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Feasibility And Applicability of Evenson Sedentary Behavior Cut Points Applied to Children with And Without Intellectual and Developmental Disabilities

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Abstract

Aim

Sedentary behavior (SB) is widely studied as it is associated with cardiometabolic health and obesity issues. However, children with Intellectual and Developmental Disabilities (IDD) have been understudied. Accelerometers are commonly used to measure SB in typically developing populations but may be inappropriate for IDD populations due to differences in body movement and physiologic responses to the activity. The use of Evenson sedentary cut-points, created based on typically developing children, has yet to be applied and/or examined in children with IDD.

Purpose

A descriptive cross-sectional study was conducted to (1) Assess the feasibility of applying Evenson sedentary cut-points in children with IDD (2) Describe SB over a two-week period between diagnosis groups.

Methods

The SB of 22 participants (8 children with Down syndrome, 6 children with spina bifida, 8 children with no chronic illness) was assessed on two separate occasions: (1) during a 7-minute sedentary protocol, and (2) over a two-week period.

Results

The study supports the preliminary efficacy of using Evenson cut-points for this population, with 100% of participants being within the Evenson counts per minute (0–100 cpm) during the 7-minute sedentary protocol. The total volume of SB over a two-week period was not significantly different between diagnosis groups (8.8 h, 8.6 h, and 7.1 h of SB for children with Down syndrome, spina bifida, or those with no chronic illness, respectively; $p = 0.36$).

Conclusions

Evenson sedentary cut-points can be used for children with IDD. Preliminary data suggest that children with IDD do not engage in significantly different SB than children without a chronic illness. Further study is warranted.

- Implications for rehabilitation
- Objective measures of physical activity and sedentary behavior for children with Down syndrome or spina bifida are rarely used due to potential differences in body movement (e.g., gait) during ambulation compared to typically developing peers that may influence the accuracy of cut-points.
- This study supports that Evenson sedentary cut-points can be used in children with Down syndrome or spina bifida to assess sedentary activity.
- Preliminary findings from this study demonstrate similarities in patterns of sedentary behaviors exhibited by our sample of children with Down syndrome, spina bifida, or no chronic illness.

Keywords:

Down syndrome, spina bifida, accelerometer, oxygen consumption, special needs

Introduction

Time spent in sedentary behavior, independent from physical activity, has been linked to cardiometabolic health issues and obesity across the lifespan[1–7]. Knowledge of an individual's pattern of and time spent in sedentary behavior provides an opportunity to intervene on prolonged periods thus promoting health[8]. However, one population that has minimal research are children with intellectual and developmental disabilities (IDD),

specifically, Down syndrome and spina bifida. Rates of obesity in children and adolescents with Down syndrome or spina bifida have been reported as high as 37% and 53%, respectively[3,9,10] compared to a prevalence of 31.8% combined overweight and obesity in their typically developing peers[11]. The higher incidence of obesity may contribute to their greater risk for cardiometabolic diseases later on in life[12,13]. While cardiometabolic health problems and overweight/obesity are multi-faceted problems, research supports that engaging in less sedentary behavior can have favorable outcomes in these areas[14]. The ability to examine the volume of and intervene on prolonged periods of sedentary behavior in children with Down syndrome or spina bifida may promote a healthy weight and decrease the risk of cardiometabolic diseases.

Sedentary behavior is commonly defined as activities that expend less than or equal to 2.0 metabolic equivalents (METs) for children and are performed while awake (e.g., sitting or reclining)[15,16]. Research examines sedentary behavior through outcomes, including total volume, sedentary bouts, and patterns of the activity[15,17]. The examination of sedentary behaviors may offer descriptive information on how sedentary behavior is accumulated throughout the day, thus providing a potential target for interventions.

Very few studies have examined sedentary behavior in children with Down syndrome or spina bifida. Soe et al.[18] observed that youth and young adults with spina bifida, 12–31 years, were significantly more likely to self-report engaging in sedentary activities (i.e., watching televisions) compared to typically developing counterparts[18]. Due to only assessing television watching, the study was unable to report a total volume or patterns of sedentary time in this population and used a subjective measure, which is susceptible to the reporter or recall bias. Esposito et al.[19] objectively measured sedentary time with accelerometers and reported that children with Down syndrome spent between 9 and 10.5 h in sedentary activities; however, they had not tested these cut-points in this population prior to applying them[19]. Finally, McGarty et al. developed accelerometer cut-points for children with IDD (8–11years, not specific to Down syndrome or spina bifida) based on direct observation[20]. The McGarty sedentary cut-points (<507 counts per minutecpm), were developed from direct observation of light intensity activities and have not been validated with physiologic data.

In the typically developing population, one of the most commonly used objective measures of physical activity and sedentary behavior are accelerometers. When accelerometers are employed in research involving children, Evenson cut-points, created from children who are typically developing, are commonly used[13]. It is important to examine these cut-points as applied to children with Down syndrome and spina bifida as there are inherent differences as compared to children who are typically developing. In a previous study examining physical activity patterns, differences were evident in the way the individuals with Down syndrome moved when they walked, possibly due to differences in their gait[19]. In children with spina bifida, orthopedic complications (e.g., contractures) or decreased muscle mass of lower extremities may influence the child's gait or walking patterns[21]. These differences in movement and musculature may have subsequent consequences such as variations in intensity and muscle contractions, which may ultimately impact accelerometer data in individuals with Down syndrome and spina bifida[22]. However, sedentary activities involve minimal body movement (e.g., not walking or ambulating) and therefore previously established cut-points for sedentary behavior may be appropriate, but this has yet to be examined.

To the researcher's knowledge, limited research exists, beyond the studies cited above, examining the application of the sedentary cut-points in children with Down syndrome and spina bifida and minimal assessment of their sedentary behaviors. Of the work reported, valid methods to objectively measure sedentary behavior in this population are limited. It is crucial to validate methods to measure the sedentary behavior in children with Down syndrome or spina bifida based on physiologic data. Once validated, measures of sedentary behavior can be examined to evaluate if it is a viable area to create and implement health-oriented interventions. Therefore, the purpose of this study is to examine the feasibility of measuring sedentary activity and describing patterns between children with Down syndrome, spina bifida or with no chronic illness. The first

aim of this paper is to assess the feasibility of applying Evenson sedentary cut-points in children with IDD[23]. The second aim of this paper is to compare the total volume of sedentary behavior and describe sedentary behavior patterns (i.e., frequency of bout durations), over a two-week period, between children with Down syndrome, spina bifida, and children with no chronic illness.

Materials and methods

Participants

This study was part of a larger cross-sectional pilot study that examined energy expenditure in children with IDD. Recruitment for the larger study was primarily from specialty clinics within a children's hospital and diagnosis-specific community organizations. The sample included 36 children, 4–18 years who had Down syndrome, spina bifida (both ambulatory and those who primarily used wheelchairs for mobility) or with no chronic illness[24]. Inclusion and exclusion criteria for the full study have been previously reported[24]. Additional inclusion criteria, specific for this sub-analysis involved the child being between 5 and 15 years who was diagnosed with spina bifida (ambulatory), Down syndrome, or with no chronic illness. Children who primarily used wheelchairs for mobility were excluded due to an inability to process the data in a consistent manner because of differences in ambulation. Additionally, two participants from the larger study were excluded from this sub-analysis because they were over 15 years of age. The hospital's Institutional Review Board provided approval for the study (IRB # 685034-15) and appropriate assent/consenting procedures for children and their parents were performed. The initial sample size for the larger study was based on determining the feasibility of a protocol to observe the relationship between energy expenditure and ambulation status and was estimated to need 36 participants.

Data collection

Participants visited a pediatric clinical and translational research unit of a Midwestern pediatric hospital. During this visit child characteristics (including age, diagnosis, weight and height) were collected; full details have been previously reported[23]. Each participant was then fitted with an ActiGraph GT3X triaxial accelerometer (ActiGraph, Pensacola, FL) and a COSMED portable indirect calorimeter (COSMED, Rome, Italy) in the controlled hospital setting. The accelerometer was placed on the right side of their hip, in line with their right knee. The indirect calorimeter measured oxygen consumption during the task; the mask was secured around their face and the portable unit was secured to the body *via* harness. No familiarization sessions were required or necessary. Participants were then asked to sit quietly for seven minutes to collect accelerometer and metabolic activity data. This provided a reference range for sedentary behavior in each child to both test the Evenson sedentary cut-points and to examine and compare during the following two-week protocol. Additionally, values from the indirect calorimeter could then be used to ensure that the metabolic requirement of the sedentary activity was within the definition of sedentary behavior (i.e., ≤ 2 METs for children).

Prior to leaving, participants were asked to wear an accelerometer on the right side of their hip, for 14 consecutive days. During this two-week free-living monitoring period, participants were encouraged to wear the accelerometer during all waking hours, except during water activities (e.g., bathing or swimming). During this time the sedentary behavior patterns were examined, including total volume, percentage of volume and bout lengths. Participants were asked not to alter their daily routines during this time.

Based on Evenson cut-points, sedentary activity is defined as a minute with an average of <100 cpm[23]. A bout of sedentary behavior was defined as consecutive minutes (≥2 min) of an average of <100 cpm. Sedentary variables of interest included total volume of sedentary time and frequency in set bout durations. Volume of sedentary behavior was calculated as the total amount of sedentary time accumulated in a 24-h period. Percentage of sedentary time represents the volume of sedentary time relative to the total wear time of the accelerometers. Sedentary bouts look at consecutive minutes (≥2 min) that an individual is sedentary. The frequency of

sedentary bouts was also examined; bout lengths examined included: 5–9, 10–19, 20–29, 30–59, 60–89, 90–119, and ≥120 min.

Data and statistical analyses

All accelerometer data were downloaded and analyzed through Actilife software (ActiGraph, Pensacola, FL). During the seven-minute sitting protocol, accelerometers were set to collect data at a sample rate of 1 s epochs. Data was analyzed using 15 s epochs to compare to the Evenson sedentary cut-points. Only the steady-state values were used in the analyses; this helped to account for any adjustment or stress that the child may have experienced when first wearing the mask. COSMED data was collected breath by breath and analyzed in the 60-s averages. Oxygen consumption (mL/kg/min) was then divided by 3.5 to obtain MET values. These MET values were then used to compare to the definition of sedentary behavior in children (i.e., activities ≤2.0 METs)[15]. Accelerometer and oxygen consumption analyses used steady-state values, which included minutes four through six of the sedentary bout, removing the first three minutes and last minute from the analysis.

Over the two-week period, data from the accelerometers were collected at a sample rate of 5 s epochs. Valid wear time analysis was performed for each subject; previous research defined valid wear days[7] and included the participant wearing the accelerometer for at least 10 waking hours in a day, for at least seven days. Participants were instructed to wear the accelerometer during waking hours, therefore, sleep time was excluded from the study. Evenson cut-points were then used to analyze the data using 15 s epochs; these cut-points have been shown to be valid in this study's age group in typically developing youth[11].

Statistical analyses were performed using SPSS Version 25 (IMB Corp, Armonk, New York). Sample characteristics were assessed through means and standard deviations with each respective diagnosis group. To test the first aim, the range of cpm of the sedentary time from the first visit were used to assess if any sedentary session minutes fell outside of the Evenson sedentary cut-point range (0–100 cpm). To be feasible for use, over 85% of the sedentary bouts performed at the hospital had to be within the Evenson cut-point range. A one-way analysis of variance was used to test the second aim to compare the total volume of sedentary behavior. Significance was set at $\alpha \leq 0.05$. Descriptive analyses (means and standard deviations) were used to examine the percentage of sedentary behavior, and frequencies of bout lengths in each diagnosis group. An effect size comparing the difference in total volume of sedentary time between diagnosis groups was calculated and used in a GPower analysis to calculate this study's power.

Results

Twenty-five participants from the larger study met the eligibility criteria for this study. One participant attended the hospital visit but did not complete the two-week follow up of the study. Additionally, two participants chose to not take the accelerometers home, leaving 22 participants included in the study and analyses. Only one participant, a child with Down syndrome, had issues wearing the COSMED mask and accelerometers. These issues occurred after the seven minutes of sedentary activity assessment; thus, they were included in this analysis as their data and valid wear time was not impacted. Sample characteristics, by subgroup, are displayed in Table 1; complete demographics for the larger sample have been previously published24. All participants wore the accelerometer for an average of 11.8 days and 13.85 hours per day.

Table 1. Sample characteristics.

	Down syndrome ***n*** **= 8**	**Spina bifida ambulatory** ***n*** **= 6**	**No chronic illness** ***n*** **= 8**
Age (years)	10.0 (4.2)	9.5 (3.6)	10.8 (3.6)
Sex (Female:Male)	2:6	5:1	4:4
Height (cm)	130.2 (25.9)	137.4 (26.9)	147.8 (22.3)

Weight (kg)	35.9 (16.9)	38.0 (18.8)	41.4 (20.0)
Body Mass Index Percentile (%)	78.5 (15.9)	71.0 (20.3)	56.7 (28.9)

Data are presented as means (standard deviation).

Results from the sedentary bout at the hospital showed that all participants (100%) were within the sedentary cpm values from the Evenson cut-point range (0–100cpm; Table 2). The highest cpm values observed during this time were in the children with no chronic illness, with an observed value of 68 cpm. Oxygen consumption values in all groups were below the sedentary definition of ≤2.0 METs by ∼0.5 METs (Table 2).

Table 2. Sedentary accelerometer and metabolic equivalent data from 7 min protocol.

	Down syndrome *n* = 8	Spina bifida ambulatory *n* = 6	no chronic illness *n* = 8
Average cpm value	0.57	0.20	2.34
Cpm range	0–39	0–13	0–68
Average MET value	1.55	1.56	1.55

Cpm: counts per minute; MET: metabolic equivalent.

Children with Down syndrome, spina bifida and no chronic illness spent 56.2%, 57.0%, and 48.9% of their 24-h day in sedentary activities, respectively. When examining total volume of sedentary behavior (in minutes), no significant differences were observed between groups based on child diagnosis (Down syndrome 527 min, spina bifida 516 min, no chronic illness 428 min; $p = 0.36$; Table 3). The effect size of this differences was $f = 0.337$; this analysis was slightly underpowered at 0.67. Further examination of sedentary patterns through bout lengths, averaged per day based on the two-week wear period, are displayed (Table 3).

Table 3. Average number of bouts per day in each bout length.

Sedentary Pattern	Down syndrome *n* = 8	Spina Bifida ambulatory *n* = 6	No chronic illness *n* = 8	All *n* = 22
Total sedentary volume (minutes)	527.7 (50.2)	516.4 (81.1)	428.8 (33.5)	488.7 (145.9)
5–9 min Bouts (number/day)	14.9 (2.1)	13.2 (1.2)	13.6 (0.7)	14.0 (0.8)
10–19 min Bouts (number/day)	10.7 (1.4)	9.6 (0.9)	10.3 (1.2)	10.3 (0.7)
20–29 min Bouts (number/day)	3.8 (0.6)	3.1 (0.2)	3.3 (0.6)	3.4 (0.3)
30–59 min Bouts (number/day)	2.9 (0.5)	2.9 (0.5)	1.8 (0.4)	2.5 (0.3)
60–89 min Bouts (number/day)	1.0 (0.3)	0.6 (0.2)	0.4 (0.7)	0.6 (0.1)
90–119 min Bouts (number/day)	0.3 (0.1)	0.4 (0.2)	0.3 (0.1)	0.3 (0.1)
≥120 min Bouts (number/day)	0.2 (0.1)	1.3 (0.3)	0.3 (0.1)	0.4 (0.1)

Data are presented as means (standard deviation).

Discussion

The current study objectively assessed sedentary behavior *via* accelerometers in children with Down syndrome, spina bifida, or typically developing and compared sedentary behavior patterns among diagnosis groups. There is a paucity in the literature examining the sedentary behavior of children with Down syndrome or spina bifida. To the author's knowledge, this is the first study that has tested the feasibility and validity of applying the Evenson cut-points for sedentary behavior to children with Down syndrome or spina bifida.

Results from our study demonstrated that Evenson cut-points, developed from and used for typically developing populations, are feasible cut-points to assess sedentary behavior in children with Down syndrome and spina bifida. Preliminary testing of measurement methods in specific populations are important for ensuring that methods are feasible and can be validated within a population. Within the present study, the oxygen consumption was <2.0 METs and thus matched the physiologic definition of sedentary behavior in children. Additionally, these cut-points are consistent among all participant diagnoses with no participant exceeding the Evenson cut-point of 100 cpm. Therefore, the Evenson sedentary cut-points appear to be appropriate and operational for these populations, reducing concern that intensity or muscle contractions have a significant impact on the accelerometer data.

There is a significant difference in sedentary cut-points between Evenson (<100cpm) and McGarty (<507cpm)[20,23]. This variation may be due to the difference in cut-point development; Evenson used physiologic data of sedentary and physical activities and McGarty directly observed physical activities, but no sedentary activities. The physiologic data from all diagnosis groups within the present study are well within the sedentary MET values for children (1.5 vs 2.0 METs) and suggests that the Evenson cut-points may be an effective and more conservative cut-point for sedentary data.

Assessing the use and validity of accelerometer cut-points is especially important in populations of Down syndrome or spina bifida because these populations may have different walking/gait patterns or muscle contractions compared to the typically developing population, which could impact the intensity level of an activity and misclassify accelerometer results[25]. While these differences that could impact physical activity are not fully understood, it appears that any differences that exist during physical activities are minimized during sedentary activities. In addition, no variation was observed in MET values (i.e. intensity) between diagnosis groups during the sedentary activity. This supports that sedentary activities are not of a higher intensity in children with Down syndrome and spina bifida as compared to their typically developing peers.

Regarding the second aim of comparing and describing sedentary behavior between the diagnosis groups, children with Down syndrome, spina bifida, and those with no chronic illness had average daily sedentary time of: 8.8 h, 8.6 h and 7.1 h, respectively. While there were no statistically significant differences between the groups, the children with IDD did engage in approximately an hour more of sedentary time each day. Cumulatively, this additional hour of sedentary activities in children with Down syndrome or spina bifida may contribute to a higher incidence of obesity and associated health risks over time. Previous research supports a relationship between participants who are more sedentary also having higher BMI percentiles, and this may be a reciprocal relationship (e.g., those with higher BMIs may also engage in more sedentary time)[26]. While this was considered, it does not explain the difference in our sample as most participants were classified within the normal weight category based on BMI percentiles. A potential consideration would be that accessibility or opportunities for physical activity may be more limited for individuals with IDD as compared to typically developing peers which have been noted in the literature[27]. The amount of sedentary time from participants in this study are lower than previous research which observed that children, 8–16 years, diagnosed with Down syndrome had an average of 9–10.5 h of sedentary time[28]. In contrast, the group averages for the total volume of sedentary time from the present study are higher than previously published research that examined sedentary behaviors in typically developing children from Canada[28]. Saunders et al.[28] examined associations between sedentary activity in children and their cardiometabolic health. Results from the study recorded about six hours of sedentary activity per day in Canadian children. In contrast to our findings, Soe et al[18] found that individuals with spina bifida, 12–31 years, were significantly more likely to engage in long bouts of sedentary behavior (i.e., television watching) as compared to typically developing children[18]. These results are comparable to the present study as the individuals with spina bifida and Down syndrome engaged in an additional hour of sedentary behaviors compared to the typically developing peers. While our study results did not have a

statistically significant difference in total sedentary time, the results should be taken with caution as this is only a subset analysis with small sample size and we were not able to test for differences based on demographics. In addition, the sample for our study was younger than the population assessed by Soe et al and did not include adults. Adults have more autonomy in choosing their activities and may therefore self-select more sedentary behaviors (e.g., choosing to watch more television). In comparison, the children and adolescents in our study may have less autonomy and rely on daily structure, created by parents and schools, therefore potentially reducing the amount of chosen sedentary activities. When considering sedentary behavior bout patterns, Saunders et al.[28] reported a similar frequency pattern within each grouping of bout duration to the current study, with short bouts (5–9 min) having more occurrence during the day than longer bouts (>30 min). While the present study had a greater number of bouts in the 5–9-min range, the most time was spent in bouts lasting 10–19 min. For all groups in this study, the cumulative time in sedentary bouts lasting 10–19 min was over two hours. Unfortunately, the context of sedentary behaviors was not examined, therefore the reasons behind the frequent interruptions in sedentary time cannot be determined.

Children with spina bifida had more bouts in the > 120 min duration, averaging at least one of these bouts each day of the week, compared to children with Down syndrome or those who are typically developing only engaged in bouts of this length every few days. This is important to note because previous research has shown that longer bout durations are more strongly correlated with higher cardiometabolic health risk[28]. Thus, interventions on patterns of sedentary behavior are warranted, specifically on longer sedentary bout durations, and may be more impactful in children with spina bifida due to the regular occurrence of these bout lengths, therefore increasing the opportunities to intervene. The longer bouts in the group of children with spina bifida may be due to the child's participation in a bowel program, because constipation is commonly associated with spina bifida[29,30]. However, Soe[18] demonstrated that higher amounts of sedentary time in individuals with spina bifida were, in their study, due to higher amounts of television time. Further research should examine the context of these longer bouts in children with spina bifida to better assess if intervening at this time is an option.

This study includes both limitations and strengths that should be considered when examining results. A limitation of this study is the small sample size which may have impacted significantly the study results and limited our ability to assess demographic differences that may impact sedentary behaviors or wear time recorded by the accelerometer. However, the similar frequencies of bout lengths and total volume averages and standard deviations are similar between groups, so there is a possibility that a larger sample size would only reinforce the current results. Additionally, we did not validate these sedentary behavior cut-points in a variety of sedentary activities, only one seated period. We measured oxygen consumption during the hospital visit and observed that METs fell within the sedentary behavior definition for children; this supports that the cut-points physiologically match the definition of sedentary behavior.

Strengths of this study include the use of an objective monitor to assess sedentary behavior and testing the cut-points used before and during the two-week free-living assessment period. The use of accelerometers eliminates any potential reporting bias and provides the ability to analyze bouts of sedentary activities that last for only a few minutes. Additionally, testing the application and feasibility of the Evenson cut-points for sedentary behavior demonstrated that these cut-points can be applied to the specific population examined, children with Down syndrome or spina bifida. Further, this study was able to consider sedentary behavior throughout the entire day rather than solely considering screen time, a common surrogate value for sedentary time, which may only contribute to a small amount of the total waking hours in a day. Finally, the high rate of participation among all groups in this study was a strength; this demonstrates that accelerometer use is feasible with the populations considered in this study.

Future research should work to replicate results from the present study in larger samples and examine the context and environment in which sedentary behavior and patterns of that behavior occur in children with

Down syndrome or spina bifida, compared to those with no chronic illness. Further, research should also assess the impact of demographics (e.g., sex, increasing age, etc) on accelerometer data between the diagnoses. Additionally, examining the extra hour of sedentary time in children with Down syndrome and spina bifida, compared to the children with no chronic illness, may be an area of consideration for future interventional work for interrupting sedentary behavior. Research in this area will provide more information to create best practices for interventions focused on disrupting sedentary time. Future research should consider assessing if methods for intervening on sedentary time in children with no chronic illness are also effective in children with spina bifida and Down syndrome, or if there are additional considerations for these populations. Finally, future studies should examine if associations between bout duration and cardiovascular health risk are similar between populations with and without IDD.

Conclusion

Children with Down syndrome or spina bifida do not engage in significantly different total time in sedentary behaviors than children without a chronic illness. Additionally, most patterns of accumulation of sedentary time were similar except for children with spina bifida who engaged in more daily bouts lasting >120 min compared to children with Down syndrome or no chronic illness. If future research continues to support that sedentary volumes and patterns are similar between these groups, but that there are significant differences in cardiometabolic health issues (including obesity) among these populations, then it would suggest that the sedentary behavior may not be as impactful on these differences. Rather, other health behaviors and/or genetic factors may account for more of these variations. Future research is needed: (1) in a larger sample to see if these findings hold, (2) to examine the context of time spent in sedentary activities by children with IDD, and (3) examine metabolic health outcomes in relation to sedentary behaviors in these populations. This will provide insight for interventions that aim to reduce obesity and improve health in this opportune population.

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No potential conflict of interest was reported by the author(s).

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