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Infant born preterm have delayed development of adaptive postural control in the first 5 months of life☆,☆☆

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ABSTRACT

Infants born preterm are at increased risk of developmental disabilities, that may be attributed to their early experiences and ability to learn. The purpose of this paper was to evaluate the ability of infants born preterm to adapt their postural control to changing task demands.

Methods: This study included 18 infants born at 32 weeks of gestation or less whose posture was compared in supine under 2 conditions, with and without a visual stimulus presented. The postural variability, measured with root mean squared displacement of the center of pressure, and postural complexity, measured with the approximate entropy of the center of pressure displacement were measured longitudinally from 2.5 to 5 months of age.

Results and discussion: The infants looked at the toys in midline for several months prior to adapting their postural variability in a manner similar to full term infants. Only after postural variability was reduced in both the caudal cephalic and medial lateral direction in the toy condition did the infants learn to reach for the toy. Postural complexity did not vary between conditions. These findings suggest that infants used a variety of strategies to control their posture. In contrast to research with infants born full term, the infants born preterm in this study did not identify the successful strategy of reducing movement of the center of pressure until months after showing interest in the toy. This delayed adaptation may impact the infants ability to learn over time.

1. Introduction

Healthy, typically developing infants learn about the world around them through the interaction between their abilities and their experiences (Gibson, 1988; Lobo, Kokkoni, Cunha, & Galloway, 2014; Lobo, Kokkoni, de Campos, & Galloway, 2014).

Abbreviations: RMS, root mean squared; COP, center of pressure; ApEN, Approximate Entropy; cc, caudal cephalic direction; ml, medical lateral direction.

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However, infants born preterm often have different early experiences in the Neonatal Intensive Care Unit (NICU) and medical factors that may alter their experiences in the first year of life (Als et al., 2004; Vandenberg, 2007). While it has been well documented that infants born preterm are at high-risk of cerebral palsy, developmental coordination disorder, and learning disabilities (Allen, Cristofalo, & Kim, 2011; Potharst et al., 2013; Serenius et al., 2013), there has been less research on how infants born preterm learn from the environment during the first year of life (Heathcock, Bhat, Lobo, & Galloway, 2004). In the following sections we will highlight the role of postural control, experience, and the ability to adapt postural control during development in healthy infants and infants born preterm. The purpose of this study is to fill knowledge gaps on the development of adaptive postural control in infants born preterm. Postural variability, postural complexity and adaptive postural control are important concepts in a modern understanding of postural development.

1.1. Postural control experience and adaptation

Postural control involves controlling the body's position in order to maintain an appropriate relationship between body segments and the environment while having stability (Prieto, Myklebust, Hoffmann, Lovett, & Myklebust, 1996). Through experience, infants learn to maintain postural control while interacting within an environment. This requires a complex interaction of developing systems including the sensory, motor, and physiological systems (Reed, 1982; Goldfield, 1995).

Postural variability is a measure of the magnitude of displacement of the center of pressure around a mean value, or the amount of sway utilized during a task. Historically, postural variability was considered to measure error in the postural control system (Stergiou & Decker, 2011). Postural complexity is the repeatability of the postural control strategy or degree of overlap in the sway paths during a task. Optimal postural complexity is a midrange of complexity in which the system is not completely repetitive (low complexity) or chaotic (very high complexity). Our previous research has evaluated the change in postural variability and postural complexity during the development of midline head control and reaching in supine in both infants born full term and preterm (Dusing, Kyvelidou, Mercer, & Stergiou, 2009; Dusing, Thacker, Stergiou, & Galloway, 2012; Dusing, Izzo, Thacker, & Galloway, 2014a; Dusing, Izzo, Thacker, & Galloway, 2014b). Our work, combined with that of others, has demonstrated inconsistency in postural variability while learning early motor skills. In contrast, a consistent pattern of higher postural complexity prior to and early in skill development followed by a reduction in complexity during the learning process has been documented during development of head control, reaching and sitting (Harbourne & Stergiou, 2003; Cignetti, Kyvelidou, Harbourne, & Stergiou, 2011; Dusing et al., 2012, 2014a, 2014b). Each of these studies demonstrated that early postural complexity facilitated the learning of developmental skills such as reaching, head control, and sitting. Early in skills development, non-repetitive postural control strategies (higher postural complexity) allowed the infant to experience movement and interact with the environment from multiple vantage points (Dusing et al., 2014a, 2014b). Thus, the infant could practice a variety of strategies. As the infant learns the skills, the infant can reduce the number of strategies, developing a set of preferred strategies. While the infant may continue to use the preferred strategies most of the time, the early experience using other strategies allows the infant to utilized the previous practiced strategies if a new task requires a non-preferred strategy (Dusing & Harbourne, 2010). Infant with neonatal brain injury show altered patterns of postural complexity with either chaotic or repetitive patterns early in skills development which may impact their development of new skills (Dusing et al., 2014a, 2014b).

Adaptive postural control is a term used in this line of research to describe the ability of an infant to change their postural variability and/or postural complexity in response to changing task demand or conditions. In healthy full term infants, adaptive postural control allowed infants to adjust their postural control strategy to changing task demands while reaching from supine (Dusing et al., 2012). These healthy infants reduced their postural variability or the magnitude of their center of pressure (COP) displacement when presented with a visual stimulus. However, they did not change their postural complexity between conditions. We proposed that this represented the healthy infant ability to still their body or reduce postural variability in order to visualize the toy and prepare for reaching, while maintaining non-repetitive postural control strategies and supplementing non-preferred but previously practiced strategies for the preferred strategies when needed. This adaptive response demonstrates flexibility in the postural control system allowing the infant to learn from their environment. To our knowledge no research has specifically assess the ability of infants born preterm to adapt their postural control to changing task demands in the first months of life. The aim of this paper is to fill this knowledge gap and provide an initial group analysis of the postural adaptability of infants born preterm.

1.2. Experience and adaptive motor control

Infants and fetuses learn about the world through their early experiences. Fetuses begin active movement in utero around 7 weeks of post-conceptual age (de Vries & Fong, 2006). Once initiated the movements of a fetus persist throughout gestation and by delivery are complex and variable, providing the infant with a wealth of perceptual motor experience (de Vries & Fong, 2006; Myowa-Yamakoshi & Takeshita, 2006). Infants in the first weeks of life demonstrate their ability to use sensory information to adapt their hand position to explore objects (Molina & Jouen, 2004; Lobo, Kokkoni, Cunha et al., 2014; Lobo, Kokkoni, de Campos et al., 2014). Infants as young as 3 months of age can learn to activate a mobile through their kicking in specific motor patterns, even if the pattern requires an uncoupling of typically coupled joint movements (Sargent, Schweighofer, Kubo, & Fetters, 2014). While infants demonstrate the early ability to learn from the environment and modify motor patterns, these learned adaptations are task specific and do not directly transfer from one task, such as crawling, to