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Original Article

Artigo Original

Cardiorespiratory parameters and their relation with gestational age and level of oral feeding skills in preterm infants

Parâmetros cardiorrespiratórios e sua relação com a idade gestacional e nível de habilidade de alimentação oral de recém-nascido pré-termo

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ABSTRACT

Purpose: To correlate cardiorespiratory parameters with gestational age and level of oral feeding skills in the first oral feeding in preterm infants. **Methods**: Study participants were 37 clinically stable preterm infants. Cardiorespiratory rate was assessed before and after introduction of oral feeding. The newborns were divided into three strata according to gestational age at birth. Oral skill was classified into four levels: I - low oral skill and low resistance to feeding; II - low oral skill and high resistance to feeding; III - high oral skill and low resistance to feeding; IV - high oral skill and high resistance to feeding. **Results**: No difference was observed in heart and respiratory rate between the strata of gestational age at birth and between the levels of oral skill. Comparison between pre- and post-cardiorespiratory rates within each level of oral skill and stratum of gestational age showed difference between heart rate in the strata of gestational ages of 30 to 33 weeks and of 34 to 36 weeks, as well as between oral skill of levels I, II, and IV. With regard to the comparison between pre- and post- respiratory rates, difference was found in the oral skill of level I. **Conclusion**: Differences were observed between pre- and post-prandial cardiorespiratory rates regarding the first oral feeding, as well as between strata of gestational age at birth and levels of oral feeding skills.

Keywords

Sucking Behavior
Preterm Infant
Feeding
Heart Rate
Respiratory Rate

RESUMO

Objetivo: Correlacionar os parâmetros cardiorrespiratórios com a idade gestacional e com o nível de habilidade de alimentação oral na introdução da alimentação oral de recém-nascidos pré-termo. **Método:** Participaram desta pesquisa 37 recém-nascidos pré-termo, clinicamente estáveis. A verificação das frequências cardíaca e respiratória foi realizada antes e após a introdução da primeira alimentação por via oral. Os recém-nascidos foram distribuídos em três estratos conforme a idade gestacional do nascimento. A habilidade oral foi classificada em quatro níveis: I - baixa habilidade oral e baixa resistência para alimentação; II - baixa habilidade oral e alta resistência para alimentação; III - alta habilidade oral e baixa resistência para alimentação; IV - alta habilidade oral e alta resistência para alimentação. **Resultados:** Não houve diferença na frequência cardíaca e respiratória entre os estratos da idade gestacional e entre os níveis de habilidade oral. Ao comparar a frequência cardíaca e respiratória inicial e final dentro de cada nível de habilidade oral e estrato da idade gestacional, observou-se diferença entre a frequência cardíaca nos estratos das idades gestacionais entre 30 e 33 semanas e entre 34 e 36 semanas, bem como nos níveis de habilidade oral I, II e IV; com relação à comparação entre a frequência respiratória inicial e final, foi encontrada diferença no nível I de habilidade de alimentação oral. **Conclusão:** As frequências cardíaca e respiratória sofreram alterações quando comparadas com dados pré e pós-prandial na primeira alimentação por via oral, assim como quando comparadas sobre aspectos da idade gestacional e nível de habilidade oral.

Descritores

Comportamento de Sucção
Recém-nascido Pré-termo
Alimentação
Frequência Cardíaca
Frequência Respiratória

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INTRODUCTION

At birth, the preterm newborn (PTN) presents urgency with respect to nutritional needs similar to or even greater than that expected for a fetus with the same gestational age (GA). However, the nutritional needs of this infant are not fully established and change according to gestational age and clinical condition. Considering these difficulties, the effort to reach growth development, as it occurs in the uterus, is a difficult task to accomplish[1].

The intercurrences that the PTN may present during the neonatal period are responsible for prolonged periods of hospitalization and sequelae that may compromise clinical evolution, including that related to the feeding process[2,3]. Neurological immaturity, modified muscle tone, minimized oral reflexes, general weakness, and difficulties in self-regulation may interfere with the quality of oral motor skills of PTNs[2,4] and may also be sufficiently justifiable factors to provoke irregularity in their cardiorespiratory pattern[5].

Oral feeding (OF) can be initiated when the PTN presents corrected gestational age (CGA) of approximately 34 weeks, a time when the infant begins to acquire efficient coordination between the functions of sucking, swallowing, and breathing (S/S/B)[6-8], although more recent studies report that it is already possible to observe coordination between these functions as of the 32nd week of CGA[9]. Although CGA is important in the decision for oral feeding readiness[10], it should not be considered a determining factor[11].

Heart (HR) and respiratory (RR) rates may change during OF[12], being essential to control them before, during, or after feeding. In a clinically stable PTN, HR should range from 120 to 160 beats per minute (bpm) and RR should not exceed 60 respirations per minute (rpm), with the latter being fundamental in the decision for oral feeding readiness[13].

It is imperative that the speech-language pathologist have access to and knowledge regarding the procedures for monitoring the PTN and use the cardiorespiratory parameters observed at rest, in motion, and during the assessment[13] as important tools indicative of possible adverse occurrence during feeding. Clinical evaluation is important in cardiorespiratory conditions and professionals should not consider the values indicated on the equipment screen as an only reference, and should compare them with data from behavioral observation[14].

Being able to be fed orally is defined as readiness for OF introduction, as well as having interest in feeding[15]. For hospital discharge, in addition to being clinically stable, the PTN should be able to be fed exclusively through OF[16,17].

Based on these considerations, the objective of the present study was to verify the cardiorespiratory parameters, through heart and respiratory rate, before and after introduction of oral feeding, correlated with gestational age at birth and with level of oral feeding skills, in preterm infants.

METHODS

This study of cross-sectional, quantitative design was approved by the Research Ethics Committee of the aforementioned institution under protocol no. 11155312.7.0000.5346. All parents/guardians of the participating preterm infants signed an Informed Consent Form (ICF) prior to study commencement.

The study sample was composed of 37 preterm newborns (PTN) hospitalized in the Neonatal Intensive Care Unit (NICU) of a university hospital. Inclusion criteria comprised healthy, clinically stable premature neonates, whereas exclusion criteria included PTNs with neurogenic alterations, genetic syndromes, head and/or neck malformations, neonatal asphyxia (5-minute Apgar score ≤ 5), hyperbilirubinic encephalopathy, intraventricular hemorrhage grades III and IV, and infants who had received prior speech-language pathology stimulation.

All participants were evaluated after release by the medical team to initiate OF. During assessment, the PTNs were in air-heated incubators.

Pre- and post-prandial HR and RR of PTNs were measured, that is, before the speech-language pathology assessment and after completion of the first OF. HR was assessed for one minute using a stethoscope available at the NICU. RR was evaluated for one minute from the observation of the thoracoabdominal excursions of the infants.

The preterm neonates were stratified into groups according to gestational age at birth: Group A - between 26 and 29 weeks and 6 days; Group B - between 30 weeks and 33 weeks and 6 days; and Group C - between 34 weeks and 36 weeks and 6 days.

The level of oral skill, evaluated during the first OF, was obtained from a combination of the parameters proficiency (PRO) and rate of milk transfer (RT), as proposed in the literature[18]. As for PRO, which represents the percentage of the volume ingested in relation to the volume prescribed in the first five minutes, these first five minutes of the feeding are monitored, believing that during this period the fatigue factor is minimal and thus represents the actual OF capacity or ability of the PTN. Rate of milk transfer, which is the volume of milk accepted per minute during the entire feeding session, reflects a resistance index. Based on these data, the level of oral feeding skills (OFS) of the preterm infants was classified as follows: Level I = PRO < 30% and RT < 1.5 ml/min (low OFS and low resistance - high fatigue); Level 2 = PRO < 30% and RT > 1.5 ml/min (low OFS and high resistance - low fatigue); Level 3 = PRO > 30% and RT < 1.5 ml/min (high OFS and low resistance - high fatigue); and Level 4 = PRO > 30% and RT > 1.5 ml/min (high OFS and high resistance - low fatigue).

The results were classified and analyzed using the STATA 10.0 statistical software. Analysis of variance (ANOVA) and the paired Student's t test were used for comparison between the means, whereas the Chi-square test was used for comparison between the variables. A level of statistical significance of 5% (p<0.05) was applied to all analyses.

RESULTS

Table 1 shows the characterization of the studied sample. Of the 37 PTNs investigated, 56.8% were female with weight at birth of 1658 (±505) grams and GA of 33 (±2.0) weeks. First OF occurred at chronological age of approximately 15.6 (±11) days, CGA of 35.1 (±1,3) weeks, with weight of 1873 (±393) grams.

Table 2 shows the variables weight and GA, as well as HR and RR for pre- and post-first OF, according to the strata of GA at birth. As expected, significant difference was observed regarding weight (p=0.001) and GA at birth (p=0.000), according to the three strata assessed. The preterm infants were released for OF with approximately 34 weeks, except those born with GA between 34 and 36 weeks (p<0.001). Also as expected, significant difference was observed with regard to chronological age at first OF (p<0.001). As for both pre- and post-HR and RR, no statistically significant difference was found between the groups, with the mean value within the normality range.

The variables weight and GA at birth and at first OF, as well as pre- and post-first oral feeding HR and RR, according to the level of OFS observed (Lau and Smith, 2011), are shown in Table 3. Of the 37 PTNs analyzed, 21 (56.7%) were classified as level I; five (13.5%) as level II; two (5.4%) as level III; and nine (24.4%) as level IV. No difference was found according to level for the variables weight and CGA at first OF, as well as for pre- and post- HR and RR. Although no significant difference was observed, the preterm neonates with high OFS and resistance (level IV) presented greater stability in relation to the RR parameters. The two PTNs classified as level III, with low resistance to feeding, showed the higher increase in RR (51 ±1.4 *vs.* 75 ± 19.1 for pre- and post-RR, respectively).

As for the comparison of vital signs (HR and RR) before and after the first OF, HR presented significant increase (although within the normality range) for infants in the strata of GA at birth between 30 and 33 weeks (p=0.001) and 34 and 36 weeks (p=0.007) and in infants classified as level I (p=0.001), level II (p=0.027), and level IV (p=0.041) of oral feeding skill. Significant increase was observed for the RR (although within the normality range) for infants classified as level I of OFS (p=0.006) (Table 4).

Table 1. General characteristics of the 37 preterm newborns at birth and at first oral feeding

Variables	
Gender (%)	
Male (n=16)	43.2
Female (n=21)	56.8
At birth	
Gestational age (weeks)*	32.7 (±2)
Weight (grams)*	1658 (±505)
At first oral feeding	
Corrected Gestational age (weeks)*	35.1 (±1.3)
Chronological age (days)*	15.6 (±11)
Weight (grams)*	1873 (±393)
Heart rate before (bpm)*	147 (±11.4)
Heart rate after (bpm)*	160 (±14)
Respiratory rate before (rpm)*	51 (±6.4)
Respiratory rate after (rpm)*	57 (±16.9)

***Values expressed in mean and standard deviation**

DISCUSSION

Studies investigating the heart (HR) and respiratory (RR) rates before and after the first oral feeding (OF) in groups of preterm newborns (PTN) of different gestational ages (GA) and levels of oral feeding skills (OFS) have not yet been described in the specific literature. In the current speech-language pathology clinical practice, more importance is given to the observation of oxygen saturation during OF, with measures of RR and HR being left in the background of assessment parameters.

Corrected gestational age (CGA) and weight have been used as decision-making criteria for introduction of OF in PTNs, although they are often not sufficient for adequate performance during OF. In the present study, it was possible to observe the following CGAs of PTNs at first OF: 34.1 (±0.6), 34.5 9±0.9), and 36.2 (±14) weeks for infants with GAs at birth between 26-29, 30-33, and 34-36 weeks, respectively. This result meets one of the criteria used in the neonatal unit evaluated, that is, the presence of CGA of approximately 34 weeks. This criterion has been adopted because this is the time when coordination

Table 2. Comparison between the variables "at birth" and "at first oral feeding" expressed in mean and standard deviation (M±SD) and the strata of gestational age of the preterm newborns

Variables	Gestational age at birth (weeks)			*p*
	Group A 26-29 (n=2)	Group B 30-33 (n = 22)	Group C 34-36 (n =13)	
At birth				
Gestational age (weeks)	28.5 (± 0.7)	31.8 (±1.1)	34.8 (±0.8)	0.000*
Weight (grams)	992 (±286)	1515 (±261)	2001 (±632.8)	0.001*
At first oral feeding				
Corrected Gestational age (weeks)	34.1 (±0.6)	34.5 (±0.9)	36.2 (±1.4)	0.000*
Weight (grams)	1722 (±10.6)	1774 (±86.4)	2064 (±624.3)	0.090
Chronological age (days)	38 (±9.9)	18 (±8.9)	8 (±7.7)	0.000*
Heart rate before	154 (±14)	149 (±10.5)	142 (±12)	0.175
Heart rate after	169 (±0.7)	162 (±14.5)	156 (±13.5)	0.308
Respiratory rate before	57 (±7)	51 (±6.1)	51 (±7)	0.454
Respiratory rate after	58 (±26)	56 (±13)	61 (±22)	0.681

***Statistically significant values (p<0.05)**

Table 3. Comparison between the variables "at birth" and "at first oral feeding" expressed in mean and standard deviation (M±SD) and the levels of oral feeding skill at birth and at first oral feeding

Variables	Oral Feeding Skill				*p*
	Level I n = 21	**Level II** n = 5	**Level III** n = 2	**Level IV** n = 9	
At birth					
Gestational age (weeks)	32.3 (±1.8)	32.2 (±1.5)	35 (±0)	33.3 (±2.5)	0.197
Weight (grams)	1714 (±587)	1401 (±260)	1950 (±162)	1604 (±419)	0.007*
At first oral feeding					
Corrected Gestational age (weeks)	34.7 (±1.4)	35.1 (±0.8)	36.5 (±1.1)	35.6 (±1.2)	0.190
Weight (grams)	1925 (±501)	1766 (±77.6)	1987 (±95)	1785 (±193.5)	0.732
Chronological age (days)	16 (±10.2)	19 (±8.9)	6 (±7)	15 (±14.4)	0.562
Heart rate before	150 (±11)	141 (±9.1)	143 (±4.2)	144 (±13.5)	0.399
Heart rate after	163 (±14.4)	159 (±15.3)	150 (±9.2)	156 (±13.1)	0.518
Respiratory rate before	51 (±5.7)	49 (±5.2)	51 (±1.4)	53 (±9.2)	0.731
Respiratory rate after	59 (±13)	57 (±31.3)	75 (±19.1)	50 (±13.5)	0.252

***Statistically significant values (p≤0.05)**

Table 4. Comparison between the variables "at birth" and "at first oral feeding" expressed in mean and standard deviation (M±SD) and the pre- and post-prandial vital signs

Variables	Vital Signs						
	n	**HRb**	**HRa**	***p***	**RRb**	**RRa**	***p***
Gestational age							
Group A	2	154 (±14.1)	169 (±0.7)	0.142	57 (±7.1)	58 (±26.2)	0.491
Group B	22	149 (±10.5)	162 (±14.5)	0.001*	51 (±6.1)	56 (±13.0)	0.073
Group C	13	142 (±12.0)	156 (±13.5)	0.007*	51 (±7.0)	61 (±21.9)	0.068
Oral feeding skill							
Level I	21	150 (±11.2)	163 (±14.4)	0.001*	51 (±5.7)	59 (±12.9)	0.006*
Level II	5	141 (±9.1)	159 (±15.3)	0.027*	49 (±5.2)	57 (±31.3)	0.303
Level III	2	143 (±4.2)	150 (±9.2)	0.202	51 (±1.4)	75 (±19.1)	0.106
Level IV	9	144 (±13.5)	156 (±13.1)	0.041*	53 (±9.2)	50 (±13.5)	0.294

*Statistically significant Values (p<0.05).
Caption: HRb – heart rate before; HRa – heart rate after; RRb – respiratory rate before; RRa – respiratory rate after

between the sucking, swallowing, and breathing (S/S/B) functions begin[6,7,8].

The means of chronological age are in compliance with GA at birth; the lower the GA, the longer it takes the PTN to reach the adequate CGA for first OF.

For the variable HR after OF, it is possible to observe results above the maximum expected in PTNs with GA between 26 and 29 weeks, with mean of 169 bpm, and in those with GA between 30 and 33 weeks, with mean of 162 bpm, which are believed to occur due to prematurity, in function of a compromised clinical condition, or even owing to cardiac immaturity. For the variable RR after OF, it was also possible to observe results above the maximum expected (RR mean of 62 rpm) in PTNs with GA between 34 and 36 weeks. Nevertheless, the literature describes increases in HR of up to 10 bpm as common during OF, but increases above this index may indicate that OF is overburdening the neonate[19], demonstrating that the fatigue factor influences the RR[20] and the change in behavioral status after nutritive suction (NS)[21].

A study on HR and RR with groups of stimulated and unstimulated PTNs reports a trend of the infants of the stimulated group to stabilize their post-first oral feeding RR, as well as their HR after NS in complete OF for 24 hours[12], demonstrating that perhaps resistance training with non-nutritive sucking (NNS), along with an oral sensorimotor stimulation program may assist PTNs to regulate their vital functions in the pre- and post-prandial HR and RR. In another survey[19], no difference was observed between HR and RR during sucking on a bottle or breastfeeding.

Preterm infants classified as Level I[18], who present low OFS and low resistance to feeding showed difference in the pre- and post-prandial comparison for both HR and RR. At Level II, for the PTNs that presented low OFS and high resistance and at Level IV, for the PTNs that showed high OFS and high resistance, significant difference in the comparison was observed only for HR. These data indicate that even with adequate CGA and weight at first OF, these PTNs were not efficiently prepared to fulfill the NS activity, because the monitoring of HR and RR before and after OF is important to evaluate possible physiological intercurrences in face of the effort made by the PTN during OF.

Preterm infants of Levels I, II, and IV presented means of post-prandial HR with more than 10 bpm above the means of

pre-prandial HR. In the comparison of the pre-RR, all PTNs stratified into the levels showed means within the normal range; however, in the post-RR, only PTNs of Level III presented data above normality of 60 rpm, with post-RR mean of 7 rpm. The justification for this finding may be that Level III infants present high OFS but low resistance to feeding[18], which could explain the fact that fatigue has caused an increase in the respiratory movements in these infants, although the number of individuals for this skill level group, as well as for group A of GA, does not allow statistical analysis due to sample size (n=2).

Oral feeding skill and resistance to feeding are equally important to determine the success of OF[18]. The classification of oral skills into levels has been used by some authors considering that the test presents an indicator that allows quantification of the ability of PTNs to receive OF, whose evaluation occurs in the first five minutes of the feeding, and during this period, the difficulties caused by fatigue would not be observed yet[18,22-25].

In full-term newborns, during suction groups, the RR may decrease, recovering during the pauses between suction groups, maintaining the total RR at adequate levels; however, in preterm neonates with GA between 34 and 36 weeks, the RR may show a decrease during the continuous suction phase, in which discrete recovery occurs during the intermittent suction phase. Therefore, newborns with RR > 65 rpm, on alertness or presenting respiratory alterations, may show signs of respiratory discomfort during bottle sucking, preventing NS from occurring at this moment[19].

The monitoring of HR and RR indices allows the speech-language pathologist to detect possible changes during stimulation or OF and suspend the procedure, avoiding episodes of aspiration or clinical destabilization, ensuring the success of the transition[26]. Furthermore, the hospital discharge of PTNs requires them to perform OF exclusively, safely and efficiently[27], which is an important achievement in their development[17,22], because the long periods of hospitalization, the lack of adequate oral stimulation, and the necessary medical procedures can contribute to alimentary difficulties[2,3].

Proper analysis of the vital signs of PTNs at the moment of OF is based on the observation of the feeding situation and on whether it represents a moment in which the HR and RR indices undergo considerable changes. Therefore, it is essential that the speech-language pathologist participate in the Neonatal Team, taking conducts, and be attentive to the clinical conditions of the infants during the feeding situation, observing the HR and RR indices in order to avoid potential clinical complications. Based on the outcomes of this study, further research on the observation of the HR and RR indices is suggested, so that the real conditions of preterm infants at first OF can be evidenced.

CONCLUSION

No difference between the groups was observed with respect to pre- and post-heart and respiratory rates, which presented mean values within the normality range. Concerning gestational age and levels of oral feeding skills, significant correlation was found for heart rate variation. Differences were also observed between pre- and post-prandial cardiorespiratory rates regarding the first oral feeding, as well as between strata of gestational age at birth and levels of oral feeding skills.

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Author contributions

RCCY classified and analyzed the data and contributed to the writing of the manuscript and study corrections; LSP evaluated the study participants and contributed to the writing of the manuscript and study corrections; LCB evaluated the study participants and contributed to the writing of the manuscript and study corrections; ARMW was the study co-adviser, analyzed the data, and contributed to the writing of the manuscript and study corrections; MKS was the study adviser, analyzed the data, and contributed to the writing of the manuscript and study corrections.