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Shifting of the body center of gravity in low-risk preterm infants: A video-pedoscope study

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ABSTRACT

Aim: To evaluate whether there is any developmental course of the shifting of the center of gravity (COG) in healthy preterm infants.
Methods: Eleven healthy preterm infants were assessed on a computerized pedoscope from early preterm to term age. Data from the pedoscope and the videorecorder were analyzed with a special software for the assessment of the COG shifting. Infants were placed on the pedoscope in supine position for 5 min. We scored the positions of the COG during its shifting, the body parts most frequently involved in its shifting and the shifting' amplitude at each epoch. We scored the frequency of the COG shifting in head, trunk and bottom, its direction and amplitude using a semi-quantitative scale.
Results: A developmental course of the COG shifting from preterm throughout post-term ages was demonstrated, with COG position displaced from head to bottom. The shifting amplitude decreased with increasing age. Lateral shifting were never observed.
Interpretation: The developmental course of the COG shifting suggests the maturation of postural behaviour in healthy preterm infants. The displacement of the COG from head to bottom and the reduced amplitude of the COG shifting from preterm to post-term age indicates a more stable body position.

1. Introduction

Several studies have been dedicated to the posture and body position of preterm infants but only few of them have been specifically dedicated to balance and its development in newborn infants during the first months of life [1–3].

During their first weeks of life, newborn infants seem to be poorly adapted to counteract the force of gravity due to the low muscle power and to a delayed maturation of the neural mechanisms responsible for postural behaviour in relation to space. They have a variable but limited repertoire of body postures which seem to lack systematic responses to the orientation in space. These age-specific postures are proprioceptive driven and the vestibulum system seems to be scarcely involved. Hence, they are referred as “body-oriented postures”. At the beginning of the third month post-term age (PTA), a major transformation of many neural functions takes place. In addition, infants show their balancing strategies against the force of gravity. Responses to positional changes are clearly antigravity and turn the posture now into “space-oriented”. The transition from “body-oriented” to “space-oriented” postures demonstrates a new adaptation to the extra-uterine environment [2,3].

This adaptation develops parallel to the General Movements (GMs) occurring. GMs are age-specific patterns, involving the entire body in a variable sequence of arm, leg, neck and trunk movements. They are variable in intensity and speed with a gradual onset and offset [4].

As far as the posture in the preterm period is concerned, it has been reported that 30-week-old preterm infants have a dominant flat posture with beginning of flexion of hips and knees [5,6]. By contrast, such an age-specific preference posture could not be confirmed by other studies [7–11]. In their study on motor and postural behaviour in low-risk

Abbreviations: COG, center of gravity; PMA, postmenstrual age; PTA, post-term age; NICU, Neonatal Intensive Care Unit; GMs, general movements; COP, Center of Pres

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preterm infants, Ferrari and colleagues [12] confirmed earlier findings that relevant motor and postural changes take place between preterm age and the third to fourth month PTA [2]. The preterm infant's body posture at 30 to 33 weeks is predominant flat: hips, shoulders and trunk lie flat on the mattress and the head is turned to one side. Increasing hip adduction from the initial flat position and shoulder lifting from the mattress are observed in a large number of preterm infants when they are 43–54 weeks PMA [12].

Spontaneous motility also changes from preterm to post-term age, as it is influenced by development of posture: abrupt movements (such as sudden opening of the fingers, abrupt hand and/or limb movements, rolling to side, frozen postures of arms and legs) pointing to loss of balance-like movements during general movements are common at preterm and term age and tend to disappear when the infants is 46–54 weeks PMA [12]. These movements may be of concern for the Neonatal Intensive Care Unit (NICU) healthcare professionals as they are accompanied by heart and respiration instability: cry and even apneas may be seen after these abrupt movements. These movements are also of concern for the parents when they handle their baby.

According to the infant and family-centered individualized developmental care principles and to the single unit guidelines, in the NICU the parents are taught to wrap the infants with a soft, loosen piece of cloth when they are ready for the kangaroo mother care and/or during breast or bottle feeding [13]. Sleep should be promoted by regulating the microenvironment (sounds, light and activities), by nesting the infants in an individualized nest, by adopting different postures which promote and facilitate movements close to the infant's body [14].

If the best environment has to be offered to the infants born preterm at five months of corrected age we need to know more about postural behaviour and its development at early ages.

One major item of postural behaviour is the shifting of the body's center of gravity (COG). The shifting maintains the COG aligned and stable within the weight bearing surfaces and by doing that it contributes to generate those continual postural adjustments that ensure a stable posture against gravity [15].

Maekawa et al. [16] analyzed the movements of the COG and changes in activities of the extremities in term infants lying in supine or prone position on a pedoscope. They noted that the quantity of movements of the COG and of the extremities increased at an early postnatal stage, followed by a decrease before increasing again. According to the authors, this was the result of a difference in muscle tone: after birth the muscle tone decreases and it increases again as soon as the adaptation to the extra-uterine environment is over. Mewes Gaetan and Moura-Ribeiro [17] studied the development of postural behaviour in preterm and full term infants by means of a special table with an acrylic top and a mirror angled at 45° on which the infants were placed in supine, prone and sitting position. They demonstrated that both preterm and full term infants presented a sequential development of postural behaviour during their first three months of age, but motor performance of some preterm infants at the same level of ability proved to be less mature compared to the full term infants.

Another study demonstrated that infants born at full term exhibited displacements of the Center of Pressure (COP) in the caudal-cephalic direction, which were smaller in amplitude, but likely more complex or less predictable, than those of infants born preterm. According to these authors, infants born preterm exhibited a less stable posture and more stereotypic patterns of movement, resulting in large, but repetitive, COP excursions [18,19].

We addressed the following questions: how does the COG shifting develop from preterm to early post-term age? Does the width of the COG shifting have a developmental trend from the preterm to post term age? Is there any temporal correlation between GMs and COG localization?

2. Materials and methods

2.1. Subjects

Twelve healthy preterm infants, born at the University Hospital of Modena, were recruited for this study. One infant was transferred to a far-away regional hospital after the first video recording. Hence, the final study group consisted of 11 infants, 5 girls and 6 boys. Postmenstrual age at birth ranged from 26 to 32 weeks (median 29 weeks), birth weight was between 680 and 1400 g (median 1040 g). The Ethics Committee of the University Hospital of Modena approved the study and all the parents of the infants signed informed consent. Beside preterm birth, the selection criteria were the following: birth weight > 10th and < 90th centile [20], uneventful pregnancy and delivery according to a detailed list of pre- and perinatal optimal conditions [21], absence of clear neurological syndromes, absence of severe sepsis, absence of chromosomal defects or other recognizable malformations of the brain or other organs, and absence of metabolic disorders.

All study cases needed respiratory support from day 1 to 6, and all infants had CPAP for a few days. Ultrasound scans, serially performed from birth until term age, were normal in 6 infants, transient increased echogenicity was found in 3 infants, intraventricular hemorrhage (IVH) grade 1 in one infant and prolonged increased echogenicity in one infant (Table 1) [22]. All participants had a normal neurological outcome at 2 years of age according to the Griffiths developmental scale [23,24].

2.2. Experimental protocol

The definitions for COG and balance have to be cleared before focusing on the study in details. The COG is defined as the point in a body of matter about which the weight is evenly balanced in any position; balance is the condition that exists when two opposing forces are equal [25]. For the assessment of the shiftings of the COG, we used a computerized pedoscope (produced by BAT Buratto Advanced Technology S.r.l., Treviso – Italy) which is a baropodometric platform with a dedicated software, and a videorecorder connected to a computer with a special software. The infants were placed on the pedoscope in supine position dressed only with a nappy for 5 min.

Each infant was assessed at three different epochs: 33–37 + 6 weeks, 38–42 + 6 weeks and 43–46 + 6 weeks PMA. Three infants were not assessed at 33–37 weeks because their weight was too low for the pedoscope recording sensors, although the weight was higher than 10th percentile for PMA.

From 38 to 42 weeks onwards, a 1-minute state assessment was performed before we started the pedoscope recording. The infants were recorded only if they were awake, not crying, otherwise the recording was stopped or postponed, according to the GMs assessment method. The pacifier was not allowed during recordings as it is known to modify the posture of the infants.

The observation started 10 s before the infants began to move to assess the COG at rest as well. The pedoscope analysis and the video recording of the infants' posture and movements started simultaneously due to a special synchronizing software. We observed every position of the COG displayed during its shifting and we assessed the body parts inside which the COG shifted most frequently at each epoch during the video recording. We also scored the direction and amplitude of the COG shifting.

For each epoch, we observed how frequent the COG was present in every body part (head, trunk and bottom) and we scored the body part in which the COG was displayed most frequently by means of a semi-quantitative plus (+) scale; + indicating occasional, + + frequent, and + + + very frequent. We applied the same scoring for the direction, vertical and horizontal shifting.

We classified the amplitude of the COG shifting as large (category 1), medium (category 2) and small (category 3).