Ambulatory Physical Activity Performance in Youth With Cerebral Palsy and Youth Who Are Developing Typically

Kristie F Bjornson, Basia Belza, Deborah Kartin, Rebecca Logsdon, John F McLaughlin

Background and Purpose

Assessment of walking activity in youth with cerebral palsy (CP) has traditionally been "capacity-based." The purpose of this study was to describe the day-to-day ambulatory activity "performance" of youth with CP compared with youth who were developing typically.

Subjects

Eighty-one youth with CP, aged 10 to 13 years, who were categorized as being in Gross Motor Function Classification System (GMFCS) levels I to III and 30 age-matched youth who were developing typically were recruited.

Methods

Using a cross-sectional design, participants wore the StepWatch monitor for 7 days while documenting average daily total step counts, percentage of time they were active, ratio of medium to low activity levels, and percentage of time at high activity levels.

Results

The youth with CP demonstrated significantly lower levels of all outcomes than the comparison group.

Discussion and Conclusion

Daily walking activity and variability decreased as functional walking level (GMFCS level) decreased. Ambulatory activity performance within the context of the daily life for youth with CP appears valid and feasible as an outcome for mobility interventions in CP.

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The ambulatory types of cerebral palsy (CP), hemiplegia and diplegia, comprise 48% to 79% of all cases.[1] Most people with CP who are ambulatory experience limitations in their walking skills and physical activity. One of the components of the *International Classification of Functioning, Disability and Health*[2] (ICF) is "activities and participation." In this context, *activity* is defined as the execution of a task or action by an individual, and *participation* is defined as involvement in a life situation. The activity component can be measured through the constructs of capacity and performance. *Capacity* is the execution of a task in a controlled environment such as performance of tasks in the standardized gross motor function tests that are administered by clinicians and therapists. These measures tell us what a child is "capable" of doing when asked to perform in a structured clinical situation. *Performance* is the execution of a task in the natural environment. This would be what the child "really does" when out on the playground at school, at home, or in their community.

Thus, youth with CP who are ambulatory demonstrate limitations in activity capacity and performance, with potential implications for participation in life as well. Van den Berg-Emons et al[3] reported that school children with spastic diplegia CP were less physically active than a control group of healthy individuals. Using the School Function Assessment (SFA), Schenker et al[4] demonstrated similar findings with regard to activity performance and participation in a school setting for youth in Gross Motor Function Classification System (GMFCS) levels II to IV.[5] In a study of school-based activity performance and participation in Israel,[6] youth with CP had significantly lower physical activity performance as measured by the SFA. The youth with CP also participated in daily school activities (ie, playground games and moving to other areas of the school) significantly less often than their peers who were typically developing.[6] Motor function also has been shown to be predictive of restrictive participation in mobility, education, and social relations for children with CP.[7] Physical activity limitations in people with CP appear to be related to the ability to participate in day-to-day activities.

Clinicians have observed a general decrease in physical activity as well as walking skills as children with CP grow. Bar-Or[8] documented decreased work capacity from adolescence to young adulthood for people with CP related to an increase in adipose tissue and body weight without a matching increase in muscle strength (force-generating capacity). The increasing energy cost for walking as individuals with CP age has been confirmed using energy consumption studies.[9,10] Johnson et al[11] also documented a decrease in independent walking overtime between ages 4 and 14 years in children with spastic CP.

Levels of activity between the ages of 9 and 18 years can significantly predict adult physical activity.[12] Youth who are inactive are at risk for becoming inactive and overweight adults, with resultant risk for numerous health problems. Physical activity levels based on pedometer data have been established for optimal body mass index (BMI) in youth who are developing typically. Tudor-Locke and colleagues[13] reported the cutoff points for optimal BMI for youth aged 6 to 12 years in an international sample of 1,954 children. The optimal cutoff points for girls were determined to be 12,000 steps per day, while the optimal cutoff points for boys were higher at 15,000 steps per day. These cutoff points for optimal weight are higher than the adult step goal per day of 10,000.[14] People with disabilities are at risk for the same health problems as people in the general population. Due to their disabilities, they also are at risk for developing secondary conditions that may further affect their health and quality of life.[15] In 2004, the Centers for Disease Control and Prevention (CDC) reported that a significantly lower percentage of people with a disability (28.4%) self-reported their health to be "excellent" compared with people without disabilities (84%).[15]

Clinical and research-based measurements of walking activity in people with CP have focused primarily on measures of capacity such as computerized 3-dimensional gait analysis, gross motor function tests, energy cost, time vertical, and clinical gait analysis. None of these measures report walking step activity within the context of the daily lives of children with CP. In order to quantify activity performance (ICF framework) in youth with CP, measures need to reflect their day-to-day life experiences within the environment in which they live.

Few true validated measures of activity performance in youth with physical limitations exist to date. Tieman et al[16] reported evidence for significant differences between capacity and performance of children with CP, as well as performance across settings. For example, of the children who were capable of walking with support, 56% did not walk with support at home, 32% did not walk at school, and 59% did not walk outdoors or in the community. A parent-completed questionnaire was used to measure "what a child does" or the construct of performance in that study. These differences in measured capacity versus performance of gross motor skills have implications for treatment decision making. Young and colleagues[17] documented that capacity exceeded performance, as measured by the Activity Scale for Kids (ASK), by 18% in 28 children with a variety of developmental disabilities. The ASK is a self-report measure of childhood physical performance and capacity for youth aged 5 to 15 years.[18,19] The performance scale of this measure was developed to query what a youth "usually does," taking into account the environment in which the child functions. Reliability is excellent (intraclass correlation coefficient=.97), and the ASK has been validated against the parent-report–based Child Health Questionnaire, clinician global ratings of change, and observations, with significant Spearman rank correlations ranging from .81 to .92, in children with mobility limitations.

In the past decade, small accelerometers have been developed that have improved quantification of walking physical activity capacity as well as performance with in the context of day-to-day life.[20] One such device is the StepWatch monitor.* This device has been used to measure daily activity in youth who are developing typically and to document decreased ambulatory activity levels for children with obesity and muscular dystrophy.[21–24] Reliability of step measurements compared with observer-counted steps in walking has been documented at .91 to .99 (Pearson *r*).[21,23]

Using a 2-week sampling period, McDonald et al[21] documented 3-day ambulatory activity in 97 youth who were developing typically, aged 6 to 20 years, with the StepWatch monitor. Boys and girls in the 6- to 10-year-old age range were the most active on a daily basis, and boys in all age groups had higher stepping rates (greater than 42 steps per minute) than girls. Although a 3-day monitoring time frame was attempted, the authors reported that only 87% of the participants had completed only one consecutive 24-hour wearing period. This finding suggests that the reported results were based on varying durations of monitor wearing across participants, which may not be an adequate sample of activity. The authors classified "low" walking activity as fewer than 15 steps per minute, "medium" walking activity as ranging from 15 to 42 steps per minute, and "high" levels as more than 42 steps per minute based on the adult StepWatch data of Coleman and colleagues.[25]

Subsequently, Song et al[23] collected a total of 6 weeks of daily StepWatch monitor data on 20 children who were typically developing in the age groups of 5 to 7 years and 9 to 11 years, equally distributed by sex. StepWatch monitor accuracy was documented for walking and running, with Pearson correlations of .97 and .96, respectively, when correlated to manual counts of steps taken. Total steps per day ranged from 4,864 to 14,591, suggesting that the longer monitoring time sample (14 days versus 4 days in the study by McDonald et al[21]) may be indicated to capture the variability of daily step activity. Average percentages of time spent in low, medium, and high activity levels were 67.7%, 21.7%, and 23.7%, respectively.

The discriminative validity of data obtained with the StepWatch monitor for assessing pediatric obesity was documented by McDonald and colleagues[24] for 20 children who

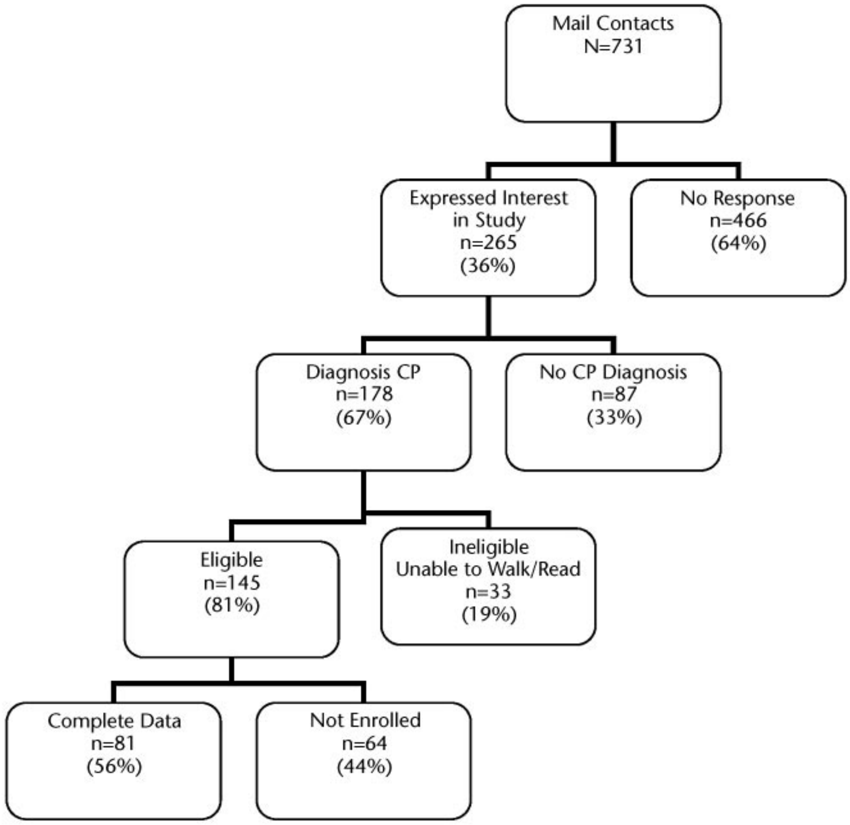

Figure 1.
Results of recruitment of participants with cerebral palsy (CP) showing numbers and reasons for exclusions.

* Cyma Corp, 6405 218th St SW, Suite 100, Mountlake Terrace, WA 98043-2180.

were obese, aged 8 to 10 years, as compared with 27 age-matched children who were not obese. Strong concurrent validity (r = .99) of data obtained with the StepWatch monitor as compared with manual counts of steps taken by direct observation was documented for 42 youth who were developing typically, aged 7 to 21 years, over a 4-day time period. Youth with Duchenne muscular dystrophy[22] also were found with the StepWatch monitor to have significantly more inactive minutes, to take fewer total steps, and to spend less time in moderate or high activity levels compared with youth who were developing typically.

A better understanding of the day-to-day walking activity (capacity and performance) of youth with CP who are ambulatory is warranted to enhance the understanding of interventions aimed at mobility limitations. The purpose of this study was to describe ambulatory activity performance, as measured by the StepWatch monitor, of youth with CP compared with children who are developing typically. We predicted that activity performance would be ordered by functional walking activity level as measured by the GMFCS such that children who were developing typically would be more active than children with CP in GMFCS level I. Children with CP in GMFCS level I are more active than those in level II, and children in level II are more active than those in level III.[26]

Table 1.
Characteristics of the Sample

Characteristic	Youth With Cerebral Palsy (n=81)	Youth Who Were Developing Typically (n=30)	P^a
Age (y), $\overline{X}$ (SD)	11.8 (1.3)	11.9 (1.2)	.98
Sex, n (%)			.86
Male	42 (52)	15 (50)	
Female	39 (48)	15 (50)	
Gross Motor Function Classification System (GMFCS)			
Level I	31		
Level II	30		
Level III	20		
Race (%)			
Caucasian	63 (77.8)	25 (83.4)	.78
Hispanic	8 (9.9)	1 (3.3)	
Asian	5 (6.2)	3 (10)	
Black	3 (3.7)	1 (3.3)	
Other	2 (2.5)	0	
Parental characteristics			
Vocational school or college, n (%)	32 (39.5)	8 (26.7)	.18

[a] Level of significance was determined by a one-way analysis of variance for continuous variables and chi-square tests for categorical variables.

Method

Participants

Inclusion criteria for the youth with CP were: GMFCS levels I to III and ages 10 to 13 years. The comparison group of children who were developing typically were in the same age range and were matched by sex with the children with CP. All participants lived within 800 km (500 miles) of Seattle, Wash. Exclusion criteria for all participants were parental report of a fracture, sprain, or strain injury of the lower extremities in the past 6 months, neurological or orthopedic surgery in the last 12 months, exercise-induced asthma, a congenital heart defect with cardiac compromise, or an uncontrolled seizure disorder.

For a prospective cross-sectional design, the study sample was recruited using a focused direct mailing to the guardians of children with CP who were ambulatory and who had been seen at 1 of 3 children's hospitals or 1 regional military hospital in the Pacific Northwest, to school-based nurses, and physical therapists and occupational therapists in the state of Washington. Youth who were developing typically were recruited through the participants with CP and a pediatric therapist mailing in the same region. A total of 111 youth were enrolled in the study. Eighty-one of the participants had CP, and 30 participants were developing typically. Figure 1 reflects the recruitment results for the youth with CP.

Demographic characteristics of the participants are presented in Table 1. The group of children who were developing typically included 15 siblings of the participants with CP. Of the remaining children in the comparison group, 5 were friends of participants and 10 were recruited through the therapist mailing. For the youth with CP, recruitment progressed within each GMFCS level until the goal sample size of 30 participants in each level was reached. Full proposed enrollment in level III was

Table 2.
Mean (Confidence Interval) for Step Activity Variables for Youth With Cerebral Palsy and Youth Who Were Developing Typically[a]

Variable	Youth With Cerebral Palsy (n=81)	Youth Who Were Developing Typically (n=30)	*P*
Average daily total steps	4,222 (3,739–4,749)	6,739 (6,123–7,355)	.000
Percentage of time participants were active	40.2 (37–43)	49.6 (46–52)	.000
Ratio of medium to low activity levels	0.33 (0.29–0.36)	0.47 (0.43–0.51)	.000
Percentage of time at high activity levels	5.6 (4.7–6.5)	9.7 (8.3–11.1)	.000

[a] Results remained the same for analysis with only siblings or nonsiblings as the comparison group of youth who were developing typically ($P<.01$). Low activity=<15 steps per minute, medium activity=15–42 steps per minute, and high activity=>42 steps per minute.

not reached (n=20). The sample size of 30 participants per group was chosen to approximate a normal distribution with the smallest sample size.

Procedure

All participants gave written informed assent and their parent or legal guardian provided written informed consent after initial contact by telephone or mail. Data collection took place within the protocol of a study of self-reported health status and quality of life in youth with CP.[27]

Measures

Functional level. Participants with CP were categorized by GMFCS levels I to III as a definition of functional walking activity level.[26] The GMFCS classifies the motor involvement of children with CP on the basis of their functional sitting and walking abilities and their need for assistive technology and wheeled mobility. Youth in level I are able to climb stairs without upper-extremity assistance, those in level II require upper-extremity assistance to climb stairs, and those in level III are unable to climb stairs and walk only with an assistive device. The GMFCS classification was initially based on parental report during the screening telephone interview. Parental report of GMFCS level has been shown to be a reliable measure of motor severity.[28] The GMFCS levels were subsequently confirmed by direct observation of walking function by the principal investigator (KFB) at the data collection visit. Palisano and colleagues[26] have suggested that therapists who are familiar with the GMFCS level definitions can reliably classify motor function based on familiarity with the definitions of the levels.

Activity performance. The StepWatch monitor was used to measure the variety of step activity (gait) frequency and patterns within the context of daily life.[29] *Activity level* was defined as: (1) the average daily total step counts, (2) percentage of time participants were active, (3) ratio of medium to low activity, and (4) percentage of time at high activity levels collected over 5 days from a 7-day sample by the StepWatch monitor. The 5 days were made up of 4 school days and 1 weekend day. The StepWatch monitor utilizes a specialized 2-plane accelerometer designed to be sensitive to a variety of walking patterns, thus measuring specifically "steps" per period of time.[25] For this analysis, "low" walking activity was defined as fewer than 15 steps per minute, "medium" walking activity was defined as 15 to 42 steps per minute, and "high" walking activity was defined as more than 42 steps per minute. These definitions are based on StepWatch monitor data for adults who maintained daily diaries.[25] A child at the high level would be running, whereas a child the low level would be walking slowly.[25]

The StepWatch activity monitor was calibrated to each participant's walking pattern and checked for accuracy against a trial walking sample at the first of 2 home-based study visits. Monitor calibration accuracy to a manual count of the walking sample averaged 99.7% (SD=2.9%) for the study sample. Each participant was given written, demonstrated, and verbal instructions by the investigators on how to attach the StepWatch monitor to the lateral aspect of the ankle using a knitted cuff. Participants wore the monitor all of their waking hours for 7 consecutive days, except when bathing or swimming.

The StepWatch monitor averages the number of steps taken for each 1-minute epoch of the period that the monitor is turned on. Data from the monitors were downloaded after retrieval during a second visit or when returned to the principal investigator by mail. In order to sample school-aged youth during their typical daily life experience, data collection occurred only during months when school was in session. The principal investigator and a trained research assistant provided monitor calibration and downloading of monitor data on all participants. The principal investigator had 4 years of clinical experience with the monitor. Procedural reliability for study visits averaged 99%, with rechecks throughout the project (every 4 months).

Data collection occurred between September 2004 and June 2005 and between September and November 2005. No monitor malfunctions were noted. One monitor was lost.

Data Analysis

Seven consecutive days of StepWatch monitor data were collected, with five 24-hour days analyzed for the full study sample. The analysis time frame consisted of 4 school days and 1 weekend day. A 7-day sampling epoch was chosen based on the variability of data collected with children who are developing typically.[21,23] The days on which the monitor was applied and taken off were not analyzed due to incomplete monitoring data. Incomplete data were defined as data obtained on days with greater than 3 hours of inadequate monitoring during daytime hours (6:00 AM–10:00 PM). Inadequate monitoring was defined as wearing the monitor upside down, not wearing the monitor, or wearing the monitor incorrectly on the ankle (not in the correct plane).

Comparability of the children with CP and the comparison group was analyzed using an independent *t* test for age or chi-square tests for sex, race, and socioeconomic status (SES). The consenting parent's educational level served as a proxy measure of SES. A factorial analysis of variance (ANOVA), controlling for the covariates of age, sex, and SES, tested for mean differences in average daily steps, percentage of time participants were active, ratio of medium to low activity levels, and percentage of time at high activity levels across all functional levels. A *post hoc* univariate ANOVA with Tukey correction for multiple analyses was used to test activity performance level differences within the functional levels. Because this project is the first reporting of ambulatory activity in youth with CP, outliers (>3 SD) were included in the analysis to provide descriptive depth. Statistical significance was set at the $P<.05$ level, with all analysis completed with SPSS, version 13.0.† All outliers were included in the analysis.

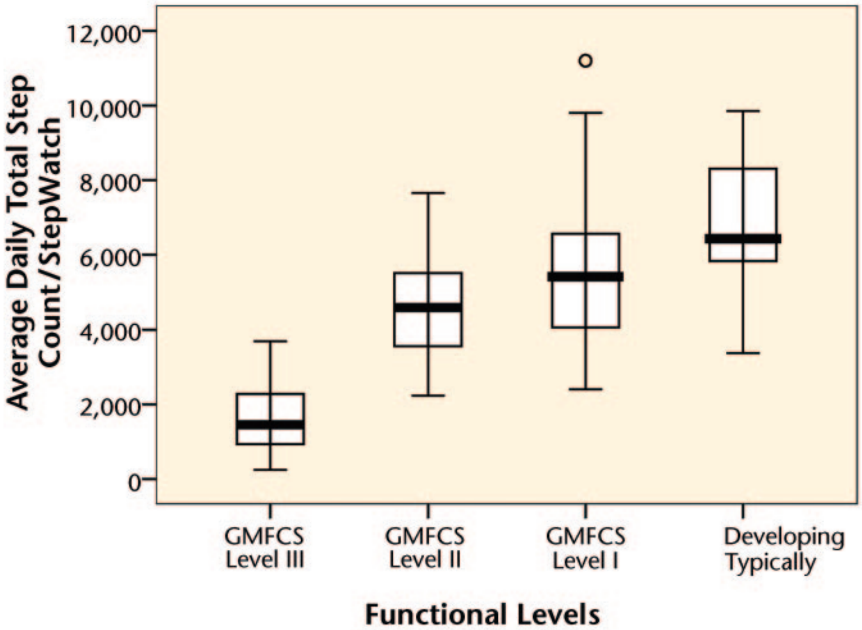

Figure 2.
Median and interquartile range for average daily step counts as measured by the StepWatch monitor by functional levels (Gross Motor Function Classification System [GMFCS] levels). Comparison between children who were developing typically and children with cerebral palsy (CP) in GMFCS levels I, II, and III ($P<.001$); comparison between children who were developing typically and children with CP in GMFCS level I ($P=.04$); comparison between children with CP in GMFCS levels I and II ($P=.09$); comparison between children with CP in GMFCS levels I and III ($P<.001$); comparison between children with CP in GMFCS levels II and III ($P<.001$).

Results

Educational level of the parents or legal guardians was slightly greater for the group of children with CP than for the comparison group (39.5% versus 26.7%), with sample characteristics summarized in Table 1. No significant differences between the children with CP and the comparison group were found for any of the variables (Tab. 1).

The activity performance variables of average daily total steps, percentage of time participants were active, ratio of medium to low activity levels, and percentage of time at high activity levels were significantly different between the children with CP and the comparison group (Tab. 2). None of the covariates (sex, age, and SES) were found to contribute significantly to the variance. The children with CP demonstrated lower daily walking activity than did the comparison group. In *post hoc* analysis of average daily total steps, all within-group differences were significant except between GMFCS levels I and II ($P=.09$, Fig. 2). One outlier in the level I group averaged 11,119 steps per day compared with a level mean of 5,603 steps per day.

The children with CP were significantly less active than the children in the comparison group (percentage of time participants were active=

† SPSS Inc, 233 S Wacker Dr, Chicago, IL 60606.

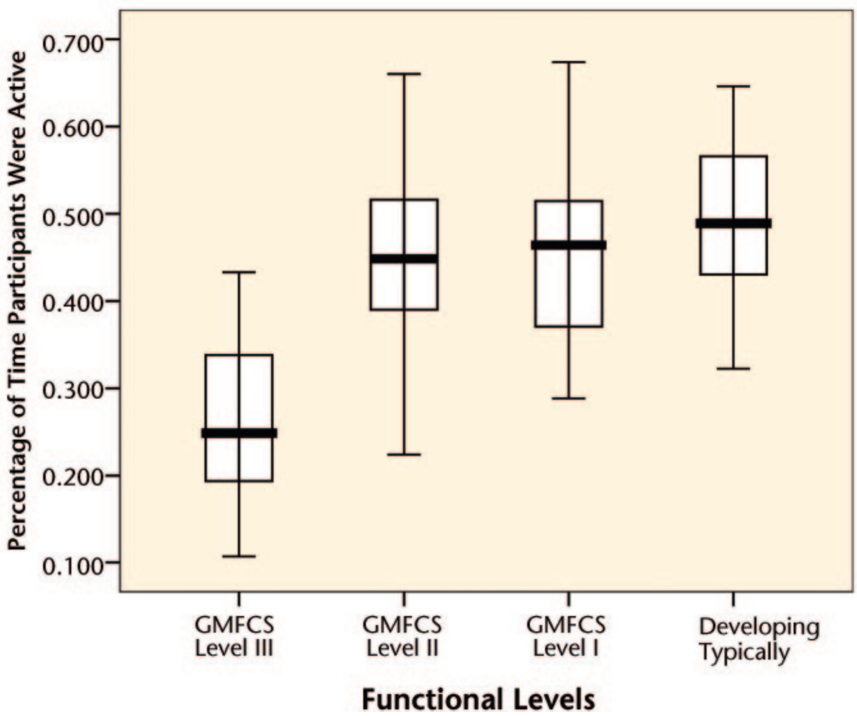

Figure 3.
Median and interquartile range for percentage of wearing time that the participants were active by functional levels (Gross Motor Function Classification System [GMFCS] levels). Comparison between children who were developing typically and children with cerebral palsy (CP) in GMFCS level III ($P<.001$); comparison between children who were developing typically and children with CP in GMFCS level II ($P=.10$); comparison between children who were developing typically and children with CP in GMFCS level I ($P=.39$); comparison between children with CP in GMFCS levels I and III ($P<.001$); comparison between children with CP in GMFCS levels I and II ($P=.88$); comparison between children with CP in GMFCS levels II and III ($P<.001$).

40.2% and 49.6%, respectively). Within-group analysis of percentage of time participants were active (Fig. 3) revealed significant differences between children with CP in GMFCS level III and the comparison group and between the children with CP in level III and those in levels I and II.

The ratio of medium to low activity was significant between the comparison group and the children with CP in GMFCS levels II and III, among levels I to III, and between levels II and III, with 4 outliers identified for level I, level II, and comparison group data (Fig. 4). The comparison group had significantly higher percentages of time at high activity levels compared with children with CP in GMFCS levels II and III, children in level I had significantly higher percentages of time at high activity levels than those in level III, and children in level II had significantly higher percentages of time at high activity levels than those in level III (Fig. 5). Four outliers in level III were between 5% and 10% of total time active, with one outlier in the comparison group at 20%.

Discussion and Conclusions

Walking performance activity as measured by a 5-day sample of StepWatch monitor data confirmed the hypothesis that the children who were developing typically would be more active on a daily basis than the youth with CP. These results provide evidence for performance-based walking activity level differences among GMFCS levels in youth with CP. Overall, the highest functioning youth with CP (GMFCS level I) appeared to be as active as the children who were developing typically. Youth with CP in level I also appeared to be capable of various levels of activity (percentage of medium to low activity) and spent a similar amount of time in high step activity (>42 steps per minute) as the children who were developing typically. Youth who required assistive devices to walk (GMFCS level III) had the greatest limitation in number of steps taken per day, overall active time, and variability of activity levels or ability to attain high activity levels. Interventions aimed at improving daily ambulatory activity performance appear to have the most potential for change in youth with CP in GMFCS levels II and III, as these levels are most divergent from the functional levels of children who are developing typically.

Percentage of time participants were active (Fig. 3) data suggests that youth with CP in GMFCS level III are overall less active than youth with CP in levels I and II and children who are typically developing. This may be due to greater mobility limitations, type of assistive device used, increased energy expenditure, or opportunities to be active for youth in level III. Lack of variability of movements and activity is a common clinical observation of youth with CP. The ratio of medium to low activity levels and percentage of time at high activity levels (Figs. 4 and 5) confirm that youth with CP at level I can vary in their walking intensity, similar to children who are developing typically. Yet, as functional level decreases (levels II and III), they have decreasing variability of walking intensity or time at high activity levels. Clinically, these data suggest that our physical therapy interventions (ie, gait or treadmill training) or structured recreational activities should offer differing levels of walking or exercise intensity for youth at levels II and III. Are youth with CP who require assistive devices (level III) given as much opportunity to be active as youth in levels I and II on a daily basis? By virtue of using assistive devices, our society may not be offering youth at level III the same opportunities to be active at school, at home, or in the community. Would different types of assistive devices (ie, wheeled walker, nonwheeled walker, forearm crutches) influence the overall activity level of these youth?

Daily walking activity decreased as functional level decreased. This finding is consistent with previous work that documented time in the upright position ordered by clinical severity reported by Pirpiris and Graham.[30] Significantly fewer severe impairments (ie, spasticity, decreased range of motion, and selective motor control) are found in youth with CP who walk without assistance.[31] Walking activity differences by functional level are likely to be influenced by the documented increased energy cost for walking in children and adolescents with CP.[9,10]

It should be noted that the StepWatch monitor measures only the steps of one leg. Thus, comparison of these data with previously published public health pedometer data[13] requires doubling of the step counts. Youth with CP as a group in this study actually walked approximately 8,400 steps (counting both legs), whereas the children who were developing typically averaged 13,400 steps per day. The data presented in this article are consistent with the recommended levels of physical activity for a healthy body composition (BMI) or weight for children who are developing typically.[13] It is unclear whether the cutoff points (12,000 steps per day for girls aged 6–12 years, 15,000 steps per day for boys aged 6–12 years) are appropriate for youth with CP. Body mass index may not be a good indicator of health for youth with CP, as their energy requirements have been documented to be higher than those of children who are developing typically.

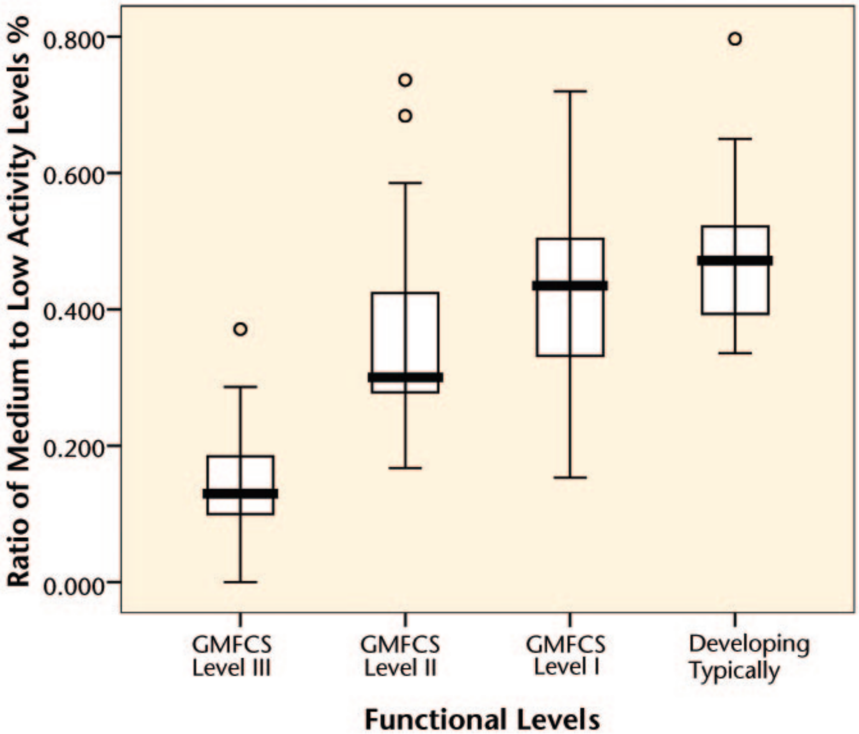

Figure 4.
Median and interquartile range for ratio of medium to low activity levels (expressed as a percentage) by functional levels (Gross Motor Function Classification System [GMFCS] levels). Comparison between children who were developing typically and children with cerebral palsy (CP) in GMFCS level I ($P=.31$); comparison between children who were developing typically and children with CP in GMFCS levels II and III ($P<.002$); comparison between children with CP in GMFCS levels I and II ($P=.18$); comparison between children with CP in GMFCS levels I and III ($P<.001$); comparison between children with CP in GMFCS levels II and III ($P<.001$).

The data presented in this article are a partial analysis of a project describing the self-reported health status separate from quality of life in youth with CP who are ambulatory and an exploration of the relationship of ambulatory performance to these constructs.[27,32] Study limitations include the lack of a population-based sample and small sample size. The definitions of low, medium, and high activity levels were based on descriptive adult data from the original development and validation of the StepWatch monitor[25] and may not be meaningful categories for children and youth. It is possible that there are relative activity levels specific for youth with CP who are ambulatory that are lower than those for children who are developing typically.

This study confirms the use of ambulatory activity monitoring as a valid and feasible process and outcome measure for youth with CP who are ambulatory. The step activity data

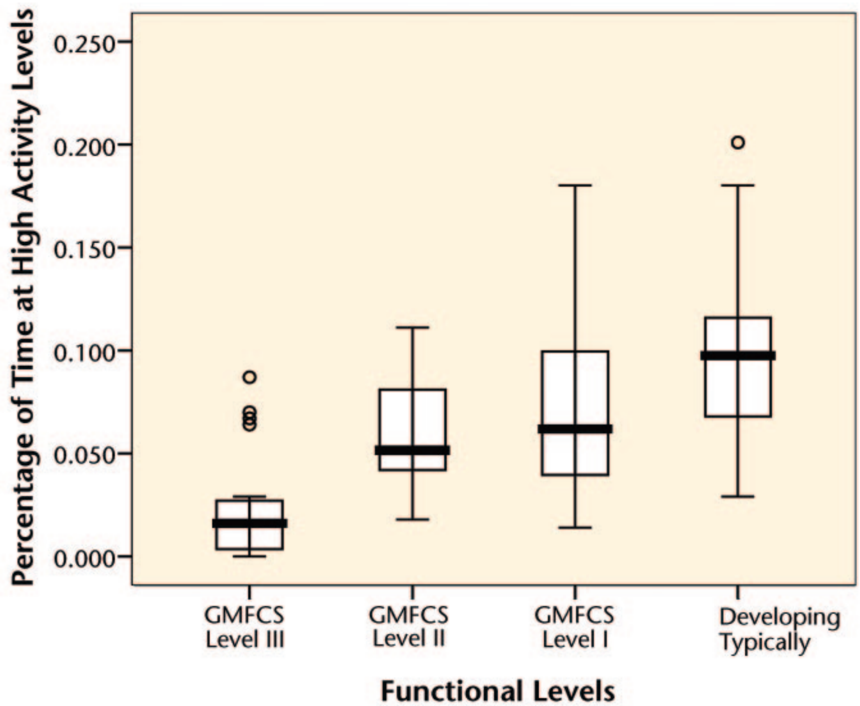

Figure 5.
Median and interquartile range of percentage of time at high activity levels (>42 steps per minute) by functional levels (Gross Motor Function Classification System [GMFCS] levels). Comparison between children who were developing typically and children with cerebral palsy (CP) in GMFCS level I (P=.08); comparison between children who were developing typically and children with CP in GMFCS levels II and III (P<.001); comparison between children with CP in GMFCS levels I and II (P=.33); comparison between children with CP in GMFCS levels I and III (P<.001); comparison between children with CP in GMFCS levels II and III (P<.001).

presented confirm the relative functional walking levels of the GMFCS. Clinically, walking activity levels can be used to describe the daily effect of interventions and modalities such as orthoses, assistive walking devices, serial casting, oral or intrathecal medications for movement disorders, therapy regimens, and orthopedic or neurological surgeries. For research purposes, ambulatory activity monitoring complements the currently used capacity based outcomes. Step activity data support documentation of intervention effectiveness as the activity performance component of the ICF framework. Longitudinally, step activity data would help in documenting walking function as people with CP age because impairments and limitations may change with physical growth and maturation. This study suggests that we now have the potential to examine the management decisions or interventions for ambulatory impairments by using ambulatory activity measurements within the context of the daily life for youth with CP.

Dr Bjornson, Dr Belza, Dr Kartin, and Dr Logsdon provided concept/idea/research design. Dr Bjornson, Dr Belza, and Dr Kartin provided writing. Dr Bjornson provided data collection and analysis, project management, and clerical support. Dr Bjornson and Dr Belza provided fund procurement and institutional liaisons. Dr McLaughlin provided subjects and facilities/equipment. All four authors provided consultation (including review of manuscript before submission).

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The study protocol was approved by the Institutional Review Board of Children's Hospital and Regional Medical Center, Seattle, Wash.

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Invited Commentary

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Time after time, parents of children with cerebral palsy (CP) ask clinicians, "Will my child walk?" To support this goal, a wide variety of therapeutic interventions and surgeries are offered. Research studies on the effectiveness of these approaches, however, often fail to provide outcome measures that are meaningful to children with CP and their families. To be meaningful, it is essential that the outcomes are ecologically valid and measure what the children do routinely in the context of their daily life and the extent to which the children are able to participate in age, gender, cultural, and community life roles and responsibilities.

Bjornson and colleagues' study, therefore, is timely and a valuable extension of previous work on daily ambulatory measures for children. The primary purpose of their study was to compare day-to-day ambulatory performance of youth with CP in comparison with youth developing typically, utilizing a StepWatch monitor.[1] A second purpose was to examine the validity and feasibility of ambulatory activity monitoring of children with CP. As defined in the *International Classification of Functioning, Disability and Health* terminology,[2] Bjornson and colleagues' measurement of performance (ie, "what the child really does" in the child's natural situation) unequivocally meets the criteria for a meaningful outcome. The focus of my commentary, therefore, will be on the magnitude of homogeneity in ambulatory performance within Gross Motor Function Classification System (GMFCS) categories I, II, and III[3] and the feasibility of monitoring ambulatory activity of children with CP.

One of the barriers to understanding the effectiveness of physical therapy for children with CP has been our inability to summarize disparate evidence across studies due to wide variations in the characteristics of the participants and the lack of ecologically valid outcome measures. Bjornson and colleagues' examination of ambulatory performance based on GMFCS level further eluci-