Development of a technique for evaluating temporal parameters of sucking in breastfeeding preterm newborns

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Abstract

Aims: The aim of the current study was developed and test the reliability of a technique for measuring temporal parameters of sucking in breastfeeding infants.

Methods: The technique was developed using a cohort of 11 term and 12 preterm infants, and subsequently evaluated using a cohort of 43 preterm infants. Measurements related to sucking pressure in the term and preterm infants were acquired. The signals were recorded for 5 min, saved on a computer, and stored for analysis. For purposes of analysis, the minute with the highest quality signal was chosen. Signal analysis was performed by two researchers, and inter- and intra-observer agreement was assessed. The newborns in the sample had different gestational ages.

Results: A technique was developed for the analysis of temporal parameters of sucking during breastfeeding and evaluated in 43 preterm infants with different gestational ages for the following variables: number of bursts per minute, number of sucks per burst, sucking rate, pause rate, and duration of pauses. The intra-observer agreement was 0.85 and the inter-observer agreement was 0.85.

Conclusions: The technique that was developed and validated proved capable of measuring temporal parameters of sucking in breastfeeding newborns.

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1. Introduction

Suckling is the ideal way to feed any newborn; however, preterm infants do not suck when they are born due to the immaturity of their sucking–swallowing and breathing patterns and their clinical condition. Preterm newborns' non-nutritive sucking and nutritive sucking skills and the anatomy of their oral structures should be evaluated as soon as they are clinically stable [1]. The newborn's capacity to perform non-nutritive sucking is evaluated with the clinician's gloved finger, and nutritive sucking is evaluated with a bottle, cup, or breastfeeding; however, these procedures provide only subjective information.

The majority of the published studies on sucking parameters have been conducted with artificial nipples [1–9], and it is not known whether these results can be used as references for breastfeeding. For example, the literature includes reports of computerized techniques using pressure transducers and electromyography to assess nutritive sucking parameters. These techniques collect objective data on temporal parameters of sucking while allowing observation of the coordination of jaw and cheek movements and the lip seal by using visual feedback. In these studies, positive and negative pressure changes generated during milk extraction correspond to the mechanism of nipple expression and sucking [2, 3, and 4].

The aim of the current study was to developed and test the reliability of a technique for measuring temporal parameters of sucking in breastfeeding infants.

2. Methods

The study was approved by the Fernandes Figueiras Institutional Review Board/Research Ethics Committee and by the neonatal unit where the research was conducted. Informed consent was obtained from the parents/guardians of the newborns prior to their participation in the study.

The study was divided into two stages: the first for development of the technique and the second for test the reliability of this technique in newborns infants.

During the technique's development stage, 11 term newborns were evaluated after at least 48 h of breastfeeding, and 12 preterm infants were evaluated after they had already begun oral feeding (gestational age of at least 32 weeks and the capacity for coordinated sucking, swallowing and breathed, which was assessed by 2 speech therapists). The coordination suck–breath was observed by records...
oral negative pressures were transmitted to the transducer. When the infant’s lips and tongue compressed the breast and when the signal obtained was the effect of the pressure changes that occurred during sucking. The pressure transducer was coupled to the catheter to detect and record pressure variations that occurred during sucking. The pressure transducer was calibrated using a water column gage as the reference. Milk was only obtained when the newborn expressed the mother’s breast. Therefore, there was no nutrient flow unless the newborn sucked and developed negative intra-oral pressure. Thus there is a linear relationship between the negative pressure generated and the amount of milk flow over the course of the sucking period. The researchers are certain that milk is flowing because they evaluated the mother’s milk production before placing the infant to suck. In addition, mothers related breast sensation of breast emptiness after exam.

Signals were recorded for 5 min, saved on a computer, and stored for analysis. For the analysis, we chose the minute with the best quality signal (1 min of recording time). The adapter board used for the analog-to-digital conversion was a DT-2081 from Data Translation Systems, and the analog signal acquisition software was PCLAB (Data Translations). To analyze and process the digital data, we used the ANADAT/LABDAT software (Meakies Chrities, Montreal, Canada).

Use of a polyethylene catheter for acquisition of the signals did not allow for precise analysis of the pressure values, which are related to the sucking force. Thus, the negative and positive pressure variations were used for analysis of the parameters related to sucking rhythm. To evaluate respiratory flow, we used a technique that is able to identify respiratory flow volume but not quantify it because some air escapes due to the lack of a seal at the nasal cavity. Therefore, the goal was to only evaluate the presence of flow and its relationship with sucking. We initially used a 0 prong with one tip closed and the other coupled to a pneumotachograph (Fleisch 00). It was necessary to decrease the prong’s length in order to allow a larger space between the newborn’s nose and the mother’s breast (especially in cases of mothers with large breasts). This adaptation did not interfere with the recording of the respiratory flow.

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The readouts allow analysis of the temporal parameters of sucking, which include: the duration of sucking bursts (in seconds), number of sucking bursts per minute, frequency of sucks (number of sucks per burst), number of sucks per second, number of sucks per minute, and number and duration of pauses. The readouts also allow for analysis of the respiratory flow concurrent with sucking (Fig. 1).

During the development of this technique, we observed that in mothers with voluminous milk production and ejection, acquisition of the sucking pressure signal was jeopardized because the tube filled with milk. We solved this problem by turning the tip of the tube (connected to the pressure transducer) upward (Fig. 2).

Thus, even when the catheter was at the same level as the mother’s nipple, the milk did not produce pressure resistance inside the system because the milk did not pass inside the catheter.

As part of the technique’s development, we also tested the best time to conduct the evaluation. Ideally, the newborns should be awake and alert during the test (Brazelton level 5 state of consciousness [10]).

As part of the hospital’s routine protocol, when newborns reach 1600 g in body weight, they begin to receive their feeding at 3-hour intervals, and infants were evaluated at 09:00 AM, 12:00 noon, and 3:00 PM. However, the newborns were unable to reach a state of alertness at 12:00 and 3:00 PM, even when stimulated. Thus, the times when the newborns responded best to examination were 09:00 AM for newborns weighing more than 1600 g and 10:00 AM for those weighing less than 1600 g.

At the time of examination, newborns were in Brazelton level 5 state of consciousness; their diapers had been recently changed, they were hungry, and they were monitored with a pulse oxymeter. Demographic characteristics of the newborns are described in Table 1.

Term infants participated in the study because we considered that was necessary to have healthy babies in breastfeeding as reference. As showing in Table 2 the results in term infants are significantly different comparing preterm infants.

### Table 1

Characteristics of the newborns. Fernandes Figueira Institute, Rio de Janeiro, Brazil, 2009 (n = 43).

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mean</th>
<th>SD</th>
<th>Median</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth weight (grams)</td>
<td>1196.51</td>
<td>208.12</td>
<td>1220</td>
<td>630</td>
<td>1500</td>
</tr>
<tr>
<td>Gestational age at birth (weeks)</td>
<td>30.3</td>
<td>1.1</td>
<td>30</td>
<td>28.4</td>
<td>33.2</td>
</tr>
<tr>
<td>Duration of O,therapy (days)</td>
<td>4.23</td>
<td>6.24</td>
<td>2</td>
<td>0</td>
<td>27</td>
</tr>
<tr>
<td>Duration of orotracheal intubation</td>
<td>0.72</td>
<td>1.67</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Age (days) at recovery of birth weight</td>
<td>13.23</td>
<td>4.89</td>
<td>13</td>
<td>3</td>
<td>22</td>
</tr>
<tr>
<td>Age (days) at in a full diet</td>
<td>10.26</td>
<td>3.03</td>
<td>10</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>Weight at first evaluation (grams)</td>
<td>1543.26</td>
<td>175.98</td>
<td>1560</td>
<td>820</td>
<td>1880</td>
</tr>
<tr>
<td>Gestational age at first evaluations (weeks)</td>
<td>34.2</td>
<td>1.4</td>
<td>35.0</td>
<td>32.0</td>
<td>36.0</td>
</tr>
</tbody>
</table>

### Table 2

Temporal parameters of sucking at the mother’s breast at the start of oral feeding in preterm newborns (n = 43) and term infants (n = 11).

<table>
<thead>
<tr>
<th></th>
<th>Term infants (n = 11)</th>
<th>32–33 (n = 10)</th>
<th>34 (n = 9)</th>
<th>35 (n = 16)</th>
<th>36 (n = 8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sucking rate (sucking/min)</td>
<td>Median (min–max)</td>
<td>Median (min–max)</td>
<td>Median (min–max)</td>
<td>Median (min–max)</td>
<td>Median (min–max)</td>
</tr>
<tr>
<td></td>
<td>56 (52–66)</td>
<td>16.0 (7–51)</td>
<td>21 (7–46)</td>
<td>36 (13–56)</td>
<td>41 (20–65)</td>
</tr>
<tr>
<td>Burst rate (bursts/min)</td>
<td>1</td>
<td>4 (2–5)</td>
<td>3 (2–6)</td>
<td>4 (2–9)</td>
<td>5 (2–10)</td>
</tr>
<tr>
<td>Pause rate (pauses/min)</td>
<td>0</td>
<td>4 (2–5)</td>
<td>4 (1–7)</td>
<td>3 (1–9)</td>
<td>5 (3–11)</td>
</tr>
<tr>
<td>Duration of pauses (seconds)</td>
<td>0</td>
<td>8.8 (5.1–12.3)</td>
<td>9.1 (3.3–17.1)</td>
<td>7.8 (2.1–17.3)</td>
<td>7.1 (3.2–8.3)</td>
</tr>
<tr>
<td>Sucks/burst</td>
<td>56</td>
<td>7.1 (2.8–29.0)</td>
<td>6.2 (3.0–23.0)</td>
<td>8.4 (4.3–28.0)</td>
<td>7.7 (4.0–26.0)</td>
</tr>
</tbody>
</table>

### 3.2. Evaluation of the technique

Using the technique that had been developed, temporal parameters of sucking were evaluated in 43 newborns (20 boys and 23 girls) with a birth weight of less than 1500 g and a gestational age at birth from 28 to 32 weeks.

High intra- and inter-observer agreement was observed for all recorded variables with a coefficient of variation (Cronbach’s alpha) greater than 0.80 for all the target variables.

The following variables were evaluated: the duration of sucking bursts (in seconds), number of sucking bursts per minute, frequency of sucks (number of sucks per burst), number of sucks per second, number of sucks per minute, and number and duration of pauses. The readouts also allow for analysis of the respiratory flow concurrent with sucking.

We observed a progression related a gestational age in the follow parameters sucking rate (p = 0.02) and burst rate (p = 0.09) in preterm infants that indicated a trend related to increasing gestational age as showing in Table 2 (Kruskall–Wallis Test). In the parameters, pause rate, duration of pauses and sucks/burst, we didn’t observe statistically significant differences. When we compared term and preterm infants we observed statistically significant differences in all parameters studied.

### 4. Discussion

Various studies that have aimed to quantitatively evaluate sucking behavior have been published since 1968 [1–3,5,6,9,11,12]. These studies measured the positive and negative pressure changes generated when newborns sucked artificial nipples connected to plethysmographs. Catheters with pressure sensors coupled to an artificial nipple have been used for some time to obtain sucking pressure and temporal components, which is a non-invasive system
for capturing positive and negative pressure changes. [1,2,5,6,12–14] However, such sensors are not available in Brazil, and therefore a modification was necessary in order to achieve the objectives proposed herein.

Interestingly, in the acquisition and analysis of signals from sucking at the mother’s breast, our findings were similar to those of Medoff-Cooper [15] and Cunha et al. [16], who used bottles, but different from those of Gewolb [5] and Mizuno and Ueda [14]. The differences between the studies could be explained by differences in the methodologies and in the profile of the newborns.

Although this technique has some objective aspects, using it to evaluate sucking involves a degree of subjectivity because the signal can sometimes produce noise, which only an experienced evaluator can detect. Analysis of intra- and inter-observer agreement is thus necessary.

The findings of this study indicate that the technique is adequate for objectively measuring newborns’ nutritive sucking patterns at their mother’s breast. This technique can provide better knowledge of sucking patterns in various clinical conditions.

The decision to introduce an oral feeding to preterm newborns is normally based on clinical judgment and the institution’s protocol. Quantification of specific behaviors related to feeding capacity provides an objective measure of the newborn’s sucking skills, allowing for a more accurate assessment of the infant’s feeding competency. This objectivity requires measuring milk intake efficiency, the capacity to coordinate sucking with breathing and swallowing, and measurements of sucking parameters. Measurements of sucking parameters can be used to determine whether the newborn is mature and organized for its gestational age, and these measurements do not require the clinician’s subjective criteria. Even if the methodology is not used routinely, when used, it can produce useful knowledge for clinical protocols.

During the neonatal period, temporal organization of sucking undergoes changes with increasing gestational age. [2,5,9,14,15]. With the technique proposed in our study, analyzing the sucking behavior of preterm newborns at their mother’s breast was possible for each gestational age bracket when the newborns are capable of initiating oral feeding. According to our study, two of the five sucking parameters showed changes with increasing gestational age. However, we did not analyze the progression in the sucking pattern as gestational age increased, and the number of newborns per age bracket was insufficient for more definitive conclusions.

The results of this study indicate that the proposed methodology is appropriate for objectively measuring temporal parameters of newborns’ nutritive sucking patterns at their mother’s breast. This methodology can be used to obtain better knowledge of temporal parameters of sucking under diverse clinical conditions.

Further studies are necessary to validate this technique in preterm infants in different gestational ages using a larger sample. Comparisons between performances in preterms are the way to try to do it. Another study could be very important to provide clinical and laboratorial ways to help these infants to discharged breastfeeding.

Acknowledgments

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References