



Full length article

Maturational and situational determinants of reaching at its onset



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ARTICLE INFO

Article history:

Received 27 January 2015

Received in revised form 1 June 2015

Accepted 10 June 2015

Available online 2 September 2015

Keywords:

Reaching

Gender

Infant

Motor development

ABSTRACT

At 3 months of age, reaching behavior was measured in a group of 10 girls and 10 boys born at term. The assessments were carried out on the average 2 days after reaching onset. Reaching kinematics was measured in both supine and reclined positions. Girls reached more than boys, had straighter reaching trajectories and movements of shorter durations as well as fewer movement units. The reclined position gave rise to straighter trajectories in both girls and boys. Several anthropometric parameters were measured. Girls had less length and volume of the forearm than boys but similar upper arm volumes. There was a weak relation between kinematic and anthropometric variables.

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1. Introduction

During the first months of life, infants exercise forward extended movements towards objects in their surroundings. However, only at around 3–4 months, the forward extended movements begin to be successful, that is, they end up on the object that has elicited the reach (von Hofsten, 1984; Thelen et al., 1993). The onset of purposeful reaching provides infants with opportunities to manually explore and manipulate the environment (Lobo & Galloway, 2013; Thelen et al., 1993; von Hofsten, 1984). To begin with, at around 3–4 months of age, the movements are poorly coordinated, with fragmented and irregular trajectories (Rocha, Silva, & Tudella, 2006; Konczak & Dichgans, 1997; Thelen, Corbetta, & Spencer, 1996). In this initial learning period infants begin to find solutions to the movement control problems (Corbetta, Thelen, & Johnson, 2000; Thelen et al., 1993; Gibson, 1986). The purpose of the present study is to examine quantitatively to what degree these solutions are a function of maturational factors and how they depend on the situation. We analyzed the reaching characteristics of infants on the average 2 days after reaching onset with respect to gender (a maturational factor) and reaching position (a situational factor).

One important consideration concerns the way postural control is implemented in the very first successful reaches. For instance, previous research is inconclusive about which mechanism can best explain previously found differences

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between reaching in supine and reclined position: torque differences or differences in feedforward processing. Postural stability and activation of postural muscles are closely related to the improvement of reaching performance as they facilitate the adoption of more efficient strategies for touching and grasping objects (Bakker, De Graaf-Peters, van Eykern, Otten, & Hadders-Algra, 2010; Bertenthal & von Hofsten, 1998; De Graaf-Peters, Bakker, van Eykern, Otten, & Hadders-Algra, 2007; Hopkins & Rönnqvist, 2002; Out, van Soest, Savelsbergh, & Hopkins, 1998; Rochat & Goubet, 1995; Savelsbergh & van der Kamp, 1994). Thus, different body positions may affect reaching performance differently (Carvalho, Tudella, & Savelsbergh, 2007; Wimmers, Savelsbergh, Beek, & Hopkins, 1998). This happens because even if the task is the same in the different positions, the forces that act on the upper limbs and the demands on the motor system are quite different (Out et al., 1998). Studies have demonstrated that a supine posture generates higher muscle torques at the beginning of reaching movement and leads to instability of the upper limbs, which hampers the movement quality (Out et al., 1998; Carvalho et al., 2007; De Graaf-Peters et al., 2007). Furthermore, in 4–6-month-olds it has been observed that seated reclined (70° from the horizontal axis) position promotes more reaching movements with shorter duration and lower deceleration (Carvalho et al., 2007). It has been suggested that this is due to the diminished torque demands of the reclined posture (Savelsbergh & van der Kamp, 1994). However, Out et al. (1998) concluded that 8- to 20-week-old infants had similar levels of shoulder torque in supine and reclined positions. Differences in reaching behavior were suggested to be due to the degree of error in feed-forward control signal.

Another inconclusiveness in earlier research concerns gender differences. It has been found that boys are heavier, longer, and have greater head circumference at birth than girls (Voldner, Frey Frosli, Godang, Bollerslev, & Henriksen, 2009). It is therefore possible that this has implication for early motor behavior. Touwen (1976) investigated a large variety of milestones and found appreciable gender differences in several of these. He concluded that while boys develop somewhat faster in gross motor tasks, girls appear to be more forward in functional tasks such as grasping. Cossette, Malcuit, and Pomerleau (1991) reported that the number of arm movements begin to increase from 2.5 months of age irrespective of gender. De Campos et al. (2013) reported that typically developing boys performed more reaches than girls at 4 months of age. In a different context, Piek, Gasson, Barrett, and Case (2002) found that during spontaneous movements in supine position, 4-month-old girls show more synchronous movements of the two upper limbs than boys. According to the authors, at 4 months of age girls have tighter synchrony between the joints of the two arms than boys. Taken together, there are only weak evidence of better coordination in girls than in boys at the onset of successful reaching. One reason might be that subject groups in earlier studies were mainly determined by age. In contrast, the subject groups in the present study were defined by the onset of reaching. The subjects were selected as early as possible, that is, on the average 2 days after reaching onset.

Anthropometric measures may also be of importance for gender differences in early reaching. Studies have shown that boys have, on the average, 5 mm longer upper limbs compared to girls (Davenport, 1944; Thomas & French, 1985) and 2 mm longer radius and hands during the first postnatal year (Davenport, 1944). Specifically at 3–5 months of age, when the onset of reaching occurs, boys have, on the average, higher body weight (7.25 kg), greater mid-arm circumference (14.1 cm) and longer length of upper limb (12.8 cm) compared to girls (6.75 kg; 13.8 cm, 12.2 cm [McDowell, Fryar, Ogden, & Flegal, 2008]). This difference continues up to adolescence (Malina & Bouchard, 1991). Since anthropometric data reflect infants' developmental status (McDowell et al., 2008), upper limb measures have to be taken into consideration when comparing the differences in reaching performance between boys and girls. It is expected that boys have higher volumes of the upper arm and the forearm than girls and that this may have consequences for the control of arm movements.

Considering that girls at this early age have been found to be more advanced in reaching than boys (Touwen, 1976), and that their fine manual control is more advanced at 30 to 60 months than boys (Drachler, Marshall, and Leite (2007), we hypothesize that they perform more precise and fluent reaches than boys at this early age. Thus, we expect that reaches of young girls are faster, straighter, with fewer movement units and with less time required to decelerate the arm before touching the object compared to boys. As the length of the upper limb differs between girls and boys throughout development (Davenport, 1944; Malina & Bouchard, 1991), their arms were measured and correlated with the kinematic parameters of reaching.

2. Method

2.1. Design and participants

The study was cross sectional. Twenty healthy infants participated. They were born at 37 to 41 weeks gestational age ($M = 39.3 \pm 1.2$ weeks) and were 3–4 months old at the time of testing ($M = 13.1$ weeks ± 0.8). There were 10 girls (13.0 ± 0.6 , weeks old) and 10 boys (13.3 ± 1.3 , weeks old). The chronological and the gestational ages were similar in both groups. The infants performed between the 25% and 75% at the Alberta Infant Motor Scale (AIMS), indicating typical gross motor development (Piper & Darrah, 1994).

2.2. Procedures and equipment

The study was approved by the Ethics Committee of the Federal University of Sao Carlos (protocol no. 516/2009). Infants' parents were recruited by telephone from health center records in the city of São Carlos (São Paulo, Brazil). From two weeks before the infants' three-month birthday, the examiner contacted the parents by phone, informed them of the nature of the

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