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Use of technology to facilitate physical activity in children with autism spectrum disorders: A pilot study

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ABSTRACT

Deficits in social behavior and communication skills are correlated with reduced gross motor skills in children with autism spectrum disorders (ASD). The *ExerciseBuddy* application (EB app) was designed to communicate these motor skills to those with ASD and integrates evidence-based practices such as visual support and video modeling supported by The National Professional Development Center on Autism Spectrum Disorders. The purpose of this study was to determine the effectiveness of the EB app in facilitating increased physiologic responses to physical activity via a continuous measurement of energy expenditure and heart rate versus practice-style teaching methods in children with ASD. Six children, ages 5 to 10 years, diagnosed with ASD were recruited. Each participant performed a variety of locomotor or object control skills as defined by the *Test of Gross Motor Development-2* once per week for 4 weeks. Motor skills were communicated and demonstrated using either practice-style teaching methods or the instructional section of the EB app. Energy expenditure and heart rate were measured continuously during each 12-minute session. A Wilcoxon signed-rank test was performed to assess any differences between the use of the app and practice-style teaching methods. The use of the EB app elicited greater values for peak energy expenditure ($p = 0.043$) and peak heart rate response ($p = 0.028$) while performing locomotor skills but no differences were observed while performing object control skills. Similarities were observed with average physiologic responses between the use of the EB app and practice-style teaching methods. The use of the EB app may allow for a greater peak physiologic response during more dynamic movements and a similar average cardiovascular and metabolic response when compared to practice-style teaching methods in children with ASD.

1. Introduction

According to the Centers for Disease Control and Prevention, 1 in 68 children are currently diagnosed with autism spectrum disorder (ASD) in the United States [1]. Although 5 times more prevalent in males, ASD occurs in all ethnicities and socioeconomic groups. Children with ASD have repetitive behaviors, deficits in social and communication skills, and motor development delays that manifest prior to 3 years of age [2,3]. Teachers and families must therefore consider alternative methods to support the physical and gross motor development of those with ASD. The use of various modalities of physical activity have recently received much attention as a method to improve the quality-of-life in children with ASD [4,5].

1.1. Physical activity

A growing number of children with ASD may not possess the skills needed to be physically active and participate in sport and recreational teams in their local school or community [6]. Physical activity can be an inexpensive and safe option for the promotion of overall health and quality-of-life by providing physical and cognitive benefits. To improve cardiorespiratory fitness, prescribing a proper exercise intensity level is crucial. Several methods, including percentages of age-predicted maximum heart rate and relative energy expenditure, are commonly used to quantify light, moderate and vigorous intensities of exercise [7]. It has been reported that children with ASD do not exercise at a moderate-to-vigorous level as frequently as their typically developing peers [8] and may be at greater risk for developing cardiovascular, pulmonary, or metabolic diseases [9]. Indeed, the prevalence of obesity in children with ASD is 30.4% compared to 23.6% in children without ASD [10]. However, in children ages 9 to 11 years with ASD, body mass index (BMI) is decreased and time spent engaging in moderate-to-vigorous physical activity is increased when compared to children ages 12 to 18 years with ASD [11]. The ability to quantify physiologic responses to exercise in children younger than 9 years of age may be a useful tool for prescribing physical activity throughout childhood and adolescence.

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Additionally, physical activity may decrease the incidence of behavioral outbursts and episodes of aggression in children with ASD [12]. There are a variety of teaching modalities, such as video modeling, that may increase physical activity levels for children with ASD.

1.2. Video modeling

Instruction during physical activity typically relies heavily on verbal communication and social interactions. These 2 behavioral aspects may be difficult to execute for those with ASD. With more effective instructional methods, children may have longer periods of sustained engagement during periods of physical activity. Children with ASD have strengths in processing visual information but may not retain or be able to recall verbal instructions [13]. Video modeling is an evidence-based practice for children with ASD that includes the use of a model (e.g., animated self, peer) consistently demonstrating a skill [14]. This alternative mode of instruction can be displayed on a computer, television monitor, or on various hand-held devices including a tablet or phone. It has been reported that teachers may prefer tablets and video strategies over non-electronic, picture-based systems due to ease of use, less preparation time, and improved communication with their students [15]. Additionally, video modeling has been reported to be more time and cost efficient than practice-style teaching methods [16]. Practice-style is one of the most common teaching strategies used during physical activity. Practice-style instruction begins with a demonstration and description of what is to be achieved. The students then practice the skill, and the teacher observes their performance and offers feedback [17].

The use of video modeling may allow children with ASD to engage in more appropriate behaviors related to a given task and learn more motor skills [18]. While researchers have reported conflicting results [19], Bellini and Akullian concluded that video modeling is an effective strategy because there is a removal of external stimuli [20]. This may allow for enhanced focus and less distractions for children with ASD. Video modeling also allows the learner to view the same model and demonstration repeatedly, helping to improve learning and retention [21]. When compared to tasks using video modeling, tasks using live modeling took 274% longer to complete [17]. In those with ASD, the ability to focus and complete activities in an appropriate time frame utilizing video modeling may elicit a greater total value for energy expenditure and greater heart rate response when compared to live modeling of similar duration. No empirical studies to date have included an examination of this effect.

1.3. ExerciseBuddy application

Available on Apple and Android handheld devices, the *ExerciseBuddy* application (EB app) is based on a visual exercise system for children with ASD. Pioneered by David Geslak, the EB app was developed to provide training techniques for teachers and parents of individuals with ASD. The EB app integrates evidence-based practices such as video modeling supported by The National Professional Development Center on ASD [22,23] and contains over 180 exercise videos of varying duration. Using the EB app, parents and teachers, including those with little to no experience teaching physical activities, may provide physical activity instruction and motor skill practice to their child with ASD.

1.4. Purpose

The purpose of this study was to determine the effectiveness of the EB app in facilitating increased physiologic responses to physical activity via a continuous measurement of energy expenditure and heart rate versus practice-style teaching methods in children with ASD.

2. Methods

2.1. Participants

Purposive sampling was used to recruit 6 children, 5 to 10 years of age, diagnosed with ASD from a university outreach program designed to improve gross motor skills in children with developmental delays. Participants attended the outreach program once per week for 4 consecutive weeks with data collected in 12-minute periods. All procedures were approved by the university's institutional review board. All parents gave written, informed consent and all children gave verbal assent prior to the start of all procedures.

2.2. Entry session

The parents of the participants were asked to complete a medical history questionnaire and an informed consent on behalf of their child for enrollment into the study. Inclusion criteria were chronological age of 5 to 10 years, a diagnosis of ASD, a severity level rating of 1 (i.e., needs support) or 2 (i.e., needs substantial support) [2], and at least a total raw score of '2' on the *Test of Gross Motor Development-2* (*TGMD-2*) [24]. The *TGMD-2* is comprised of 2 subtests: object control skills and locomotor skills. Each subtest contains 6 skills that are designated to help evaluate functional motor skills. Each skill includes 3 to 5 performance criteria. When scoring the *TGMD-2*, a '1' is recorded when the performance criteria are demonstrated and a '0' is recorded when the performance criteria are not demonstrated. Participants needed to score at least a '1' on both the locomotor and object control subtests to be enrolled in the study. The researchers administered the *TGMD-2* to all participants.

At the start of the entry session, verbal assent (i.e., participants provided verbal affirmation of their willingness to participate in the day's activities when asked verbally by the researcher) was obtained. The assent process was recorded by hand by at least two researchers before any procedures were started for the day. During the session, the participants were familiarized with the protocol and the equipment used in the study. The participant's height and weight were measured with weight assessed using a digital scale and height assessed using a stadiometer (Detecto Scale Company, Webb City, MO). Body mass index (BMI) was calculated from these measures. The participants were then shown the Actiheart monitor (CamNTech Inc., Boerne, TX), the device used to measure energy expenditure and heart rate, and the accompanying surface electrodes. During the remainder of the entry session, the monitor and electrodes were worn by all of the participants for at least 12 min. The two electrodes, placed on the chest, served as a connection between the monitor and participant. The Actiheart monitor has been validated to measure light-, moderate- and vigorous-intensity levels of physical activity in children with chronic disease [25,26]. Participants were instructed that 2 stickers (i.e., the electrodes) would be placed on their chest to measure their heartbeat. The monitor was then attached to the participant via connectors on the electrodes. The participants were instructed not to interfere or "touch" the stickers on their chest. Only one participant indicated sensitivity toward electrodes during the entry session. For this participant, the paraprofessional was given electrodes to place on the participant's chest (without the monitor) once per day, for a minimum of 12 min, to be completed on 4 consecutive days prior to the start of the first physical activity session. This was the only adverse response to the placement of the electrodes and monitor throughout the study.

2.3. Physical activity sessions

Prior to the start of each physical activity session, all experimental procedures were reviewed with the participants using age-appropriate verbiage, after which, the participants were re-assented in a similar manner as the entry session. The Actiheart monitor and surface