Early Human Development xxx (2013) xxx–xxx

Contents lists available at SciVerse ScienceDirect

Early Human Development

journal homepage: www.elsevier.com/locate/earlhumdev

Prediction of gross motor development and independent walking in infants born very preterm using the Test of Infant Motor Performance and the Alberta Infant Motor Scale

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ARTICLE INFO

Article history:
Received 5 February 2013
Received in revised form 29 April 2013
Accepted 30 April 2013
Available online xxxx

Keywords:
Concurrent validity
Predictive validity
Gross motor development
Prematurity
Independent walking

ABSTRACT

Background: One objective of a neonatal follow-up program is to examine and predict gross motor outcome of infants born preterm.
Aims: To assess the concurrent validity of the Test of Infant Motor Performance (TIMP) and the Alberta Infant Motor Scale (AIMS), the ability to predict gross motor outcome around 15 months corrected age (CA), and to explore factors associated with the age of independent walking.
Methods: 95 infants, born at a gestational age <30 weeks, were assessed around 3, 6 and 15 months CA. At 3 months CA, correlations of raw-scores, Z-scores, and diagnostic agreement between TIMP and AIMS were determined. AIMS-score at 15 months CA and parental-reported walking age were outcome measures for regression analyses.
Results: The correlation between TIMP and AIMS raw-scores was 0.82, and between Z-scores 0.71. A cut-off Z-score of −1.0 on the TIMP had 92% diagnostic agreement ($\kappa = 0.67$) with an AIMS-score < P10. Neither TIMP- nor AIMS-scores at 3 months CA were associated with the gross motor outcome at 15 months CA. The AIMS-scores at 6 months CA predicted the AIMS-scores at 15 months CA with an explained variance of 19%. Median walking age was 15.7 months CA, with which only the hazard ratio of the AIMS at 6 months CA and ethnicity were significantly associated.
Conclusions: Prediction of gross motor development at 15 months CA and independent walking was not possible prior to 6 months CA using the AIMS, with restricted predictive value. Cultural and infant factors seem to influence the onset of independent walking.

1. Introduction

Advantages in neonatal intensive care have improved the survival rate of infants born at younger gestational ages [1]. The incidence of infants with very premature birth (<32 weeks gestation) who survived the neonatal period was 9.6/1000 in 2008, and of infants <30 weeks 3.3/1000 according to the Netherlands Perinatal Registration (www.perinatreg.nl). The younger the gestational age (GA) or the lower the birth weight (BW), the more risk factors for delayed or impaired development [2–4]. Infants with a GA <30 weeks are at high risk, therefore their neuromotor development is often monitored in a neonatal follow-up clinic. One of the objectives of a neonatal follow-up program is to predict gross motor outcome and target those infants who might benefit from early intervention. For parents it is important to know if and when their child might start to walk independently [5,6].

Motor skill acquisition is influenced by infant, cultural and contextual factors [7,8]. Compared to their full-term born counterparts, infants born preterm are delayed in the onset of walking [9–12]. Infant factors, like neuromaturation, postural control, and muscle strength play an important role in the development of walking skills [13–15]. The Alberta Infant Motor Scale (AIMS) measures early gross motor development [16] and the Test of Infant Motor Performance (TIMP) postural and selective motor control needed for functional performance in early infancy [17]. The concurrent validity of these instruments, both designed to apply early in life, and their ability to identify infants with a suspect motor development has been described as fair to good [18–20]. Considering the different constructs of both tests, the question arose, which instrument would be of better clinical value predicting gross motor development in the neonatal follow-up. In the present

Abbreviations: TIMP, Test of Infant Motor Performance; AIMS, Alberta Infant Motor Scale; GA, Gestational age; BW, Birth weight; CA, Corrected age.

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http://dx.doi.org/10.1016/j.earlhumdev.2013.04.016

study we analyzed the predictability of gross motor development and independent walking in a birth cohort of infants born very preterm, comparing the two tests.

The objectives were:

1. To assess the concurrent validity and diagnostic agreement between the TIMP and the AIMS used at three months corrected age (CA) in infants born at <30 weeks of gestation or with a BW <1000 g.
2. To determine the ability of the TIMP and the AIMS to predict the level of gross motor maturation and independent walking around 15 months CA.
3. To explore predictors associated with the age of independent walking.

2. Methods

2.1. Design and subjects

The participants in this study were recruited as part of a longitudinal study on motor performance of infants born very preterm in or referred to a level three neonatal intensive care unit within one week of birth, from January 2009 through to October 2010. Inclusion criteria were: infants born at a GA <30 weeks or with a BW <1000 g, who participated in the neonatal follow-up program. Infants diagnosed with chromosomal, genetic, major neurological or sensory abnormalities were excluded. The Institutional Review Board previously approved the study and all parents provided informed consent prior to enrolment in the study.

In this prospective cohort study, all infants were examined three consecutive times by a pediatric physical therapist using the TIMP and/or the AIMS. The first author (JN) performed the first assessment using the AIMS and the TIMP in their home setting at three months CA (T1). The administration of the AIMS always preceded that of the TIMP. The next assessments, by one of three pediatric physical therapists (ICvH, MJCE or JN), took place in the neonatal follow-up clinic around six months (T2) and 15 months (T3) CA. All therapists had extensive experience with the assessment of infants born preterm.

2.2. Measurements

The TIMP is designed to identify infants with a developmental delay prior to four months of age. The test examines postural and selective motor control needed for functional performance in daily life in infants between 34 weeks post-menstrual age to 17 weeks post-term. Within 25–35 min, 13 items have to be observed and 42 elicited [17]. The TIMP was used only at T1. The AIMS is a standardized norm-referenced test to assess the gross motor repertoire of infants between 0 and 19 months. It consists of observations reflecting the level of maturation in four positions: supine, prone, sitting and standing [16]. The instrument requires minimal handling and can usually be completed within 10–20 min. Norm values for infants born with a GA ≤32 weeks are also described [21]. The AIMS was performed three times: at T1, T2 and T3.

At the age of three months, the TIMP and AIMS raw-scores have been shown to have a significant correlation of 0.64 in a mixed population, indicating a shared variance of 41% [19]. According to the same study, a cut-off value of −0.5 standard deviation (SD) from the mean TIMP score identified 80% of the same infants categorized as above or below the AIMS cut-off (P10) [18] for prediction of an abnormal developmental outcome. We wanted to examine whether these values for concurrent validity and diagnostic agreement were comparable in our cohort of infants born very preterm.

One item of the AIMS standing subscale is 'early stepping'. 'Early stepping' is defined as the ability of the infant to take five independent steps. According to the manual, 50% of the normative sample (n = 2200 Canadian infants) received credit for this item between 11 and 12 months of age, while 90% of the 14-month-old infants successfully performed this item [16]. The definition of independent walking used in our study was comparable to the item 'early stepping': ≥5 steps walking without support. The age of onset of independent walking was monitored and reported by the parents. If the infant had not yet reached the stage of independent walking at T3, the information was retrieved at the next follow-up visit or by e-mail.

To explore additional factors to predict independent walking, demographic data (gender, ethnicity), perinatal data (GA, BW, mode of delivery, multiple birth, Apgar score at 5 min), and medical history (duration of admission, duration of mechanical ventilation, diagnosis of chronic lung disease [Grades I–II] [22], necrotizing enterocolitis, sepsis, and cranial ultrasound findings during admission including intraventricular hemorrhage [Grades I–IV] [23] and periventricular leukomalacia [Grades I–III] [23,24]) were recorded. Ethnicity was defined based on the cultural background of the parents according to Statistics Netherlands (www.cbs.nl): Western (including Dutch) or non-Western (one or both parents).

2.3. Data analysis

Statistical analyses were performed in SPSS (version 20.0; IBM, Armonk, New York, USA). Frequencies, means, SDs, medians (interquartile range) and proportions were calculated where appropriate. The TIMP and AIMS raw-scores were converted into Z-scores. We analyzed correlations of the raw-scores and Z-scores at 3 months CA (Pearson) and sensitivity/specificity of cut-off scores of both tests (Kappa [κ] and a receiver operating characteristic [ROC] curve). The AIMS full-term norm values were used for the concurrent analysis with the TIMP at T1. In the prediction analysis the preterm norm values of the AIMS were applied [21]. Linear regression was used to determine predictive validity on the level of gross motor maturation. Age of walking independently is presented using Kaplan–Meier curves. Predictors associated with the age of independent walking were determined by using Cox proportional hazard regression [25], since the stage of this ability had not yet been established in some infants at the end of the study.

The incidence of plurality is high in cohorts of infants born preterm. Because a dependency in motor development is presumed among twins and triplets [26], selection of one of the surviving infants born from a multiple birth was performed at random for our analyses.

3. Results

During the study period, 158 infants born with a GA <30 weeks or a BW <1000 g started the neonatal follow-up program around term-equivalent age. Due to social reasons or long traveling distance to the hospital, the parents of 10 infants were not approached. Ten more parents declined to participate. From the remaining 138 infants, 17 (12%) had to be excluded due to medical conditions: two infants presented with a sensory system disorder (one auditory, one visual), seven with a congenital malformation or syndrome, and two with an obstetric brachial plexus lesion. Six infants were excluded due to severe brain abnormalities on the term-equivalent MRI and subsequently abnormal movement patterns or tone: three were diagnosed with a spastic unilateral cerebral palsy, one with severe psychomotor retardation, while in two infants the dystonia turned out to be transient. At T2 and T3, 3 and 5 infants respectively (8/121), no longer participated in the follow-up program and were subsequently excluded from all analyses. No significant differences were found in the characteristics of infants enrolled in the study compared with those whose parents declined participation, neither with the infants lost to follow-up or who missed one of the assessments.

The final study cohort consisted of 113 infants (Fig. 1) with a mean GA of 28 ± 1.6 weeks (minimum 24.7, maximum 32.0), and a mean BW of 1064 ± 241 g (minimum 570, maximum 1680). Six infants (5%) had a BW <1000 g, while their GA was ≥30 weeks. Eleven (10%) were small for GA, which was defined as a BW < P10 according to the reference

Please cite this article as: Nuysink J, et al, Prediction of gross motor development and independent walking in infants born very preterm using the Test of Infant Motor Performa..., Early Human Development (2013), http://dx.doi.org/10.1016/j.earlhumdev.2013.04.016