Motor Performance of Children With Down Syndrome and Typical Development at 2 to 4 and 26 Months

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Purpose: To compare gross motor performance of children with Down syndrome (DS) and typical development (TD) at 2 to 4 months (Phase I) and at 2 years of age (Phase II) and to investigate the relation between early motor performance and later outcome. Methods: Seventeen infants (10 with TD and 7 with DS) were assessed in Phase I using the Test of Infant Motor Performance (TIMP); 25 children were assessed in Phase II using the gross motor scale of the Bayley Scales of Infant and Toddler Development (Bayley-III); 10 participants were enrolled in both phases. Results: TIMP and Bayley-III scores were lower in the DS group. In both groups, TIMP z scores were predictive of Bayley-III scores. Conclusions: Children with DS show difficulties in early postural control and activities requiring speed, postural control, and balance. The finding that early performance relates to later outcome reinforces the relevance of early and task-specific intervention. (Pediatr Phys Ther 2015;27:135–141) Key words: child/preschool, Down syndrome, female, infant, male, motor performance, postural balance

INTRODUCTION AND PURPOSE

Beginning at birth, infants with typical development (TD) interact with the environment by means of a repertoire of motor behaviors that include spontaneous movements and reactions such as orienting the head toward visual and auditory stimuli. These movements are the earliest manifestation of the wide range of motor actions that constitute human motor behavior. Over time, these simple movements evolve into increasingly complex motor behaviors through the acquisition of new motor skills, which in this study are defined as specific, observable movements such as rolling, sitting, walking, etc. The emergence of new motor skills during development dramatically changes the quality of interactions and expands the infants’ opportunities to learn about the world. For example, acquiring head stability facilitates oculomotor control and spatial abilities such as depth perception. Therefore, gross motor skills acquired during the first few months of life contribute to the emergence of other motor and cognitive skills later in life both in infants with TD and in infants at risk for developmental delays.
The performance of early motor behaviors and complex motor skills can be assessed at several points in development and used as indicators of the need for intervention and to guide treatment strategies in populations at risk for motor delays.\(^7,8\)

In this study, we investigated gross motor performance in infants and children with Down syndrome (DS). Findings such as reduced variability, speed and symmetry of general movements,\(^9\) and less vigorous spontaneous kicks compared to infants with TD,\(^10\) demonstrate that the repertoire of early motor behaviors is adversely affected in infants with DS. Regarding early postural control, cross-sectional studies have shown that head righting, protective reactions, and other responses are also impaired.\(^11,12\) In addition, longitudinal studies have demonstrated that the acquisition of motor skills, especially midline behaviors\(^13\) and vertical postures,\(^14\) is often delayed. Later in childhood, the acquisition of gross motor skills such as walking and running also occurs later in children with DS compared with children with TD.\(^15,16\) In fact, the older the child, the more delayed his or her gross motor performance may be compared with children with TD. For example, children with DS are more delayed in comparison with their peers between 7 and 12 months than between 3 and 7 months,\(^13\) and more delayed at 36 than at 18 months of age.\(^16\) These findings may be explained by the fact that over time, the complexity of motor skills seen in TD increases and motor performance becomes more challenging for children with DS due to difficulties with components of postural control.\(^16\)

To fully understand the characteristics of motor development in DS and the possible role of the impairments seen early in life on later motor performance, it is important to investigate longitudinally detailed aspects of the early repertoire of motor behaviors that are relevant to the acquisition of motor skills. Early in development, this is possible by using the Test of Infant Motor Performance (TIMP), an ecologically valid test that measures postures and movements reflecting infants’ interactions with their caregivers with high predictive and discriminative validity.\(^8,17,18\) The TIMP also considers variability and quality of movements, which reflect the integrity of neuronal networks and are key to motor development, based on recent theoretical approaches.\(^19\) In infants born preterm, studies have shown that the gross motor performance measured by the TIMP at term age predicts motor and functional performance at 12 months’ corrected age,\(^20\) whereas performance at 3 months’ corrected age predicts motor performance at preschool age.\(^21\) These studies demonstrate a link between early motor behaviors and skills acquired later in development, although perinatal complications and socioeconomic factors also influence later outcome.\(^20\)

Further investigation of this link requires long-term follow-up of the same sample and use of valid diagnostic tests at later ages, such as the Bayley Scales of Infant and Toddler Development (Bayley III), which allows for the identification of delayed motor performance and suggests the need for continued intervention.\(^22\)

Given this background, the aims of this study were (1) to assess the gross motor performance in 2- to 4-month-old infants with DS by using the TIMP, and in 2-year-old children by using the gross motor scale of the Bayley-III, in comparison with peers with TD; and (2) to test the relation between early gross motor performance (2-4 months of age) and gross motor performance at 2 years of age.

**METHODS**

For this study, data were collected in 2 phases. Phase I: infants were assessed from 2 to 4 months of age; Phase II: infants were reassessed at age 2 years. The local Ethics Committee approved both phases and participants were included only after parents/guardians signed an informed consent.

**Participants**

During Phase I, 10 infants with TD (6 girls) and 7 infants with DS (4 girls) were enrolled. Based on our inclusion criteria, all the infants were born at term age (infants with TD: mean = 38.8 weeks, SD = 0.36; infants with DS: mean = 38 weeks, SD = 0.89), with birth weight greater than 2500 g (infants with TD: mean = 3100 g, SD = 600; infants with DS: mean = 3140 g, SD = 240) and Apgar scores greater than 7 in the 1st and 5th minutes. All infants with DS were enrolled in early intervention programs throughout this phase. The parents/guardians of the same infants included in Phase I were invited to enroll in Phase II. Of 17 infants, 10 were reassessed (TD: n = 5, 2 girls; DS: n = 5, 2 girls) and 7 were lost to follow-up. Reasons for the dropout included families that moved to distant cities, inability to reach the family by using the available contact information at the time of Phase II assessments, and families that decided not to participate again. An additional 15 children were included in Phase II only, based on the same inclusion criteria previously described. A new consent was obtained from all the participants’ parents and a new questionnaire about the children’s development was applied to check for the absence of developmental disabilities other than DS and any other health concerns. In total, Phase II included 25 children. Of these, 13 were children with TD (mean age = 26.57 months, SD = 1.84, 8 girls) and 12 were children with DS (mean age: 27.01 months, SD = 0.86, 3 girls). Seven of 12 children with DS were attending early intervention programs by the time of Phase II assessments.

**Materials and Procedures**

During Phase I, the TIMP\(^23\) was administered by 1 of 3 examiners trained in handling infants at risk and in the use of the scale. For reliability, all raters scored tests from several infants who were not part of this study and their scores were compared with an experienced examiner’s scores. Interrater agreement reached 84%, across all examiners. Each test session was recorded and subsequently scored.
Participants were assessed within ±7 days of their 2-, 3- and 4-month birthdays at hours that did not coincide with the infants’ feeding or nap times. During the test, the infants were dressed only in diapers and the examiner made sure that the infant remained in an alert state. Each test lasted from 30 to 60 minutes. In case of crying or fussiness, the test was either momentarily interrupted or rescheduled for another time within the next 24 hours.

The TIMP was designed to assess infants from 34 weeks' postconceptual age to 4 months' corrected or chronological age. Forty-two items are included in the TIMP. Thirteen are observational; that is, they test spontaneous movements performed by infants, with the remaining items elicited by the examiner (eg, rolling, pull to sit). The TIMP’s reliability has been demonstrated in previous reports24,25 and has also been shown to be valid in detecting changes over age and identifying infants at risk for developmental delays.24 A standardized protocol was used to administer the TIMP, beginning with the observational items. Each item was scored as 1 for the presence of the expected motor response and 0 for the absence of the response. Elicited items were then evaluated, with up to 3 repetitions of each item; scores vary from 0 to 6, depending on the item. The best response was chosen for scoring purposes. Raw scores were obtained from the sum of the values obtained in each of the items. Z scores were calculated on the basis of the instrument’s normative values, as they are described as most appropriate for comparing infants within the same-age range.26 On the basis of these scores, the infants’ performance can be described as either typical (z score ≥−0.5) or atypical (z score ≤−0.5).

During Phase II, children were assessed at the age of 26 months ± 2 months. The instrument of choice was the gross motor scale of the Bayley-III, which has been shown to be reliable and valid in detecting delays and determining the need for intervention.22,27 The Bayley-III gross motor scale includes tests such as going up and down stairs, balance on one foot, running, jumping, and kicking a ball. The set of tasks applied may vary depending on the children’s age and performance. Each task is scored as 1 (full completion) or 0 (partial completion or not able to do at all). For this study, performance was measured by means of scaled scores, which are standardized scores based on the instrument’s normative sample. The scaled score varies from 1 to 19 (mean = 10; SD = 3), and performance within the average should be between 7 and 13. At least 2 trained examiners were present during the test application; scoring was performed as the tasks were applied. Before the study started, the examiners were trained to test children from several age ranges who were not part of the study; scores were compared between examiners and the percentage of agreement reached 94%.

Statistical Analysis

After checking the data for normality and homogeneity (Shapiro-Wilk and Levene tests, respectively), parametric methods were chosen for the analyses. Two-way ANOVA was used to test the effect of group (TD × DS) and age (2, 3, and 4 months) on TIMP z scores. Data were used from all infants included in Phase 1 (n = 17). Data from all participants assessed in Phase 2 (n = 25) were used to compare the groups for Bayley-III gross motor scores at the age of 2 years by means of an independent-samples t test. The performance in isolated BSTID-III tasks was compared between groups using the Fisher test.

Average z scores for each infant were entered into the regression model, plus the group factor. The regression model was applied to data from participants who were assessed in both study phases (n = 10). For all tests, a 5% significance level was applied.

RESULTS

Results from Phase I showed significant main effects for group in TIMP z scores (F1 = 33.805; P < .001). Infants with TD had higher scores than infants with DS at all ages. No changes in z scores were found for age (F2 = 0.290; P = .750) and the interaction between group and age was not significant (F1 = 1.877; P = .166). Figure 1 shows the distribution of z scores in both groups of infants.

In Phase II, Bayley-III gross motor scaled scores were significantly different between groups (t(24) = 5.543; P < .00012). The mean score in the DS group was 3.08 (SD = 3.7) and for the TD group, 11.73 (SD = 2.7). The performance of all children in the TD group was classified as within or above the average interval, whereas most children with DS were below the average interval, as shown in Figure 2.
Analysis of individual Bayley-III tasks showed group differences in the following tasks: walking backward, running, balance in the right/left foot, jump from step, jump forward, kicking a ball, walk over a path, going up stairs without support, and walking on tip toes (see Table 1).

Tasks that were not significantly different included standing, standing up, walking alone, and throwing a ball.

The regression analysis showed that average TIMP z scores ($\beta = 0.906; \ P = .007$) explained 88.7% of the variation in Bayley-III gross motor scores at the age of 2 years, independently of group ($\beta = -0.044; \ P = .852$). The distribution of scores is shown in Figure 3.

**DISCUSSION**

This report provides data on the gross motor performance of infants and children with DS compared with peers with TD and provides information on specific aspects of motor performance that may be challenging for this population. Additional information about the relationship between infant motor performance and gross motor performance at the age of 2 years in a subsample is provided.

As expected, the results from Phase I showed that TIMP z scores were lower in infants with DS than in infants with TD, a finding consistent with another report regarding acquisition and refinement of motor skills.28 Although the majority of previous studies focused on the acquisition of motor milestones such as rolling from supine to prone, sitting, and head control, and a few studies have addressed postural control in DS,11,12 few longitudinal studies followed the same group of children.29,30 Recently, Tudella et al13 and Pereira et al14 have provided longitudinal information on the acquisition of midline behaviors and vertical postures in infants with DS. The current study adds to the existing literature by providing data on aspects such as...
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As spontaneous motor behavior and early postural control, tested by the TIMP from ages 2 to 4 months. At all ages tested on the TIMP, the motor performance of infants with DS was below average. According to Campbell et al., scores that fall more than 0.5 below the mean indicate motor delay and the need for intervention. Although the infants with DS in this study were all enrolled in early intervention programs, postural control and variability of spontaneous movements are issues that may need to be of even greater focus.

No significant differences in z scores across age were found in either group; that is, the rate of change was constant across groups throughout the age range examined. This is because the z score is a normative score, derived from a sample of children with TD in the same age range. Previous studies have suggested that the magnitude of developmental delays in DS increases over time; that is, performance becomes more discrepant from that of infants with TD. In the current study, a nonsignificant trend toward increased difference between groups over age was seen (Figure 1). This finding may indicate that delays become more noticeable later in life, or that motor components that may be particularly impaired in infants with DS were not evidenced through the measurements used in the current study. In addition, it is also possible that the small sample size may have decreased the power to detect a difference. Therefore, future longitudinal studies should include larger samples and address specific components of postural control, such as the activation of postural muscles and their relation to responses such as head and trunk righting in young infants.

Again, at the age of 2 years, children with DS showed lower gross motor performance than children with TD, as shown by significant differences found when comparing scaled scores. Relative to the Bayley-III normative values, most children with DS (n = 6) were between 1 and 2 SD below the mean, which indicates mild delay. However, interindividual variability was a noticeable feature of this sample, as reported in previous studies. Some participants (n = 3) performed within normal limits, while others (n = 3) were classified as having moderate delay (Figure 2). The 3rd edition of the Bayley was the first to assess the gross motor domain independently from the fine motor domain. Using this version, the interpretation of motor delay should be viewed with caution, since recent concerns have been raised regarding underestimation of motor delays using current normative values. Indeed, compared with a previous study, our study had a larger proportion of participants with mild rather than moderate delay, which may be due to an overestimation issue with the Bayley-III. Nevertheless, considering the statistical results, our data indicate gross motor delay at the age of 2 years in DS, at least at the group level, whereas further testing may be needed to determine individual needs.

In this sense, the analysis of individual Bayley-III tasks was able to reveal specific aspects of the children’s gross motor performance. Some of the tasks we tested, such as running, jumping, and kicking, require fast muscle activation, acceleration, and deceleration of movements. Other tasks require antigravity control, reciprocal patterns of muscular contraction, and interlimb coordination, such as going up and downs stairs, single limb support, and walking backward. Several aspects of DS may have played a role in the performance of these movements. For example, the ability to project the body into space is essential to running and jumping and may be impaired in the presence of proprioceptive deficits such as the ones observed in individuals with DS. Children with DS were shown to have higher muscle co-contraction during the early phase of walking acquisition than seen in children with TD. This strategy has been suggested to compensate for intrinsic low stiffness and could possibly impair the control of reciprocal movements. In addition, children with DS as young as 1 year and throughout their development have been reported to demonstrate delayed and inefficient postural adjustments. By 9 years, they still use compensatory postural adjustments such as excessive trunk inclination when climbing stairs. Consistent with previous findings, our results demonstrate that difficulties in performing tasks involving reciprocal muscle contractions and postural control are present beginning at early ages and should not be overlooked.

In several countries, children with DS are commonly discharged from early intervention services as soon as they acquire independent walking; however, this practice is not based on scientific evidence. In fact, in this study it became evident that the main differences in gross motor performance reside in activities requiring speed and complex postural adjustments. Studies have shown that children...
with DS are responsive to specific training in these types of gross motor skills. Therefore, it is necessary to provide the children with opportunities to practice these components before discharge (eg, training complex skills such as running and jumping based on individual needs) and to inform the families about the need to engage their children in sports and recreational activities that may support continuing improvements in motor performance.

Another finding of this study was that gross motor performance in infants predicted gross motor outcome in the second year of life, in both groups of children. Previous studies have reported that gross motor performance measured by the TIMP in infants born at term or preterm was predictive of gross motor performance assessed by using the Alberta Infant Motor Scale at 12 months and of functional performance measured by the Pediatric Evaluation of Disability Inventory at 14 months. Moderate associations between motor performance of infants born preterm measured by the Bayley-II and later motor outcome have also been reported in a recent meta-analysis. Although a much larger sample would be needed to validate the predictive value of the TIMP for children with DS that were later assessed by using the Bayley-III, the results of this study suggest a role of early skills on later outcome and highlight the sensitivity of the TIMP as a quantitative measure of infant motor performance.

Several changes happen in infants’ motor behavior around 4 to 6 months of age, such as improved postural control, stability of head and neck, midline orientation, and emergence of the first whole-body transitional movement by means of block rolling, which generates rich proprioceptive, tactile, vestibular, and visual feedback and expands the possibilities of interaction with the environment. These experiences may explain the role of early motor behaviors in the acquisition of other skills later in life. In children with DS, the emergence of complex motor skills may be delayed as a result of reduced sensorimotor experiences early in life, which in turn reinforces the need for early assessment and intervention.

Recent studies have shown the role of infant motor skills in overall development. It is also increasingly clear that early motor skills are potentially changeable. These findings, in accordance with the results of this study, inspire new questions regarding the mechanisms of plasticity in infants with DS, and motivate further research on how to maximize development of children with DS.

CONCLUSION

Limitations of this study include the small sample size enrolled in the 2 phases of the study, which reflects challenges intrinsic to longitudinal studies, and the lack of additional measures at the age of 2 years that could confirm the severity of the motor delay. Nevertheless, this study showed that gross motor performance of infants with DS was delayed compared with that of infants with TD between 2 and 4 months of life, and also at the age of 2 years. In addition, the gross motor performance of 2-year-old children was predicted by their motor performance early in life. Because refined motor skills promote children’s overall development and social inclusion, the results point to the need for detecting early delays and for continuously evaluating individual needs.

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REFERENCES


