Electromyographic activity of head and trunk muscles in newborns

Atividade eletromiográfica dos músculos da cabeça e do tronco em recém-nascidos

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Abstract

Introduction: The electric activity of muscles can be assessed using electromyography to determine their function and help identify possible delays in motor development. Objective: Determine the amplitude of the electromyographic activity of the head and trunk flexor and extensor muscles of term and preterm newborns. Method: This is a longitudinal pilot study where 20 preterm and 20 term newborns admitted to the Prof. Fernando Figueira Institute of Comprehensive Medicine were assessed. All the newborns were evaluated between 24 and 72 hours after delivery, with the premature children assessed a second time when term equivalent age was reached at 40 weeks. Data were recorded using a surface electromyograph and the electrodes were attached to the muscle bellies of the sternocleidomastoid, upper portion of the trapezius, rectus abdominis and erector spinae muscles. Results: Comparison of the electromyographic activity between the preterm newborns showed significantly higher values in all the muscles when the group reached term equivalent age. Additionally, the electromyographic activity of the term group was greater than that obtained by the preterm newborns. Conclusion: With advancing age and maturation of

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The World Health Organization (WHO) defines prematurity as a child born after less than 37 weeks of pregnancy [1]. Prematurity has been linked to greater risk of motor development deficits, mainly when its behavior is compared to that of term babies [2,3]. Motor development is influenced by biological and environmental factors in terms of performance in acquired motor skills [4,5].

Delayed motor development is typically associated with the presence of hypotony in preterm newborns, who exhibit extension postures in the supine position. By contrast, term babies display flexion in the same position [6], in addition to the absent or diminished primitive reflexes and reduced spontaneous movements, according to the degree of prematurity [7].

Given that the head movements of children are an important influence on subsequent motor development acquisition [5], efficient organization of shoulder, trunk and neck muscles is essential [8]. Trunk control, which stabilizes posture [9], initiates with antigravitational domination of the head, followed by control of the upper, middle and lower thoracic and lumber regions [10,11].

Thus, dorsal and ventral muscle activity development is in the cephalocaudal direction, with the neck and trunk muscles activated in that order [12,13]. As such, specific and targeted synergy of these muscles is needed [12] to maintain body alignment and control during functional activities [14].

In this development process, an important tool in evaluating the electrical activity of newborn muscles is electromyography [15], which assesses alterations in electric power from the depolarization of muscle fibers at rest and during voluntary contractions [16,17], enabling a detailed analysis of muscle function and identification of atypical motor behavior.

Although clinical assessment of the newborn development of babies is well established [18], little is known about the electromyographic activity of their...
head and trunk flexor and extensor muscles, which are vital in achieving the main motor milestones. The aim of this study was to determine the amplitude of electromyographic activity of the head and trunk flexor and extensor muscles in term and preterm infants.

**Method**

This is a longitudinal pilot study conducted at the Prof. Fernando Figueiro Institute of Comprehensive Medicine (IMIP), in Recife, Brazil, between March and November 2018. The project was approved by the IMIP Human Research Ethics Committee under protocol CAAE: 61377516.3.0000.5201. All participants provided written informed consent.

A total of 40 newborns of both sexes were included, 20 preterm (PTNB) and 20 term (TNB) with gestational age between 28 and 34 and 37 and 40 weeks, respectively, admitted to the Intermediate Kangaroo Care Unit (UCICA) and nurseries of the institution. Excluded were those born with 5-minute Apgar scores of less than 7, grade III or IV intracranial hemorrhage, convulsion, congenital infection, post-natal infections of the central nervous system (meningitis or encephalitis) or malformations in the central nervous system and submitted to the kangaroo position.

Clinical data were collected from the children's medical charts, and myoelectric data obtained using a Miotool 400® electromyograph (Miotec Equipamentos Biomédicos – Brasil). All the newborns were assessed between 24 and 72 hours after delivery and the PTNB were evaluated again after reaching term equivalent age (NB-TEA) at 40 weeks. These newborns were clinically stable, tolerating food well and breathing without the help of devices or oxygen therapy.

The newborns were placed in dorsal decubitus to assess the rectus abdominis and sternocleidomastoid muscles and in lateral decubitus for the trapezius and erector spinae muscles, on a 30° wedge mat, in relation to the horizontal plane. A system of channels and self-adhesive electrodes (Meditrace 100 - Infantil®), 3 cm in diameter, were used to connect the newborn baby to the signal acquisition system. The recording electrodes (two on each muscle) were placed (unilaterally), in order, on each of the muscle segments: sternocleidomastoid, rectus abdominis, erector spinae and trapezius, with one muscle assessed at a time. The electrodes were placed on the central portion of the muscle belly, between the motor point and myotendinous junction, and arranged parallel to the muscle fibers, according to surface electromyography recommendations for noninvasive muscle assessment (SENIAM) [19]. In the case of the trapezius muscle, the electrode was placed on the upper portion. The reference electrode was always positioned on the right lateral malleolus.

In order to evaluate electromyographic activity, the root mean square-transformed values recorded during signal quisition were used. The signal was collected over a 60-second electromyographic reading, but only a 10-second window was used. When active newborn movements occurred during the recording, the electromyographic signal was rejected and a new recording performed. The Myographic 2.0 program (Miotec Equipamentos Biomédicos – Brasil) was used and the signals stored in a laptop computer.

The statistical comparison of the data collected (clinical and electromyographic) occurred as follows: The Student's t-test for independent samples was applied between the TNB and PTNB groups and the Student's t-test for paired samples in the PTNB group between the first and second assessment. The alpha error to reject the null hypothesis was p<0.05. The Sigma-Stat program, version 3.5 5 (Systat Software Inc – USA), was used for statistical analysis.

**Results**

The newborns' clinical and biological characteristics were similar in maternal age and Apgar scores. Intergroup comparison showed that the weight (p<0.001) and gestational age (p<0.001) of the preterm newborns was lower than that of the TNB (Table 1).

A comparison between the electromyographic activity of the PTNB group showed significantly higher values in all the muscles when the group reached term equivalent age (Table 2).

TNB electromyographic activity at birth was higher than that found in the PTNB group (Table 3). However, there was no statistical significance in any of the muscles assessed when the electromyographic activity of TNB was compared with that of the newborns at term equivalent age (Table 4).
Table 1 - Maternal and newborn characteristics at birth

| Variables                              | PTNB (n=20)       | TNB (n=20)       | p-value*     |
|----------------------------------------|-------------------|------------------|--------------|
| Maternal age in years (mean± SD)       | 24.25 ± 8.61      | 25.75 ± 6.74     | NS           |
| NB gestational age in weeks (mean± SD) | 31.63 ± 2.75      | 37.52 ± 0.99     | < 0.001      |
| Corrected gestational age in weeks     | 32.9 ± 1.97       | 39.4 ± 1.19      | < 0.001      |
| Birth weight (g)                       | 1438.5 ± 346.17   | 3168 ± 443.72    | < 0.001      |
| 5-minute Apgar, Mean (min-max)         | 8.64 (6-10)       | 9.35 (8-10)      | NS           |

Note: PTNB = Preterm newborn. TNB = Term newborn. SD = Standard deviation. NB = Newborn. G = gram. NS = Non-significant. *t-test for independent samples.

Table 2 - Electromyographic activity (RMS) of the rectus abdominis, sternocleidomastoid, trapezius, and erector spinae muscles in PTNB and NB-TEA

| MUSCLES                  | PTNB (Mean ± SD) | NB-TEA (Mean ± SD) | p-value* |
|--------------------------|------------------|---------------------|----------|
| Rectus abdominis         | 19.73 ± 6.08     | 25.60 ± 5.90        | 0.008    |
| Sternocleidomastoid      | 16.19 ± 8.27     | 21.61 ± 3.13        | 0.030    |
| Trapezius                | 18.96 ± 9.44     | 25.19 ± 7.73        | 0.039    |
| Erector spinae           | 12.76 ± 5.92     | 20.07 ± 8.26        | 0.008    |

Note: PTNB = Preterm newborn. NB-TEA = Newborn at term equivalent age. SD = Standard deviation. RMS = Root Mean Square. *paired t-test.

Table 3 - Electromyographic activity (RMS) of rectus abdominis, sternocleidomastoid, trapezius and erector spinae muscles of PTNB and TNB

| MUSCLES                  | PTNB (Mean ± SD) | NB-TEA (Mean ± SD) | p-value* |
|--------------------------|------------------|---------------------|----------|
| Rectus abdominis         | 19.73 ± 6.08     | 29.71 ± 10.24       | 0.003    |
| Sternocleidomastoid      | 16.19 ± 8.27     | 23.19 ± 5.35        | 0.012    |
| Trapezius                | 18.96 ± 9.44     | 25.18 ± 5.22        | 0.025    |
| Erector spinae           | 12.76 ± 5.92     | 19.24 ± 8.05        | 0.014    |

Note: PTNB = Preterm newborn. TNB = Term newborn. SD = Standard deviation. RMS = Root Mean Square. *t-test for independent samples.

Table 4 - Electromyographic activity (RMS) of the rectus abdominis, sternocleidomastoid, trapezius and erector spinae muscles of NB-TEA and TNB

| MUSCLES                  | NB-TEA (Mean ± SD) | TNB (Mean ± SD)  | p-value* |
|--------------------------|-------------------|------------------|----------|
| Rectus abdominis         | 25.60 ± 5.90      | 29.71 ± 10.24    | 0.177    |
| Sternocleidomastoid      | 21.61 ± 3.13      | 23.19 ± 5.35     | 0.348    |
| Trapezius                | 25.19 ± 7.73      | 25.18 ± 5.22     | 0.998    |
| Erector spinae           | 20.07 ± 8.26      | 19.24 ± 8.05     | 0.786    |

Note: NB-TEA = Newborn at term equivalent age. TNB = Term newborn. SD = Standard deviation. RMS = Root Mean Square. *t-test for independent samples.

Discussion

According to the results obtained, the amplitude of electromyographic activity of the axial muscles of premature newborns at birth is lower than that of term newborns, but upon reaching term equivalent age, the prematures exhibited the same electromyographic activity as that of term newborns. This result indicates that the motor activity of preterm newborns only receiving basic clinical care may develop adequately.
The trapezius and sternocleidomastoid muscles studied here are responsible for controlling the head, which is important in postural control and precedes the subsequent functional motor skills [20, 21]. Rocha et al. [22] analyzed the postural control of typical infants aged between 0 and 4 months, in supine and prone postures and found that their motor behavior in the first month of life varied considerably, but upon reaching the second month, this variability decreased, exhibiting more stable motor behavior. This may be due to acquiring better biomechanical alignment and postural stability, in addition to flexor-extensor phase transition [22]. Although we did not study motor behavior variability of term children from birth to the first month of life, preterm babies at birth exhibited a variation in their motor activity, identified by standard deviations of around 30 to 50% of mean values. However, when reaching term equivalent age, this variability became much smaller, between 14.5 and 40% in the different muscles.

These results are noteworthy because it was also observed [23] that the postural control of preterm and term babies at 15 days, 1 month, 2 months and 3 months of life exhibited a similar sequence to that of term newborns. Petti et al. [24] assessed the development of cervical control in 18 infants applying the TIMP scale (Test of Infant Motor Performance), at 4 months of age, with gestational age corrected in the preterms. The authors found no significant intergroup differences in the development of cervical control over the months, but term babies obtained a higher score than that of preterms in items 32, 35 and 36 on the TIMP scale. By contrast, the findings of the present study differed from those of Sato and Tudella [25], who assessed the level of trunk control in late preterm newborns with corrected age, and term babies between 6 and 8 months of age, where the former displayed delays in acquiring trunk control when compared to the latter.

Another study [26] investigated the development of postural adjustments during the reaching movements of premature babies. This study assessed 12 preterms between 4 and 18 months of corrected age, using electromyography in different postures: supine, sitting semi-reclined, sitting vertical with and without support. The authors found that preterm newborns reached successfully and were able to sit without support but were more delayed when compared to term babies. This is because premature babies may experience delays in motor development [27,28].

Diniz KT et al. [29] used surface electromyography to investigate the effect of the kangaroo position on brachial and ischiotibial biceps (biceps femoris) in premature newborns, concluding that the kangaroo position increased short-term electromyographic activity in the group submitted to that position.

Although the evidence indicates that birth weight influences the motor behavior of infants and children [30,31], Manacero and Nunes [32] showed that premature infants divided into groups below and above 1,750g exhibited a progressive sequence of motor skills and that there was no influence of birth weight on acquiring motor patterns when the percentiles were assessed by the Alberta Infant Motor Scale (AIMS). This was also observed in the present study, where there was a significant difference between the weight of PTNB and TNB, but the muscle activity of the NB-TEA was the same as that of the TNB. Similarly, Volpi et al. [33] conducted a longitudinal study of preterm infants free of neurosensitive sequelae with weight <1,500g and gestational age < 34 weeks, and found that very low birth weight premature acquired their motor skills within the limits expected for corrected ages.

The main limitation of this study was the absence of motor development assessment that correlated with the electromyographic activity of the newborns. This limitation demonstrates the need for more studies in the area.

**Conclusion**

The results obtained lead us to conclude that as preterm infants age and their physiological systems mature, including the muscle system, they tend to exhibit a similar muscle activation behavior to that of term newborns, thereby enabling normal motor development for the corrected age.

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