Weekday Physical Activity and Health-Related Fitness of Youths with Visual Impairments and Those with Autism Spectrum Disorder and Visual Impairments

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Structured abstract: *Introduction:* Youths with visual impairments (that is, those who are blind or have low vision), as well as those who are visually impaired and have autism spectrum disorder (hereafter, autism), tend to be physically inactive and have low health-related fitness. However, little is known about individuals with dual disabilities, such as those with autism and visual impairments. Thus, the aim of this study was to perform an initial exploration of physical activity and health-related fitness for these students in comparison to students with visual impairments alone. *Methods:* Twelve participants (six with visual impairments, six with autism and visual impairments) aged 8–16 years ($M_{age} = 12.4$) who came from a school for students with visual impairments were participants. Participants wore tri-axial accelerometers on their right hips for four consecutive weekdays, during waking hours, to measure weekday physical activity. Following that task, they completed four health-related fitness tests, including a half-mile walk or run to measure aerobic endurance, a push-up test to measure upper-body muscular endurance, a modified curl-up test to measure abdominal muscular endurance, and a sit-and-reach test to determine flexibility. Data were analyzed using descriptive statistics and independent sample *t*-tests to identify differences between groups. *Results:* On average, the participants accrued 650.17 ± 141.44 minutes of sedentary time, 129.80 ± 66.78 minutes of light physical activity, and 19.78 ± 3.35 minutes of moderate-to-vigorous physical activity per weekday. No participants met the 60-minute recommendations of daily moderate-to-vigorous physical activity. Participants with autism and visual impairments were significantly less physically active ($p = .02$) and less likely to pass fitness tests ($p = .01$) than were their peers with visual impairments alone. *Discussion:* This study provides the first empirical exploration of health-related variables for youths with autism and visual impairments. It is clear that developing and implementing interventions to help enhance physical activity and health-related fitness for those youths are needed. *Implications for practitioners:* Additional training and resources to understand the unique needs of these youths

are essential in providing opportunities to participate in physical activities and enhancing health-related physical fitness.

According to the Centers for Disease Control and Prevention (CDC, 2015), developing a physical activity lifestyle at an early age can decrease the chances of developing health-related conditions such as obesity, diabetes, anxiety, and depression throughout the lifespan. Because of the health-related benefits of physical activity, the U.S. Department of Health and Human Services (USDHHS, 2008) recommends that American youths ages 6 to 17 years complete at least 60 minutes of moderate-to-vigorous physical activity each day to gain substantial health-related benefits. Unfortunately, previous research suggests that youths with visual impairments (that is, those who are blind or have low vision) tend to be physically inactive and are less likely to meet physical activity guidelines than are their peers without disabilities (Haegele & Porretta, 2015; Longmuir & Bar-Or, 2000). A number of barriers have been reported that may influence physical activity participation for individuals with visual impairments, including a lack of encouragement from parents, a fear of injury during activities, and a lack of opportunity to participate (Perkins, Columna, Lieberman, & Bailey, 2013; Stuart, Lieberman, & Hand, 2006). Because these individuals tend to be less physically active than their sighted peers, they are at greater risk of developing health-related conditions associated with sedentary lifestyles, such as obesity (Lieberman, Byrne, Mattern, Watt, & Fernandez-Vivo, 2010).

Like those with visual impairments, students with autism spectrum disorder (hereafter, autism) are also more likely to become obese and tend to have low health-related fitness levels (Corvey, Menear, Preskitt, Goldfarb, & Menachemi, 2016; Srinivasan, Pescatello, & Bhat, 2014). Although students with autism who regularly participate in physical activity can decrease the chances of developing obesity (Rimmer, Rowland, & Yamaki, 2007), research indicates that they have low physical activity levels at home and during school-based physical activity times (Pan et al., 2015; Tyler, MacDonald, & Menear, 2014). For these students, low physical activity levels are attributed to a number of different factors such as social-communication barriers and motor skill deficiencies (Srinivasan et al., 2014).

Research demonstrates that individuals who are visually impaired and those who have autism tend to participate in little physical activity and have poor health-related fitness in comparison to their peers without disabilities. However, little is known about individuals with the dual disabilities of visual impairment and autism. The presence of dual disabilities can have a very significant effect on students, and the needs of these students tend to be poorly understood (Bell & Bell, 2010; Gense & Gense, 2005). It is reasonable to suggest that the barriers that may influence the physical activity participation of

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students with visual impairments alone (for instance, lack of encouragement from parents) and autism alone (for example, motor deficiencies) may influence those with autism in addition to visual impairments. Although it is known that individuals with visual impairments and those with autism tend to demonstrate low physical activity participation during and outside of school and have poor health-related fitness levels in comparison to typically developing peers, no research in the existing literature, to the knowledge of the researchers, currently explores these variables with individuals with both autism and visual impairments.

In a recent study, physical education teachers working at schools for students with visual impairments in the United States reported that up to 50% of their students were diagnosed with autism and visual impairments (Haegele & Lieberman, 2016). Furthermore, approximately 25% of these teachers reported that this group were the students that they felt least prepared to teach in physical education (Haegele & Lieberman, 2016). Because so little is known about the physical activity behavior and health-related fitness of these youths, it is challenging to make recommendations for interventions or programs to better educate them in school-based physical education contexts. To best serve these students, we must first have an understanding of their current physical activity participation and health-related fitness, as well as their predictors. Thus, the aim of this study was to perform an initial exploration of physical activity and health-related fitness for students with autism and visual impairments in comparison to students with visual impairments alone.

Methods

Participant recruitment and characteristics

School-aged youths with visual impairments alone and both autism and visual impairments were recruited to participate in this study from a school for students with visual impairments in the Mid-Atlantic region of the United States. Approximately 30 students total who received services at the school because of a visual impairment or an autism and visual impairment diagnosis were invited to participate in this study. A recruitment letter and parental consent form were distributed to parents through the school's physical education teacher. The recruitment letter included critical information about the proposed research study, the time commitment, and its protocols, as well as the primary researcher's contact information. Parents were instructed to e-mail or call the primary researcher with any questions about their child's participation. All participant recruitment and data collection procedures were reviewed and approved by the authors' institutional review board.

Of the 30 targeted students, the parents of 12 students (six with visual impairments, six with autism and visual impairments) returned parental permission forms, and each of these students assented to participant. Thus, 12 participants (including four females) aged 8–16 years (M_{age} = 12.4 years) were enrolled in this study. Eight had B1 vision (complete blindness), three had B2 vision (travel vision), and one had B3 vision

Table 1
Participant characteristics by diagnosis.

Variable	ASD/VI	VI	Total
Gender			
Female	2	2	4
Male	4	4	8
Visual impairment level			
B1	6	2	8
B2	–	3	3
B3	–	1	1
Ethnicity or race			
African American	2	3	5
Asian American	2	–	2
Caucasian	2	3	5
Residential status			
Full-time residential	3	–	3
Part-time residential	–	2	2
Non-residential	3	4	7

Note: B1 = completely blind; B2 = travel vision; B3 = low vision; ASD/VI = individuals diagnosed with autism and visual impairment; VI = individuals diagnosed with visual impairment alone.

(low vision). The B1–B3 classification used in this study is a medically based Paralympic classification system for blind sport designated by the United States Association of Blind Athletes (USABA). Table 1 displays further participant characteristics by diagnoses.

Measures

Physical activity

Weekday physical activity was measured using the ActiGraph GT3x accelerometer (ActiGraph, Pensacola, Florida). The ActiGraph GT3x output represents data separately across three axes (medio-lateral, vertical, and anteroposterior) and provides activity counts as a composite vector magnitude of these three axes. It measures accelerations at a 30-Hz sampling rate. This specific model was selected because it is considered a valid and reliable measure of physical activity for youths (Robusto & Trost, 2012), is commonly utilized in physical activity research focusing on individuals with autism (Ayvazoglu, Kozub, Butera, & Murray, 2015; Tyler et al., 2014), and has capabilities similar to a previously validated accelerometer, the Tritac-RT-3 activity monitor, for individuals with visual impairments (Kozub, Oh, & Rider, 2005). Of additional importance, Rosser and Frey (2005) demonstrated that children with autism can tolerate instruments similar to this because of its small size (4.6 cm × 3.3 cm × 1.5 cm) and light weight (19 g).

Health-related fitness

Procedures for health-related fitness test items were derived from the Brockport Physical Fitness Test (Winnick & Short, 2014) and were guided by procedures used by Lieberman and colleagues (2010) when examining health-related fitness among youths with visual impairments. Procedures were modified, when needed, to fit the needs of youths with visual impairment alone and those with autism and visual impairment, the unique data collection setting, and time constraints.

Aerobic capacity. Aerobic capacity was measured using a half-mile walk or run test conducted on a closed course in the school gymnasium. The closed course was comprised of 19 circulations around the perimeter of the gymnasium, which was measured three times by the research team prior to data collection. All participants were instructed to complete the distance in the shortest time possible. Although some participants ran independently, most ran with a research team member or paraeducator alongside them with a tether (Lieberman et al., 2010). Each participant's time was recorded using a stopwatch, and times were doubled for comparison with health-related fitness zone criteria.

Upper-body muscular endurance. Upper-body muscular endurance was measured using a push-up test. To begin, each participant was instructed to start in a prone position on a mat with hands placed under the shoulders, fingers outstretched, and legs straight and slightly apart. A push-up was considered complete when the participant pushed to an up position in which arms were completely straight and the body was stiff in a plank position. For this test, participants were asked to complete as many push-ups as possible, and a research team member verified each completed push-up with proper form. Push-ups without proper form (for instance, knees touching the floor, arms not in a straight position, or jerky movement) were not recorded. The test was terminated when the participants were no longer able to perform push-ups with proper form. The total number of completed push-ups with proper form was considered the score for this health-related fitness item.

Abdominal muscular endurance. Abdominal muscular endurance was measured using a modified curl-up test (Winnick & Short, 2014). Each participant was instructed to start by lying in a supine position on a mat, with their hands placed on the front of their thighs and their knees flexed. A curl-up was considered complete when the participants' hands slid along their thighs until their fingertips contacted the patellae (approximately four inches). After touching the patellae, participants were instructed to return to the starting supine position. For this test, participants were asked to complete as many modified curl-ups as possible, and a research member verified each completed modified curl-up for proper form. Modified curl-ups without proper form (such as pushing off with elbows or kicking legs) were not recorded. The test was terminated when the participants were no longer able to perform curl-ups with proper form. The total number of completed modified curl-ups was considered the score for this health-related fitness item.

Flexibility. The back-saver sit-and-reach test was used to measure flexibility. Two sit-and-reach boxes (each one-and-a-half-foot metal box was set against the wall with a six-inch extension from the front) were used during data collection. Prior to testing, all participants initially felt the structure of the box and a research team member's hand moving the sit-and-reach bar (Lieberman et al., 2010). Each participant was asked to remove his or her shoes, and to sit down in front of a sit-and-reach box. The participants extended one leg fully with the foot flat against the end of the box under the six-inch extension, with the other knee bent and the sole of the foot flat against the floor (Winnick & Short, 2014). The participants were then instructed to reach their extended arms forward over the sit-and-reach box, with their palms down, and to hold their hands over the measurement apparatus on the box for one second. The point at which the participants' hands were held for one second, with no knee flexion, was considered their score (in inches). Participants were asked to complete the back-saver sit-and-reach test three times per leg, and the best score across three reps per leg was recorded. Passing rates were determined based on both scores for both legs (that is, both legs had to pass standards in order for the participant to have a passing score).

Data collection procedures

Data were collected over a one-week period. After consent forms were returned and assent was obtained, each participant's height and weight were measured during physical education classes using a standard scale and stadiometer. Height and weight were used to initialize accelerometers, as well as to calculate body mass index (BMI) scores. Participants were then asked to wear one physical activity monitor on their right hip using an elastic belt for four consecutive weekdays (Monday through Thursday), during waking hours, for a minimum of eight hours per day. Eight hours was selected because previous research demonstrated that youths with autism would tolerate eight hours of wear time, and parents indicated that this was representative of their highest potential physical activity levels (Pan & Frey, 2006). Participants were not asked to engage in any activities outside of their typical physical activity while wearing the monitors, in order to gain an understanding of their habitual behaviors. At the culmination of the four days, accelerometers were collected. Of the 12 participants, just one (with visual impairments) did not return the accelerometer at the end of the week.

The following day (Friday), participants completed the four health-related fitness test items adopted from the Brockport Physical Fitness Test (Winnick & Short, 2014), in a familiar setting (the gymnasium) and during regularly scheduled physical education classes. Test items included a half-mile walk or run to measure aerobic endurance, a push-up test to measure upper-body muscular endurance, a modified curl-up test to measure abdominal muscular endurance, and a sit-and-reach test to determine flexibility. Each activity was directed by the school's full-time physical education teacher, with support from school staff members (paraeducators) and the research team, when necessary. Because these items were regularly occurring fitness tests, the physical education teacher had set procedures that were familiar to the participants and were adopted for this study. Since class sizes were relatively small (ranging from three to six students), data were collected on entire classes concurrently. For aerobic tests (the half-mile walk or run), all participants engaged in the tests concurrently, and each student was offered a running guide if preferred. For the push-up, curl-up, and sit-and-reach tests, stations were used in which one or two students would engage in each activity at a time and rotate among completion.

Data treatment

After data collection was completed, all demographic and health-related fitness data were entered into an Excel spreadsheet. BMI data were garnered by inputting participants' height and weight into a BMI chart (Winnick & Short, 2014), and healthy fitness zone pass-or-fail rates were determined using participants' BMI, gender, and age according to FitnessGram standards (Cooper Institute, 2013). The authors then compared participants' aerobic capacity, upper-body muscular endurance, abdominal muscular endurance, and flexibility to age- and gender-specific FitnessGram Standards (Cooper Institute, 2013) to identify pass-or-fail rates across

Table 2
Participant weekday physical activity and percent of wear time.

Time	Mean	*SD*	Skewness	Kurtosis	Wear time (%)
Sedentary (min.)	650.17	141.44	.30	.22	74.66 ± 2.72
Light physical activity (min.)	129.80	66.78	.13	.42	21.83 ± 7.93
Moderate-to-vigorous physical activity (min.)	19.78	3.35	.60	1.13	3.51 ± 1.70

all health-related fitness items. Accelerometer data were then downloaded with ActiLife 6 software. Participants were included in the analysis if they met a minimum of three days of monitoring with eight hours of wear time per day. A 15-second epoch was employed, and validated and published cut points for children by Evenson, Catellier, Gill, Ondrak, and McMurray (2008) were used to process the data. Therefore, data were reduced and classified into one of four physical activity categories: sedentary activity (0–100 counts per minute), light physical activity (101–2,295 counts per minute), moderate physical activity (2,296–4,011 counts per minute), and vigorous physical activity (4,012+ counts per minute). Moderate-to-vigorous physical activity was calculated as the mean of the sum of moderate and vigorous physical activity. Percentages of wear time in each physical activity category were calculated by dividing category scores (such as light physical activity) by total wear time scores.

Data analysis

To explore participants' weekday physical activity and health-related fitness performances, the following data analyses were conducted. First, descriptive analyses (mean, standard deviations, univariate kurtosis, and skewness) were performed on participants' weekday sedentary time, light physical activity time, moderate-to-vigorous physical activity time, and health-related fitness performances. Following that, the percentage of participants meeting the age- and gender-specific fitness criteria for each, and for all four health-related fitness tests, were computed. Finally, independent sample *t*-tests were utilized to identify potential differences in weekday moderate-to-vigorous physical activity and the pass rate of the health-related fitness tests between participants with visual impairments only and those with autism and visual impairments.

Results

As shown in Table 2, the participants on average accrued 650.17 ± 141.44 minutes of sedentary time, 129.80 ± 66.78 minutes of light physical activity, and 19.78 ± 3.35 minutes of moderate-to-vigorous physical activity per weekday. Clearly, weekday time was dominated by sedentary behaviors, accounting for about 74.66% of the average wearing time. Light and moderate-to-vigorous physical activity time accounted for just 21.83% and 3.51% of average wear time, respectively. No participants in this study accumulated the USDHHS (2008) recommendation of 60 minutes of moderate-to-vigorous physical activity per day.

The participants' four health-related fitness test scores and passing rates are highlighted in Table 3. As shown there, the majority of the participants' perfor-

Table 3
Performance and percentage of participants meeting health-related fitness criteria.

Variable	$M \pm SD$	Met criteria (%)	Did not meet criteria (%)
Half-mile run (seconds)	674.64 (347.64)	8.30	91.70
Push-up (number)	5.27 (6.51)	25.00	75.00
Sit-up (number)	15.27 (11.87)	33.30	66.70
Sit-and-reach (inches)	7.52 (3.40)	25.00	75.00
Body mass index	19.08 (4.11)	66.70	33.30

The mean and standard deviations for the sit-and-reach are the aggregates of both left and right testing.

mances in these tests did not meet the age- and gender-specific criteria, ranging from 66.70% for the abdominal muscular endurance test to 91.70% for the aerobic capacity test. Only 25% of participants met the fitness test criteria for upper-body muscular endurance and flexibility.

Participants' weekday moderate-to-vigorous physical activity and percentage of meeting health-related fitness criteria are shown in Figure 1, separated between those with visual impairments alone and those with autism and visual impairments. The average weekday moderate-to-vigorous physical activity for participants with visual impairments alone was 27.58 minutes per day, and 13.28 minutes per day for those with autism and visual impairments. The average percentage of meeting fitness criteria for the four tests was 41.67% for those with visual impairments alone, and 4.17% for those with autism and visual impairments. Equality of variances between these two groups was established for both moderate-to-vigorous physical activity (Levene's $F = 1.06$, $p = .33$), and percentage of meeting fitness criteria (Levene's $F = 3.62$, $p = .09$). Independent sample t-tests showed that there were significant differences between participants with visual impairments alone and those with autism and visual impairments in their mean weekday moderate-to-vigorous physical activity ($t = 2.72$, $p = .02$), and in the percentage of meeting fitness tests criteria ($t = 3.31$, $p = .01$). Those with autism and visual impairments had a significantly lower weekday moderate-to-vigorous physical activity and a lower percentage of meeting fitness tests criteria than those with visual impairments alone (see Figure 1).

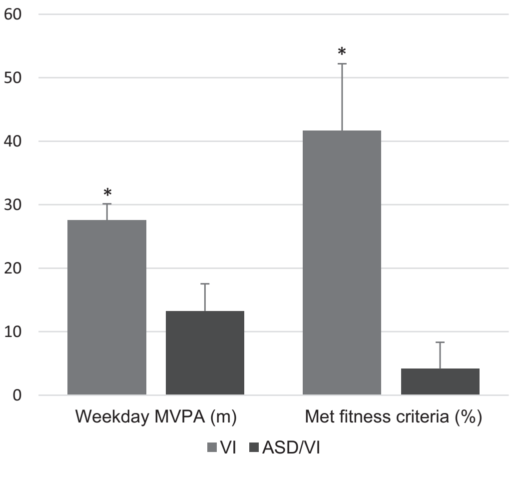

Figure 1. Participant weekday moderate-to-vigorous (MVPA) in minutes and percentage of meeting fitness criteria for those with visual impairments alone (VI) and those with autism and visual impairments (ASD/VI).

Discussion

The aim of this study was to perform an initial exploration of physical activity and health-related fitness for students with autism and visual impairments in comparison to students with visual impairments alone. To the knowledge of the authors, this is the first study to examine these health-related variables among youths with the dual diagnoses of autism and visual impairments. This study's findings affirm our previous understanding of physical activity and health-related fitness among youths with visual impairments, while extending the research base to include youths with autism and visual impairments.

The results of this study regarding youths with visual impairments are consistent with and provide new data affirming previous research. As in previous research (Haegele & Porretta, 2015; Kozub, 2006; Lieberman et al., 2010), youths with visual impairments in this study tended to spend the majority of their time engaged in sedentary activities, did not meet physical activity recommendations, and had low health-related fitness passing rates. Thus, it is reasonable to suggest that commonly reported barriers to physical activity engagement, such as a lack of opportunities to participate and a lack of parental encouragement (Perkins et al., 2013), continue to affect the ability of youths with visual impairments to engage in weekday physical activity. It can be argued that since participants attended a school for students with visual impairments, they would likely be provided with more opportunities for sport and recreation during and after school hours. However, none of the participants with visual impairments in this study were full-time residential students, and thus a lack of opportunities and a lack of parental encouragement may still be important barriers to physical activity engagement in their lives, particularly in the after-school hours.

The main focus of this study was to extend the literature by examining the physical activity behaviors and health-related fitness test passing rates of youths with autism and visual impairments. The results of this study revealed that youths with autism and visual impairments engaged in significantly less weekday physical activity (13.28 minutes per day) than did their peers with visual impairments alone (27.58 minutes per day). In addition to experiencing barriers to physical activity typical of youths with visual impairments, it is likely that those with autism and visual impairments also experience barriers that typify the experiences of youths with autism. For example, research has shown that youths with autism experience social communication and motor skill deficiencies that can negatively affect their ability to successfully engage in physical activities (Srinivasan et al., 2014). Thus, it is reasonable to suggest that these factors, which can be compounded by issues experienced by those with visual impairments, deter those with autism and visual impairments from engaging in regular physical activity. Future research should seek to elucidate what specific factors are prominent in facilitating and impeding physical activity engagement among this population. Because students with autism and visual impairments were less physically active and spent most of their time engaged in sedentary pursuits, it is not surprising to learn that they were also significantly less likely to pass health-related fitness test items than were their peers with visual impairments alone.

The findings of this study point to the importance of developing and implementing interventions to help enhance physical activity and health-related fitness for youths with autism and visual impairments. One option for developing and implementing interventions for this population may be to modify previously designed interventions that target either individuals with visual impairments alone (Cervantes & Porretta, 2013) or autism alone (Bremer, Crozier, & Lloyd, 2016), accounting for the additional needs of those with dual disabilities. For example, aquatics interventions, such as the one developed by Pan (2011) that was designed to enhance fitness for children with autism, could be modified to meet the needs of youths with autism and visual impairments by supplementing visual schedules and work systems with braille displays. Interventionists may also consider targeting parents of children with autism and visual impairments when attempting to promote physical activity and health-related fitness. According to Columna, Rocco-Dillon, Norris, Dolphin, and McCabe (2017), parents of children with disabilities, particularly those with visual impairments, report valuing physical activity and exercise; however, they also expressed concern that they lacked the skills to teach their children how to be physically active. Developing and implementing interventions that provide parents with the skills and knowledge to promote physical activity and exercise can improve opportunities for youths with autism and visual impairments to be active in community or family settings. Last, research suggests that up to 50% of physical educators' workloads at schools for students with visual impairments are composed of teaching students with autism and visual impairments, but many feel unprepared to do so (Haegele & Lieberman, 2016). Thus, it is essential for these instructors to have a sound understanding of how to facilitate physical activity opportunities for this population. Additional training and resources designed to provide an understanding of the unique needs of these youths are essential for such students to participate in physical activities and to enhance health-related physical fitness.

This study boasts several strengths and limitations. First, it focused on a unique population that has yet to be included in adapted physical education or activity research. It provides the first empirical evidence in this area focusing on youths with autism and visual impairments, which we believe provides a foundation for those interested in engaging in intervention research to help enhance physical activity and fitness levels for this population. A second strength is the utilization of accelerometers, objective physical activity monitors, to measure weekday physical activity. Their use allowed the researchers to objectively gauge the duration and intensities (for example, sedentary, light, and moderate-to-vigorous) of activities that may not be otherwise possible with self-reports (Cervantes & Porretta, 2010).

Accelerometer use, however, is not without limitations. They primarily measure lower-body movement, and miss any upper-body physical activity (Lee & Shiroma, 2014). Thus, we are unsure if any of the participants engaged in physical activities that were primarily upper-body movements. The small samples of youths in this study may also be considered a limitation. In many cases, researchers view small samples as having a low value because results cannot be generalized to the population of interest. However, we would argue that the low incidence of the targeted participants in this study (those with autism and visual impairments) partially allayed the low sample size. Third, although the physical educator had previously instructed each of the skills included in the health-related fitness test to the participants, it is unclear whether or not participants (in particular, those with autism and visual impairments) understood complex body movements such as push-ups clearly. Future researchers may consider exploring fitness test items or tests that are fundamentally simpler, ensuring that participants' lack of vision and their communication deficits do not mask their muscular endurance abilities. Fourth, all participants in this study were recruited from a school for students with visual impairments, where they likely have increased opportunities for sport and physical activity that is modified to meet their needs. Therefore, its results may not be generalizable to the greater population of youths with visual impairments alone and those with autism and visual impairments who are educated in integrated public school settings. Last, the severity of students' autism, as well as additional comorbidities, were not recorded by the research team during data collection. Thus, it is unknown whether or not participants experienced additional limitations that also influenced their physical activity engagement or health-related fitness passing rates.

In conclusion, this study provides the first empirical examination of physical activity participation and health-related fitness of youths with autism and visual impairments. Although no participants (those with visual impairments alone or autism and visual impairments) met physical activity recommendations of 60 minutes per day, those with autism and visual impairments were significantly less physically active and were less likely to meet health-related fitness criteria than peers with visual impairments alone. This study identifies a substantial need for health promotion for youths with autism and visual impairments, and findings demonstrate a need for intervention programs to help enhance these health-related variables.

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