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Physical Activity and Walking Onset in Infants With Down Syndrome

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Infants with Down syndrome (DS) are described as being less active and they also experience significant delays in motor development. It is hypothesized that early infant physical activity may be influential for the acquisition of independent walking. Physical activity was monitored longitudinally in 30 infants with DS starting at an average age of 10 months participating in a treadmill training intervention. Actiwatches were placed on infants' trunk and right ankle for a 24-hr period, every other month until walking onset. Data were analyzed to separate sedentary-to-light activity (low-act) and moderate-to-vigorous activity (high-act). Results showed that more leg high-act at an average age of 12 and 14 months is related to earlier onset of walking. It is recommended that early leg activity should be promoted in infants with DS.

Early motor activity is thought to be important for the development of several critical subsystems of motor development (e.g., strength, endurance, coordination, and neural connections; McKay & Angulo-Barroso, 2006; Thelen & Smith, 1994; Ulrich & Ulrich, 1995). According to neuronal group selection theory (Edelman, 1987; Hadders-Algra, 2000), the cortical and subcortical networks within the brain are dynamically organized, and it is hypothesized that the neural networks and connections are established and/or strengthened by afferent information produced via behavior and experience. Although early activity is thought to be critical for development, its role in the motor development of children with atypical development has scarcely been investigated. Furthermore, the relationship between early activity and motor milestones is unclear, especially in infants with disabilities (Jahari, Saco-Pollitt, Husaini, & Pollitt, 2000; McKay & Angulo-Barroso, 2006; Thelen & Smith, 1994).

Down syndrome (DS) is a genetic condition that results in both cognitive and motor delays. In the United States, the prevalence of DS is approximately 1.36 per

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1000 live births (CDC, 2006). People with DS commonly experience moderate to severe intellectual disabilities and the acquisition of motor milestones is significantly delayed (Block, 1991; Chapman & Hesketh, 2000; Palisano et al., 2001; Spano et al., 1999). For example, children with DS usually walk independently at approximately 2 years of age, whereas children with typical development (TD) usually walk around 1 year of age (Block, 1991; Newberger, 2000; Palisano et al., 2001; Ulrich, Ulrich, Angulo-Kinzler, & Yun, 2001; Ulrich, Lloyd, Tiernan, Looper, & Angulo-Barroso, 2008). We define children with TD as children with no known physiological or cognitive disorders.

The physiological attributes that can negatively impact motor development in infants and young children with DS include low muscle tone, ligamentous laxity, poor postural control, and balance (Block, 1991; Crome, Cowie, & Slater, 1966; Davis & Kelso, 1982; Newberger, 2000). Infants and young children with DS have also been characterized by parents and professionals as being less active than their peers; however, there is little empirical evidence to support this characterization (Mazzone, Mugno, & Mazzone, 2004; McKay & Angulo-Barroso, 2006; Sharav & Bowman, 1992; Whitt-Glover, O'Neill, & Stettler, 2006).

The relationship between early infant activity and the onset of motor milestones is not well understood in infants with TD or infants with, or at risk for, developmental disabilities (McKay & Angulo-Barroso, 2006). In a study conducted in Indonesia on infants with TD who were nutritionally at risk, a correlation was found between amount of motor activity and motor milestone achievement (Jahari et al., 2000). In another study by Baird (2004) on Chinese infants with mild iodine deficiency, motor activity was measured at 6, 9, and 12 months using a two-hour observational video recording at each time point. Baird found that more active motor behaviors were predictive of earlier walking (2004). Both these studies provide preliminary evidence that early motor behaviors may be related to the onset of motor milestones. It is hypothesized that early motor activity is important for all populations; however, it may have particular importance for children with developmental disabilities.

Three studies have examined the movement behavior of very young infants with DS. Mazzone and colleagues (2004) studied the general movements of infants with DS compared with infants with TD. Between birth and 2 months of age, the general movements of the infants with DS were described as slow, having a high amplitude and variable fluency. In addition, they found that the sequences of arm, leg, neck, and trunk movements were generally less frequent, compared with the infants with TD, and the spontaneous motor activity was more variable in the infants with DS. At each measurement point, a significant difference was found between the infants with TD and the infants with DS, with the infants with TD exhibiting more movement (Mazzone et al., 2004). These results indicate that even in the first weeks of life, infants with DS are exhibiting atypical motor behavior, which may have implications for future motor development. Ulrich and Ulrich (1995) used behavioral observations to investigate the frequency and quality of specific leg movements of infants 4–6 months of age with and without DS. Results indicated that there were no differences in the overall frequency of movements; however, infants with DS produced fewer kicks than the infants with TD, and the infants that kicked less walked later. McKay and Angulo-Barroso (2006) conducted a study of the leg motor activity in infants with and without DS between 3–6 months of age. Using accelerometers placed on the right ankle, physical activity was measured for 48 hours at each monthly interval. Results indicated that infants with DS spent significantly more awake time engaged in low intensity activity compared with the infants with TD at 3 months of age. They also found that the integral of low activity during the day was consistently related to later onset of independent walking in infants with and without DS. In other words, in this study, all the infants who spent more time in low intensity activity walked later (McKay & Angulo-Barroso, 2006).

McKay and Angulo-Barroso (2006) and Ulrich and Ulrich (1995) established that in infants with and without DS, leg activity in early infancy (3–6 months of age) is related to the attainment of independent walking. What is not known is whether, as development progresses (i.e., in older infants), the leg or trunk activity is still relevant. The current study used a sample pool from a treadmill intervention program where infants with DS received either high-individualized (HI) or low-generalized (LG) training. Interestingly, the activity levels of these two group were not different during the initial phase of the intervention while they differed at the end of the intervention (Angulo-Barroso, Burghardt, Lloyd, & Ulrich, 2008; Ulrich et al., 2008). Therefore, the current study focused on this early phase of the intervention, approximately 10–14 months of age, when the two groups do not show differential effects of the training protocol. The purpose was to examine the relationships between "early" levels of activity and onset of independent walking in the entire cohort. In addition, such relationships were also examined separated by group to corroborate that there were no differential effects of treadmill training intensity during the early phase.

While it is acknowledged that there are multiple factors that likely impact on the onset of walking (e.g., BMI, strength, postural control, motivation), the aim of this paper was to elucidate what role trunk and leg activity play in the onset of independent walking. Specifically, the purpose of this paper was twofold: (a) to establish whether a relationship existed between leg and trunk activity at an average age of 10, 12, and 14 months and independent walking onset and (b) to establish whether other growth and developmental factors influence the onset of walking using a multivariate analysis. We hypothesized that early activity in the leg would be a good predictor of walking onset; however, leg and trunk activity would be differentially related to independent walking onset. Specifically, we proposed that the level of physical activity of the leg in those relatively early months (10–14) would be a better predictor of walking than the physical activity of the trunk based on the previous work of McKay and Angulo-Barroso (2006). If the relationship between physical activity and onset of motor milestones is robust, it should be independent of how quickly the infants progress through developmental milestones. Therefore, we chose to observe physical activity levels in the leg and trunk, independent of a treadmill training intervention that was being implemented.

Method

Participants

A voluntary sample of infants with DS was randomly assigned to receive two different partial-body-weight supported treadmill interventions designed to promote the achievement walking (Ulrich et al., 2008). Average age at entry into this study was 10.7 ± 1.9 months, and 14 females and 16 males participated; 26 were Caucasian, 2 were African American, and 2 parents self-identified their child's race/ethnicity as "other". This sample was recruited from local parent-support groups. All methods and procedures were reviewed and approved by the University Institutional Review Board, and all parents signed informed written consent before the initiation of the study; additionally, the treatment of the participants was in accordance with the ethical standards of APA.

Treadmill Protocol

Thirty infants were enrolled in this study; sixteen were randomly assigned to a high-individualized intensity (HI) treadmill training group, while 14 were randomly assigned to a low-generalized intensity (LG) treadmill training group (Angulo-Barroso et al., 2008; Ulrich et al., 2008). The infants were followed longitudinally from initial enrollment (average age of 10.7 months, standard deviation 1.9 months) until 15 months of independent walking experience on average. To begin participation in the study, infants needed to be able to take a minimum of 6 spontaneous steps on the infant treadmill while supported by the researcher in any given minute of a 5 minute testing session. Exclusion criteria were the following: the presence of a seizure disorder, noncorrectable vision problems, and any other medical conditions that would severely limit the child's participation in the treadmill intervention (Angulo-Barroso et al., 2008; Ulrich et al., 2008; Wu, Looper, Ulrich, Ulrich, & Angulo-Barroso, 2007). Both groups were given a custom-built infant

Table 1 Participant Characteristics at Study Entry and Average Ages of Motor Milestone Achievement

Characteristic	Details
Sex	14 Females, 16 Males
Karyotype	28 Trisomy 21, 2 Mosaicism
Race Ethnicity	26 Caucasian, 2 African American, 2 other
Household income	$60–80,000 (mean)
BSID-II motor scale raw score at entry	41.1 (5.69) *
Age at entry	10.7 (1.9)**
Height at entry	68.89 (3.16) cm
Weight at entry	8.47 (1.12) kg
Height at walking onset	77.83 (4.13) cm
Weight at walking onset	10.45 (1.32) kg
BSID-II motor scale raw score at walking	62.87 (3.39)
Age at crawling	12.6 (2.0)
Age at pulling to stand	14.4 (2.5)
Age at cruising	15.8 (2.7)
Age at walking (BSID-II item #62)	20.45 (4.0)

* mean (st. dev); ** Age in months

treadmill (Carlin's Creations, Sturgis MI) to keep in their homes where parents implemented the prescribed protocol until the infant could take 3 independent walking steps—Bayley Scales of Infant Development (BSID-II)—Motor item #62 "Walks alone" (Bayley, 1993). The HI group participated in the treadmill intervention with progressively increasing treadmill belt speed, time, and percent of ankle weights, while the LG group sustained the same speed and time and used no ankle weights (Ulrich et al., 2008; Wu et al., 2007). The treadmill training protocol for the LG group included 8 min per day, 5 days each week, at a belt speed of .15m/sec throughout the intervention. In the HI group, as infants progressed in their stepping performance, we added ankle weights, increased belt speed, and increased daily duration in an effort to maximize stepping response. These conditions were initiated once the infant displayed the ability to take 10 steps per minute and increased when the infant was able to take 20, 30, and 40 steps per minute. The decision of when to increase the training conditions was based on their videotaped performance during the biweekly follow-up sessions conducted by our research team. The amount of ankle weight added was individualized as a percentage (50, 75, 100, and 125%) of the child's calf mass (Ulrich, Ulrich, & Angulo-Kinzler, 1998; Ulrich et al., 2008; Wu et al., 2007). Because the primary purpose of this paper is independent of training protocol and there were no group differences on age of entry, height, weight, or age at walking onset between the two groups, we treated this sample of thirty infants as one group in our first analysis. To ensure that such relationship still holds depending on training protocol, separate analyses were also conducted by group.

Physical Activity Measurement Procedures

Physical activity was measured by placing one activity monitor (Actiwatch, Respironics/Mini Mitter, Bend OR) on the right ankle using a Velcro band, and a second activity monitor was placed just above the right iliac crest using medical tape. The Actiwatch has an omni-directional accelerometer with a sensitivity threshold of 0.05g and a frequency recording of 32 Hz. The Actiwatch data were collected with a sampling epoch of 15 s. The detector finds the peak value of each 1-s sampling and adds each of the peak values for the specified epoch length to provide a cumulative number for the 15 s epoch. Activity data were collected for 24 consecutive hours beginning at entry into the study (average age of 10.7 months, standard deviation 1.9 months) and continuing every other month until the onset of independent walking (Table 1; Angulo-Barroso et al., 2008).

Data Reduction

Following the 24-hr monitoring period, the data were downloaded onto a computer for analysis. To examine potential differences due to different activity levels, the data were analyzed to determine the separation of moderate-to-vigorous (high-act) and sedentary-to-light (low-act) intensity activity based on a criterion value or threshold. The threshold was determined separately for the leg and trunk data using the data from infants enrolled in the study for at least 7 bimonthly activity monitoring sessions (approximately 68% of all data; Angulo-Barroso et al., 2008). For threshold calculation purposes, data with a zero value were removed. The resultant threshold was used to split the data into approximately 70% low-act and 30% high-act for our analyses by generating a frequency distribution using 20 bins per participant's file. The two bins surrounding 70% of the active data were then used to calculate the threshold at the midpoint of these two bins. The selection of the approximate ratio 70/30 was used in two recently published studies (Angulo-Barroso et al., 2008; McKay & Angulo-Barroso, 2006). The overall average threshold for the leg data was calculated to be 131 movement units/15-s. The same procedure was used for the trunk data, where the calculated threshold for trunk data was 61 movement units/15-s (Angulo-Barroso et al., 2008).

The data for each infant was also classified as sleep or wake state (Angulo-Barroso et al., 2008); this was done by using an algorithm provided with the software (Mini Mitter/Respironics, Bend OR). In addition, average magnitude of activity was calculated by averaging the values of the 15-s epochs. Duration and magnitude variables were computed separately for the low-act and high-act. A product variable for activity was computed by multiplying the time spent in activity by the magnitude of the activity; additionally, product variables of high-act and low-act were also calculated separately (e.g., time in high-act multiplied by magnitude of high-act; Angulo-Barroso et al., 2008; McKay & Angulo-Barroso, 2006). This was calculated for the trunk and the leg separately. These product variables provide an estimate of the integral of activity. In this study, no sleep data or data for the night period are reported.

Statistical Analysis

To answer the primary question of whether early activity is related to walking onset, 6 linear regression models were created where the first three available (initial) measures of physical activity (activity collected at an average age of 10, 12 & 14 months) were predictors for age of walking onset. Separate models were created for each of the 6 activity variables: product of trunk total-act, product of trunk high-act, product of trunk low-act, product of leg total-act, product of leg high-act, and product of leg low-act with age of walking as the dependent variable. Adjusted R2 are reported as a correction due to the small sample size and the multiple predictors within the models.

To address the secondary research question, regression analysis using the activity variables as the independent variable (e.g., leg high-act) at each time-point (initial sessions 1, 2, 3) were used as predictors of the onset of independent walking (the dependent variable). This was repeated for each independent variable separately. In these multivariate analyses, height, weight, BSID-II raw motor score, all from the respective time point, were included in the regression models in addition to the appropriate activity variable. Using backward selection, if a variable was not significantly contributing to the model it was taken out.

All analyses were performed using SPSS 15.0 and the significance level was set at 0.05. Furthermore, all analyses were also executed on the two intervention groups separately. Individual group results were consistent across groups and overall sample indicating that the findings held regardless of group assignment.

Results

There were no differences in age (p = 0.30), height (p = 0.67), weight (p = 0.95), or BSID-II motor scale raw scores (p = 0.77) at entry to the study between the two groups. There were also no statistical differences in the age of walking between the HI and LG groups for the age of walking onset (p = 0.14); further justifying the use of just one group of 30 infants with DS for this manuscript.

Figure 1 illustrates the trajectory of average high-act and low-act for the trunk and leg over the first three initial physical activity assessments (average age of 10, 12, 14 months); the product of all the activity variables (trunk and leg, high-act and low-act) stays fairly constant over the initial 3 visits. The product of leg high-act and leg low-act are considerably higher than those of the trunk across the three assessments.

The regression models using the 3 initial physical activity measurements for the product of total trunk-act did not predict onset of walking, and this result did not change when the groups were examined individually The regression models for product of total leg-act explained a significant amount of the variance (adjusted R^2 = 0.371, p = 0.015) for the onset of independent walking (BSID-II #62); specifically, product of total leg activity at initial assessments 2 (p = 0.04) and 3 (p = 0.01; 12 and 14 months, respectively) were significant predictors of walking.

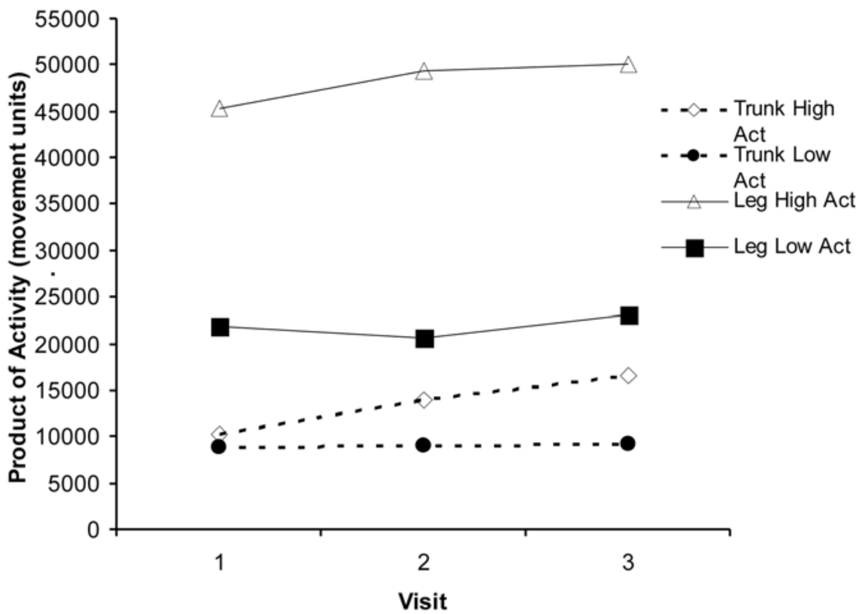


Figure 1 — Average physical activity levels (high-act and low-act) for the trunk and the leg over initial 3 physical activity assessments.

The above results indicate that total product of leg activity is related to the onset of independent walking in infants with DS. To determine whether high-act or low-act is the more important factor, further regression analyses were performed by separating out the two levels of activity. The regression model using the 3 initial physical activity assessments for the product of leg high-act explained a significant amount of the variance (adjusted $R^2 = 0.349$, $p = 0.022$) for the onset of independent walking. Specifically, the product of leg high-act at both initial assessment 2 and initial assessment 3 (Figure 2b) were negatively related of earlier walking ($t = -2.10$, $p = 0.047$ and $t = -2.61$, $p = 0.016$, respectively). These relationships indicate that more high-act in the leg at an average age of 12 and 14 months relates to earlier walking onset in infants with DS. Consistent with the previous result on total trunk activity, neither trunk high-act nor low-act was related to the onset of walking.

To determine if these effects were different by experimental group, further regression analysis was performed by group. When product of total leg activity was examined separately by group, the regression model for the HI group approached significance (Adjusted $R^2 = 0.445$, $p = 0.08$), specifically at initial assessment 3 ($p = 0.06$). For the LG group, the regression model approached significance in explaining the variance for the onset of walking (Adjusted $R^2 = 0.651$, $p = 0.05$); product of total leg activity at initial assessment 2 ($p = 0.06$) and initial assessment 3 ($p = 0.09$) were contributors of walking. When the high-act and low-act were separated by group the results provide evidence that the relationship between leg high-act at 12 and 14 months and walking onset held. The full regression model for the leg high-act in the HI group approached significance (adjusted $R^2 = 0.477$, $p = 0.060$). Specifically, within this model at initial assessment 3, leg high-act was significant ($t = -2.23$, $p = 0.048$; see Figure 3c. This indicates that even with a smaller sample size leg high-act at 14 months is related to onset of walking. For the LG group, the full regression model for leg high-act also showed a trend toward significance (adjusted $R^2 = 0.613$, $p = 0.070$). Specifically, at initial assessment 2, leg high-act was a significant predictor of walking ($t = -2.59$, p = 0.036; see Figure 3b). Therefore, in the LG group more high-act in the leg at 12 months is related to earlier walking. In sum these results indicate that regardless of the intervention group, more high-act in the leg at an average age of 12 and 14 months is a good predictor of walking onset in children with DS as depicted in Figures 2 and 3.

None of the multivariate regression models where height, weight, BSID-II raw scores in addition to the activity variables were included significantly predicted walking onset. This indicates that although height and weight are important in the overall growth and development of infants with DS, in this sample they were not predictive of walking onset. Using backward selection, nonsignificant variables were taken out of the regression models that resulted in only one statistically significant model. The regression model where the product of leg high-act at initial session 3 predicted age of walking onset, adjusted $R^2 = 0.20$, $t = -2.79$, p = 0.009. This means that more leg high activity at an average age of 14 months for infants with DS is consistently related to earlier walking.

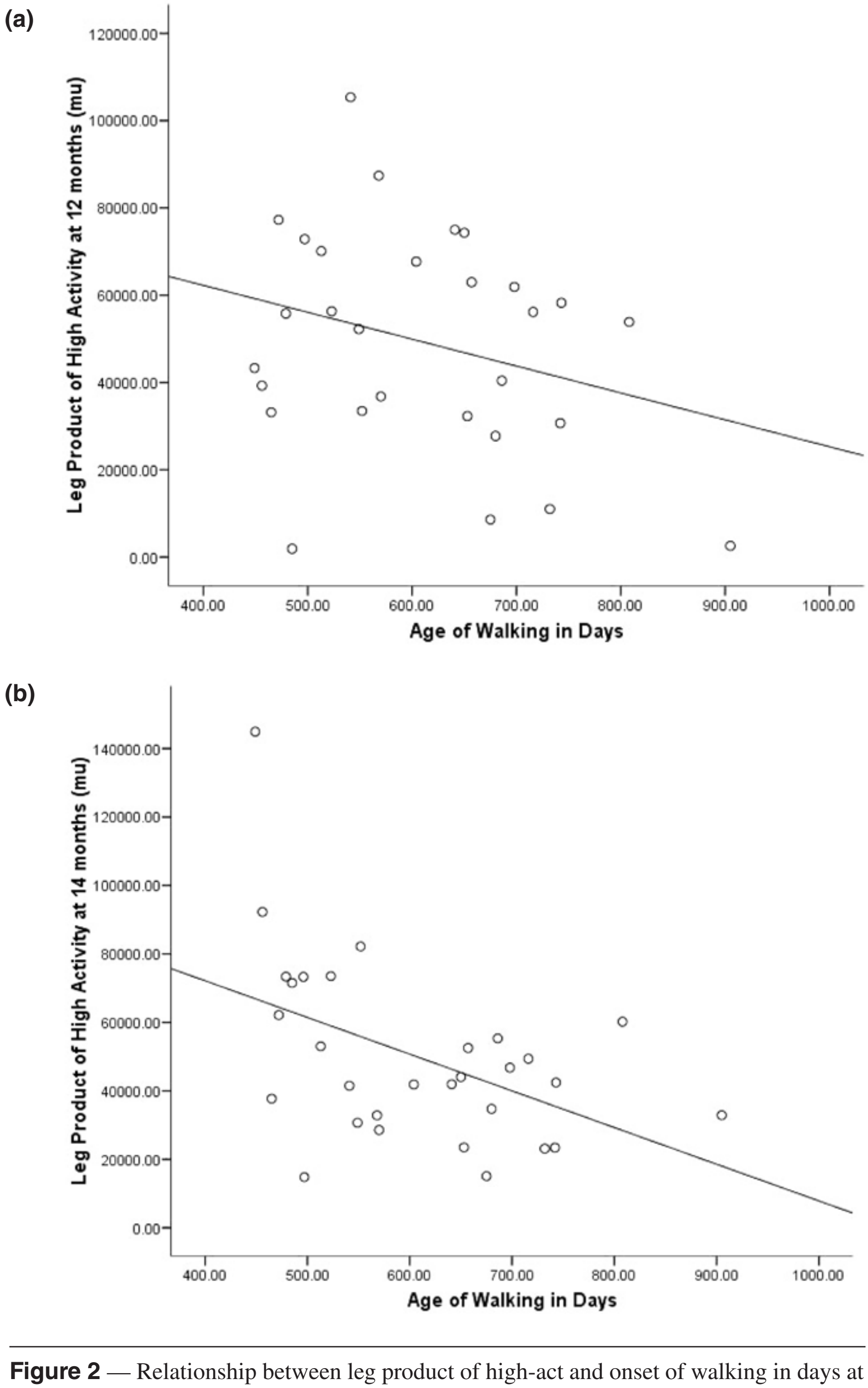


Figure 2 — Relationship between leg product of high-act and onset of walking in days at 12 months and 14 months (groups combined).

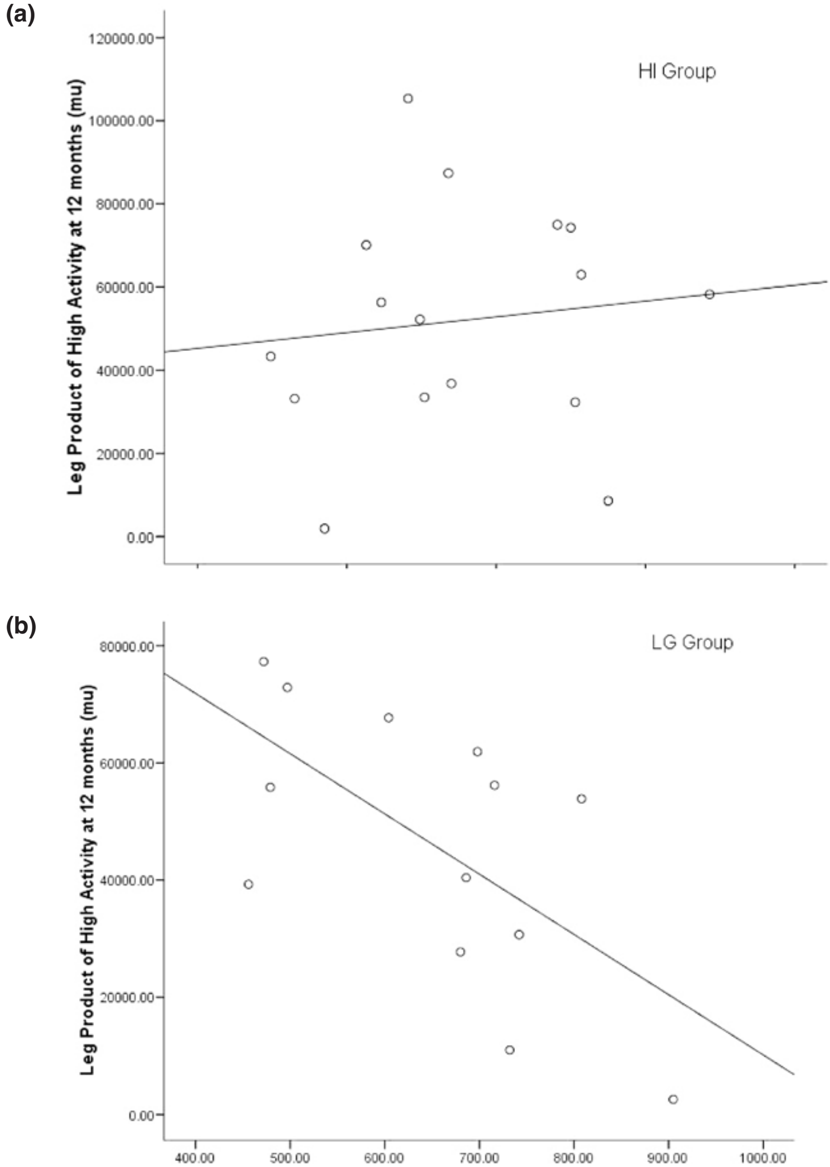
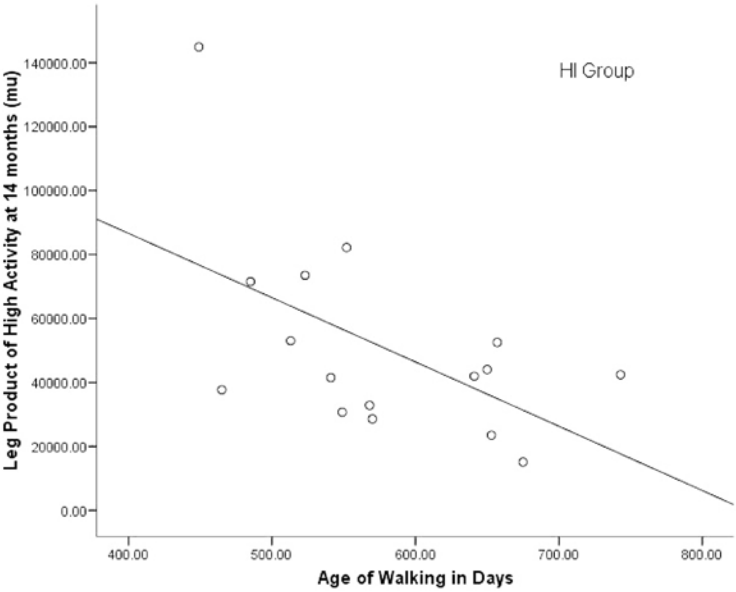


Figure 3 — Relationship between leg product high-act and onset of walking in days by group: (a) HI group at 12 months, (b) LG group at 12 months, (c) HI group at 14 months, and (d) LG group at 14 months.

(c)



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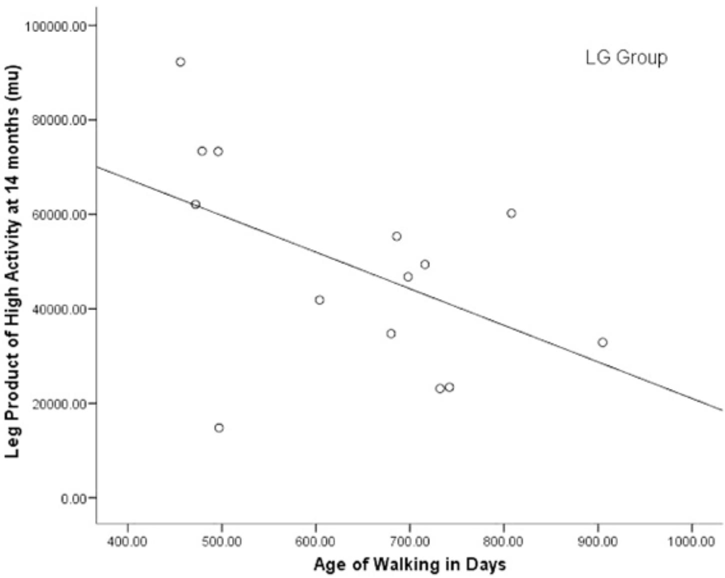

Figure 3 ***(continued)***

Discussion

There were two primary research questions guiding this paper, first to establish whether a relationship existed between the leg and/or trunk activity (at 10, 12 and 14 months) and the onset of independent walking. Results indicate that there is a relationship between leg high-activity at 12 and 14 months and the onset of walking in this sample of infants with DS. The second question was to explore whether other developmental factors contribute to the onset of walking in infants with DS. The analysis revealed that leg high-activity was the main factor significantly related to the onset of walking in this sample.

We found that physical activity stayed fairly constant in our sample between 10–14 months, which is similar to what was found in a sample of Swedish infants from 9 to 14 months with TD (Tennefors, Coward, Hernell, Wright, & Forsum, 2003). This indicates that infants with DS in this age group, and receiving a treadmill intervention, may have similar patterns of physical activity in terms of trajectory (not magnitude) as infants with TD.

We also found that more high-act in the leg at 12 and 14 months on average was related to earlier walking onset. It must be emphasized that these results are not generalizable to the entire population of children with DS. All the participants in this study were taking part in a partial-body-weight supported treadmill training program designed to promote the onset of walking. The use of treadmill training in developmentally delayed pediatric populations, however, has increased significantly in recent years, and the use of treadmill training for infants with DS is becoming more common (Begnoche & Pitetti, 2007; Bodkin, Baxter, & Heriza, 2003; Day, Fox, Lowe, Swales, & Behrman, 2004; Ulrich et al., 2001; Ulrich et al., 2008; Wu et al., 2007). Interestingly, the activity levels of these two groups were not different during the initial phase of the intervention while they differed at the end of the intervention (Angulo-Barroso et al., 2008; Ulrich et al., 2008). The current study focused on this early phase of the intervention (approximately 10–14 months of age), when the two groups do not show differential effects of the training protocol. At this time, we cannot draw causal inferences about early leg activity in infants with DS; additionally, our sample was part of a treadmill intervention study. Future research should investigate interventions that target leg high-act between 10–14 months in infants with DS, and a true control group needs to be included to be able to generalize the results.

Our results also demonstrate similar relationships no matter what analysis was conducted. It could be concluded that the relationship is robust even when levels of activity are increased at the late phase of the intervention by a higher and individualized intensity training (HI) compared with a generalized treadmill training protocol (LG; Angulo-Barroso et al., 2008). Despite the limitation of the treadmill intervention, we contend that relationships between early leg high-act and motor development are robust and could exist regardless of individual developmental trajectories. Furthermore, such a relationship was found before in younger infants with and without DS (McKay & Angulo-Barroso, 2006; Ulrich & Ulrich, 1995), providing further support to this proposal.

Implications

McKay and Angulo-Barroso (2006) found in a sample of 8 infants with DS and 8 without DS (3–6 months of age) that more low-act during the day was related to later age of walking onset. Ulrich and Ulrich (1995) also found in their behavioral observation of 10 infants with DS and 20 infants with TD (4–6 months of age) that the amount of kicking between 4–6 months was inversely related to the age of onset of walking. We found, in a sample of 30 infants with DS, that more high-act in the leg at 12 and 14 months of age was also inversely related to the onset of walking, and this relationship existed even when the intervention groups were separated. Taken together, the results of these 3 studies indicate that leg activity is important along a continuum of early development for the onset of walking in infants with DS. We hypothesize that increased early leg activity in infants with DS promotes neural connections and allows the infants to explore the constraints of their developing system through sensory information and feedback in addition to increased strength, endurance, and coordination (Angulo-Barroso et al., 2008; Edelman, 1987; Hadders-Algra, Brogren, & Forssberg, 1997; Thelen, 1981; Thelen & Smith, 1994; Ulrich & Ulrich, 1995). Mazzone and colleagues (2004) found that infants with DS generally move less, their movements are slower, and the amplitude is lower compared with infants with TD. Therefore it is plausible that decreased levels of early motor movements have long-term consequences on the developing nervous system. The data from this study (McKay & Angulo-Barroso, 2006; Ulrich & Ulrich,1995) indicate that the early leg activity of infants with DS is important for later motor development.

The importance of leg activity in early development is highly suggestive that the promotion of earlier motor milestone achievement may provide a scaffolding effect for further motor development (Adolph, 1997). The activity levels of the legs and the trunk during infancy may be differentially important at different developmental times. We propose that very early in development, low levels of leg activity may be a discriminatory factor in developmental delay; shortly after, leg high-act becomes critical to development. When monitoring physical activity, the developmental shift from creeping and crawling to bipedal locomotion necessitates that the activity monitor is placed on the hip for accurate data collection. At this developmental time point, the level of activity found at the hip (trunk) is best to measure overall child activity (Heil, 2006). Developmentally, it is likely that low-activity is most prevalent in the early stages of walking with high-activity becoming more common with the emergence of better motor skills allowing for more complex movements and activities by the child.

There are a multitude of factors that contribute to the onset of independent walking; the purpose of this study was to examine the role of early activity. It was a secondary question to explore whether variables such as height and weight were related to the onset of walking, and, in fact, they were not. There are, however, several physiological constraints that contribute to the motor delays of children with DS (e.g., hypotonia, ligamentous laxity). Due to the nature of these characteristics, they are not easily measured or quantified; therefore, we were not able to be control for them in this study. We acknowledge that other factors potentially contribute to early motor development.

Limitations

All the participants in this study were participating in a partial-body-weight support treadmill training program without a true control group; therefore, the results may not be generalizable to the general population of infants with DS. Further research is needed to study this question.

Recommendations

In conclusion, the results of this study demonstrate that early leg activity in infancy is important for motor development. The results also provide evidence that 10 months of age is an appropriate developmental age for infants with DS to start a partial-body-weight support treadmill training program where the legs are specifically targeted. We suggest that therapists, when working with infants with DS, continue to work on developmentally appropriate skills; however, based on the results of this study in conjunction with previous research (Angulo-Barroso et al., 2008; Baird, 2004; McKay & Angulo-Barroso, 2006; Ulrich & Ulrich, 1995), we contend that early leg activity in the first year of life is critical to the development of independent walking. There is also no reason, based on our data or previous research, that increased leg activity would impede the acquisition of four-point crawling or any other early developmental skills. Taking together the existing evidence, it seems that early interventions, such as using partial body-weight-supported treadmill training or a kicking intervention (just 2 examples) even before the onset of creeping and crawling, should be deemed appropriate and advisable in addition to developmental activities used in therapy. This study provides evidence that relatively early leg activity (10–14 months of age) should not be overlooked in infants with DS; it should be promoted even in the stages when crawling and pulling to stand are emerging.

Acknowledgments

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