

Physical activity levels of children and adolescents with moderate to severe intellectual disability

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ABSTRACT

Background: Regular participation of children and adolescents with intellectual disabilities in physical activity is important to maintain good health and to acquire motor skills. The aim of this study was to investigate the habitual physical activity in these children.

Methods: Sixty-eight children and adolescents (2–18 years) with a moderate-to-severe intellectual disability were included in the analyses. They wore an accelerometer on eight consecutive days. Data was analyzed by use of descriptive statistics and multiple linear regression analyses.

Results: The participants took on average $6,677 \pm 2,600$ steps per day, with intensity of $1,040 \pm 431$ counts per minute. In total, 47% of the participants were meeting physical activity recommendations. Low motor development was associated with low physical activity.

Conclusions: As more than half of the participants were not meeting the recommendations, family and caregivers of these children should focus on supporting and motivating them to explore and expand their physical activities.

INTRODUCTION

Physical and mental health benefits of physical activity in childhood and adolescence are well known [1-6]. Physical activity is also critical to acquire motor skills [3] such as running and jumping, that are important to remain physically active and fit over time [3, 7]. The World Health Organization (WHO) recommendation for healthy physical activity behavior for children and adolescents is at least 60 min of moderate-to-vigorous physical activity (MVPA) every day [8], which is comparable to approximately 12,000 steps per day [9]. The positive effects of physical activity are even more important for children and adolescents with intellectual disabilities, as they have more health and motor problems [10], less physical fitness [11-13] and less developed motor skills than typically developing (TD) peers [4, 14-16].

Previous research on the physical activity behavior of individuals with intellectual disability, measured with accelerometers, showed that children and adolescents with intellectual disability were less active than TD children and adolescents [17-21]. Published percentages of children and adolescents with intellectual disability complying with the physical activity recommendations vary considerably from 0 to 42% [19, 20, 22-24].

Within previous research, physical activity levels differed among subgroups. Several studies, both in TD children and in children with intellectual disability, found a negative association between age and volume and/or intensity of physical activity [25-28]. Other studies did not find any age effect [18, 23, 29, 30].

As in TD children and adolescents, sex is an important covariate for the volume of physical activity. Boys with intellectual disability were more active than girls [18, 27, 29, 31]. Furthermore, children and adolescents with Down syndrome (DS) were less active than their peers with other causes of intellectual disability [31], which makes DS an important covariate too. The difference between boys and girls, and children and adolescents with and without DS, might be due to the difference in motor development. Girls with intellectual disability have less developed motor skills than boys with intellectual disability [16, 32, 33], and children and adolescents with DS have a greater delay in motor development than their peers with other causes of intellectual disability [34, 35]. As far as the present authors know, the association between motor development and the volume of physical activity has never been studied in children and adolescents with intellectual disability, while this would give potential directions for interventions to improve the physical activity in this specific population. Studies in adults and older people show that physical activity levels decrease with increasing severity of intellectual disability [31, 36], but no information is available on this association in children and adolescents with intellectual disability. Furthermore, little is known on the habitual physical activity levels of children and adolescents with more severe levels of intellectual disability, as the majority of previous studies were conducted in children and adolescents with mild-to-moderate intellectual disability [22]. Only few studies included children or adolescents with severe intellectual disability. One study focused only on physical activity during physical

education and recess [37]. In this study, adolescents with intellectual disability spent less time in MVPA during recess than their TD peers. In a more recent study [23], 24% of participants (5–15 years) from special education schools with moderate-to-severe learning disabilities were reaching the physical activity recommendation and their mean habitual MVPA was 49 min per day. Another study showed even lower rates of daily MVPA: only 5% of Icelandic children and adolescents with mild-to-severe intellectual disability (6–16 years) were achieving the recommendations of 60-min MVPA every day [19].

Even though these studies give us an idea of the volume of habitual physical activity of children and adolescents with more severe intellectual disability, important information is missing. No sub analyses were performed on the level of intellectual disability, and motor development was not assessed. Moreover, in these previous studies, cut-points based on energy expenditure data of TD children and adolescents were used to classify MVPA. However, it is likely that the energy expenditure of individuals with intellectual disability is higher than that of the general population during tasks like walking [38, 39], possibly caused by autonomic dysfunction [40] and different gait patterns [41]. Therefore, cut-points based on the general population might not be representative for individuals with intellectual disability. This has been confirmed by McGarty, Penpraze [42], who developed and validated specific cut-points for children and adolescents with intellectual disability (8–11 years) against direct observation. McGarty's cut-points differ fairly from the cut-points for TD children like those from Evenson, Catellier [43] as can be seen in Table 1. It is therefore likely that use of cut-points for TD children will lead to underestimation of MVPA in children and adolescents with intellectual disability.

Based on the above, the present authors conclude that information is needed on habitual physical activity of children and adolescents with more severe intellectual disability. The lack of this knowledge is the more problematic as these individuals are likely to be at a higher risk of chronic health conditions than their peers with less severe intellectual disability [44, 45]. More information on the volume and intensity of physical activity and child characteristics associated with low physical activity will help professionals and researchers developing and targeting interventions to increase the physical activity of children and adolescents with moderate-to-severe intellectual disability.

Therefore, the following questions were to be answered in the current study: (a) What is the volume and intensity of PA of children and adolescents with moderate-to-severe intellectual disability?; (b) How many participants are active enough to reach the physical activity recommendations of 60-min MVPA per day?; and (c) Which child characteristics (age, sex, level of intellectual disability, DS, motor development) are associated with physical activity outcomes?

Table 1. Cut-points to classify the intensity of physical activity based on counts per minute (cpm).

	Evenson et al., 2008		McGarty et al. 2016	
	Vertical axis	Vertical axis	Vertical axis	Vector magnitude
Sedentary	≤100	≤507	≤507	≤1,863
Light intensity	100 - 2,295	508 - 1,007	508 - 1,007	1,864 - 2,609
Moderate intensity	2,296 - 4,011	1,008 - 2,300	1,008 - 2,300	2,610 - 4,214
Vigorous intensity	≥4,012	≥2,301	≥2,301	≥4,215

METHODS

Participants

Children aged 2–18 years with a moderate-to-severe intellectual disability who were able to walk independently were invited to participate in this cross-sectional study, which was part of a larger study focusing on physical fitness. All potential participants received care or support in one of seven specialized day program facilities of a service provider for people with disabilities in the Netherlands. These day program facilities are specialized to support children and adolescents with intellectual disability that are unable to go to a mainstream or special school, due to their severe developmental delay or additional medical or behavioral comorbidity.

Suitability to participate in the study with regard to the level of intellectual disability was performed by the behavioral therapist or psychologist of the child, based on available psychological test results (moderate intellectual disability: IQ 40–55; severe intellectual disability: IQ 20–40). Parents or legal representatives of the children and adolescents who met the inclusion criteria received an invitation letter. Children were included in the study after their parents or legal representatives had signed the informed consent form.

Ethical approval was obtained (MEC-2013-491) from the Ethics Committee of the Erasmus Medical Center. The study adheres to the Declaration of Helsinki for research involving human subjects [46].

Physical activity assessment

Physical activity was measured with triaxial accelerometers, Actigraph GT3x+ (Manufacturing Technologies Inc.). These devices translate movement in the direction of three internal axes into counts. Actigraphs have been validated in TD children and adolescents [47, 48], children and adolescents with physical disabilities [49] and with intellectual disability [42]. Participants were asked to wear the accelerometer on the right hip, by use of an elastic belt. Their parents or caregivers were instructed to let the child wear it continuously on eight consecutive days during waking hours, except during water-based activities like showering and swimming. Parents or caregivers were asked to record special events like sickness on a standardized sheet. On this sheet, activities such as swimming and cycling could also be recorded. The

present authors did not include these outcomes in the analysis, because of a large number of missing values.

Data processing

Data were sampled with a frequency of 30 Hz. Raw data were acquired in 15-s time sampling intervals (epochs). A 15-s epoch was selected, because of the fragmentary nature of children's physical activity [50, 51].

Non-wear time was defined as ≥ 20 min of consecutive zeros, with no allowance of epochs with counts above zero [52]. In studies with TD children, 10- and 20-min strings of zeros are the most common [51-54]. In previous studies with children and adolescents with intellectual disability, strings of consecutive zeros of 10 min [31], 30 min [19] and 60 min [27] were used.

Non-wear time was excluded from analysis. Data with at least 4 days of recording, with a minimum of 480 registered minutes (8 hr) per day were included in the analysis, as this is said to have a reliability of 91%–92% [55]. No distinction was made between week or weekend days, as no significant differences were found between the physical activity on week or weekend days (data not shown).

Total volume of daily PA was expressed as steps per day. The overall activity level was calculated by summation of counts and expressed as counts per minute (cpm). Higher cpm means greater activity intensity. The intensity of physical activity was categorized as sedentary behavior, light, moderate and vigorous activity based on specific vector magnitude (VM) cut-points established in children with intellectual disability [42] (Table 1). To compare the outcomes with previous and future studies, cpm based on the vertical axis, and intensity derived with Evenson's cut-points [43] were also presented in Table 3.

Total time spent in the different categories of intensity was expressed in minutes and as a percentage of total daily wear time. Total time spent in moderate-to-vigorous physical activity (MVPA) was calculated by summing the time spent in moderate and vigorous intensity.

Motor development

The gross motor scale of the Bayley Scale of Infant and Toddler Development, third edition (BSID-III) [56] was completed by physical therapists and was used to give insight into the gross motor development. The BSID-III is designed to measure the developmental status of young children and adolescents up to 42 months, but it can also be used to assess the development of individuals with severe delays, such as children and adolescents with intellectual disability [57]. A score of 42-43 corresponds to the development of a TD child aged 12 months, a score of 57 to 24 months, 64 points to a 36 months, and the maximum score (67-72 points) to 42 months [56].

Other measurements

Height was measured with a portable stadiometer (Seca 213, Hamburg, Germany), accurate at 0.1 cm level. Body weight was measured using an electronic calibrated scale (Tanita TBF-300A, Illinois, USA), accurate at 0.1 kg level. The participants were on bare feet and wore light clothes. BMI was calculated as body weight in kg divided by height in meters squared. BMI-for-age-Z scores (zBMI) were calculated according to the WHO Growth references [58, 59]. Participants were classified as underweight when zBMI was <2 SD. Participants at age 0-5 years with BMI >2 SD were classified as overweight, >3 SD as obese. For older children and adolescents (6-18 years), >1 SD was classified as overweight, and >2 SD as obese [60].

Information on autism spectrum disorder (ASD) was provided by the behavioral therapist or psychologist of the participants. Information on chronological age, DS and physical disabilities was extracted from the records of the care provider.

Adaptive behavior was used as an indicator of the level of intellectual disability, as intellectual disability is characterized by significant limitations both in intellectual functioning and in adaptive behavior [61]. Adaptive behavior was assessed by the Dutch version of the Vineland Adaptive Behavioral Scale [62, 63]. In this scale, three types of skills are covered: conceptual, social and practical skills. The scale was filled in by the caregiver of the child, and scored and converted to relative age score by the own behavioral therapist or physiologist.

Data analysis

Normality of all variables was checked by using Kolmogorov-Smirnov test, and skewness and kurtosis values.

Children with at least 4 days of eight hour data were selected for data analysis. The characteristics of the participants were compared to the non-participants (with not enough valid data) to investigate selective drop-out. For this comparison, χ^2 statistics and independent *t*-tests were used, and Mann-Whitney *U* test as non-parametric alternative.

Descriptive statistics were used to study the wear time and physical activity parameters (steps per day, cpm, minutes MVPA, distribution of physical activity intensities, and the percentage participants reaching physical activity recommendations of daily ≥ 60 min MVPA). These physical activity parameters were presented for the total sample in Table 3. In the appendix, in Table A1, the results were sorted by, respectively, boys and girls, and children and adolescents with DS and with other causes of intellectual disability.

To find associations of the child characteristics and the physical activity outcomes, linear regression analyses were performed with steps per day, cpm, and minutes MVPA, determined by McGarty's cut-points as dependent variables. The independent variables were entered in two blocks into the regression analysis (block 1: sex, age, adaptive behavior, DS; block 2: motor development). For this analysis, the present authors checked the assumptions of multicollinearity with the variance inflation factor (VIF), which needed to be below 10, and with the correlations between the independent variables, which should not contain correlations

above 0.8. Homoscedasticity was checked with a plot of regression standardized residual (*ZRESID) against regression standardized predicted value (*ZPRED) [64].

Data were processed and analyzed using Actilife 6, Excel (Microsoft 2016) and IBM SPSS Statistics 21. Alpha was set at 5%.

RESULTS

Participants

Of 130 children and adolescents that were included in the study, 68 participants had enough valid accelerometer data to be included in the analysis (Figure 1). The sample consisted of 43 boys and 25 girls, their age ranged between 2 and 18 years. Characteristics of the participants with physical activity data were not significantly different from those of the non-participants (Table 2). According to the records of the children, two participants had motor disabilities (one cerebral palsy, one scoliosis).

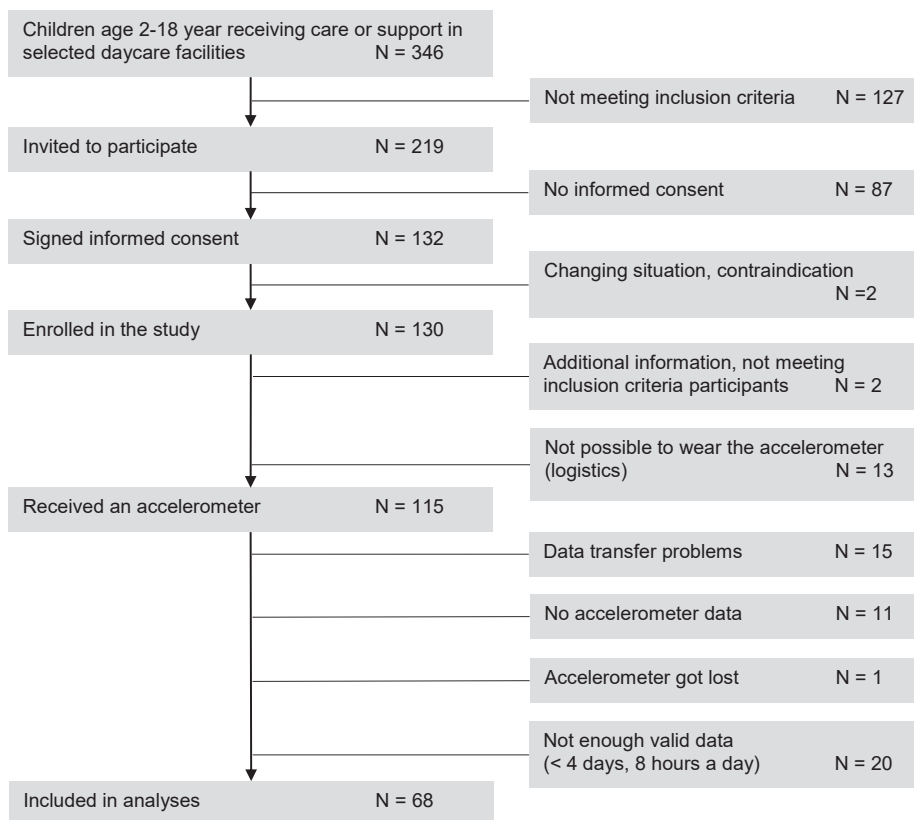


Figure 1. Flow diagram of inclusion process

Table 2. Characteristics of participants included in the study, and the participants excluded from the study.

	Included participants			Excluded participants		
	<i>n</i>	%	<i>M</i> ± <i>SD</i>	<i>n</i>	%	<i>M</i> ± <i>SD</i>
Total	68	100		60	100	
Sex						
Boys	43	63		40	67	
Girls	25	37		20	33	
Age (year)	68		9.4 ± 4.3	60		9.8 ± 3.8
2-7	28	41		16	27	
8-12	20	29		24	40	
13-18	20	29		20	33	
Level of intellectual disability						
Moderate	30	44		24	40	
Severe	38	57		35	58	
Adaptive behavior (year) ^a	60		1.9 ± 1.6	51		1.9 ± 0.9
Motor development (score BSID-III)	68		61 ± 7	50		58 ± 8
Down syndrome						
With	16	24		14	23	
Without	52	76		46	77	
ASD						
With	20	29		24	40	
Without	45	66		35	58	
BMI (kg/m ²)	62		19.0 ± 4.2	56		19.7 ± 4.6
zBMI	62		0.8 ± 1.3	56		0.9 ± 1.1
Overweight	22	32		25	42	

Notes. No significant difference between participants with and without PA-data.

M= mean; *SD*= standard deviation; PA= physical activity; ASD= autism spectrum disorder; BMI= body mass index; ^a As continuous indicator of level of intellectual disability.

Physical activity

The participants wore the accelerometer on 4 to 8 days (mean 6.5 ± 1.3 days, 95% Confidence Interval (CI) = 6.1–6.8). For 58 of the 68 children, at least one weekend day was included. Average wearing time per day was 675 ± 76 min (95%CI = 656–693). For the total group, the volume of physical activity was on average $6,677 \pm 2,600$ steps per day (95%CI = 6,048–7,306), with an activity level of $1,040 \pm 431$ VM-cpm (95%CI = 936–1,144) and 92 ± 46 min of MVPA per day (95%CI = 81–103) using the McGarty's cut-points (Table 3).

More than three quarters of the day (78%, 530 ± 91 min) were spent sedentary, when using McGarty's cut-points. The remaining time was spent with light intensity (8%, 53 ± 17 min), moderate intensity (9%, 59 ± 26 min) and vigorous intensity (5%, 33 ± 25 min).

Forty-seven per cent of the participants were active enough to meet the recommendations of at least 60 min of MVPA every day, according to McGarty's cut-points (Table 3).

The results of the linear regression analysis (Table 4) indicated that the number of steps per day was associated with boys ($\beta = -0.33$; $p = 0.01$) and having DS ($\beta = -0.25$; $p < 0.05$) in the first model. However, in model 2 when motor development was added, sex and DS were no longer significant predictors, but motor development was, for all three physical activity parameters ($\beta = 0.49$ – 0.52 ; $p < 0.01$). For cpm, adaptive behavior became also a significant predictor in the second model ($\beta = -0.34$, $p = 0.04$).

Table 3. Descriptive statistics of physical activity parameters ($M \pm SD$, 95% CI), analyzed with VM-cut-points of McGarty et al. and vertical axis-cut-points of Evenson et al.

	McGarty et al. 2016		Evenson et al. 2008	
	$M \pm SD$	95% CI	$M \pm SD$	95% CI
Steps per day	6677 ± 2600	6048-7306		
Counts per minute	1040 ± 431	936-1144	447 ± 244	388-506
MVPA (min)	92 ± 46	81-103	28 ± 20	24-33
Daily ≥60 min MVPA (n (%))	32 (47)	35-59	3 (4)	0-9
Distribution of daily physical activity levels (%)				
Sedentary	78 ± 9	76-80	59 ± 11	56-61
Light PA	8 ± 3	7-8	37 ± 9	35-39
Moderate PA	9 ± 4	8-10	3 ± 2	2-3
Vigorous PA	5 ± 4	4-6	1 ± 1	1-2

Note. MVPA= moderate-to-vigorous physical activity.

DISCUSSION

This study into the physical activity of 68 children and adolescents with moderate-to-severe intellectual disability shows that only 47% is meeting the WHO-recommendations of at least 60 min of daily moderate-to-vigorous physical activity (MVPA) according to intellectual disability-specific intensity cut-points. The participants take on average $6,677 \pm 2,600$ steps per day. The average intensity is $1,040 \pm 431$ counts per minute (cpm), and the children and adolescents spent 92 ± 46 min per day at moderate-to-vigorous intensity. Motor development and adaptive behavior (as indicator of level of intellectual disability) are the only child characteristic associated with the volume and/or intensity of the physical activity.

The percentage of participants complying with the recommendations of MVPA in the current study (47%) is higher than seen in previous studies in children and adolescents with intellectual disability (0%–42%) [19, 22, 23]. This difference may be explained by the different cut-points used. The present authors were the first to use intellectual disability-specific cut-points that differ from cut-points based on data from typically developing (TD) children

Table 4. Linear regression analysis ($n = 60$) on physical activity outcomes analyzed with use of McGarty's cut-points

	Steps per day				Counts per minute				Minutes MVPA						
	B	SEB	β	p	Adj R ²	B	SEB	β	p	Adj R ²	B	SEB	β	p	Adj R ²
Model 1	13%				0%				4%						
Intercept	9,633	1,168			1,304	212					134.4	21.5			
Sex (0 = boy; 1 = girl)	-1,770	682	-0.33	0.01	61	124	-0.07	0.62			-20.2	12.5	-0.21	0.11	
Age (year)	-95	80	-0.15	0.24	-15	15	-0.14	0.32			-2.3	1.5	-0.21	0.13	
Adaptive behavior (year) ¹	359	213	0.22	0.10	-15	39	-0.06	0.69			3.4	3.9	0.12	0.38	
DS (0 = no DS; 1 = DS)	-1,567	779	-0.25	0.049	-12	141	-0.01	0.93			4.6	14.3	0.04	0.75	
Model 2	26%				12%				15%						
Intercept	-1,111	3,414			-588	623					-34.4	64.4			
Sex (0 = boy; 1 = girl)	-715	703	-0.13	0.31	125	128	0.14	0.33			-3.7	13.3	-0.04	0.78	
Age (year)	-54	75	-0.09	0.48	-7	14	-0.07	0.59			-1.6	1.4	-0.15	0.25	
Adaptive behavior (year) ^a	-77	236	-0.05	0.74	-92	43	-0.34	0.04			-3.4	4.5	-0.12	0.44	
DS (0 = no DS; 1 = DS)	-1,098	730	-0.18	0.14	70	133	0.07	0.60			12.0	13.8	0.11	0.39	
Motor development (score)	167	50	0.49	<0.01	29	9	0.52	<0.01			2.7	0.9	0.44	<0.01	

Notes. DS= down syndrome; The bold values represent the significant values in the regression models.

^aAs continuous indicator of level of intellectual disability.

and adolescents (Table 1). The present authors did analyze our data with the cut-points for TD children and adolescents, and then, only 4% of the participants was reaching the recommended 60 min of MVPA every day. This illustrates the huge effect cut-points have on the outcome, and thereby the conclusions drawn.

Even though only one study has been conducted on the intellectual disability-specific cut-points [42], it is plausible that individuals with intellectual disability need specific cut-points, as their energy expenditure during activities like walking is higher [38, 39]. Further research is definitely needed to cross-validate these cut-points, and study children and adolescents in other age groups (<8 years and >11 years) and individuals with specific syndromes like Down syndrome. Furthermore, an intellectual disability-specific recommendation for steps per day is needed, as the current recommendation is based on the energy expenditure of TD children and adolescents [9]. This intellectual disability-specific recommendation will be accessible and relevant for clinical practice, as steps per day captures the imagination of children, parents and care givers, and activity tracking applications on smart phones and smart watches display their outcomes in steps per day.

Comparison of results of different studies is difficult when different measurement methods are being used: type of accelerometers (Actigraph, RT3 and Actical), wear location (waist and lower back) and data processing (epoch, classification of valid data and non-wear time) differed in previous research. Due to new insights like new types of accelerometers and intellectual disability-specific cut-points [42], such differences will continue to exist. Therefore, accurate description of the methods, and presentation of raw data are important to interpret results and make comparison more feasible to clarify differences.

From previous research in children and adolescents with intellectual disability, raw data have hardly been reported. Only Phillips and Holland [31] reported steps per day: in their small pediatric subgroup (12–15 years; $n = 7$), boys took $7,181 \pm 179$ steps per day, and girls $6,918 \pm 749$, which is comparable to the current results ($6,677 \pm 2,600$, Table 3). Counts per minute were more often reported: many studies in youth with intellectual disability showed average cpm between 300 and 450 cpm [19, 20, 27, 29, 65–67]. Phillips and Holland [31] found higher cpm (680–836 cpm). These cpm were based on vertical activity counts and are not comparable to the cpm-values based on VM. Therefore, in the current study, the present authors also report the cpm based on vertical activity (447 ± 244 cpm), to be comparable to the outcomes of previous research.

Recent reviews on physical activity interventions performed in children and adolescents with intellectual disability showed that an increase in physical activity is difficult [68, 69]. In the review by Frey, Temple [68], nine of eleven studies reported a direct positive effect of the intervention on physical activity, and also long-term positive effects were found in three studies. However, the review also illustrated that there is a lack of studies with good quality focusing on physical activity interventions for youth with intellectual disability. The authors of the review conclude that effective intervention components cannot be concluded from

the outcomes. McGarty, Downs [69] concluded in their review of five studies and meta-analysis of two studies that current interventions are ineffective in increasing physical activity levels. Therefore, research on effective intervention components for this specific population is needed.

One of these components might be motor skills. The current study indicated that participants with low motor development were less physically active than the participants with more developed motor skills. Unfortunately, little is known on the effectiveness of interventions increasing motor skills in children and adolescents with ID. Based on previous studies, Lucas, Elliott [70] and Hocking, McNeil [71] suggested in their reviews that task-specific training may be useful, but that the overall quality of evidence is low. More research is needed to study if and how motor development can be increased in children and adolescents with intellectual disability and whether increased motor development positively influences the volume of physical activity directly (in childhood or adolescence) and in the future (in adulthood), as is seen in TD children and adolescents [3, 7].

In the current study, some differences between boys and girls, and children and adolescents with DS and with other causes of intellectual disability were found, but when adding motor development to the regression model, the sex and DS difference were no longer significant (Table 4). This suggests that motor development is at least partly explaining the effect of sex and DS, which is in accordance with previous research that found less motor skills in girls with intellectual disability compared to boys with intellectual disability [16, 32, 33], and in children and adolescents with DS compared to children and adolescents with other causes of intellectual disability [34, 35].

The level of intellectual disability was another potential factor influencing the volume of physical activity, but until now, it was mainly studied in adults and elderly [31, 36]. In the current study, adaptive behavior, as an indicator for level of intellectual disability, explained a part of the cpm-variance in the second model of the regression analysis: higher adaptive behavior was associated with lower intensity. This is in contradiction to previous research, which showed that physical activity levels seem to decrease with increasing severity of intellectual disability in adults and elderly [31, 36]. The difference could be explained by the difference between youth and adults. Children and adolescents with intellectual disability are dependent on their parents or caregivers, while in the adult population, individuals with less severe levels of intellectual disability are more independent and thereby more physically active to perform the activities of daily living. Another potential explanation of the unexpected finding is that our sample consisted of children and adolescents with moderate-to-severe intellectual disability attending specialized day program centers. The day activity programs are likely different from those for children and adolescents attending a regular of special education school. Further research focusing on the relation between physical activity and level of intellectual disability in children and adolescents with intellectual disability is clearly needed, to effectively target interventions.

The fact that adaptive behavior became a significant predictor in the second model could be caused by the overlap in explained variance between adaptive behavior and motor development. Both motor development and adaptive behavior are complicated constructs that are linked to specific brain structures and are interrelated [72]. Therefore, more research is required to study the relationship between adaptive behavior, motor development and physical activity in children and adolescents with intellectual disability.

Strengths and limitations

The present authors studied physical activity levels by use of accelerometry in a specific group of children and adolescents that has hardly been studied. As far as the present authors know, this is the first study that used intellectual disability-specific cut-points to classify intensity of physical activity, and the first that assessed the relation between motor development and physical activity in children and adolescents with intellectual disability.

Some limitations do apply to this study. First, limitations are inherently associated with using accelerometers to study physical activity. Accelerometers are the preferred option to objectively study physical activity in children and adolescents with and without intellectual disability [21, 50, 73]. However, activities like swimming are not registered by accelerometers. Parents could note these events on standardized sheets, but these were rarely completed. Therefore, an underestimation of the volume of physical activity could have occurred.

Furthermore, the intellectual disability-specific cut-points used in the current study [42] were developed in children aged 8 to 11 years. These cut-points were not studied in children with other ages; therefore, the present authors cannot be sure under- or overestimation has occurred in our participants with other ages. However, based on the study of Trost, Loprinzi [74] which indicated that Evensons' cut-points (developed for TD children age 5–8 years) were suitable for older TD children and adolescents (5–15 years) as well, the present authors think this effect is likely to be small.

In the current study, only 59% (68/115) participants receiving an accelerometer had enough data to be included in the analyses. Eleven participants did not wear the accelerometer at all. In previous research in children and adolescents with intellectual disability, compliance rates of 50%–100% were seen [22]. The present authors asked the parents or caregivers to complete a sheet in case of special events, and more effort was potentially needed to increase compliance. The dropout, however, did not seem to be selective, so it did not influence the generalizability of our results to children and adolescents with moderate-to-severe intellectual disability, attending specialized day program centers. However, generalizability to other groups of children and adolescents is not appropriate.

With regard to the statistics, the present authors used relatively many predictors in the regression models. The risk of putting too many predictors in the model is that small effects are difficult to detect. Furthermore, the present authors found small explained variance in the

models. Therefore, a large portion of the variance in physical activity outcomes is caused by other variables. Further research is necessary to study the nature of these variables.

Lastly, the current study had a cross-sectional design. It gives insight into possible associations between physical activity behavior and child characteristics, but not into causality of motor development for physical activity. Longitudinal studies are required to study this relationship over time.

Implications for research and practice

Future research should focus on the effectiveness of interventions to promote physical activity and motor development in children and adolescents with moderate-to-severe intellectual disability, and the transfer of physical activity and its benefits over time in this population. Furthermore, raw data of accelerometers should be included in the manuscripts.

Policy makers, therapists, parents and caregivers should pay more attention to improve the physical activity behavior in children and adolescents with moderate-to-severe intellectual disability attending specialized day program centers. Attention is needed for the volume of habitual physical activity, but also on the quality of physical activity. It seems important to stimulate the development of motor skills, in order to increase the volume of physical activity now and in the future. In this field, professionals in the field of adapted physical activity and education can play exquisite pivotal role.

Conclusion

More than half of the participants were not meeting the physical activity recommendation of minimal 60-min MVPA per day. Family and caregivers of these children should focus on supporting and motivating them to explore and expand their physical activities.

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APPENDIX

Table A. Descriptive statistics of physical activity parameters sorted by boys vs. girls, and diagnosed with Down syndrome or not ($M \pm SD$, 95% CI).

	Boys			Girls		
	$M \pm SD$	SD	95% CI	$M \pm SD$	SD	95% CI
<i>N</i>	43			25		
Valid days (<i>n</i>)	6.6 ± 1.3		6.2 - 7.0	6.2 ± 1.3		5.7 - 6.7
Wear time (min)	683 ± 80		658 - 707	661 ± 67		633 - 689
Steps per day	7,257 ± 2,554		6,471 - 8,043	5,680 ± 2,412		4,685 - 6,676
Counts per minute	1,070 ± 364		958 - 1,182	988 ± 531		769 - 1,207
Minutes MVPA ^a	101 ± 44		87 - 114	77 ± 46		58 - 97
Daily ≥60min MVPA ^a (<i>n</i> ; %)	26 60%		45 - 76	6 24%		6 - 42 *
Distribution throughout the day (%) ^a						
Sedentary	77 ± 9		74 - 80	81 ± 9		77 - 84
Light PA	8 ± 3		7 - 9	7 ± 2		7 - 8
Moderate PA	10 ± 4		8 - 11	7 ± 3		6 - 9
Vigorous PA	5 ± 3		4 - 6	4 ± 5		2 - 6

	No DS			DS		
	$M \pm SD$	SD	95% CI	$M \pm SD$	SD	95% CI
<i>N</i>	52			16		
Valid days (<i>n</i>)	6.3 ± 1.3		6.0 - 6.7	6.9 ± 1.4		6.2 - 7.6
Wear time (min)	671 ± 64		653 - 689	687 ± 109		629 - 745
Steps per day	6,865 ± 2,758		6,097 - 7,633	6,067 ± 1,951		5,028 - 7,107
Counts per minute	1,030 ± 464		900 - 1,159	1,074 ± 310		908 - 1,239
Minutes MVPA ^a	88 ± 47		75 - 102	104 ± 39		83 - 124
Daily ≥60min MVPA ^a (<i>n</i> ; %)	24 46%		32 - 60	8 50%		22 - 78
Distribution throughout the day (%) ^a						
Sedentary	79 ± 9		76 - 81	77 ± 7		73 - 81
Light PA	8 ± 3		7 - 9	8 ± 2		7 - 9
Moderate PA	9 ± 4		7 - 10	10 ± 4		8 - 11
Vigorous PA	5 ± 4		4 - 6	6 ± 3		4 - 7

Notes. DS, down syndrome; PA, physical activity; MVPA, moderate to vigorous physical activity; * Group difference ($\chi^2(1) = 8,438$; $p=0.004$); ^a Intensity based on McGarty's VM cut-points.