decline in CRF with age, and they also discussed possible determinants for these CRF scores (i.e., motivation, task understanding, gait and pacing problems, chronotropic incompetence, unfamiliar task and environment, poor leg strength, and high levels of physical inactivity). Regarding CRF in youth with ASD, two reviews reported on the effects of exercise in this population (Lang et al., 2010; Sowa & Meulenbroek, 2012). Although outcomes were mostly related to (the improvement of) behavior, academic, and social functioning in the 18 studies reviewed by Lang et al., only four studies measured CRF and reported improvements in these measures (Fragala-Pinkham, Haley, & O'Neil, 2011; Lochbaum & Crews, 2003; Pan, 2011; Yilmaz, Yanardag, Birkan, & Bumin, 2004). Exercise was the dependent variable in only one study (Todd & Reid, 2006), which did not directly measure CRF but reported an increase in exercise behavior (distance covered snow shoeing or walking) using a self-monitor board, verbal prompts, and edible reinforcers.

Among youth, PA has been reported to be inversely correlated with body weight and body fat and positively correlated with fat-free mass and aerobic fitness (albeit weakly or modestly) (Janssen & LeBlanc, 2010; Lohman, Hingle, & Going, 2013; Neto, 2013). These findings were partly due to difficulties in measuring PA (Dencker & Andersen, 2008) and the various types of activities, as well as the movement patterns of children (Welk & Blair, 2008). However, physical fitness directly depends on the individual's level of PA (Ruiz et al., 2011). What is important, however, is the notion that time spent (i.e., duration as opposed to level of intensity) in moderate-to-vigorous PA (MVPA) has been shown to be more consistently and strongly related to obesity (Janssen & LeBlanc, 2010). It has been suggested that the focus should be on PA behavior rather than on physical fitness (Cale & Harris, 2002). Evidence suggested, however, that 60% to 75% of all youth, and especially with increasing age, do not satisfy the recommended PA guidelines for gaining and maintaining the health benefits of being physically active (Armstrong, 2013). In particular, very low levels of PA have been reported among youth with disabilities (Hinckson & Curtis, 2013; Seaman, 1999).

The benefits of regular PA for both the general youth population and youth with disabilities include, among others include: (a) building and maintaining healthy bones, (b) muscles and joints, (c) lowering the risk for heart disease, (d) hypertension, (e) type II diabetes (Janssen & LeBlanc, 2010; McTiernan, 2003), (f) improvement in body composition and fitness levels, and (h) improvement in psychological and social functioning (Anderson & Heyne, 2010; Bar-Or, 2000; Goldfield, Adamo, Rutherford, & Murray, 2012; Lohman et al., 2013; Seaman, 1999). For most health outcomes, additional benefits occurred as the amount of PA increased through higher intensity, greater frequency, and/or longer duration (U.S. Department of Health and Human Services, 2009). Anderson and Heyne (2010) reported that the benefits of regular PA for general population youth were amplified in youth with disabilities, especially because these youth were inclined to be less active, be less physically fit, and have a higher prevalence of obesity.

In general, research showed that PA levels of children with ASD were lower than those of their typically developing (TD) peers (Potvin, Snider, Prelock, Kehayia, & Wood-Dauphinee, 2013; Solish, Perry, & Minnes, 2010). Studies investigating the PA levels or patterns of adolescents with ASD (Borremans, Rintala, & McCubbin, 2010; MacDonald, Esposito, & Ulrich, 2011; Pan & Frey, 2005; Pan & Frey, 2006) reported that they had lower PA levels (in terms of both time spent and intensity) not only compared to typically developing adolescents, but also compared to younger children with ASD. As in the case of youth with ASD having significantly higher odds of being obese than other population groups, the reason for their having such low PA levels are also multifaceted and complex. Several factors (or a combination thereof) related to ASD's core and/or concurrent conditions may influence PA behavior. Although sensory and motor impairments are not considered core features of ASD, a high prevalence of these impairments has been acknowledged (Gowen & Hamilton, 2013; Green et al., 2002; Staples & Reid, 2010). The prevalence of motor abnormalities has been reported to be between 21% and 100% in youth with ASD (Green et al., 2002). To be included in activities (and to "practice" social, communication, behavioral, and coping skills learned), these individuals need the motor skills which allow them to be included. The lack of such skills may discourage the individual from engaging in PA—leading to decreases in fitness which may result in obesity. ASD severity, cognitive disability (related to understanding activity/sport concepts and/or directions, compliance, motivation, and persistence), as well as stereotypies, overselectivity, and rigidity of schedule may also prevent these youth from successfully participating in PA (Lang et al., 2010). Additional barriers that prevented youth with ASD from participating in PA include not only socioeconomic and physical barriers but also a lack of opportunities (due to social and behavioral problems and limited availability of sport programs), secondary medical problems, stigmatization and social isolation, overprotective parents/caretakers, as well as screen time (video games, movies, watching TV) “addiction” (Casey, Rasmussen, & Mackenzie, 2010; Grondhuis & Aman, 2013; Holcomb et al., 2009; Kozub, 2003; Riner & Selhorst, 2013).

The negative effects of inactivity are exacerbated by today’s technology-insulated world. Sedentary behavior refers to activities while sitting, such as watching TV, playing video/ computer games, reading, riding in cars, and playing a musical instrument, while screen time refers to time spent in front of a screen (TV, video games, watching movies, computer games, Internet, cell phones, social media, etc.). The negative effects of sedentary behaviors (especially screen time)—not only on health, but also on social, emotional, and academic functioning—have been shown (Forsyth & Jarvis, 2002; Mâsse, Miller, Shen, Schiariti, & Roxborough, 2012). The American Medical Association has recommended no more than 2 hr of screen time per day for children and adolescents (Barlow & Expert Committee, 2007), however, typically developing adolescents have reported using some form of screen time for between 6 and 7 hr per day (Graham, Schneider, & Cooper, 2008). Screen time during childhood has been strongly linked with obesity in the general population (Adamo, Prince, Tricco, Connor-Gorber, & Tremblay,

2009) as well as among youth with disabilities (Grondhuis & Aman, 2013; Johnson, 2009; Pitetti, Baynard, & Agiovlasitis, 2013). These behaviors may track into adulthood (Adamo et al., 2009). Although an emerging field of study, the research available for youth with ASD showed that they spent more in screen time than their TD siblings, as well as other disability groups. Youth with ASD also spent significantly more time in screen time than any other leisure activity (almost 80% of their free time, an average 4.5 hr per day) (Mazurek & Wenstrup, 2013; Mazurek, Shattuck, Wagner, & Cooper, 2012; Shane & Albert, 2008). The reasons for youth with ASD having become "addicted" to screen time are also multifaceted and complex, and many of the same factors that lead to low levels of PA (such as not having the cognitive, motor, social, communication, coping, and/or behavioral skills to successfully participate; being stigmatized or socially isolated; and/or being overweight and unfit and not experiencing PA as enjoyable) also pertained to this population's high levels of screen time. Minihan et al. (2007) quoted a compelling comment from a parent, who stated that, "as a virtual world, cyberspace was for her child the one place where his disability did not matter and could be readily hidden."

The overall health benefits (physiological and psychosocial) of being physically fit (and by implication physically active) during childhood and adolescents are well documented, and with the high prevalence of obesity, low PA levels, and high sedentary behavior among youth with ASD, it is important to find ways in which to get (and keep) this population physically active.

Several intervention techniques have been implemented to teach youth with ASD a variety of skills, including physical/sport skills. Examples of such techniques include physical and/or verbal prompting, demonstrations and modeling, and the use of several forms of reinforcements (for example, verbal praise and rewards in the form of edibles, trinkets, and tokens that could be exchanged for preferred activities). Interventions employed in teaching (any) skills to children are based on specific educational, psychological, and other theories, models, and approaches. The approach that has shown the greatest amount of success regarding behavior modification in children with ASD has been Applied Behavior Analysis (ABA)—the most frequently implemented and best empirically evaluated intervention approach within this population (Matson et al., 2012). Ivar Lovaas, in the early 1960s, applied ABA to children with autism. Subsequently, Siedentrop was the first to introduce this approach to physical education, when he provided practical guidelines regarding its application within the physical education context (Ward & Barrett, 2002). ABA is grounded in the work of B. F. Skinner, who defined the term *operant conditioning* as “behavior controlled by its consequences” and investigated reinforcement schedules and how controlling the delivery of reinforcement influenced learning new behaviors (Wilkins & Matson, 2009; Staddon & Cerutti, 2003).

Using automated systems to reinforce (positively as well as negatively) individuals with disabilities while exercising has been investigated by several researchers throughout the past 45 years, and the most commonly used equipment for such studies has been a stationary bicycle (Caouette & Reid, 1985; Lancioni et al., 2003; Sechrest, 1968). Almost all the research conducted within this field has been with older youth/adults with intellectual disabilities, and reinforcers have included trinkets, food/candy treats, audio, as well as visual stimulation (music, videos, movies, video games). In general, children tend to find sedentary behaviors (such as screen time) more reinforcing or motivating than physical activity and would rather work to be sedentary than to be active (Roemmich et al., 2012). Behavioral engineering systems, in which feedback could either be closed-loop or open-loop, use contingent access to sedentary behaviors to increase physical activity levels (Goldfield, Kalakanis, Ernst, & Epstein, 2000). In an open-loop system, the preferred/selected sedentary behavior is presented after an activity task has been successfully completed. For example, after every 20 min of cycling at a predetermined intensity on an ergometer cycle, 10 min of watching a favorite TV show is afforded to the participant. Closed-loop systems, which involve interfacing exercise equipment with sedentary activities (such as watching TV), have the capacity to measure the physical activity (steps taken on a treadmill, pedal revolutions on an ergometer, or heart rate monitored), determine whether the preset goal has been met, and make the sedentary activity contingent on that physical activity. An example is when pedaling an ergometer cycle at a preset intensity allows for the TV to be on, but as soon as the participant pedals too slowly or too fast, the TV goes off.

Given that youth with ASD tend to be less active and more sedentary than their TD peers, have added “issues” related to exercise or being physically active (such as a lack of motivation and refusal or problems with compliance), and possibly also having a specific form of screen time use as an “obsession,” such a closed-loop feedback system may offer a way in which to initiate and/or increase PA levels among this population. New, innovative, and very affordable technology has greatly reduced the financial cost of such automated sensing-and-control systems, and the physical size of microprocessors and DVD players allows the entire system to be mounted on a stationary cycle. Cycling data can be wirelessly relayed to a laptop for researchers (or parents) to view in real time and can be stored concurrently on either the laptop or a flash drive plugged into the microprocessor.

In two studies in which heart rate was to be monitored by a pulse sensor (clipped onto the index finger) and the reinforcement (TV) was to be controlled by output from a heart rate monitor (via a programmable remote control device), the authors reported interference or compatibility problems that were extensive enough to cause them to forgo the use of heart rate monitors in the studies (Anderson, 2011; Mathieson, 1991). New-generation heart rate monitors have no chest strap and consist of only a thin wristband from which continuous heart rate is sent (wirelessly and in real time) to a smart phone.

Closed-loop systems, with their immediate feedback and reinforcement, have been reported to increase physical activity by eightfold (Saelens & Epstein, 1998), but their use is limited by the fact that they require costly (stationary) physical activity equipment and the inconvenience of connecting them to a TV, DVD, or video game equipment (Goldfield et al., 2000). However, with the latest technological innovations, a closed-loop system could even be created using a small, lightweight, portable pedal/arm crank exerciser that costs under $20 for use by individuals of any age and ability—thus providing for a personalized, age-appropriate, enjoyable activity for all.

Purpose of the Study

The purpose of this study was to assess the efficacy of the contingent use of screen time (watching preferred movies/shows on a DVD) on compliance with a stationary cycling program by three adolescent males with ASD. In other words, could the use of a system that makes watching a favorite DVD contingent on cycling a stationary bicycle be an effective way to get this population to comply with goals for PA (in terms of duration and/or intensity)? Research has yet to examine the efficacy of such a closed system on adolescents with ASD. It was therefore hypothesized that the stationary bicycle system used in the study would result in this population complying with the cycling program implemented in terms of cycling duration and intensity.

Research Questions

Two major research questions were systematically addressed in this study.

RQ1: Did the contingent use of reinforcement (in the form of screen time) increase participants' physical activity compliance (cycling; in terms of duration and/or intensity) above that attained during a baseline phase?

RQ2: Did changing the criterion in addition to the contingent use of reinforcement (screen time) increase the duration and/or intensity of physical activity (cycling) to the extent that the participants met the American College of Sport Medicine's (2010) recommendations for levels of physical activity that enhance health-related benefits?

Independent and Dependent Variables

One independent variable and a total of six dependent variables were evaluated in this study.

Independent Variable

1. Treatment (contingency-based, bidirectional changing criterion video cycling program).

Dependent Variables

1. Time (duration) pedaled during each session.
2. Average pedaling RPM for each session (intensity).
3. Average RPM while pedaling within the target range during each session (intensity).
4. Amount/duration of time pedaled within the criterion range during each session (percentage compliance).
5. Total output per session (time pedaled × average RPM per session).

6. Heart rate before, during, and after each cycling session (multiple measures, indicating intensity).

Delimitations

The study was delimited as follows:

1. The participants were students at the Founders Center of Commonwealth Autism (formerly known as the Dominion School for Autism), which had only male adolescent students enrolled at the time of the study.
2. Adolescents aged 16 to 18 years old were recruited for the study to reduce participant variability.
3. The ASD diagnoses of participants ranged from Level 1 to Level 2 (*DSM-5*).
4. The study was implemented on a daily basis over a period of 5 weeks, with each daily session lasting 15 to 20 min.
5. A regular mountain bicycle mounted on an indoor magnetic bicycle trainer was used in this study.
6. New, innovative, and cost-effective technology was implemented to collect, analyze, and display data, as well as to control the reinforcement (DVD). This entire system was mounted on the bicycle.
7. A credit card sized microcomputer processed all data.
8. Feedback displays (RPM zones and time pedaled) were colorful and animated.
9. A self-monitoring board was implemented for each participant to record his time pedaled during each session.
10. A new-generation wrist heart rate monitor was used to send continuous data in real time to the researcher's smart phone.

Limitations

The following limitations and assumptions may have impacted the outcome of the study:

1. Participants had a broad range of ASD diagnoses and exhibited varying degrees of severity and language ability, which was not controlled for in this study.
2. A small sample size was utilized because only seven students were enrolled in the school.
3. The study did not control for participants' experience in cycling.
4. The study did not control for participants' use of medications.
5. In youth, heart rate formulas using age to calculate maximum heart rate do not have a linear relationship (as it does in adults) with oxygen uptake and thus may overestimate maximum heart rate (Rowlands, Eston, & Ingledew, 1997). Although utilizing the, more accurate, heart rate reserve (HRR) method in this study (da Cunha, Farinatti, & Midgley, 2011) it must be noted that heart rate have large variability and is influenced by several factors, such as emotional stress, fitness level, temperature, time since last food intake, and previous activity. (ACSM, 2010).
6. Proxy reporting by parents and teachers/aides regarding participants' average daily time spent in moderate-to-vigorous activities, as well as their average daily time spent in screen-time activities may not have been accurate.
7. It was assumed that the participant-chosen reinforcer (movie/show) had strong intrinsic value for the participant.

Definitions of Terms and Abbreviations

1. *Arduino*: The programmable circuit board (microcontroller) used in the sensing-actuating control system (SACS).
2. *ASD (Autism Spectrum Disorders)*: A set of complex, heterogeneous, neuro-developmental conditions with severity ranging from Level 1 (“mild”) to Level 3 (“severe”) characterized by persistent deficits in social communication and social interaction, as well as restricted, repetitive patterns of behavior, interests, or activities (American Psychiatric Association, 2013).
3. *Contingent screen time*: When the DVD’s status (playing “normally,” pausing, or shut off) depends on the intensity level (RPM range) of the participant’s pedaling; thus, watching the DVD is contingent on the participant’s cycling compliance.
4. *DVD (digital versatile disc)*: The collective term used in this study for any movie, video, program, or TV show chosen by the participant to watch during the cycling session.
5. *ER (entertainment reinforcement) display*: An 8-inch external DVD player mounted on the handle bars of the bicycle on which the reinforcement (preferred movie/show/program) was displayed.
6. *Feedback display*: A 2.8" touch screen display mounted on the bicycle handle bars above the DVD player on which visual information, in the form of a bar graph and animated bicycle icon, were provided about pedal revolutions per minute and time pedaled, respectively.
7. *FITT principle*: The set of rules that should be adhered to in order to benefit from any form of exercise/physical activity program. It comprises the frequency, intensity, time/duration, and type of the exercise/activity.

8. *HR (heart rate)*: The average beats per minute (monitored for 15 s and then multiplied by 4) at the end of the 1-min pre- and post-cycling session readings, 1 min into followed by every 3 min during the cycling session, as well as at the end of 5-min post-exercise period.
9. *MVPA (moderate-to-vigorous physical activity)*: Considered to be the minimum intensity activity required to produce health benefits. Moderate activity may be equivalent to activities ranging from brisk walking to jogging, dancing, doubles tennis, shooting baskets, recreational swimming, hiking, playing back-yard games, gardening/yard work, moderate house work, etc.) (ACSM, 2010).
10. *Noncontingent screen time*: When the DVD plays continuously during a cycling session (baseline).
11. *PA (physical activity)*: A complex set of behaviors that entail any voluntary bodily movement produced by muscle action resulting in energy expenditure (Dishman, Washburn, & Schoeller, 2001).
12. *RPM (revolutions per minute)*: The number of pedal revolutions per minute cycled/pedaled by the participant.
13. *RPM target range ("green zone")*: The range (5 RPM above and 5 RPM below the actual RPM value calculated, and rounded off to the nearest 5 RPM) predetermined as the criterion/target range for the participant to pedal within during each session—indicated by the "blue pointer" on the feedback display.
14. *SACS (sensing actuating control system)*: The technology system implemented in this study through which data was collected, analyzed, displayed, saved, and used to control the reinforcement (DVD player).

15. *Screen time*: Refers in this study to any/all activities that involve a “screen”— i.e., watching TV/movies/DVDs, playing video/Internet games, browsing the Internet, doing emails/social media/texting on a regular television/tablet/smart phone, etc. (Hardy et al., 2013).
16. *Social validity*: A measurement of the meaningfulness of the goals of an intervention in terms of its social significance, appropriateness, and importance (Wolf, 1978).
17. *TD (typically developing)*: Refers to the general population.
18. *THRZ (target heart rate zone)*: To monitor the intensity at which each participant is pedaling at, a heart rate per minute range was set as the goal to strive for during each cycling session (Ekkekakis, 2009). Calculated as 40% to 70% of each participant’s heart rate reserve (HRR).
19. *TOS (total output per session)*: Indicates a participant’s actual output per session and is calculated as the average revolutions per minute × the average time pedaled per session.
20. *TP (time pedaled)*: refers to the duration of time that the participant cycled/pedaled on the stationary bicycle within the criterion zone.

CHAPTER 2

REVIEW OF LITERATURE

The purpose of this study was to assess the efficacy of contingent screen time (watching preferred movies/shows/programs on a DVD) on stationary cycling compliance in terms of (a) time pedaled, RPM pedaled at, and total output during each session; (b) average time and RPM pedaled within the criterion zones; and (c) heart rate (intensity) pedaled at per session. This chapter presents a review of literature pertaining to the prevalence of and factors associated with obesity, low levels of physical activity, and high levels of sedentary behavior (specifically screen time) among youth with ASD, and relevant literature is examined and critiqued. The theoretical framework underlying this study is defined, followed by an exploration into the area of automated systems of reinforcement and a review of behavioral engineering of activity in the field of exercise/PA, specifically focusing on literature relevant to individuals with intellectual/developmental disabilities. In conclusion, the need to identify feasible, practical, and affordable ways for getting youth, and especially those with ASD, off the couch and active without reinventing the wheel, but instead refining and/or improving existing interventions, is justified.

Epidemiology of Autism Spectrum Disorders

Leo Kanner (1943) first coined the term “autism” for the developmental disorder consisting of markedly abnormal development in social interaction and communication skills that were accompanied by abnormal behaviors and interests. Today, the “spectrum” nature of this complex, heterogeneous, neurodevelopmental condition whose exact etiology still eludes us, has been recognized (Lai et al., 2013). Although specific syndromes, such as Angelman, Prader-Willi, and Rett, have a phenotypic and genetic overlay with autism, both genetics and environment play a role in the cause of ASD (Carter & Scherer, 2013; Samaco, Hogart, & LaSalle, 2005). In defining ASD, the newly published *DSM-5* (2013) collapsed the four previous diagnostic categories (i.e., autistic disorder; Asperger's disorder; childhood disintegrative disorder; and pervasive developmental disorder—not otherwise specified [PDD-NOS]) into the single category of autism spectrum disorder. Three functional levels defining severity were based on social communication and restricted, repetitive behavior (Buxbaum & Baron-Cohen, 2013). A short summary of each severity level follows:

- Level 3 - *Requiring very substantial support:* These children have severe deficits in verbal/nonverbal communication, social interactions, and rigidity in behaviors which lead to impairments in functioning.
- Level 2 - *Requiring substantial support:* These children show pronounced deficits in verbal/nonverbal communication, social interaction, and rigidity of behavior which interferes in a variety of context; occurring often enough and at a level obvious even to the casual observer.
- Level 1 - *Requiring support:* These children require more minimal support. Without support deficits in verbal/nonverbal communication, social interactions, and behaviors may lead to noticeable impairments. These children may be able to communicate in full sentences, but display difficulty initiating social interactions and may display atypical/unsuccessful response to social overtures of others.

The ADDM (2012) reported a 78% increase in ASD prevalence over recent decades with one in 88 individuals in the USA currently reported as being diagnosed with ASD. The magnitude of the increase in prevalence was greater for boys who were 4 times more likely than girls to have ASD, as well as for adolescents aged 14 to17 years (Blumberg et al., 2013). When deciding on participants for this study, these findings were thus taken into account.

Concurrent Conditions in ASD

Compounding and/or additional issues related to the already unique “make-up” and extreme heterogeneity of ASD often result in particular idiosyncrasies that may manifest in different ways/forms unique to each individual (Militerni et al., 2002). In their extensive paper on ASD, Lai et al. (2013) reported that more than 70% of individuals with ASD have concurrent medical, developmental, or psychiatric conditions. These and other authors have noted that the most common concurrent conditions include, but are not limited to: (a) intellectual disability, (b) behavior problems, (c) ADHD, (d) seizure disorders, (d) depression, (e) stereotypies, (f) self-stimulation, (g) motor impairments, (h) sensory stimuli sensitivity, (i) overselectivity, (j) gastrointestinal problems, (k) chronic inflammation, (l) allergies, (m) sleep disorders, (n) eating disorders, (o) obesity, and (p) the negative effects of many psychotropic drugs prescribed (Broder-Fingert et al., 2014; Correll, 2007; Crollick, Mancil, & Stopka, 2006; Cubala-Kucharska, 2010; Magnuson & Constantino, 2011; Memari et al., 2012; Minihan et al., 2007; Talay-Ongan & Wood, 2000). These conditions, individually or combined with one or more others, could impact the acquisition of physical activity skills, as well as influence the motivation for and enjoyment of such activities.

Obesity

Obesity, from a pathophysiological perspective, is a metabolic and morphological disorder that is multifactorial in etiology (Malina, 2001). Contributing factors include diet; PA; psychosocial, behavioral, cultural, and economic issues; molecular, metabolic and endocrine tissue abnormalities; and genotype—as well as their very intricate and complex interactions (Flegal, 1999; Hill & Melanson, 1999; Perrin, Bloom, & Gortmaker, 2007; Zametkin, Zoon, Klein, & Munson, 2004; Turconi & Cana, 2007). Simply stated, obesity is a result of a complex biology (genetic/metabolic/neural)–environment (food habits/PA/sociocultural) interaction (Nammi et al., 2004). Body weight is dependent on the balance between energy intake and energy expenditure. Obesity, therefore, is defined as an excessive accumulation of fat (adipose tissue) due to an energy intake in excess of expenditure (Malina, 2001).

The most commonly used method to measure obesity is body mass index (BMI), calculated as weight in kilograms divided by height in meters squared (Ebbeling & Ludwig, 2008). In adults, weight status is determined directly by BMI. Due to growth and maturation during childhood and adolescence, the CDC (Centers for Disease Control and Prevention, 2013) released sex-specific BMI-for-age growth charts for youth aged 2 to 20 years with specific cutoff points for categories of weight status: overweight is a BMI $\geq$ 85th but $<$ 95th percentile, and obese is a BMI $\geq$ 95th percentile.

The prevalence of overweight and obesity among US children and adolescents in the general population has quadrupled since the mid-1960s. It has been estimated that, currently, 34.5% of children and adolescents aged 2 to 19 are overweight and 17% are obese (Odgen et al., 2014). In addition, adolescents have been reported to be more likely to be overweight than children (Odgen et al., 2006; Eaton et al., 2012).

The consequences of the childhood obesity epidemic pose a great threat to the short- and long-term health of our youth in terms of their physiological, medical, and psychosocial well-being (Dietz & Robinson, 2005). The associated health risks include, but are not limited to the following: type II diabetes mellitus, cardiovascular disease risk factors (including hypertension, lipidemia, atherosclerosis, high cholesterol, and/or elevated serum insulin levels) (Sinha & King, 2009; Speiser et al., 2005), musculoskeletal and orthopedic problems (Schonau et al., 2013; Taylor et al., 2006), gallbladder disease (Dietz & Robinson, 2005), sleep apnea (Dietz & Robinson, 2005; Krebs et al., 2007), asthma (Nammi et al., 2004), depression (Goodman & Whitaker, 2002; Johnson & Taliaferro, 2011), and psychosocial problems (such as low self-esteem, anxiety, and/or being teased/bullied/ stigmatized) (Li & Rukavina, 2009; Muth, 2013**)**. Clustered together, diabetes, dyslipidemia, and hypertension manifest as the metabolic syndrome; the prevalence of metabolic syndrome in severely obese adolescents has been estimated to be as high as 50% (Jasik & Lustig, 2008). Obesity is associated with earlier onset of puberty, which, in turn, is associated with other health issues such as higher incidences of psychiatric disorders, substance abuse, sexual risk-taking, and menstrual irregularities (Graber, Seeley, Brooks-Gunn, & Lewinsohn, 2004). However, it is not clear whether the increased weight comes before early puberty or whether early puberty predisposes to weight gain or both (Jasik & Lustig, 2008). Adolescent obesity also places children at heightened risk of adult morbidity and premature death, regardless of weight status during adulthood (Jasik & Lustig, 2008; Must, Phillips, & Naumova, 2012).

Susceptibility to obesity is largely a genetic factor, but the environment determines whether the phenotype is expressed, and currently more than 600 genes, markers, and chromosomal regions are linked to the obesity phenotype. It is estimated that these genetic factors explain between a third and a half of our propensity for obesity (Speiser et al., 2005). Noteworthy is the fact that identifiable endocrine abnormalities or syndromes only account for less than 1% of cases of obesity (Dietz & Robinson, 2005). Psychosocial factors, low socioeconomic status (with related issues such as single-parent families, parental educational level, food affordability, availability and safety of recreational areas, and healthcare accessibility), as well as too little sleep, and parental obesity are further risk factors for childhood obesity (Dev et al., 2013; Gordon-Larsen, Nelson, Page, & Popkin, 2006; Kipping, Jago, & Lawlor, 2008; Muth, 2013; Poortinga, Gebel, Bauman, & Moudon, 2011; Speiser et al., 2005).

Obesity and ASD. In recent years studies that investigated the prevalence of overweight and obesity among youth with ASD reported prevalence ranging between 11% and 43%, and when compared to the general population, as well as other disability populations, youth with ASD had significantly higher body mass index (BMI) values (Broder-Fingert et al., 2014; Chen et al., 2010; Curtin et al., 2005; Curtin et al., 2010; Eaves & Ho, 2008; Holcomb et al., 2009; Rimmer et al., 2010; Zuckerman et al., 2014). The above-mentioned risk factors and consequences of obesity pertain, in exactly the same manner, to youth with ASD and their families. Some of these factors, however, may be compounded by inherent or concurrent factors associated with the diagnosis. In addition, and especially relevant to this study were the factors related to merely being adolescents. Regarding adolescence, the following factors may be especially pertinent: (a) depression and anxiety (already an issue for adolescents with ASD) that have an increased risk for obesity (Goodman & Whitaker, 2002), (b) teenager dietary "habits" (such as the consumption of sugar-sweetened beverages, energy-dense foods, low fruit/vegetable intake, meal infrequency/snacking) added to the already-existing eating problems associated with ASD (Jasik & Lustig, 2008; Kipping et al., 2008; Krebs et al., 2007; Sinha & King, 2009), (c) being less physically active and engaging in more sedentary behaviors (Grondhuis & Aman, 2013; Hinckson & Curtis, 2013; Reinehr, Dobe, Winkel, Schaefer, & Hoffmann, 2010), and (d) a heightened awareness of the physical self (Eklund & Bianco, 2000). Myles and Simpson (2002) noted that especially children with high-functioning autism and Asperger syndrome were very aware of being different from their peers. Factors related specifically to ASD that may contribute to the complex and multifaceted problem of obesity in this population include, among others, the severity of ASD (Broder-Fingert et al., 2014; Egan et al., 2013; Ho, Eaves, & Peabody, 1997), poor sleep, gastrointestinal disturbances, and the effects of some medications (Correll, 2007; Zuckerman et al., 2014). However, the most important contributors to obesity in all population groups (and ages) are diet and sedentary lifestyle—consuming too many calories and not being physically active (Centers for Disease Control and Prevention; Muth, 2013; Krebs et al., 2007). Noteworthy is the fact that food is often used with children with ASD as a reward by teachers and parents. In addition, parents often find it difficult to set limits around food choices due to having to “pick their battles,” because they feel guilty about all the other things their children are unable to do, or because they attempt to have their child “fit in” with peers by packing a lunch box with (unhealthy) foods such as high-density snacks and soda (Grondhuis & Aman, 2013; Minihan et al., 2007; Strahan & Elder, 2013). Interestingly, Holcomb et al. (2009) noted that youth with ASD are not necessarily obese due to poor dietary habits, but possibly as a result of very low levels of physical activity (in about 50% of this population).

A summary of recent studies that reported on the prevalence of obesity among youth with ASD is given in Table 1. In a recent retrospective analysis of data, Broder-Fingert et al. (2014) utilized the Partners Health Care System Research Patient Database Repository (RPDR) to identify 6,672 children and youth ages 2 to 20 years who had at least one measure of height and weight recorded, from which they calculated BMI. Of this group, 299 youth were diagnosed with autism, 300 with Asperger syndrome (AS), and 6073 were typically developing youth (control group). Four age groups were also identified: ages 2–5, 6–11, 12–15, and 16–20. Multinomial logistic regression was used to compare the odds of overweight and obesity between groups (reported as odds ratios and 95% confidence intervals), and logistic regression was used to evaluate factors associated with overweight/obesity. For the latter, information was gathered on age, gender, ethnicity, insurance type, medication use (five categories), and co-occurring conditions (i.e., congenital, perinatal, metabolic, and sleep disorders). The major findings were that, compared to the control group, youth with autism and AS had significantly higher odds of being overweight (OR = 2.24, 95% CI [1.74, 2.88] and OR = 1.49, 95% CI [1.12, 1.97] for autism and AS, respectively) and obese (OR = 4.83, 95% CI [3.85, 6.06] and OR = 5.69, 95% CI [4.5, 7.21], respectively). Compared to children aged 6–11 years, older children with autism had higher odds for obesity (for ages 12–15 years, OR = 1.87, 95% CI [1.33, 2.63] and for ages 16–20 years, OR = 1.94, 95% CI [1.39, 2.71]). According to the BMI classification, 14.8% of youth with autism, 11.1% of those with AS, and 10.9% of the control group were overweight, whereas 23.2% of youth with autism, 25.3% of those with AS, and 6.3% of the control group were obese. This data indicated that obesity rates were higher than the rates of overweight in both groups of youth with autism and with AS. The authors hypothesized that the dietary patterns and PA levels among youth who had more severe forms of autism and AS resulted in their being more obese than overweight—indicating that the degree of ASD severity may be associated with the degree of obesity (Zuckerman et al., 2014). However, an explanation for youth with AS being more obese than those with autism remained speculative. Only sleep disorders and older age were factors associated with overweight/obesity in this population. Notably, medication was not found to be a factor, and the authors speculated that the study might have been underpowered to detect differences due to the small number of patients who had prescriptions for these medications. Limitations of this study included it being a cross-sectional design (one-off data), only a few determining factors examined, and the control group not matched by age, gender, or ethnicity, as well as the fact that the data were from only one medical center database.

A vast majority of studies have reported that obesity among all youth was a result of low levels of physical activity and high levels of sedentary behavior (especially screen time) (Armstrong, 2011; Bauman et al., 2012; Hamilton et al., 2008; Jago et al., 2010; Laframboise, 2011; Prentice-Dunn & Prentice-Dunn, 2012; Villaire, 2001). Table 1 follows.

Table 1

A Summary of Recent Studies on the Prevalence of Obesity among Adolescents with ASD

Study	Purpose and Description	Sample, Duration, Setting	Statistical Analysis, Measures	Findings, Analysis of Findings
Curtin et al., 2005	Reported on prevalence of OWT in youth w/ ADHD and ASD. Retrospective chart review	140 charts: 98 ADHD, 42 ASD & aged-matched reference population CG (NHANES 1999-2002), ages 3-18; 1992-2003 charts N/A	Descriptive statistics, OWT & OB (BMI)	ASD: 35.7% OWT, 19% OB, ADHD: 29% OWT, 17.3% OB Non-significant values higher for AS. OWT & OB = highest in ASD adolescent group (12-18 yr); Chart review of care clinic thus children from special population and not generalizable, clinically derived diagnosis thus no objective measures, one-time measures.
Curtin et al., 2010	Reported on prevalence of OB in youth w/ ASD. Telephone interview of parents	85,272 children: 454 ASD, age-matched reference population CG (NSCH), ages 3-17; 2003-2004 NSCH data; N/A	Descriptive statistics, chi-square (compare prevalence), linear regression (prevalence odds) Parent reported ASD diagnosis, (BMI), concurrent conditions	ASD prevalence: 1/189, 94% ASD youth had 1+ concurrent condition compared to 17% in CG, ASD OB = 30.4% compared to 23.6% in CG. ASD 40% more likely to be obese than those w/o ASD. Nationally representative data, but parent-reported diagnosis, height & weight.
Rimmer et al., 2010	Reported on OB and related secondary conditions in adolescents w/ IDD. Web-based survey	461 parents of OB adolescents w/ IDD (*M* =1 4.9 yr, *SD* = 1.9) & CG (2007 YRBS) N/A N/A	Descriptive stats, OR, Fisher's exact test (compared weight status & secondary conditions), 1-way ANOVA, Tukey test (post hoc comparisons) BMI, 15 OB related secondary conditions	ASD sig heavier & taller than other disability groups, ASD more likely to be OB and OWT compared to youth w/o IDD: OB—24.6% vs. 13%, OR = 2.19, 95% CI [1.44, 3.31]. OWT—42.4% vs. 28.8%, OR = 1.84, 95% CI [1.28, 2.64]. OWT & OB rates for ASD = 42.5% & 24.6%, respectively, & for adol w/o IDD = 28.8% & 13%, respectively. IDD sig higher prevalence

				of secondary health conditions, especially w/ high cholesterol, diabetes, early maturation. Small no. of minority youth, BMI may be not applicable for some disabilities, parent reported height/weight, only 15 secondary conditions.
Zuckerman et al., 2014	Reported on OWT/OB in ASD youth, ASD characteristics/ comorbidities/treatments. Retrospective chart review (ATN registry)	376 children (majority <8yr), ages 2-18 2008-2012 charts N/A	Descriptive stats, univariate & bivariate methods: chi-square tests, Levene's test (assumption of homogeneity), 1-way Kruskal-Wallis tests, permutation tests (nonparametric), p < .5, stepwise logistic regression (joint associations). BMI, sociodemographics, ASD characteristics (4 diagnostic tests), sleep problems, GI issues, CAM, meds (6 classes)	Healthy weight = 64.9%, OWT = 18.1%, OB = 17%, combined = 34.6%. OB associated w/ sleep problems, melatonin use & affective problems. OB is cause & consequence of many additional problems, majority of youth were < 8 yr.
Broder-Fingert et al., 2014	Reported on OWT/OB in clinical sample of youth with ASD. Retrospective analysis of electronic medical record data (RPDR)	6,672 children: 299 autism, 300 AS, 6073 CG, ages 2-20 2008-2011 RPDR data N/A	Descriptive stats, adjusted multivariate logistic regression, multinomial logistic regression, chi-square, OR, 95% CI BMI, demographics, medication use (5 categories), co-occurring conditions (4 groups)	Autism OWT = 14.8%, OB = 23.2% AS OWT = 11.1%, OB = 25.3% CG OWT = 10.9%, OB = 6.3%, Autism (OR = 2.24, 95% CI [1.74, 2.88]) & AS (OR = 1.49, 95% CI [1.12-1.97]) sig higher odds of OWT than CG. Autism (OR = 4.83, 95% CI [3.85, 6.06]) & AS (OR = 5.69, 95% CI [4.5-7.21]) sig higher odds of OB than CG. OB rates higher than OWT rates in autism & AS. OB rates higher in AS than autism. Older age & sleep disorders = associated w/ OWT/OB

Note: ADHD = attention deficit hyperactivity disorder; AS = Asperger syndrome; ASD = autism spectrum disorders; ATN = Autism Treatment Network; CAM = complementary and alternative medicine; CG = control group; GI = gastrointestinal; IDD = intellectual/developmental disabilities; NHANES = National Health and Nutrition examination Survey; NSCH = National Survey of Children's Health; OB = obese; OWT = overweight; RPDR = Partners Health Care System Research Patients Database Repository; sig = significantly; w/ = with; YRBS = Youth Risk Behavior Survey.

Physical Activity

A distinction has been made between different forms of activity. Physical activity pertains to all modes of movement; it is a broadly used term, heterogeneous in nature, and activity levels vary greatly among individuals (Ortega, Ruiz, Castillo, & Sjöström, 2008; Rauner, Mess, & Wolf, 2013). Physical exercise, a subset of physical activity, has been defined as planned, structured, systematic, and purposeful physical activity—usually with the objective of improving or maintaining physical fitness (Anderson & Jakicic, 2003; Sherrill, 2004). Physical fitness has been described as a set of attributes that individuals have or achieve which are related to their ability to perform physical activity, such as endurance, strength, and flexibility (Krebs et al., 2007). For the purpose of this paper, the term physical activity (PA) was used.

Physical activity has been reported to be the most variable component of a person's total daily energy expenditure (Dishman, Washburn, & Schoeller, 2001) and is categorized in terms of frequency, intensity, type, and time/duration (FITT principles, ACSM, 2010). Several recommendations based on these principles have been made for gaining and maintaining the health benefits of PA in all youth populations (ACSM, 2010; Armstrong, 2013; Mountjoy et al., 2011). However, evidence suggested that 60% to 75% of all youth, and especially as they get older, did not adhere to these guidelines (Armstrong, 2013). In response to the very low levels of PA reported for youth with disabilities, it has been suggested that PA should, ideally, be engaged in on a daily basis for as many minutes as can be tolerated and/or accumulated throughout the day (preferably 20–60 min), and at intensities of 50% to 70% of maximal heart rate (or 40% to 60% of heart rate reserve) (ACSM, 2010; Short & Winnick, 2005). Although PA in youth has been shown to have an inverse correlation with body weight and body fat, and only a weak or modest positive correlation with fat-free mass and aerobic fitness (Janssen & LeBlanc, 2010;

Lohman et al., 2013; Neto, 2013), it is important to note that physical fitness directly depends on an individual's level of physical activity (Ruiz et al., 2011).

The benefits of regular PA for all youth—with and without disabilities—have been extensively studied. It builds and maintains healthy bones, muscles, and joints, and lowers the risk of high blood pressure, type II diabetes, and colon and other cancers (Janssen & LeBlanc, 2010; McTiernan, 2003; Villaire, 2001). Improvements in sensitivity to insulin, lipoprotein profile, immune function, and fitness levels, as well as decreases in chronic inflammation and in body weight/fat (albeit modest) have been reported (Bar-Or, 2000; Escalante, Saavedra, García-Hermoso, & Domínguez, 2012; Lohman et al., 2013; You, Aresenis, Disanzo, & Lamonte, 2013). It is important to note that additional benefits on health outcomes occur as the amount of PA increases through greater frequency, higher intensity, and/or longer time/duration (U.S. Department of Health and Human Services, 2009). In addition to health outcomes, PA participation has been reported to have psychological and social benefits for adolescents, such as building self-esteem; enhancing team-work, reducing anxiety and depression, and improving self-discipline, socialization, and mood levels (Eime, Young, Harvey, Charity, & Payne, 2013; Goldfield et al., 2012; Johnson & Taliaferro, 2011; Villaire, 2001). Participation in PA has been positively related to academic performance as it related to improved cognitive functioning (Singh, Uijtdewilligen, Twisk, van Mechelen, & Chinapaw, 2012). Regular PA's benefits for the general population youth were reportedly amplified in youth with disabilities, especially because these youth had a higher prevalence of obesity, were inclined to be less physically fit, and less active (Anderson and Heyne, 2010).

Physical activity and ASD. As was the case with obesity, adolescents with ASD, once again, seemed to be the worse off in that, not only were their PA levels much lower than those of typically developing youth, but it was also lower (in terms of time spent, as well as intensity levels) compared to younger children with ASD (Borremans et al., 2010; MacDonald et al., 2011; Pan & Frey, 2006; Pan & Frey, 2005; Potvin et al., 2013; Solish et al., 2010). Once again, the reasons for their low PA levels were complex and multifaceted, as well as having been compounded by the core features of ASD and many/combinations of the concurrent conditions. These factors included but are not limited to the following: (a) severity of ID/ASD; (b) cognitive abilities (related to understanding weight/nutritional/ activity concepts and/or directions); (c) behavior problems; (d) social and communication deficits; (e) compliance issues; (f) limited opportunities for PA; (g) sensory and motor impairments; (h) stereotypies; (i) overselectivity; (j) rigidity in schedule; (k) low physical fitness; (l) secondary medical problems (e.g., gastrointestinal problems and epilepsy); (m) effects of medications; (n) sleep problems; (o) lower levels of motivation/persistence; (p) social isolation, stimatization, and/or depression; and (q) reduced coping skills (Anderson & Heyne, 2010; Butte, Treuth, Voigt, Llorente, and Heird, 1999; Casey et al., 2010; Crollick et al., 2006; Gillberg & Billstedt, 2000; Grondhuis & Aman, 2013; Holcomb et al., 2009; Kozub, 2003; Kral, Eriksen, Souders, & Pinto-Martin, 2013; Lang et al., 2010; Lionti, Reid, Reddihough, & Sabin, 2013; Pan, 2009; Reinehr et al., 2010). Additional barriers to participating in PA included economic factors (parents' time and financial constraints), physical issues (neighborhood safety, the (un)availability of extracurricular activities, transportation), the many hours spent in therapy, overprotective parents/teacher, as well as the adolescent not enjoying PA may all influence participation in PA (Anderson & Heyne, 2010; Grondhuis & Aman, 2013; Riner & Selhorst, 2013). Both during and after school, the lack of opportunity has been seen as one of the major contributors toward low PA levels and resorting to sedentary behaviors (Memari et al., 2012; Pan, 2009; Reid, O'Connor, & Lloyd, 2003).

Although motor impairment has not been considered a core feature of ASD, the prevalence of a diverse range of motor abnormalities has been reported (Gowen & Hamilton, 2013; Green et al., 2002; Staples & Reid, 2010). Many studies have reported on motor issues, such as (a) overall fundamental skill delays (Berkeley, Zittel, Pitney, & Nichols, 2001); (b) clumsiness, especially in children with high functioning autism or AS (Reid & Collier, 2002); (c) deficits on most of the five specific neurological subsystems (i.e., fine and gross motor functions, balance, coordination, and oral motor functions) (Noterdaeme, Mildenberger, Minow, & Amorosa, 2002); and (d) gross motor issues such as low muscle tone/strength/endurance and poor stability/gait (Chessen, 2013). Motor skill proficiency is essential for successful participation in PA and sport. Conversely, PA is essential for the development of various motor skills in early childhood. A lack of PA may lead to impaired skills which in turn, might discourage the child from engaging in PA and/or result in withdrawal, and eventually fitness would have decreased—which may result in the child becoming sedentary and/or obese (Cliff et al., 2012). Pahkala et al. (2013) postulated that physical inactivity, rather than being the cause, may be the result of obesity, in that being overweight makes physical activities less fun for overweight children, who then withdraw from such activities.

However, Morgan et al. (2013) found that programs that included learning experiences in developmentally appropriate fundamental movement skills (FMS) were able to significantly improve FMS proficiency even during early adolescence. By doing so, the foundation for future PA participation and subsequent improvements in fitness levels (with accompanied health-related gains) were set. The physical, medical, and social communication benefits of PA discussed in the previous section have been reported to be just as applicable and important to youth with ASD. In fact, Lang et al. (2010), as well as Sowa and Meulenbroek (2012) reviewed the effects of exercise on individuals with ASD and reported positive effects as a result of PA/exercise. In their systematic review, Lang et al. (2010) evaluated 18 studies in terms of sample characteristics, exercise type, instructional procedures used to increase exercise, outcome measures, and research methodology. A total of 64 participants aged 3 to 41 years were included in these studies. A variety of exercise activities were employed—running/jogging was the most common mode of exercise. The most commonly used instructional procedures were modeling and physical guidance. All studies reported improvements in either behavior, academics, or physical fitness/exercise behavior. The majority of the studies reviewed used a single-subject design methodology. Four studies reported improvement in fitness as a result of increased exercise (Fragala-Pinkham et al., 2008; Lochbaum & Crews, 2003; Pitetti, Rendoff, Grover, & Beets, 2007; Yilmaz et al., 2004) and one study employed exercise as a dependent variable while reporting on exercise behavior improvements (i.e., increase in distance walked/snowshoed) (Todd & Reid, 2006). Antecedent exercise has also been shown to improve attention, academic performance, and behavior, as well as reduce repetitive behaviors and aggression in children and adolescents with ASD (Anderson-Hanley, Tureck, & Schneiderman, 2011).

Table 2 summarizes PA studies relevant to adolescents with ASD. In the first study of its kind, Lochbaum & Crews (2003) investigated the viability of cardiorespiratory and muscular strength programs for adolescents with ASD and mild ID. Three participants (ages ranging from 16 to 21 years) participated in a moderate-intensity exercise program consisting of 20 min stationary cycling per session and two participants (ages 16 and 17 years) participated in a weight-training program. All exercise sessions were three times per week for 18 sessions (6 to 7 weeks). Measures employed in this study included: using the power-work-capacity (PWC_{150}) fitness test to determine aerobic fitness (percentage change in resistance required to achieve a heart rate of 150 beats per minute) and one-repetition maximal lifts for three different strength tests. The data from this pre-post-test design indicates that the aerobic fitness values of all three participants increased with between 33% and 50%, and that the muscle strength (all three measures) of the two participants increased with between 12% and 47%. The ages and type/level of disability of the participants, as well as mode of exercise implemented in the Lochbaum and Crews (2003) study closely resembled that of this dissertation study. Limitations of this study were the fact that it had a small sample size, results were based on a single pre-post-test with percentage difference design, and there was no maintenance check. In addition, compliance to the moderate-intensity exercise sessions (set at a very small range of 65% to 70% of age-appropriate maximal heart rate) were based solely on heart rate measures obtained from a wrist monitor during exercise. No mention was made regarding how often heart rate was measured during each training session, nor if pre-post exercise measures were obtained. Furthermore, no information on the speed or resistance settings of the stationary cycle during exercise was reported.

In another intervention (single-subject design) study, Todd and Reid (2006) had three males with ASD (ages 15 to 20 years) snowshoe or walk around a soccer field for nine and 23 sessions, respectively. These activities took place for 30 min at a time, twice per week. Participants were taught to place smiley-face stickers on a self-monitoring board each time a circuit was completed, and verbal cues as well as edible reinforcement were presented by the researchers. The program was divided into three conditions: A (baseline), B (self-monitoring,

Table 2

A Summary of Relevant Studies related to Physical Activity and Adolescents with ASD

Study	Purpose and Description	Sample, Duration, Setting	Measures, Statistical Analysis,	Findings, Analysis of Findings
Lochbaum & Crews, 2003	Intervention study for viability of aerobic & strength program for adol w/ ASD. Within subject design. Moderate intensity exercise program: AT on stationary bike & ST in gym (leg press, low row, chest press, shoulder press, bicep curl, crunches)	5 Ss, ages 16-21, autism + mild ID 12-14 wk, 3x p/w, 3Ss @ 20 min for 6-7 wk AT, 2 Ss < 60 min for 6-7 wk ST) Special school	PWC_{150}, 1-RM for 3 strength tests %change (pre-post)	Aerobic fitness for all 3 Ss increased between 33% & 50%, muscle strength of 2 Ss increased between 12% & 47%. Small sample size, only % change measured, First study of its kind
Pan & Frey, 2005	Assessed PA determinants in youth w/ ASD. Cross sectional design. Parents & Ss wore accelerometers for 7days	30 Ss & parents, ages 10-19, HFA, no ID/behavior problems 7 days accelerometer wear Home/school	BMI, parent & child activity log, Social Support toward PA Scales (pre-post), from accelerometer: CPM & average time in MVPA. ANOVA, correlation coeff, multiple regression analysis	Youth more active than adults (CPM mean = 35% & 44% higher than dad & mom; MVPA = 113% & 198% than dad & mom Youth Age negatively correlated w/ BMI ($r(22) = -.59$, $p < .01$) & MVPA ($r(22) = -.69$, $p < .01$ Sedentary behavior negatively correlated w/ overall PA ($r(22) = -.47$, $p < .01$), Youth age explained 30% & 44% of variance in overall PA & MVPA, & sedentary behave explained additional variance in overall PA. Parent support/ modeling not predictive of PA. Age & sedentary behavior = significant in affecting PA, but not parental support. Cross-sectional design, only HFA, small sample
Pan & Frey, 2006	(Used same sample as above) Assessed PA levels in youth w/ ASD. Cross sectional design. Ss wore accelerometers for	30 Ss, ages 10-19, HFA, no ID/behavior problems 7 days accelerometer wear Home/school	BMI, child activity log, CPM, average time in MVPA, CAAL Independent t-tests, intraclass corr coeff & 95%	Sig diff in PA btwn groups on all PA variables during different periods of time. MS/HS youth less active than younger Ss & less time in MVPA. No consistent patterns in PA regarding day or time period. Only 1 HS S (0.8%) met

	7days. PA measures: weekdays/weekends & w/in day (9-2; 3-6pm, etc)		CI, 2-way ANOVA,	daily recommended PA guidelines while 67% MS & 78% ES did. Cross-sectional design, only HFA, small sample size
Todd & Reid, 2006	Intervention to increase PA SSD- changing criterion design (ABC), Snowshoeing (winter), then walking/jogging. Used self-monitor board, verbal cues, edible reinforce - thinned	3 males, ages 15-20, Severe ASD 9-23 sessions, 2x p/w @ 30 min Special school	Distance walked per session, no. of edibles, no. of verbal cues SSD—visual inspection	All participants increased walking distance & edibles & verbal cueing decreased. Which was prime mediator - edibles, cues? 2 baselines = 2 different places/situations, small sample size
Pitetti et al., 2007	Intervention for efficacy of treadmill walking Between subjects design Ss walked on treadmill, staff logged data daily.	10 Ss (6 males), ages 14-18, 5 CG= regular PE, 5 in TWG had 30 min during PE & during free time/after school. Severe autism 9 months, 3x p/w @ 30 min. Residential facility	Treadmill info (freq, speed, elevation, duration) in daily log, Weekly caloric expenditure, BMI. Descriptive stats (monthly), independent sample tests, t-tests, Effect size calculated, Spearman rank order coeff	Signif increases in monthly frequency, speed elevation, calories expended & BMI of TWG. Valdity of caloric expenditure formula not established, small sample size, high demand on caretaker (recoding).
Todd et al., 2010	Intervention to increase PA SSD—multiple baseline changing criterion design, Self-regulation instruction during cycling (adapted bike/tricycle)	3 Ss (2 males), ages 15-17, Severe ASD 16 wks, 3x p/w @ 30 min Special school	Distance cycled per session, # edibles, goal-setting accuracy, self-efficacy assessed. SSD—visual inspection	Two Ss greatly increased distance cycled, goal setting more accurate w/ 2 Ss, edibles decreased. Small sample size
Borremans et al, 2010	Comparative study: Fitness & PA of AS & TD Cross-sectional design	60 Ss: 30 AS (21 males), 30 age/peer-matched TD, ages 15-21, AS—no ID Over 1 wk Vocational education program	Scores on Eurofit fitness test & PA questionnaires (PAR-Q + Baecke), BMI. Descriptive stats, MANOVA, univariate F-tests, effect size, $p < .05$	PAR-Q: 80% of AS did no PA per week & if they do it's less intense than CG. AS preferred solitary PA. No gender differences Eurofit: AS scored significantly lower on all fitness tests than CG. BMI: similar but AS had much larger range, especially on high end. Cross-sectional, adapted distance run!
MacDonald et al., 2011	Assessed PA patterns of youth w/ ASD Cross sectional	72 Ss w/ ASD: 42 ages 9-11, 30 ages 12-18, Varied ASD levels	PA measures: during-, after school & evening ito sedentary, mod & vigorous	PA decreases, MVPA decreases & sedentary behavior increases as the get older. 43% of children were OWT. Mean time spent in MVPA

	Ss wore accelerometers for 7 days.	7 days accelerometer wear Part of APA intervention study	PA , height, weight, 2 skinfolds (%BF). Psychometric (IQ, verbal &/or nonverbal intelligence, autistic traits). Descriptive stats, ANCOVA,	after school decreases by 10 min for adolescents, but in total they spend about 90 min in MVPA per day, albeit moderate activity. No CG, cross sectional design, good sample
Memari et al., 2012	Assessed PA in children & adolescents Cross sectional, across age Ss wore accelerometers for 7 days.	90 Ss w/ ASD (55 males), ages 7-14, HFA (no behavior issues) 7 day accelerometer wear Special schools in Iran	PA measures: week vs weekend; during,after, & total PA in cpm. CAAL. Descriptive stats, 1-way ANOVA , independent t-tests, paired sample t-tests, Pearson's correlations, multi linear regressions	Substantial reduction in PA levels across adolescent years. Sig diffs btwn age groups for overall PA (F = 4.88, p < .004), PA during weekdays (F = 5.4, p < .020), weekends (F = 3.42, p < .02), school time (F = 4.16, p < .009), school time (F = 4.16, p < .009 & after-school (F = 3.41, p < .02). Children were sig less active in school vs out, & PA declined weekdays vs weekends. Determinants of PA in youth w/ ASD = sedentary behavior, obesity & comorbidities.
Magnusson et al., 2012	Intervention to improve fitness & behavior Pre-post-test Individualized rehab program – input from all stakeholders, exercise w/ great variety	6 Ss (4 males), ages 9-15, Autism & mild ID 8-12 wks, 2x p/w @ 1 hr Clinical setting	HR, BP, BMI, Fitness test (6 ST tests & Bruce protocol AT), Behaviors. No indication of stats used …but has tables w/ mean scores (pre-post)	Overall improvement but sig changes in aerobic fitness (z = -2.201, p < .5) & ab strength (z = -2.207, p < .05). All positive behaviors improved significantly—also social & academic skills. Great idea & pre-testing but sloppy article.
Hinckson et al., 2013	Intervention using PA & diet to improve health of youth w/ ID or ASD. Baseline, pre-, post-test & 24-wk follow-up Collab school-based-based: parents, teachers & students involved. A program to increase PA, diet/nutrition info,	17 Ss total, ages all > 7. 6 had ASD (3 OWT) ASD diagnosis not stated 10 wks (18 sessions), 2x p/w @ 1-2 hr School-based	6-min walk, BMI, waist circumference, proxy PA questionnaire & other qualitative tests on health behaviors (baseline, pre-, post & 24-wk follow-up). Paired t-tests, used Hopkins spreadsheet	Qualitative data = unclear or trivial, 24-wk follow-up = 6-min walk test—all walked an average of 51 m further. Collab is good, small sample size, weather ?

Note: AS = Asperger syndrome; AT = aerobic training; BMI = body mass index; BP = blood pressure; CAAL = Child & Adolescent Activity Log; CPM = counts per minute; HR = heart rate; HFA = high functioning autism; ID = intellectual disability; ES/MS/HS =elementary/middle/high school; MVPA = moderate-to-vigorous PA; PA = physical activity; RM = maximal repetition; ST = strength training; TD = typically developing population; wk = week(s); sig diff = significant difference; Ss = students; TWG = treadmill walking group verbal cueing, plus edible reinforcers—the latter was thinned during this condition), and C (self-monitoring and verbal cueing without edible reinforcers). The result of this changing-conditions-design study indicated that all participants increased their distances covered per session (while verbal cueing decreased) over the course of the intervention. Participants continued exercising without the implementation of these procedures. Limitations of this study included that the exercise program started with snowshoeing but ended with walking (different activity), and that several variables could have been the main mediator of performance. This was a detailed study with ample description of methods, procedures, and prompts.

In a study investigating PA activity patterns, MacDonald et al. (2011) had 72 children with ASD (42 in age group 9-11 years, and 30 in age group 12-18 years) wear accelerometers for 7 days to investigate their moderate-vigorous physical activity (MVPA) and sedentary behavior. Measures obtained included: psychometrics (IQ, verbal/nonverbal intelligence, autistic traits); height, weight, and two skinfold measures; and accelerometer readings. The accelerometer had to be worn for at least 4 days (including 1 weekend day) and for at least 10 hr per day, and the data were reduced to the (preestablished steps counted) categories of MVPA (≥ 376 counts) and sedentary (< 25 counts). Based on the time of day, the data were also divided into the following periods: school time (8:00 am–3:00 pm), after-school (3:00 pm–5:00 pm), and evening (5:00 pm–12:00 am). The results of this cross-sectional study showed that 43% of the children were overweight and as they aged, there was a clear decrease in MVPA, as well as an increase in sedentary activity. Patterns of MVPA, as well as sedentary activity showed significant differences in the total, in school, after-school, and evening patterns. The mean amount of time spent in MVPA after school for the adolescent group was 10 min. However, in total, they spent approximately 90 min per day in MVPA (albeit mainly moderate activity). The study design was well described with clearly presented results, although the cross-sectional design was a limitation.

Borremans et al. (2010) compared physical fitness and PA levels of 30 Finnish adolescents with Asperger syndrome (AS; 21 males and 9 females) with an age- and gender-matched control group (CG). Both groups completed the Physical Activity Research Questionnaire (PAR-Q) and the Baecke Habitual Physical Activity questionnaire, after which the Eurofit battery test was administered. Information from the PAR-Q revealed that 80% of the adolescents with AS did not participate in any PA per week, or if they did participate, it was in less intense PA than the CG. It was also found that the AS group preferred solitary PA, such as walking, swimming, and cycling. Data from the fitness battery showed that adolescents with AS had significantly lower scores than the CG on all fitness subtests. The two groups had similar BMIs, but the AS group had a much larger BMI range, especially on the higher end, than the CG. The major limitation of the study was its cross-sectional design and the fact that the small sample of convenience limited generalization to the broader population.

Sedentary Behavior (Screen Time)

Sedentary behavior has been referred to as activities while sitting and was defined as activities with METs (metabolic equivalent units) of 1–1.5. These behaviors are complex and multifaceted, not limited to a single behavior, and challenging to measure (Hardy et al., 2013). Adamo et al. (2009) also noted that these behaviors may track into adulthood. Examples of sedentary behaviors include the following: reading; visiting/talking with friends; listening to music; doing homework; riding in cars; playing a musical instrument; and watching TV/movies/programs, playing video/computer games, and being occupied on a computer/

Internet/smart phone/tablet. For the purpose of this study, activities that involved any form of electronic (screen) device during free or leisure time were termed screen time.

There has been a sharp increase in the reported use of screen time among adolescents over the past few years. In 2008, a range of 6 to 7 hr of screen time per day was reported for adolescents (Graham, Schneider, & Cooper, 2008), and in 2013 this value had increased to >11 hr per day (American Academy of Pediatrics, Council on Communications and Media, 2013). More recent studies have calculated screen time use by the amounts of downloads, texts sent/received, etc. (Rideout, Foehr, & Roberts, 2010).

Negative effects of sedentary behaviors (especially screen time) affect health, as well as social, emotional, and academic functioning (Forsyth & Jarvis, 2002; Mâsse et al., 2012; Olds, Maher, Ridley, & Kittel, 2010; Pate et al., 2013; Prentice-Dunn & Prentice-Dunn, 2012). Screen time among youth has been strongly linked with obesity (Adam et al., 2009). In addition, watching TV (Olds et al., 2010) and playing video games (Gebremariam et al., 2013; Mellecker, Lanningham-Foster, Levine, & McManus, 2010) have both been associated with increased snacking and sugar-sweetened beverage (SSB) consumption. Other risks related to screen time (more so social media) include cyber-bullying, privacy issues, the accessibility to inappropriate material, the powerful/negative influences of behavior advertisement, “Facebook depression,” and “sexting” (O'Keeffe, Clarke-Pearson, & Council on Communications and Media, 2011). These authors, however, also refer to the benefits of social media in that it allows for socialization, communication and enhanced learning opportunities.

Screen time and ASD. The majority of studies that investigated the sedentary behavior of youth with ASD (using accelerometer counts and/or parent logs for recording screen time/sedentary behavior) have reported high levels of sedentary behaviors (and screen time) in this population (MacDonald et al., 2011; Memari et al., 2012; Pan & Frey, 2006). Although an emerging field of study, research specifically examining the screen time use of youth with ASD have reported these youth to spend more time in screen time compared to their siblings and youth with other disabilities, as well as the fact that it constitutes the majority (up to 80%) of their free time (Mazurek & Wenstrup, 2013; Mazurek et al., 2012; Orsmond & Kuo, 2011; Shane & Albert, 2008).

The reason for the propensity of youth with ASD to engage in sedentary behaviors, including screen-time activities, is also complex and multifaceted in the sense that the interplay between the core features of ASD, concurrent conditions, and the environment (easy access to electronic devices) is very intricate. In their review on the use of touch-screen mobile devices by individuals with developmental disabilities, Stephenson & Limbrick (2013) reported that most of the research done was related to such devices being used as speech generators, as a means of video/audio/pictorial prompting, and as a tool for listening to music and watching videos during leisure/free time. It has been reported that individuals with ASD have a preference for visual media (Shane & Albert, 2008) and that they prefer solitary activities (Borremans et al., 2010; Orsmond & Kuo, 2011). Minihan et al. (2007) stated that many of the same factors leading to low PA levels among these adolescents also contributed to their higher sedentary/screen-time behavior. Some of these factors were: (a) not possessing the cognitive, motor, social, communication, coping, and/or behavior skills to be included in a team or during leisure PA; (b) being obese and finding PA aversive; (c) having screen time, a movie, or a program as an "obsession"; and/or (d) being stigmatized and socially isolated. On the other hand, many video/Internet games with their powerful reward systems and immediate feedback could have addictive properties. In one study examining problem behaviors and game use in boys with ASD, it was found that boys who played certain genres of video games (role-play and shooter games) had significantly higher levels of problematic game use, as well as oppositional behavior (Mazurek & Engelhardt, 2013).

A summary of the three studies reporting on screen time among adolescents with ASD is given in Table 3.

Theoretical Framework

The starting point in the history of interventions in special education was approaches oriented to the students' disability label and not to their individual needs (Browder, 2001). Since then, interventions have evolved through incorporating and/or combining approaches based within, among others, medical, developmental, psychosocial, learning, curricular, motivational, behavioral, cognitive, and functional schools of thought or theories. One of the initial steps in deciding on a research design is to consider one's philosophy and the underlying theory/models (Glass & Hopkins, 1996). The major theoretical foundations of this study are embedded in operant conditioning (the basis of applied behavior analysis) and the behavioral economics (behavioral choice theory), although some principles and aspects of other model/theories were also woven in.

Table 3

A Summary of Relevant Studies Examining Screen Time among Adolescents with ASD

Study	Purpose and Description	Sample, Duration, Setting	Measures, Statistical Analysis,	Findings, Analysis of Findings
Shane & Albert, 2008	Reported screen time among youth w/ ASD Mailed 21-page survey to parents/caregivers Questions on time allotted to screen media, observable behaviors, communicative responses	89 parents of, ages <18yrs, N/A N/A	4 sections: demographics, TV, video & computer use as they relate to nature of interaction among Ss w/ ASD, extent of interaction, & parent perspectives of these behaviors. Qualitative: Frequency responses, percentages & discussion on open-ended questions	Those who spent >3 hr in screen time did so to the exclusion of other leisure activities, 66% had clear preference for animated programs, preferred programs w/ humans tended to be high-energy shows (sports, realistic news), cartoons were favorite movies, many were "Internet junkies", >50% can tune out environmental distractions when in screen time, about 50% verbally/physically imitated programs during/after watching them. Most were higher socioeconomic status, 1st investigation of nature/extent of screen time use
Mazurek et al., 2012	Reported prevalence & correlates of screen time among youth w/ ASD Computer Assisted Telephone Interviewing Purpose: prevalence of various solitary screen-based media; Compared to ID, LD, SL; ASD correlates of screen-based media use	Parents of: 920 ASD, 860 SL, 880 LD & 850 ID; ages 13-17yrs N/A N/A	Screen-based media use, family characteristics, ASD core deficit severity wrt to TV, video games & social media & compared to other disabilities. % calculations & 95% CI, logistic regressions, multivar logistic regression	64.2% of ASD youth spend most time in non-social screen time. Odds of using electronic media or computer games during free time = higher w/ higher cog skills (OR, 1.1) & computer at home (OR, 3.2).60.3% of ASD youth spend most of their time watching TV/videos – same as ID youth. 41.4% of ASD youth spent free time playing video games (also related to higher cognition & access). 64.4% of AD youth did not use email/chat – 2x lower than for LD & SL .No TD controls, parent report.
Mazurek & Wenstrup, 2013	Reported on TV, video games & social media use among ASD & TD siblings Comparative study – parents completed web survey about amount & intensity of screen media use of their ASD & TD siblings, as well as related to participation in other activities	Parents of 202 ASD & 179 siblings, ages 8-18yr N/A N/A	Demographics, time in screen time & other activities, video game use & patterns, problematic video game use. Descriptive stats, Pearson's correlations, Chi-square analysis, ANOVA	ASD youth spent average 4.5 hr /day in screen-time activities (very little thereof in social media) compared to 2.8 hr in non-screen activities. ASD spent signif less time in social media that TD siblings ($F(1,253)= 25$, $p<.001$ for boys, $F(1,118)= 21.2$ $p<.001$ for girls. Boys w/ ASD has signif higher problematic video gaming ($M=38.9$, $SD=11.6$) than TD boys ($M=33.7$, $SD=9.8$).

Note: CI = confidence interval; ID = intellectual disability, LD = learning disability; multivar = multivariate; OR = odds ratio; SL = speech/language disability; Ss = students; TD = typically developing peers/population; wrt = with regard to

In their paper on PA instruction and ASD, Staples, Todd, and Reid (2006) described six guiding principles (person-centered approach, motor behavior as multifaceted, context, choice and autonomy, adaptation, and behaviorism and reflective practice) emanating from several models/theories underlying assessment and instruction of PA to children with ASD. These authors also listed 10 PA intervention strategies for this specific population: familiarization, communication, individualized instruction, structure, prompting, feedback and reinforcement, successful experience, sensory issues, order of activities, and generalization. This study made an earnest attempt to incorporate as many as possible of these strategies.

Operant Conditioning

During the 1920s some behaviorists, including B. F. Skinner, started proposing new forms of learning theories (other than classical conditioning). Behaviorists used learning principles to bring about (observable) behavior change through conditioning (Myers, 2011). Skinner believed that the best way of understanding a behavior was by examining the causes and consequences of an action – a term he coined as operant conditioning in 1938. He distinguished between two types of behaviors: respondent behaviors (occurred automatically or reflexive) and operant behaviors (under conscious control). Regarding the latter, it was the consequences of these actions that then influenced whether or not they occurred again (http://www.bfskinner. org/operant.asp). According to Skinner, operant behavior was behavior “controlled by its consequences”; thus any well-trained operant was, in effect, a habit (Staddon & Cerutti, 2003).

Operant conditioning was based on Thorndike’s law of effect, to which Skinner introduced a term, i.e., reinforcement. Behavior that was reinforced tended to be repeated (strengthened), whereas behavior not reinforced tended to be extinguished (weakened) (Myers, 2011). According to Skinner, responses (an operant) from the environment that followed a behavior could be neutral, reinforcement (positive or negative), or punishment. Positive reinforcement strengthened a behavior by providing a consequence that the individual found rewarding, whereas negative reinforcement pertained to the removal of an unpleasant reinforcer—which also strengthened the behavior (Wilkins & Matson, 2009). Thus, the core "tools" of operant conditioning were reinforcement and punishment. Different types of positive reinforcements were identified: primary reinforcement was when the reward, by itself, strengthened a behavior; secondary reinforcement was when something strengthened a behavior because it resulted in a primary reinforcement (an example being token economy, where a targeted behavior was reinforced with tokens that could later be exchanged for rewards). Skinner and his colleagues extensively explored reinforcement schedules and how controlling the delivery of reinforcement influenced the learning of new behaviors (Wilkins & Matson, 2003).

Applied Behavior Analysis

The discipline of Applied Behavior Analysis (ABA) directly descended from Skinner's work. ABA holds that behavior can be explained in four terms: a conditioned stimulus, a discriminative stimulus, a response, and a reinforcement stimulus (Myers, 2011). The goal of ABA is to look at the conditions causing the challenging behavior (discriminative stimuli) and to introduce a replacement behavior (through shaping and scheduled reinforcement) that could overcome the circumstances producing that challenging behavior. More specifically, it addresses socially significant human behaviors that are objectively defined (Eldar, 2008). In order to identify the environmental variables that maintain challenging behaviors, a comprehensive approach called functional analysis is used to assess the events preceding (antecedents) and following (consequences) the behavior, i.e., information about why a challenging behavior is occurring or why a desired behavior is not occurring (Shippen, Simpson, & Crites, 2003). Thus, functional analysis allows for an understanding of the reasons for certain behaviors, as well as the motivating factors that maintain them to be achieved (Eldar, 2008). Ivar Lovaas applied ABA (more specifically, discreet trial training) to children with autism in the early 1960s, and it became commonly known as the “Lovaas therapy” due to his empirical studies and continued research (Wilkins & Matson, 2009). Among the numerous ASD interventions, ABA is the most frequently implemented and best empirically evaluated (Matson et al., 2012).

Behavioral Economics

Behavioral economics, also called behavioral choice theory, is also grounded in Skinner’s work and is partly based on learning theory, cognitive behavior theory, decision making theory, and economic theory (Epstein, 1998). It thus bridges different approaches to PA intervention and involves understanding factors that influence choices between two or more alternatives. Behavioral economics is a theoretical approach that was developed in an attempt to understand decision making and how time and responses are allocated when options are available (Epstein, Smith, Vara, & Rodefer, 1991). The general principles derived from research based on this theory can be applied to individuals who are sedentary, since, when given the opportunity for sedentary or physical activity, these sedentary individuals reliably choose the sedentary activity (Epstein, 1998). The first general principle deals with choice of an alternative depending on the behavioral cost—the choice of being sedentary is very responsive to cost. Two methods for reducing sedentary behaviors according to this principle are: (1) reducing the accessibility of sedentary behaviors and (2) increasing the cost of being sedentary. A second general principle addresses the fact that the choice and reinforcing value of a “commodity” (being sedentary) depends in part on the available alternative. However, the reinforcement value of the alternative may change over time, or it may be modified by other behaviors (King, Stokols, Talen, Brassington, & Killingsworth, 2002). Several studies have investigated the importance of the strength of reinforcers and how best to identify such reinforcers (Hardman, Horne, & Lowe, 2011). Specifically related to ASD, it has also been suggested that obsessive behaviors appeared to be highly potent reinforcers, that they require no preconditioning, and that they may even be considered primary reinforcers (Charlo-Christy & Haynes, 1998). The third general principle pertains to the fact that giving individuals a choice is important to them for acquisition of a reinforcer. Finally, the fourth principle addresses the fact that choice partly depends on the delay between choosing and receiving the alternative—and reinforcers that are immediately available seem to have a higher value.

When the access to or the option for a certain activity is changed in a choice situation, it often influences other behaviors (Epstein & Roemmich, 2001). According to these authors, and based on behavioral economics, behaviors can be related as substitutes, they can also be complements (occurring together), or they can be independent of each other.

Some individuals find exercise very reinforcing, whereas others find sedentary activities more reinforcing. The reasons and factors associated with this phenomenon have been studied in terms of several variables, such as obesity, accessibility of PA, the “power” (high or low preference) of sedentary behaviors in competing with being active, and the motivation for engaging in activity (how much the activity is liked) (Epstein, 1998; Epstein & Roemmich, 2001). King et al (2002) reported that excessive participation in sedentary screen time activities was one example of environmental factors that constrain/decrease PA levels. When using consequences to modify a response (as per operant conditioning), the effectiveness of a consequence can be increased or decreased by various factors, including satiation, immediacy, and contingency (Staddon & Cerutti, 2003). Finally, it should be noted that the terms “rewards” and "reinforcers" have often, wrongly, been used interchangeably; something can be a reward, but it will not necessarily be a reinforcer (Malone, 2006).

Automated Systems of Reinforcement

The most commonly used exercise equipment in studies exploring automatic delivery of reinforcement has been the exercise bicycle (Anderson, 2011; Caouette & Reid, 1985; Mathieson, 1991; Saelens & Epstein, 1999), although steppers, treadmills, and walkers with switches (Lancioni et. al., 2003) have been implemented on occasion. There has also been a surge in the use of virtual reality technology for this purpose (Reid & Collier, 2002; Schultheis & Rizzo, 2001; Shih, Shih, & Luo, 2013).

One of the main reasons for having systems that deliver reinforcement automatically is the practical advantage of saving staff time. Other advantages of such systems are: (a) they can be cost effective; (b) reinforcement can be immediately delivered depending on criteria set (which are automatically detected), thus curbing the monotony of these activities and possibly increase willingness and/or motivation to engage in them; (c) they are easily accessible and suitable within any school, rehabilitation, and home setting; and (d) they are culturally acceptable/meaningful (Lancioni et al., 2003). With new technological innovations, microprocessors are able to collect and store data, as well as control a variety of electronic media, including small screen devices (such as portable DVD players, tablets, smart phones, etc.), thus affording the participants a wide variety of choices among their preferred activities.

Behavioral Engineering of Activity

Behavioral engineering systems use technology to increase PA while providing contingent access to a sedentary behavior (e.g., watching TV/movies or playing video games). Based on behavioral economics, the strong reinforcing value of these sedentary behaviors allows for their use in motivating individuals to engage in physical activity (Roemmich, Gurgol, & Epstein, 2004). Behavior engineering systems can be open loop or closed loop (Goldfield et al., 2006). In an open-loop system, the preferred/selected sedentary behavior is presented after an activity task has been successfully completed. Closed-loop systems, which involve interfacing exercise equipment with sedentary activities (such as watching TV), have the capacity to measure the physical activity (steps taken on a treadmill, pedal revolutions on an ergometer, or heart rate monitored), determine whether the preset goal has been met, and make the sedentary activity contingent on that physical activity. The advantages of a closed system are the automatic detection of whether the goals (pedal revolutions per minute, duration/time of activity, heart rate criterion set) have been met, and the automatic delivery of the contingent reinforcer (TV, movie, music), which takes place independent of any subjective evaluation. It can be adapted to most indoor exercise equipment and can control many sedentary behaviors/activities. However, there are limitations to such systems in that they are only available to a small range of PA and sedentary activities, as well as to only indoor equipment, and having to connect a TV or VCR/DVD player to the exercise equipment may be cumbersome and inconvenient. Furthermore, there are costs related to exercise equipment. Open-loop systems, on the other hand, are more flexible in that they allow for more types of activities to be targeted, and the reinforcers can be expanded to anything the participant likes/prefers, while access can be regulated by the parent. Limitations of open-loop systems include the fact that their efficacy is dependent on the accurate monitoring and calculations of PA and sedentary behaviors (using pedometers, accelerometers, and parent/participant logs of time spent in PA and/or sedentary activity) and thus a higher researcher/parent burden, as well as the dependence on proper/accurate implementation of the set reinforcement schedule (Goldfield et al., 2000;

Goldfield et al., 2006; Roemmich et al., 2004; Saelens & Epstein, 1998).

With the availability and affordability of new compact computers, other electronic devices, and the "basic" exercise equipment, behavioral engineering (especially the closed-loop system) stands to be "revived." The following section looks at the findings of research on open- and closed-loop systems using ergometers.

Behavioral Engineering Implementing a Stationary Bicycle

In studies with open-loop feedback, access to sedentary activities was contingent on physical activities. The participants (all between the ages of 8 and 12 years) first did physical activities and then, based on activity counts (from pedometers or accelerometers), they were allotted pre-determined periods of TV/VCR/DVD time. They thus "worked for" their TV allowance. Goldfield et al. (2000) conducted their research in a laboratory where they assigned 34 obese children to three groups: during 20 min, if group 1 accrued 1500 pedometer counts on the indoor equipment (stationary cycling, steppers, Twist 'n' Ski, and trampolines), they received 10 min of video games/movies afterwards; if group 2 accrued 750 counts they received 10 min of video games; and a control group had non-contingent access to sedentary behaviors (video games/movies) for the entire 30 min. Contingent access to sedentary activities resulted in children in groups 1 and 2 being significantly more active than those in the control group. Goldfield et al. (2006), Roemmich et al. (2004), and Roemmich et al. (2012) conducted similar studies, but pedometer or accelerometer counts per day were recorded by parents and TV time was allotted based on preset criteria (e.g., 400 counts earned 1 hr of TV). In the home settings, the TVs were all "locked" until parents entered a code or a token that equaled the TV time earned by the participant. In one study (Jason & Johnson, 1995), such a home setting was implemented for a 9-year-old boy with Down syndrome who had been watching TV an average of 6.39 hr per day (baseline measures). Using a “control-the-TV” system designed to count pedal revolutions on a stationary bicycle, 15 revolutions earned him 30 min of TV time. The TV was controlled by a special key, and parents could enter the amount of TV time earned before turning the key (and turning the TV on). After the 30-day intervention, the boy’s average time watching TV per day had decreased to 2.71 hr.

Research among the general population, including those who are obese (ages ranging between 8 and 25 years) during which TV/movies were contingent on cycling a stationary bicycle have either implemented a predetermined RPM criterion (Coleman, Paluch, & Epstein, 1997) or a target heart rate range criterion (Faith et al., 2001) to be cycling in for the sedentary behavior to remain on. Coleman et al. (1997) added a negative reinforcement factor in that, when a participant cycled outside the RPM criterion range, a beeper would sound that would override the music that he or she could hear when cycling within the RPM criterion range. All studies reported increases in PA and decreases in sedentary behaviors following these closed-loop feedback interventions.

Table 4 summarizes relevant studies of reinforcement contingent on cycling with individuals with disabilities. With the exception of one study (Anderson, 2011) all participants had varying levels of intellectual disabilities, ranging from moderate to profound. A total of 50 participants (40 males) participated in these studies, and their ages ranged from 6 to 41 years. Only four studies (Ellis, Cress, & Spellman, 1993; Lancioni et al., 2004; Sechrest, 1968; Shih et al., 2013) included adolescents in their studies. A range of reinforcements were employed; the majority were videos/movies/DVDs, but also included were pictures, trinkets, candy, lights, music/songs, air blowing, excited voices, hand clapping, and vibratory stimulation.

Table 4

A Summary of Relevant Stationary Cycle, Closed-loop Feedback Studies with Individuals with Disabilities

Study	Purpose and Description	Sample, Duration, Setting	Statistical Analysis, Measures	Findings, Analysis of Findings
Sechrest (1968)	Examined whether pedaling a stationary cycle constituted an operant response—compared pedal revolutions during 15 min when pictures/candy/trinkets were dispensed w/ 15 min of no reinforcement	8 children (7 boys), ages 10-19, mod-severe ID; 14 days (during free time); school; home (1 boy)	Descriptive statistics; no. of pedal revolutions during each condition	Considerable margin in favor of reinforcement condition in all but one day (no. of pedal revolutions higher). Slight preference for pictures; No statistics (significant differences?), no individual data, time on cycle relied on taking turns (teacher monitored), short study period
Caouette & Reid (1985)	Compared effects of auditory (music) & visual (colored lights) stimulation as reinforcers to increase cycle ergometer work output (pedal rate). Voltage from dynamo incrementally powered 5 lights at 100 -120% of baseline pedal rate, tape recorder manually switched on at pedal rates above 120% of baseline pedal rate	6 male adults, ages 22-30; severe ID; 7 wks, 5x per wk, 18 min; residential psychiatric hospital	SSD—A-$B_{\text{vis or aud}}$ -B_{comb} –A; pedal revolutions (counter), work output (Watt), HR	All participants increased work output after initial baseline & all but one maintained/increased output under subsequent contingencies. Reinforcement contingencies only effective in 4 participants. Speculated that auditory stimulation may be more effective. HR not very high. ABAB instead of ABBA?
Mathieson (1991)	Examined efficacy of TV (recorded shows/programs) contingent on pedaling a cycling ergometer w/in a set RPM range & participants' rated enjoyment of the activity	3 adults (2 males), ages 30-41; moderate-severe ID; 8^{+} wks, 3x per wk, 30 min session; residential home	SSD—AB – changing criterion w/ bi-directional change. During baseline participant was prompted to pedal for 20 min w/ TV on continuously. Treatment required 20 min pedaling in predetermined RPM zone after	All participants showed increase in duration pedaled (reached 20 min during early treatment). 2 participants increased RPM pedaled at & bi-directional change indicated contingent use of TV improved their exercise behavior. One participant was inconsistent in meeting RPM

			which RPM was increased (when 3 sessions RPM remained in zone). After 3 consecutive criterion changes = bi-directional (RPM decreased) change. DV: duration pedaled, average RPM, time/RPM in zone, pre-post HR & enjoyment per session	zones. Enjoyment ratings were inconclusive. Exercise HR demonstrated slight increase across sessions. Complete data for all DVs shown; participants had choice of TV shows; no HR during exercise; %compliance (HR &/or RPM) unclear
Todd & Reid (1992)	Examined effects of TV (videos) contingent on pedaling cycle ergometer ≥12 RPM (dynamo powered). Verbal encouragement added every 30 sec.	7 adults (4 males), ages 23-29; severe-profound ID—3 lethargic & 3 “energetic”; 8 wks, 4x per wk, 15 min; residential institution	SSD—A-B$_{\text{changing criterion}}$ -A, After 14 sessions, workload was increased (1-1.25 kP) Pedal revolutions (counter), work output (rev/15 min)	Work output increased during treatment & increased kP. No differences between participants w/ different energy levels. No maintenance check, same video each session.
Ellis et al., Study 1 (1993)	Taught adolescents to control exercycling intensity using audible signals from HR monitor. Above upper & below lower THRZ limits had different beeper sounds—no beeping = cycling in THRZ	5 youth (4 males), ages 12-18; moderate ID; 10 weeks, 3x per wk, 10 min (during 45-min exercise session); school	SSD—A-B$_{\text{changing criterion}}$ –A-B Lower limit HR value increased when THRZ was maintained during 3 sessions HR (30-sec digital read-outs recorded by observer)	All participants generally increased pace (HR) to avoid lower limit beeper. Mean HR did not significantly increase from baseline, but session sample HRs’ distribution were highly consistent during treatments. Prompts given were specified, training/learning sessions were included after 1st baseline, only 2 participants received tokens for compliance—no other rewards, no RPM/speed/distance measures.
Ellis et al., Study 2(1993)	Taught older adolescents to control treadmill walking & exercycling intensity using audible	5 youth (3 males), ages 18-19; moderate ID; 6 wks, 5x per wk, 5 min cycling after HR = 130	SSD—1 ABAB, 2 HR changing criteria & follow-up, 2 added music HR (30-sec digital read-outs	All participants increased pace (HR) to avoid lower limit beep. Some increased HR but not RPM. Data too variable & limited to compare

	signals from HR monitor. Outside THRZ limits different beepers sounded—no bleeping = working in THRZ. Music (cassettes) contingent on cycling w/in THRZ were added for 2 participants.	bpm during treadmill walking multi-purpose facility	recorded by observer) RPM (distance) Points (exchangeable for preferred objects) rewarded for HR above lower limits	contingent music & beeper avoidance as pacing motives. Reciprocating handle bars & pedals may affect HR (interplay btwn legs & arms). Unclarity of tasks?
Lancioni et al (2003)	Examined effects of stimulation (music, blowing air, encouraging messages, hand clapping, vibrations) on stepping, stationary cycling, and happiness (smile, laugh, excited vocalizations). While participant walked/pedaled, stimulation was automatically delivered during treatment.	3 male adults, ages 22-26 multiple disabilities (profoundly ID and VI) 4.5 months, 2-4 5-min sessions/day; center for individuals w/ multiple disabilities	SSD—multiple probe design across exercise tools (stepper & stationary cycle) w/ reversal for 2nd tool (cycle) Step contacts & half pedal cycles recorded Sessions videotaped—coded & scored indices of happiness	1 participant did not increase steps & another did not increase pedal rate; however, for each of stepper and cycle, 2 partipants increased activity significantly. Data of 2nd baseline & intervention mirrored previous phases. Happiness indices differences significant for 2 participants. Pre- & during study screening for preferred stimuli, minimal info on study procedures or conditions (ABABAB?), only 5-min sessions.
Lancioni et al. (2004)	Examined effects of stimulation (music, noise from musical instruments, excited voices, hand clapping, vibrations on stationary cycling, stepping, and happiness (smile, laugh, excited vocalizations). While subjects pedaled/walked, stimulation was automatically delivered during treatment.	2 males, ages 14 & 22; multiple disabilities (profoundly ID & totally blind); 7 months, 2-4 15-min sessions/day; center for individuals w/ multiple disabilities	SSD—multiple probe design across exercise tools (cycle & stepper) Half pedal cycles & step contacts recorded Sessions videotaped—coded & scored indices of happiness	Across probes, pedaling for both increased significantly (39-486-900 cycles for one & 381-460-610 for the other). Also steps on stepper increased significantly from baseline to treatment (43-144 for one & 107-173 steps for the other). Differences in happiness indices = significant for both pre- & during study screening for adding preferred stimuli. Little info on study procedures or conditions.

Anderson (2011)	Compared contingent & delayed reinforcement (watching DVD) as it related to time pedaled on a recumbent ergometer in a pre-determined THRZ	9 children (7 boys), ages 6-11; mild ASD 2+ wks, 5x per day (max 60 min) Center for Children with Autism	SSD—alternating AB design. Split-middle technique used to test for changes over phases. In contingent condition, DVD was manually switched on when participant cycled in pre-determined THRZ & switched off if outside THRZ. In delayed reinforcement condition, 1 min cycled = 1 min watching DVD after session. Total time & time pedaled in THRZ were recorded (by study assistant).	6 participants pedaled longer & had positive trends in pedaling in contingent condition—one's average time pedaled was close to 60 min/day. 8/9 participants demonstrated a greater avg amount of time pedaled w/in THRZ during contingent than delayed phase. Only one participant had a very strong negative slope during contingent cycling—not motivated by DVD. "Baseline" measure for THRZ only administered once (1 day before study); used HRR and HR_{max} interchangeably?; DVD list randomly compiled; no script for prompts/verbal reinforcement; good description of split-middle technique.
Shih et al. (2013)	effectiveness of TV (favorite movie) contingent on "effective PA" (V_{PA}) as detected by gyration air mouse from w/in pocket of participants. Air mouse relayed data to control system coded to play videos when above adjustable critical value (V_C).	2 males, ages 16 & 18; obese; moderate-severe ID; 10+ wks, 2-3 sessions/day (3 min ea)	SSD—ABAB. During basline, air mouse was in pocket, no TV & only teacher prompt to be active. In treatment, if $V_{PA} > V_C$, video plays; if not, no reinforcement on TV. Recorded time duration for participant to maintain their PA status (TDMPAS).	Time in PA of both participants increased significantly from A_1 to B_1 (25.88 to 153.62 sec & 32.25 to 158.67 sec, respectively; $p < .01$). Data was mirrored in next phases. Innovative/affordable devices, no description of type of PA prompted to do or study setting.

Note: ASD = Autism Spectrum Disorder; bpm = beats per minute; DV = dependent variables; ea = each; HR = heart rate; ID = intellectual disability; kP = kilo-Pascal; PA = physical activity; RPM = pedal revolutions per minute; SSD – single-subject design; THRZ = target heart rate zone; TV = television viewing; VI = visually impaired; w/ = with; w/o = without.

The research by Ellis et al. (1993) included a pilot study and a second study, and the authors implemented a negative reinforcement (alarm sounding when not cycling in the heart rate range), as well as positive reinforcement (in the second study only) in the form of music/songs playing if participants cycled within the heart rate range. All studies implemented some form of single-subject design. The outcome measure is most of the studies was pedal rates (the number of pedal revolutions, RPM), while two studies (Anderson, 2011; Ellis et al., 1993) monitored cycling within a predetermined heart rate range, and one study (Shih et al., 2013) measured the time/duration of PA. When pedal revolutions were measured, the TV shut off as soon as the participants pedaled below (or above) the predetermined RPM criteria.

Mathieson (1991) conducted a study investigating whether the time and intensity of cycling on an ergometer by three adults with ID could be increased during an exercise program when implementing such a closed-loop system. The study was conducted three times a week over a period of 10 weeks. During a baseline phase, the participants cycled for (or toward the targeted) 20 min while noncontingent reinforcement of watching TV played continuously. The data collected were analyzed to determine an appropriate and individualized level (in terms of duration and then intensity) for the intervention phase to begin. During the intervention phase, participants cycled, first, toward reaching the goal of 20 min of continuous cycling, whereafter intensity was periodically increased when 85% compliance was attained during at least three sessions. While the participants were cycling, the TV remained on as long as they pedaled within their predetermined target intensity (RPM) range, but when they pedaled more than 5 RPM slower or faster, the TV would shut down until the participants resumed pedaling within the target range. Two of the three participants were able to cycle for 20 min at a time, followed by achieving several increases in RPM target ranges. This was a well-planned and well-designed study, but some points of critique are worth mentioning. With regard to percentage of compliance, the author initially defined it as being time cycled within the criterion range, but later descriptions of and tables depicting these scores were based on the percentage of RPM within the target range—one being a time concept, while the other was an intensity (RPM) concept. Due to problems (overheating) experienced with the light sensor placed on the index finger to automatically measure and record heart rate during exercise, only pre- and post-exercise heart rate values could be obtained in this study. No detailed descriptions were given with regard to each session's procedures in terms of timing or types and numbers of prompts and/or reinforcement received by the participants. The word *pedaling* was misspelled (as "peddling") throughout the paper.

Only one study was found to have applied the concept of behavioral engineering with children with ASD. This study by Anderson (2011) included seven boys and two girls aged 6 to 11 years. The author compared the effectiveness of contingent and delayed reinforcement as a motivating factor for pedaling a recumbent stationary cycle within individually predetermined target heart rate zones (at 40–59% of HR_{max}). One day before the study, a continuous incremental "procedure" was administered during which the participant cycled at each level (the cycle had 20 resistance level settings) for 3 min until his/her target heart rate was reached; that was the level at which the participant cycled for the duration of the study. The participants were randomly assigned (cross-over method) to one of two groups that were to receive both treatments for a period 5 sessions. For the delayed reinforcement group, every minute cycled within the target heart rate zone (THRZ) counted towards 1 min of TV/DVD allowance following the session. For participants in the contingent reinforcement group, their chosen DVD played as long as they cycled within their THRZ, but as soon as they cycled below the lower limit of the zone for 20 to

30 s, an assistant (who was monitoring the telemetry heart rate monitor) manually switched the TV off. The TV was switched on again as soon as they were pedaling within their THRZ. The heart rate monitor digitally displayed heart rate every 5 s. A maximum heart rate level was established at 75% HR_{max}—when the participant would be verbally prompted to slow down. The maximum time allotted per session was 60 min; the participants did not have to cycle continuously during this period but could take breaks or stop whenever they wanted to. Initially, the heart rate monitor was used to activate the Entertainer (a device that operates similar to a TV remote control device) into which each participant's THRZ was programmed. However, due to discrepancies between the Entertainer and the heart rate monitor's heart rate zones, the TV would be turned off at different zones than those recorded by the heart rate monitor. It was thus decided to have an assistant monitor the heart rate on the digital display and manually switch the TV off/on when the participant's heart rate was below/in the THRZ. To analyze the data (total time pedaled and time pedaled within THRZ) of this single-subject (alternating AB) design, the split-middle technique was used. Although total time pedaled for the contingent reinforcement phase was longer and at a positive slope, it was not consistent in all nine participants and there were many variations. Two participants had positive trends in pedaling time in both phases, four had positive trends in the contingent phase but negative trends in the delayed reinforcement phase, and three participants had negative trends in both phases. One participant came close to pedaling for 60 min per session, whereas one participant showed a very strong negative trend during the contingent phase (DVD did not motivate him at all). With regard to the duration of time pedaled within the THRZ, six of the nine participants had a positive trend of pedaling in the THRZ during the contingency phase. The average time pedaled in THRZ was higher for eight participants in the contingent phase, whereas one participant's average time pedaled in the THRZ

decreased (from 2.4 min/day in the delayed phase to 0.6 min/day in the contingent phase). Only three participants pedaled long enough within the THRZ to possibly see some type of health benefit. It was concluded that contingent reinforcement was more effective in motivating children to pedal longer in their THRZ than delayed reinforcement. Limitations of this study included obtaining only a single baseline data point and only five data points per group session. Although the authors explained how the THRZ for each participant was calculated according to heart rate reserve method, HR_{max} value ranges were implemented as criteria. Even though there is an overlap in the percentage values for each of these methods, there are definite differences, especially at the low and high ends of the ranges. In addition, had a pilot study been implemented (or the reliability of the equipment been thoroughly tested), the equipment failure (miscommunication between the heart rate device and the TV remote control) could have been avoided. Finally, not much detail was given regarding the exact procedures during the hour-long exercise sessions.

Purpose of the Study

Cycling is an age-appropriate and enjoyable form of physical activity for youth with ASD and has been reported to have positive psychosocial and motor effects on youth with ASD (MacDonald et al., 2011). As was shown in the above literature review, this mode of exercise, albeit on a variety of stationary bicycles, has been implemented in several studies specifically designed to increase PA levels of individuals with intellectual disabilities by using their preferred sedentary activity (screen time) as a form of immediate reinforcement. In an attempt to take into account some specific characteristics of adolescents with ASD, as well as implementing empirically proven strategies and utilizing suggestions from previous studies, this study was a refinement of previous similar studies. Examples of novel features include the following:

1. This was the first known study of its kind with adolescents with ASD; the ASD severity of participants ranged from moderate (Level 2) to mild (Level 1).
2. A regular bicycle mounted on an indoor magnetic trainer was used instead of a cycle ergometer; new, innovative, affordable technology that recorded and relayed data in real time was applied (microprocessor, portable DVD player).
3. The DVD player and feedback display were mounted on the bicycle's handle bars allowing for the entire "system" to be a portable and independent, small-space unit.
4. An animated bicycle moving across the feedback display provided a visual account of time cycled.
5. A self-monitor board (for recording time pedaled) was implemented as an additional visual motivator and to teach self-management.
6. Heart rate was continuously monitored via an application on the researcher's smart phone before, during, and after every session using a light-weight heart rate band that does not require a chest strap.
7. The RPM feedback display had a green zone (RPM criterion, DVD on), a yellow warning zone (5 RPM above and below the green zone, DVD paused), and on the outer sides of the yellow zones, a red zone on each end (DVD shut off).
8. Reinforcement selection entailed input from parents, teachers, and the participants (a choice of at least five DVDs for each participant).
9. An individualized two-item (personal picture) enjoyment rating scale administered before, during, and after each session.

10. A measure for social validity was administered within 1 week after the study was completed.

The purpose of the study was to assess the efficacy of screen time contingent on compliance with pedaling a stationary cycle for three adolescent males with ASD. By measuring and plotting average RPM, time pedaled per session, and total output per session (total number of rotations per session), as well as average time and RPM pedaled within the criterion range, any differences in these dependent variables as a result of the criterion changes implemented during the treatment were visually inspected, analyzed and discussed (including in terms of the FITT principle [ACSM, 2010]). In addition, heart rate data recorded by the researcher were analyzed and reported on in terms of the intensity at which each participant was working. Finally, information gathered on participant enjoyment during each session, body composition (BMI and waist circumference pre-post study), as well as the social validity findings were analyzed and discussed.

CHAPTER 3

METHODS

Introduction

In light of the research discussed in the previous chapter, the conceptual framework for this study was based on the following research findings: (a) physical activity levels of adolescents with ASD were typically lower than those of younger children with ASD (Pan, 2009), as well as than those of their typically developing peers (Srinivasan, Pescatello, & Bhat, 2014); (b) sedentary behavior, especially screen time, has been reported to be significantly higher among adolescents with ASD compared to their typically developing peers (Mazurek & Wenstrup, 2013); (c) youth with ASD seemed to be more prone to obesity—not only in comparison to typically developing youth (Broder-Fingert et al., 2014; Curtin et al., 2010), but also in comparison to youth with other forms of disability (Chen et al., 2010); (d) obesity during adolescence in general has multiple negative short- and long-term medical and psychosocial consequences—and adolescents with intellectual and developmental disorders (IDD, including ASD) have been reported to have a significantly higher prevalence of secondary health conditions (Rimmer et al., 2010); (e) the medical/physiological, psychosocial, and cognitive benefits of regular PA in all youth have been well established (Harris & Cale, 2006), and in addition, exercise/PA in youth with ASD has been shown to improve stereotypical and behavioral problems as well as academic functioning in many instances (Lang et al., 2010); (f) as the result of not only the core deficits of youth with ASD (i.e., social and communication deficits and restricted, repetitive, and stereotypical behavior and interests) but also other concurrent conditions (such as motor impairments, ID, sensory stimuli sensitivity, and behavior problems) and additional factors (unavailability of extracurricular activities, parents' time and financial constraints, transport problems, as well as the adolescent with ASD simply not enjoying PA), opportunities for this population to engage in PA may be severely restricted (Memari et al., 2012; Minihan et al., 2007); and (g) motivational and compliance issues and challenges with youth with ASD in terms of PA have often been reported anecdotally as well as in research (Borremans et al., 2010; Sherrill, 2004). In order to address the issue of motivating this population to be physically active (while still granting them their preferred leisure activity, i.e., watching movies/shows), it was hypothesized that the contingent use of screen time would increase participants' cycling activity compliance (in terms of duration and/or intensity) above that attained during a baseline phase. In addition, by changing the criterion (RPM) during the contingent use of screen time it was hypothesized that the duration and/or intensity of this cycling activity could be increased to the extent that the participants would comply with the ACSM's (2010) recommendations for levels of physical activity beneficial for health. It was further hypothesized that participants would experience screen time being contingent on cycling as an enjoyable form of physical activity.

The purpose of this study was to assess the efficacy of the contingent use of screen time on compliance with a stationary cycling program by three adolescent males with ASD. The following research questions were addressed:

RQ1: Did the contingent use of reinforcement (in the form of screen time) increase participants' physical activity compliance (cycling; in terms of duration and/or intensity) above that attained during a baseline phase?

RQ2: Did changing the criterion in addition to the contingent use of reinforcement (screen time) increase the duration and/or intensity of physical activity (cycling) to the extent that the participants met the ACSM's (2010) recommendations for levels of physical activity that enhance health-related benefits?

This chapter outlines the participants and setting, devices and measures, treatment and design, testing procedures, and data analysis.

Participants and Setting

A convenience sample of three male adolescents with ASD, ages 16 to 18 years, was recruited from a school for children with autism located in the Eastern United States (see Table 5 for a summary of participants' demographic information). This age group was targeted for three main reasons: (a) ASD prevalence studies indicate that a large number of newly diagnosed cases involve adolescents (Blumberg et al., 2013); (b) there is a paucity of studies involving adolescents and young adults with ASD in general, including exercise/PA research (Edwards, Watkins, Lotfizadeh, & Poling, 2012; Lang et al., 2010; McDonald & Machalicek, 2013); and (c) results from the few studies that have been published indicate that this age group seems to be even less active, more sedentary, and more obese than younger children with ASD (Broder-Fingert et al., 2014; Fombonne, 2003; Pan, 2009; MacDonald et al., 2011; Memari et al., 2012; Pitetti, Jongmans, & Fernhall, 1999; Srinivasan et al., 2014).

Inclusion criteria included that participants were 16 to 18 years of age, had been diagnosed as having ASD as determined by the school's eligibility criteria, were able to follow instructions, did not have severe behavior problems, had no medical or physical problems for which participation in physical activity was contraindicated, were able to physically pedal a bicycle, had a preference for screen time (specifically movies/shows/ programs) as leisure activity, and were physically inactive (defined as a lack of attaining continuous daily moderate levels of PA for longer than 15 min). The participants were initially identified by teachers as being physically inactive and predominantly engaging in screen-time behaviors, which was subsequently confirmed by both parent(s) and teachers during a semistructured questionnaire–based interview with the researcher (Appendices B and C).

Table 5.

Demographic and clinical characteristics of each participant.

Characteristic	Participant 1	Participant 2	Participant 3
Age (as of 01/01/2015)	18 y, 3 mo	17 y, 4 mo	18 y, 9 mo
ASD diagnosis	PDD-NOS (mod)	Aspergers (mod-mild)	Autism (mod-mild)
ASD diagnostic/other tests	VABS, WISC, CARS	VABS, WISC, Conners scale	VABS, WISC, Conners scale, ADI-R
Other health, medical, and/or behavioral diagnoses	Moderate ID, very picky eater, sensory problems	Mild ID, ADHD, bipolar	Moderate ID, ADHD, anxiety, sleep problems
Medication(s)	None	ADHD, depression, psychotropic drugs	ADHD, sleep, psychotropic drugs
Height (inches):	61.75	65.0	68.25
Weight (lb)	158.25	195	135.25
BMI	29.2	32.4	20.4
Waist circumference (inches)	36	53	31.5

Note: ADHD = attention deficit hyperactivity disorder; ADI-R = Autism Diagnostic Interview–Revised; CARS = Childhood Autism rating Scale; ID = intellectual disability; lb = pounds; VABS = Vineland Adaptive Behavior Scale; WISC = Wechsler Intelligence Scale for Children.

Initially, five participants were recruited for the study. Two, however, were excluded; one of these students was excluded due to behavioral problems manifesting within 1 minute of cycling during the first two baseline sessions, and the other student was excluded for medical and equipment safety reasons (having a BMI of 51). Both of these students were diagnosed with severe autism, and both were obese.

Participant 1 was an 18-year-old male diagnosed by a physician with moderate PDD-NOS. In addition to his ASD diagnosis, he had moderate ID, was a picky eater (food intake limited to grilled cheese, goldfish, peanut butter and jelly sandwiches, and berry juice), and had sensory problems (especially with teeth brushing and nail cutting). Academically he was functioning at low elementary grade level, but he was able to complete complex and consecutive tasks, as well as identify items across settings. Behaviorally he had a history of noncompliance with instructions, leading to yelling, cursing, and falling to the floor. He was unable to wait and was inflexible with respect to change. Social stories were used to prompt and prepare him for his daily schedule and when any changes in this schedule had to be made. He had a token system in place: five tokens allowed him 5 min of iPad use (his choice was always the musical *Mary Poppins*).

Participant 2 was a 17-year-old male diagnosed by a psychologist with mild-moderate Asperger's syndrome. In addition to his ASD diagnosis, he had mild ID and bipolar disorder. Academically, he functioned near fifth-grade level. His behavioral history was one of noncompliance in following directions, loud vocalizations, aggressive episodes, and property destruction. He did not have a specified prompting schedule, but verbal prompts/reminders and modeling (when needed) were used.

Participant 3 was an 18-year-old male diagnosed with autism by a pediatric neurologist. In addition to his ASD diagnosis, he had moderate ID, attention deficit hyperactivity disorder (ADHD), sleep problems, and anxiety. Academically he functioned at a low elementary grade level—he could only sight-read words, had no reading comprehension ability, and had trouble with complex directions. Behaviorally, he had a history of physical aggression, sexual behaviors, and loud, negative vocalizations. These behaviors had recently decreased, with the most prevalent of the remaining problematic behaviors being sexual. He participated in community events and was consistently compliant with directions. His stereotypies involved engaging in loud vocalizations, clapping his hands, and jumping up and down. This participant did not have a specific prompting or token schedule, but verbal reminders and point prompts, as well as “high fives” and social praise were implemented.

All students at the school were expected to adhere to the “5-second rule”—compliance/ reaction to all request/prompts within 5 s after they are made. None of the participants had been diagnosed in accordance with *DSM-5*. However, based on observation only, the testing director at the school indicated that he thought all participants would fall within a Level 1 classification, with Participant 1 possibly meeting the criteria for borderline Level 2.

Setting

The cycling program was implemented at the school during free time on a one-to-one basis in a designated area with minimal distractions. A teacher accompanied the participants to each session.

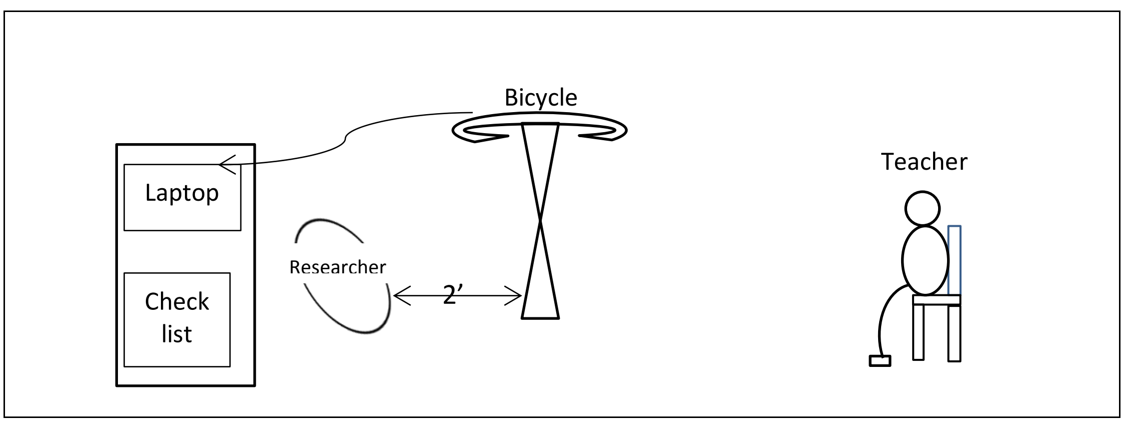


Figure 1. Setting and positioning of laptop, researcher, and stationary bicycle.

Devices and Measures

During this study, measures of the following dependent variables were obtained: (a) time pedaled (TP) during each session; (b) average pedaling revolutions per minute (RPM) for each session; (c) average RPM while pedaling in the target range (and variability—standard deviation); (d) amount of time pedaled within the criterion range during each session (percentage compliance); (e) total output per session; and (f) heart rate before, during and after each cycling session. These variables were directly related to the two research questions addressed in this study.

With the data collected from these sessions, the researcher was able to monitor each participant's performance during every session, and based on the level of compliance with set criteria, decisions were made not only with regard to participant progress throughout the study, but also in regard to the effectiveness of contingent reinforcement (watching a preferred movie/ show) in increasing the PA levels of this sample of adolescents with ASD.

The conditioning phase of any exercise/PA session constitutes the FITT principle (frequency, intensity, time, and type of exercise; ACSM, 2010). Cycling is a continuous, rhythmic, aerobic type of exercise that involves the large muscle groups and is a mode (type) of activity that results in health-related fitness. In this study, cycling sessions took place 5 days a week; thus complying to the ACSM's frequency recommendation of 3 to 5 days per week, as well as to the U.S. Surgeon General's recommendation of 5 or more days per week (U.S. Department of Health and Human Services, 2009).

Stationary Bicycle

A regular 26-inch-frame size, 18-speed mountain bike (Rallye Descent, USA) mounted on an indoor magnetic bicycle trainer (Model 5661, Soozier, China) was used for this study. As per the FITT principle, cycling represented the type (mode) of exercise in this study. The bicycle was mounted at the height where the wheel was "resting" on the roller just as it would on a flat surface without any rider on it; thus no resistance added other than general friction with the surface (see Appendix A for resistance calculations). The training stand afforded total stability to the bicycle which eliminated the need for the participant to have to maintain balance in addition to pedaling. Using a "regular" bicycle was more cost-effective and practical (light weight, storage) than, for example, an ergometer. It also allowed for the participants to potentially, in future, learn how to ride a two-wheel bicycle (by attaching adult training wheels).

If the need arose, the resistance level (using the gears) had to be manually adjusted by the researcher. The gear ratio was initially set at mid-range (front middle chain ring, and 4th rear gear) by the researcher and was manipulated (between the 2nd and 6th rear gears) if needed throughout the sessions to provide for a "comfortable" pedaling rate. For calculating the initial "force" (mass) required to move the pedal downward, a can was placed on the pedal and nails were gradually added until the pedal moved, at which point the weight of the can with nails was measured on a digital kitchen scale. Appendix A gives the mathematical equation for calculating the resistance for different bicycles. The gear setting and any changes thereof was recorded by the researcher during every session.

Saddle and handlebar heights were adjusted (and marked with colored tape for quick adjustment during the program) for each individual participant during the first session—saddle height was set at a position where the knee was bent approximately 5° with the foot on the pedal at the lowest level, and handlebar height was set as "upright" (but comfortable) as possible to prevent closing down of the chest by having to crouch forward (and disrupting/impeding breathing). For the purpose of this study, the knobby tire on the back wheel was replaced by a sleek tire in order to minimize the noise when cycling on the indoor trainer. During Phase A (baseline), additional modifications were made as a result of "issues" that arose with some participants. These were: (a) the bicycle's original seat (narrow style) was first replaced with a broader seat, and then a gel-padded cover was added; (b) the handle-turn-type gear mechanism was taped with black tape so that participants could not change gears while pedaling; (c) the brakes were disconnected to prevent participants from pulling them while pedaling; and (d) a door stop was placed under the front wheel to prevent the participants from turning the handlebars to the left or right.

Sensing-Actuating-Control System (SACS)

New, innovative, and cost-effective technology was implemented for collecting and analyzing the large amount of data needed to give accurate, rapid, and immediate feedback/reinforcement. For the participant to perceive the relationship between cycling compliance and entertainment reinforcement (i.e., the participant receiving reinforcement for the appropriate behavior), immediate and accurate feedback was essential. Figure 2 depicts the SACS architecture. The system basically consists of the following:

- two inputs from one sensor on the bicycle (time pedaled [TP] and RPM),
- the primary and secondary microcontrollers (Arduinos), and
- three outputs to two displays (an RPM and TP feedback display and an external DVD player (controlled by RPM data) used as the entertainment reinforcement [ER] display).

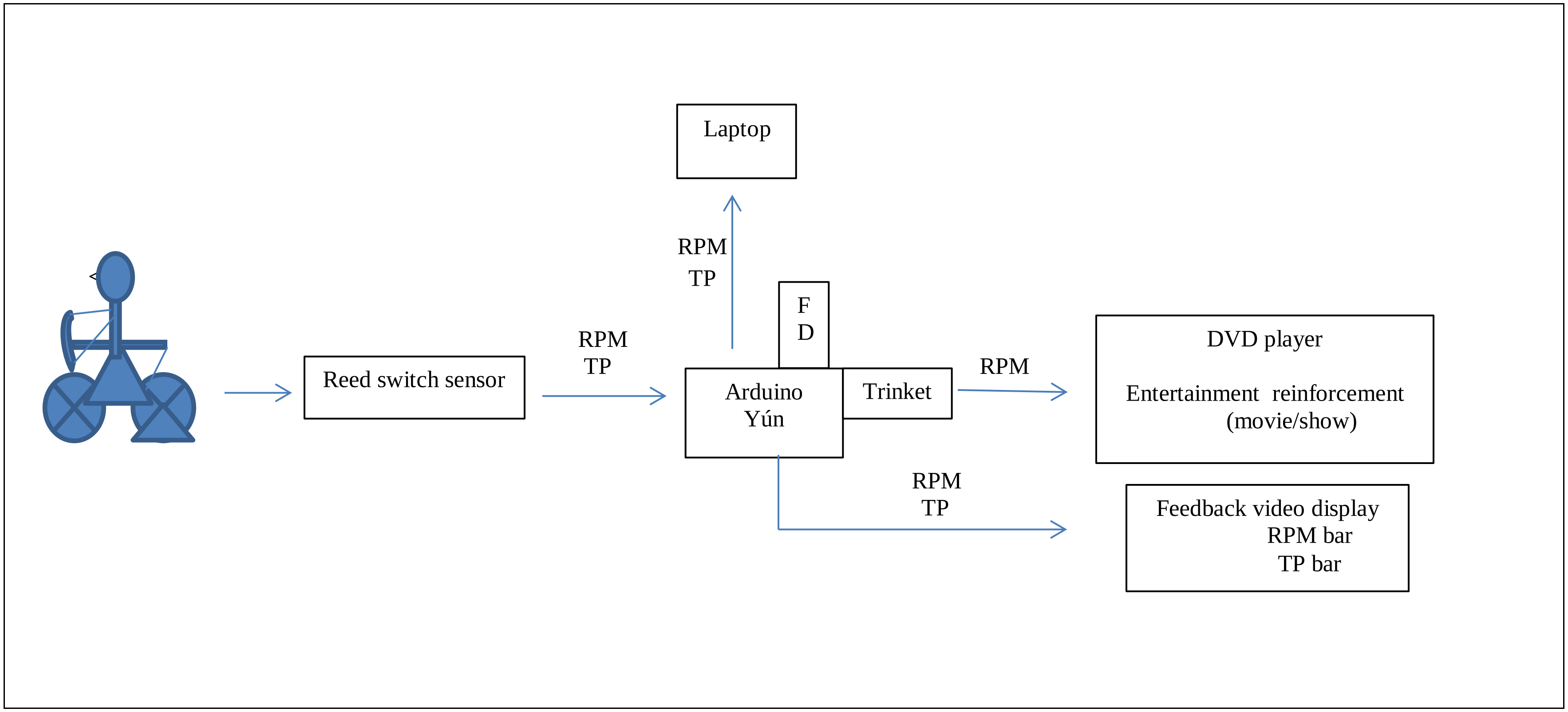


Figure 2. Layout of sensing-actuating-control-system (SACS).

Note. RPM = revolutions per minute; TP = time pedaled; FD = Flash Drive.

The SACS system was placed in a custom-built wooden box that was then mounted onto the handlebars. The mounting block allowed for adjusting the height of the box to a position in which the participant was as upright as possible while still remaining comfortable. Following every session, the researcher analyzed the collected data (TP and RPM) and, based on these results and that of heart rate monitored, made decisions regarding the next cycling session.

Pedal RPM. The rate at which an individual pedals a bicycle pertains to the FITT principle of intensity. For the purpose of this study, heart rate was monitored to gauge the intensity at which participants were "working" (see section titled Heart Rate Monitoring). For monitoring the number of RPM pedaled by the participant during the cycling session, a Reed switch (an electromagnetic motion sensor) was used. A small magnet was attached to the pedal crank and the Reed switch sensor was attached to the frame of the bicycle. As the pedal crank rotated and the magnet passed by, the sensor switch closed. This closing of the switch resulted in current passing through the switch which was detected by the Arduino and treated as the completion of one pedal revolution. The Arduino (via the Reed switch sensor) recorded RPM measures and was coded to perform four actions with these data: (a) it saved the data to a flash drive (phases A and C); (b) it communicated the data (in real time) to the laptop (phases A and C); (c) it displayed the RPM on the feedback display (phases A and C); and (d) it used the information to control the ER display (only during Phase C).

The program was coded to calculate RPM displayed on the feedback display as the average number of pedal revolutions over 5 s (multiplied by 60 to indicate RPM). This allowed adequate time for the participant to respond to the visual RPM feedback given. When a participant stopped cycling (no RPM to record), the program was coded to insert a zero value every 2.7 s for calculating accurate averages. This value was mathematically estimated as being the RPM (speed) at which, if one were riding a (free-standing) bicycle, it would be too slow for the bicycle to remain upright.

During all three phases of the study, RPM data were saved as well as relayed to the laptop; the RPM values were also displayed in the form of a bar graph on the feedback display mounted on the bicycle's handlebars. As the participant pedaled, a vertical blue pointer would move across the horizontal bar graph, which had a central, broad, green "keep pedaling there" band (target zone with upper and lower limits), a yellow "speed up" or "slow down" band (an RPM below or above the target zone's lower and upper limits, respectively), and a red "go faster" or "go slower" section (an RPM range below or above the target zone's lower and upper limits, respectively), in accordance with RPM cycled. (Appendix D). Due to the difficulty of maintaining a single RPM while cycling, a RPM criterion range (green zone) was established.

For Phase A (baseline), the criterion limits were set very wide—i.e., the red zones were set as being below 20 RPM and above 70 RPM; the yellow zones were from 20 to 29 RPM and from 61 to 70 RPM; and the green (target) zone from 30 to 60 RPM. This was implemented in an attempt to make it easier for the participants in this study to "get the feel of" pedaling within the target (green) zone and to experience success at doing so (within a wider target range).The researcher closely monitored the rate at which each participant pedaled and, if necessary, the gear setting could be changed in such a way that the participant did not pedal "too fast" (granny gear) or have to put in too much effort (slow, hard gear) during pedaling. The intention was to find a comfortable pedal rate at which each participant could maximize his success at the task (pedaling within a set RPM range for a set period of time). Gear settings and changes thereof were recorded by the researcher on the study procedure checklist during every session.

Phase B was a short learning/orienting phase consisting of several brief sessions implemented after a trend had been established during Phase A. The initial criterion range (green zone) for this phase was set based on the average RPM pedaled during all baseline sessions. The calculated average was rounded off to the closest 5 RPM, which then became the RPM criterion. The plan was that participants who were unable to pedal for 15 min during baseline would have their criterion set at 5 RPM lower than their baseline average. However, all three participants succeeded in pedaling for 15 min during baseline (Phase A); therefore the RPM criterion for the first part of Phase B (learning/orienting) was (a) first set at that equal to each participant's baseline average and (b) then increased by 5 RPM to "prepare" them for what would be the criterion range during Phase C (treatment). The three (green, yellow, and red) criterion levels were also set at the narrower ranges—as they would be in Phase C. These narrower ranges consisted of a red "go faster" or "go slower" section (> 5 RPM below or above the target zone's lower and upper limits, respectively), a yellow "speed up" or "slow down" (≤ 5 RPM below or above the target zone's lower and upper limits, respectively), and a green "keep pedaling there" (target zone with upper and lower limits 5 RPM to both sides of the criterion RPM value).

During this learning/orienting phase (Phase B), the researcher manually paused or stopped the DVD when participants pedaled outside the criterion (green zone). This allowed the participants to get the feel for what would happen during the treatment phase, as well as the opportunity to comprehend the consequences of pedaling outside the green zone—i.e., for the DVD to play normally, the participant had to pedal at a rate that kept the pointer in the green (criterion zone). Only the selected RPM criteria were recorded by the SACS during Phase B, since manually overriding the program when it was activated would have resulted in the programmed actions (playing, pausing, or stopping) to malfunction.

An RPM criterion range of 5 above and 5 below the predetermined (average during baseline) RPM level for initiating Phase B was set—the target (green) zone. In an attempt to give the participants a “warning” before the entertainment reinforcement display blacked out, the DVD paused when RPM dropped up to 5 below or went up to 5 above (yellow on bar graph) the target zone range. Below or above those (“yellow”) values, the display shut down until the participant resumed cycling within the “warning zone” (pausing), followed by the target zone (DVD playing normally). Two RPM readings in a color zone activated its action (DVD playing, pausing, or shutting off). This was coded into the program to prevent “overload” and consequent back-logging in cases where participants frequently pedaled back and forth between the color zones.

At the end of each session of phases A and C the data from the flash drive were downloaded onto the researcher’s laptop. The Arduino software was programmed to calculate the average RPM and TP (phases A and C), from which the TOS (average RPM × TP; phases A and C) was calculated, the average RPM (and standard deviation) recorded while pedaling within the criterion range (applied only to Phase C), and the percentage of time pedaled within the criterion range during each session (applied only to Phase C). The latter was used as a measure of compliance (percentage compliance) and used for making decisions about changing a participant’s criterion level during Phase C (treatment). The percentage compliance was calculated in the following manner: time (duration) pedaled within the RPM target zone during the session divided by the total TP during the session (then multiplied by 100). When a participant maintained ≥ 80% compliance over three sessions (of which two had to be consecutive sessions), the target zone (criterion level) was increased by 5 RPM. In doing so, the intensity of the cycling activity was increased gradually, and only after the TP criterion was met so that the participant could adapt to these higher intensity levels without physical discomfort (muscle soreness, fatigue, perfuse sweating)—and possibly also start benefitting from the positive continuum of health/fitness benefits with increasing exercise intensity (ACSM, 2010). A minimum number of three data points per session was decided on since research has indicated that this is the minimum number of points needed to establish a trend (Cooper, Heron, & Heward, 2007). When the participant's compliance was between 50% and 79.9% for the current criterion range, no changes were made, and when/if compliance was $\leq$ 50%, the criterion level was lowered by 5 RPM. Employing RPM level changes in increments of 5 allowed for any criterion change (up or down) to still be included within the range of the previous criterion—allowing for a modest, safe, and gradual increase in work intensity. Due to the fact that RPM was not only a more stable measure but also one that provided immediate information about the participant's compliance with cycling within the target zone, it was considered the best measure from which the immediate reinforcement could be controlled.

Some flexibility in terms of percentage compliance were to be employed when, for example, a participant had definite improvements in TP but could not consistently reach the 80% compliance criterion. This value could be lowered (to 75% compliance, for example) to allow for intensity (RPM) to be increased (criterion change implemented) and thus allow the participant to complete the study as designed. However, this lower percentage had to be maintained.

Reliability of the TP and RPM measures was established prior to the study. Initial testing involved the researcher counting the number of pedal rotations she pedaled on the bicycle during a timed minute) at two intensity levels (35 RPM and 70 RPM) for 5 min at each level. These values corresponded 100% with the RPM and time pedaled measures recorded by the Arduino (via the Reed switch sensor). For the final testing, five criterion zones were chosen (lowest-highest) to pedal at for 2 min in each. An assistant pedaled while the researcher counted the pedal rotations made by one leg during the timed 2-min session within each chosen zone. The researcher gave start/stop signals (starting/stopping program at same time). Over the five 2-min sessions at different RPM criteria; the counted and programmed values corresponded at 99.7%.

Time pedaled (duration). The primary focus of this study was to have each participant cycle for a (predetermined) period of time. Time (duration) of exercise comprises the third FITT principle. In terms of the rate of progression in an exercise program it is recommended that during the initial phase, time (duration, i.e., minutes per session) be increased (ACSM, 2010). The total time of the cycling session (from start to end) was monitored by the Arduino (via the Reed switch sensor) during phases A and C of the study. Timing of the session started as soon as the participant started pedaling. In the case where the participant stopped pedaling, zeroes were recorded every 2.7 s of nonpedaling in order to calculate the average TP for the session. This was computed in the following manner: total session time—(total number of zero counts × 2.7). All data collected were saved on a flash drive, sent to the laptop (real time), and sent to the feedback display, where it was displayed as a time line across which a bicycle icon moved as TP passed. The time line had 10 equal (invisible) markings and a yellow smiley-face sticker was placed at the “end.” Each marking represented a fraction of the TP goal set. For example, if the participant was asked to pedal for 10 min, the bicycle icon would move along the markings at a rate of one marking per minute. If the participant had to cycle for 15 min, the icon would move along the markings at a rate of 1.5 min per marking (Appendix E). The yellow smiley face replicated the yellow smiley-face sticker the participant received for his self-monitoring board when he completed the total TP that was set at the beginning of the session (Appendix F). This provided constant visual feedback with a motivational factor embedded for the participant.

During baseline (Phase A) the time line was programmed to accommodate maximum 20 minute pedaling (icon moving at a rate of one marking every 2 min). During the treatment (Phase C) each participant's TP goal was individually selected from the programmed criterion options. The TP information collected by the Arduino was saved on the flash drive and also displayed (in real time) on the laptop. In addition, the information (i.e., how long the participant had been cycling) was sent to the feedback display. Following the cycling session, the data from the flash drive were downloaded and the program calculated and displayed the total time that the participant pedaled (TP), as well as the total time pedaled within the criterion. The researcher used these data (and also took into account RPM and HR information) to make decisions regarding the criteria for the next session.

Using recorded data from both RPM and TP, the total output per session (TOS; average RPM multiplied by average time pedaled per session for both phases A and C) as well as the percentage of the time pedaled within the criterion range (a measure of compliance only applicable to Phase C) were also calculated. A 10-RPM range is somewhat narrow, especially for observing possible changes in standard deviations, and it was therefore decided to incorporate the yellow zones into calculating the compliance rate, as well as the average RPM within the "criterion" (in this case, both the yellow and green zones).

The microcontrollers (processors). One primary microcontroller was used as a data logging and control system in this study. The Arduino Yún (Smart Projects, Italy) is a 3- by 4-inch programmable circuit board that contains a Linux chip, built-in Ethernet and WiFi support, a USB-A port, and a micro-USB slot. To keep the SACS "uniform" it was decided not to employ the WiFi capabilities of the Arduino (keeping everything hard-wired). It received both the RPM and TP input from the Reed switch sensor and was programmed to do the following: (a) store the information on a flash drive, (b) communicate (via USB cable) with a laptop for real-time display of data, and (c) send the relevant information in terms of both RPM and TP to the feedback display (where they were both displayed as horizontal bar graphs). In addition and only applicable to RPM data, the primary Arduino relayed the RPM data to a secondary, smaller, 2-inch by half-inch Arduino Uno (Adafruit Pro Trinket) programmed (i.e., whether the participant was pedaling within the target zone or not) to control the ER display as per the program code. The Arduino Yún was unable to, in addition to all the functions it was coded to do, manage the control of the DVD player, and thus the Trinket was added for the purpose of solely controlling the DVD player. All data reported on were pre-coded using a Python program and the Arduino's Sketch program (which communicated with the Linux chip).

After each session's termination the data were downloaded and measures calculated, all information (RPM, TP, and heart rate values) was analyzed by the researcher, and decisions were made (such as whether or not to change criteria) regarding the individualized protocol(s) of the next session for each participant.

Feedback and entertainment video displays (reinforcement). This study had an entertainment reinforcement (ER) video display (DVD player) and above it a (second, smaller) feedback video display. The external DVD player (Sylvania 9-inch swivel screen) mounted on the bicycle's handlebars and connected via a USB cable to the Arduino played the participants' preferred movie/show/program (referred to as DVD). A small external speaker was used to amplify the sound (earphones were not tolerated by the participants). This set-up was chosen in order to provide a more confined, personal cycling space in which there would be less external distractions (than having the display screen larger but a distance away from the bicycle). It also more closely resembled many of the cycle ergometers used in most community gyms, thus making is culturally meaningful (Caouette & Reid, 1985; Reid & O'Connor, 2003; Schultheis, Boswell, & Decker, 2000).

During Phase A, the ER display showed the DVD continuously. During Phase B, the ER display was manually controlled by the researcher, whereas during Phase C, the ER display was controlled by the Arduino Trinket (regarding when the DVD played nonstop, when it paused, or when the display shut off). Information on RPM from the Reed switch sensor was relayed through the Arduino, which then controlled the movie as per the coded program. For example, if the RPM target range was 50 to 60 RPM, the movie and sound played "normally," but as soon as the RPM value fell below 50 or exceeded 60 RPM, the DVD was paused, and when the RPM value fell below 45 or exceeded 65, a signal was sent to the display causing it to shut off completely. As soon as the participant cycled back up within 5 RPM of the criterion range, the paused movie would come up again, and cycling within the criterion range itself would result in the ER display playing the movie normally again. The pause allowed for a "warning period" before the display shut off—minimizing the frustration of a sudden, immediate shut-down of the movie.

Visual information about both RPM and TP was provided on a small, separate feedback display—a 2.8-inch TFT capacitive touchscreen—above the ER video display. RPM was displayed in the form of a horizontal bar graph with red "go faster/slower," yellow "slow down/speed up," and green "keep pedaling there" (target zone) markings. A vertical blue pointer indicated the RPM at which the participant was pedaling (Appendix D). The colors for the bar graph were specifically chosen as they relate (somewhat) to traffic lights used at intersections. Below the RPM bar graph, TP was displayed as a bicycle icon moving along a horizontal time line from left to right as TP elapsed with a yellow smiley face at the "finish line." The yellow smiley face replicated the sticker the participant received when he completed the total TP goal set at the beginning of the session (Appendix D). This provided for constant visual feedback and motivation for the participant.

Heart Rate (HR) Monitoring

A fourth aspect of the FITT principal within this study is that of intensity (as already mentioned under RPM heading). HR is a physiological parameter that is able to detect changes in exercise intensity, even when movement patterns differ greatly (Crouter, Albright, & Bassett, 2004). Monitoring HR has often been used as a practical, valid, and reliable alternative to VO_{2max} as a means of establishing exercise/PA intensity levels (ACSM, 2010). For the purpose of this study, the (more accurate) formula of Gellish et al., 2007 was used to estimate HR_{max} (206.9 – [0.67 × age]), since the most commonly used prediction equation (220 – age) has a high degree of variability, notably that of overestimating HR_{max} in youth (Hills, Byrne, & Ramage, 1998). This value was then used to calculate a target HR zone (THRZ) for each participant using the heart rate reserve (HRR) method (ACSM, 2010). The rationale for using HRR was that the method took into account resting HR, and not doing so would underestimate the exercise workload (da Cunha et al., 2011). HRR has been proven an acceptable method for establishing HR zones in youth and has been used in several studies with this population (Scruggs, Beveridge, & Clockson, 2005; Stratton, 1996). HR data was used by the researcher to monitor whether the participants were moving toward or exercising within 40–70% of their respective individual HRR. This range was decided on based on several factors. Exercise intensity of a 40% (low) to an 85% (high) HRR range has commonly been recommended for the general population (ACSM, 2010) and “moderate” activity has been described as that done at between 40% and 60% of HRR (Ekkekakis, 2009). Taking into account that this study’s participants had been identified as having low PA levels and being sedentary (thus having low fitness), a 40–70% HRR was deemed as being a safe and attainable goal (including minimizing or avoiding any negative effects of exercise, such as muscle soreness, profuse sweating, etc.) to strive towards while the upper end of the range still fell within the range commonly prescribed to the general population.

To calculate HRR, resting HR (RHR) is subtracted from HR_{max}. Each participant's RHR was palpated for 15 s (and multiplied by 4) by a parent first thing in the morning after the participant awoke, and the parent reported the measure to the researcher. These values were confirmed by the researcher, who monitored (palpated for 15 s) HR over 3 days at school during "quiet time" (reading or watching TV). RHR for each participant was calculated as the average of the four values obtained. The THRZ was calculated as being the values (beats per minute) between the lower limit (40% × HRR + RHR) and the upper limit (70% × HRR + RHR) (ACSM, 2010).

When designing the study it was envisioned that an HR pulse sensor (ear lobe or index finger) would be used to monitor HR before, during, and after every cycling session. This sensor would relay HR data to the microcontroller (Arduino), which would calculate average HR before, during, and after each cycling session, store it on a flash drive, and also send it to a laptop for real-time inspection by the researcher. However, when testing the equipment prior to the study, it was found that the reliability coefficient for HR data received by the pulse sensor versus that monitored by palpation varied greatly and was consistently low (< 0.6). Literature has mentioned several limitations of HR monitoring during exercise/PA studies, such as securing the device, mode of exercise, and body position, as well as hydration level, stress, gender, and fitness status of participants (Crouter et al., 2004; Rowlands et al., 1997). In addition, neither of the two adolescents with ASD who participated in the pilot study tolerated any of the pulse sensors (neither ear lobe nor index finger). Youth with ASD refusing to wear HR monitors had also been reported by some researchers (Pitetti, Rendoff, Grover, & Beets, 2007). It was therefore decided that, for this study, HR would be monitored using either of the following methods, as tolerated/accepted by the individual participant: wristband monitor (Mio Link, www.mioglobal.com) or manual palpation (researcher using stethoscope or index finger on the participant's wrist). These methods would also be more feasible for teachers/ parents to use at school/home in the future. In addition, if, as envisaged for future use, participants were playing computer/video games (instead of watching movie/show) contingent on cycling, having a HR sensor on the index finger would not be practical.

During the first baseline (Phase A) session, the researcher presented the wristband to each participant, explaining that it measured his heart beat and requesting permission to put it on his wrist. All three participants tolerated the wristband with ease for the entire duration of the study. The wristband sent continuous HR data (via Bluetooth) to an application on the researcher's smart phone for immediate display (no storage of data). During Phase A (baseline), HR values of the wristband were recorded and then compared to simultaneous manual measures (wrist palpation for 15 s and multiplied by 4) by the researcher taken at the following times: (a) 1 min before and 1 min after the session; (b) 1 min into, followed by every 3 min during the cycling session; and (c) 5 min after the session to allow adequate time for HR recovery as suggested by Singh, Rhodes, and Gauvreau (2008). Both values (wristband and palpation) were recorded on the study procedure checklist (Appendix G) and corresponded with each other within 5 beats. For the remainder of the study, only the wrist monitor was used for obtaining HR values before, during, and after exercise. At the beginning of each week, the researcher confirmed the reliability of the wristband values by comparing them with values taken randomly during the session from wrist palpations.

After each session the preexercise and 5-min post-exercise values as well as upper and lower range values were entered onto a spreadsheet from which the average exercise heart rates were then calculated.

HR was not only monitored as an indicator of the extent to which the contingent entertainment reinforcement was effective in increasing the participants' pedaling intensity levels, but also as a safety measure. If, at any time during the study, a participant's HR were to exceed 75% of HRR for longer than 3 consecutive minutes, the participant would be requested to "take it easier" and if his HRR continued to exceed 75% for another 3 min, the session would be terminated.

Visual Motivators (Digital Timer and Self-Monitor Board)

As an additional visual motivator, and because the participants consistently used timers during the school day, each participant's personal timer was placed on a table adjacent to the bicycle's handlebars. However, during baseline it was soon noticed that the participants did not take any notice of the timer and that the moving bicycle icon (indicating progress in TP) was an adequate visual motivator by itself. The use of a timer was thus eliminated from the study. Against the wall closest to the bicycle, the participant's self-monitor board was placed. At the very end of each session, each participant placed on the board either a smiley-face sticker (if TP goal was obtained) or a colored sticker with TP recorded on it by participant, teacher, or researcher (Appendix F). As soon as the participant had a specified number of consecutive yellow smiley-face stickers on his self-monitor board, he would receive a token or choice activity (in accordance with the individualized token system used to reinforce compliance for each participant at the school). Participants also received verbal praise and encouragement from the researcher (“good job,” “perfect!,” and nonverbal “thumbs-up”) on their progress in TP (as related to the self-monitor board). The implementation of a self-monitor board had previously been reported as having a positive effect on increasing PA levels of adolescents with severe ASD (Todd & Reid, 2006).

Choice of Entertainment (Reinforcers)

From the semistructured questionnaire–based interviews with parents and teachers (Appendices B and C), as well as from the initial meeting and subsequent informal conversations with the participants, a list (and library) of preferred movies/shows/programs (available on DVD) was compiled. For the purpose of this study, the term “DVD” was used to refer to these entertainment reinforcers. At the beginning of every cycling session, the participant selected his DVD of choice to be watched during that session. It was also explained to each participant that no changes could be made in terms of DVD decisions during a cycling session and that changes or different choices could only be made at the start of the next cycling session.

Within the first two baseline sessions, the researcher realized that the participants had a difficult time choosing a preferred DVD from their individualized lists (all three participants’ teachers had to step in and “help” with making a final choice), so a single sheet of paper was divided into six or eight equal squares onto which images of the DVD covers of the participants favorite DVDs were placed. This provided for a more “organized’ and visual presentation of choices. Participant 1 had no interest in ever watching anything but *Mary Poppins* (the musical movie), whereas Participant 3’s eight choices consisted of only movies involving SpongeBob Squarepants. Participant 2 chose one movie that he watched over a period of approximately four sessions, after which he then chose a second movie, followed by a third, fourth, and fifth movie to watch from start to finish.

Additional Measures

Entertainment display (DVD) actions. Ideally, as participants become more familiar with the cycling activity, the only “prompts/cues” that should be necessary for them to remain cycling within the set green (criterion) zone, would be the DVD actions (i.e., playing normally, pausing, or shutting down). As a matter of interest/curiosity, and to further determine whether the treatment had a positive effect on the cycling activity behavior of the participants, the researcher counted the number (and types) of actions performed during each criterion change (Phase C) by the DVD player (i.e., how many times it was paused and how many times it shut off). This was done by manually going through the data files generated by the computer program during each session. For each session (and participant) this information was tallied in terms of: (a) the number of times the DVD was shut off (participant pedaling in the red zone – either on the low, or the high end); (b) the number of times the DVD was paused (participant pedaling in the yellow zone—either on the low, or the high end); and (c) how many times the participant “overcompensated.” The latter was defined as when a participant’s pedaled rate increased/decreased from one extreme to the other in quick succession, thus over compensating for one action that lead to a similar action, but at the opposite extreme. These back-and-forth spurts could entail several “pendulum” swings directly after each other, and were tallied as one “overcompensation” (type) of action. For example, when the DVD paused as a result of the participant pedaling too slowly (pointer in low yellow zone), he would over compensate by rapidly speeding up, over-shooting the green zone and suddenly be pedaling in the high red zone (resulting in the DVD to shut off), which then led to the participant stop pedaling all together, sending the pointer into the low red zone (DVD off), etc. One continuous series of such over compensations were tallied as a single "overcompensation." With regard to tallying the number of times the DVD paused/stopped, only these actions were tallied and no indication was given (during scoring) whether this action was due to the RPM (as per the pointer) was too high or too low.

Level of enjoyment. For regular exercise/PA to be sustained over time and be embedded as part of an individual's regular (daily) leisure activities, it was important that participants experienced these activities as enjoyable. Prior to, during, and after each cycling session (phases A and C), a qualitative, informal assessment was made to gauge each participant's enjoyment of the cycling activity. A two-item picture scale was implemented (to which the participant pointed or verbally answered) for indicating the level of enjoyment experienced from the cycling activity: the first picture/photograph (scored as a two) depicted the participant happy/laughing while the second picture/photograph (scored as a one) depicted the participant as being unhappy/cranky. For this study parents provided two (facial) pictures of their sons that were used to individualize each participant's scale (and to personalize it): one depicting the participant laughing, and the other depicting the participant being not happy/cranky. The lead teacher administered the scale (in "happy", as well as "not happy" situations) with each participant on several occasions during the week prior to the start of the study to show that the participants were able to "express" their happy/not happy emotions (see Appendix H for an example). Similar photographic pictures (however not personalized) have been used for teaching emotions in educational settings (www.keyeducationpublishing.com). Mathieson (1991), who studied adults with intellectual disabilities, implemented a three-item enjoyment scale in which three icons ("stick-figure faces") were depicted: a smiley face, a "neutral" face, and a sad face. For the current study, it was decided, as was suggested by Mathieson (1991), that a choice be limited to "happy" or "not happy" only. In addition, the school at which the study was conducted uses an educational DVD (www.myworldlearning.com) to introduce their students to the concepts of expressing emotions (through the characters of Mr. Smiles, Mr. Cranky Pants, and Little Miss Sad). Additionally, if the participant stated or nonverbally indicated (such as a shrug of the shoulders) that he "did not know" or was "not sure," a zero score was allotted. These scores were recorded onto the study procedure checklist (Appendix G), and at the end of the study, they were tallied to evaluate to which extent the participants enjoyed the cycling activity.

In addition, and to obtain a "global" level of happiness for that day (before and after the cycling session), the accompanying teacher "signed" a score (2 for a good day, 1 for a bad day, and 0 (zero) for a "nothing-out-of-the-ordinary" day) to the researcher on entering the exercise room. Within an hour after the session, the researcher would go to the same teacher's classroom and obtain another global happiness score from the teacher in a similar manner. These score were both recorded on the procedure checklist. Broadly defined, a "good day" (score of 2) was an indication that the participant was having an above-normal day in terms of mood, being focused, remaining on task, and/or requiring fewer prompts/reminders. A "bad" day (score of 1) indicated the participant being in a bad mood, not focused, off task, etc., whereas a zero score/sign indicated "nothing-out-of-the-ordinary."

For the purpose of data analysis, these scores were rescored so that a 2 represented a "happy"/good day, a 1 indicated a "not sure"/ordinary day, and a 0 indicated a "cranky"/ bad day. Both participant and teacher pre-exercise scores were plotted. The participant's during- and after-session scores were added together and plotted with the teacher's post-session score (which was multiplied by 2).

Total MVPA and screen time (ST) per day. From information gathered in the questionnaires administered by the researcher to parents and teachers, total moderate-to-vigorous PA (MVPA) per week and total screen time usage per day was calculated. Average MVPA, as well as screen time usage per day was calculated as follow: [5(parent + teacher weekday choices) + 2(parent weekend choice)] ÷ 7. Most-to-least preferred forms of screen time (such as movies, TV, video games, Internet, social media, etc.) were also tallied and summarized to determine trends. In addition, teachers provided the individualized reinforcement and prompting schedules of each participant—the researcher implemented these throughout the study to maintain consistency with an already-established schedule for each participant. Doing so also ensured familiarity for the participant (as well as made it easier for the researcher to have an established schedule already in place).

Body composition. Each participant's height and weight was measured by the researcher at the college gym where the students attended swimming pool sessions twice a week. Both weight and height were measured on an electronic scale-stadiometer unit (Health O Meter Professional, Model # 500KL; Pelstar, USA) with participants wearing only their swimming trunks and a T-shirt. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters and weight status was determined using the Centers for Disease and Control and Prevention's (CDC) sex-specific BMI-for-growth charts (Centers for Disease Control and Prevention, n.d.). Although BMI has been found not to be a good predictor of percentage body fat (Reed, Buck, & Gronbech, 2010) and often showing no change with improvements in aerobic fitness (Millard-Stafford et al, 2013), its reliability is high (Artero et al, 2011) and it has been described as the best available tool to screen for obesity (Ebbeling & Ludwig, 2008).

In addition to, and at the same time that height and weight was being measured, waist circumference (WC) was also measured by the researcher (this was tolerated by all three the participants). A cloth tape measure was used to obtain a single measure of WC taken at the level of the umbilicus. This method ensured minimum subject burden—the belly button is easily located and the single measure can be taken quickly, thus reducing being exposed and/or touched for too long. WC is strongly associated with visceral adipose tissue, subcutaneous abdominal tissue, and trunk fat (upper body fat) which carry an increased risk of obesity-related comorbidities (Thomas et al., 2013). It has been identified as an emergent measure of abdominal/central fat—an indicator of regional fat distribution (Guedes, 2013). When WC is combined with BMI it provides for a more accurate prediction of percentage body fat in youth (Aeberli, Gut-Knabenhans, Kusche-Ammann, Molinari, & Zimmermann, 2013). WC is non-invasive, easily implemented (requires only a tape measure and a single measurement), inexpensive, highly sensitive, recommended for use with very obese individuals, has minimal subject burden, and is a valid measurement of abdominal fat in youth (Castro-Piñero et al., 2010; Krebs et al., 2007). Although the exact location for measuring WC may differ slightly among different protocols, it does not seem to considerably influence the relationship between WC and health outcomes (Pate, Oria, & Pillsbury, 2012). Millard-Stafford et al. (2013) reported that WC improved in all the studies reviewed when there was an improvement in aerobic fitness among obese children (ages five to18 years). The possibility of aerobic improvement within the time frame of the current study is unlikely, however, due to the participants' low PA and high sedentary lifestyles, WC could be a measure that shows improvement (especially in the case of participants with high levels of abdominal fat). The pre- and post-study values for these measures are depicted in Table 7.

Social validity. Wolf (1978) stated that research should be validated on at least three levels (i.e., that of the social significance of the goal, that of the social appropriateness of the procedures, and that of the social importance of the effects). Foster and Mash (1999) referred to such "social validity" as a measurement of the meaningfulness of the goals of intervention. To gauge the social validity ("customer satisfaction") of this study parents were asked (a week after its completion) whether they thought that watching a movie/show contingent on pedaling a stationary bicycle had a positive outcome on their son. If they did, they were asked to give examples of such outcomes (Appendix I). Teachers were posed the same question and, in addition were asked whether they thought the activity was appropriate (in terms of ethics, cost, practicality, etc.). Independent of their replies, they were asked whether they had any comments/critique/ suggestions related to the study's implementation at their school (Appendix J). Finally, participants were asked whether they liked pedaling the bicycle while watching a movie/show. Independent of their replies, they were prompted to explain/elaborate on their answer (Appendix K). Since this measure was not a specific (or even an important) research question of the study, this social validity was considered a single construct to be scored dichotomously (Foster & Mash, 1999) rather than using a rating scale. Comments or feedback received from all parties were summarized and the researcher looked for trends or themes in responses and commented on them during the discussion of this study. Parent, staff, and/or participant satisfaction have been assessed using a single question, or implementing an elaborate rating scale or questionnaire in studies on PA and youth with physical disabilities (Buffart et al, 2010), developmental disabilities (Gephart & Loman, 2013), and ASD (Fragala-Pinkham et al., 2011; Hinckson, Dickinson, Water, Sands, & Penman, 2013).

Treatment and Design

The objective of this single case study was to determine the efficacy of the contingent use of screen time as reinforcement on complying with a stationary cycling program. An ABC design that incorporated a changing-criterion design with bi-directional changes was implemented. The main goal of a single case study is to establish whether there is a functional (causal) relation between the treatment (independent variable) and the outcome/dependent variable(s) (Kratochwill et al., 2010). Horner et al. (2005) stated that experimental control comprises of replicating the intervention – which could be attended to in three major ways (methods), i.e., staggering the time when the treatment was introduced (multiple baseline), repeated manipulation of the treatment (changing criterion); or reversal of the treatment. The design for this study consisted of a Phase A (baseline) that was congruent to the level of exercise compliance to be expected from each individual participant if they were cycling on a cycle ergometer at a community gym. Phase B (learning/orienting) consisted of a few short sessions during which participants were given the opportunity to experience the "consequences" of pedaling outside the criterion zone, and thus afforded them the time to comprehend what the expectations were for the task at hand. Phase C (treatment) implemented a changing-criterion design in order to first increase the average time cycled per session (at a set intensity to a predetermined duration), and after this was achieved, then increase the intensity (RPM) of the cycling activity in a controlled and safe manner while striving to increase exercise heart rate within the 40–70% range of HR Reserve (HRR). Following a minimum of three consecutive (increasing) criterion changes (i.e., 15 RPM increase in total), within this treatment phase, a (5 RPM downward) directional change was introduced. This study's design was strengthened by the fact that two methods of replication, as per Horner et al. (2005) were implemented, namely that of a criterion and a directional change.

Phase A (Baseline): Non-Contingent Screen Time

Phase A was undertaken to determine the current level of cycling compliance as executed by each participant. Before and after the first two sessions, the researcher modeled stretching activities for the participant to imitate. Thereafter, these stretches were conducted by the teacher in the classroom as a transition activity from school work to the cycling session. The entertainment reinforcement (DVD) was displayed continuously, as well as the RPM and TP feedback information. The RPM zones were set to be wider than what the actual criterion ranges would be during the treatment phase, i.e., the green/target zone was from 30 to 60 RPM, while the yellow zones were 10 RPM below and above the limits of the green zone. The red zones were set at below 20 RPM and above 70 RPM, respectively. The initial gear ratio was set at mid-range (front middle chain ring and fourth rear gear) and was manipulated (between the second and fourth rear gears) as needed throughout the session to where the participant was pedaling at a comfortable rate. Gear settings (and changes noted) were recorded for every session on the procedure checklist (Appendix G). Having a preferred DVD on during the cycling session (non-contingent reinforcement) was similar to the situations in community gyms where TV monitors are on all the time. During this phase, the participant was instructed to pedal for 15 min without stopping and the DVD was turned on and remained on. The researcher provided verbal encouragement (“great job,” “perfect!,” and nonverbal “thumbs-up”) while the participant cycled. When the participant stopped cycling, requested to stop cycling, or cycled for the full 15 min, the DVD was turned off (refer to Appendix L for detailed procedures, verbatim prompts, and verbal encouragement). Baseline sessions were also used by the researcher to establish which form of HR monitoring would be best tolerated by each individual participant. The participants were initially asked to wear the wristband during the 1-min rest before the very first sessions started, and all three participants wore the wristband throughout the study. In addition, HR was palpated at the wrist during baseline (only) to establish reliability of the HR monitor's values. The following data were recorded: RPM, TP, HR, self-monitor board, and enjoyment rating scores (from participants and a global happiness score from teachers). Furthermore, any added prompts/ reinforcements given (where applicable), as well as additional comments were also recorded on the procedure checklist.

Phase B (Learning/Orienting)

Once predictable values for TP and RPM measures were demonstrated (over three to five sessions), a learning/orienting task was implemented. This task comprised several short sessions (5+ min at a time) during which the participants were familiarized with the concept of watching a movie/show being contingent on cycling within a specific RPM range (green, target zone on the bar graph displayed on the feedback display above the ER display) and with the fact that TP was indicated as a bicycle icon moving along a time line toward the pre-determined goal for TP (culminating in the icon reaching the small smiley-face sticker). The researcher explained (while focusing attention by pointing to) the target/green zone, the "speed up/slow down" (yellow) zones, and the "too slow/fast" (red) zones to the participant while he was pedaling (see Appendix L for script of prompts). Initially during this phase, the RPM criterion was set at that of the (broader) baseline values. The reason for doing so was to afford the participants an easier obtainable/manageable target (as well as warning) zone during the orienting task, since they would still be learning the concepts related to the task, and broader zones made it easier for them to experience success during this learning/understanding period. Depending on the participant's progress and understanding of the task, the RPM criterion was then changed to a (narrower) 10 RPM range—first at the average RPM pedaled across all baseline sessions, and then (if the TP goal was achieved) at the 5 RPM higher criterion range of the initial treatment (Phase C) session. During the learning/orienting task, the researcher manipulated the DVD player by using the laptop keys. Depending on each participant's rate of learning/understanding the task (DVD stayed on when the RPM pointer was in the green zone; DVD paused when the RPM pointer was in the yellow zones; and DVD went off when RPM pointer was in the red zones), the researcher implemented the following protocol for the DVD to play normally, be paused, or be stopped: (a) anytime the participant pedaled within the green (criterion) zone, the DVD would play; (b) after three to five times (depending on the participant) pedaling in the yellow (warning) zone for 3 s or longer, the researcher would pause the DVD until pedaling RPM was in the green again; and (c) after three to five times (depending on the participant) pedaling in the red (stop) zone for 3 s or longer, the researcher would shut down the DVD until pedaling RPM was back in the green zone. The researcher used a stopwatch in timing these events, and recorded each action that was taken. For example, LR was recorded when the DVD was shut off due to pedaling in the low red zone, and HY was recorded for pausing the DVD due to pedaling in the high yellow zone. These values were used to make decisions on which criteria would be implemented during the next session. Verbal prompting was also given simultaneously for every condition (see Appendix L for verbatim prompts).

The participant's attention was also focused on the second (TP) bar graph in which the bicycle icon moved across the time line toward the TP goal (yellow smiley face). This was incorporated to ensure that each participant learned to cognitively grasp the use of the bar graph in cycling within the target zone (and understand that failing to do so resulted in the ER display going “off”), as well as to allow them to see how much they had progressed toward reaching “the end of the line” (in terms of the goal set for TP). As soon as the participant started pedaling, the researcher would point her finger to the central, green (target zone) RPM bar graph, telling the participant, “Keep the blue pointer on the green and the movie will stay on.” Similarly, as time passed, the researcher would point to the bicycle icon on the time line and state, “Look, you’re getting closer to the finish line.” The number of sessions in the learning/orienting phase depended on how quickly the researcher perceived the participant as having comprehended and learned the concept of keeping the DVD playing being contingent on his pedaling consistently within the criterion (green) zone. The only data collected (by the researcher) during this phase, were the type of DVD actions manipulated (pause, stop, play) and the number of these manipulations.

Phase C (Treatment): Contingent Reinforcement and Feedback

The entertainment reinforcement output was implemented during the treatment phase (Phase C) of the study after the participant had demonstrated predictable values for TP and RPM during baseline, and had shown a cognitive understanding of the task at hand (i.e., pedaling in the “green zone” to keep the DVD playing and pedaling until the bicycle icon reached the yellow smiley face) for Phase B. In Phase C, the participant had to cycle for 15 min within an individualized, pre-determined RPM criterion range in order for the movie/show to remain on. This initial criterion level was calculated based on each participant’s performance in terms of TP and RPM (also taking into account HR data) during the baseline phase (phase A). An attempt was made to determine the best possible initial RPM criterion range for each participant in order for him to be successful when the treatment was implemented. All three participants were able to cycle for 15 min during baseline and thus had their initial RPM set 5 RPM above that of their baseline average RPM across sessions. This criterion range was also used, at least once, during the learning/orienting phase to familiarize the participants with it. At the start of the cycling session, the researcher (just as during baseline) prompted the participant to pedal for 15 min without stopping, and the entertainment video display (DVD) was turned on. In addition, the researcher would point to the feedback display to focus the participant's attention on the bar graph and remind him to keep the blue pointer in the green zone for the DVD to remain on and to "keep pedaling there" until the bicycle icon reached the yellow smiley face. The researcher observed and provided verbal encouragement ("great job" or "perfect!" and non-verbal "thumbs up") to the participant from about 2 feet to the left side and slightly behind the participant while he was pedaling. When the DVD paused (i.e., the warning for RPM being within 5 RPM below or above the target range), the researcher would verbally encourage ("uh-oh, pedal a bit faster/slower"), point to the feedback video display, and remind the participant to either pedal faster or slower. The prompting schedule implemented during this study paralleled that used at the school with each participant. (See Appendix L for procedures and verbatim prompts prepared in case of stopping early, refusal to pedal further, etc.).

Following each cycling session during the treatment phase, the percentage compliance (percentage of time pedaled within the criterion range per cycling session) as well as the average RPM while within the criterion range were calculated (for these calculations, the criterion was across the yellow and green zones).These data were calculated in addition to all other calculations made by the program as per phase A. When a participant met the TP criterion and exercised within the target RPM range for $\geq$ 80% of the time over three sessions (of which two had to be consecutive sessions), the (current) target RPM range was increased by 5 RPM—constituting a criterion change. A provision was made for if the maximal upper level (set at 90

RPM) were to be reached by a participant in that the resistance against which he was pedaling was to be increased by lifting the roller on the training stand by a quarter turn to the right. Doing so would involve a recalculation of the stationary bicycle's actual resistance. However, this scenario was not attained by any of the participants.

After three consecutive (upward) criterion changes were accomplished by a participant, the criterion level was reversed for a minimum of three sessions, whereafter it was increased with 5 RPM again—to test whether it was, in fact, the manipulation of the independent variable that resulted in the changes exhibited by the dependent variables (TP, RPM, HR, and related measures). If it were the case, and the treatment was controlling the changes, the RPM values during this reversed criterion phase should correspond with the lower RPM for those sessions. Such a bi-directional change was thus implemented to determine whether a functional relationship existed, i.e., whether the contingent reinforcement were indeed eliciting the desired changes in the dependent variables.

After the criterion reversal phase, one session was then again conducted at an increased (5 RPM higher) criterion—the minimum data point required for this stage (Cooper, Heron, & Heward, 2007). For a second session, and on the final day of the study (and last day of the week) the researcher decided to increase the TP goal (keeping the RPM at the set criterion range) to a maximum 25 min. It was the researcher's intent to see whether the participants could reach a higher TP goal (representing an up to 10-min increase) and if not, how much longer they would pedal—since they had attained perfect compliance in terms of TP throughout the study up to that point. The researcher was also interested in observing any behavior and/or physiological (HR, breathing, sweating) changes elicited by pedaling for a longer period of time. The bicycle icon on the feedback display moved across the screen at a rate determined by the TP goal set, thus the participants were unaware of the extent of this TP increase. Calculations were based on these times pedaled, but if necessary it was possible to calculate all measures up to where the participants pedaled for 15 min because of the values recorded (and saved) by the microprocessor. Due to the time constraints of the study, the researcher was regrettably unable to conduct more sessions at a higher TP goal criterion.

As in Phase A**,** the following measures were taken during the treatment phase: TP; RPM; and HR. The enjoyment rating scales, and self-monitoring board were also administered. The only difference for the participants was that watching the preferred DVD (ER displayed) was contingent on their cycling at a set RPM. For the researcher, Phase C involved the additional calculations of average RPM in the target zone (including the standard deviation) and percentage compliance (average time pedaled within the target zone)—the latter for making decisions on implementing criterion changes. All HR and enjoyment scores, as well as any additional information/comments, were recorded (Appendix G).

For all three phases (baseline, learning/orienting, and treatment), the exact same procedures were followed during steps (numbers) 1 to 4, and 10 to 13 (refer to Appendix G, Tables G1, G2, and G3 for the three phases, respectively). During the 1-min rest period (#4) the participant sat quietly and upright on the bicycle while the HR wristband was fitted, the enjoyment scale administered, the SACS activated, and the resting (pre-exercise) HR value recorded. During the 5-min rest period (# 10) the participant remained seated (without pedaling) on the bicycle and watched the DVD that the researcher switched on again (after it stopped when TP goal was reached during the cycling session). The enjoyment scale was administered and 1- and 5-min recovery HR (post-exercise) recorded.

Testing Procedures

Approval to conduct this study was obtained from the institutional review board (IRB) at the University of Virginia (IRB-HSR 17878, Appendix M). A private institute for autism was contacted (via e-mail) to enquire about doing research and recruiting participants at that specific school. A follow-up e-mail to the director explained the purpose of and protocol required for the study, as well as criteria required by participants for inclusion in the study, i.e., male adolescents between the ages of 16 and 18 years, and diagnosed with ASD. Additional inclusion criteria included: the ability to follow directions; no severe behavior problems; no medical conditions to which exercise/PA were contraindicated; being able to physically pedal a bicycle; and having a preference for watching movies/shows during their leisure time. After IRB approval was obtained, the researcher met with the director and the lead teacher to explain the procedures for the study, discuss logistical matters (such as space to be utilized), and establish a timeline and schedule for collecting data. The director e-mailed a recruitment letter to parents in which they were informed about the study and withdraw procedures. Parents who were interesting in having their adolescents participate in the study were asked to indicate their interest in a reply e-mail. The researcher then scheduled a meeting with each participant and his parent(s) at a venue of their convenience during which she explained the purpose of the study, what would be expected from the participant during each session, as well as procedures for withdrawing from the study. All questions and concerns were also addressed. The parents were asked to consent to their son participating in this study that required them to participate in a daily stationary cycling activity session during their school day over a period of 5 to 7 weeks. During the meeting with the parents and participant, a semi-structured questionnaire was administered to the parents (Appendix B). Afterward, the participant was asked to name his favorite movies/shows through informal conversation. Information regarding ASD diagnosis (i.e., tests used and/or eligibility process) and tests administered were obtained from official school records. A similar semi-structured questionnaire was also used in an interview with the teacher in order to obtain input regarding preferred movies/shows, PA levels, sedentary behavior, as well as each participant's individualized token/reward system and prompting schedule procedures (Appendix C). Demographic information obtained from the questionnaires is shown in Table 5.

Prior to the study examples of the prospective questionnaires were sent to five experts in the field of adapted physical activity for review to provide evidence of face validity. The experts were asked to critique and make suggestions on the conciseness and applicability of the questions posed to parents and teachers in gathering demographic, ASD diagnostic, medical, "personal" (such as preferred movies/shows and preferred reinforcers of the participants), PA levels, and screen time use. Feedback, comments and suggestions made by all experts were listed, then tallied and summarized. Changes were made to the questionnaires when at least two experts suggested a change or clarification. One expert commented on confusing wording (rating vs. ranking) and the question was re-phrased. The same experts were then asked to rate each question on a scale of 1 to 5 (1 indicating not applicable at all, and 5 indicating extremely applicable) in terms of the following: (a) whether the question was effective in assessing information pertaining to the question; (b) whether the content of the question was sufficient to fulfill the objective of the question; and (c) whether the content of the question aligned with research on the topic within the question. Criteria for accepting a question were set at 80% of the experts giving a rating score of ≥4. Experts were asked to add comments to any question rated ≤3. All questions received a score of 4 o4 higher, except for one that received a 3 (comment was related to defining a term within the question).

During the 3 months before the study was initiated, the researcher volunteered at the school for the whole day at least twice a week in order to build a rapport with (all) the students, get to know the staff, and learn about their routines. The participants were thus already familiar with the researcher when the study started. Within a week of volunteering at the school, the researcher set up the stationary bicycle (without the SACS) in the school's common room for students to see it, get used to it, and sit or pedal on it during free time if they wanted to. Only one student requested to sit on it once (and slowly pedaled for fewer than 3 min). The only interest some of the other students showed in the bicycle was spinning the back wheel or pushing the pedal with their hands while sitting or standing next to the bicycle. It must also be noted that none of the students showed any interest in the treadmill that was also in the common room.

Prior to the study being conducted, the researcher trained in and practiced the exact protocol that was to be followed for each session throughout all phases of the study, as well as on operating the equipment safely and how to trouble-shoot possible problems with the SACS. The researcher is a certified physical education and special education teacher with 25+ years' experience with youth and adults with a wide variety of disabilities and a former emergency medical technician (EMT) with current certification in cardiopulmonary resuscitation (CPR) and First Aid.

In addition, and prior to the actual study, a modified (compacted) version of the study was piloted using two youth with ASD (males, ages 10 and 13 years)—not only for testing the equipment and study protocol, but also to verify that this population was capable of cognitively learning and understanding that watching a movie/show was contingent on their cycling at a specified RPM (as indicated on the feedback video display). Neither of the participants tolerated the pulse sensor (ear lobe or index finger) or the earphones; one tolerated the wristband, while the researcher palpated HR at the wrist for the other participant. Both cognitively understood that the DVD would remain on as long as they cycled “in the green zone” and that when the bicycle icon had reached the end of the time line (TP displayed on the feedback video display), they had reached the session’s goal of pedaling for the required time (duration). Because the main purpose was to “test” the SACS and session procedure, and to determine that this population could, indeed, learn to and understand what the task required, no data were saved. The TP was set at 10 min, and average RPM was calculated after a two-session “baseline.” During the following three sessions, the “treatment” phase was implemented. During this phase both children started pedaling at 35 RPM. One child learned, within the first session, that if he pedaled in the “green zone,” his movie *(Green Lantern)* would remain on. He was able to cycle for 10 min during the first session, so his RPM was raised by 5 on the third day. This small increase in RPM did not seem to have any effect and he cycled the full 10 min. The other child initially showed some frustration at his movie (a SpongeBob Squarepants movie) going off, but after his teacher aide modeled the task (adding verbal cues) a few times, he was able to maintain steady pedaling for short periods at a time. By the third day, he was able to pedal for 10 min continuously. The researcher took notes on the data displayed in real time on the laptop (i.e., RPM pedaled at, TP, as well as HR data taken at rest, during pedaling [every 3 min], and 3 min post-exercise). HR of neither boy ever exceeded 50% HRR. These findings were sufficient for the researcher to be confident that this was a viable (and do-able) study.

During the 2 days before data collection started, participants were introduced to the equipment, could sit and pedal on the bike, could see the video display mounted on the handlebars play a video, and were shown the HR monitoring systems (and how/where they would be used/placed). Any questions they had were addressed.

During the actual study, the three participants partook in the stationary cycling program for 5 days a week (except when school was closed due to snow) over a 5-week period. Daily sessions were decided upon in an attempt to make this PA part of their "daily routine." This time period was originally planned to allow for 25 measures, but the study was completed after only a total of 20–22 sessions—due to the fact that all students were in perfect compliance throughout the study, thus requiring the minimum number of data points per phase. In their review of 809 single-subject-design studies, Shadish and Sullivan (2011) found the median and mode number of data points in these studies were both 20, and Kratochwill et al. (2010) recommended three to five data points to obtain a stable, flat baseline. Five to 10 sessions were allotted for phases A and B, and 14 to 17 sessions for Phase C (with upward criterion changes [RPM] after each third session if compliance was met [totaling nine sessions at minimum] followed by a reversed criterion change [minimum three sessions], and another upward criterion change for the remainder of sessions). Included were a few days allotted for absences, holidays, and participants having "bad days."

The equipment was set up in a separate room in the school building, and precautions were taken to ensure minimal noise level, interruptions, and distractions. Participants completed each session individually with their teacher accompanying them. The procedures for each session are included in Appendix L. This table was modified (presented in checklist format) and completed for each participant during every cycling session to ensure procedural consistency (Appendix G).

Data Analysis

A single-subject design has been shown to be an appropriate methodological design to implement in research or youth with disabilities (Horner et al, 2005). Advantages of such designs include, but are not limited to the following: they are cost effective (require fewer participants, and may require fewer resources, time and research assistants); assumptions normally found in parametric statistics (such as normal distribution) are not required; responders and nonresponders can be more easily identified/singled out by the researcher and circumstances explained (Horner et al, 2005). The characteristics of youth with ASD being very diverse, as well as having a limited pool of participants to choose from, also made a single-subject design beneficial.

After every cycling session, data recorded during that session were downloaded from an encrypted flash drive onto a password- and fingerprint-protected laptop, where the data were then stored. The program was coded to calculate the specific measures related to TP and RPM. These data, together with HR values and enjoyment scores recorded onto the procedure checklist (Appendix G), were then entered into a statistical program (IBM SPSS, 2013), analyzed, and plotted (using MATLAB, 2010) for visual inspection. For each participant, scatterplot graphs were generated based on the data (dependent variables). For time spent pedaling in each session (phases A and C), average TP per session and average TP within the target criterion both plotted. Thus, for every session (on the x-axis) there were two data points (plotted against the y-axis). Similarly, the RPM values for each session were plotted as the average RPM per session and the average RPM within the target criterion. For the average RPM pedaled within the target criterion, indicators of standard deviations for each session were also added. In addition, the TOS per session (average RPM × TP), percentage compliance, and average HR per session for each participant also were plotted in a similar manner on separate scatter-plots (indicated by a single data point each). For HR data points, the HR range per session was also included in the graph. These scatterplots were visually inspected to look for trends indicating differences within the above-mentioned dependent variables from baseline to treatment and between criterion changes within the treatment phase. The descriptive analyses of the dependent variables were presented in tabular format as the mean and standard deviation for each participant during baseline, during each criterion change within the treatment, and during the post-treatment baseline, as well as the mean and standard deviation for the total treatment phase. Finally, for every participant, a separate table listed the data obtained for all dependent variables.

Each participant's enjoyment rating scores (before each session and [combined] for during and after each session), together with the "global happiness" scores obtained from the teachers before and after each session, were plotted on a scatterplot, as well as depicted in a table. Pre- and post-study measures for weight, BMI, and waist circumference were compared to see if any changes had occurred during the study period, although no significant changes (improvement) were expected due to the short period of the study. Qualitative data (average PA and screen time scores, preferred type of screen time, and social validity comments) were tallied and summarized, and trends/themes elicited were discussed.

Conclusion

Following an extensive literature review conducted on the inherent and diverse characteristics associated with ASD in adolescents, specifically as related to obesity, low levels of physical activity, and high levels of sedentary behavior (especially screen time), as well as the interventions that have been employed to curb the negative effects of these three debilitating "conditions," a physical activity intervention (compliance) study geared towards this specific population was designed and conducted. This single-subject-design study was based on previously implemented closed-loop behavioral engineering systems within the field of physical activity and took into account the limitations of, as well as suggestions made in, the limited number of previous studies of this kind with individuals with disabilities. In addition, this study was able to take advantage of the new, innovative, and cost-effective technology available today.

The two main research questions were: (a) whether the contingent use of reinforcement (screen time) would increase participants' physical activity (stationary cycling) above that attained during a baseline phase, and (b) whether changing the criterion in addition to the contingent use of reinforcement (screen time) would increase the duration and/or intensity of such a physical activity (cycling) to the extent that participants would meet the recommended levels of physical activity that enhances health-related benefits. This chapter outlined the research questions, devices and measures, treatment and design, testing procedures, as well as analysis of the quantitative and qualitative data obtained.

CHAPTER 4

RESULTS

The purpose of this study was to assess the efficacy of contingent reinforcement, in the form of screen time (watching a DVD), on compliance with a stationary cycling activity by three adolescent males with ASD. The following two research questions were addressed: (a) whether contingent use of screen time (as reinforcement) would increase the participants' physical (cycling) activity compliance (in terms of duration and/or intensity) above that attained during a baseline phase and (b) whether changing the criterion (in addition to the contingent use of screen time as reinforcement) would increase the participants' physical (cycling) activity sufficiently for them to meet the ACSM recommendations for enhancing health-related benefits. The dependent variables included: (a) time (duration) pedaled; (b) average RPM pedaled during the session in totality (intensity); (c) average RPM pedaled within the target range per session (intensity); (d) percentage compliance (amount of time pedaled within the criterion range); (e) total output per session (time pedaled × average RPM per session); and (f) heart rate before, during, and after each cycling session (intensity).

The intent of this chapter was to present the data collected during the study in a manner that would allow for systematic and unbiased evaluation of the effect of contingent screen time on the compliance of the participants' cycling activity. Data are presented in terms of each dependent variable with an overview of the descriptive statistics (means and standard deviations), followed by graphic illustration of each participant's individual data.

Single-subject-design research relies, traditionally, on visual analysis for determining relationships between baseline and treatment conditions (Gage & Lewis, 2013). According to Kratochwill et al. (2010), this analytic technique relies on analyzing and interpreting the following six features of a graphic display of data: (a) level (mean values of data within each phase), (b) trend (the approximate slope within each phase), (c) variability (deviations and/or range of spread) of the data points within each phase, (d) immediacy of the effect (changes in level, trend, and variability between phases), (e) overlap of data points between phases, and (f) consistency of a data pattern across similar phases (replication effects). The graphic displays derived from the data in this study were thus visually inspected in terms of the above-mentioned features to identify and determine how (if any) and to what extent the changing criterion controlled the outcome measures. It is noteworthy that an overlap of data was most likely to occur within this study due to the (purposely designed) overlap in RPM criterion target ranges within Phase C (treatment) and that trend within phases may be difficult to determine in some cases (wide variability among data points) due to each phase only consisting of three data points.

An ABC design was implemented in the study, where Phase A constituted a baseline; Phase B, a short learning/orienting phase; and Phase C, a bidirectional criterion change. During Phase B, no data were collected for dependent variables. However, the time pedaled, the set RPM, and the number of times the DVD was manually paused or stopped by the researcher were recorded. These data will be presented before those related to each dependent variable (and only applicable to Phases A [baseline] and C [treatment]).

Learning/Orienting Phase

Phase B (learning/orienting) afforded the participants several short cycling sessions during which they were exposed to the “consequences” of pedaling outside the target range (green zone). It provided them with the opportunity to get the feel for what would take place during the treatment phase, as well as the time to learn and comprehend the task at hand (i.e., to pedal within the green zone for the DVD to play normally). The researcher manually manipulated the actions of the ER display (DVD player) according to predetermined conditions set. Table 6 summarizes the sessions, time, RPM criterion, and number of times (and types) of actions taken by the researcher for all participants.

Table 6

Sessions, Time, RPM criterion, Number of Times, and Types of Actions Taken During Phase B

	Participant 1				Participant 2				Participant 3			
Condition	S1*	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
TP (min)	7	6	10		8	5	5		5	5	5	5
RPM	30–60[a]	40–50[b]	45–55[c]		30–60[a]	45–55[b]	50–60[c]		30–60[a]	50–60[b]	55–65[c]	55–65[c]
DVD paused low	2	2	2		2	2	1		1	2	2	1
DVD paused high	0	1	0		1	1	0		1	2	1	1
DVD stop low	0	2	1		1	0	0		1	0	1	0
DVD stop high	0	0	0		1	0	0		0	1	1	0

*Participant 1 completed sessions 1 and 2 (S1 and S2) over a single 15-min session; during a bathroom break, the RPM was increased.

[a] RPM at baseline criterion.

[b] RPM equal to baseline average RPM of individual participants.

[c] RPM equal to 5 RPM above average baseline RPM of individual participants.

From this table it can be seen that the “actions” taken by the researcher (pausing and/or stopping the DVD) decreased for all participants with regard to the majority of actions. Participant 1, however, had the DVD paused twice for going into the low yellow zone in all three sessions. An explanation of a session within this phase follows: during Participant 3’s second learning/training session, he pedaled for 5 min at set RPM criterion of 50–60 RPM, during which time the researcher manually paused the DVD twice (for pedaling for the third time in the low yellow zone for approximately three seconds), and another two times (for pedaling three times in the high yellow zone for approximately three seconds) until the participant pedaled back into the target/green zone (50–60 RPM). For the same (protocol) reasons, the researcher also stopped the DVD once during the session—when the participant pedaled in the high red zone. For this participant, the initial gear setting (front middle chainring and fourth rear gear) was changed to front middle chainring and fifth rear gear during this Learning Session—a seemingly more comfortable gear for him to pedal at within the set RPM criterion (55–65 RPM), but also a slightly increased pedal resistance.

Time Pedaled (TP)

Time pedaled was recorded by the Arduino microprocessor via the Reed switch (electromagnetic motion sensor) mounted on the pedal crank. For each session, two separate TP values were calculated and reported (by the microprocessor): (a) the total time pedaled during the session (from start to finish) and (b) the time pedaled within the set target criterion range (for these calculations both the yellow and the green zones were included). The TP goal (15 min) was entered into the SACS before the session started, and the session terminated automatically when 15 min of pedaling within the target criterion range was attained. Mention must be made of the fact that, on the last day of the study (Session 20), after one data point had been attained by all participants during the previous session (the first criterion increase after the introduction of the reversal criterion change), and at the TP goal set for 15 min, the researcher set the TP goal at a maximum of 25 min. Due to the programmed TP criteria set at increments of 5 min (Appendix E), such a (maximum) 10-min increase would allow for the researcher to observe (and calculate the dependent variables related to) whether the participants were capable of moving onto the next TP goal (of 20 min), as well as to what extent, and with what "consequences" they were able to exceed this next TP goal, if at all. The reason was to get some insight into how the participants would react to an increase of 10 min (at most) in the TP goal—not only in terms of achieving the TP goal, but possibly also in terms of the other variables (RPM, TOS, percentage compliance, HR values, enjoyment, behavior, etc.). Participants 1, 2, and 3 pedaled 20.6, 22.8, and 22.7 min, respectively, during this session. None of the participants achieved the maximum TP goal set at 25 min; one participant (Participant 1) stopped abruptly after 20 min, whereas participants 2 and 3 gradually slowed down until the DVD remained off (red zone), putting forth no effort to speed up again into the target criterion (green) zone, and then they both stopped pedaling all together. Table 7 provides the descriptive data (means and standard deviations) for each participant during Phase A (baseline) and Phase C (treatment).

This table demonstrates the perfect compliance of all participants in pedaling for the 15 min TP goal set during Phase C (treatment). The TP mean for two participants (participants 1 and 2) during baseline was 15.1 min (because both pedaled the full duration during every session), whereas the third participant's TP mean was 13.2 min (he only pedaled for 7.6 min during the first baseline session). During treatment, both the mean total TP per session, as well as the mean TP within the criterion range were in compliance with the set goal of pedaling 15 min. The total within-criterion mean values for all three participants were slightly above 15 min (ranging from 15.4 to 15.6 min) as a result of the longer time pedaled during the final session of the study. When Session 20's data point was removed from the calculations, these mean values were exactly 15 min – with a 0.0 *SD*, because all participants complied 100% with the TP goal set – the session automatically terminated at the set TP (15 min), so no-one pedaled longer, and no-one pedaled less.

Table 7

Descriptive Data of Time Pedaled (TP) for Participants and Phases

	Participant 1		Participant 2		Participant 3	
Parameter & Phase	*M*	*SD*	*M*	*SD*	*M*	*SD*
Total session TP (min)						
Baseline	15.1	0.1	15.1	0.1	13.2	3.7
Treatment (*N* = 14)	15.9	1.5	15.9	2.2	15.9	2.2
Treatment* (*N* = 13)	15.5	0.7	15.3	0.5	15.3	0.4
Total within-criterion TP (min)						
Treatment (*N* = 14)	15.4	1.4	15.6	2.1	15.6	2.1
Treatment* (*N* = 13)	15.0	0.0	15.0	0.0	15.0	0.0

*Session 20 data point excluded

The explanation for the differences in the means between total session TP and total within criterion TP for all participants lay in the fact that during baseline only one time measure (i.e., total time pedaled in the 15 min TP set) was recorded. Thus, if the participant pedaled for the full 15 min during all baseline sessions, the standard deviation would be minimal. During Phase C, two sets of time were recorded, namely one related to the set TP goal (15 min) pedaled within the RPM criterion range, and a second recording of the total time within it took to attain the set TP goal. During treatment the (within criterion) time stopped when the participant pedaled outside the criterion (i.e., in the red when no values for nonpedaling were included), whereas the total time pedaled remained being recorded continuously, irrespective of whether the participant pedaled within the criterion or outside of it (in the red). This also explained the (small) discrepancies in mean TP standard deviation values between those of total session TP and total within criterion TP.

The standard deviations of the mean TP values for all participants were noticeably influenced by Session 20’s increased TP. When included in the descriptive analysis, the standard deviations of the total session TP treatment means for two participants (participants 1 and 2) were 1.4 and 2.1 min, respectively, higher than the standard deviations of their baseline sessions. Participant 3’s total session TP treatment standard deviation was 1.5 min lower than that for basement, because he had one low TP value (7.6 min, Session 1). However, when the higher TP value of Session 20 was excluded from the descriptive analysis, the increase in the total session TP standard deviations from baseline to treatment increased with only 0.6 and 0.4 min for participants 1 and 2, respectively, whereas these values for Participant 3 decreased significantly from a baseline value of 3.7 min to a mere 0.4 min. The differences in the standard deviations for the total treatment session TP from when Session 20's value was included to when it was excluded ranged from 0.8 min (Participant 1) to 1.8 min (Participant 3).

Figure 3 depicts a graphic display of actual TP data per session (in min) for each participant based on the data recorded per session during the study (Appendix N, Tables N1, N2, and N3 for participants 1, 2, and 3, respectively).

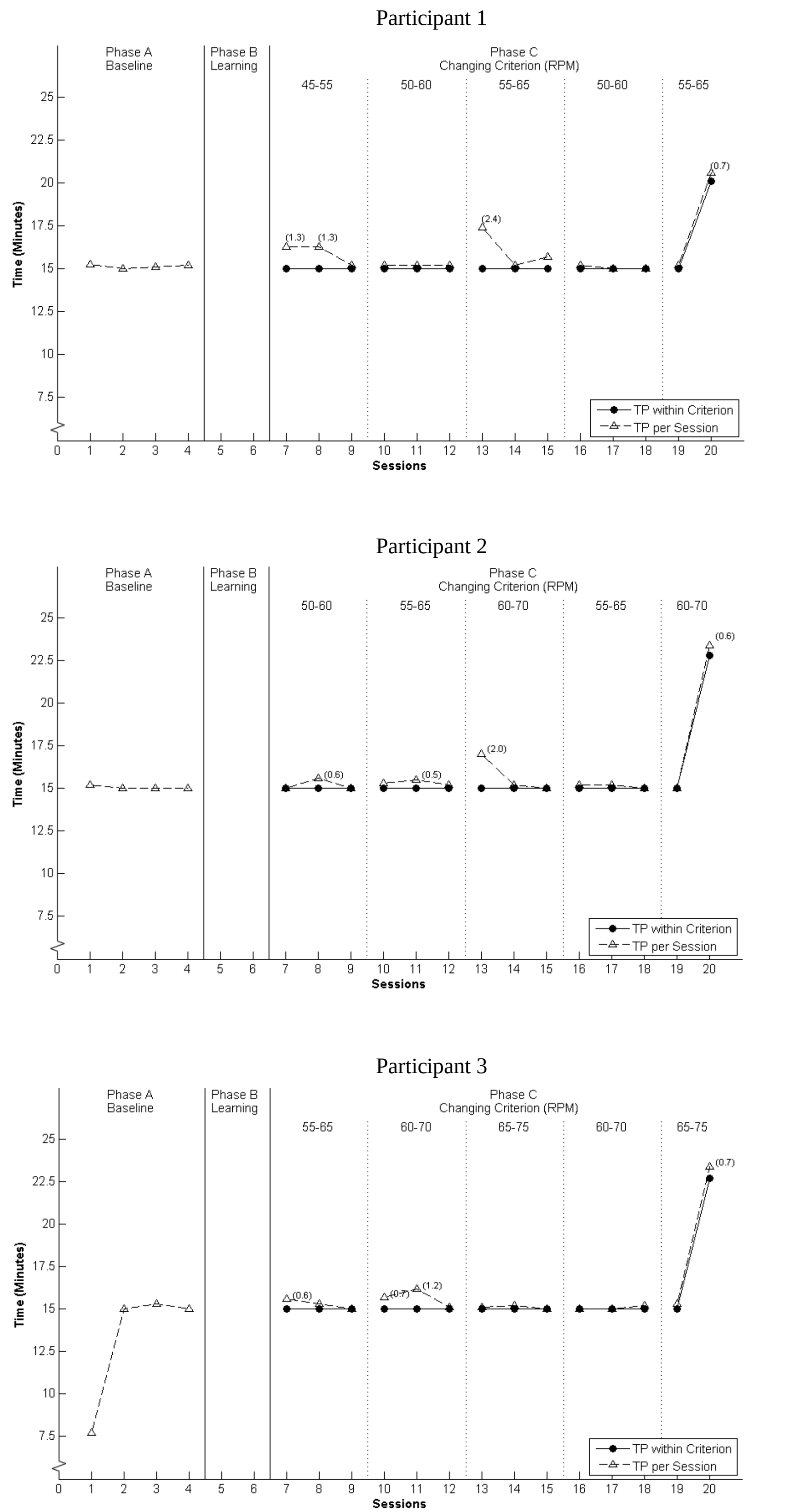


Figure 3. Time pedaled (TP) per session and phase for all participants. During Phase B, learning took place and no data were collected.

As shown in Figure 3, all participants completed all sessions of the study. During the course of the study, there were three snow days—two days during baseline (after Sessions 2 and 3), and one day during treatment (after Session 10). This figure illustrates the perfect compliance by all participants in terms of the 15-min TP goal set by the researcher. Figures 3, 4, and 5 provide separate graphic displays of the TP data for participants 1, 2, and 3, respectively. Participant 1's graph (Figure 4) showed that he attained the 15-min TP goal from the very first session (baseline, sessions 1–4) throughout the treatment phase (sessions 7–19). During Session 20, the TP was increased by 10 min (25-min TP goal set), and he pedaled for a total of 20.6 min within the target criterion range. There were four occasions during the study when his total TP per session and the total within-criterion TP differed noticeably: during sessions 7 and 8 (in both cases he pedaled in the red or stopped for 1.3 min during the session) and during sessions 13 and 15, when he pedaled in the red or stopped for a total of 2.4 and 0.7 min, respectively. These instances are indicated in parentheses on the graph.

The graphical illustration of Participant 2's data points (Figure 5) shows that he too attained the 15-min TP goal from the very first session (baseline) throughout the treatment phase. During Session 20, when the TP was increased by 10 min, he pedaled for a total of 22.8 min within the target criterion range. There were four occasions during the study when his total TP per session and the total within-criterion TP differed noticeably. These were during sessions 8, 11, 13, and 20 (indicated on the graph in parentheses). The durations of his pedaling in the red or stopping were 0.6, 0.5, 2.0, and 0.6 min, respectively.

Participant 3's graph (Figure 6) indicates that during the first session he only pedaled for 7.6 min. However, for the following three sessions he achieved the 15-min TP goal and a trend was established. When the TP goal was increased in the final session of the study (25 min),

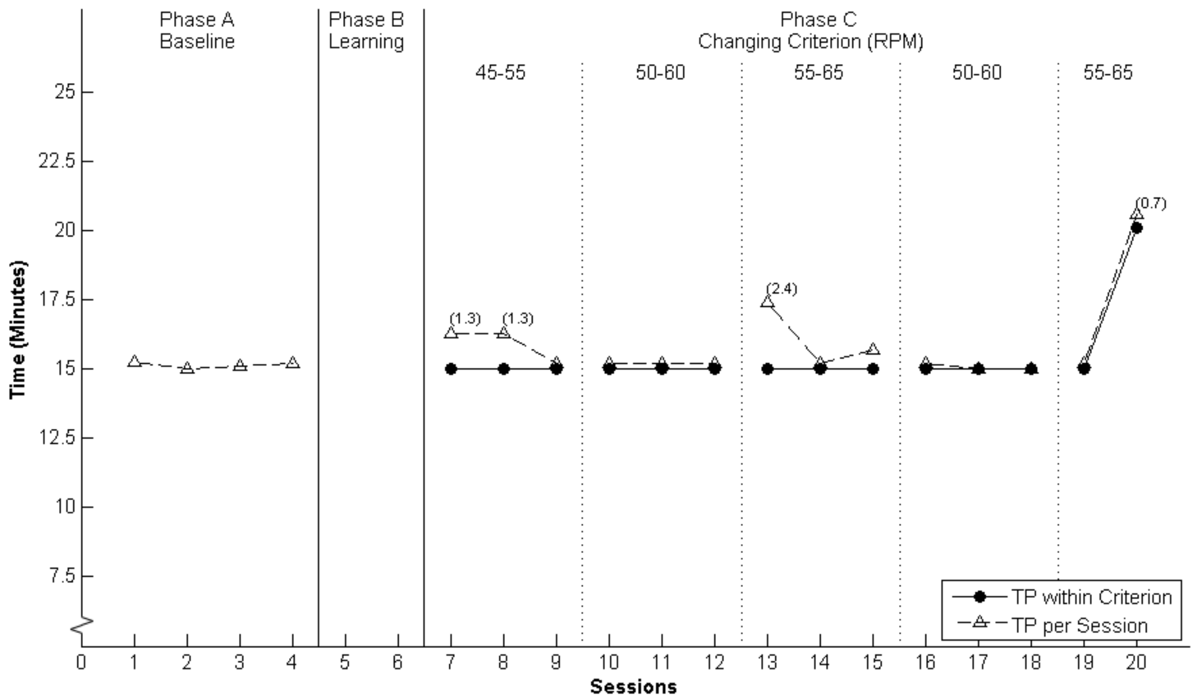


Figure 4. Time pedaled data for Participant 1. The numbers in parentheses indicate time pedaled outside the criterion range in either the low or high red zone. During Phase B, learning took place and no data were collected.

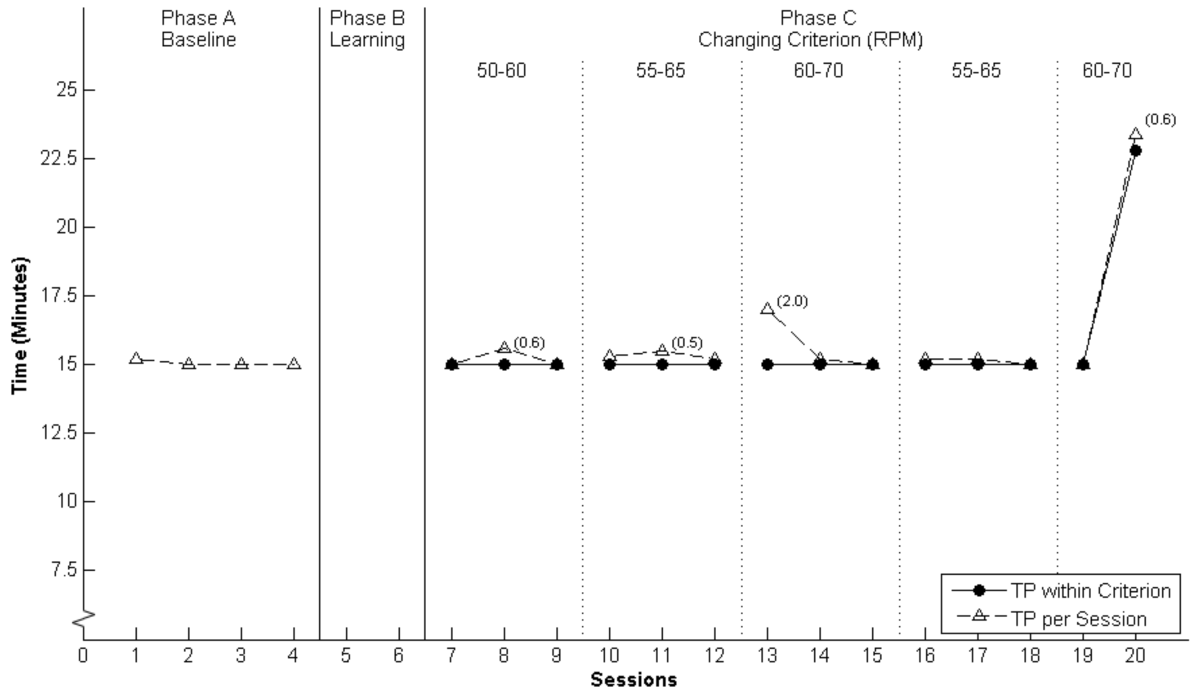


Figure 5. Time pedaled data for Participant 2. The numbers in parentheses indicate time pedaled outside the criterion range in either the low or high red zone. During Phase B, learning took place and no data were collected.

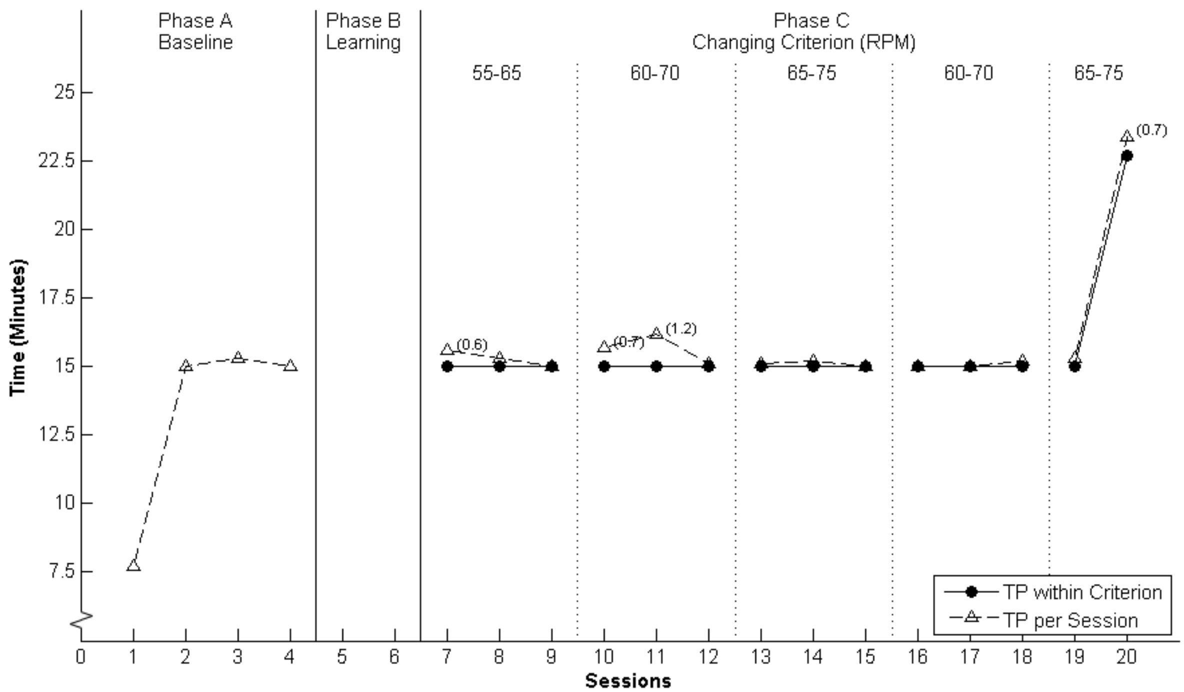


Figure 6. Time pedaled data for Participant 3. The numbers in parentheses indicate time pedaled outside the criterion range in either the low or high red zone. During Phase B, learning took place and no data were collected.

the participant was able to pedal for 22.7 min within the target criterion range. On four occasions during the study, the participant's total TP per session and the total within-criterion TP differed noticeably—during sessions 7, 10, 11, and 20. During these sessions, respectively, he pedaled in the red or stopped pedaling for 0.6, 0.7, 1.2, and 0.7 min.

The descriptive and graphic TP data presented show that all participants were in compliance with the set TP goal (15 min) throughout treatment.

No increase in TP was introduced during the treatment phase, except in the very last session of the study (Session 20), during which the TP goal was set at 25 min. None of the participants reached the 25-min TP goal, but all pedaled for 20+ min. Due to the time constraints of the study, no further measures at this higher TP goal were obtained.

Pedal Revolutions per Minute (RPM)

Pedal revolutions were recorded by the microprocessor via a Reed switch mounted on the pedal crank, and the RPM values provided an indication of the exercise intensity at which a participant cycled. For each session, two separate RPM values were calculated and reported: (a) the average RPM for the total session and (b) the average RPM pedaled within the target range (both the green and yellow zones) during a session. In addition, the standard deviation was calculated for the RPM pedaled within the criterion zone. Table 8 presents each participant's descriptive RPM data (means and standard deviations) for Phase A (baseline) and Phase C (treatment), as well as the RPM data for each individual changing-criterion phase within the treatment.

Table 8

Descriptive Data of RPM for Participants and Phases

Parameter & Phase	Participant 1		Participant 2		Participant 3	
	M	*SD*	*M*	*SD*	*M*	*SD*
Total session RPM						
Baseline (n = 4)	43.4	5.2	48.9	2.7	54.2	2.6
Treatment (n = 14)	55.1	4.2	59.4	3.7	64.8	4.1
Treatment* (n = 13)	55.0	4.2	58.9	3.5	64.5	4.1
Total within-criterion RPM						
Treatment (n = 14)	55.7	3.8	59.5	3.8	65.2	4.0
Treatment* (n = 13)	55.4	3.8	59.1	3.5	64.9	4.0
Within-criterion RPM						
Initial criterion (RPM criterion)	49.8 (45-55)	1.5	53.8 (50-60)	0.5	59.6 (55-65)	0.1
Increased criterion (RPM criterion)	56.4 (50-60)	0.7	58.3 (55-65)	1.1	63.8 (60-70)	0.6
Increased criterion (RPM criterion)	58.4 (55-65)	2.2	62.2 (60-70)	0.8	69.8 (65-75)	1.1
Reversed criterion (RPM criterion)	55.2 (50-60)	1.4	60.3 (55-65)	1.4	64.6 (60-70)	0.5
Increased criterion (RPM criterion)	60.1 60.6* (55-65)	0.7	64.7 64.1* (60-70)	0.8	69.8 69.9* (65-75)	0.2

*Session 20 data point excluded.

These descriptive RPM data (Table 8) show an increase of ≥ 10 RPM in means from baseline to treatment for each participant whether Session 20's (higher TP) data were included or not. The data also reveal that differences between each participant's total session and total treatment RPM were negligible, indicating that the participants were all pedaling within the criterion zone the vast majority of the time. The within-criterion RPM data show that as the criterion changes increased, so did the mean RPM values, and when the criterion was reversed, the mean RPM of each participant decreased accordingly.

For two participants (Participant 2 and Participant 3), the standard deviation increased between baseline and treatment, whereas for the third participant (Participant 1) it decreased.

Looking at the RPM values during each criterion phase within the treatment, the RPM data for all participants mirrored a classical changing-criterion design with directional change, i.e., the RPM values (behavior, dependent variable) changed with concomitant change in criterion changes. Table 8 also demonstrates that the mean RPM values for each participant were very close to the midpoint of each respective target criterion range, with relatively small standard deviations (ranging from 0.2 RPM for Participant 3 to 2.2 RPM for Participant 1). The next highest standard deviation was 1.5 RPM (also Participant 1). During Session 13 (third criterion change), Participant 1 pedaled very erratically for the first part of the session, resulting in a greater variance of RPM pedaled.

A related question was based on the researcher's interest in seeing whether, as the study progressed, the participants (a) were able to find a steady pedal rate at which they consistently pedaled within each criterion range or (b) found it easier to maintain a steady pedal rate within any specific RPM range. Table 9 provides the descriptive SD data (means) for each participant when pedaling within the criterion (yellow-green) range.

Table 9

Descriptive Data for Standard Deviation of Average RPM Pedaled Within the Criterion for Participants

Phase	Mean *SD*		
	Participant 1	Participant 2	Participant 3
Total within-criterion SD (RPM)			
Treatment (*N* = 14)	2.2	3.0	2.6
Treatment* (*N* = 13)	2.2	3.0	2.5
Within-criterion SD (RPM)			
Initial criterion (RPM criterion)	2.7 (45-55)	2.8 (50-60)	2.6 (55-65)
Increased criterion (RPM criterion)	2.5 (50-60)	3.2 (55-65)	2.5 (60-70)
Increased criterion (RPM criterion)	1.5 (55-65)	3.3 (60-70)	2.4 (65-75)
Reversed criterion (RPM criterion)	2.2 (50-60)	2.5 (55-65)	2.3 (60-70)
Increased criterion (RPM criterion)	1.8 1.7* (55-65)	3.6 3.4* (60-70)	3.3 2.9* (65-75)

*Session 20 data point excluded.

It must be noted that during the final session of the study (Session 20), the researcher increased the TP goal to 25 min (for reasons described under the section on time pedaled). Although none of the participants were able to complete the 25-min cycling session, they all cycled at least 5 min longer than in previous sessions during this (increased) target criterion. This only had a minor effect on the participants' RPM values for that session (as indicated in Table 8). During the final (upward) criterion change (sessions 19 and 20), excluding Session 20's data decreased the standard deviations by 0.1, 0.2, and 0.4 RPM for participants 1, 2, and 3, respectively.

The mean standard deviation (calculated across the yellow plus green zone, thus a 20-RPM range) for all participants across treatment ranged from 2 to 3 RPM. The mean standard deviation values of both Participant 1(more clearly so) and Participant 3 showed a decrease across treatment with the exception of the standard deviation value that increased for Participant 1 during the reversal criterion change (sessions 16–18) and the slight increase for Participant 3 of the standard deviation value during the final criterion change (sessions 19 and 20). Interestingly, Participants 1's mean standard deviation value for the final (increased) criterion change (sessions 19 and 20) during which he pedaled for 20.6 minutes in the final session decreased slightly from 2.2 to 1.8 RPM. Thus, the longer time that he pedaled did not seem to affect his standard deviation value. For both Participant 2 and Participant 3, and whether or not Session 20's data were included, the mean standard deviation values increased with the final (upward) criterion change. Participant 2's mean standard deviation values mirrored that of the classical changing-criterion design, i.e., when the criterion changes increased, so did the mean standard deviation values, when the reversal change was implemented the mean standard deviation values decreased, and when the final (increasing) criterion change was introduced, his mean standard deviation values increased. In addition, Participant 3 seemed to have maintained a relatively "stable" pedaling rate throughout the entire treatment phase (*SD* 2.3–2.6, excluding the final session's data).

Figure 7 depicts a graphic display of actual RPM data per session for each participant based on the data recorded per session during the study (Appendix N, Tables N1, N2, and N3 for participants 1, 2, and 3, respectively).

As can be observed in Figure 7, all participants completed the design as intended, and their data portrayed the pattern of the classic changing-criterion design with a bidirectional change in terms of consistency of a data pattern across the treatment phases (thus, each participant's cycling activity behavior changed with the changes in criterion), immediacy of effect, relatively narrow variability, as well as some indication of trend within each criterion change. The RPM data points clearly showed that (a) with the three consecutive upward criterion changes (sessions 7-9, 10-12, and 13-15), RPM also increased; (b) the increase was followed by a "step-down" in RPM data points when the reversal criterion (sessions 16-18) was implemented, and (c) the step-down was followed in turn by a "step-up" again when the final (increasing; sessions 19 and 20) criterion change was implemented. In addition, all three participants required only the minimum number of sessions (i.e., ≥ 80% compliance for three consecutive sessions) for a criterion to be changed.

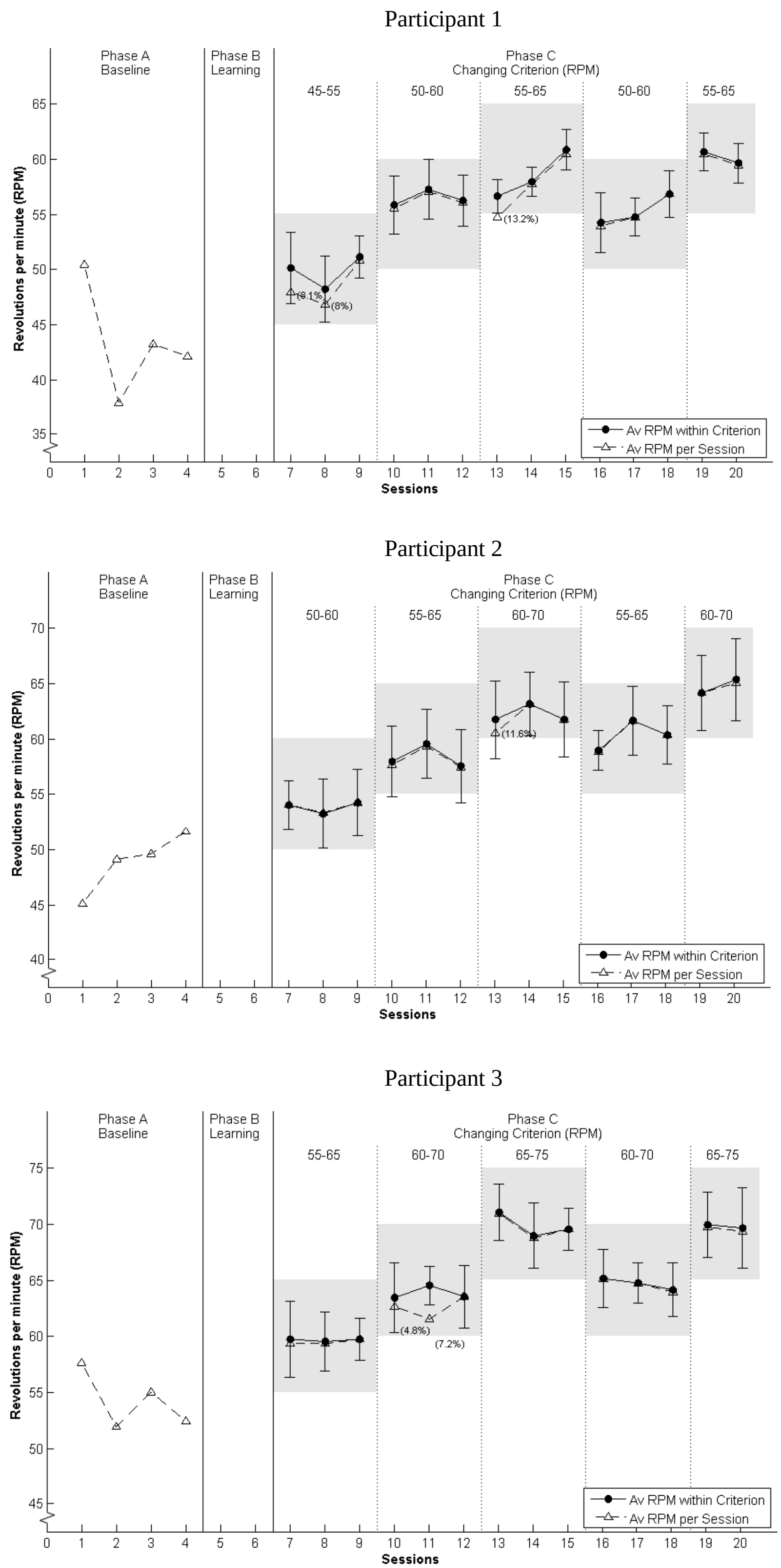


Figure 7. Average RPM per session and phase for all participants. Error bars indicate the *SD* for each data point. During Phase B, learning took place and no data were collected.

Figures 7, 8, and 9 are separate graphic displays of the RPM data for participants 1, 2, and 3, respectively. Participant 1's baseline RPM values showed some variance, but data points within the treatment phase (target criterion ranges) were more narrowly banded (Figure 8). Even though the participant's total and within-criterion RPM values per session were very similar throughout the study, there were three sessions during which these two values differed noticeably—during the first two sessions of the initial criterion change (sessions 7 and 8) and during the first session of the third criterion change (Session 13), where 8.1%, 8%, and 13.8% of his RPM values were below the boundaries of the within-criterion range, respectively (indicated in brackets on the graph). A possible explanation for this could be that, with the introduction of a narrower RPM range (45–55 RPM) during the initial criterion change, this participant needed some time to get used to the pedaling "rhythm" of this RPM change—even though he was able to pedal at this RPM range during the learning phase (although for only 10 min). When the TP goal was increased (Session 20) and the participant pedaled 5 min longer than during previous sessions, his RPM value showed a slight decrease (although still remaining within the criterion set). This showed that he, on average, pedaled slightly slower during the 20-min session than during the (previous) 15-min session.

Participant 2 steadily increased his RPM values during baseline (Figure 9). Interestingly, and with the exception of the initial changing criterion following phases A and B (Session 8), this participant's second (mid) session RPM values were always the highest within each criterion (sessions 11, 14, and 17). During the third "step-up" in criterion (sessions 13 to 15), all three of his RPM data points were in the lower half of the criterion range. Thus, although he pedaled within the set RPM criterion range (60–70 RPM), he did so on average or consistently within the lower range. This could have been an indication that this (highest) criterion range was a bit difficult for him. Only once during the study was his total RPM value noticeably less than that of his within-criterion RPM—during the third criterion change (Session 13), when 11.6% of his RPM values were outside the boundaries of the within-criterion range (indicated in parentheses on the graph)—another indication that this RPM criterion was a bit difficult for him. However, with the increase in TP goal during the final session of Phase C (Session 20) during which the criterion was also 60–70 RPM, the participant's RPM values showed a slight increase (he pedaled for 22.8 min during that session). For this participant, the gears were changed (from the initial setting of front middle chainring and fourth rear gear to the front middle chainring and fifth rear gear) during Session 12. This seemed to be a more comfortable gear for him to pedal at within the set RPM criterion (50–60 RPM), but also slightly increased the resistance at which he was pedaling.

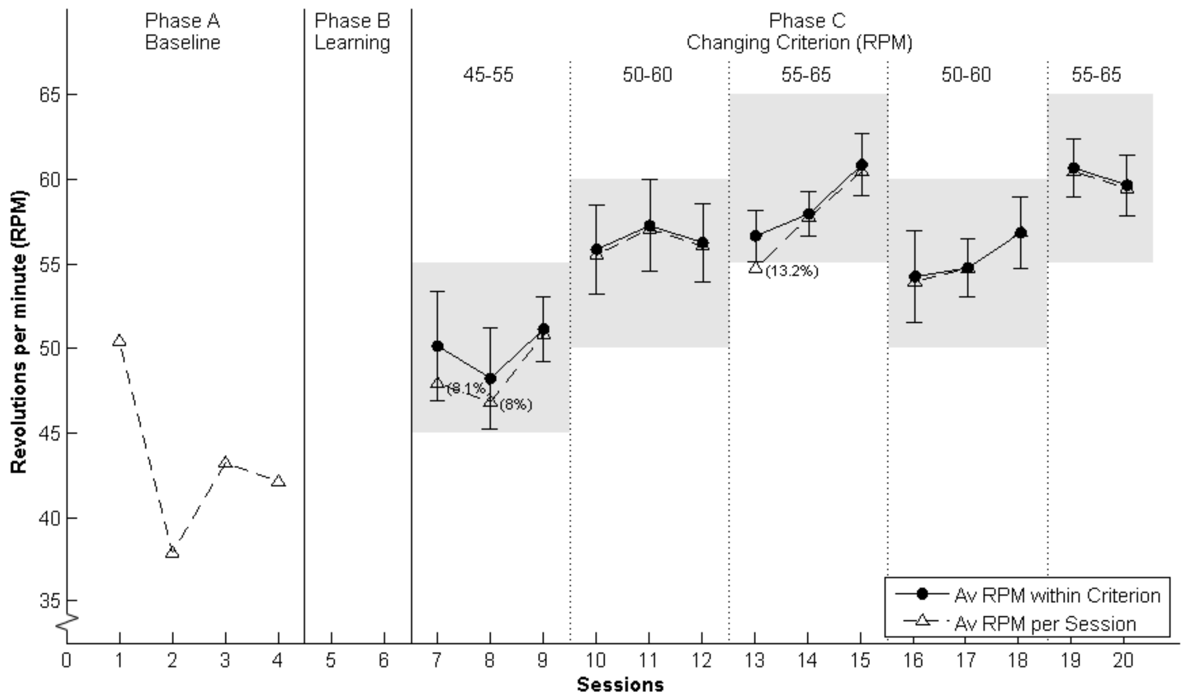


Figure 8. RPM data for Participant 1. Error bars indicate the *SD* for each data point. During Phase B, learning took place and no data were collected.

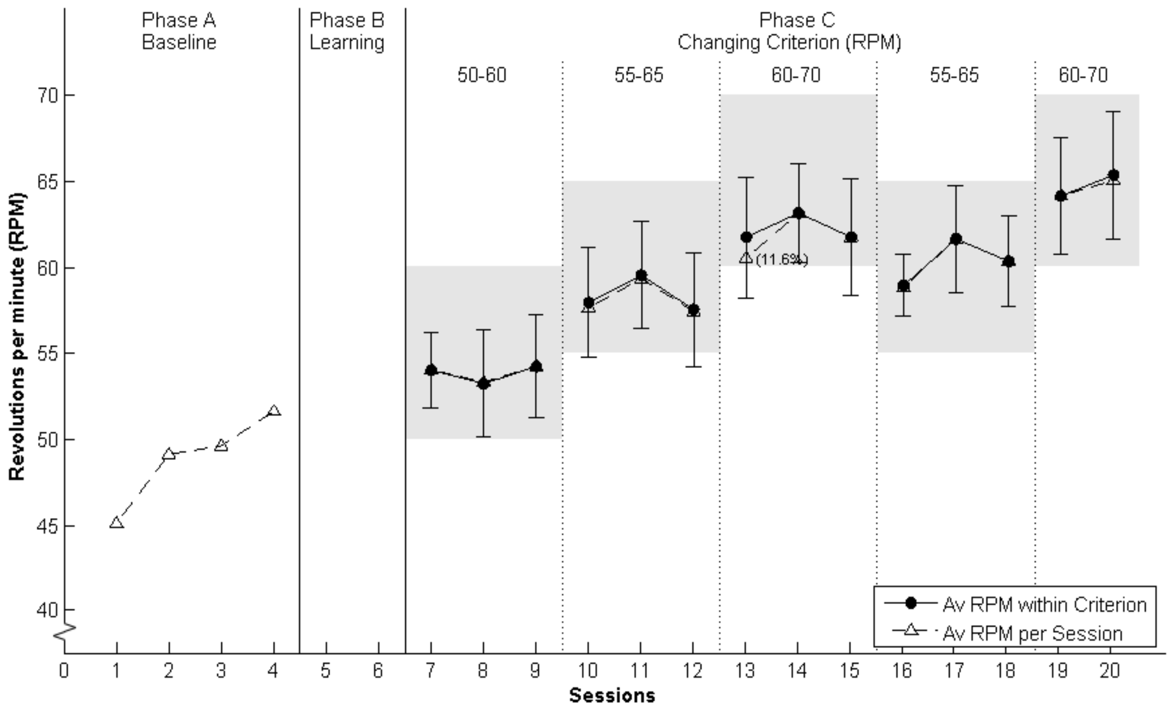


Figure 9. RPM data for Participant 2. Error bars indicate the *SD* for each data point. During Phase B, learning took place and no data were collected.

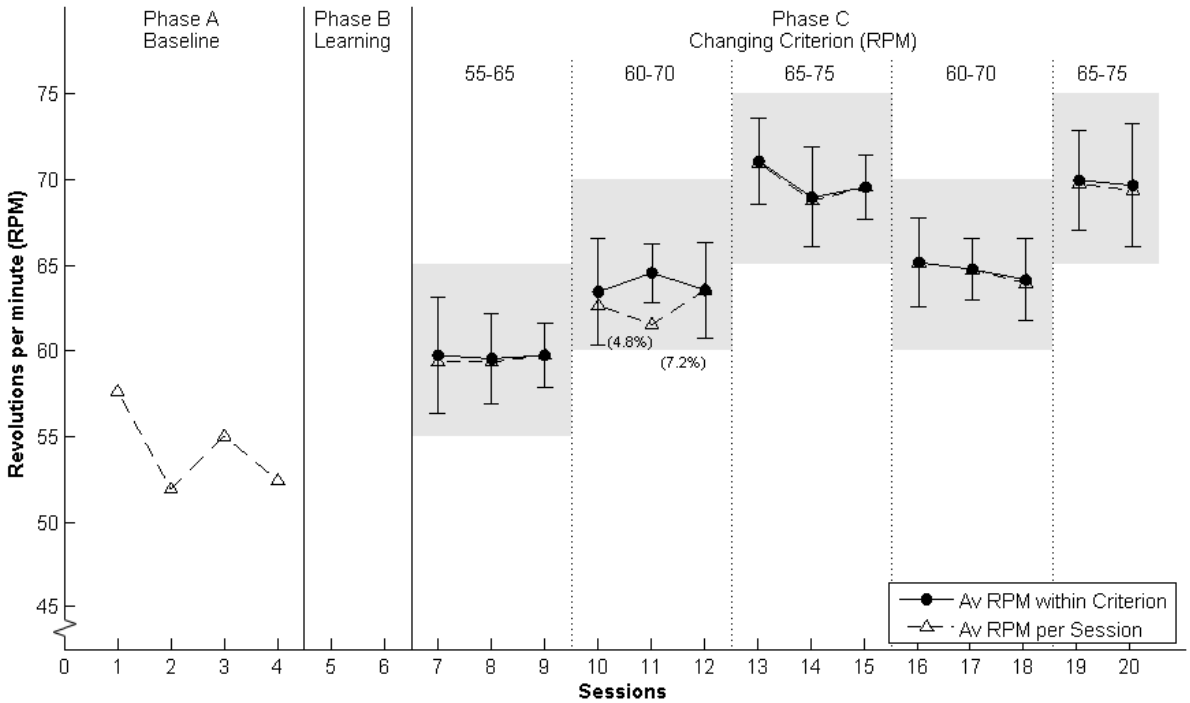


Figure 10. RPM data for Participant 3. Error bars indicate the *SD* for each data point. During Phase B, learning took place and no data were collected.

Participant 3's baseline RPM data points showed some variance, but they became more narrowly banded during Phase C (Figure 10). During the second criterion change, his total RPM values and within-criterion RPM values differed noticeably in the first and second sessions, with 4.8% (Session 10) and 7.2% (Session 11), respectively, of his RPM values below the boundaries of the within-criterion range. The second criterion change (sessions 10–12) was also the period during which all this participant's RPM values were in the bottom half of the set criterion level, i.e., he consistently pedaled within the lower green zone.

With the increase in TP goal during the final session of Phase C (Session 20), the participant's RPM values showed a very slight decrease (he pedaled for 22.7 min during that session). Interestingly, during the third criterion change (sessions 13–15, constituting a "step-up"), as well as during the next (reversal) criterion change (sessions 16–18), this participant's data points showed a slight negative slope even though he maintained pedaling within the set RPM criterion.

The RPM data presented indicate a positive influence on all participants' compliance with the cycling activity (and in terms of exercise intensity). Both descriptive and graphic displays of data presented also indicated an increase in RPM from baseline to treatment, as well as within the changing criteria in the treatment phase. The first research question (RQ 1) was thus (positively) answered. The second research question (RQ 2) could not be answered—although RPM values did increase during the changing-criterion phase (treatment), the extent to which the increase was of meaningful magnitude with respect to health was assessed by heart rate monitoring (reported on below).

Total Output per Session

The total number of revolutions per session (work output) was "counted" by the Reed switch and recorded and utilized by the microprocessor, which was programmed to calculate the average RPM per session (by dividing the total revolutions by the total TP per session). Thus, the total output per session (TOS) is, in fact, the same as multiplying each session's TP by the average RPM. It provided for an additional way of inspecting the work (output) exerted by the participants during the cycling activity. Table 10 displays the descriptive data (means and standard deviations) for each participant during Phase A (baseline) and Phase C (treatment), as well as for each session within the treatment phase.

These descriptive data clearly indicate an increase in the mean TOS values for all participants between baseline (Phase A) and treatment (Phase B). The magnitude of these increases was, however, affected (inflated) by the increased TP goal set for the final session. If Session 20's data were removed from these calculations (as shown in Table 10), Participant 1's final criterion-change value (a single data point within the set 55–65 RPM criterion range) would be 906 RPM—an increase of 79 RPM from the previous (reversal) criterion change (50–60 RPM range). In the previous similar criterion change for this participant with the same values, namely from the second criterion change (sessions 10–12) to the third criterion change (sessions 13–15)—i.e., from the 50–60 RPM criterion range to the 55–65 RPM criterion range—the increase from one criterion change to the next was only 21.5 RPM.

Table 10

Descriptive Data of Total Output per Session for Participants and Phases

Parameter & Phase	Participant 1		Participant 2		Participant 3	
	M	*SD*	*M*	*SD*	*M*	*SD*
Total session TOS (revolutions)						
Baseline (N = 4)	651.0	78.0	732.8	40.9	707.0	180.5
Treatment (N = 14)	851.0	123.1	962.5	167.6	1010.7	172.4
Treatment* (N = 13)	822.2	62.8	883.7	52.3	967.4	61.6
Within-criterion TOS (revolutions)						
Initial criterion (RPM criterion)	727.5 (45–55)	31.0	807.5 (50–60)	7.1	891.5 (55–65)	3.5
Increased criterion (RPM criterion)	842.5 (50–60)	11.5	871.5 (55–65)	15.7	938.0 (60–70)	15.0
Increased criterion (RPM criterion)	864.0 (55–65)	42.8	926.5 (60–70)	19.5	1045.5 (65–75)	16.7
Reversed criterion (RPM criterion)	827.0 (50–60)	22.5	903.5 (55–65)	21.0	968.5 (60–70)	9.2
Increased criterion (RPM criterion)	1064.8 906* (55–65)	224.6	1221.8 961.5* (60–70)	368.0	1309.3 1045.5* (65–75)	373.1

*Session 20 data excluded.

Similarly, if Session 2's data were to be removed, Participant 2's final criterion-change value (a single value for that 60–70 RPM criterion range) would have been 961.5 RPM, an increase of 58 RPM from the previous (reversal) criterion change (55– 65 RPM criterion range). In the previous similar criterion change for this participant with the same values, namely from the second criterion change (sessions 10–12) to the third criterion change (sessions 13–15)—i.e., from the 55–65 RPM criterion range to the 60–70 RPM criterion range)—the increase from the one criterion change to the next was 55 RPM. Finally, had the same been done with Session 20's data for Participant 3, his final criterion change value (a single value for his 65–75 RPM criterion range) would have been 1045.5 RPM—an increase of 77 RPM from the previous (reversal) criterion change (60–70 RPM criterion range). In the previous similar criterion change for this participant with the same values—i.e., from the second criterion change (sessions 10–12 with RPM criterion set at 60–70) to the third criterion change (sessions 13–15 with RPM criterion set at 65–75)—the increase in RPM from the one criterion change to the next was a larger 107.5 RPM. However, the fact remained that all participants' work output increased from the reversal criterion change (sessions 16–18) to the (next level) increased criterion change whether Session 20 was included or excluded.

Table 10 revealed that there was an increase in mean TOS SD values (with and without Session 20's data point) for one participant (Participant 2) between baseline and treatment. This was the case for Participant 2 only when the final data point was included; when it was excluded, his mean TOS standard deviation value decreased. Participant 3's standard deviation values revealed a small decrease from baseline to treatment when Session 20's data were included, but a significantly large decrease in mean TOS standard deviation on excluding the final data point.

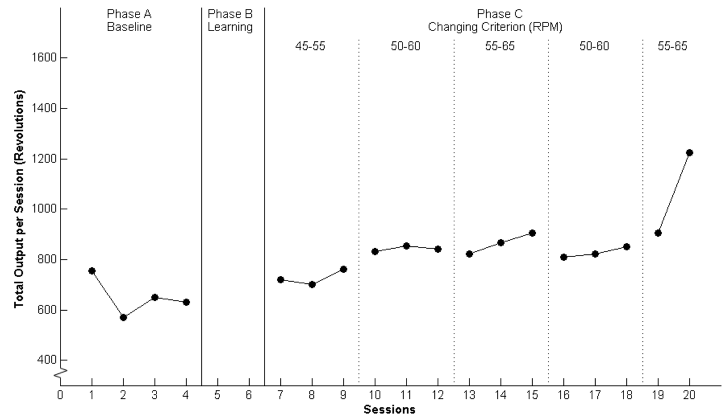
Throughout Phase C (treatment) Participant 3 had the lowest and a relative stable mean TOS standard deviation, whereas Participant 1's standard deviations were the highest.

Within the treatment phase, the mean TOS of each participant increased steadily with the first three (increasing) criterion changes, then decreased during the reversal criterion change, and with the final (step-up) criterion change (to which an additional 5 to 8 min of pedaling was added), an increase in the mean TOS values ranged from 238 (Participant 1) to 341 (Participant 3) – and even without Session 20's data taken into account the corresponding increase in mean TOS ranged from 58 (Participant 2) to 79 (Participant 1). This pedaling behavior (TOS) change in accordance with changes in criteria exemplified the classic changing-criterion design with bidirectional changes. The mean TOS values for the second increasing (sessions 10–12) and fourth reversal (sessions 16–18) criterion changes (constituting identical RPM criterion ranges for each participant) indicated that for two participants (participants 2 and 3), these values increased when they pedaled at the same RPM criterion (and same TP goal) for the "second" time. The opposite was the case for Participant 1. However, the mean TOS values increased for all participants from the third criterion change (sessions 13–15) to the fifth (following reversal) criterion change (sessions 19 and 20), which also constituted identical RPM criterion ranges. For participants 1 and 2, these increases mirrored the increases of their mean RPM data. For Participant 3, however, the mean TOS increase was not mirrored by that participant's mean RPM value, which remained the same; TP (7.7-min increase) is thus the only other factor in the equation (TOS = average RPM × TP), which resulted in the increased TOS during the final criterion change for this participant.

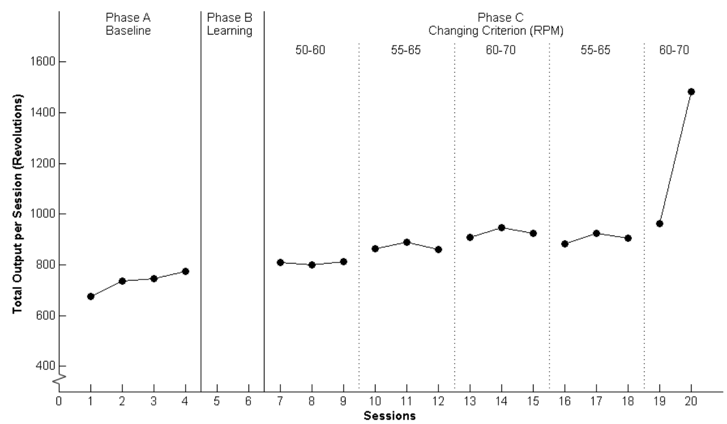
Figure 11 graphically displays the actual TOS data per session based on the data recorded during each session of this study (Appendix N, Tables N1, N2, and N3 for participants 1, 2, and 3, respectively).

All the participants' data points depicted, in the same way that the descriptive data did, a mirroring of the classic changing-criterion design with bidirectional change. The cycling activity behavior (in terms of work output) thus changed with a change in criterion. In addition, data points within each criterion point were narrowly banded, and changes in level (i.e., immediacy of the effect) between each criterion-change phase (i.e., at the line between adjacent phases) were clearly visible. These graphic illustrations of each participant's mean TOS values closely mirrored their respective mean RPM graphs, but the data points in the TOS graphs had less variability than those in the RPM graphs for all participants (as a result of perfect compliance with the set 15-min TP goal). In addition, when compared to the RPM graphs, the only difference in data points was related to that of the final (Session 20) values. The mean TOS value for this final session was considerably greater than any other data point on the graph for all participants.

Participant 1



Participant 2



Participant 3

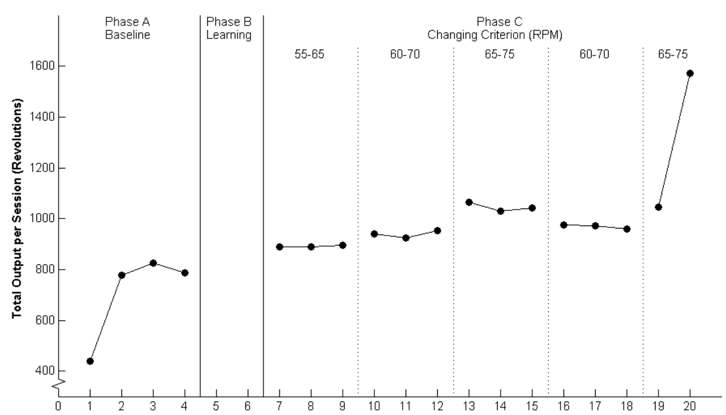


Figure 11. Average total output per session (TOS) per session and phase for all participants. During Phase B, learning took place and no data were collected.

The separate graphic presentations of the TOS values for participants 1, 2, and 3 are given in Figures 11, 12, and 13. Participant 1's baseline TOS values (Figure 12) showed some degree of variability, but became more narrowly banded during the treatment phase. An upward trend (except during the second criterion change during sessions 10–12) within each criterion change, as well as changes in level between criterion-change phases were visible in Participant 1's TOS graph. Comparison of this participant's TOS data graph and RPM graph shows that the major (only data point) difference was related to the data point of the final session (Session 20). The fact that his RPM data point was slightly lower than the previous session's RPM data point while his TOS value was noticeably higher than the TOS value of the previous session indicated that the only cause for this higher TOS value was the increased time (5 min) this participant spent pedaling.

As can be seen in the graphical depiction of Participant 2's TOS values (Figure 13), his baseline data depicted a steady and gradual upward trend. The TOS data points within each criterion-change phase for this participant were narrowly banded with clear changes (level differences) between adjacent criterion changes. Compared to the RPM data graph for this participant, the main difference in his TOS graph was the final data point (Session 20). Although the participant's RPM value for this session was slightly higher than that of the previous session, there was a substantial increase in the TOS value. The only factor that could have been responsible for this sharp increase was the fact that this participant pedaled for a total duration of 22.8 min during that final session.

The graph depicting the TOS values for Participant 3 (Figure 14) demonstrates some level of variability within the baseline phase, followed by tightly banded data points during each criterion phase and clear level changes between criterion changes. As was the case for his RPM data, this participant's data points for the third upward criterion change (sessions 13 – 15) followed by the reversal criterion change (sessions 16–18) show a slight downward slope. A comparison between Participant 3's RPM and TOS data graphs showed only one difference, i.e., between the values of Session 20 for RPM and TOS. Once again, the increased time pedaled during the final session (in this participant's case, 22.7 min) provided the only explanation for the significant increase in the TOS data point during the session while the corresponding RPM value was slightly lower than the value obtained during the previous session.

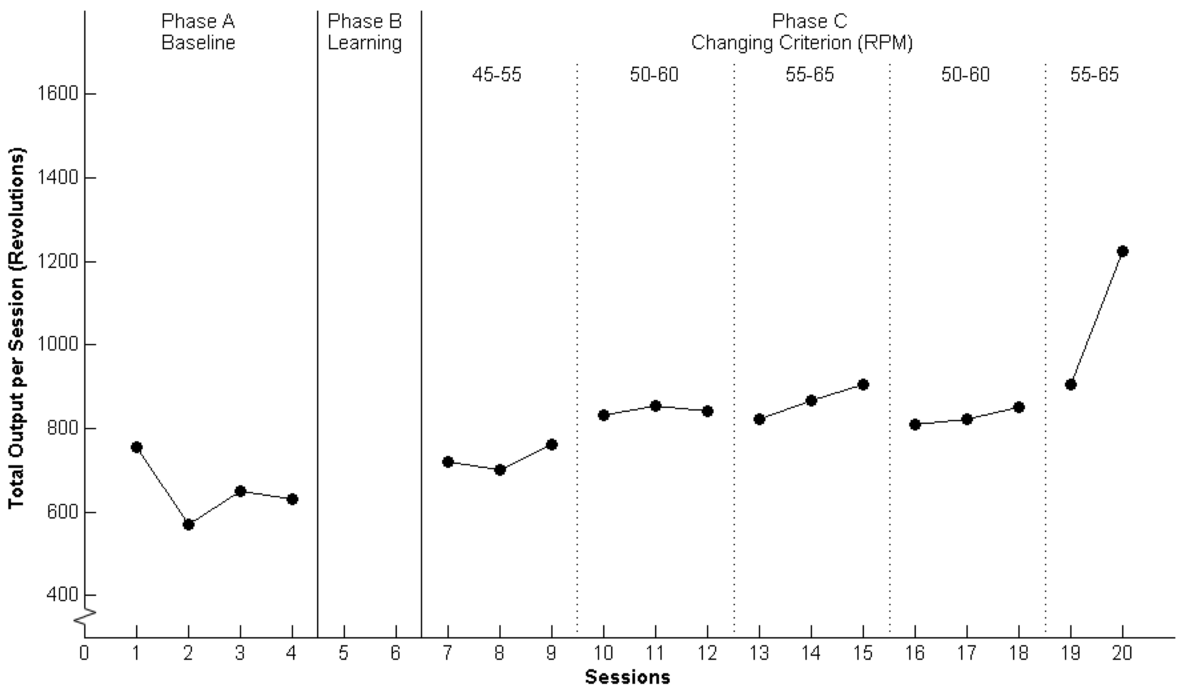


Figure 12. TOS data for Participant 1. During Phase B, learning took place and no data were collected.

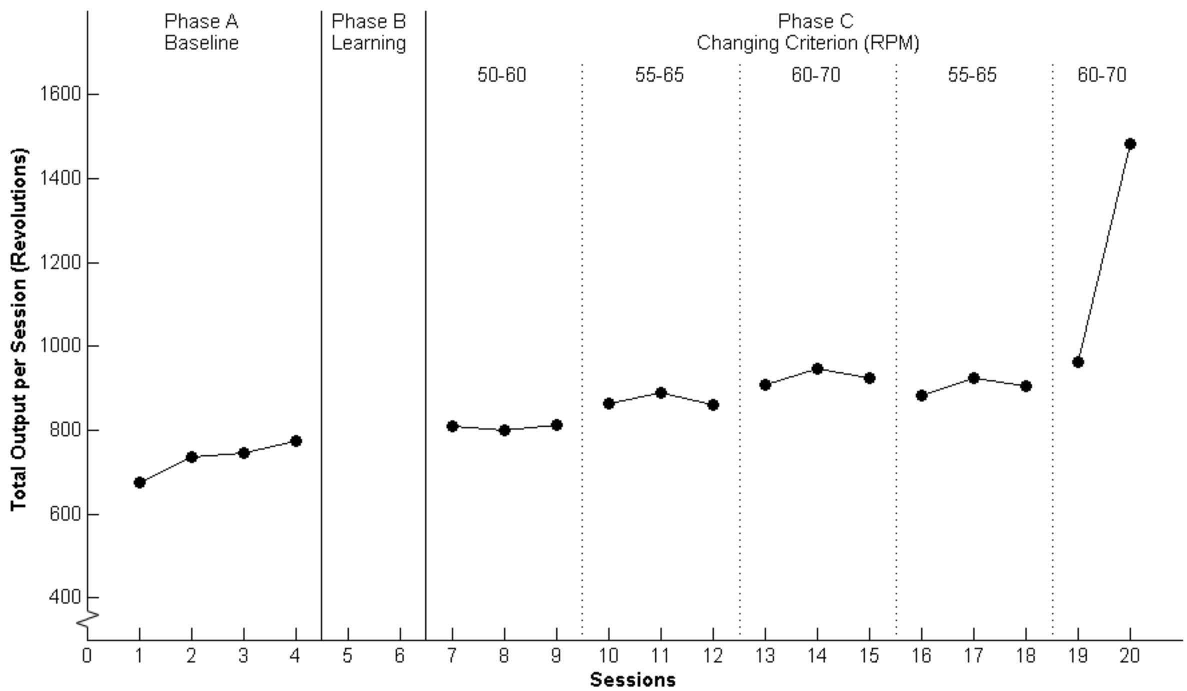


Figure 13. TOS data for Participant 2. During Phase B, learning took place and no data were collected.

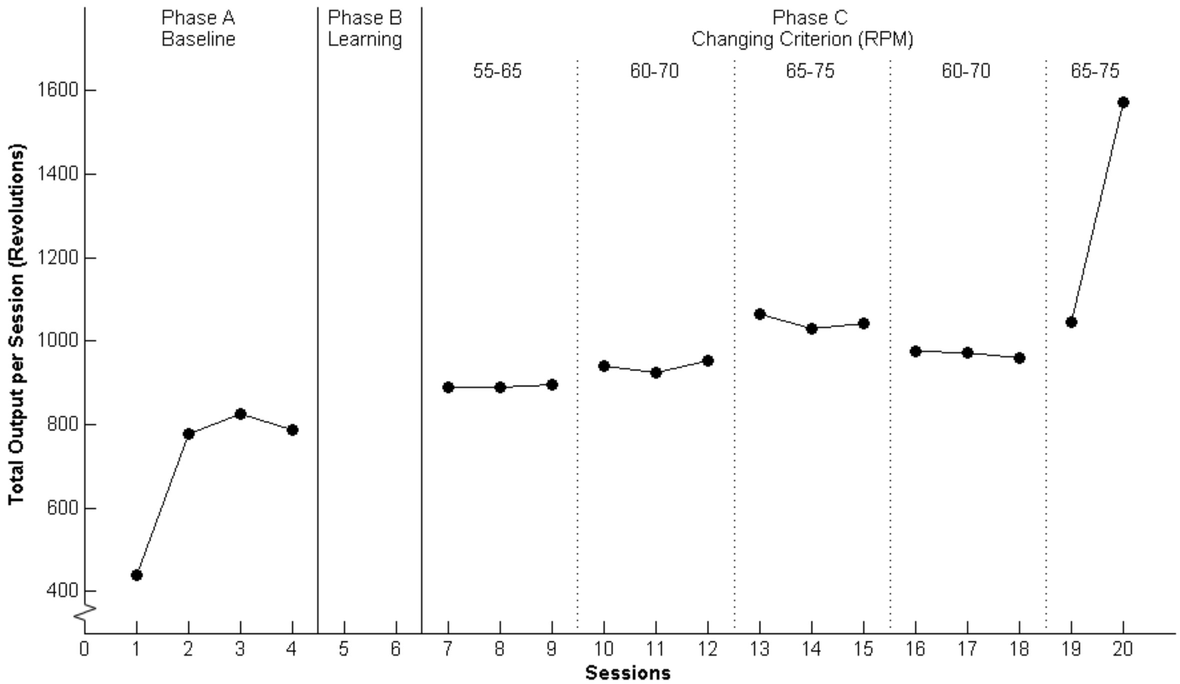


Figure 14. TOS data for Participant 3. During Phase B, learning took place and no data were collected.

These descriptive and graphic presentations of the TOS data demonstrate an increase in compliance of all participants (in terms of work output, a "combination" of duration/time and intensity) between Phase A (baseline) and Phase C (treatment). RQ 1 was positively answered, while RQ 2 could not be answered because these results did not give any information in regard to whether intensity levels that were meaningful for health benefits were reached.

Percentage Compliance

The microprocessor was programmed to calculate the percentage compliance from the recorded data after each session—the TP pedaled within the criterion over the total TP pedaled per session, expressed as a percentage. This value was only implemented during Phase C (treatment) when it was used by the researcher to make decisions concerning each cycling activity session in terms of the following: (a) when to implement a criterion change and (b) when to implement the reversal (directional) change. For a criterion change (i.e., a 5-RPM increase) to be implemented, a participant had to have maintained $\geq$ 80% compliance over three sessions (of which two had to be consecutive). After three consecutive upward criterion changes were accomplished by a participant, the criterion level was reversed for a minimum of three sessions, whereafter it was increased again by 5 RPM to test whether it was, in fact, the manipulation of the independent variable (i.e., the contingent-based, changing-criterion cycling activity) that resulted in the changes exhibited by the dependent variables. The descriptive data (means and standard deviations) of the percentage compliance of each participant are presented in Table 11.

Table 11

Descriptive Data of Percentage Compliance for all Participants during Phase C

Parameter & Phase		Participant 1		Participant 2		Participant 3	
		M	*SD*	*M*	*SD*	*M*	*SD*
Total within-criterion % compliance							
	Treatment (*N* = 14)	96.9	4.1	98.0	3.0	98.1	2.2
	Treatment* (*N* = 13)	96.7	4.2	98.0	3.1	98.2	2.2
Within-criterion % compliance							
	Initial criterion (RPM criterion)	94.1 (45–55)	3.7	98.7 (50–60)	2.0	98.1 (55–65)	1.8
	Increased criterion (RPM criterion)	98.9 (50–60)	0.1	97.8 (55–65)	1.1	96.0 (60–70)	3.3
	Increased criterion (RPM criterion)	93.6 (55–65)	6.6	95.6 (60–70)	6.3	99.4 (65–75)	0.6
	Reversed criterion (RPM criterion)	99.6 (50–60)	0.7	99.3 (55–65)	0.6	99.7 (60–70)	0.6
	Increased criterion (RPM criterion)	98.9 98.9* (55–65)	0.2	98.6 100.0* (60–70)	2.0	97.4 98.0* (65–75)	0.8

* Session 20 data point excluded.

The mean percentage compliance rates were remarkably high for all participants. This was due to the fact that all participants complied 100% with the TP goal set (at 15 min per session) throughout the study. The effects of including Session 20's data point were negligible. None of the mean compliance values within the changing criterion ranges set for each individual participant ever dropped below 93.6% (Participant 1).

Figure 15 gives an overview of the actual percentage compliance data as per the data recorded (and calculations made) per session (Appendix N, Tables N1, N2, and N3 for participants 1, 2, 3, respectively).

All participants complied with the minimum number of sessions for criterion changes to be implemented, and for all participants a reversal criterion change was implemented after the third consecutive (increasing) criterion change. Although the percentage compliance values were distinctly high, with the vast majority of the values falling at or above the 98% point, some individual variability existed within each participant's percentage compliance data points. Only one participant's percentage compliance data points indicated a very modest upward trend across treatment phases (Participant 1), whereas the data points of the other two participants showed hardly any slope across the treatment phase. These two participants had high percentage compliance rate from the start and noticeable increases in slope were thus difficult to achieve at these already high values.

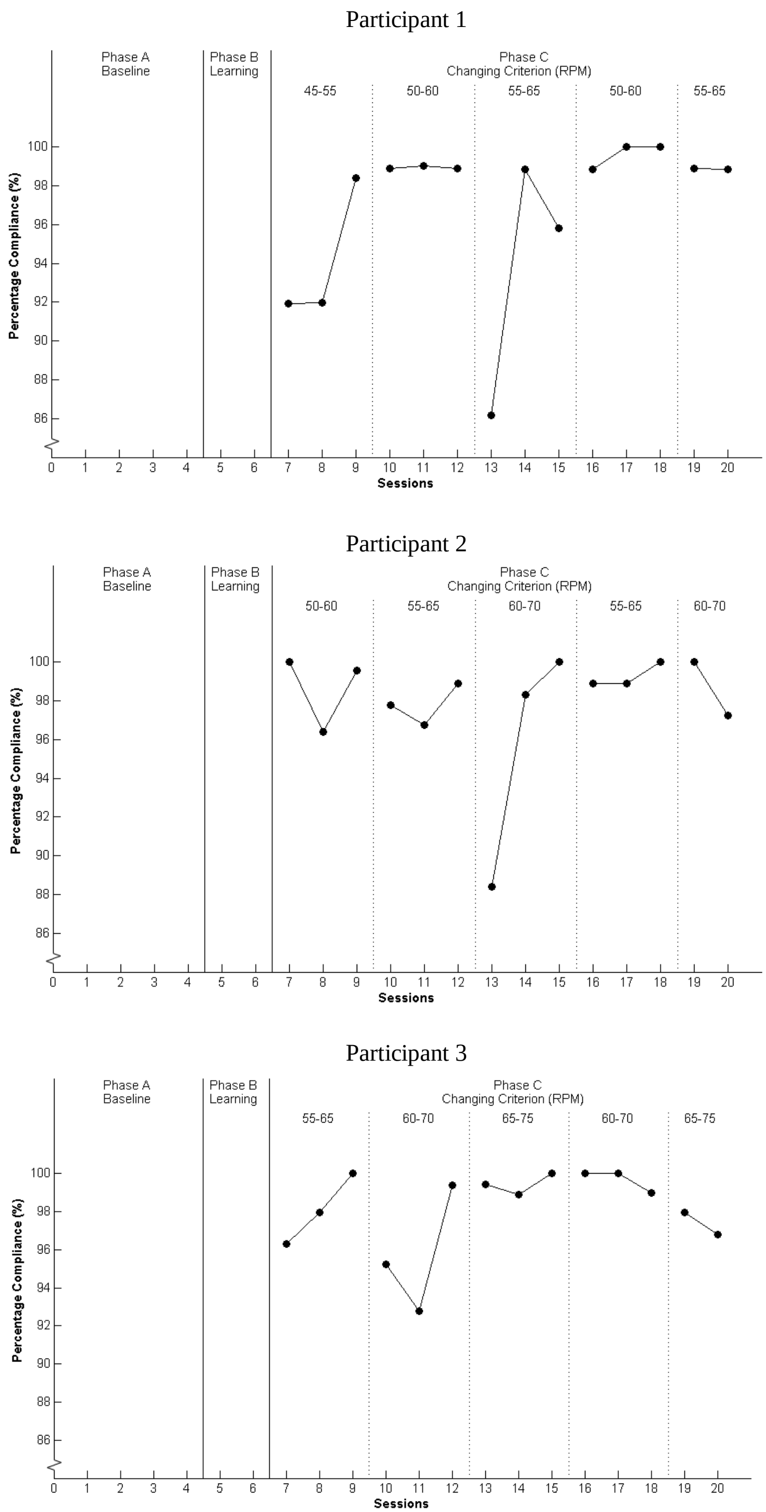


Figure 15. Percentage compliance per session for all participants during treatment phase. During Phase B, learning took place and no data were collected.

Figures 15, 16, and 17 depict the graphic displays of the percentage compliance for participants 1, 2, and 3, respectively. The graph exhibiting the percentage compliance data for Participant 1 (Figure 16) shows a very modest increase in these values across criterion changes. Participant 1 had one low “outlying” value (at 86.5% during Session 13) and two (consecutive) 100% compliance scores during the reversal criterion change (sessions 17 and 18). An explanation for the low outlier value was that during this session, the researcher’s advisor came to observe the cycling sessions. However, the researcher forgot to mention the visit to Participant 1’s teacher the previous day so that it could be added to his social story for his daily schedule. He was thus unprepared for having an unknown individual attend the cycling session. During the session, he had his (not unusual) “slow start,” but was unable to “find his rhythm” for the first 5.5 min, during which the DVD stopped five times due to his pedaling too slowly. After that, he “settled down” and maintained a perfect within-criterion (green zone) pedal rate for the remainder of the time. His low percentage compliance for that session was due to pedaling too slow. Prior to this session, his previous (two) lowest percentage compliance vales, both 92%, were during the initial criterion change (sessions 1 and 2). This could be an indication that he was still in a “learning period” during that time.

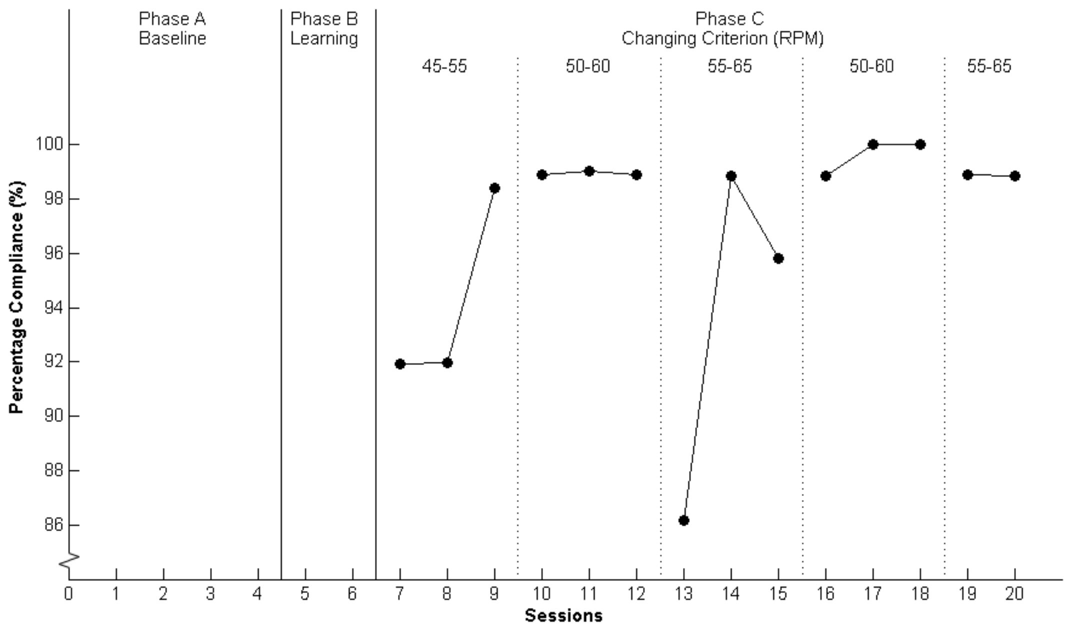


Figure 16. Percentage compliance data for Participant 1. During Phase B, learning took place and no data were collected.

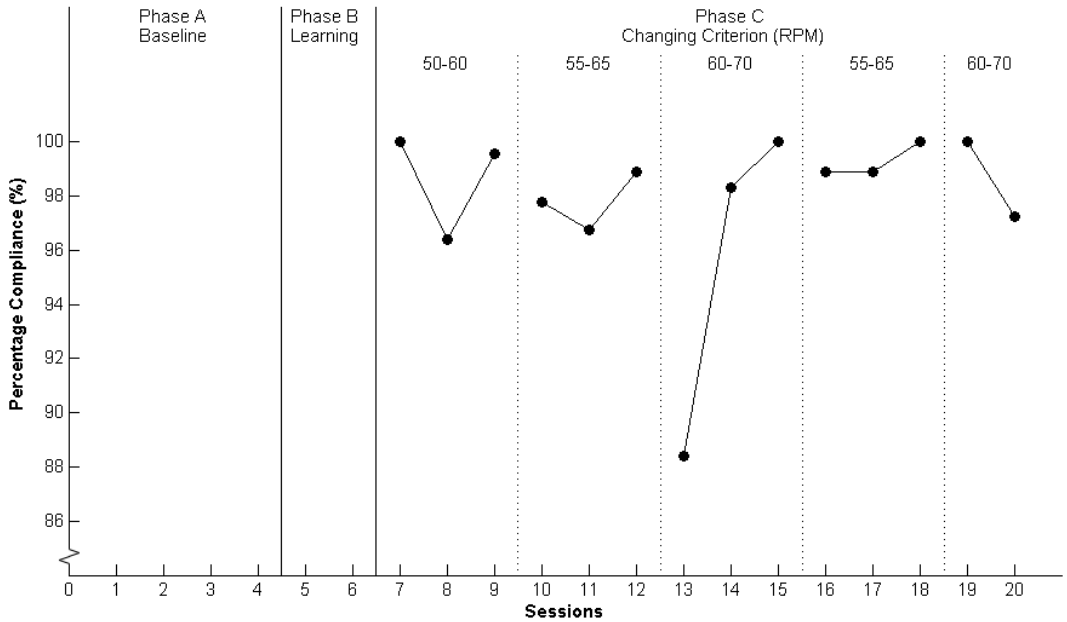


Figure 17. Percentage compliance data for Participant 2. During Phase B, learning took place and no data were collected.

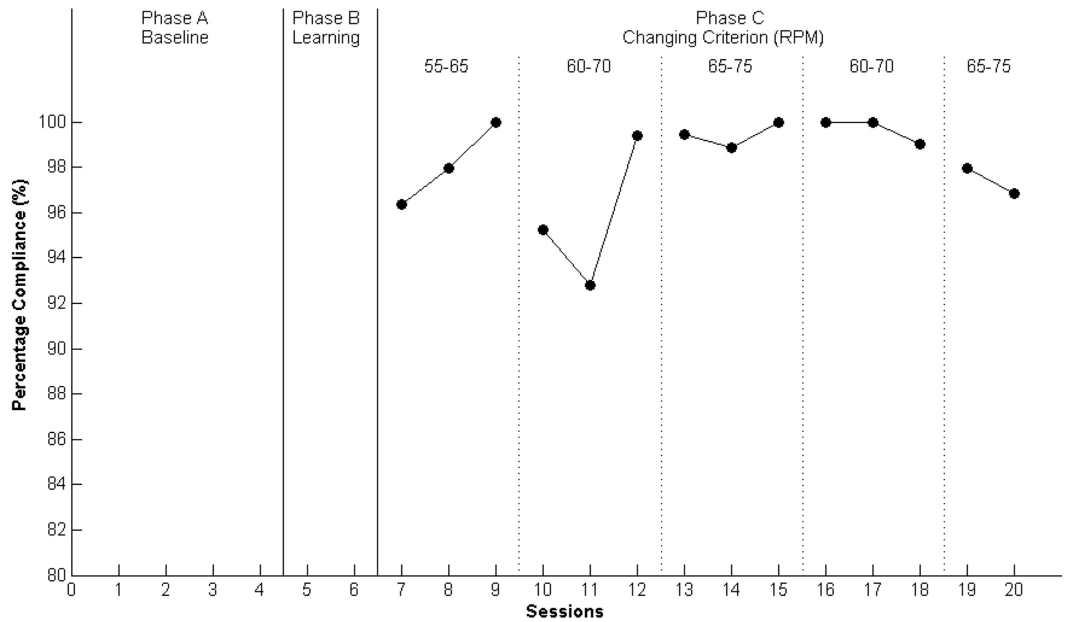


Figure 18. Percentage compliance data for Participant 3. During Phase B, learning took place and no data were collected.

The graphical presentation of Participant 2’s percentage compliance (Figure 17) shows a negligible (positive) trend across the treatment phase with one low “outlier” value (at 88.6% during Session 13), and four 100% compliance scores spread out across the treatment phase (sessions 1, 15, 18, and 19). The researcher’s advisor observing Session 13 could also have played a role in the “outlier” value for percentage compliance that day, however, the participant had started watching a (new) movie that day – and the reason for his lower percentage compliance value was because he became very excited during the movie, and consequently pedaled too fast and above the set criterion range (60–70 RPM).

Participant 3’s percentage compliance graph (Figure 18) depicts an insignificant (upward) trend across Phase C, but the data points seemed to have a three-point trend within or between the criterion changes and irrespective of whether the criterion change was increased or reversed: one within the initial criterion change (sessions 7–9), and three of these with values into the next, adjacent criterion change (sessions 12–14, sessions 15–17, and sessions 18–20). The former and latter trend, however, were negative trends—the latter more so than the former. Of the four 100% compliance values for this participant, the first was obtained during Session 9, whereas three were consecutive and extended across the changing criterion line between the third criterion change and the reversal change in criterion (sessions 15–17).

The percentage compliance data showed very high values for this dependent variable, thus reflecting that, even though increased changes in criterion (RPM) were being implemented throughout the treatment phase, all participants were able to consistently meet (greatly exceed) the preset ≥ 80% compliance criteria set by the researcher.

Heart Rate (HR) Monitoring

As an indicator of exercise intensity, heart rate was monitored at the following time periods during each session: (a) 1 min before; (b) 1 min into, and then every 3 min during exercise/pedaling; and (c) 1 and 5 min post-exercise. A Mio Link wristband monitor that displayed (but did not store) continuous HR on the researcher's smart phone was used with all students during the study. Its reliability was checked against wrist palpation of HR by the researcher during Phase A (baseline) The recorded values were included in Appendix N, (Tables N1, N2, and N3 for participants 1, 2, and 3, respectively). The recovery heart rates (1- and 5-min) for each participant indicated in these tables did not yield any significant trends or relation in regard to RPM criterion (intensity) pedaled at. One-minute recovery HR for all participants were higher than their pre-exercise HR; on average 11, 26, and 24 bpm for participants 1, 2, and 3, respectively. Five-minute recovery HR for participants 2 and 3 were on average 7 and 6 bpm higher than their respective pre-exercise HR. Interestingly, only 50% of Participant 1's 5-min recovery HR values were higher than that of his pre-exercise HR – these values ranging from 6 bmp below to 5 bpm above pre-exercise HR values. For the purpose of analyzing and reporting the results, only HR values recorded during each cycling session were used to calculate the average HR per cycling session and to record the highest and lowest HR values (range) attained by each participant during all sessions. Since Sessions 20's data did not have a significance effect on the results, this value was included. Table 12 presents the descriptive HR data for each participant for phases A (baseline) and C (treatment). As discussed in Chapter 3 (Methods), a 40–70% HRR, which encompassed moderate intensity PA as well as the lower end of vigorous PA (60–70% HRR), was deemed a safe and attainable goal to strive for during this study. The researcher calculated each participant's 40–70% HRR values from resting HR measures provided by the parents as well as those obtained by the researcher during "quiet time" at school. These ranges were indicated on each participant's individual graph.

Table 12

Descriptive Data for HR During Exercise for Participants and Phases

Parameter & Phase	Participant 1			Participant 2			Participant 3		
	M	*SD*	Range	*M*	*SD*	Range	*M*	*SD*	Range
Total session HR (bpm)									
Baseline	99.4	2.0	92–106	110.8	8.1	92–128	119.3	3.5	102–122
Treatment (*N* = 14)	106.2	6.8	91–137	125.3	15.5	87–160	127.8	9.8	102–154
Treatment* (*N* = 13)	106.2	7.1	91–137	123.3	14.2	87–158	127.0	9.7	102–154
Within-criterion HR (bpm)									
Initial criterion (RPM criterion)	101.2 (45-55)	5.8	91–112	112.0 (50-60)	7.2	87–138	125.0 (55-65)	6.3	102–136
Increased criterion (RPM criterion)	103.2 (50-60)	1.9	89–112	111.2 (55-65)	6.1	92–122	129.2 (60-70)	11.4	106–150
Increased criterion (RPM criterion)	111.3 (55-65)	11.5	92–137	128.7 (60-70)	17.0	106–150	137.6 (65-75)	5.7	120–154
Reversed criterion (RPM criterion)	109.8 (50-60)	4.6	98–128	135.6 (55-65)	2.3	111–155	116.3 (60-70)	3.1	105–126
Increased criterion (RPM criterion)	105.5 104.5* (55-65)	1.3	101–115	145.7 140.8* (60-70)	6.9	113–160	132.3 126.0* (65-75)	8.9	109–148

*Session 20 data point excluded.

All participants demonstrated an increase of mean HR values from baseline to treatment phases. These increases ranged from 7 bpm (beats per minute) to 15 bpm (for participants 1 and 2, respectively). Standard deviations of the mean HR values increased (from two- to three-fold) from baseline to treatment for all participants. Mean HR values, as well as corresponding minimum and maximum values (range), for all participants demonstrated an increase across the changing criterion phases within the treatment phase. The mean HR values of two participants (Participant 1 and Participant 3) exemplified the classic changing-criterion with bidirectional changes design—these participants' HR values changed with the changing criterion. Participant 2's mean HR values increased throughout the study. The third criterion change (sessions 13–15) elicited, by far, the largest standard deviation values for participants 1 and 2. In addition, it was also in this changing-criterion phase that these same two participants had their largest increases (as well as highest values during the study) of HR means after a "step-up" to the next target criterion range. Only Participant 2 experienced his highest mean HR for the entire study during the final increased criterion change (which, in addition, involved him pedaling 7.8 min longer during Session 20 at this highest RPM criterion set during the study).

Figure 19 is a depiction of all participants' mean HR values, including the range (indicated by error bars) for each data point.

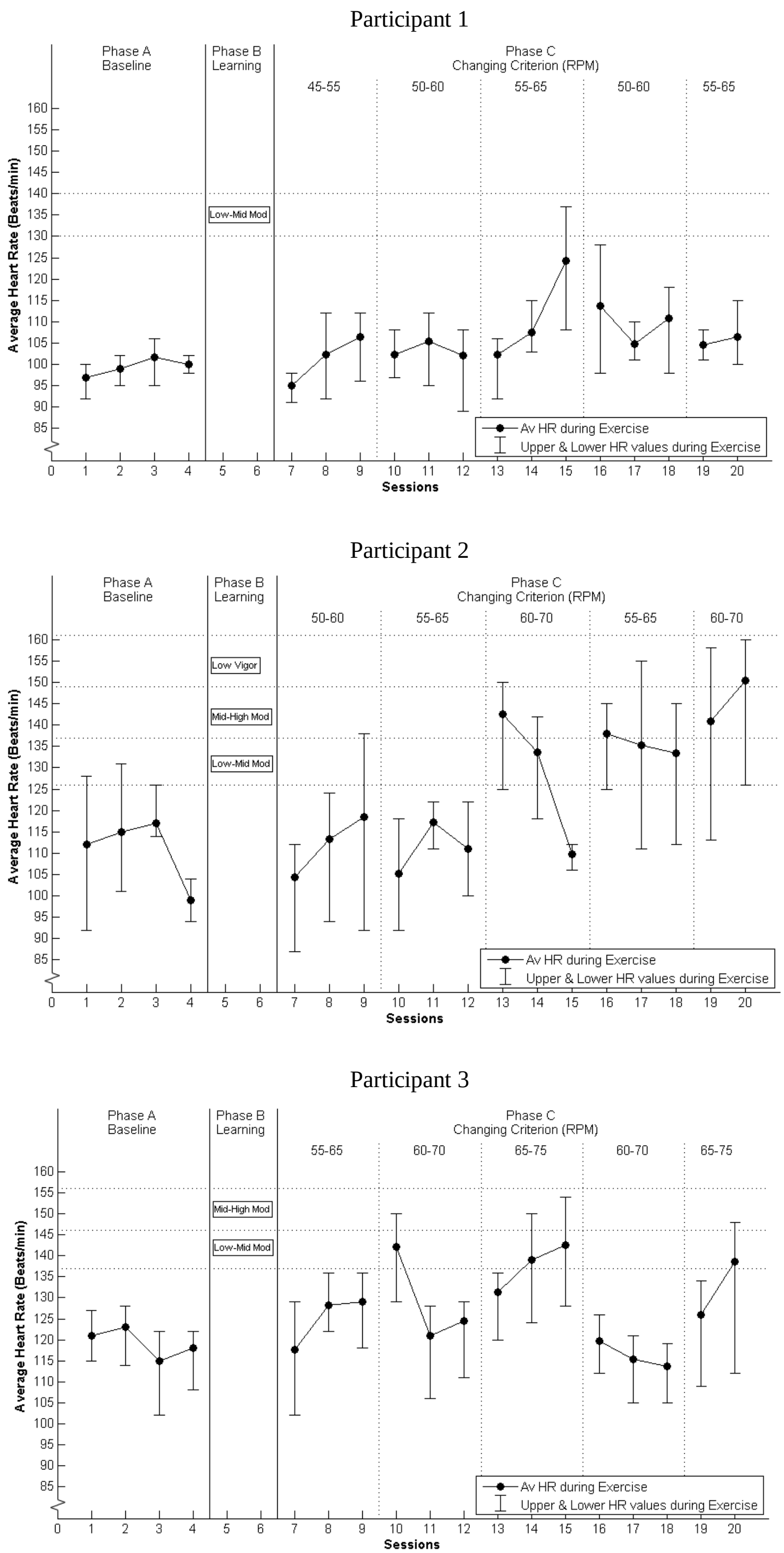


Figure 19. Average HR per session and phase for all participants. Error bars indicate the HR range for each data point. During Phase B. learning took place and no data were collected.

These data points demonstrated a steady increase in HR values for all participants throughout the study, but most strongly for Participant 2. The mean HR range was the greatest for Participant 1, with the difference between his maximum and minimum HR values varying from 30 to 50 bpm across sessions, whereas the corresponding values for Participant 1 varied from 14 to 45 bpm. Two participants (participants 2 and 3) were able to achieve HR levels high enough to elevate them into the moderate intensity PA level, and Participant 2 even reached the lower level of vigorous PA.

Figures 19, 20, and 21 present the HR values, with corresponding lowest/highest values recorded during every session for each participant. Each participant's individual 40–70% HRR is indicated below the graph of his data. The graph depicting the HR data plots for Participant 1 (Figure 20) shows a slight but steady, increasing trend of these values across the treatment phase. Although Participant 1's mean HR was not elevated into his personalized moderate-to-low-vigorous PA level (130–162 bpm) during treatment, his higher range HR did reach into the moderate intensity PA level on one occasion (Session 15). These results indicated that Participant 1 was, slowly but surely, on his way to being able to exercise at least at a moderate intensity PA level.

The graphical illustration of Participant 2's HR data (Figure 21) showed a steeper, increasing slope of these values and an elevation thereof into his individualized moderate to low-vigorous PA levels (126–161 bpm) from the third criterion change (Session 13) onward. In total, this participant maintained his HR level within the moderate intensity PA range, including one occasion (Session 20) into the low-vigorous PA level, for 50% of the time during Phase C (a total of seven out of the 14 treatment sessions).

Participant 3's individualized moderate to low-vigorous PA levels were calculated as ranging from 137 to 166 bpm. His graph (Figure 22) indicated that his baseline HR levels started off at a higher average HR value. Thus, even though his HR increased with a lesser slope throughout the treatment phase, he attained his moderate intensity PA level during the second criterion change (Session 10), after which he pedaled within that level for almost 30% of the time during Phase C (a total of four out of the 14 sessions). However, his highest HR values per session reached into the moderate intensity PA level during one additional session (Session 10), and came within one HR value from reaching the low-moderate intensity PA level during three further sessions (sessions 8, 9, and 13) throughout the treatment phase.

These data showed an increase of exercise HR from baseline to treatment and across the treatment phase, but the descriptive data also indicated a mirroring of the classic changing-criterion design with bidirectional changes, thus positively answering RQ 1. Two of the participants were able to attain, at least, a moderate level of PA for 30–60% of the time in treatment, while the third participant's data showed a strong indication that he was moving toward his individualized moderate intensity PA level. RQ 2 was thus also positively answered.

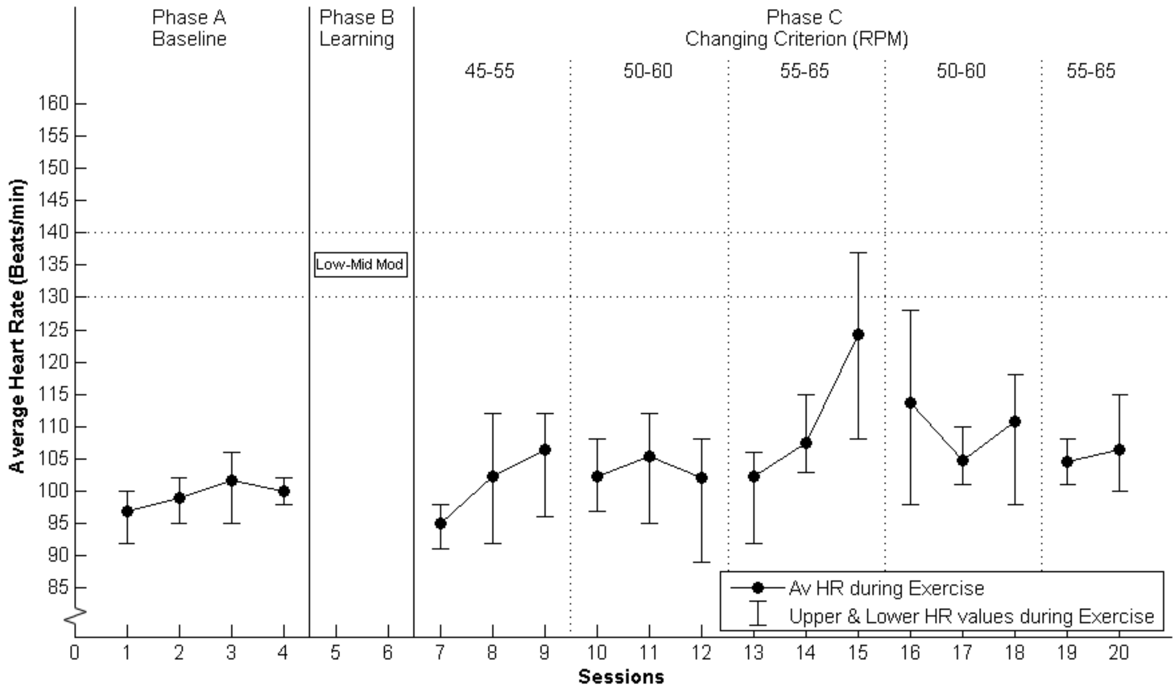


Figure 20. HR data for Participant 1. Error bars indicate HR range values. 40-70% HRR = 130-162 bpm (130-140 bpm = low-mid Mod; 141-151 bpm = mid-high Mod; 152-162 bpm = low Vigorous). During Phase B. learning took place and no data were collected.

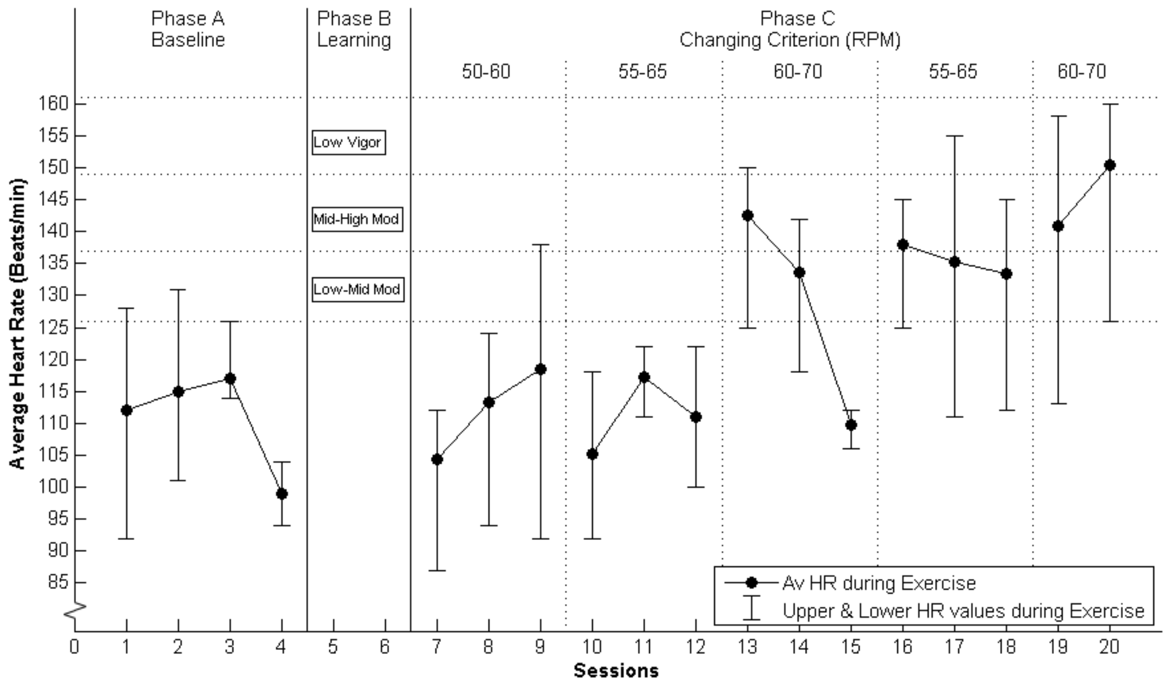


Figure 21. HR data for Participant 2. Error bars indicate HR range values. 40-70% HRR = 126-161 bpm (126-137 bpm = low-mid Mod; 138-149 bpm = mid-high Mod; 150-161 bpm = low Vigorous). During Phase B. learning took place and no data were collected.

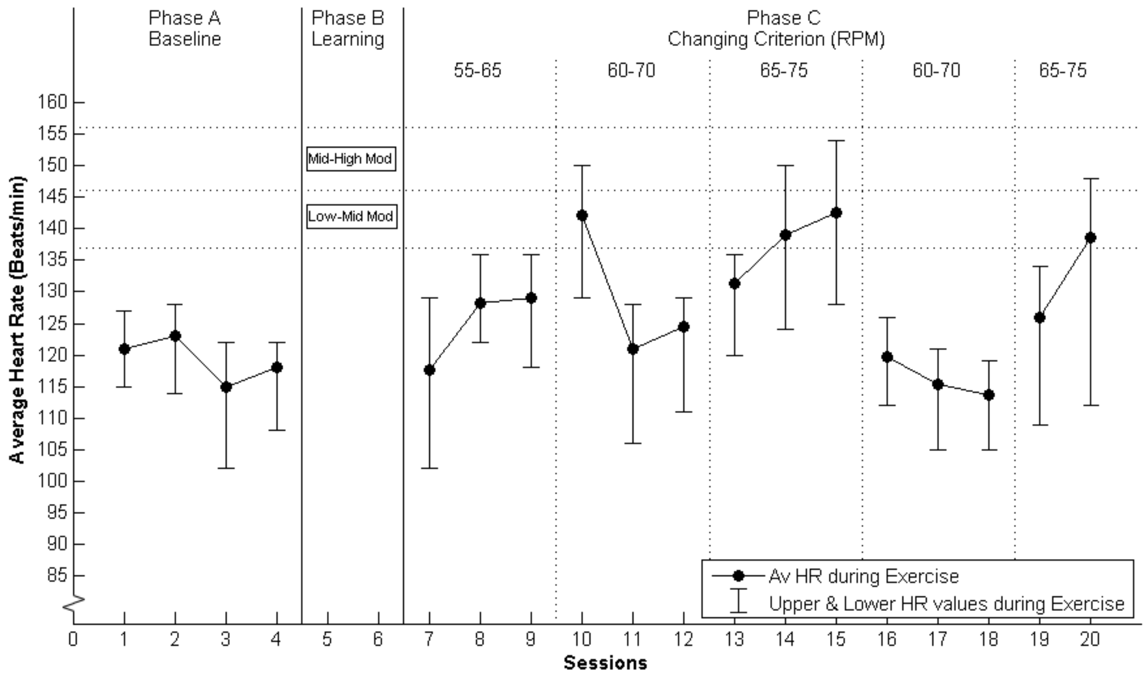


Figure 22. HR data for Participant 3. Error bars indicate HR range values. 40-70% HRR = 137 – 166 bpm (137-146 = low-mid Mod; 147-156 = mid-high Mod; 157-166 = low Vigorous). During Phase B. learning took place and no data were collected.

Additional Measures

Entertainment Display (DVD) Actions Taken

Out of interest and pure curiosity, as well as the fact that this information was available, the researcher counted three actions taken by the DVD player, namely (a) paused due to pedaling slightly too fast/slow, (b) stopped due to pedaling ≥ 5 RPM too fast/slow; and (c) “overcompensation”. Table 13 provides a summary of these tallied actions.

The means across all actions were between 0.2 (overcompensating by Participant 1) and 3.2 (DVD paused for Participant). These two actions also had the lowest standard deviation (0.4 for Participant 1 overcompensating) and the highest standard deviation (2.4 for Participant 2 having the DVD paused). Participant 3’s standard deviation across all three actions were 1.4, indicating low variability in DVD actions taken for this participant. The tallied data in this table indicated a slight general trend for all participants to have experienced less actions, in total, taken by the DVD player as the treatment (Phase C) progressed. Also, as the treatment phase progressed, the researcher was able to greatly fade verbal and nonverbal cues/prompts given to all participants during their cycling sessions—without there being an increase in DVD actions. This was an indication that Participants 2 and 3, especially, did not require much, if any, “input” from the researcher during most of the cycling sessions throughout the later stages of the treatment phase, and that the SACS alone was responsible for the participants’ compliance with the cycling activity. Participant 1 required nonverbal (rhythmic arm-swing actions) cues from the researcher during (only) the very beginning of each cycling session—once he “got going” in the green zone, he maintained the most stable and consistent cycling rhythm of all participants.

Table 13

Descriptive and Tallied Data of Actions Taken by the DVD Player for Participants

	Participant 1			Participant 2			Participant 3		
Session	Over-compensate	Pause	Stop	Over-compensate	Pause	Stop	Over-compensate	Pause	Stop
7	0	3	2	1	0	0	1	1	2
8	1	2	2	2	5	2	1	2	1
9	0	1	1	1	1	1	0	0	0
10	1	5	0	3	5	1	1	5	5
11	0	6	0	2	2	3	2	1	0
12	0	2	4	4	4	0	0	3	1
13	0	1	0	6	8	5	0	2	1
14	0	7	5	0	2	3	2	3	0
15	1	1	0	0	7	0	0	1	0
16	0	0	0	0	0	1	1	1	0
17	0	0	0	1	4	2	0	0	0
18	0	1	0	0	2	0	0	1	1
19	0	0	1	2	2	0	2	2	3
20	0	0	1	5	3	2	5	3	1
Total	3	29	16	27	45	20	15	25	15
M	0.2	2.1	1.1	1.9	3.2	1.4	1.1	1.8	1.1
SD	0.4	2.3	1.6	1.9	2.4	1.5	1.4	1.4	1.4

Participant 2 (especially) and Participant 3 both had exceptionally high overcompensation scores during Session 20 compared to the majority of their scores within that action. Participant 1 had the lowest total number of actions taken throughout the treatment phase (48), followed by Participant 3 (55), and Participant 2 (92). The action most commonly taken by the DVD player was pausing (29, 45, and 25 times for participants 1, 2, and 3, respectively). Participant 1 did not seem to over compensate – totaling only three times during this phase. The highest number of actions experienced by a participant during a single session was 19 (Participant 2, Session 13), and this session also included the largest number of times one specific action took place during a single session (i.e., paused eight times).

Figure 23 is a graphic illustration of all three participant's data related to actions taken by the DVD player throughout Phase C (treatment).

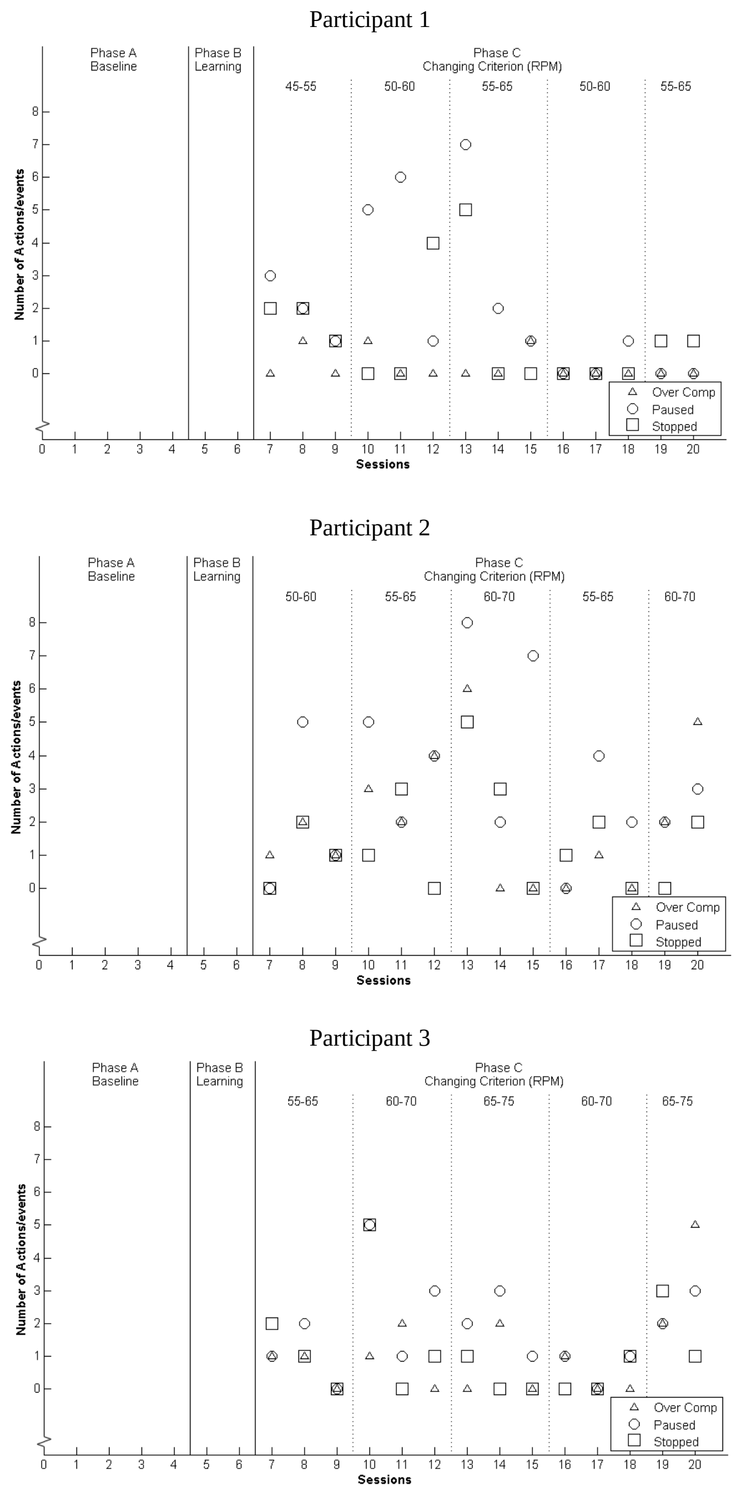


Figure 23. DVD player actions per session for all participants during treatment phase. During Phase B, learning took place and no data were collected.

Participant 2 (especially) and Participant 3 both had exceptionally high overcompensation scores during Session 20 compared to the majority of their scores within that action. Participant 1 had the lowest total number of actions taken throughout the treatment phase (48), followed by Participant 3 (55), and Participant 2 (92). The action most commonly taken by the DVD player was pausing (29, 45, and 25 times for participants 1, 2, and 3, respectively). Participant 1 did not seem to over compensate – totaling only three times during this phase. The highest number of actions experienced by a participant during a single session was 19 (Participant 2, Session 13), and this session also included the largest number of times one specific action took place during a single session (i.e., paused eight times).

Figures 23, 24, and 25 represent graphical depictions of the actions taken by the DVD for participants 1, 2, and 3, respectively.

With the exception of four pauses (for three, five, six, and seven times during sessions 7, 10, 11, and 13, respectively) and two stops (four and five times during sessions 12 and 13, respectively) throughout the entire treatment phase, Participant 1's number of actions per sessions (Figure 24) were ≤ 2 per action. The five high-occurring (≥ 5 times) actions all took place during the second (sessions 10–12) and third (Session 13) upward criterion changes, after which all actions taken were ≤ 1 per session. Participant 1 only overcompensated once during two sessions (sessions 8 and 10), and his DVD was never stopped in a total of seven (50%) of the 14 treatment sessions.

Participant 2's graph shows great variability throughout the treatment phase (especially in sessions 7–15) in terms of the number and types of actions. Except for three higher-occurring actions (two pauses in Sessions 17 and 20, and one overcompensation during Session 20) during the last four sessions, he was able to decrease all actions taken to ≤ 2 per session.

Apart from three "outlier" actions (five pauses and five stops during Session 10, and five overcompensations during Session 20), Participant 3 was able to maintain the number of actions per session at ≤ 3. He only had three incidents where the DVD was paused three times (Sessions 12, 14, and 20) and three stops in one session (Session 19). Apart from these, any actions taken were at a rate of ≤ 2 per session for the vast majority of sessions.

Interestingly, the higher-occurring number of actions (≥ 3 times per session) for all participants (if applicable) were restricted to a total of only five sessions throughout the treatment phase (sessions 10, 11, 13, 19, and 20) with Session 13 having the largest number of actions taken.

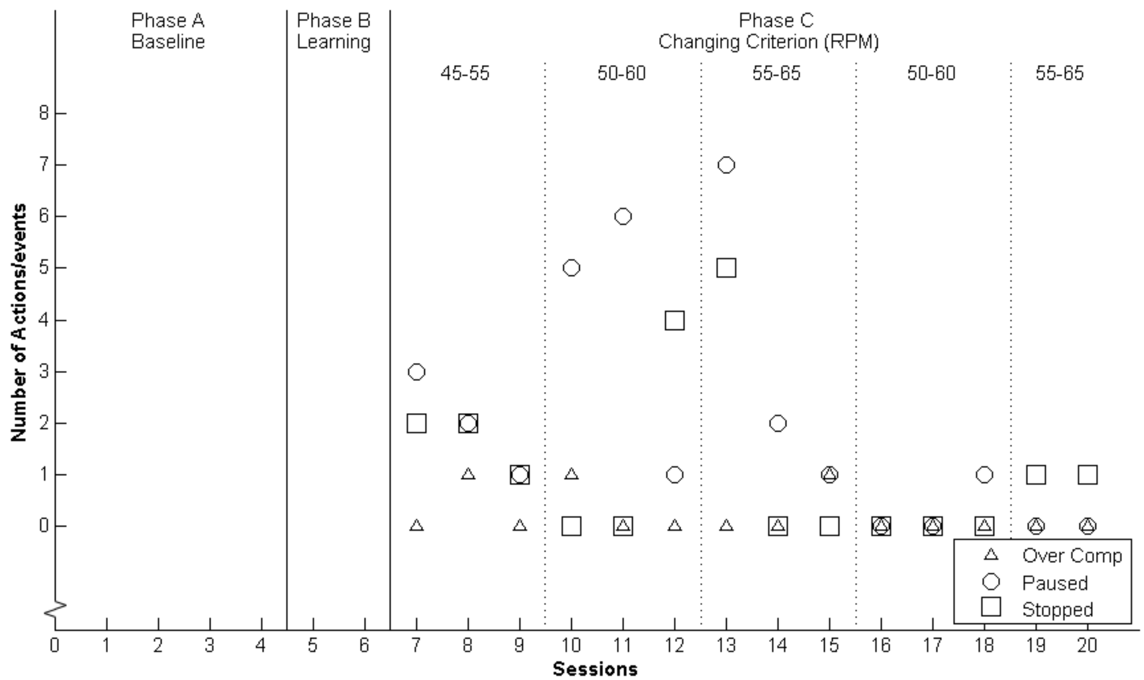


Figure 24. Data on actions taken by DVD during treatment phase for Participant 1. During Phase B, learning took place and no data were collected.

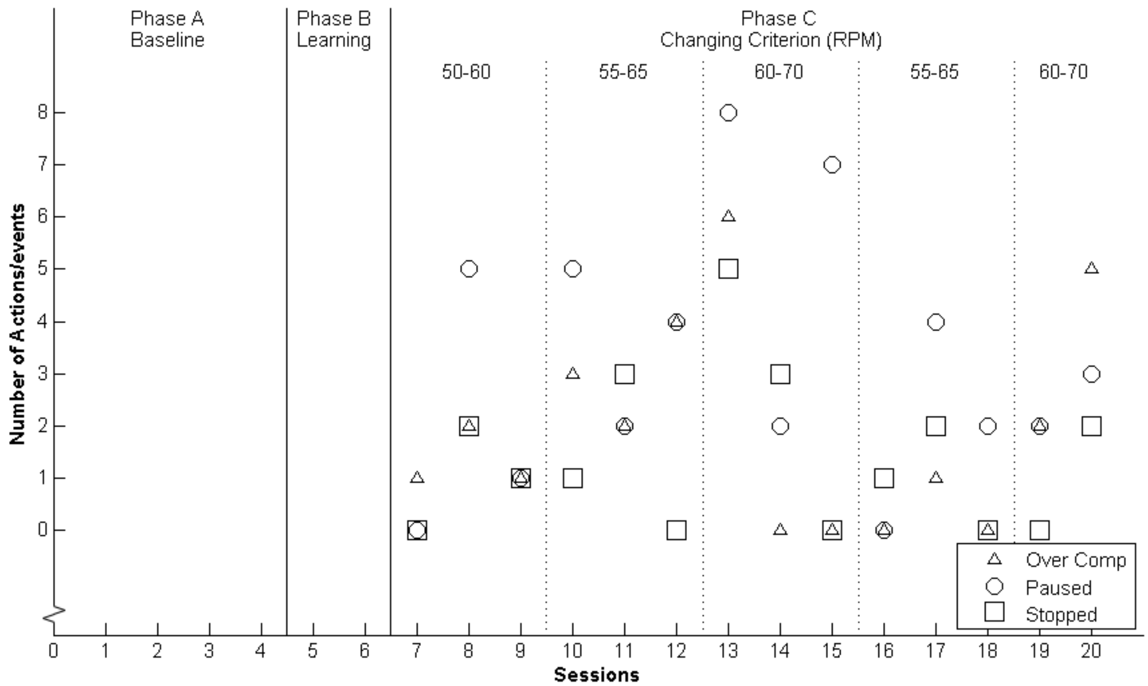


Figure 25. Data on actions taken by DVD during treatment phase for Participant 2. During Phase B, learning took place and no data were collected.

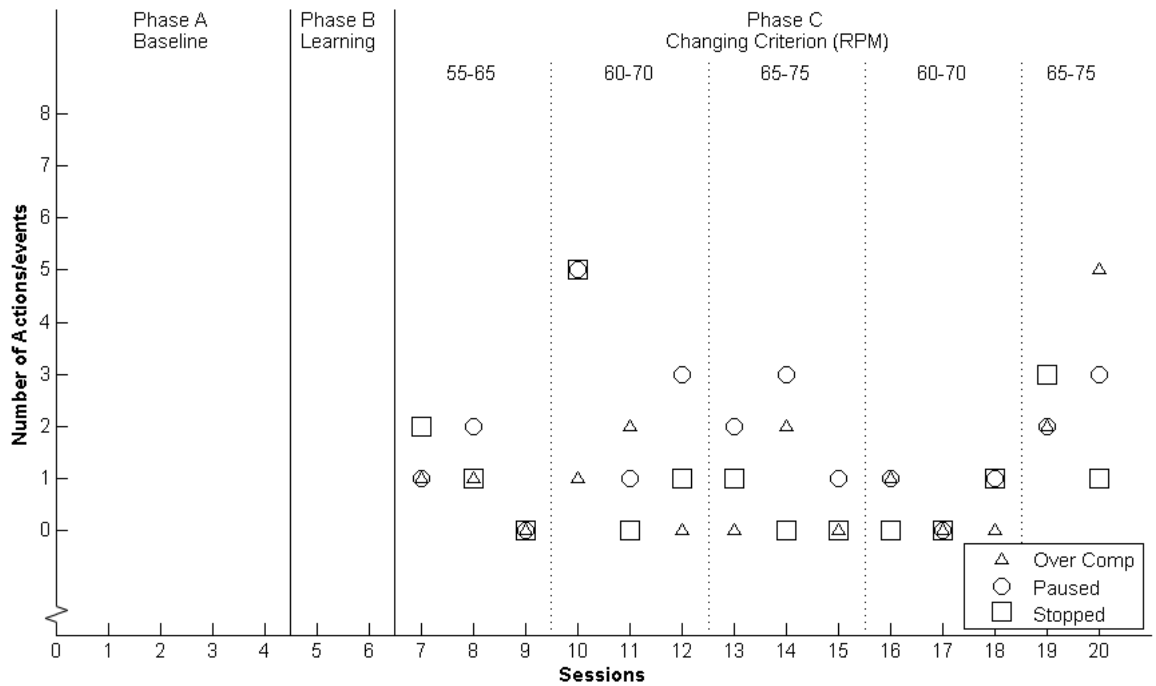


Figure 26. Data on actions taken by DVD during treatment phase for Participant 3. During Phase B, learning took place and no data were collected.

Level of Enjoyment

In an attempt to gain insight into whether the participants experienced the cycling activity as enjoyable, a qualitative, informal assessment was made using a two-item personalized picture scale. Before the session began, halfway throughout the cycling session, and after each session, the researcher showed the picture scale to the participant and asked how he felt about "riding the bike." In replying, each participants either pointed to his happy-face picture or verbally stated that he was happy (received a score of 2), or pointed to his not-happy/cranky-face picture or stated that he was not happy/cranky (receiving a score of 1). The latter was never the case for any participant throughout the study. When a participant indicated (verbally or nonverbally) that he was "unsure" (and seemingly could not make a choice between the two pictures), a score of 0 (zero) was allotted.

In addition, and as a "comparative" measure, the accompanying teacher indicated the global "type" of day the participant had had thus far (by signing this "score") as he entered the exercise room. The teacher signed a "1" if the participant had a difficult/bad day (distracted, off task, etc.); a "2" if the participant had had a good, productive, focused day; and a "0" if it had been a "nothing-out-of-the-ordinary" day. Within an hour after each session ended, the researcher would obtain a "post" cycling activity (global) score from the teacher in a similar manner.

No descriptive analysis was applied to these data due to the scores representing subjective ratings. For the purpose of graphically presenting the scores in a more logical manner, these data were rescored by switching the values of not happy/cranky/bad day and that of not sure/neutral/nothing-out-of-the-ordinary around. Thus, being happy or having had a good day scored a 2, being unsure or a "neutral" day scored a 1, and being cranky or having a bad day scored a 0. In addition, the participants' during- and post-pedaling-session scores were combined and compared to those obtained from the teachers after each session—the teachers' scores were doubled for the purpose of this graphical "comparison." However, by adding the during- and post-session rating scores of the participant, a score of 3 could be obtained (resulting from adding a 2 [happy] and a 1 [not sure]). Since no 0 rating score (which would become a score of one after rescoring) was ever obtained from any participant, participants could not achieve a during- and post-session score below 2.

Figures 26, 27, and 28 present the participants' pre-session scores enjoyment/happiness rating scores together with the teachers' pre-session global scores (upper panels) as well as the participants' during- and post-session scores together with the teachers' post-session global scores (lower panels) for participants 1, 2, and 3, respectively.

Figure 27 demonstrates that throughout Phase A (baseline) and Phase C (treatment), Participant 1 only indicated three times (sessions 1, 3, and 10) that he was unsure about how he felt—at all other times he indicated that he was happy. His teachers, for the most part, indicated that he had had a "regular" day with nothing out of the ordinary. The participant's and teachers' scores overlapped on four occasions—twice when both indicated a happy/good day (Sessions 9 and 18) and twice when both indicated a not sure/regular day (sessions 3 and 10). Although the teacher indicated that the participant was having a bad day on the day of Session 15, the participant's own rating was that of being happy.

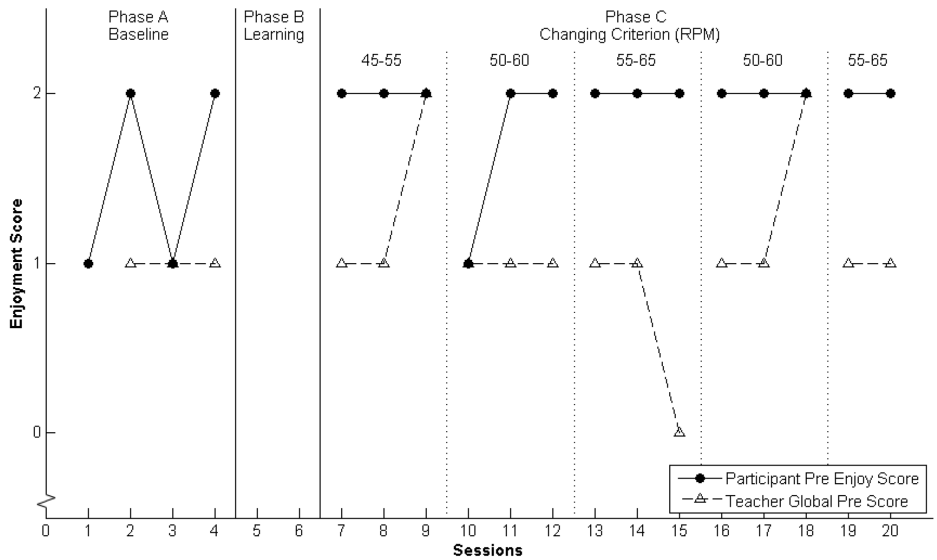
The data in Figure 27 show that Participant 1 was happy during and after the sessions for 16 out of the 18 sessions, with the remaining two scores containing a combination of happy and not sure (sessions 3 and 7). Following Session 7, his teacher indicated that he was having a bad day, although the participant indicated a combination of happy and neutral.

The pre-session enjoyment graph (Fig 28, upper panel) for Participant 2 indicates that on four occasions (before sessions 1, 2, 4, and 10) he was unsure about his feelings toward the cycling session and rated his pre-session enjoyment level as happy for the remainder of the study. However, his teachers' global rating scores for six sessions spread throughout the study indicated that he was having a bad day—two of these sessions (sessions 2 and 4) coincided with the participant not being sure about his enjoyment level. Participant 2's during- and post-session scores for sessions 2 and 8 (Figure 28, lower panel) show a combination of being happy and not being sure, however, on the day of Session 4 he was unsure about his happiness both during and after the session—which coincides with his pre-session score. With regard to the post-session global rating scores of Participant 2's teachers, the data show an "improvement" in that he was rated as having a bad day only once (Session 13). In fact, on three occasions (sessions 3, 11, and 17), his teachers' scores mirrored his feeling happy during and after the cycling activity.

The pre-session and during-/post-session participant and corresponding teacher evaluations (global rating scores) for Participant 3 are shown in Figure 29. Participant 3 indicated that he was happy before all sessions, and his teachers' global rating scores agreed, indicating that he was having a good day, for a total of 11 of the 17 scored sessions. At no time did any of his teachers rate this participant as having a bad day. As was the case for the pre-session rating, Participant 3 indicated only that he was happy during and after all sessions of this study (Figure 29, lower panel). Similarly, his teachers also only indicated his day as being "regular" on six occasions during the entire study (sessions 7, 8, 15, 17, 19, and 20)—for the rest of the sessions they all rated him as having a good day. The teachers' "1" scores (nothing-out-of-the-ordinary day) matched with pre- and post-global ratings for sessions 7, 19, and 20).

In summary, these enjoyment/happiness and teacher global rating scores (pre-, during, and post-sessions) were not very variable, and showed no immediacy of effect or consistency of a data pattern across the different criterion changes. When compared with each other, participant and teacher scores range from being polar opposites to being identical. One very positive finding is the fact that no participant's score was ever a 0—indicating that the participants did not experience negative emotions related to the cycling activity.

Pre-Session



During- and Post-Session

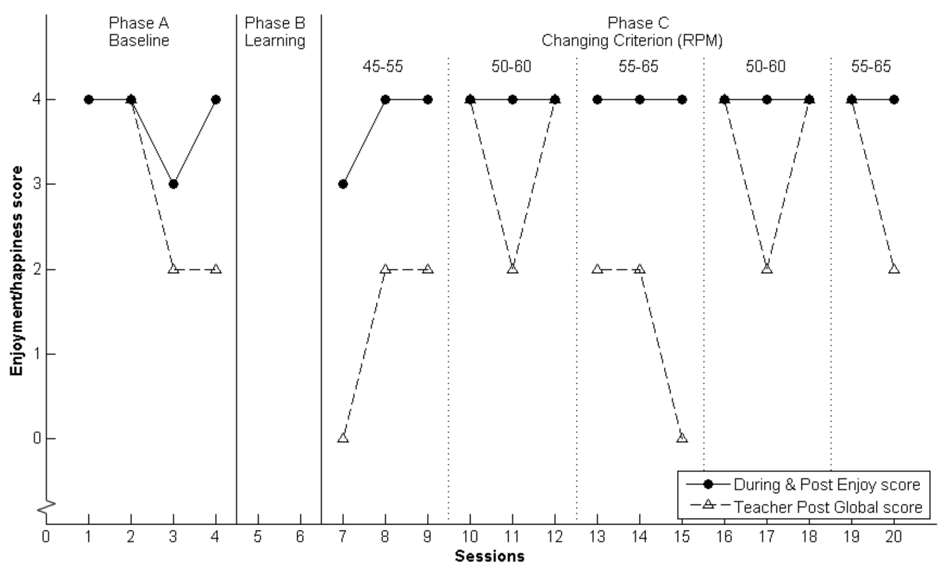
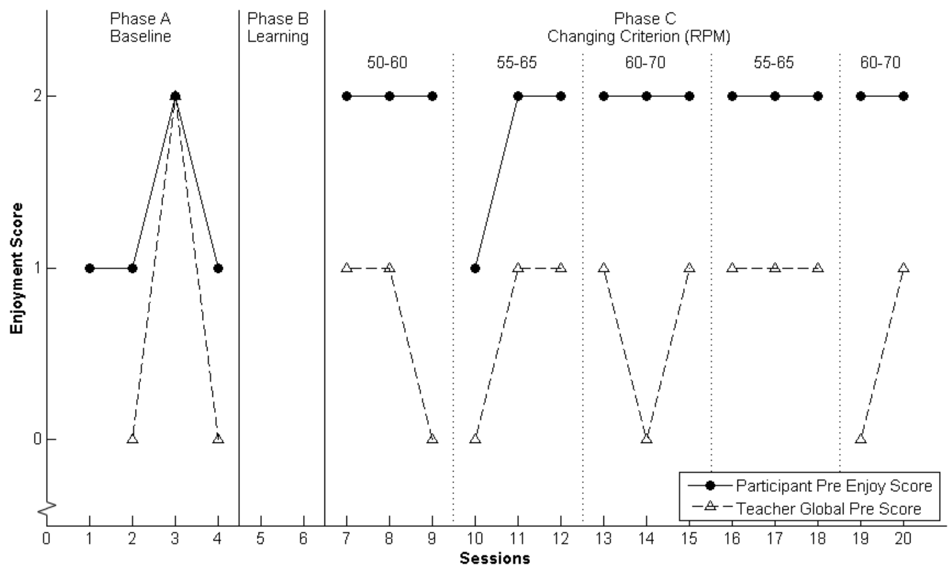


Figure 27. Enjoyment and teachers' global rating scores for Participant 1. During Phase B, learning took place and no data were collected.

Pre-Session



During- and Post-Session

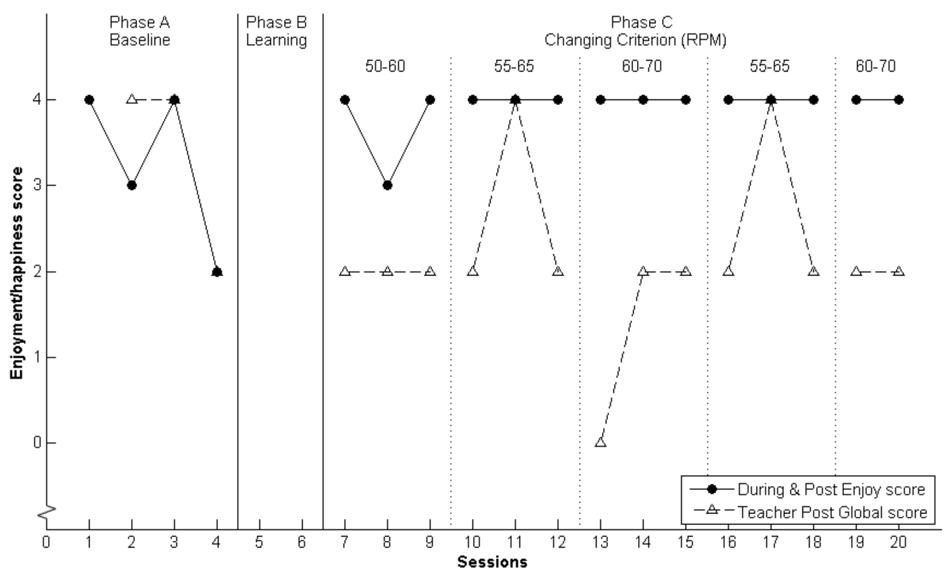
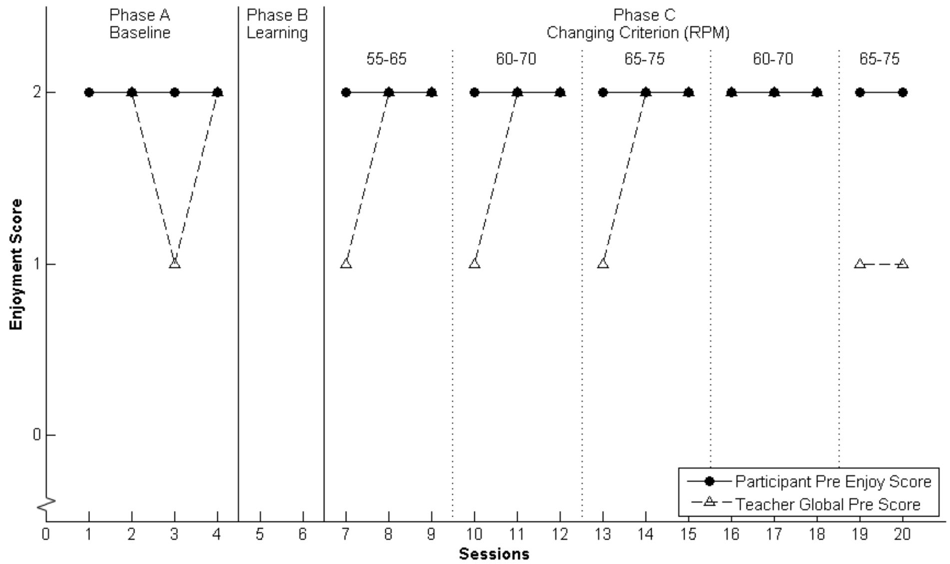


Figure 28. Enjoyment and teachers' glbal rating scores for Participant 2. During Phase B, learning took place and no data were collected.

Pre-Session Enjoyment



During- and Post-Session Enjoyment

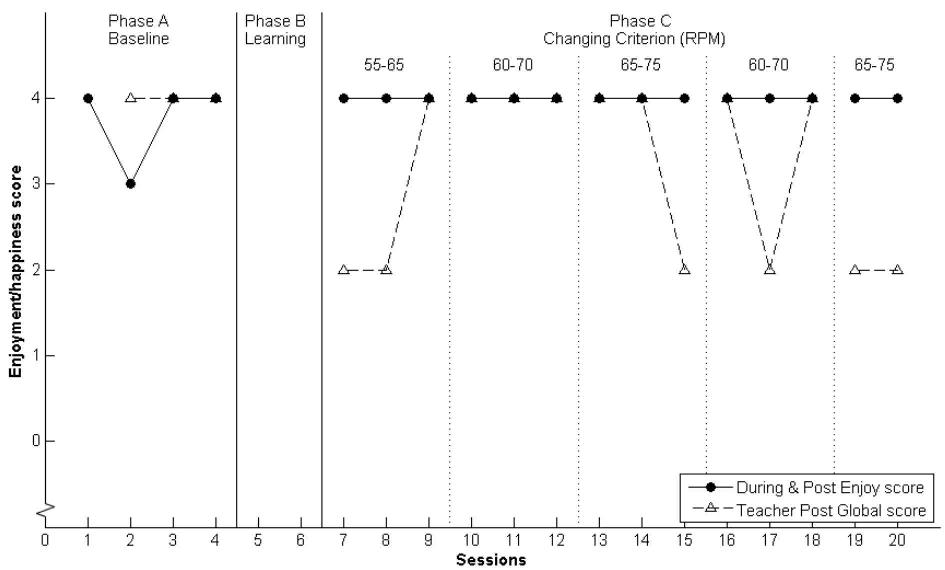


Figure 29. Enjoyment and teachers' global rating scores for Participant 3. During Phase B, learning took place and no data were collected.

Total MVPA and ST

Prior to the start of the study, information on each participant's physical activity levels (specifically MVPA) and their screen time (ST) behaviors were assessed through information obtained from the questionnaires-based interview administered to both the parents and teachers (Appendices B and C). This was done in an attempt to establish a realistic and attainable TP goal for each participant. Being a volunteer at the school for an extended period of time before the start of the study was also very helpful in seeing how active and/or sedentary the participants were. A summary of reported MVPA (in minutes) and ST (in hours) per day, as well as preferred ST, is reported in Table 14.

Table 14

Average MVPA and ST per Day with Preferred ST Activities and Devices Used

Description	Participant 1	Participant 2	Participant 3
Average MVPA per day (min)	< 10	10–19	< 10
Average ST per day (hr)	3–4	4–5	4–6+
Preferred ST	Movies/DVDs/TV programs Electronic games	TV programs/DVDs/ movies Internet searches Electronic games	Electronic games Internet searches TV programs/DVDs movies
Devices most often used during ST	iPad Home TV	Computer iPad Home TV	Computer (laptop) iPad Home TV

The data provided in Table 14 show a frightfully low level of PA per day among all three participants. Noteworthy is that after the researcher clearly defined (including giving examples) moderate and vigorous PA when conducting the questionnaire-based interviews (Appendices B and C), both teachers and parents stated that the participants' PA levels were never at levels higher than low moderate, or for periods longer than 3–5 min (depending on the individual participant). Participant 2's actual calculated average (low moderate at most) PA level per day was 17.6 min per day—he had a respite worker who walked, biked, or swam with him twice a week. However, it was specifically mentioned that this participant stopped doing anything active (at about 5 min, depending on the activity) "the moment he was hot, tired, or sweating." The most common PA for all three participants was walking. The biweekly outing to the local university's gymnasium constituted very little PA as observed by the researcher—one participant did some walking (strolling) around the track, while the others "swam" (standing in the shallow end of the pool catching and throwing a ball tossed at them by the teacher from the side).

The amount of time spent in ST ranged from a total of 3 to 4 hours (Participant 1) to 4 to 6+ hours (Participant 3) per day—indicating that a huge part of the day spent in sedentary activity. Participant 3's parent indicated that he spent at least 6 hours per day in ST (mostly TV programs/DVDs/movies) during each weekend day, although "he did take short breaks often" during which he would walk around in the backyard blowing bubbles. Although TV programs and movies/DVDs were separate items on the questionnaire-based interviews, they were combined in this summary of results, since the participants usually watched recordings (DVDs) of TV programs. Watching movies/DVDs/TV programs and playing electronic games (that included some educational games) were ranked within the three most preferred ST activities for all three participants. None of the students used social media, and only Participants 1and 2 used the Internet for doing searches (“Googling”). The information on types of ST gathered from the teachers stated that one participant (Participant 1) played exergames (Wii bowling) as a free time activity during school. However, the researcher observed him playing Wii bowling on multiple occasions, and found that he sat on the couch facing the TV and “bowled” by only flicking his wrist; thus very limited physical (and only arm) activity was involved.

The school had several iPads that were circulated among the students for educational, as well as leisure activities. Participants 2 and 3 had a computer in the room, and they used it for Internet searches (both for school work and as a choice activity). At home, all participants utilized the home TV, and two of them (participants 2 and 3) had access to a home computer. None of the participants owned a personal cell phone.

Body Composition

This study took place over a period of 5 weeks, which, according the ACSM (2010), is not an adequate time period to achieve aerobic improvements. Taking into account the very low PA levels, as well as high sedentary (ST) behavior of the participants in the study, pre-post study measures (height, weight, BMI, and waist circumference [WC]) were obtained to investigate whether the cycling activity could possibly have had an effect on body composition within the relatively short, albeit daily, period of time.

Table 15 summarizes the pre- and post-study body composition measures for all the participants. As can been seen in the table, two of the participants were obese (Participant 1 being at the 95th percentile and Participant 2 at the 98th percentile), whereas Participant 3 was well within the healthy weight range (at the 22nd percentile).

Table 15

Pre- and Post-Study Height, Weight, BMI, and Waist Circumference Measures of Participants

	Participant 1		Participant 2		Participant 3	
Measure	Pre	Post	Pre	Post	Pre	Post
Height (inches)	61.75	61.75	65.0	65.0	68.25	68.25
Weight (pounds)	158.25	157.0	195.0	191.25	135.25	135.25
BMI	29.2	28.9	32.4	31.8	20.4	20.4
BMI percentile*	95th	94th	98th	98th	22nd	22nd
WC (inches)	36.0	36.0	53.0	48.0	31.5	30.0

*CDC (2013) sex-specific BMI-for-age percentile growth charts.

Participant 1 had a 1.25-lb change in body weight that placed him in the 94th BMI for age percentile after the study. He was the participant who, in terms of HR values, did not achieve levels within the moderate intensity PA range at any time during the study—although his HR graph indicated a slightly increasing slope across the treatment phase, indicating that he was “on the way” to achieving at least lower levels of moderate intensity PA. Participant 2 lost 3.75 lb over the course of the study—not surprisingly, since he was the heaviest participant. He also shed 5 inches around his waist. According to the HR values obtained during each session, this participant did, in fact, attain moderate to low-vigorous levels of PA during the study’s cycling activities. These outcomes could be explained in terms of his initial low level of PA and high level of sedentary (ST) behavior, i.e., at these initial low PA and high ST levels, even 15 min of pedaling the bike on a daily basis over 5 weeks did show a (small) improvement in his body composition—the participant broke a sweat (and did so consistently) from Session 13 onward. Interestingly, Participant 3, who fell well within the healthy BMI range, lost 1.5 inches from his waist. By the third criterion change (Session 13) this student was pedaling in a 65–75 RPM criterion with the gears set higher (fifth gear, smaller back sprocket) than during baseline (thus, slightly higher resistance). Looking at his HR data, this criterion change (sessions 13–15) also coincided with him reaching moderate, albeit low, PA levels.

Social Validity

In order to validate this study, i.e., gauge its social validity, parents, teachers, and participants were asked to give their thoughts on it (Appendices I, J, and K, respectively). The questions were posed to everyone (six teachers, three parents, and three participants) in person within a week of the study ending. Table 16 summarizes the findings of these social validation questions.

Table 16 indicates that there were no negative replies to any of the questions and only twice did an individual (one teacher in response to Question 1 and one in response to Question 3) reply “not sure.” For Question 2 (examples of positive outcomes), only two teachers had no comment. Teachers’ comments for this question centered around the motivational aspect of the DVD (and its actions) that kept the participants pedaling/exercising (and working harder), the participants’ being excited and/or commenting about the movie they watched, and the fact that none of the participants quit at any time. One teacher commented that “they all seemed to be more calmer [sic] after doing the bike.” Two parents mentioned that their children talked about riding the bike at school and that they enjoyed it.

In response to the question posed to the participants about liking the activity, one participant said, “I want one [pointing at the bike] at home,” while the other two participants commented about their movies not being “over” yet.

Three teachers commented on the appropriateness of the study in that it was a “great” way to increase the participants’ exercise, that it was not “disruptive” in terms of taking up too much time and space, and that it “fit in with our daily schedule.”

Table 16

Summary of Replies to Social Validation Question(s)

	Replies/Comments		
Question	Teachers (*N* = 6)	Parents (*N* = 3)	Participants (*N* = 3)
Question 1: Did study, as designed, have a positive outcome on participants?	Yes = 5 Not sure = 1*	Yes = 3	
Question 1: Did you like pedaling the bike while watching DVDs?			Yes = 3
Question 2: Examples of positive outcomes	Comments provided = 4 No comments = 2	Comments provided = 3	Comments provided = 3
Question 3: Was the study appropriate?	Yes = 5 Not sure = 1*		
Question 4: Any additional comments/ suggestions?	Comments provided = 3 No comments = 3		

* The teacher who gave the not sure” responses also commented that she only observed once or twice.

Conclusion

The purpose of this chapter was to present the data that were collected throughout the study. Based upon the descriptive data and visual inspection of the graphical representations of each participant's data, it appears that the contingent use of screen time was effective in enhancing compliance with the cycling activity, especially in terms of exercise intensity. Chapter 5 will discuss these results, examine the limitations and strengths of this study, and explore future directions of behavioral engineering-based research for youth with disabilities.

CHAPTER 5

DISCUSSION

The purpose of the current study was to determine the efficacy of the contingent use of screen time (watching preferred DVDs as reinforcement) on complying with a stationary cycling program for three adolescent males with ASD. The following two research questions were systematically addressed. The first research question asked whether the contingent use of reinforcement (screen time) increased the participants' physical activity compliance (cycling, in terms of duration and/or intensity) to a higher level than that attained during a baseline phase. The second research question asked whether changing the criterion, in addition to the contingent use of reinforcement (screen time), would increase the duration and/or intensity of the cycling activity to the level where the participants met the ACSM's (2010) recommended PA levels for health-related benefits.

The extensive review of the literature presented in Chapter 2 illustrates to what extent and on how many levels factors such as obesity, low levels of physical activity, and high levels of sedentary behavior (especially in the form of screen time) affect not only the health and psychosocial well-being of our youth, but also the longevity of adults as a result of these factors/conditions being present at a very young age and being carried over into adulthood. (Dietz & Robinson, 2005; Must et al., 2012). Obesity rates among youth in general (Odgen et al., 2014) and to a greater extent in those with disabilities (particularly syndromic conditions and intellectual as well as developmental disabilities) (Curtin et al., 2010; Rimmer et al., 2010)—particularly in youth with ASD (Broder-Fingert et al., 2014)—have reached levels of epic proportions. The reasons are complex and multifaceted, but experts have reached a consensus that dietary habits, low levels of physical activity, and high levels of sedentary behavior are by far the biggest culprits. Research has demonstrated significantly lower levels of PA and higher levels of ST use in youth—and particularly adolescents— with ASD than in the typically developing population. It has been suggested that the unique and intricate characteristics of ASD (social and communication behaviors, and restricted, repetitive, and stereotyped behavior patterns), as well as some of the concurrent conditions experienced by many individuals with ASD (such as intellectual disability, behavior problems, seizure disorders, motor impairments, sensory stimuli sensitivity, overselectivity, and social isolation), predispose this population, especially as they get older, to a sedentary lifestyle (Grondhuis & Aman, 2013; Pan & Frey, 2006) in which screen time dominates the majority of their free time. Studies have reported on the PA levels of this population being lower than those of their typically developing peers, but also those of other disability groups within the same age range (Borremans et al., 2010; Pan & Frey, 2006; Potvin et al., 2013). A few studies that have investigated screen time behaviors among youth with ASD also indicated higher levels of screen time use by this population group, citing their preference for visual media and solitary activities, a specific movie/program/game as an "obsession," as well as the powerful reward system and immediate feedback of video/Internet games as contributing factors (Mazurek & Wenstrup, 2013; Minihan et al., 2007; Pan & Frey, 2005; Shane & Albert, 2008).

A plethora of programs and innovations (incorporating many different and diverse methods and strategies) have been developed and/or launched by those in the research and public sector for prevention of, intervention in and compliance with programs related to the problems of obesity, low PA levels, and high levels of sedentary behavior among typically developing youth, as well as those with disabilities (www.ACEfitness.org; www.CANFIT.org; Comprehensive School Physical Activity Programs (2013) —www.CDC.gov; www.GENyouthfoundation.org; www.Letsmove.gov). One strategy that has been employed sporadically since the 1960s is implementation of a behavioral engineering system—tackling both the issue of low PA levels and the issue of high levels of screen time simultaneously (Epstein, 1998). These behavioral engineering systems were either open loop or closed loop; the latter relying on screen time being contingent on physical activity that was executed on some form of stationary (indoor) exercise apparatus (such as a cycle ergometer, treadmill, or stepper), since the reinforcer (usually a TV) was connected, in some way or the other, to a control system connecting the exercise apparatus and the reinforcer. A very limited number of studies of this kind have been conducted specifically with youth with disabilities, and only one study involving children with ASD was identified (Anderson, 2011). The current study implemented such a closed-loop behavioral engineering system using a regular bicycle mounted on an indoor stand and an automated system of reinforcement with adolescent boys with ASD. The use of a regular bicycle and new, innovative, and affordable technology (microprocessor with wireless capabilities and a portable DVD player) allowed for this system to be safe, relatively cheap, portable, and space-saving and not require constant caretaker supervision—thus overcoming many of the disadvantages mentioned by others (Goldfield et al., 2000; Goldfield et al., 2006). In accordance with the FITT principle (ACSM, 2010), this cycling activity (large muscle, continuous type of exercise) was conducted on a daily basis, i.e., 5 days per week (minimum frequency recommendation exceeded).

Single-subject designs are implemented in research as a measure of intraindividual effects and to establish whether a functional (causal) relationship exists between the treatment (independent variable) and the outcome/dependent variable(s) (Gage & Lewis, 2013; Kratochwill et al., 2010). The current study's design (ABC) employed a changing criterion with a directional change. According to Tawney & Gast (1984) a changing-criterion design "is appropriate to evaluate programs to shape behaviors that … do not occur at an acceptable rate. … [It] has been employed to monitor programs in which motivational or compliance problems are responsible for a subject's failure to meet a specific criterion." Proving the efficacy of contingent screen time on the participants' cycling activity was based in the premise that each time the criterion level was changed, there was a concomitant change in the behavior/dependent variable (i.e., TP, RPM, percentage compliance, TOS, or HR). Such replication of effect controlled for internal validity, whereas systematic replication controlled for external validity (Horner et al., 2005; Tawney & Gast, 1984). In an attempt to control for confounding variables, the researcher adhered to the described study procedures (Appendix L).

The current study (design, procedures, and equipment) clearly/distinctly/ unambiguously demonstrated that implementing/using contingent reinforcement (in the form of watching preferred DVDs) was a "very" effective way to ensure/confirm compliance by these three adolescent boys with ASD with a stationary cycling program presented to them. During the entire study the three participants complied with, and even exceeded the FITT principle recommendations suggested by the ACSM (2010) for obese persons and by Srinivasan et al. (2014) for youth with ASD when initiating a physical activity program—continuous cycling (type) for more than 10 min at a time (duration/time), 5 days per week (frequency), and at increasing intensities (changing RPM criteria, as well as increased HR values).

An overview of the results of this study in terms of the dependent variables as they pertained to the two major hypotheses follows below. Additional outcome measures obtained are also addressed.

Time Pedaled

This dependent variable related to the time/duration of activity factor of the FITT principle. The graphical display of TP results (Figure 3, Chapter 4), indicated that two participants (participants 1 and 2) pedaled for the set TP goal of 15 min consistently from the very first (baseline) session into the treatment phase (when criterion changes were systematically introduced) to Session 19, after which Participant 1 pedaled for 20.6 min and Participant 2 for 22.8 min during Session 20 (when the TP goal was set at a maximum of 25 min). Participant 3 pedaled only 7.6 min during Session 1, after which he consistently pedaled for 15 min throughout the study up to Session 20, when he pedaled a total of 22.7 min. All three participants attained perfect compliance in terms of the 15-min TP goal.

In addition, Figure 3 indicated each participant's total TP per session—the total time it took a participant to pedal the 15 min within the RPM criterion range. Each participant had four occasions during which he pedaled for longer than 0.5 min outside the criterion range (i.e., in the red and indicated in brackets on the graphs). The longest time a participant spent pedaling in the red was 2.4 min (Participant 1, Session 13). It must be noted that these values did not indicate whether the participant was pedaling in the low and/or high red.

The first hypothesis addressed by this study involved whether the contingent use of watching a DVD increased the participants' compliance with pedaling the bicycle (in terms of duration and/or intensity) to a level higher than what was attained during baseline (which mimicked a gym setting with TVs continuously playing). Excluding the data from Session 20, participants 1 and 2 pedaled from the very start for 15 minutes per session during Phase A (baseline) and maintained compliance with this TP goal throughout Phase C—they thus did not increase, specifically, the duration (time) pedaled above their baseline values, and the hypothesis regarding RQ 1 was not supported. Only Participant 3 showed a small increase in TP above that attained during baseline, and in this case RQ 1 was positively answered. If Session 20's (single) data point were included, all three participants' average TP across Phase C (treatment) showed a very small increase above those of the baseline values. However, RQ 1 could not be positively answered on the outcome of a single data point.

The second hypothesis addressed was whether changing the criterion in addition to the contingent use of screen time increased the duration and/or intensity of the cycling activity to a meaningful level in term of health benefits (RQ 2). The ACSM's (2010) recommendations for adequate levels of PA for youth to obtain/maintain health benefits is at least 30 min, but preferably 60 min, per day of MVPA. With or without Session 20's (single) data point, the hypothesis related to RQ 2 was not supported in terms of duration of physical (cycling) activity, because the participants only pedaled for a 15-min period. Encouraging, however, was the fact that all participants were able to increase TP during the final, albeit single, session (Session 20).

There were several reasons why the TP goal was not increased when all the participants complied with the 15-min goal by Session 2 (during baseline). Methodologically, the researcher did not want to change two independent variables (RPM and time/duration) within a criterion change. With regard to the information obtained on MVPA levels and screen-time behavior during the questionnaire-based interview prior to the study, extremely low PA levels (< 10 min/day) and screen times of an average 3 to 5+ hours per day were reported by both the teachers and the parents (Table 14). Information on coexisting conditions and/or additional problem areas of the participants also indicated histories of noncompliance and (even severe) behavioral outbursts. Participants 1 and 2 were also obese (Table 15). Based on the researcher's personal, subjective observation during the 3 months as a volunteer at the school before the study started, a 15-min session was deemed an adequate and gradual introduction to being continuously physically active, also in light of the fact that the sessions would take place on a daily basis. It was important to the researcher that the cycling activity be enjoyable, "pain free," and provide an opportunity for the participants to experience success. Thus, in terms of the FITT principle, this cycling activity was already more frequent and intense and longer in time/duration than what the participants had been accustomed to. Both the American Heart Association (AHA, 2015) and the ACSM (2010) recommend that with time constraints in youth and for obese adults, respectively, moderate intensity exercise sessions should start off at above 10 min to 15 min per session. In addition, as reported by Srinivasan et al. (2014), there is a lack of ACSM guidelines for exercise prescriptions in individuals with ASD, and therefore their recommended exercise guidelines for this population were based on studies in typically developing youth, as well as youth with other disabilities. These authors suggested the following exercise prescription (based on the FITT principle) when starting a PA program: 3 days a week of moderate aerobic PA consisting of 20 to 30 minutes per day accumulated over short bursts. The researcher did not envisage these participants (given their low PA levels, high sedentary behavior, and of noncompliance) complying with the treatment, and especially with the TP goal that was set, at the level and consistency that they did!

Looking at each of the participant's pedaling behavior during Session 20 (when TP was increased by 10 min), Participants 1, 2, and 3 only pedaled for 20.6, 22.8, and 22.7 min, respectively, after which Participant 1 abruptly stopped (saying that he was tired) while the other two participants gradually pedaled more slowly and made no effort to “try to keep the pointer in the green” before they stopped. This was interesting in that, over the previous 5 weeks, none of the participants ever stopped pedaling (at least for longer than a few seconds) before the bicycle icon had reached the end (smiley face). This begs the question whether the participants would have complied with pedaling for longer (for example 20 min) if the TP goal had been set higher at the beginning of the study.

Also noteworthy was that the researcher did not tell the participants that the TP had been increased (Session 20) and the bicycle icon moved along “as usual” across the feedback display (although at a slower speed than during 15-min TPs). The bicycle icon was a great motivator during the previous sessions—all participants would comment on its progress across the feedback display at some stage during the session, and it was noticed (and observed from the session data printouts) that Participant 3, when the icon got within the final 5-min position, he would start cycling slightly faster (not realizing that the icon’s progression across the screen was independent of how fast he pedaled). Albert and Shane (2008) conducted a survey with 89 parents of youth with ASD under the age of 18 years on screen-time behaviors and found that 66% of the subjects had a clear preference for animated figures (programs/ movies). It has also been reported that individuals with ASD have a preference for visual learning/approaches (visual models, prompts, schedules) and that prompts were considered to be extra stimuli that were added to a learning environment to ensure correct learning (Lovaas, Koegel, & Schreibman, 1979; Mesibov & Shea, 2010). One strategy suggested for teaching youth physical education/activity to youth with ASD was that of incorporating visual schedules and cues (Groft-Jones & Block, 2006; Schultheis et al., 2000)—thus confirming the strength of the animated bicycle icon as a motivator as well as a prompt (representing progress on duration of the activity).

Finally, the participants' daily routine at the school consisted of 15–20 min of "work," followed by a short (3- to 5-min) break. This time period for remaining on task and focused might already be "ingrained" in the participants, since the researcher commented on the daily check sheet that, during Session 20's increased pedaling, Participant 2 got slightly "antsy" toward the end of the session, shifting around on his seat and standing up on the pedals while cycling. Participant 3 started looking at his feet instead of the DVD playing (or the feedback display) and when asked what he was looking at, he replied "the bicycle."

In the view of the above-mentioned factors, it is suggested that these cycling activity sessions be consistently scheduled (thus becoming part of the daily routine) at least twice a day (for 15–20 min) in order to accumulate 30 min or more, even 60 min of MVPA per day (ACSM, 2010). This is on a par with studies that have shown that short bouts of PA reflected the typical activity patterns of youth (Ford & Swaine, 2012), as well as the recommendations specifically for youth with ASD suggested by Srinivasan et al. (2014).

Revolutions per Minute (RPM)

RPM was chosen as the dependent variable on which criterion changes within the treatment phase were based, since it constituted an easily obtainable and stable measure (of resistance). However, RPM is also an indication of exercise intensity and a component of the FITT principle. The graphical displays of all participants' RPM results (Figure 7, Chapter 4) clearly show strict compliance with the changing-criterion design with directional change treatment design. The participants all started treatment (Phase C) in a different RPM criterion range: (a) Participant 1 started in the 45–55 RPM criterion, (b) Participant 2 started in the 50–60 RPM criterion, and (c) Participant 3 started in the 55–65 RPM range. Noteworthy is that the increased TP in Session 20 had a negligible effect on the participants' RPMs pedaled. Only one participant (Participant 2 who pedaled for 22. 8 minutes) increased his RPM during Session 20, whereas the other two participants had a decrease in RPM for that session (Participant 1 pedaled 20.6 minutes and Participant 3 pedaled 22.7 min).

Baseline data for both participants 1 and 3 showed some variability, whereas Participant 2's baseline data showed a steady upward trend. During Phase C, immediacy of the effect and consistency of a data pattern across similar phases (replication effect) were clearly shown.

Two interesting phenomena are noticeable from the data of two participants. For Participant 2, the mid data point in three (and to some extent a fourth) of the five criterion phases within the treatment phase were all the highest RPM value recorded for the specific criterion change. Participant 3's RPM data demonstrated a slight negative slope across sessions 13–15, as well as across sessions 16–18.

In addition, Figure 7 indicated each participant's total RPM per session, and their total RPM pedaled within the target criterion range. On very few occasions did these two values differ noticeably—the percentage RPM pedaled outside the criterion range was indicated in parentheses on each graph. The standard deviation for every RPM data point was also indicated by an error bar on each participant's graph. Only Participant 1 showed a noticeable negative slope across the treatment phase in mean standard deviations. He was thus able to maintain a steadier pedaling rate as the treatment phase progressed. This participant chose to watch the same DVD during every session—the musical *Mary Poppins*—and it may be possible that the rhythm of the music helped him maintain a steady pedaling rate.

In terms of the first hypothesis addressed in this study, i.e. whether the contingent use of watching DVDs increased the participants' compliance (as it related to exercise duration and/or intensity), the results showed a definite compliance with this cycling activity and a distinct increase in intensity from baseline to, and across, the treatment phase by all participants.

The second hypothesis addressed the question of whether changing the criterion, in addition to the contingent use of watching DVDs would be adequate (in terms of exercise duration and/or intensity) in increasing the activity levels of the participants to a meaningful level (in terms of health benefits). Although all participants complied with the changing criterion conditions within the treatment phase and increased the RPM levels they pedaled at (thus exercise intensity), with approximately 16 RPM total across Phase C, this progress does not allow for an interpretation in terms of the ACSM's (2010) recommendations for health-benefitting levels of PA.

A big issue cited by researchers and educators involved in PA for youth with ASD has been obtaining compliance with exercise intensities of at least moderate levels and for a minimum of 10 min continuously (Lang et al., 2010; Oppewal et al., 2013). The reasons for this are complex, but the unique and diverse idiosyncrasies that are prevalent in many youth with ASD and that may affect their participation in moderate-intensity PA include, among others (a) being highly sensitive to sensory stimuli (sound, visual, smell, touch), (b) having problems with overselectivity, (c) being obese, (d) finding PA stressful and intolerable, (e) low fitness levels, and (f) not liking to sweat (Crollick, Mancil, & Stopka, 2006; Pan & Frey, 2006; Sowa & Meulenbroek, 2012). If/when these factors are overcome, a second issue that then becomes a problem, is how to measure intensity levels. Accelerometers, heart monitors, and other portable devices may not be tolerated by everyone, apart from the fact that many of these devices are costly, prone to becoming an object of obsession, as well as getting broken or lost. One of the advantages of the using a stationary bicycle in this study was that a stable and reliable measure of intensity (i.e., RPM) could be easily obtained. Connecting an electromagnetic motion senor to the bicycle's pedal and connecting that to a microcomputer allowed not only for revolutions (and time) to be recorded, but also for the computer to be programmed to make relevant calculations—thus an easily manipulated system. Many studies employing closed-loop behavioral engineering systems have used pedal/wheel revolutions to obtain an intensity measure and/or to specify RPM criteria for cycling at, above, or within (Coleman et al., 1997; Lancioni et al., 2003; Saelens & Epstein, 1998).

The current study had a 5-RPM warning zone on both sides of the criterion zone (during which the DVD paused), followed by a red zone on both ends (DVD would shut off). An advantage of having limits set on both the lower and upper end of the criterion was that it prevented the participants from not only pedaling too slowly, but also too fast. The latter could result in a participant pedaling at higher RPM (intensity) than he was able to sustain and then stopping (early) because he exhausted himself. Participant 2 in this study had the propensity for getting very engrossed in or excited about the dragon movies he chose and would often pedal too fast during these times—the DVD pausing or stopping had him cycle back within the criterion range immediately after it paused/stopped. Thus, in addition to the (upper) limit set by the program controlling for over-exertion (a safety, as well as compliance issue), both upper and lower limits effectively acted as a pacing guide/cue for the participants.

A (small) issue of efficiency in pedaling arose with one participant (Participant 2) who did/could not pedal with the ball of his foot, but rather placed the center of his foot on the pedal. The researcher fitted the pedals with toe cages, but the participant did not want to place his foot in them. This inefficient way of pedaling could have influenced his pedaling rate (RPM) to a small extent, especially at higher RPM levels. The results showed that he had a higher mean standard deviation (3.0 RPM) than the other participants and that he was the only participant whose mean standard deviations increased as the study progressed. How much his foot placement played a role in these RPM results is difficult to know. In addition, two further adaptations were made to the bicycle within the first few sessions—i.e., the brakes were disconnected—because one participant would pull on them while cycling, causing the back wheel to brake, and the handle-rotating-type gears were taped so that participants could not accidentally change the gear setting by turning the handlebars while pedaling. These were all factors that could influence RPM results.

The (traffic light–colored) horizontal RPM bar with a pointer that indicated at what level/rate the participant was pedaling provided for not only a visual motivator, but also a visual prompt for the student to take an action. All three participants, and at different times throughout the study, were able to prevent an action (pause or stop) before it happened by speeding up, or slowing down quickly enough before the action took place. This confirmed that the participants not only were able to comprehend the consequences, but also learned how to prevent those consequences by appropriate preemptive actions—a sign that the SACS could independently get participants to comply with the stationary cycling activity.

The RPM results in the current study replicated that of an almost identical study done by Mathieson (1991) who investigated whether the contingent watching of TV could increase the duration (20 min) and intensity (increments of 10-RPM ranges) of ergometer cycling by three adults with intellectual disability for 3 days a week over a period of 10 weeks. The TV would shut off when the subjects pedaled outside the 10-RPM criterion established, and it would turn on as soon as they went back to cycling within the criterion range. Two of his subjects were able to cycle for the full 20 min, and their RPM results showed consistency of a data pattern across phases. No other studies were found using such a closed-loop system based on RPM measures with youth with ASD. In fact, there seemed to be a paucity of studies of this kind even with the availability of new, reliable, inexpensive electronic devices available on the market.

Total output per session (TOS) is a “combination” of both time pedaled (TP) and RPM, namely duration/time and intensity, and another way to look at the work output produced by the participants during each session. Both the descriptive (Table 10) and graphical presentations (Figure 11) of these data for each participant showed a mirroring of the classic changing-criterion design and, with that, a mirroring of their individual RPM graphs. Apart from the TOS graphs depicting all participants’ data points more narrowly banded (due to their perfect compliance to TP), the only significant difference were in the data points of the final session (Session 20)—when the TP goal was increased and all participants pedaled for a longer duration. This resulted in inflated results for the final criterion change (sessions 19 and 20), since one of only two data points were higher. What remained important was the strong control of the design as it related to the participants’ work output (TOS)—each participant’s TOS increased from baseline to treatment, as well as concomitant to criterion changes within the treatment phase.

The TOS results (as a product of TP and RPM) did not support RQ 1 that addressed the question of whether the contingent use of watching a DVD increased the participants’ cycling activity compliance above the baseline level.

Although intensity (RPM) was consistently changed during Phase C, and the TOS results mirrored these changes, these data gave no indication of the levels of intensity, and thus RQ 2 could not be answered—i.e., that levels of PA meaningful for health benefits(in terms of duration and intensity) could be attained.

Percentage Compliance

The percentage compliance (Figure 15) in this study was calculated as the time spent pedaling within the set RPM criterion range for every session during Phase C (treatment). For a criterion change to be introduced the participant had to have maintained a ≥ 80% compliance for at least three sessions, of which two had to be consecutive. After three consecutive criterion changes, a reversal criterion change was implemented (to show control of the design), followed by a final (upward) criterion change.

The percentage compliance of all participants was markedly high—well above the expectations of the researcher. The lowest mean percentage compliance attained throughout the study was 93.6% (Participant 1) and the vast majority of values were at or above the 98% mark.

The first hypothesis addressed in this study focused on whether watching a DVD contingent on pedaling the stationary bicycle increased the participants' compliance in terms of duration and/or intensity to levels higher than those obtained during the baseline (when the DVD played continuously). Although percentage compliance was calculated as a function of duration and intensity and consistently high compliance rates were achieved, no baseline data were available to compare these treatment values with and thus RQ 1 cannot be addressed for this dependent variable.

The second hypothesis addressed in the study, i.e., whether changing the criterion, in addition to contingent DVD watching, would increase the duration and/or intensity of pedaling the bicycle to a level with health-benefitting effects. All three participants achieved very high percentage compliance from the very start of the treatment, which would be difficult to improve. In addition, no values relating to exercise levels at those benefitting health were indicated, and addressing this dependent variable in terms of the second hypothesis (RQ 2) was thus not applicable.

In an almost identical study of its kind, Mathieson (1991) set the percentage compliance required for introducing a criterion change at 85%. Only two of the three adult subjects with intellectual disability participating in the study achieved this goal—and at noticeably lower levels (percentage compliance) than the participants in the current study. The author's suggestion for making a provision for those who could not achieve the set compliance rate was followed in designing and planning for the current study, although the need did not arise for having to lower the percentage compliance.

In some way related to the issue of compliance was whether there were any trends that could be elicited from looking at the number and types (pauses or stops) of actions taken by the DVD player for each participant during each session (Table 13 and Figure 23). The microprocessor was coded to indicate the action (i.e., low red stopped, high yellow paused) every 5 s when the average RPM and time were recorded. On glancing through the printouts of these session recordings and tallying the actions that were taken, it was noticed that, apart from pausing in high/low yellow RPM range and stopping in the high/low red RPM range as designed to do, an additional "event" triggered an action from the DVD player, i.e., a pendulum-type effect caused by the participant overcompensating for an action. The number of these pendulum swings varied greatly—ranging from only two to up to six (although difficult to manually count). Although not indicated in the descriptive or graphical depictions of the results, several interesting observations were made. Participant 1 was a "slow starter"—for the most part, the actions taken by the DVD took place within the first few minutes of each session. However, once he was "up to speed," he was able to maintain a steady pedaling rate with few actions/interruptions. He very seldom overcompensated. Participant 2, on the other hand, was an overcompensator and the majority of his overcompensating actions were initiated because he pedaled too high/fast (due to overexcitement about the movie playing) and then "pendulumed" too low. Most of the reasons for the DVD being paused for him were also due to his pedaling at too high a rate. This shed a possible light on why, according to information received from parents/teachers, this participant could/did not sustain PA for longer than 5 min; it could be that he could not pace himself and thus became overexerted. In a sense then, the system in this study whereby the DVD paused or stopped, acted as a pacer for this student, and because he could now pace himself, he was able to comply with longer, continuous PA sessions. Participant 3 did not show any trends. Most of the actions for him were pausing (on both high and low ends) and he seldom overcompensated.

As previously stated, problems related to compliance with and motivation for PA in youth with ASD have been reported by several authors (Borremans et al., 2010; Minihan et al., 2007), and several techniques and strategies have been implemented in attempts to improve levels of compliance and/or motivation (Staples & Reid, 2010). For the current study, an inclusion criterion was for participants to have high levels of screen-time behavior so that this preference for screen time (movies/programs) could be used as a reinforcer. In their study on the effectiveness of using objects of obsession as reinforcers, Charlo-Christy and Haymes (1998) found that, compared with typical tokens (stickers, stars), the percentage of correct task responses was higher and the percentage of inappropriate behaviors was lower during a work session when highly preferred tokens were used. The strength of the reinforcer (DVD) was imperative in the participants' compliance with the cycling activity and the importance of having a choice (self-determination) has been stressed in PA research with youth with ASD (Todd & Reid, 2006; Todd et al., 2010). Interestingly, Participant 1 only chose to watch the musical *Mary Poppins* for every session (even when other musical movies were available to choose from), Participant 2 only chose SpongeBob Squarepants (thankfully there were multiple episodes available), and Participant 3 had a variety of movies that he watched. These were strong enough reinforcers that allowed for RPM to be increased (albeit gradually and with small increments) without the participants "noticing" a difference pedal rate required to keep pedaling in the green, or to override having to work harder at higher RPMs. An example was when Participant 3's third (highest, at 65–75 RPM) criterion change was introduced he asked "why is this so hard?" within minutes after starting to pedal. However, something SpongeBob did on the movie caught his attention, he "forgot" about finding the pedaling more difficult, and kept on pedaling.

In addition to the visual (animated) RPM green-yellow-red bar with a moving pointer and the moving bike icon on the feedback display, as well as a choice of preferred DVDs to watch, an additional "motivator" was included in the form of a self-monitor board. This was linked to the bicycle icon on the feedback display in that the participants received a yellow smiley-face sticker at the end of each session (for pedaling the full 15 min) that was the same as the small yellow smiley-face sticker at the "finish line" of the bicycle icon. On several occasions, participants 1 and 3 "reminded" the researcher during the 5-min post-exercise rest on the bicycle that they had earned their stickers for the day—an indication that the self-monitor board had some motivational effect.

Another motivating factor for participation in PA is the level of enjoyment. In an attempt to identify whether the participants enjoyed the cycling activity, the participants indicated their level of enjoyment (happy, cranky, not happy) on a personalized two-picture scale (before each session, as well as during and after each session). Such enjoyment scales had been used in similar studies in the past; students with multiple disabilities were videotaped and then scored (using a partial-interval procedure, 10 s observation followed by 5 s recording) on indices of happiness (Lancioni et al., 2003; Lancioni et al., 2004). In studies with typically developing youth and adults, more complex, validated activity liking scales (such as the Physical Activity Enjoyment Scale [PACES]) or 10-cm visual analog scales anchored by “don’t like at all” and “like very much” were used (Goldfield et al., 2000; Roemmich et al., 2012; Saelens & Epstein, 1999). In agreement with the findings of Mathieson (1991), it was unclear whether the participants comprehended that they were to rate their enjoyment with regard to the cycling activity. The question remained whether they connected their “mood” to the cycling activity. In addition, a multitude of factors could influence the participants’ choice about their enjoyment—for example, the fact that they like the happy face on the picture of themselves, they’re having a good day, they like the cycling/bike, they like watching their favorite movie, they like getting out of the classroom, and/or they like the researcher (since she does all play and no work). In fact, Participant 3 referred to the researcher as “Miss Liza bike.”

What was clear from the results generated from these enjoyment rating scales was that (a) there was great variability in the responses and (b) that these participants never indicated that they were unhappy.

In the researcher’s opinion, the success of this study was at least partly due to the implementation of the additional, visual, and animated motivational strategies included in the design.

Heart Rate

A thin, lightweight wristband-type heart rate band (with no display) was used to monitor heart rate—an indication of the intensity level at which the participant was exercising (pedaling). Although HR zones could be programmed into the monitor, this was not done, since a green or red light on the wristband would blink when HR was too high or too low. This might have caused the participants to focus on that instead of the DVD and feedback display. All three participants tolerated the wristband from the very first session of the baseline phase; Participant 2 enquired about what it did and how it worked, and the researcher showed him the continuous monitoring of his HR on her smart phone.

The descriptive and graphical depictions of HR data (Table 12 and Figure 19) indicate that all participants' mean HR increased from baseline to treatment, with increases ranging from 7 to 15 bpm. These low increases were an indication of the gradual increase in exercise intensity, as was designed. The mean HR values during the treatment phase for participants 1 and 3 changed with the changing criterion, whereas the mean HR values for Participant 2 increased steadily throughout the treatment, culminating in his highest HR value obtained during the final session (Session 20) of the study. Participant 2's HR graph, however, shows a distinct increase in HR values only starting at Session 13—when he achieved moderate-level activity—and increased from then onward. At these higher HR values, the corresponding HR range for each session also increased. It is noteworthy that Participant 2 had the lowest resting HR (80 bpm) of the three participants.

Both Participant 1's and Participant 3's HR values demonstrated a more steady increase over the course of the study, with Participant 3 starting with higher HR values (his resting HR was 97 bpm) and pedaling within the moderate-activity level on several occasions. Participant 1, who had a resting HR of 86 bpm, did not achieve a mean HR within the moderate-activity level during the study, but the slightly positive slope indicated that he was on his way to reaching this level.

In terms of the first hypothesis addressed in this study, i.e. whether the contingent use of watching DVDs increased compliance (as it related to exercise duration and/or intensity) with this cycling activity, the HR results showed an increase of HR means above the baseline as well as an increase across the treatment phase by all participants. RQ 1 was thus positively answered.

The second hypothesis addressed the question of whether changing the criterion, in addition to the contingent use of watching DVDs, would be adequate (in terms of exercise duration and/or intensity) for increasing the activity levels of the participants to a meaningful level (in terms of health benefits). Two participants (participants 2 and 3) were able to achieve pedaling within their moderate-intensity PA levels (40-60% of their individual HRR), with Participant 2 reaching the level of vigorous PA. RQ 2 was thus positively answered in terms of the result for these two participants. Even though Participant 1 did not achieve pedaling within a moderate intensity PA level, the slight but steady increase in HR values across the treatment phase indicated that this participant was slowly moving in the right direction.

The relative cost-effectiveness and unobtrusiveness as well as the ease of use and the reliability of the latest wristband HR monitors make them ideal for use in PA situation such as this study, if tolerated by the participants. Even though HR monitoring is commonly used to gauge exercise intensity in field studies, it is a sensitive measure in that several factors affect HR, such as food intake prior to the activity, hydration, fitness level, temperature, and emotional stress (ACSM, 2010). During the study, the effect of emotional stress was demonstrated by Participant 3 on the second day during the baseline phase. Forty-five minutes before he was scheduled to do the cycling activity, a new student at the school had a severe behavior outburst during which she screamed and cursed, attacked the teachers, threw chairs, and tore up the classroom for approximately 15 min. Participant 3 happened to be in an adjacent room during the outburst. Although he did not verbalize any distress to his teacher during that time, his pre-session resting HR was 102 bpm when he came to pedal the bicycle about 30 minutes later.

During the study only one participant noticeably worked harder (higher-intensity exercise) as the treatment phase progressed, and by Session 13 he was breaking a sweat. Knowing that this particular participant had an aversion to sweating and being hot, the researcher provided him with a small hand towel (which was, serendipitously, monogrammed with the student's initials) that he draped over the handle bar of the bicycle to wipe his face with when needed—he referred to the researcher as "my personal trainer."

Two participants (Participant 1 and Participant 2) in the study were obese, with BMIs in the 95th and 98th percentile, respectively. The suggested minimum time period in which to expect an exercise effect (and depending on the FITT principles applied) starts at 8 weeks (ASCM, 2010). This study, due to time restrictions, took place over a period of 5 weeks on a daily basis. Lochbaum and Crews (2003) conducted a 6- to 7-week stationary cycle program with three adolescents with ASD for 20 min a day, three times a week. A pre and post power-work-capacity (PWC) fitness test was administered. This test calculated the percentage change in resistance required for achieving a HR of 150 bpm for each subject, and these values showed an increase of between 33% and 50% among the subjects on conclusion of the study. This indicated that an exercise effect was possible within a shorter period of time than what was recommended.

As an additional measure, pre- and post-study body composition measures (height, weight, and waist circumference) were measured for all participants (Table 15). Participant 2, who had a BMI within the 98th percentile, and who pedaled consistently within the moderate-intensity PA level (and even higher), lost 4 lb during the 5 weeks, as well as 5 inches in waist circumference. This was an unexpected result, especially given the short timeframe. However, given this participant's initial level of fitness and obesity, exercise effects could be expected within a shorter period than usual. Participant 1 who was also obese, but pedaled at lower RPM criterion values, as well as lower HR values, did not achieve pedaling at a moderate intensity PA level and showed no pre-post differences in the body composition measures. Interestingly, Participant 3 (BMI in 22nd percentile) who had a healthy weight, lost 1.5 inches at the waist. This could be a result of a "toning" effect, in the sense that an individual in the healthy weight range could still be "flabby" due to a lack of PA (and high sedentary behavior); this participant spent 4 to 6+ hours per day in screen time.

Social Validity

In an attempt to obtain feedback and thus validate the study, the researcher asked the teachers, parents, and participants about their experience with the study. No negative comments/critique were received. However, this could be due to the fact that no one wanted to be impolite toward the researcher. A few examples of comments received from teachers were:

- "*The DVD motivated the students to continue pedaling the bike, even if they had to work harder. These are students who otherwise would not have participated in such a physical activity.*"
- *"[Participant 1] has often said 'I love this bike riding.'"*

- *"[Participant 2] does not usually sweat while doing physical activity and if he does, he immediately quits. However, he worked up a sweat while biking and never complained or quit."*

Parents were asked whether they thought the cycling activity had had a positive outcome on their son. Examples of comments received from parents were:

- *"... anytime he looks forward to exercising is a very good thing!*
- *"... I found him in the basement riding my training bicycle and watching a DVD. I did not know he knew how to work the DVD player. He has never showed any interest in my training bicycle before and now he goes down and rides it, mostly over weekends."*

Study Strengths and Limitations

Study Strengths

The ultimate strength of the study lay in the potency of the reinforcer. The importance of and need for the assessment of reinforcers and the value of using powerful reinforcers have been established in past research (Hardman et al., 2011; Mason, McGee, Farmer-Dougan, & Risley, 1989). For the current study, the researcher obtained information from the teachers and parents as well as the participants themselves about the participants' favorite movies/shows/programs and provided at least eight options for the participants to choose from. However, in some circumstances there was also a negative side attached to the strength of the reinforcer in that when the participants became so engrossed in and excited by the movie, they would pedal too fast (thus outside the green target RPM criterion range). An advantage of also including upper limits (yellow and red zones on the upper end of the target RPM criterion zone) in the study design was to prevent participants from pedaling too hard and tiring themselves before the set TP goal could or had been reached—thus “forcing” participants to maintain a steady, comfortable, safe cycling pace. Participant 1 very seldom pedaled at a too high a rate, whereas Participant 2 was more prone to doing so. It is foreseeable that some youth with ASD may not have a movie/program that is strong enough to motivate them to the desired levels of activity (in terms of duration and intensity). The researcher also observed that some students at the school would/could not maintain focus on a single video/program/game for more than a few minutes. They would constantly be changing channels or “swipe” (on the tablet) between them. However, this problem could be overcome if, as envisaged, the SACS system were set up to control a laptop or tablet wirelessly in the way it did the DVD player.

Related to the strength of the reinforcer was the motivational value of the visual, colorful, animated and printed feedback displayed. The green-yellow-red RPM bar (emulating a traffic light) with the moving indicator/pointer and the animated bicycle icon moving across the display screen towards a yellow smiley face as the TP progressed gave appropriate, and not overwhelming cues to the participants. In addition, the self-monitor board (and it’s “connection” to the smiley face on the feedback display) as a final activity of each session proved to be a powerful motivator—on the last day of the study, Participant 3 asked if he could have his self-monitor board home.

Another key strength of the study was that the SACS consistently and with 100% reliability did everything it was programmed to do—i.e., sensed the input (pedal rotations), analyzed the information, used this information to control the DVD actions, displayed the information in real time on the feedback display and the researcher’s laptop (thus providing immediate feedback to both participant and researcher), and saved the data onto a flash drive. In addition to not requiring the researcher to manually set, change, or control any part of the system (except for activating a new session file and selecting the TP goal and RPM criterion for each session), the SACS was quick and simple to set up. In fact, when Participant 2 wanted to show the researcher that he could ride a bicycle, all that was needed was to disconnect the electromagnetic switch from the microprocessor and slide the box containing the electronic equipment off its mounting block. For the purpose of the study, the mounting block was “permanently” fastened to the handle bars, but this could easily be made removable.

The mere structure of each cycling session proved to be another strength of the study—not only for the researcher in terms of following the testing procedures, but also for the participants. The importance of structure for individuals with ASD is well established and widely implemented (Mesibov & Shea, 2004; www.TEACCH.com). Each session’s (identical) checklist/recording sheet was followed rigorously allowing for the same routine for both participant and researcher during every session. During the study, each participant also had an added a “personal” routine. For example, Participant 1 received a second smiley-face sticker which he pasted into his daily social story book (per his request); with the start of Session 11, Participant 2 brought a water bottle to the exercise room (after which the researcher attached a water bottle holder onto the bicycle’s frame for him to use); and Participant 3 had his “sweat towel,” as described above.

Another strength of the study was the fact that the participants were familiar with the researcher (and vice versa) before the study was initiated. Given the characteristics of individuals with ASD, such familiarization reduced possible anxiety and/or problem behaviors related to a random “new” person setting expectations. It was also helpful to the researcher to have observed the participants during their daily routine and picked up on small idiosyncrasies. This, however, may also be a (minor) limiting factor in terms of the objectivity of the study.

Finally, the single-subject study design consisting of changing criterion with directional changes afforded not only for gradual increases in exercise intensity (RPM), but also controlled for possible threats to internal validity. In addition, the study utilized stable and readily attainable measures (time/duration and revolutions pedaled) that were easily analyzed by the microprocessor.

Limitations of the Study

In addition to the inherent limitations of visual inspection (i.e., a wide variety of interpretation of data, the issue of which features [trend, slope, variability] to focus on, and the outcomes not being readily comparable across similar studies) and of a changing-criterion design, specifically (i.e., limited to a relatively small range of target behaviors and dependence on the researcher's "subjective" prediction of criterion levels) (Gage & Lewis, 2013; Tawney & Gast, 1984), this study had added limitations. Due to a time restriction, but also as a result of the perfect compliance with the treatment by the participants, only the minimum (three) data points per criterion change were collected. In addition, more data points should have been collected within the criterion change following the reversal criterion change— after which the TP goal could/should have been increased. The researcher did not increase the TP goal with the initial criterion change (start of treatment) after all participants complied with the 15- min goal set during baseline for three reasons: (a) she did not want to change two independent variables (time and RPM) at the same time, (b) she wanted very gradual increases only (to allow for success and the absence of muscle soreness or participants having to work too hard and not enjoying the cycling activity), and (c) it was her "subjective prediction" that the participants were not ready for an increase in the TP goal.

A possible limitation regarding the selection of TP goals programmed into the microprocessor was that they were set at 5-min increments only, thus not allowing for smaller, 1- to 3-min increases in pedaling time.

A limitation of the questionnaire-based interviews used for teachers and parents is that this type of retrospective measure has been found to result in overestimation of activity levels (Adamo, Prince, Tricco, Connor-Gorber, & Tremblay, 2009). Such an overestimation may have affected the parent and teacher assessments of participants' activity in the present study, even though the researcher defined (with examples) the terms "moderate" and "vigorous" PA. Based on the researcher's observation of the participants during their daily routines at school (and accompanying them to the local gym where they go twice a week), it seems likely that these general activity-level assessments were indeed overestimated.

Obtaining an enjoyment rating was problematic in that too many factors interplayed in this assessment. Furthermore, the term "enjoyment" should possibly have been replaced with "mood" or "happiness"—the personalized pictures depicted mood rather than enjoyment. It was also unclear whether the participants cognitively understood or related to the rating as referring to the cycling activity. An explanation for all the "happy" ratings could be that the participants felt that they were "pleasing" the researcher or that, if they had stated they were unhappy it could/would have resulted in their having to explain why they were not happy. Furthermore, teachers were given only a broad and brief description of what their global rating entailed, and different teachers might have interpreted it differently. In addition, often the teacher who accompanied the participant to the cycling activity was not the one with him after the session was completed, thus different teachers rated the student before and after the cycling activity.

The positive comments and replies from both parents and teachers in response to the social validity questions (and the fact that there were no negative comments) could have been because these individuals were being polite and not because they really thought the program was beneficial. Although there were no differences between the comments (in terms of positive assessment or critique) of the teachers who completed the social validity questions with the researcher or those (two teachers) who completed them on their own time, it is suggested that this questionnaire should be filled in anonymously and then then returned to the researcher; the same applies to the parent social validation questionnaire.

The current equipment set up allows for limited application of the SACS, i.e., only applicable to a bicycle. However, a recumbent bicycle, as well as a hand/foot crank apparatus could be included. For the purpose of the study, the SACS was hard wired to the laptop. However, with small adaptations to the program coding, this set up can be changed to being wireless. Doing so will allow for the use of a laptop or tablet instead of the DVD player only and thus the variety of reinforcers could be expanded to include playing video or internet games, as well as general internet use. The mounting board would have to be adapted to provide a horizontal surface for the laptop/tablet at a comfortable height, but this would not be very difficult. At this stage, the set up requires a computer (or tablet) with the program installed from which the SACS is run.

Finally, objectivity of the study may have been somewhat jeopardized by the familiarization of researcher and the participants, as well as minor “personalizations” added as they related to the participant’s individual characteristics. However, the researcher took stringent precautions in following the study procedures (Appendix L), and as the study progressed, interaction with participants (prompts, reminders) were naturally faded with only positive verbal and nonverbal reinforcement remaining toward the end of the study. The fact remained that purely by virtue of doing research on a one-to-one basis with youth, and specifically youth with disabilities, objectivity will be somewhat jeopardized.

Future Directions

This study provided a solid foundation on which future research aimed at investigating the complex issue of youth with ASD's compliance with exercise or physical activity can be built. Compliance with the cycling activity was indicated by the fact that all three adolescent participants pedaled the set time (albeit during baseline already) and also demonstrated increased exercise intensity (RPM, TOS, HR) when the treatment phase was implemented. Within the treatment phase, the results for exercise intensity attained by all participants exemplified that of the classic changing-criterion design—cycling activity behavior changed with the criterion changes. It was therefore concluded that the contingent use of screen time increased the participants' cycling activity compliance, especially in terms of exercise intensity.

Future research in the area of contingent screen time as a means of increasing exercise compliance among adolescents with ASD's should address the following questions:

1. To what extent does the severity of ASD impact participants' ability to comply with the cycling program when contingent screen time (as reinforcement) is implemented?
2. Could this contingent use of screen time be applied to individuals with ASD of different age groups?

3. Could this contingent use of screen time be implemented with individuals of other disability groups (such as intellectual disability, other developmental disabilities, or physical disabilities)?
4. Could the adolescent with ASD learn to use the cycling system, as described and employed in this study, totally independently (i.e., without an adult having to activate the system and set the TP and criterion parameters)?
5. How can this cycling system be modified to accommodate individuals with more severe motor limitations?
6. Could this study be repeated by other researchers?
7. To what extent would the potency of screen time (DVD) continue to exert a strong and stable influence over participants' cycling compliance at increased levels of duration and/or intensity?
8. Would participants continue to demonstrate increased cycling compliance in the long term (months, years)?
9. What are the optimal increments (in terms of duration and intensity/RPM) for increasing or decreasing criterion changes?
10. Could the concepts of duration and intensity (pacing) of cycling transfer to other types of activities, such as walking and jogging, or is exercise compliance cycling task–specific for these adolescents with ASD?
11. To what extent does "personalizations" of small (external) factors related to the cycling activity influence/affect the cycling activity compliance (and objectivity of the study)?

12. What modifications will need to be made (bicycle, program/coding adjustments) to the current cycling system for adapting it to using a laptop or tablet as the display medium for the reinforcer?
13. Could the software for this cycling system be compacted and/or presented as an application for tablets, laptops, or TVs (a plug-and-go)?

The above-mentioned questions should be systematically addressed to develop a body of knowledge pertaining to the contingent use of screen time for increasing exercise compliance—not only for individuals with ASD, but for as diverse a population as possible, with (and without) disabilities. In addition, moving away from single-subject designs to between-groups designs would not only allow for comparisons between different groups of individuals, but also for comparing contingent screen time to other training techniques.

In a recent article, Srinivasan et al. (2014) stated, "… (for) individuals with ASDs, there is surprisingly little research assessing the efficacy of physical activity interventions for the treatment of obesity and promotion of physical fitness." It is hoped that this study will help to provide a foundation for future work that improves the quality of life and health of individuals with ASD.

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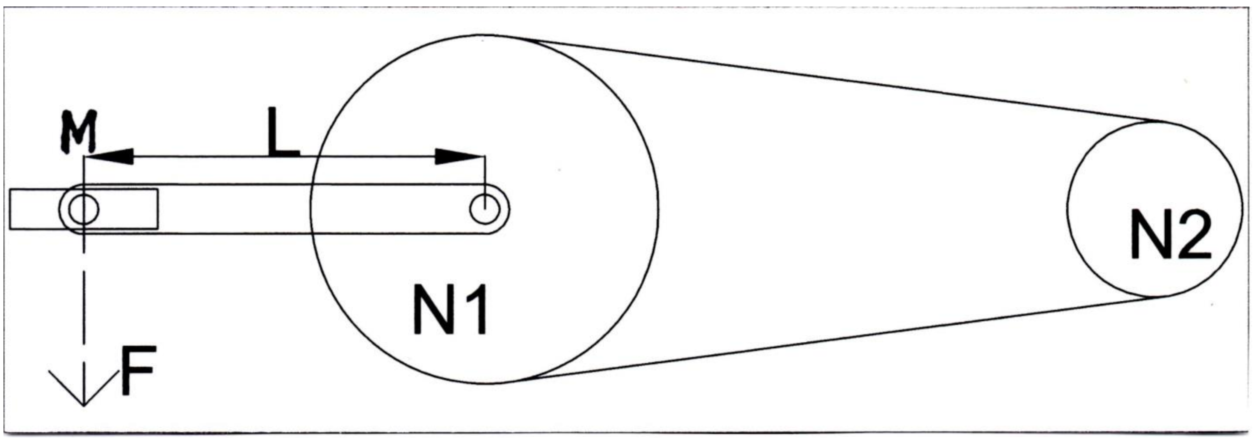
APPENDIX A

Calculation of bicycle resistance



Bicycle Resistance Calculations:

Force on pedal (F): $F = M * 9.81$ (Newton)
Torque on N_1: $T_1 = F/L$ (Newton-meter)
Torque on N_2: $T_2 = T_1 * N_2/N_1$
Power (P): T_2 * **RPM *** $2\pi/60$ (Watt)

F = force; T = torque; M = weight required to move pedal (kg);
N_1 = diameter of front chainring
N_2 = diameter of back chainring
L = length of pedal arm

Example: For gears set at middle front chainring & 4th gear back chainring and pedaling at 60 RPM, the resistance is calculated as follow:

F = 2.625 kg * 9.81 = 25.751 Newton
T_1 = 25.751/6.5625 = 3.924
T_2 = 3.924 * 3.25/4.25 = 3.001
P = 3.001 * **60** * 0.105 = 18.9 W (watt = workload – energy per unit time)

APPENDIX B

Questionnaire administered to parent(s) for gathering demographic, clinical, and lifestyle information about each participant.

---

1. Child's Name: **2.** DOB: **3.** Age:

4. What is your child's ASD diagnosis (i.e., autism, Aspergers, PDD-NOS):
Diagnosed when (month, year):
Diagnosed by whom (physician, clinician, etc.):

5. Does your child have other health, medical and /or behavioral issues (name e.g., ADHD, intellectual disability, eating problems, sleep problems, etc.). Name:

6. Is your child on any medication(s) (name of medication and why it was prescribed):

7. Physical activity: Does your child participation in organized sport/adapted physical activities?: Y/N
If YES, list: How often:

8. For what length of time does your child participate in moderate- to vigorous physical activity on average per day? (explained moderate activities as being brisk walking, roller skating for leisure, jumping on a trampoline, aerobic dancing, recreational swimming, shooting baskets, shoveling light snow, doing yard work, etc. and vigorous activities being more intense and over longer periods of time)

a) Weekdays before/after school:

Min/day	Activity
≤ 10	
10 - 19	
20 - 29	
30 - 39	
> 40	

b) During weekend days:

Min/day	Activity
≤ 10	
10 - 19	
20 - 29	
30 - 39	
> 40	

9. What are your child's preferred/favorite types of physical activity (name):

10. How many hours per day is your child involved in (recreational/leisure, non-school work related) screen time activities? (defined as any of the following: watching TV/movies/DVDs, playing video/internet games, browsing the internet, doing emails/social media, tablet/smart phone, etc.)

a) Weekdays before/after school:

Hrs/day	Activity
≤ 1	
>1 – 2	
>2 – 3	
>3 – 4	
> 4	specify hrs:

b) During weekend days:

Hrs/day	Activity
≤ 1	
>1 – 2	
>2 – 3	
>3 – 4	
> 4	specify hrs:

(Appendix B continued)

11. What is your child's preferred form of screen time and what device (smart phone, tablet, TV, etc.) does he use for each? (rated from 1 – 6 where 1 is most preferred, and 6 the least preferred; if never done, record a zero):

Form of ST	Rating	Device used
Movies/DVDs		
TV programs		
Video/internet games		
Internet		
Social media/ e-mail		
Exergames		

12. What are your child's favorite (most preferred) movies, DVDs, TV shows? Please list…

13. What is your child's most preferred reinforcers/rewards? Please name…

Question to participant during/after interview with parent(s), as well as during informal conversations at school before the study started:

14. Which are your favorite movies (or TV shows/programs)? Can you name all of them? (researcher records all named)

APPENDIX C

Questionnaire administered to teachers for gathering demographic, clinical, and lifestyle information about each participant.

---

1. Student's Name: **2.** DOB: **3.** Age:

4. ASD diagnosis (autism, Aspergers, PDD-NOS) – as per school records:
Diagnosed when (month, year):
Diagnosed by whom (physician, clinician, etc.):
Tests administered and date: ASD diagnosis (name e.g., ADI-R, ADOS):
Severity (severe, moderate, mild):
Other/additional tests (VABS, Wechscler, CARS):

5. Does the student have other health, medical and/or behavioral issues (name e.g., ADHD, intellectual disability, eating problems, sleep problems, etc.):

6. Is the student on any medication(s) (name the medication(s) and why it was prescribed):

7. Physical activity: Does the student participation in organized sport/adapted physical activities?: Y/N
If YES, list: How often:

8. For what length of time does the student participate in moderate- to vigorous physical activity on average per day? (explained moderate activities as being brisk walking, roller skating for leisure, jumping on a trampoline, aerobic dancing, recreational swimming, shooting baskets, shoveling light snow, doing yard work, etc. and vigorous activities being more intense and over longer periods of time)

Weekdays during school:

Min/day	Activity
$\leq$ 10	
10 - 19	
20 - 29	
30 - 39	
> 40	

9. What are the student's preferred/favorite types of physical activity (name):

10. How many hours per day is the student involved in (recreational/leisure, non-school work related) screen time activities? (defined as any of the following: watching TV/movies/DVDs, playing video/internet games, browsing the internet, doing emails/social media, tablet/smart phone, etc.)

Weekdays during school:

Hrs/day	Activity
$\leq$ 1	
>1 – 2	
>2 – 3	
>3 – 4	
> 4	specify hrs:

(Appendix C continued)

11. What is the student's preferred form of screen time and what device (smart phone, tablet, TV, etc.) does he use for each? (ranked from 1 – 6 where 1 is most preferred, and 6 the least preferred; if never done, record a zero):

Form of ST	Rating	Device used
Movies/DVDs		
TV programs		
Video/internet games		
Internet		
Social media/ e-mail		
Exergames		

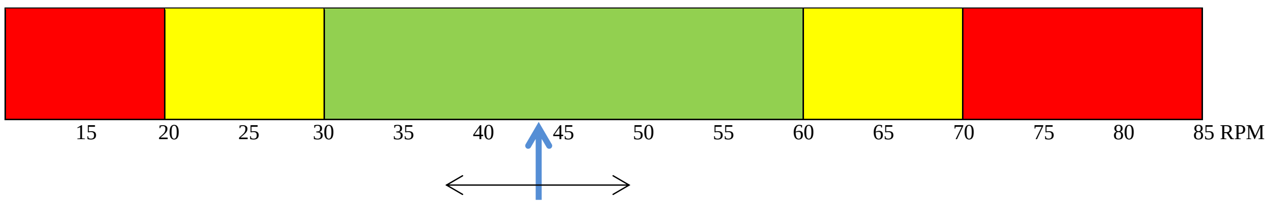
12. What are the student's favorite (most preferred) movies, DVDs, TV shows? Please list…

13. What is the student's most preferred reinforcers/rewards? Please name…

14. Please lay out the student's individualized (a) prompting schedule, and (b) reinforcement/token schedule.

APPENDIX D

Bar graph depicting revolutions per minute (RPM) criteria as shown on feedback display.



Vertical blue pointer moves across bar graph in accordance with RPM pedaled

Example of (broad) baseline criteria set:

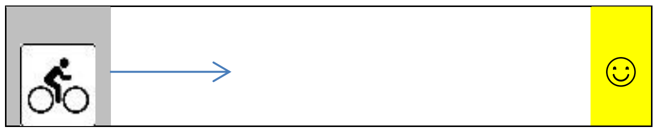
Green (DVD playing) = 30 – 60 RPM
Yellow (DVD mutes) = ≥20 < 30; >60 ≤70 RPM
Red (DVD shuts off) = <20; >70 RPM

Eleven criteria options for this study (one baseline, ten learning/intervention choices):

Criterion	Red	Green	Yellow
Baseline	<20; >70	30 – 60	≥20 <30; >60 ≤70
A	<20; >40	25 – 35	>20 <25; >35 <40
B	<25; >45	30 – 40	>25 <30; >40 <45
C	<30; >50	35 – 45	>30 <35; >45 <50
D	<35; >55	40 – 50	>35 <40; >50 <55
E	<40; >60	45 – 55	>40 <45; >55 <60
F	<45; >65	50 – 60	>45 <50; >60 <65
G	<50; >70	55 – 65	>50 <55; >65 <70
H	<55; >75	60 – 70	>55 <60; >70 <75
I	<60; >80	65 – 75	>60 <65; >75 <80
J	<65; >85	70 – 80	>65 <70; >80 <85

APPENDIX E

Horizontal time line depicting time pedaled (TP) as shown on feedback display.

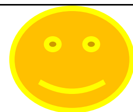
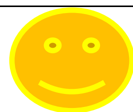
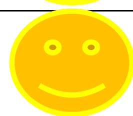


The bicycle icon moves across the time line as time pedaled elapses:

for 5 min cycling, icon moves 1 “block” every 0.5 min;
for 10 min cycling, icon moves 1 “block” block every 1 min;
for 15 min cycling, icon moves 1 “block” every 1.5 min;
for 20 min cycling, icon moves 1 “block” every 2 min;
for 25 min cycling, icon moves 1 “block” every 2.5 min;
for 30 min cycling, icon moves 1 “block” every 3 min.

APPENDIX F

Graphical depiction of the self-monitor board.

Participant's Name	
Date	Minutes pedaled
Date	8
Date	
Date	7
Date	
Date	
Date	9
Date	
Date	

 = goal set for time pedaled achieved (e.g., 15 minutes)

X number of  (as per participant's individualized reinforcement schedule) = (school) token

APPENDIX G

Table G1

Testing Procedure Checklist - BASELINE

Name (Study ID): Session #: DVD chosen: Date:

Gear setting: RPM zone: TP goal: THRZ

1.Greet and verbal confirmation/encouragement for session Warm-up (neck, shoulder, trunk, quads, hamstrings, ankles) – done in class?							
2. Participant choses DVD and place in DVD player							
3. Set seat height and mount bike							
4. Rest 1 minute: Enjoyment scale		Score:					
Fit HR wristband							
SACS activated: Participant ID, set TP, and RPM criterion							
HR value – also wrist palpated (final 15 sec x 12)							
5. Prompt: “Let’s see if you can pedal for 15 min/until bicycle reaches end of line without stopping”							
6.DVD starts. Give verbal encouragement – 30 sec intervals (“great job”, “perfect!”, non-verbal “thumbs-up)							
7. Exercise HR: wristband and palpated (final 15 sec × 12; after 1 min, then every 3 min)		1 min	4 min	7min	10 min	13 min	15 min
Pedals 15 min	**Stops early***						
8. Halfway: Enjoyment scale	Enjoyment scale	Score:					
9. At 15 min: SACS stops	Stops; wait 5 sec; Ask “Are you done cycling?” If **“yes”**: Stop SACS (go to #10) If **“no”**: Prompt to pedal; **if not**, stop SACS (go to #10) **if pedals 15 min**, stop SACS (go to #10) **if stops early again**, start at top (max 3 times)						
10. Rest 5 minute: 1 min post HR: wristband and palpate (final 15 sec)							
Enjoyment scale		Score:					
5 min post HR: wristband and palpate (final 15 sec), remove wristband							
11. Dismount bike, Final comment on SACS							
12. Self-monitor board							
13. Goodbye & verbal confirmation/encouragement about session, Cool down in class							

* Example of prompting procedure and token system (to reinforce compliance) used with one participant at school: 5 seconds delay, only one prompt per requested behavior/task; 3 correct behaviors/tasks/actions = 1 token towards a preferred activity.

Table G2

Testing Procedure Checklist – LEARNING/ORIENTING

Name (Study ID): Session #: DVD chosen: Date:
Gear setting: RPM zone: TP goal: THRZ

<table>
<tr><td colspan="2">1. Greet and verbal confirmation/encouragement for session (warm up already done in class?)</td><td colspan="6"></td></tr>
<tr><td colspan="2">2. Participant choses DVD and place in DVD player</td><td colspan="6"></td></tr>
<tr><td colspan="2">3. Set seat height and mount bike</td><td colspan="6"></td></tr>
<tr><td colspan="2">4. Rest 1 minute: Enjoyment scale</td><td colspan="6">Score:</td></tr>
<tr><td colspan="2">Fit HR wristband</td><td colspan="6"></td></tr>
<tr><td colspan="2">SACS activated: Participant ID, set TP, and RPM criterion</td><td colspan="6"></td></tr>
<tr><td colspan="2">Resting HR value</td><td colspan="5"></td><td></td></tr>
<tr><td colspan="2">5. Prompt: “Let’s see if you can pedal for 5 min without stopping”</td><td colspan="6"></td></tr>
<tr><td colspan="2">6. SACS activated and DVD starts</td><td colspan="6"></td></tr>
<tr><td colspan="2">“See the blue pointer? Keep the pointer on the green and the movie will stay on”.</td><td colspan="6"></td></tr>
<tr><td colspan="2">Give verbal encouragement throughout session – every 30 sec (“great job/perfect!/thumbs-up”)</td><td colspan="6"></td></tr>
<tr><td colspan="2">If in yellow, point to the pointer & “Uh-oh, pedal a bit faster/slower, keep the bar in the green”
After 3-5 times in yellow for >3 sec, pause DVD until pedaling in green again</td><td colspan="6"></td></tr>
<tr><td colspan="2">If in red, point to the pointer & “Uh-oh, pedal a bit faster/slower, keep the bar in the green”
After 3-5 times in yellow for >3 sec, shut off DVD until pedaling in green again</td><td colspan="6"></td></tr>
<tr><td colspan="2">Also: “See the bicycle moving? When it reaches the end/smiley face, you are done!”
Prompt and point as needed (“Keep the pointer on the green and the movie will stay on, “Uh-oh, pedal a bit faster/slower, keep the bar in the green”) and pause/shut off DVD as needed until pedaling in green again</td><td colspan="6"></td></tr>
<tr><td colspan="2">7. Exercise HR values</td><td>1 min</td><td>4 min</td><td>7min/ES</td><td>10 min</td><td>13 min</td><td>15 min</td></tr>
<tr><td>Pedals 15 min</td><td>Stops early *</td><td colspan="6"></td></tr>
<tr><td>8. Halfway: Enjoyment scale</td><td>Enjoyment scale</td><td colspan="6">Score:</td></tr>
<tr><td>9. At 15 min: SACS stop</td><td>Stops; wait 5 sec; Ask “Are you done cycling?”
If “yes”: Stop SACS (go to #10)
If “no”: Prompt to pedal; if not, stop SACS (go to #10)
if pedals 15 min, stop SACS (go to #10)
if stops early again, start at top (max 3 times)</td><td colspan="6"></td></tr>
</table>

10. Rest 5 minute: 1 min post HR value		
Enjoyment scale	Score:	
5 min post HR value, remove wristband		
11. Dismount bike, final comment on SACS		
12. Self-monitor board		
13. Goodbye & verbal confirmation/encouragement about session		

* Example of prompting procedure and token system (to reinforce compliance) used with one participant at school: 5 seconds delay, only one prompt per requested behavior/task; 3 correct behaviors/tasks/actions = 1 token towards a preferred activity.

Table G3

Testing Procedure Checklist - TREATMENT

Name (Study ID): Session #: DVD chosen: Date:

Gear setting: RPM zone: TP goal: THRZ:

1. Greet and verbal confirmation/encouragement for session (warm up done in class?)							
2. Participant choses DVD and place in DVD player							
3. Set seat height and mount bike							
4. Rest 1 minute: Enjoyment scale		Score:					
Fit HR wristband							
SACS activated: participant ID, set TP, and RPM criterion							
Resting HR value:							
5. Prompt: "Let's see if you can pedal for 15 min/until bicycle reaches end of line without stopping"							
Point to RPM display and say "Keep the pointer on the green and the movie will stay on" Give verbal encouragement– every 30 sec ("great job/perfect!/thumbs-up") - fade gradually! If too slow/fast (**yellow**), DVD pauses; if too slow/fast (**red**), DVD shuts down. Repeat from top as/when needed							
7. Exercise HR values:		1 min	4 min	7min/ES	10 min	13 min	15 min
Pedals 15 min	**Stops early ***						
8. Halfway: Enjoyment scale	Enjoyment scale	Score:					
9. At 15 min: SACS stop	Stops; wait 5 sec; point and ask "Let's see if you can pedal little while longer/until bicycle reaches end of line" Wait 5 sec; ask "Are you done cycling?" If **"yes"**: Stop SACS (go to #10) If **"no"**: Prompt to pedal; **if not** within 5 sec, stop SACS (go to #10) **if pedals 15 min**, stop SACS (go to #10) **if stops early again**, start at top (max 3 times)						
10. Rest 5 minute: 1 min post HR value							
Enjoyment scale		Score:					
5 min post HR value, remove wristband							
11. Dismount bike, final comments on SACS							
12. Self-monitor board							
13. Goodbye & verbal confirmation/encouragement about session, Cool down in class							

APPENDIX H

APPENDIX I

Parent social validity questions:

The researcher asked the following questions to the parents within a week after termination of the study:

1. Do you think that watching a DVD contingent on pedaling the bicycle (i.e., the DVD playing only when pedaling within a specified RPM zone) had a positive outcome on your son? Yes/No/Not sure

2. If yes, please give examples of such outcomes.

APPENDIX J

Teacher social validity questions

The researcher asked the following questions to the teachers within a week after termination of the study:

1. Do you think that watching a DVD contingent on pedaling the bicycle (i.e., the DVD playing only when pedaling within a specified RPM zone) had a positive outcome on the student? Yes/No/Not sure
2. If yes, please give examples of such outcomes.
3. Do you think that this activity was appropriate (in terms of ethics, cost, practicality, space used, time required, etc.)? Yes/No/Not sure
4. Do you have any comments/critique/suggestions related to this study's implementation at you school? Please name.

APPENDIX K

Participant social validity question(s)

The researcher asked the following questions to the participant within a week after termination of the study:

1. Did you like pedaling the bicycle while watching a movie/show/program?

   Yes/No/Not sure

(The researcher took notes/recorded of any comments made about the study by the student after asking the question)

APPENDIX L

Study Procedures

Warm-up (5 min):

After being accompanied to the site by his teacher (who signed the participant's global "mood" score (0, 1, or 2 for regular, bad, and good day, respectively), the participant chose his movie/show and then completed a set of total body stretching exercises led by the researcher (only for first two sessions in Phase A, whereafter warm-up/cool-down was done with teacher in class as transitional activity for/from the cycling session). Stretches consisted of:

1. Neck stretch
2. Shoulder stretch and rotations
3. Trunk stretch and rotations
4. Quadriceps stretch
5. Hamstring stretch
6. Ankle rotations

Adjusting (only once or as needed) and mounting stationary bicycle, and pre-session measures:

1. Correct saddle height (knee bent at $\pm$ 5° with foot on pedal at lowest level - determined during baseline and marked with colored tape for quick adjustment) was set for participant.
2. Participant mounted bicycle and "rested" for one minute during which:
   a. Enjoyment rating scale was administered and score recorded.
   b. HR wristband fitted and activated.
   c. SACS activated; RPM criterion and TP goal selected (via laptop).
   d. HR also measured using wrist palpation during final 15 seconds of one-minute "rest" (multiplied by 4 to verify wrist monitor) - only during phase A (to verify monitor values)

Cycling Session (15 min):

Immediately after the 1-min rest, for

a. Phase A (baseline): RPM set at broad zone (green = 30-60 RPM). The participant was told to "Let's see if you can pedal for 15 minutes (or until the bicycle reaches the end of the line - pointing at bicycle icon) without stopping" and the DVD was turned on, and remained on. The researcher provided verbal encouragement (alternating "great job", non-verbal "thumbs-up", "perfect!", non-verbal "thumbs-up" every 30 seconds) while the participant cycled.

   After pedaling for half the average time pedaled during the previous session, enjoyment rating scale was administered and score recorded.

   *If participant stopped cycling before 15 minutes elapsed, the researcher waited five seconds and asked, "Are you done cycling?" If the participant replied "yes", the researcher terminated the session. If the participant replied "no", the researcher prompted the participant to start pedaling again and if he did not start pedaling, the session was terminated. If the participant did start pedaling again after the prompt and completed a 15-minute total cycling session, the session was terminated. If the participant, again, stopped early, the prompting sequence starting with, "Are you done cycling?" was initiated (a maximum of 5 times before session was terminated).

   In the case where a participant stopped after only a few pedals and/or refused to pedal, it was envisaged that his individual prompting schedule would be implemented and any effort exhibited toward pedaling would be rewarded as per his personalized

(Appendix L continued)

reinforcement/reward schedule. Depending on the participant, as well as the situation, any or all of the following strategies would be incorporated: the researcher/teacher modeled the task; a peer modeled the task; a peer verbally encouraged/motivated the participant; the researcher physically turned the pedal (by hand); the participant received a time-out and an attempt was made thereafter; and/or the participant dismounted, continued with his daily schedule and was brought back for another attempt at a later stage during the day. Worst case scenario, that day would be written off as a "bad day".

If the participant cycled non-stop for the full 15 min, the session was terminated.

b. Phase B (learning/orienting): RPM first set at baseline setting (broad, 30-60 RPM), followed by that of the average for baseline, and finally increased by 5RPM when compliance was shown. The participant was told to "Let's see if you can pedal for 5 (or more) minutes in the green without stopping" and the entertainment video display (movie/show) was turned on. The researcher would point to the feedback display stating, "See the blue pointer? Keep the blue pointer on the green and the movie will stay on". If the participant pedaled within the "green zone" (target zone), verbal encouragement would be given (alternating "great job", non-verbal "thumbs-up", "perfect!", non-verbal "thumbs-up" every 30 seconds).
When the participant pedaled within the yellow zone, the researcher would point to the blue pointer stating, "Uh-oh, pedal a bit faster, keep the pointer/arrow in the green" and after 3-5 times (depending on participant) within the yellow for longer than 3 seconds, the researcher would pause the DVD (using laptop keys) and repeat the prompt (and pointing) to pedal a bit faster and in the green for the DVD to play. The same prompts and reinforcement were given and same conditions implemented for switching the DVD player off when the participant cycled in the red. All the actions taken by the researcher (pause/stop and whether for too high/low pedaling) were recorded.
The researcher would also focus on the animated bicycle icon (TP), pointing to it and stating "See the bicycle moving? When it reaches the end/smiley face, you are done!" In addition, prompts to remind the participant to remain in the green, pausing and switching the DVD off/on according to zone pedaled in, as well as verbal encouragement (as above) was given by the researcher.

*The same conditions described under Phase A applied when the participant stopped pedaling early, or regularly, and for completing 15 minutes of cycling.

c. Phase C (treatment): The participant was told to "Let's see if you can pedal for 15 minutes (or until the bicycle reaches to the end of the line) without stopping" and the entertainment video display (DVD) was turned on. In addition, the researcher would point to the feedback display stating, "Keep the blue pointer in the green and the movie will stay on". The researcher observed and provided verbal encouragement (alternating "great job", non-verbal "thumbs-up", "perfect!", non-verbal "thumbs-up" every 30 seconds) to the participant from the left side and slightly behind the participant while he was cycling.
If the participant pedaled too slow/fast (when DVD paused of went off), the researcher would verbally remind (while also pointing at the pointer on the feedback display) the participant to "Keep the pointer/arrow on the green and the movie will go on". These

(Appendix L continued)

prompts were faded as the participant increased/decreased pedal rate on their own to keep the pointer in the green.
Halfway through the session, enjoyment rating scale was administered and the score recorded.
*The same conditions described under Phase A applied when the participant stopped pedaling early, or regularly, and for completing 15 minutes of cycling.

In all three phases, the HR wristband relayed HR continuously to the researcher's smart phone (values recorded at pre-determined times by researcher – 1-min pre-post, 1 min into and every 3 min during, as well as 5-min post-exercise)

Cool Down (five^{+} minutes):

a. After cycling session terminated the participant rested on bicycle (DVD playing on) for 5 minutes to obtain 1- and 5 min post-exercise HR.
b. During this time, enjoyment rating scale was administered and HR wristband removed at the end.
c. Participant dismounted bicycle and SACS was shut down
d. The participant received either a yellow smiley face sticker (pedaled full 15 min) or a colored sticker with time pedaled during session written on it (by participant or researcher) that he placed on his personalized monitor-board (*5 consecutive 15-min sessions = one token consistent with token schedule implemented at the school or choice of free time activity).
e. Teacher accompanied student from site and participant completed the same set of total body stretching exercises as for warm-up (led by the teacher back in class).

Within an hour after the session, the researcher "popped into" the classroom for the teacher to sign another global "mood" score – recorded by the researcher

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* Example of prompting procedure and token system (to reinforce compliance) used with one participant at school: 5 seconds delay, only one prompt per requested behavior/task; 5 correct behaviors/tasks/actions = 1 token towards a preferred activity.

Note: These procedures were compacted into a daily check sheet for each participant and session during the study – onto which Enjoyment and HR values, as well as additional notes/comments were recorded.

APPENDIX M

University of Virginia Human Subjects Research IRB

Protection of Human Subjects Approval
Assurance Identification/Certification/Declaration
(Common Federal Rule)

HSR # 17878

Event:	Type:	Sponsor(s):
Approval New Protocol - Expedited	Protocol	Sponsor Protocol #:
		Principal Investigator: Martin Block

Title: The Efficacy of contingent reinforcement with compliance to a stationary cycling program by adolescent boys with Autism Spectrum Disorders

Assurance: Federal Wide Assurance (FWA)#: 00006183

Certification of IRB Review: The IRB-HSR abides by 21CFR50, 21CFR56, 45CFR46, 45CFR160, 45CFR164, 32CFR219 and ICH guidelines. This activity has been reviewed by the IRB in accordance with these regulations.

Event Date: 02/11/15

Protocol Expiration Date: 02/10/16

Number of Subjects: 7

HSR Protocol Version Date: 02/06/15

Current Status: Open to enrollment

Consent Version Dates:

Adult/Minor Consent -- 02/06/2015

Committee Members (did not vote):

Comments: The IRB determined the protocol met the criteria for approval per the federal regulations and was approved.

It is open to enrollment.

The purpose of this study is to assess the efficacy of watching DVDs contingent on complying with cycling, on a stationary bicycle in subjects with autism spectrum disorder.

The study will take place at a school for boys with autism spectrum disorders and will involve cycling sessions while watching a DVD with time and RPM goals.

For the baseline phase, participants will be asked to pedal the bike while watching their preferred DVD.

For the treatment phase, participants will cycle at a pre-determined RPM with the DVD display controlled by maintaining pedaling within a target range.

Questionnaires will be given to parents, teachers and staff members.

There is no outside sponsor for this study.

N= 7 subjects

(Appendix M continued)

Ages: 15 to 18 years

The following documents were submitted with this protocol:
1) enjoyment rating scale
2) Parent-child questionnaire
3) teacher questionnaire
4) example of self-monitor board
5) session data calculations example
6) social validity questionnaire
7) procedure checklist
8) SACS lay-out

Vulnerable populations to be enrolled include children, and 18 year olds who are cognitively impaired.

This study has been reviewed and approved by ISPRO.

Participants will receive a free DVD.

Letter of support from Founder's Commonwealth Center for Autism on file .

Approved with this protocol is the following recruitment material: letter to parents.

REGULATORY INFORMATION:

The IRB determined this protocol met the criteria of minimal risk.

Protocol Expedited by Category #1: Clinical studies of drugs and medical devices only when conditions (a) or (b) is met: a. Research on drugs for which an investigational new drug application is not required. b. Research on medical devices for which: i. an investigational device exemption (IDE) application is not required; or ii. the medical device is cleared/approved for marketing and the medical device is being used in accordance with its cleared/approved labeling.

Protocol Expedited by Category #4: Collection of data through non-invasive procedures (not involving general anesthesia or sedation) employed in clinical practice, excluding procedures involving x-rays or microwaves.

Where medical devices are employed, they must be cleared/approved for marketing.

Protocol Expedited by Category #7: Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

This protocol has been granted a Waiver of Consent to identify potential subjects via 45CFR46.116.

This protocol has been granted a Waiver of Consent via 45CFR46.116 and a Waiver of HIPAA Authorization via 45CFR 164.512(i)(2) to contact subjects by direct contact by a person who is not their health care provider.

Direct contact may include phone, letter, direct email or approaching potential subjects while at UVa.

(Appendix M continued)

Phone, letter or emails will be approved by the IRB-HSR prior to use.

The following HIPPA identifiers may be collected: Name, medical record number, date of birth and contact information appropriate to the recruitment plan.

The minimum necessary PHI to be collected includes only those items related to the inclusion/ exclusion criteria.

Written consent will be obtained for this study.

The consent form signed will have a non-expired IRB-HSR approval stamp.

Children are approved to enroll in this protocol per 45CFR46.404 and 21CFR50.51.

This protocol requires the signature of one parent per 45CFR46.408(b) and 21CFR50.555/(e)(1).

This protocol requires the written assent of the child per 45CFR46.408(a)/21CFR50.55a.

Use of a Legally Authorized Representative approved under 45CFR46.116/21CFR56.111 for subjects who are 18 years old and cognitively impaired.

PLEASE REMEMBER:

* If an outside sponsor is providing funding or supplies, you must contact the SOM Grants and Contracts Office/ OSP regarding the need for a contract and letter of indemnification. If it is determined that either of these documents is required, participants cannot be enrolled until these documents are complete.
* You must notify the IRB of any new personnel working on the protocol PRIOR to them beginning work.
* You must obtain IRB approval prior to implementing any changes to the approved protocol or consent form except in an emergency, if necessary to safeguard the well-being of currently enrolled subjects.
* If you are obtaining consent from subjects, prisoners are not allowed to be enrolled in this study unless the IRB-HSR previously approved the enrollment of prisoners. If one of your subjects becomes a prisoner after they are enrolled in the protocol you must notify the IRB immediately.
* You must notify the IRB-HSR office within 30 days of the closure of this study.
* Continuation of this study past the expiration date requires re-approval by the IRB-HSR.

The official signing below certifies that the information provided above is correct and that, as required, future reviews will be performed and certification will be provided.

Name: Lynn R. Noland , RN PhD Title: Vice Chair, Institutional Review Board for Health Sciences Research Phone: 434-924-9634 Fax: 434-924-2932	Name and Address of Institution: Institutional Review Board for Health Sciences Research PO Box 800483 University of Virginia Charlottesville, VA 22908
Signature: Lyn R. Noland	Date: FEB 12 2015

APPENDIX N

Table N1

Data recorded during Phases A and C for Participant 1

Session	RPM Crit	Gears	Total TP/S	Av. RPM	TOS	TP in Crit	Av RPM in Crit	SD of RPM in Crit	%age Compl	Pre-Ex HR	During Session Av. HR	During Session HR Range	1-Min Post Ex HR	5-Min Post Ex HR
1	30-60	2-4	15.3	50.4	756.00					90	97.00	92-100	90	87
2	30-60	2-4	15.0	37.9	568.50					85	99.00	95-102	90	83
3	30-60	2-4	15.1	43.2	648.00					86	101.70	95-106	98	87
4	30-60	2-4	15.2	42.1	631.50					88	100.00	98-102	98	83
L	E	A	R	N	I	N	G	-	P	H	A	S	E	S
7	45-55	2-4	16.3	47.9	718.50	15.0	50.1	3.2	91.93	79	95.00	91-98	82	78
8	45-55	2-4	16.3	46.8	702.00	15.0	48.2	3.0	91.99	84	102.20	92-112	102	88
9	45-55	2-4	15.2	50.8	762.00	15.0	51.1	1.9	98.39	82	106.50	96-112	96	87
10	50-60	2-4	15.2	55.5	832.50	15.0	55.8	2.6	98.89	88	102.20	97-108	99	86
11	50-60	2-4	15.2	57.0	855.00	15.0	57.2	2.7	99.02	89	105.30	95-112	100	85
12	50-60	2-4	15.2	56.0	840.00	15.0	56.2	2.3	98.92	84	102.00	89-108	94	82
13	55-65	2-4	17.4	54.7	820.50	15.0	56.6	1.5	86.16	83	102.20	92-106	96	87
14	55-65	2-4	15.2	57.7	865.50	15.0	57.9	1.3	98.86	84	107.50	103-115	93	82
15	55-65	2-4	15.7	60.4	906.00	15.0	60.8	1.8	95.80	92	124.20	108-137	112	98
16	50-60	2-4	15.2	53.9	808.50	15.0	54.2	2.7	98.85	86	113.80	98-128	89	81
17	50-60	2-4	15.0	54.7	820.50	15.0	54.7	1.7	100.00	84	104.70	101-110	95	85
18	50-60	2-4	15.0	56.8	852.00	15.0	56.8	2.1	100.00	86	110.80	98-118	108	90
19	55-65	2-4	15.2	60.4	906.00	15.0	60.6	1.7	98.90	89	104.50	101-108	95	83
20	55-65	2-4	20.1	59.4	1223.60	20.6	59.6	1.8	98.87	87	106.40	100-115	106	90

RHR = 86 bpm. 40-70% HRR = 130-162 bpm (130-140 bpm = low-mid Mod; 141-151 bpm = mid-high Mod; 152-162 bpm = low Vigorous)
Note: Av = average, Compl = compliance, Crit = criterion.

APPENDIX N

Table N2

Data recorded during Phases A and C for Participant 2

Session	RPM Crit	Gears	Total TP/S	Av. RPM	TOS	TP in Crit	Av RPM in Crit	SD of RPM in Crit	%age Compl	Pre-Ex HR	During Session Av. HR	During Session HR Range	1-Min Post Ex HR	5-Min Post Ex HR
1	30-60	2-4	15.2	45.1	676.50					85	112.00	92-128	102	96
2	30-60	2-4	15.0	49.1	736.50					90	115.00	101-131	110	93
3	30-60	2-4	15.0	49.6	744.00					88	117.00	114-126	104	92
4	30-60	2-4	15.0	51.6	774.00					94	99.00	94-104	98	90
L	E	A	R	N	I	N	G	-	P	H	A	S		E
7	50-60	2-4	15.0	54.0	810.00	15.0	54.0	2.2	100.00	92	104.30	87-112	116	108
8	50-60	2-4	15.6	53.3	799.50	15.0	53.2	3.1	96.41	81	113.30	94-124	118	94
9	50-60	2-4	15.0	54.2	813.00	15.0	54.2	3.0	99.59	87	118.50	92-138	127	100
10	55-65	2-4	15.3	57.6	864.00	15.0	57.9	3.2	97.79	89	105.20	92-118	102	90
11	55-65	2-4	15.5	59.3	889.50	15.0	59.5	3.1	96.76	90	117.30	111-122	103	92
12	55-65	2-5	15.2	57.4	861.00	15.0	57.5	3.3	98.90	84	111.00	100-122	102	90
13	60-70	2-5	17.0	60.5	907.50	15.0	61.7	3.5	88.39	92	142.50	125-150	125	100
14	60-70	2-5	15.2	63.1	946.50	15.0	63.1	2.9	98.32	90	133.70	118-142	123	101
15	60-70	2-5	15.0	61.7	925.50	15.0	61.7	3.4	100.00	84	109.80	106-112	96	87
16	55-65	2-5	15.2	58.8	882.00	15.0	58.9	1.8	98.90	92	138.00	125-145	122	96
17	55-65	2-5	15.2	61.6	924.00	15.0	61.6	3.1	98.89	95	135.30	111-155	120	99
18	55-65	2-5	15.0	60.3	904.50	15.0	60.3	2.6	100.00	87	133.50	112-145	128	97
19	60-70	2-5	15.0	64.1	961.50	15.0	64.1	3.4	100.00	91	140.80	113-158	131	98
20	60-70	2-5	23.4	65.0	1482.00	22.8	65.3	3.7	97.26	94	150.50	126-160	148	104

RHR = 80 bpm. 40-70% HRR = 126-161 bpm (126-137 bpm = low-mid Mod; 138-149 bpm = mid-high Mod; 150-161 bpm = low Vigorous)
Note: Av = average, Compl = compliance, Crit = criterion.

APPENDIX N

Table N3

Data Recorded during Phases A and C for Participant 3

Session	RPM Crit	Gears	Total TP/S	Av. RPM	TOS	TP in Crit	Av RPM in Crit	SD of RPM in Crit	%age Compl	Pre-Ex HR	During Session Av. HR	During Session HR Range	1-Min Post Ex HR	5-Min Post Ex HR
1	30-60	2-4	7.7	57.6	437.80					98	121.00	115-127	118	97
2	30-60	2-4	15.0	51.9	778.50					102	123.00	114-128	114	104
3	30-60	2-4	15.3	55.0	825.00					90	115.00	102-122	100	92
4	30-60	2-4	15.0	52.4	786.00					96	118.00	108-122	114	97
L	E	A	R	N	I	N	G	-	P	H	A	S		E
7	55-65	2-5	15.6	59.3	889.50	15.0	59.7	3.4	96.33	92	117.70	102-129	121	104
8	55-65	2-5	15.3	59.3	889.50	15.0	59.5	2.6	97.96	94	128.30	122-136	128	108
9	55-65	2-5	15.0	59.7	895.50	15.0	59.7	1.9	100.00	95	129.00	118-136	126	100
10	60-70	2-5	15.7	62.6	939.00	15.0	63.4	3.1	95.25	86	142.20	129-150	120	95
11	60-70	2-5	16.2	61.5	922.50	15.0	64.5	1.7	92.78	88	121.00	106-128	108	94
12	60-70	2-5	15.1	63.5	952.50	15.0	63.5	2.8	99.39	97	124.50	111-129	113	98
13	65-75	2-5	15.1	70.9	1063.50	15.0	71.0	2.5	99.44	97	131.30	120-136	127	106
14	65-75	2-5	15.2	68.7	1030.50	15.0	68.9	2.9	98.88	98	139.00	124-150	131	97
15	65-75	2-5	15.0	69.5	1042.50	15.0	69.5	1.9	100.00	98	142.50	128-154	136	108
16	60-70	2-5	15.0	65.1	976.50	15.0	65.1	2.6	100.00	89	119.80	112-126	108	94
17	60-70	2-5	15.0	64.7	970.50	15.0	64.7	1.8	100.00	91	115.30	105-121	108	90
18	60-70	2-5	15.2	63.9	958.50	15.0	64.1	2.4	98.99	88	113.80	105-119	95	86
19	65-75	2-5	15.3	69.7	1045.50	15.0	69.9	2.9	97.96	88	126.00	109-134	112	92
20	65-75	2-5	23.4	69.3	1573.10	22.7	69.6	3.6	96.82	87	138.60	112-148	126	96

RHR = 97 bpm. 40-70% HRR = 137 – 166 bpm (137-146 bpm = low-mid Mod; 147-156 bpm = mid-high Mod; 157-166 bpm = low Vigorous)
Note: Av = average, Compl = compliance, Crit = criterion.