



High variability of individual longitudinal motor performance over five years in very preterm infants



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ARTICLE INFO

Article history:

Received 21 February 2016

Received in revised form 25 August 2016

Accepted 19 September 2016

Number of reviews completed is 3

Keywords:

Premature birth

Motor skills

Longitudinal studies

ABSTRACT

Aim: To determine longitudinal motor performance in very preterm (VPT) infants from 6 months to 5 years of age for the entire cohort of infants, according to gender and gestational age and at the individual level.

Method: Single-center, prospective longitudinal study of 201 VPT infants (106 boys) without severe impairments.

Outcomes: Motor performance was assessed with the Bayley Scales of Infant Development (BSID-II-MS: 6, 12, 24 months) and the Movement Assessment Battery for Children (MABC-2-NL: 5 years).

Results: At 6, 12, and 24 months and then at 5 years, 77%, 80%, 48%, and 22% of the infants, respectively, showed delayed motor performance ($<-1SD$). At 5 years, girls performed significantly better than boys in manual dexterity and balance.

Mixed model analyses: that examined interactions between time and gender and time and gestational age, revealed no significant interactions. The variance at child level was 29%. Linear mixed model analysis revealed that mean z-scores of -1.46 at 6 months of age declined significantly to -0.52 at 5 years. Individual longitudinal motor performance showed high variability.

Implications: Longitudinal motor performance improved almost 1 SD over five years. However, the variability of individual longitudinal motor performance hampers evaluation in clinical care and research.

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What this paper adds

This paper evaluates improvements in motor performance over time of individual VPT infants without known severe impairments. Longitudinal research with four assessment time points and the number of included infants is scarce. Norm-referenced motor tests are used in both clinical care and research to evaluate development over time. Such motor tests use norm tables to recalculate the raw scores into age-related scores to make the results comparable over age ranges. These norm tables are based on cross-sectional studies. We hypothesize that the high variability found in individual longitudinal motor performance in these VPT infants is at least partly due to cross-sectional gathered norm scores and statistical modeling. For future research we suggest sampling the norm scores based on longitudinal data and perhaps longitudinal modeling of typical development, including individual variability. These models are needed to evaluate motor interventions in clinical care and research.

1. Introduction

Very preterm (VPT) infants are those born at less than 32⁺⁰ weeks of pregnancy (World Health Organization [WHO], 2004). The WHO estimated that in 2015, 15 million infants globally every year were born before 37 weeks of gestation. Across 184 countries, the rate of preterm birth ranges from 5% to 18% (WHO, 2015).

In 2013 in the Netherlands, 12,921 (7.6%) infants were born before 37 weeks, and 2,577 infants (1.5%) were born before 32 weeks of gestation (Brouwers et al., 2014). These infants are at increased risk of developing neurodevelopmental impairments, vision and hearing impairment, growth failure, behavior problems, and chronic health problems (Vohr, 2007; Woodward et al., 2009).

1.1. Motor performance in VPT infants

A meta-analysis of 41 cross-sectional studies revealed that VPT infants are at risk for poor motor performance throughout childhood (de Kieviet, Piek, Arnoudse-Moens, & Oosterlaan, 2009). In the neonatal follow-up program, assessment of motor performance can therefore be considered an integral part of the clinical care provided to these infants. In its 2014 guidelines, the Dutch Neonatal Follow-Up Network lowered the gestational age (GA) for inclusion in its follow-up program from 32 to 30 weeks. Moreover, the GA cut-off for inclusion in follow-up and intervention programs varies among studies worldwide, making comparison difficult (Spittle, Orton, Anderson, Boyd, & Doyle, 2015).

Most of the infants included in follow-up programs are born at fewer than 32, 30, or 28 weeks of gestation. As a result of the differences in inclusion criteria, follow-up results show large differences in prevalence rates of delayed motor performance, varying from 15% to 70% (Williams, Lee, & Anderson, 2010). In their systematic review, Williams et al. (2010) recommended estimating the prevalence rates of performance in GA subgroups because none of the studies included in the systematic review had a sufficient number of participants.

In the studies, male VPT infants and the infants with the lowest GAs were most vulnerable to adverse neurodevelopmental outcomes (Kuban et al., 2016; de Kieviet et al., 2009; Larroque et al., 2008; Ment & Vohr, 2008). Infants born at a lower GA are also more at risk for delayed motor performance (Cooke, 2005), but no information on prevalence is available; therefore, we decided to analyze the results for the entire group and all GA subgroups. In our follow-up program, infants born at fewer than 32 weeks GA were included so that motor performance delay for different GA cut-offs could be calculated. Because girls, in general, tend to perform better than boys (Månsson, Fellman, Stjernqvist, & EXPRESS Study Group, 2015; Peacock, Marston, Marlow, Calvert, & Greenough, 2012), we also decided to analyze motor performance scores for both boys and girls.

1.2. Dynamic systems theory

The dynamic systems theory is used to understand infant motor development. Dynamic refers to how a system evolves over time. Motor development is seen as a complex system that evolves over time in interaction with the environment. Because the behavior is not specified, but emergent, the system can be said to be self-organizing. Thelen (1989) proposed a theory of infant motor development based on a dynamical system perspective (Kamm, Thelen, & Jensen, 1990). From a dynamic systems perspective, infant motor development is considered a nonlinear process and not a continuous process (Thelen, 1989). A child may have periods of rapid development alternating with periods of stable motor performance, and vice versa.

Motor development is influenced by many subsystems such as the nervous, musculoskeletal, perceptual, and affective system. These subsystems mature at different times and rates, and each one acts as a controller in the production of new behavior; a new behavior only emerges when all systems have reached a particular level, resulting in nonlinear development (Thelen & Ulrich, 1991).

In VPT infants the subsystems are less adapted for the challenges outside the womb. Therefore, the complex adaptive interaction with the environment results in different behavior. Ment and Vohr (2008) noted that the lower the infant's GA, the less the subsystems such as the nervous system are matured. This finding has consequences for the development of the brain (Lubsen et al., 2011). In a meta-analysis was found that VPT children from 8 to 18 years have a significantly smaller total brain volume ($d = 0.58$; 95% confidence interval [CI] = $0.43-0.73$) than a term-born comparison group. The VPT children

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