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MODERAÇÃO E MEDIAÇÃO NA ANÁLISE DO PADRÃO DE SUCÇÃO NÃO NUTRITIVA EM RECÉM-NASCIDOS PREMATUROS

MODERATION AND MODERATED MEDIATION IN THE ANALYSIS OF NON-NUTRITIVE SUCKING PATTERN OF PRETERM NEWBORNS

MODERACIÓN Y MEDIACIÓN EN EL ANÁLISIS DEL PATRÓN DE SUCCIÓN NUTRICIONAL EN RECIÉN NACIDOS PREMATUROS

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RESUMO

Introdução: A estimulação da sucção não nutritiva mostrou influenciar o processo de maturação da sucção nutritiva.
Objetivo: Analisar o efeito da maturação sobre o padrão de sucção, mediado pelo tempo de experiência.
Métodos: Amostra constituída por 34 recém-nascidos com idade gestacional média de 33,2 semanas e tempo médio de experiência de 14,7 dias. Utilizámos o padrão de sucção como modelo de moderação. A variável dependente é o número médio de sucções, e as variáveis independentes consideradas são a idade gestacional (maturação) e o tempo de experiência (moderador).
Resultados: Foi encontrada uma relação positiva da experiência sobre o padrão de sucção, variável com o tempo de prática e mais evidente a partir das 32 semanas de idade gestacional.
Conclusão: A evidência estatística encontrada tem relevância clínica na elaboração de programas de intervenção na estimulação da sucção dos recém-nascidos prematuros, e interessa a profissionais de saúde com intervenção no domínio.

Palavras-chave: sucção; recém-nascido; estimulação; maturação; mediação; moderação

ABSTRACT

Introduction: Stimulation of non-nutritive suction has been shown to influence the maturation process of nutritive suction.
Objective: Analyze the effect of maturation on the suction pattern, mediated by the time of experience.
Methods: Sample consisting of 34 newborns with an average gestational age of 33.2 weeks and an average experience time of 14.7 days. We used the suction pattern as a moderation model. The dependent variable is the average number of sucks, and the independent variables considered are gestational age (maturation) and length of experience (moderator).
Results: A positive relationship between experience and suction pattern was found, variable with time of practice and more evident after 32 weeks of gestational age.
Conclusion: The statistical evidence found has clinical relevance in the design of intervention programs to stimulate the sucking of premature newborns, and is of interest to health professionals with intervention in the field.

Keywords: suction; newborn; stimulation; maturation; mediation; moderation

RESUMEN

Introducción: Se ha demostrado que la estimulación de la succión no nutritiva influye en el proceso de maduración de la succión nutritiva.
Objetivo: Analizar el efecto de la maduración sobre el patrón de succión, mediado por el tiempo de experiencia.
Métodos: Muestra compuesta por 34 recién nacidos con una edad gestacional promedio de 33.2 semanas y un tiempo de experiencia promedio de 14.7 días. Usamos el patrón de succión como modelo de moderación. La variable dependiente es el promedio de succiones y las variables independientes consideradas son la edad gestacional (maduración) y la duración de la experiencia (moderador).
Resultados: Se encontró una relación positiva entre experiencia y patrón de succión, variable con el tiempo de práctica y más evidente después de las 32 semanas de edad gestacional.
Conclusión: La evidencia estadística encontrada tiene relevancia clínica en el diseño de programas de intervención para estimular la succión de recién nacidos prematuros, y es de interés para los profesionales de la salud con intervención en el campo.

Palabras clave: succión; recién nacido; estimulación; maduración; mediación; moderación

INTRODUTION

About 1% of Portuguese newborns (NB's) are premature with less than 32 weeks of gestational age and / or birth weight below 1500g, that is, very low birth weight (VLBW), approximately 1000 VLBW per year (Peixoto, Guimarães, Machado, et al., 2002). The growth and development of these newborns occurs largely outside the maternal womb, in intensive care units, with a high risk of sequelae, both from the nutritional point of view (Moreira, Matos, Rebelo Pacheco , Cunha, 2020) as from the neurodevelopment (Matos, Costa, Rebelo Pacheco, Moreira, Cunha, Barroso, 2019).
The sucking capacity has a direct effect on growth and development and may be considered an indicator of the appropriate neurodevelopment outcome (Medoff-Cooper, Mcgrath, Bilker, 2000).

The effectiveness of suction depends not only on maturation but also on training or experience, and is also influenced by other variables such as weight (Cunha, Barreiros, Gonçalves, Figueiredo, 2009). The stimulation of this essential competence plays an important role in the development of the VLBW.

During the neonatal period the success of oral feeding depends on the coordination of sucking, swallowing and breathing, and also on the newborn's alertness (Finan and Barlow, 1998; Fucile, Gisel, and Lau, 2005; Lundqvist and Hafström, 1999). The sucking rhythm and the suction intensity are good indicators of the suction competence and have clinical relevance because, providing indirect information about the neuromuscular activity and the maturation of the sucking pattern (Finan and Barlow, 1998; Barlow, Finan, Lee and Chu, 2008).

There is a controversy about the effects of maturation (gestational age) and experience in the formation and evolution of the sucking rhythm, and it is recognized that experience and practice improve motor skills and suction-swallowing-breathing coordination. The maturation of the suction behavior seems to follow a caudo-cephalic progression, that is, the stabilization of the swallowing rhythm seems to precede the stabilization of the sucking rhythm (Finan and Barlow, 1998; Barlow et al., 2008; Cunha et al., 2009), and is influenced by stimulation, as demonstrated by research that shows that non-nutritive sucking stimulation programs influence the maturation process of nutritive sucking (Cunha et al, 2009; Fucile et al, 2005; Rocha, Moreira, Pimenta, Ramos, Lucena, 2007).

The direct observation of an experimental intervention or of a natural variation in behavior carries ethical and methodological limitations. If the results indicate a no stimulation effect it is not possible to understand why a given intervention was not effective. On the contrary, in the presence of a positive effect of stimulation there is no way to identify the key components of the stimulation program since the stimulation program is usually designed as a unit. In fact, many experimental interventions may have only indirect effects or produce effects through other nearby or intermediate variables. To overcome these limitations it is recommended to investigate the "third" variables that influence or interfere in the mechanisms that operate between the intervention and the final result (Bauman, Sallis, Dzewaltowski and Owen, 2002). This model, known as: stimulus - organism – response, states that the effect of a certain stimulus on behavior is mediated by the various internal processes of the organism, but other models based on the direct stimulus-response relationship do not consider the interventional role of the organism. Ecological models of human development consider that, in addition to the direct effect of a variable, it is also necessary to consider the effects of mediating (or moderating) variables on such effect (Muller, Judd, Yzerbyt, 2005).

The aim of the present study is to apply the moderation model to observe the effect of maturation on suction, mediated by experience. This method was notapplied to the development of the suction pattern in NB and VLBW, so far.

1. METHODS

This is a non-experimental study of a moderation statistical model, about the interaction effects of maturation and experience in non-nutritive sucking, using a convenience sample of premature newborns. The hypothesis under investigation is that the suction rhythm depends on maturation, observed by gestational age, but it is influenced by the NB's experience in sucking.

A device with a pressure sensor pneumatically connected to a pacifier was used, ensuring non-invasive measurement through galvanic isolation, and connected to a Biopac A/D to convert analog data to digital data (ADC). The temporal structure and the sucking pressure were collected. The variables used to characterize the sucking pattern were the interval between sucks, the number of burst, the interval between bursts, the number of suctions per burst, the minimum and maximum pressure and the amplitude of each suction. Periods of 10 minutes of non-nutritive sucking were measured before a newborn's breastfeeding with a sampling frequency of 10 Hz (Cunha et al. 2009; Cunha, Barreiros, Pereira et al. 2019).

Data collection was approved by the hospital's ethics committee and informed consent was individually obtained from the parents.

Statistical analysis

The average number of sucks as considered a dependent variable, and the independent variables were gestational age (maturation) and time of intervention (experience), as a moderating variable.

Mediation

Mediation can be defined as an indirect effect that occurs when there is an effect of a given independent variable (predictor) on a dependent variable (result) that is transmitted by a mediator. We term this three-variable system *simple mediation*. Simple mediation is illustrated in the path diagram in Figure 1 (Muller, et al. , 2005). Mediation models take into consideration the sum of direct effects, indirect effects and spurious effects. In the figure, *a* refers to the (unstandardized) slope coefficient of M (mediator) regressed on X (independent predictor variable), and *b* and *c'* denote the conditional coefficients of Y (dependent variable) regressed on M and X, respectively, when both are included as simultaneous predictors of Y . Letting *c* represent the effect of X on Y in the absence of M (time of experience), the indirect effect is traditionally quantified as *c – c'*, which is ordinarily equivalent to *axb* ((Preacher, Rucker and Hayes, 2007; Fairchild and MacKinnon, 2009; Muller, et al., 2005))

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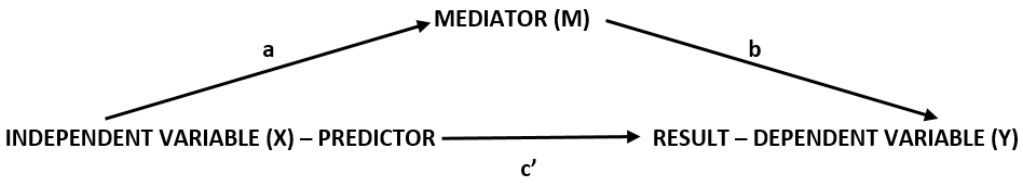

Figure 1 - mediation example: independent variable (preditor x); dependent variable (result y); mediator (m) (adapted from muller, et al., 2005).

Mediator

The mediator, or causal variable of the intervention, acts between the exposure to the intervention and the final outcome (Bauman et al., 2002). There may be simultaneously one or more mediators in this causal relationship. The mediating variable answers the question of "how" or "why" the variable X causes the effect Y, that is, the mediator explains the relationship between the predictor and the outcome.

Moderation

When the strength of the relationship between two variables is dependent on a third variable, *moderation* is said to be occurring. The third variable, or *moderator* (M), interacts with X in predicting Y if the regression weight of Y on X varies as a function of W, see example in figure 2. (Preacher et al ., 2007; Fairchild and MacKinnon, 2009; Muller, et al., 2005). Moderation is also popularly known as *interaction.* Interaction or moderation hypotheses can be tested with regression analysis without requiring that *X* and *W* are categorical. (Hayes & Rockwood, 2016)

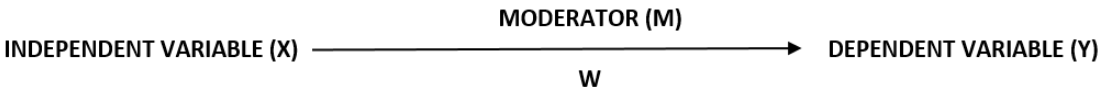

Figure 2 - moderation example: moderator (m); independent variable (x); dependent variable (y); influence of y regression on variable x as a moderator (w) (adapted from muller, et al., 2005).

Moderator

The moderating variable reduces or increases the strength of the relationship between the predictor and the dependent variable, modifying the relationship between the predictor or independent variable and the dependent variable. But it can also change the direction of the relationship between the two variables, acting as a "mediator" which influences the final result (Bauman et al., 2002). When a correlation between two variables is observed it is reasonable to question what other variables can interfere in such relationship. In the present case, there is a positive correlation between gestational age, time of experience and suction efficiency, that is, suction efficiency increases with gestational age, but on the other hand, more experienced babies have better suction efficiency (Cunha, et al., 2009). If the time of experience is a moderator then the sucking effectiveness will be greater with longer experience time but it will also vary with the gestational age.

Studies of the effects of interaction applying this model with continuous variables recommended the use of moderate hierarchical regression (Markland, 1999). Alternatively, it is possible to dichotomize the moderating variable and then compare its correlations between the predictor and the dependent variable at different levels of the moderator, or more commonly, dichotomize the two independent variables and then perform a two-way ANOVA analysis. However, it has been shown that this procedure leads to a great loss of information, which can be avoided using a regression method (Markland, 1999; Palmeira, Markland, Silva, et al., 2009).

2. RESULTS

The sample consists of 34 newborns (NB) with an average gestational age of 29.3 weeks, in the majority males (61%), with an average birth weight of 1237.3 g. At the time of assessment the group had an average corrected age of 33.3 weeks and an average experience time (ET) of 14.7 days. Other variables are described in Table 1.

Table 1 - Descriptive statistics of the sample characteristics

	N = 34	Minimum	Maximum	Mean	Standard deviation
Gestational Age (weeks)		26	35	29,4	2,1
Birth Weight (g)		700	2310	1237,5	320,1
Gender (Male / Female)	21/13				
Apgar Score (median)		6	10	(8,5)	
Corrected Gestational Age at evaluation		28	40,6	33,3	2,4
Chronological Age at evaluation (days)		7	77	27,7	13,6
Weight at evaluation (g)		729	2420	1503,2	362,7
Experience Time (days)		0	67	14,7	13,5
Average of Bursts		3	88	30	17,7
Average of Sucks per Burst		2	12	6,5	2,3
Suck Amplitude (mmHg)		2,6	20,5	10,9	4,8

A positive and significant linear correlation was found between each of the independent variables and the dependent variable (Table 2).

Table 2 - Linear correlation between the dependent variable and the independent variables

	N = 34	CorrA	TExp	MNSuc	ZCorrA	ZTExp
TExp	Pearson' Correlation	0,772**				
	Sig. (bilateral)	0,000				
MNSuc	Pearson' Correlation	0,477**	0,412*			
	Sig. (bilateral)	0,004	0,015			
ZCorrA	Pearson' Correlation	1,000**	0,772**	0,477**		
	Sig. (bilateral)	0,000	0,000	0,004		
ZTExp	Pearson' Correlation	0,772**	1,000**	0,412*	0,772**	
	Sig. (bilateral)	0,000	0,000	0,015	0,000	
PZCorrATExp	Pearson' Correlation	0,769**	0,988**	0,421*	0,769**	0,988**
	Sig. (bilateral)	0,000	0,000	0,013	0,000	0,000

**. Coorelation is significant at level 0,01 (bilateral). *. Correlation is significant at level 0,05 (bilateral). CorrA: corrected gestational age; TExp: Time of experience; MNSuc: mean Number of Sucks per Burst; ZCorrA: Standardized Corrected gestational age; ZTexp: Standardized Time of experience; PZCorrATExp: Product of ZCorrA and ZTExp.

Since the independent variables have very different scales and dispersions, we standardized them to obtain zero averages and unitary standard deviations. For this purpose we determined the mean and standard deviation of each variable and using the formula (value X - mean X / standard deviation X) new standardized variables were obtained (variable Z) (Table 2).
The new standardized variables are also correlated (in Table 2, variable Z) and their product was calculated in order to obtain a new variable that expresses the interaction of the independent variable and the moderator (in Table 2, variable PZ).
The standardization procedure allows to directly compare the relative influence (parameter estimates) of various variables with different scales and dispersions. Then, the results of a multiple linear regression indicated that the independent variables, as well as their standardized versions, do not significantly explain the effect of the dependent variable - average number of suctions. More specifically, the determination coefficient obtained for the multiple linear regression models was r2 = 0.232 (23.2% of explained variation) and the regression coefficients associated with the independent variables were not significantly significant (p> 0.05) (Table 3).

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Table 3 - multiple linear regression between independent variables and dependent variable

Model summary [b]				
Model	R	R square	R square adjusted	Estimated Standard error
1 e 2	,482[a]	0,232	0,183	2,149
a. Predictor's: (Constant), TExp, CoorA; ZCorrA				
b. Dependent Variable: MNSucks				

Coeficient's[a]								
		Nonstandard coefficients		Standard coefficients			95.0% B Confidence interval	
Model		B	Standard Error	Beta	t	Sig.	Lower Limit	Upper Limit
1	(Constant)	-6,495	7,564		-0,859	0,397	-21,921	8,931
	CORRECTED AGE	0,384	0,241	0,394	1,591	0,122	-0,108	0,876
	TIME OF EXPERIENCE	0,019	0,044	0,108	0,434	0,667	-0,070	0,108
	(Constant)	-1,233	4,319		-0,286	0,777	-10,042	7,576
2	ZCorrA	0,384	0,241	0,394	1,591	0,122	-0,108	0,876
	ZTExp	0,019	0,044	0,108	0,434	0,667	-0,070	0,108

Using Hayes' methodology (Hayes and Rockwood, 2016), by applying the PROCESS macro to SPSS®, we obtained the graph shown in figure 3. The curves obtained through the "slope graphs" or "plot slopes" show a dichotomous interaction between maturation and experience in what refers to the number of sucks (Figure 3). According to the model the cut-off value for the time of experience was: low value of experience time = 1.2 days, average value = 14.2 days, and the high value = 28.4 days. In the lower gestational ages (≤ 30 weeks GA), greater experience shows a tendency to have fewer sucks. On the other hand, in higher gestational ages individuals (≥35 weeks GA), a longer time of experience clearly increased the number of suctions. The cutoff occurs at 32 weeks of corrected gestational age (Figure 3). However, this trend did not show statistically significant differences, as can be observed by the difference between the slopes (z score) (Table 4). For a low, medium or high ET value, the moderating effect obtained through the application of PROCESS by the z score found was not statistically significant for any level of significance (Table 4).

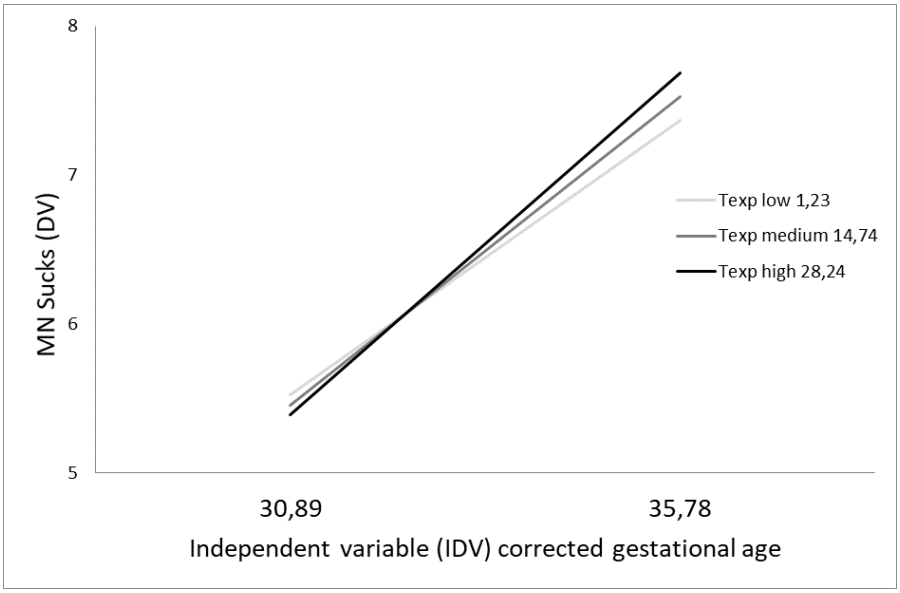

Figure 3 - variation of the average number of sucks with low (≤30s) or high (≥35s) gestational age and according to the low, medium or high experience time (moderator). intersection point 32.3 weeks ga.

Table 4 - Differences between slopes

	raw (b)	Standard error (s.e.)	Value t	Critical value of Z
Mod*=TE low	0,378	0,245	1,546	(+/-) 1.96 p < 0.05
Mod=TE medium	0,424	0,259	1,638	(+/-) 2.58 p < 0.01
Mod= TE high	0,470	0,307	1,532	(+/-) 3.29 p < 0.001
Low vs medium				
b low	s.e b low	b medium	s.e. b medium	Z-score
0,378	0,245	0,424	0,259	-0,129
Low vs high				
b low	s.e. b low	b high	s.e. b high	Z-score
0,378	0,245	0,470	0,307	-0,235
Medium vs high				
b medium	s.e. b medium	b high	s.e. b high	Z-score
0,424	0,259	0,470	0,307	-0,115

*Mod= TE (Moderator Time of Experience)

3. DISCUSSION

The influence of maturation and experience in the suction of the newborn is a topic of debate and research but there is no consensus about the role of several variables under investigation (Qureshi, Vice and Taciak, 2002; Mizuno and Ueda, 2006; Taki, Mizuno, Murase, et al., 2010). In addition, other variables, such as weight, may also play an influence on the behavior of the suction pattern (Cunha et al., 2009; Wrotniak, Stettler and Medoff-Cooper, 2009). Therefore it is important to apply a model that takes into consideration the active role of the organism and that may clarify the complex nature of the maturation/experience relationship in the development of suction competence in newborns. The application of classical statistical models does not allow to effectively assess the mediation of the sucking experience on maturation. The use of PROCESS points out that this influence manifests itself, as in other biological phenomena, through a dichotomy of moderation in which; in the first phase, there seems to be a disorganization of the movement pattern in order to subsequently achieve equilibrium, as demonstrated in the present study.

The most recent development theories suggest that experience or practice play an important role in the development of a better response (Hadders-Algra, 2000a; Chervyakov, Sinitsyn and Piradov, 2016). However, the existence of several neurons with the same function and the possibility of several neuronal synapses that stimulate the same movement lead to a greater variability in the first phase of development until an equilibrium point is reached with best performance and the lowest energy expenditure (Hadders-Algra, 2000a; Chervyakov et al., 2016; Hadders-Algra, 2000b). Spontaneous activity and experience seem to play an important role in the selection of neuronal circuits that are initially defined by maturation for a given movement or set of movements (Chervyakov et al., 2016) and this mechanism seems to occur in the suction of the newborn. Suction is a highly differentiated movement that depends on central pattern generators and neuronal circuits located in the brain stem. Their relationship with other central pattern generators such as swallowing and breathing depends on experience (Finan and Barlow, 1998; Fucile et al., 2005; Lundqvist and Hafström, 1999).

Our results using the non-nutritive sucking pattern in a moderation model, which considers the average number of sucks as dependent variable, and gestational age (maturation) and time of experience (moderator) as independent variables, show that there is a positive association to experience on the suction pattern, which varies with time of practice. This effect is more evident after 32 weeks of corrected gestational age, however without statistical significance. The positive effect of the experience (training) has been demonstrated by different authors (Cunha, et al., 2009; Fucile, et al., 2005; Mizuno and Ueda, 2006; Qureshi, Vice and Taciak, 2002; Rocha, et al. , 2007; Taki, et al., 2010).

3.1 Limitations

The sample studied is small and, perhaps for that reason, without the statistical power necessary to obtain a significant result. The use of non-nutritive suction, which is more accessible from the point of view of movement quantification, can be considered another limitation since it only allows an inference about the competence development of nutritive suction.

CONCLUSION

The use of the moderation model allows to confirm the positive association of experience in the evolution of the suction pattern. Although our study did not obtain a statistically significant result it points to the positive role of prolonged intervention time. In addition, the conclusion that the gestational age of 32 weeks is the age at which intervention programs will be most effective was corroborated. This hypothesis calls for further research oriented to the investigation of nutritive sucking, with larger samples, and it must be taken into account by clinicians and speech therapists, who participate in suction of premature newborns intervention programs.

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