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# An Instrument To Measure Independent Walking: Are There Differences Between Preterm and Fullterm Infants?

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## ABSTRACT

In clinical practice walking independently has always been considered a major milestone in development. Nevertheless, little attention has been paid to the quality of movement expressed in the first attempts at walking free. Even when children achieve walking within a normal time range, some of them show features that are deviant. Early walking is difficult to judge, but at the same time may provide a sensitive means for detecting possible developmental impairments. The main aim of this paper is to provide a standardized clinical instrument for the qualitative assessment of early walking in a structured free field situation and to compare preterm and fullterm infants. All subjects were assessed 14 days after being able to walk 5 meters independently. The study group consisted of 52 children, of whom 33 were born prematurely (further distinguished in terms of being small- or appropriate-for-gestational age), and 19 were born fullterm. Judgments of walking performance were made in terms of optimal, near-optimal, near-poor, or poor. After correction for age, the preterm group was still later in the onset of walking, but more importantly, showed a qualitatively different pattern of locomotion. Those who were the youngest and small-for-gestational age were overrepresented in the near-poor and poor categories of walking. (*J Child Neurol* 1997;12:37-41).

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A number of studies have reported that the onset of independent walking has a wide age range in normal infants. For example, Nelligan<sup>1</sup> gives a range of 9.7 to 15.8 months of age, Touwen<sup>2</sup> reports 13.5 to 18 months, and the Bayley Motor Scale for the Dutch population,<sup>3</sup> 10.7 to 17.6 months of age. Comparisons between such studies are difficult due to the great variety of definitions used to capture walking independently.

Prematurely born infants generally are reported to be delayed in the onset of upright locomotion<sup>4,5</sup> which may be

a sign of later morbidity.<sup>6</sup> There is no real agreement for how long after birth the chronological age of these infants should be corrected for gestational age and, if correction is used, for which domain of development it is applicable.<sup>7,8</sup> Most studies do not use correction after the age of 1 year. In the present study, we use both chronological and corrected age.

There have been a number of studies that have carried out detailed analyses of the kinematics of gait in young children.<sup>9</sup> Such studies require the cooperation of children in realizing reliable measures, something which is not possible below the age of about 5 years. What is presently missing is an instrument for the assessment of walking in much younger children that can be incorporated in routine clinical practice. In this respect, little attention has been paid to the qualitative aspects of walking particularly with regard to its onset. This is particularly the case in comparisons involving preterm and fullterm infants. A child may achieve walking independently within the normal age range and yet show qualitative features that can be considered to be deviant. Thus, qualitative assessments of walking may constitute a sensitive clinical tool for detecting those infants with possible developmental impairments such as transient dystonia, which in turn may be indicative of later minor neurologic dysfunctions.<sup>10</sup>

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Several factors should be taken into account when assessing the quality of walking performance of young infants in general and preterm infants in particular. First, toddlers in the initial stages of walking are typically not very cooperative. Therefore, walking independently should be assessed in a free field situation that is structured to encourage bouts of walking. Second, infants should be equated for walking experience so as to control for a confounding between maturation and learning to walk. Third and fourth, in comparing preterm and fullterm infants, the examiner should be blind as to the gestational age of the child, and gestation should be related to birthweight, because muscle mass may influence the quality of independent walking.

The aim of this paper is threefold. In the first instance, to document differences between preterm and fullterm infants in the onset of independent walking, using both chronological and corrected ages. Next, to present an instrument that can be used by clinicians to make a qualitative assessment of the onset of walking using a semiquantitative scoring system. Finally, to use this instrument to identify those features of early walking that differ between preterm and fullterm infants.

## METHOD

### Subjects

The study group consisted of 52 carefully selected children, of whom 33 were born prematurely and 19 were born after a fullterm pregnancy. The preterm population was recruited from the intensive care unit of the Academic Hospital of the Vrije Universiteit and other regional hospitals near Amsterdam in the period from January 1989 to January 1993 inclusive. The preterm group was selected to be at low risk for later developmental problems. All were Caucasian singletons with gestational ages between 27 and 34 weeks at birth. No child had any evidence of hypoglycemia and none were recruited if they had severe periventricular hemorrhage (Papile grade 3 and 4), periventricular leucomalacia, or asphyxia. Children were selected only if they showed no karyotypic abnormality, fetal infection, or malformation. All had mothers who were between 18 and 40 years of age and measured more than 1.60 meters in height. The recorded alcohol consumption was less than three glasses of wine or an equivalent per week. The dating of pregnancy was based upon reliable maternal information and an early ultrasound scan. The neonatal status of these children is given in Table 1. All preterm infants were examined at 35 weeks post menstrual age and at their expected date of delivery. Children were entered into the study only if they had a normal neurologic assessment. Twenty-one infants had birthweights between the 25th and 75th percentile (appropriate-for-gestational age [AGA]) and 12 had a birthweight under the 10th percentile (small-for-gestational age [SGA]), according to the growth curves for the Dutch population.<sup>11</sup>

A comparison group of fullterm infants was collected via midwives in the region. Gestational age ranged from 38 to 42 weeks and all had an appropriate weight for gestational age. All were examined within 1 week of birth and found to be normal before entering the study.

**Table 1. Subjects**

(Sub) group	n	Mean Birthweight, g (Range)	Mean Gestational Age, wk (Range)
Fullterm	19	3320 (2960–4000)	39 + 1 (38 + 1–41 + 4)
Preterm	33	1536 (765–2370)	30 + 6 (27 + 1–34 + 4)
Average-for-gestational age	21	1751 (1000–2370)	30 + 3 (27 + 1–34 + 3)
Small-for-gestational age	12	1141 (765–1535)	31 + 3 (29 + 2–34 + 4)
< 32 wk	19	1381 (765–1350)	30 + 6 (27 + 1–32 + 4)
> 32 wk	14	1765 (1170–2370)	33 + 6 (33 + 1–34 + 4)

### Procedure

Parents were asked to contact the examiner (L.d.G.) when their child first walked free for 5 meters. The assessment took place 14 days later. Thus, all children had the same limited amount of walking experience.

The children were assessed in a large (8 × 10 m), light, and warm room (22°C) in the Faculty of Human Movement Sciences. When the child and parents seemed to be at ease, the child was undressed so that posture while standing and walking could be easily observed. Assessments were done only when the child was in a cooperative state. The parents were present during the whole assessment. A portable video camera was placed at a distance of 6 meters from the child and was moved with the child when walking across the room. During the course of the examination, toys were presented, when needed, to elicit the behavior under study. A small ball, a toy to be pulled (a locomotive), and a large beach ball were used to encourage the child to start walking (at different speeds) and to provoke the act of picking up a toy.

### Instrument and Scoring System

The initial assessment instrument consisted of 25 items covering four areas of performance:

For *posture standing*, the child's posture before walking was assessed. The curve of the spine was described, the positioning of the feet as well as the amount of flexion in the hips and knees and the (a)symmetry in these body parts. For *walking free*, defined as 15 steps in 5 seconds, the footstrike, gait direction, rhythm, width between the legs, and variability in arm movements were judged and given a score. *Walking at speed*, defined as 15 steps in 3 seconds, was observed, as well as the onset and offset. The third area, termed *picking up a toy*, was judged by observing if the child could pick up the toy from the floor and whether this was performed with a good flexion-extension movement in the legs and without loss of balance. Sixteen items were judged on a three-point scale with 3 indicating optimal function, 2 near-poor, and 1 poor outcome. For the nine items on a two-point scale, 2 meant optimal performance and 1 poor outcome. For picking up a toy, 2 was optimal and 1 nonoptimal. Symmetry was assessed separately for each area of performance. (For more detailed information on the original assessment and scoring system see Appendix.)

Some of the items in the original assessment instrument were removed, because they did not discriminate between the children.

**Table 2. Optimal Score for Walking Independently**

Area of Performance	Score
Standing	Moderate lordosis
	Normal flexed knees
	No asymmetry in hips and knees
Walking	Straight legs
	Normal strike
	Straight and steady gait direction
	Regular rhythm
	Optimal width, legs under pelvis
Walking faster	Normal variability in arm movements and no asymmetry
	Fluent start
	Gait normal for age
	Good stop
Picking up toy from a standing posture	Child can do it
	Does it with smooth extension-flexion, good balance

These were scoliosis, exorotation, endorotation, hip flexion, asymmetry while standing, feet while walking and asymmetry during walking (see items marked\* in Appendix). The definite instrument to assess walking performance consisted of 15 items covering the four areas of performance. The internal consistency (Crombach's alpha) for each area ranged from 0.80 for posture standing to 0.90 in walking free and with walking at speed having a value of 0.85. The internal consistency for the total score based on 15 items resulted in an alpha of 0.92. The evaluations constituting an optimal score, for walking, in a child with 14 days walking experience are given in Table 2.

Scores were summed and cut-off points were used to categorize the children as showing optimal (15 items in the optimal range), near-optimal (14–10 items), near-poor (9–4 items), or poor walking quality (less than 4 items). To test the reliability of the scoring system, an interlater reliability study was done with an experienced child neurologist, resulting in 90% agreement on a pilot group of 12 children. All assessments were done by the same examiner who was blind to the history of the child. Each assessment took approximately 20 minutes and judgments made were rechecked on the video recording.

## RESULTS

Relative to the fullterm infants, the onset of walking in the preterm group, as a whole, was significantly later for chronological age as well as for corrected age as shown in Table 3. For comparisons between the preterm subgroups and the fullterm infants a one-way analysis of variance (followed by a post hoc Scheffe's range test) was used. This revealed that preterm appropriate-for-gestational age (PTAGA) children were still significantly later in the onset of walking than the fullterm infants, even after correction for age ( $P < .05$ ). When a distinction was made for gestational age within the preterm group, the younger preterm children ( $\leq 32$  wk) differed significantly from the older ones ( $P < .05$ ).

For the assessment of walking quality, there were only six fullterm and two preterm appropriate-for-gestational age infants who showed optimal walking performance. There were 11 fullterm, 10 preterm appropriate-for-gestational age, and only 1 preterm small-for-gestational age infant in the near-optimal group. The near-poor group consisted of two fullterm, one preterm appropriate-for-gestational age, and five preterm small-for-gestational age children. The two fullterm children in this group had shown low tone during the whole first year of life, but did not show any recognizable impairment or mental retardation. There were no fullterm children in the poor category, which contained eight preterm appropriate-for-gestational age and six preterm small-for-gestational age infants. Thus, the preterm small-for-gestational age children were overrepresented in the near-poor and poor group ( $\chi^2 = 5.71$ ;  $df = 1$ ;  $P < .02$ ). In accounting for gestational age, only one of the younger preterm infants ( $\leq 32$  wk) was in the optimal group and five in the near-optimal group; nine of them were in the poor and four in the near-poor group. Thus, 13 of the 19 younger preterm infants had poor to near-poor scores (Figures 1 and 2). All children in the study who were born both small-for-gestational age and at 32 weeks' or less gestational age ( $n = 7$ ) belonged to the poor outcome group ( $\chi^2 = 10.01$ ;  $df = 1$ ;  $P < .005$ ).

**Table 3. Onset of Walking in Days**

	FT ( $n = 19$ )		PT ( $n = 33$ )		<i>t</i>	<i>df</i>	<i>P</i>
	Mean	(SD)	Mean	(SD)			
Chronological age	436.3	(60.4)	537.5	(55.4)	6.14	50	.001
Corrected age			<b>481.2</b>	(49.0)	<b>2.94</b>	<b>50</b>	<b>.005</b>

	FT		PT AGA ( $n = 21$ )		PT SGA ( $n = 12$ )		<i>F</i>	<i>df</i>	<i>P</i>
	Mean	(SD)	Mean	(SD)	Mean	(SD)			
Chronological age	436.3	(60.4)	541.7	(60.5)	530.3	(46.8)	18.7	2/49	.001
Corrected age			<b>486.0</b>	(55.2)	473.3	(36.5)	4.49	2/49	.016

	FT		PT $\leq 32$ wk ( $n = 19$ )		PT $> 32$ wk ( $n = 14$ )		<i>F</i>	<i>df</i>	<i>P</i>
	Mean	(SD)	Mean	(SD)	Mean	(SD)			
Chronological age	436.3	(60.4)	565.7	(33.2)	489.2	(44.9)	35.06	2/49	.001
Corrected age			<b>500.1</b>	(32.8)	445.6	(44.2)	9.9	2/49	.0003

FT = fullterm; PT = preterm; AGA = appropriate-for-gestational age; SGA = small-for-gestational age.

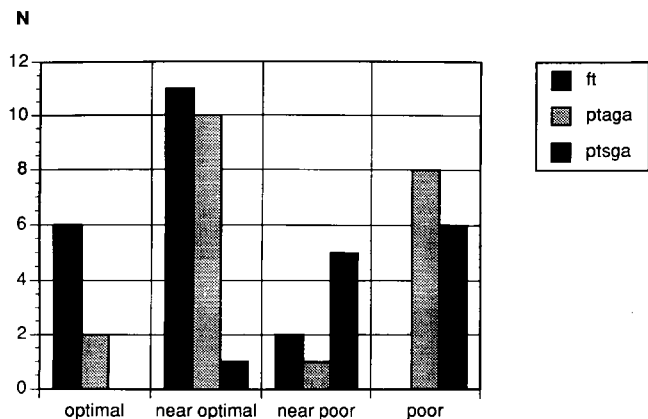


Figure 1. Comparison of walking quality in the fullterm and preterm appropriate-for-gestational-age, and the preterm small-for-gestational age groups.

The four areas of performance were all significantly related with each other. From Table 4 it is clear that children who had problems in walking free also showed a poor performance in standing, walking at speed, and picking up a toy.

**DISCUSSION**

The proposed optimal score for the quality of walking derived in the present study seems to be too stringent in that only six fullterm children were considered to be optimal. Most of the fullterm children were found in a near-optimal group, so it seems that the near-optimal score should be considered as an optimal outcome for children with little walking experience. The preterm group was not only significantly later in the onset of walking, even after correcting for gestational age, but they scored far worse in terms of movement quality, thus indicating the discriminant validity of the instrument. In particular, the preterm small-for-gestational age infants were overrepresented in the poor and near-poor categories. An explanation for this finding could lie in the mechanics of generating muscle power. However, since locomotion is an accomplishment of several interrelated components, the deviant walking quality seen in the preterm small-for-gestational age infants could be due to cerebellar or vestibular dysfunctions, which in turn influence movements through their roles in the regulation of tone and posture.

**Table 4. Correlation Coefficients**

	Standing	Walking	Walking at Speed	Picking up a Toy
Standing	1.00			
Walking	.60*	1.00		
Walking at speed	.56*	.84*	1.00	
Picking up toy	.49*	.55*	.69*	1.00

\*= significant correlations between the different areas.

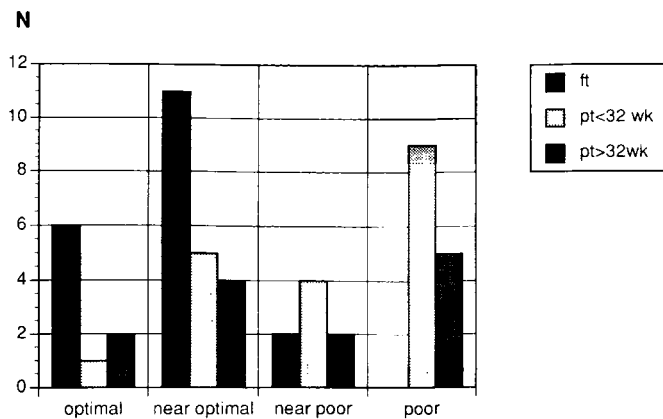


Figure 2. Comparison of walking quality in the fullterm and the preterm 32 weeks' and under, and the preterm over 32 weeks' gestation.

The delay of locomotion could be a sign of cerebral palsy. Our preterm group was delayed in the onset of this function, but none developed overt cerebral palsy. This is not surprising, since our study group consisted of low-risk infants. Nevertheless, subtle deviances in coordination and muscle power regulation were found. While some of the children in the poor group had combinations of symptoms such as asymmetry and coordination problems, they could not be classified as suffering from hemiplegia. Many of the asymmetries found may have their origin in the development of muscle power.<sup>12</sup> Preterm children seem to have more difficulties in the timing and regulation of muscle power. Coordination problems seen during picking up a toy and stopping locomotion could arise from these subtle deviances, involving the coordination of flexion and extension, which brings about problems in postural control and balance.<sup>13</sup> However, when we look at the symptoms found in the poor group, it is striking that none of the children had problems with the regulation of muscle power only, which indicates that there is no overt pathological subcortical and spinal involvement as seen in cerebral palsy.

This interpretation is in agreement with that drawn by Forslund and Bjerre<sup>14</sup> who did not find any differences in muscle power between their preterm and fullterm groups even at the age of 18 months. They observed normal knee and ankle jerks, but nevertheless gross motor functions were delayed in the preterm children. Dystonias, specifically hyperextension of the trunk and back muscles and hip extension, were prominent symptoms in their study. At younger ages, these symptoms have been described as occurring in preterm infants by a number of other authors<sup>15-18</sup> and are evidently related to a discrepancy between active and passive muscle power in such functions as sitting<sup>13</sup> and walking, in children born prematurely. These children seem to have more problems coordinating the sequence of flexion-extension activity, which in most cases disappears through practice and adaptation to the external environment, but in other cases remains observable as subtle disturbances in function.



The most striking finding in our study was that in preterm children, when divided into subgroups, the youngest ones ( $\leq 32$  wk) and the ones with the lowest birthweight (preterm small-for-gestational age) were overrepresented in the poor and near-poor walking groups. It seems plausible that those children born with a low birthweight or low gestational age show a different adjustment to the demands of upright locomotion. The regulation of muscle power needed for coordination and balance functions still gives rise to problems in some of those small and prematurely born children.

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## APPENDIX

### Walking Independently

#### A. Posture Standing

##### Trunk

##### Lordosis

1. strong
2. none
3. moderate

##### Scoliosis \*

1. strong
2. moderate
3. none

##### Legs

##### Exorotation \*

1. strong
2. moderate
3. none

##### Endorotation \*

1. strong
2. moderate
3. none

##### Straight legs

1. no
2. yes

##### Asymmetry \*

1. yes
2. no

##### Hip flexion\*

1. strong
2. none
3. moderate

##### Asymmetry \*

1. yes
2. no

##### Knees

1. constantly flexed
2. hyperextended
3. normal

##### Asymmetry \*

1. yes
2. no

### B. Walking

#### Feet while walking \*

1. exorotation
2. endorotation
3. semi straight

#### Asymmetry \*

1. yes
2. no

#### Toe-heel relationship

1. walks on tip toes
2. shuffles feet
3. normal strike whole foot

#### Gait direction

1. marked unsteadiness
2. some unsteadiness
3. straight and steady

#### Rhythm

1. very irregular
2. some variation
3. regular rhythm

#### Width

1. very broad
2. rather broad
3. optimal, legs under pelvis

#### Arm movements

1. too much abduction
2. moderate abduction
3. variable

#### Asymmetry \*

1. yes
2. no

### C. Walking at Speed

#### Start

1. stumbling start
2. hesitant start
3. fluent start

#### Gait

1. runs on tip toe
2. stumbles over feet
3. normal for age

#### Stop

1. stops by falling
2. stops while swaying
3. good stop

### D. Picking Up a Toy

1. cannot do it
2. can do it
1. poor balance, needs support
2. too much extension, sudden flexion
3. smooth extension-flexion, good balance

\*Items removed from original assessment instrument (further information discussed in text).