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The influence of behavioral state on sucking patterns in preterm infants

Influência do estado comportamental nos padrões de sucção de recém-nascidos pré-termo

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ABSTRACT

Purpose: To verify the influence of preterm infants' behavioral states in non-nutritive sucking, nutritive sucking and feeding performance at the moment of oral feeding release. **Methods:** Thirty-two preterm infants participated in the study. They were hospitalized in a Neonatal Intensive Care Unit and presented stable clinical conditions. After medical release for oral feeding, the following aspects of infants were observed by the same speech therapist: behavioral state, postural pattern, oral reflexes, phono-articulatory organs' characteristics, non-nutritive and nutritive sucking, number of sucks per block, rate of milk transfer and oral feeding performance. **Results:** No relationship was found between the infants' behavioral states and non-nutritive sucking. In nutritive sucking it was verified the influence of behavioral states on the number of sucks in the three first blocks intervals sucking/pause. This means that at the moment of oral feeding start infants in the alertness state presented a higher number of sucks than those in the sleep state. Consequently an impact on feeding performance was verified, with a higher rate of milk transfer and an increased oral feeding performance. Nonetheless no statistical significance was found in regards to these aspects. **Conclusion:** This research's findings show that behavioral states did not influence on non-nutritive sucking aspects. But in nutritive sucking, infants in the alertness state presented a higher number of sucks per block than those in the sleep state.

Keywords: Suction; Sucking behavior; Infant, Premature; Consciousness; Feeding

RESUMO

Objetivo: Verificar a influência do estado comportamental na sucção não nutritiva, na sucção nutritiva e na *performance* alimentar de recém-nascidos pré-termo, no momento da liberação da via oral. **Métodos:** Participaram 32 recém-nascidos pré-termo, clinicamente estáveis, internados em uma unidade de terapia intensiva neonatal. Foram realizadas, por um fonoaudiólogo, as avaliações do estado comportamental, padrão postural, reflexos orais, características dos órgãos fonoarticulatórios, sucção não nutritiva e nutritiva, número de sucções por bloco de sucção, taxa de transferência e desempenho alimentar, após a liberação médica para início da alimentação por via oral. **Resultados:** Não foi possível verificar associação do estado comportamental com a sucção não nutritiva. Na sucção nutritiva, verificou-se influência do estado comportamental sobre o número de sucções nos três primeiros blocos, ou seja, o estado de alerta, ao iniciar a mamada, possibilitou aos recém-nascidos apresentarem maior número de sucções, quando comparados aos recém-nascidos em estado de sono. Isto se refletiu na *performance* alimentar, por meio da maior taxa de transferência e melhor desempenho, embora não tenha sido observada significância estatística quanto a esses aspectos. **Conclusão:** Os achados mostram que o estado comportamental não influenciou os aspectos de sucção não nutritiva, considerados, entretanto, na sucção nutritiva. O estado de alerta apresentou associação com maior número de sucções por bloco, em relação ao estado de sono.

Descritores: Sucção; Comportamento de sucção; Prematuro; Estado de consciência; Alimentação

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INTRODUCTION

Behavioral states are considered as important factors of influence on a range of childhood behaviours[1,2], including feeding aspects[3-5].

Since the first stages of development, infants experience changes between the states of wakefulness and sleep. These are primitive regulatory mechanisms used to control endogenous and exogenous tensions and to organize the process of living[6].

In term infants, the consciousness or behavioral state tends to occur in an organized pattern, interacting with the environment[1]. However, preterm infants may have difficulties to maintain a certain behavioral state due to their physiological immaturity, as there is a relationship between the behavioral state and the central nervous system maturity[7,8].

The alertness state is considered ideal for feeding in the literature, as in this state the infant is more conscious and with a higher readiness for feeding[5,9]. Contrarily, the sleep state may interfere with infants' capacities to maintain a rhythm and strength of sucking[10].

Term infants in the sleep state present a pattern of non-nutritive sucking (NNS) less strong and less frequent when compared to the alertness state[11]. Authors have observed in preterm infants an improvement of NNS patterns correlated with an enhancement of the alertness state[12,13]. These findings show that the child's behavioral state is a determining factor of sucking patterns and one that must be considered when oral feeding skills are being treated[14].

According to the literature, preterm infants present higher feeding performance when more awake and alert[3,5,8]. For preterm infants the maintenance of the alertness state is a necessary condition for oral feeding, to allow a coordinated pattern between suck, swallow and breathing (S/S/B) and to maintain the cardiorespiratory stability. As a result it allows the preterm infant to ingest the calories necessary for his/her growth and development [15].

The literature describes six state of consciousness: deep sleep, active or light sleep, lethargy or intermediate state, alertness state or awake, state of agitated alert and crying[16].

Although the behavioral state has influence in the infant's readiness for oral feeding[4], in the literature this is little related to feeding performance. Therefore this study's aim was to verify the influence of behavioral states on non-nutritive sucking (NNS), nutritive sucking (NS) and feeding performance of preterm infants at the moment to start oral feeding (OF).

METHODS

This cross-sectional study was performed from the research database of a project developed at the Neonatal Intensive Care Unit of the University Hospital of Santa Maria (RS). The Research Ethics Committee of the Universidade Federal de Santa Maria (UFSM) previously approved the project, under the number 11155312.7.0000.5346.

The present study comprised 32 clinically stable preterm infants, ready to start oral feeding and whose parents consented to participate in the research by signing the Free and Informed Consent Form.

The sample was composed by 46,88% males and 53,13% females. The average birth weight was 1,639 (± 526) grams and the average gestational age at birth was 33 (± 2,1) weeks. 31,25% were classified as small, 62,5% as adequate and 6,25% as large for the gestational age. At the moment of evaluation, the sample's corrected gestational age was 35,11 (± 1,40) weeks, the chronological age 16,2 (± 11,46) days and the weight 1.864 (± 417) grams.

Excluded criterion involved the presence of dysfunctions that could affect the performance of oral functions, like: head and neck congenital malformations; genetic syndromes; intracranial hemorrhage; perinatal asphyxia; hyperbilirrubinemia encephalopathy and broncho-pulmonary dysplasia.

The participants' identification details were obtained through interviews with parents and the review of medical reports during hospitalization. One single speech therapist with neonatal expertise conducted the evaluations, which comprised the following aspects: vital signs; behavioral state; postural pattern; structural, postural and mobility conditions of phono-articulatory organs; oral reflexes; non-nutritive sucking; nutritive sucking.

The evaluations were performed as soon as the staff released the transition from tube to oral feeding. The criteria for this transition comprised the following aspects: minimum corrected gestational age 33-34 weeks, minimum weight 1.600 grams, clinical stability, absence of respiratory distress and respiratory rate equal or less than 60 movements per minute. All infants were examined immediately before their first oral bottle feeding.

The infants' states of behavioral organization were assessed in three different moments: before NNS, before NS (the moment coinciding with the end of NNS) and after NS. The classification used for the behavioral states was the following: deep sleep, when the infantwas with his/her eyes shut, with deep breath and absence of motor activity; active or light sleep, when the infant was also with his/her eyes shut, but with a short and irregular breath, may wrinkle his/her face and move his/her mouth; intermediate state or lethargy, when the infant opened and closed his/her eyes, presented arms and legs movements, but seems disoriented; alertness state or awake, when the infant's body and face was inactive but with a shiny look; agitated alert state, when the infant's movements were disorganized and spasmodic, representing a transition state to crying; and cry[16].

For analysis purposes, the present study classified the above-described behavioral states in the following three groups[14]:

- Sleep: deep sleep and light sleep;
- Alertness: lethargy state, alertness state and agitated state;
- Agitated: crying.

Sucking reflexes were stimulated in order to perform the non-nutritive sucking evaluation.This stimulation was given by the introduction of the evaluator's gloved little finger inside the infant's oral cavity. The infant was in the supine position, with his head in midline in relation to the body. The following aspects were evaluated: labial sealing; tongue cupping; strength; rhythm and coordination of sucking and the number of sucks of the three first blocks.

For the nutritive sucking assessment the infant was positioned in the same way as the previous evaluation. In this case placing the feeding bottle's nipple inside the infant's oral cavity stimulated his sucking reflexes. During NS we evaluated: labial sealing and rhythm of sucking, coordination S/S/B and feeding's duration, prescribed volume, ingested volume and some aspects during feeding, such as signs of retraction, satiety, stress and food refusal[17,18]. Coordination S/S/B was considered as the balance between feeding efficiency and sucking, swallowing and breathing functions, without the presence of stress signs[19], such as: oxygen desaturation; respiratory and/or heart rate alterations; cyanosis and cough. The minimum prescribed volume for each feeding session was 10 ml/kg (equivalent to 80 ml/kg a day).

In order to estimate the number of sucks per block the evaluations were filmed and three speech therapist evaluators analyzed the video footages. The number of sucks per block represented the consensus between them, being also established the average for the first three blocks[20].

As feeding performance we considered the rate of milk transfer and the oral feeding performance, which were calculated with the data obtained from feeding duration, volume prescribed and volume ingested for the first oral feeding. The rate of milk transfer was determined by volume of ingested milk during the total feeding period, and the oral feeding performance represented the percentage of milk ingested in relation to the total prescribed volume[21].

The software STATA 10.0 was used to analyze the gathered data. Statistical significance was established in levels below 5%. Fisher's exact test was used in order to verify the variables potentially related to behavioral states. In order to compare the average number of sucks per block, the rate of milk transfer and the oral feeding performance among the different behavioral states we used the ANOVA analysis of variance, Student's t-test and Wilcoxon's test.

RESULTS

During NNS evaluation no relationship was observed between the aspects of tongue cupping, labial sealing, strength, rhythm and coordination and the infants' behavioral state (Table 1). Equally, the behavioral state did not influence on the average number of sucks of the first three blocks in NNS (Table 2).

During the NS evaluation, the aspects of tongue cupping, labial sealing, strength, rhythm and coordination were also not influenced by the infants' behavioral states. However, it was observed a trend for a relationship between the presence of coordination S/S/B and the alertness state (Table 3).

Infants in the alertness state presented a number of sucks per block (average) considerably higher than the ones sleeping. Table 4 depicts the data in regards to the number of sucks per block, the rate of milk transfer and the oral feeding performance, considering the infants' behavioral states.

Table 1. NNS aspects in relation to the infant's behavioral state

NNS aspects	Behavioral state			p-value
	Sleep (n=6)	Alertness (n=25)	Agitated (n=1)	
	n (%)	n (%)	n (%)	
Tongue cupping				
Present	3 (50.00)	20 (80.00)	1 (100.00)	0.37
Absent	3 (50.00)	5 (20.00)	0 (0.0)	
Labial sealing				
Present	6 (100.00)	22 (88.00)	1 (100.00)	1.00
Absent	0 (0.00)	3 (12.00)	0 (0.00)	
Strength				
Present	3 (50.00)	16 (64.00)	1 (100.00)	0.78
Absent	3 (50.00)	9 (36.00)	0 (0.00)	
Rhythm				
Present	3 (50.00)	7 (28.00)	0 (0.00)	0.36
Absent	3 (50.00)	18 (72.00)	1 (100.00)	
Coordination				
Present	5 (83.33)	20 (80.00)	1 (100.00)	1.00
Absent	1 (16.66)	5 (20.00)	0 (0.0)	

Fisher's test ($p<0.05$)
Note: NNS = Non-nutritive sucking

Table 2. Mean and standard deviationsof the number of sucks per block during NNS, according to the behavioral state

Sucks per block in NNS	Behavioral state			p-value
	Sleep (n=6)	Alertness (n=25)	Agitated (n=1)	
Sucks in first three blocks in NNS (Mean ± SD)	4.11 (±2.40)	4.92 (±4.15)	4	0.82

ANOVA (p<0.05)
Note: NNS = Non-nutritive sucking; SD = standard deviation

Table 3. NS aspects in relation to the infant's behavioral state

NS aspects	Behavioral state		p-value
	Sleep (n=3)	Alertness (n=28)	
	n (%)	n (%)	
Labial sealing			
Present	3 (33.33)	28 (96.55)	0.90
Absent	0 (0.00)	1 (3.45)	
Rhythm			
Present	2 (66.67)	10 (34.48)	0.54
Absent	1 (33.33)	19 (65.52)	
Coordination			
Present	1 (33.33)	25 (86.21)	0.08
Absent	2 (66.67)	4 (13.89)	

Fisher's test (p<0.05)
Note: NS = Nutritive sucking

Table 4. Number of sucks per block in the first three blocks during NS, rate of milk transfer and oral feeding performance of preterm infants in relation to their behavioral states

Variables	Behavioral state		p-value
	Sleep (n=3)	Alertness (n=29)	
***Sucks per block in the first three blocks**			
Median	1	6.33	0.01
1º quartile	0	2.67	
3º quartile	1	10.67	
***Rate of milk transfer (ml/min)**			
Median	0.86	1.54	0.27
1º quartile	0	0.82	
3º quartile	1.96	2.90	
****Oral feeding performance (%)**			
Mean	17.78	23.34	0.29
DP	16.78	16.94	

*Mediumand quartiles expressed values (p<0,05) –Wilcoxon test; **mean and standard deviation values expressed (p<0.05) – Student's t test
Note: NS = nutritive-sucking

It was also verified in NNS and NS evaluations that the act of handling the babies contributed to a clear alteration of their behavioral states. NNS contributed to reduce the number of infants in the sleep state. At the end of NS it was observed an increase in the number of infants in the sleep state. Table 5 describes the infants' behavioral states at the moments of evaluation.

Table 5. Infants' behavioral states during the three evaluations conducted by the speech therapists

At the moments of evaluation	Behavioral state		
	Sleep n (%)	Alertness n (%)	Agitated n (%)
Before NNS	6 (18.75)	25 (78.13)	1 (3.13)
Before NS	3 (9.38)	29 (90.63)	0
After NS	7 (21.88)	24 (75.00)	1 (3.13)

Note: NNS = Non-nutritive sucking; NS = Nutritive sucking

DISCUSSION

The independent oral feeding is influenced for many factors among them the infant's behavioral state, since it relates to his/her capacity to respond to the environment[14,16]. Nevertheless this aspect is rarely considered as a relevant parameter in the evaluation of oral feeding readiness[22]. In view of this, the present study tried to clarify the potential influence of behavioral states on the oral feeding process of preterm infants, by relating this aspect to some NNS and NS characteristics and to feeding performance.

NNS is an important aspect of analysis as it presents indicators of the infant's maturity to start oral feeding and must be considered together with other aspects of the infant's behavior[20,23]. In this study, the NNS aspects considered were: tongue cupping; labial sealing; strength; rhythm and coordination; and the number of sucks on the three first blocks. They were chosen due to their fundamental importance in the organization and success of the infant's oral feeding[10,20,23].

The fact that behavioral states did not influence on NNS (Tables 1 and 2) is convergent with literature findings. Previous studies have indicated that behavioral states impact exclusively on the maintenance and stability of NNS' rhythm[24]. In our study, the aspect of rhythm maintenance was not considered due to the short duration of NNS evaluation.

During the evaluation of the infant's conditions for start oral feeding the verification of his/her sucking functionality is fundamental, as the readiness assessed by NNS may not guarantee a successful oral feeding. For this reason we evaluated also some aspects of the NS (labial sealing, strength, rhythm and coordination) and related them to the infant's behavioral at the moment of evaluation (Table 3). The analysis demonstrated that behavioral states did not influence the NS aspects here considered. However a trend for significant relationships between the alertness state and the presence of coordination S/S/B was

observed, suggesting that behavioral states can influence on the success of oral feeding, since coordination is an essential factor that allow the infant to reach a safe oral feeding[22].

When comparing the number of sucks per block during NS (Table 4), a significant difference was observed between the behavioral states. Infants in the state of alertness presented a higher number of sucks per block than infants in the sleep state. The literature supports this finding as it affirms that the alertness state, if maintained before and during the process of oral feeding, helps the infant to achieve a higher number of sucks, which positively impact on his/her oral feeding skills[22].

The higher number of sucks per block observed in NS in comparison with NNS could be explained by the presence of milk, since infants were evaluated at the moment of oral feeding, when they were hungry. It could be argued that during NS the gustative delight obtained from milk may have influenced the better response observed in the babies in alertness state.

Authors[25] have verified that a higher number of sucks is related to better feeding outcomes, a convergent result with our findings. Even though no significant difference was observed, it has been possible to verify that infants in the alertness state presented higher rate of milk transfer and better oral feeding performance than those in the sleep state.

The rate of milk transfer is an indicator of the infant's resistance to oral feeding. In the literature, a rate of milk transfer equal or more than 1,5 ml/min is considered as a sign of success in oral feeding[21]. The present study verified that infants in the alertness state achieved an average rate of milk transfer of 1,54 ml/min, while the average of infants in the sleep state was 0,86 ml/min. Even without statistical difference these data indicate that the behavioral state of alertness may contribute to better feeding efficiency or performance.

Oral feeding performance is considered adequate when the infant is able to ingest at least 80% of the prescribed volume of milk[21]. In the present study infants' average oral feeding performance remained below the expected to be considered as successful. Nevertheless, a higher oral feeding performance was observed in alert infants ($p>0,05$). The lack of rhythm may be a plausible explanation for the poor oral feeding performance observed in our babies. It is known that rhythm is directly linked to sucking efficiency[26].

Some points were observed in relation to behavioral state changes. During the NNS evaluation, it was noted an increase in the number of infants in the alertness state, a decrease in the number of infants in state of sleep and the suppression of the agitated state. These data confirm that NNS contributes to the infant's organization[26] and induce him/her into the alertness state[27]. On the other hand, NS induced some infants into the sleep state, which could be partially explained by the satiety provided by milk ingestion. Fatigue may also have contributed to infants' sleep state, since is common the presence of low resistance during oral feeding in this babies[21]. The resistance to oral feeding is defined by the amount of ingested milk in relation to feeding's duration. In terms of success for independent oral feeding, resistance is as important as the presence of oral feeding skills in these babies[28].

In view of our findings, the induction of an alertness state previously to bottle or breastfeeding, may increase the chances of a successful oral feeding. Non-nutritive sucking stimulation is an oral motor-sensorial method that, among other benefits, can facilitate the alertness state and contribute to a better oral feeding performance[27,29,30]. Hence NNS stimulation is understood as a useful strategy in order to wake the infant up. Additionally it may also contribute to the infant's sucking organization and facilitate the achievement of independent oral feeding in a shorter period of time[19].

We suggested further studies with larger samples in order to confirm this research's findings, in which it was observed the influence of behavioral states during NS on the oral feeding performance of preterm babies. Other aspects related to oral feeding skills or readiness may be investigated with the objective to better clarify these influences on preterm infants oral feeding success.

CONCLUSION

In this study the behavioral state did not influence on the aspects of tongue cupping, labial sealing, strength, rhythm, coordination and number of sucks per block during NNS. In regards to NS, it was verified the influence of behavioral states on the number of sucks, reflecting on infant feeding performance.

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