REVIEW

Effect of oral stimulation on premature newborns' feeding performance: a systematic review

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Abstract

Objectives: to analyze the correlation between oral stimulation, the sucking pattern and feeding performance of premature newborns.

Methods: systematic review following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Statement guidelines. The databases consulted included PubMed-Central, Cielo, LILACS, and via EBSCOHost, with no temporal or language restrictions. The research process was carried out from October to November 2023. The selection, screening, and integration of studies were conducted using the Rayyan® software, in collaboration with another researcher. Evidence analysis was performed using the Quality Assessment Tool for Quantitative Studies instrument.

Results: 358 articles were found, of which 13 were selected after eliminating duplicates and application of the qualification criteria. Three additional articles were included through reference analysis, totaling a sample of 16 original studies. Evidence levels varied, with one study classified as weak, three as moderate, and twelve as strong. The results obtained demonstrated that oral stimulation improved the sucking pattern and feeding performance, contributing to early hospital discharge.

Conclusion: the literature supports that oral stimulation techniques, non-nutritive sucking and Premature Infant Oral Motor Intervention have beneficial effects on the premature newborns' feeding process.

Key words *Infant premature, Feeding methods, Sucking, Sucking behavior, Deglutition*

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Introduction

Prematurity refers to all live newborns who are younger than 37 weeks.[1] A premature newborn has an underdeveloped nervous system as a result of neurological immaturity, and for this reason, changes in the coordination of the sucking-swallowing-breathing pattern.[2] As the sucking pattern is usually reduced, oral motor skills will be compromised and consequently oral feeding can become challenging for these children.[2]

It is important to note that clinical practice has shown that premature infants do not suddenly start sucking efficiently, and there is a need for preparation and training so that their sucking and swallowing patterns become coordinated. This training period must be constantly evaluated and stimulated, with the aim of preparing the newborn for more robust and effective sucking.[3] The proper coordination of sucking, swallowing and breathing is a determining factor in ensuring safe feeding. Compromising any of these three functions can put the newborn at risk, specifically aspiration, pneumonia, oxygen desaturation, apnea and bradycardia.[4]

Due to the use of an alternative feeding route, these newborns often present difficulties and alterations in oro-motor functions, hindering the safe and efficient transition to the oral route.[5]

The stimulation for nutritive and non-nutritive sucking are forms of oral sensorimotor stimulation. The framework for their use is related to the development of the phonoarticulatory organs, which occurs due to the occurrence of muscular pressure during the babies' sucking function.[6] By performing nutritive or non-nutritive sucking, the newborn will be developing the phonoarticulatory organs properly, thus promoting the correct functioning of the oromotor structures due to the relationship that exists between the stomatognathic system and the other organs and functions.[7]

The technique of non-nutritive sucking with the gloved little finger[8] is one of the most common routine in the neonatal intensive care units, followed by non-nutritive sucking with a pacifier.[8] This technique can be used alone or combined with other strategies in specific intervention programs.

The oral stimulation program[9] can be implemented for this purpose. This program includes 15 minutes of intervention, in which the first 12 minutes consist of stimulating the cheeks, lips, gums and tongue, and the last three minutes consist of non-nutritive sucking on a pacifier commonly used in the nursery.[9] Oral sensorimotor stimulation in premature newborns accelerates the maturation process of oral reflexes, helping to develop the ability to feed orally in a safe and effective way.[10]

In particular, the Premature Infant Oral Motor Intervention (PIOMI) is an oral stimulation program created by Lessen[11] that provides (i) assisted movements to activate muscle contraction of the phonoarticulatory organs (ii) against resistance to increase strength.[11] Given the difficulties that prematurity brings, it is important to understand how different techniques can facilitate the feeding pattern on premature newborns, since it is essential for them to be able to make the feeding transition in a safe and effective way.

Therefore this study aims to examine the effects of oral stimulation on the feeding performance of premature newborns. The aim is to analyze the relationship among oral stimulation, the sucking pattern and the feeding performance of these newborns.

Methods

This study is of a methodological nature and consists of a systematic review of the literature that aims to analyze the importance of oral stimulation in the performance of the premature newborns' on feeding pattern and sucking. This review has been registered on the International Platform of Registered Systematic Review and Meta-analysis Protocols (INPLASY) under the registration number INPLASY2024100083.

The question of the present study was carried out in PICO format, i.e. Population (P), Intervention (I), Comparator (C) and Outcome (O), considering the question: "What is the importance of oral stimulation (I) compared to the standard procedure (C) in the feeding performance (O) of preterm newborns (P)?". In particular, for the outcome under study (i.e. feeding performance), measures of i) milk transfer rate, ii) overall milk intake volume, iii) feeding performance/sucking pattern, iv) oral feeding initiation time, v) independent oral feeding, vi) effective breastfeeding and vii) early hospital discharge were analyzed.

Eligibility criteria were established for this study, as follows. Regarding the inclusion criteria, primary studies were included with premature newborns who presented feeding difficulties, born between 25-36 weeks of gestation who were stable and did not require mechanical ventilation, subject to oral stimulation programs and non-nutritive sucking. Articles duplicated in the database,

letters to the editor, gray literature articles, case reports, secondary reports, studies integrating newborns with primary diagnoses and studies that did not answer the research question were excluded. Articles were not excluded based on the level of evidence.

The search for the present investigation was carried out by two independent researchers through the PubMed Central, SciELO, LILACS databases and a search of the following databases through the EBSCOHost platform: CINA-HL Complete, Cochrane Collection Plus, Nursing & Allied Health Collection and Medic Latina. No time or language restrictions were set. The specific descriptors and search keys for each database are shown in Table 1. Four key terms were used for the search key: speech therapy, premature newborns and sucking pattern. The Medical Subject Headings (MeSH term) "speech therapy" and the natural language term "stimulation" were used for the concept "speech therapy". For "premature newborns", the MeSH term "infant, premature" and the natural language terms "preterm infant" and "infant, preterm" were used. For "sucking pattern", the MeSH terms "sucking behavior", "breast feeding", "feeding behavior" and the natural language terms "breastfeeding", "breast fed" and "wet nursing" were used. The descriptors were combined with Boolean operators AND and OR and proximity operators "" and (). To increase comprehensiveness during the search, no filters were used in the databases (e.g. time period of publication, type of study).

Following the literature search, it was necessary to remove duplicates and assess the titles and abstracts of the remaining results, in order to judge whether they should be included. At this stage, the program Rayyan® was used,[12] thus facilitating the organization of the studies and the screening process. This selection was carried out independently by two researchers. Studies that met the inclusion criteria were selected and those that did not fit the topic under study were removed after reading the titles and abstracts. This program also made it possible to obtain basic bibliometric information, helping to reduce bias among researchers, attach full texts, resolve duplicates and justify the exclusion of studies through labeling.[12] In the event of non-consensus, the collaboration of a third researcher was predicted.

Once all the studies that met the previously defined criteria had been included, their bibliographic references were consulted in order to examine possible additional sources of information that had not been detected in the initial search. Subsequently, the studies selected after a consensus meeting were read in full by a researcher and a detailed analysis was carried out.

The selection of studies was described in a flowchart, following the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Statement (PRISMA)[13] (Appendix 1). The evidence analysis was carried out for each study according to the Quality Assessment Tool For Quantitative Studies.[14] This tool allows the final classification of the quality of studies by assigning sub-classifications (strong, moderate or weak) to a set of six topics: sample representativeness, study design, confounding factors, blinding, data collection and retention (dropouts). An overall classification was determined based on the sub-classifications assigned: strong if there were no weak sub-classifications; moderate if there was one weak sub-classification; weak if there were more than two weak sub-classifications.[14] The results obtained are organized in Table 2, which includes the reference of each one, the types of study, the population, the methodology, the results, the conclusions and the evidence analysis.[14] Table 3 organizes the different outcomes studied at the end of each investigation.

Results

Figure 1 shows the flowchart that integrates the process of integrating the studies for the present investigation, which contains information on the process of identifying and screening studies. It also shows the reasons for excluding records. The results of the search in the different databases (n=358) were imported into the program Rayyan®. Secondary reports (n=33), case reports (n=11) and those that did not answer the study question (n=231) were then excluded, with the titles first being analyzed and, if there were any doubts, the abstract. Articles which could not be accessed in full were also excluded (n=2). The researchers of these studies were contacted, but no reply was received. As a result, 13 studies were integrated and three were added by analyzing the bibliographical references of the studies already selected, giving a total of 16 articles as a sample of original studies. When the sample of original studies was reviewed with a second researcher, there was total consensus and agreement.

Of the 16 studies analyzed, one had a weak level of evidence, three had a moderate level of evidence and 12 were classified as having a strong level of evidence. The evidence analysis is present in all the columns of

Table 1

Research key and results in the different databases.

	Research key (PUBMED Central)	Results
#1	(speech therapy[MeSH Terms]) OR (stimulation)	1,472,764
#2	**(((((Breastfeeding) OR (Breast Fed)) OR (Wet nursing)) OR (Sucking Behavior[MeSH Terms])) OR (breast feeding[MeSH Terms])) OR (feeding behavior[MeSH Terms])**	**222,730**
#3	((infant, premature[MeSH Terms]) OR (preterm Infant)) OR (Infant, Preterm)	127,265
#4	#1 AND #2 AND #3	230
	Research key (SciELO)	**Results**
#1	(speech therapy) OR stimulation	4785
#2	(Sucking Behavior) OR (Breast Feeding) OR (feeding behavior) OR (Breastfeeding) OR (Breast Fed) OR (Wet Nursing)	5336
#3	(infant, premature) OR (Preterm Infants) OR (Infant, Preterm)	1431
#4	((speech therapy) OR stimulation) AND ((Sucking Behavior) OR (Breast Feeding) OR (feeding behavior) OR (Breastfeeding) OR (Breast Fed) OR (Wet Nursing)) AND ((infant, premature) OR (Preterm Infants) OR (Infant, Preterm))	16
	Research key (SciELO)	**Results**
#1	(Speech therapy) OR stimulation	1 844
#2	(Sucking Behavior) OR (Breast Feeding) OR (feeding behavior) OR (partial breastfeeding)	3212
#3	(extremely premature infant) OR (Premature newborn)	711
#4	((Speech therapy) OR stimulation) AND ((Sucking behavior) OR (breastfeeding) OR (feeding behavior) OR (partial breastfeeding)) AND ((extremely premature infant) OR (Premature newborn))	16
	Research key (LILACS)	**Results**
#1	(speech therapy) OR stimulation	11897
#2	(Sucking Behavior) OR (Breast Feeding) OR (feeding behavior) OR (Breastfeeding) OR (Breast Fed) OR (Wet Nursing)	12599
#3	(infant, premature) OR (Preterm Infants) OR (Infant, Preterm)	5104
#4	((speech therapy) OR stimulation) AND ((Sucking Behavior) OR (Breast Feeding) OR (feeding behavior) OR (Breastfeeding) OR (Breast Fed) OR (Wet Nursing)) AND ((infant, premature) OR (Preterm Infants) OR (Infant, Preterm))	44
	Research key (CINA-HL Complete, Cochrane Collection Plus, Nursing & Allied Health Collection and Medic Latina via EBSCOHost)	**Results**
#1	(speech therapy) OR stimulation	275,395
#2	(Sucking Behavior) OR (Breast Feeding) OR (feeding behavior) OR (Breastfeeding) OR (Breast Fed) OR (Wet Nursing)	90572
#3	(infant, premature) OR (Preterm Infants) OR (Infant, Preterm)	35828
#4	((speech therapy) OR stimulation) AND ((Sucking Behavior) OR (Breast Feeding) OR (feeding behavior) OR (Breastfeeding) OR (Breast Fed) OR (Wet Nursing)) AND ((infant, premature) OR (Preterm Infants) OR (Infant, Preterm))	53

Table 1. All the integrated studies made comparisons with control groups that were made up of sham (simulated procedures) or standard neonatal care, which refers to the set of practices and interventions carried out to promote the health and well-being of newborns. This care includes medical assistance, monitoring and support for newborns, focusing on the prevention, early diagnosis and treatment of conditions that may threaten their life or development.

The 16 studies selected for this investigation date from between 2002 and 2022, with the majority originating from the United States (Fucile *et al.*[9]; Fucile *et al.*[15]; Lessen[11]; Fucile *et al.*[16]), with some from Brazil (Rocha *et al.*,[17] Costa *et al.*[18]), India (Arora *et al.*[19]; Thakkar *et al.*,[20]; Kore and Mathew[21]), Iran (Ghomi *et al.*[22]; Mahmoodi *et al.*[23]; Ostadi *et al.*[24]), Luxembourg (Bache *et al.*[25]), China (Lyu *et al.*[26]), Thailand (Lessen *et al.*,[27]), and Spain (Aguilar-Rodríguez *et al.*[28]).

As mentioned above, in order to better organize the integrated studies and the results, three tables were drawn up: Table 1 contains the different results of each study and Table 2 presents a compilation of the outcomes studied in all the articles analyzed.

Table 2

Synthesis of included studies.

Reference	Type of study	Population	Methodology	Experimental Group Results	Conclusions	Evidence level
Fucile *et al.*,[9]	Double-blind randomized clinical trial	32 premature newborns	Experimental group (n=16): oral stimulation program and non-nutritive sucking (15 minutes, once a day for 10 days). Control group (n=16): Sham procedure (simulated procedure).	Milk transfer rate: better performance in overall milk transfer over time, reaching 100% of total intake in 1 to 2 oral feedings per day compared to the control group. Independent oral feeding: achieved independent oral feeding faster. Volume of milk ingested: the rate of volume ingested was higher than in the control group. Feeding performance/sucking pattern: Better sucking performance compared to the control group. Early hospital discharge: The difference in time to hospital discharge was not significant.	Pre-feeding oral stimulation program may benefit feeding performance. Faster transition to independent oral feeding was associated with better oral feeding performance.	Strong
Fucile *et al.*,[15]	Double-blind randomized clinical trial	32 premature newborns	Experimental group (n=16): non-nutritive sucking program for oral stimulation (15 minutes). Control group (n=16): Sham procedure (simulated procedure).	Milk transfer rate: higher milk transfer rate. Overall milk intake volume: higher overall intake volume. Feeding performance/sucking pattern: Both groups showed maturation of the sucking pattern and a decrease in sucking frequency over time (The sucking frequency for the experimental group was 2.3 and 1.1 from the 1st to 2nd and from the 6th to 8th oral feedings/day, respectively. For the control group, it was 2.6 and 1.3 at these two moments).	A non-nutritive oral stimulation program that facilitates the development of the expression component of sucking can improve oral feeding performance.	Strong
Lyu *et al.*,[26]	Double-blind randomized clinical trial	63 premature newborns	Experimental group (n=32): oral stimulation and non-nutritive sucking (15 minutes). Control group (n=31): Standard neonatal care (no stimulation).	Milk transfer rate: No differences in milk volume transfer. Feeding performance/sucking pattern: higher feeding performance (34.70 and the control group 35.66). Independent oral feeding: Experimental group: shorter time to gain independent feeding (9.56 and the control group 13.19). Early hospital discharge: no significant difference - experimental group - 39.97 ± 14.81 days; control group - 41.25 ± 16.15 days.	This program can shorten the time from tube feeding to full oral feeding. Oral stimulation brought benefits in feeding performance and the introduction of oral feeding.	
Arora *et al.*,[19]	Double-blind randomized clinical trial	30 premature newborns	Experimental group (n=16): PIOMI before feeding (5 minutes for 7 days). Control group (n=14): Sham procedure (simulated procedure).	Feeding performance/sucking pattern: better score on the Neonatal Oral-Motor Assessment scale (9.25 *vs* 4.79). Independent oral feeding: earlier transition from tube to independent oral feeding (4 *vs* 6.6). Early hospital discharge: shorter hospital stay (13.6 *vs* 16.1).	It was effective in reducing the transition time from tube feeding to independent oral feeding and in improving the oromotor performance of premature babies.	

Fucile *et al.*,[16]	Double-blind randomized clinical trial	31 premature newborns	Experimental group (n=16): sensorimotor intervention (15 minutes, once a day for 10 days). Control group (n=15): Sham procedure (simulated procedure).	Independent oral feeding: achieved full oral feeding 8 days earlier.Breastfeeding: higher breastfeeding rate at hospital discharge (11 *vs* 5). Early hospital discharge: discharged 10 days earlier.	Oral sensorimotor intervention can facilitate the transition from tube feeding to oral feeding and increase direct breastfeeding rates at hospital discharge.	
Thakkar *et al.*,[20]	Double-blind randomized clinical trial	102 premature newborns + 10 of Hawthorne's group	Intervention group (n=51): PIOMI (2 times a day, for 5 minutes). Control group (n=51): Standard neonatal care (no stimulation). Hawthorne group (n=10): No intervention of any kind.	Milk transfer rate: No differences. No difference between the control group and Hawthorne.Overall milk intake volume: intake volume (10.37 *vs*. 9.81). Feeding performance/sucking pattern: No differences. Independent oral feeding: shorter transition period to reach 4 oral feedings/day and 8 oral feedings/day. Early hospital discharge: shorter length of stay (22.12 *vs* 24.88). No difference between the control group and Hawthorne.	Oral stimulation in preterm infants improves feeding performance, promotes earlier achievement of independent oral feeding and reduces length of hospital stay.	
Ghomi *et al.*,[22]	Double-blind randomized clinical trial	30 premature newborns	Experimental group (n=15): PIOMI (5 minutes, once a day for 10 days). Control group (n=15): Standard neonatal care (no stimulation).	Feeding performance/sucking pattern: 1st oral feeding (7.2 days) and 8 oral feedings (13.47 days) earlier. Time to start oral feeding: feeding progression was 6.27 days shorter. Independent oral feeding: 14.73 days earlier transition from tube to independent oral feeding.Early hospital discharge: discharged 9.47 days earlier.	PIOMI is suitable for premature infants and has a positive impact on the development of oral motor skills, feeding progression and reduction in hospital stay.	Strong
Lessen *et al.*,[27]	Double-blind randomized clinical trial	30 premature newborns	Experimental group (n=15): PIOMI (5 minutes, once a day, for 7 days). Control group (n=15): Standard neonatal care (no stimulation).	Overall milk intake volume: higher oral milk intake volume over the 5 days (61.66 on day 5 vs 34.83). Feeding performance/sucking pattern and time to start oral feeding: rate of improvement over the 5 days exceeded that of the control group, showing a more efficient first feeding (39.64 vs 26.62).	PIOMI increased the average volume of oral intake of the newborns who benefited from the intervention.	Moderated
Mahmoodi *et al.*,[23]	Double-blind randomized clinical trial	40 premature newborns	Experimental group (n=20): PIOMI (5 minutes, for 7 days). Control group (n=20): Standard neonatal care (no stimulation).	Time to start oral feeding: average time to start oral feeding was earlier (9.55±1.70 days; in the control group it was 11.5±2.77 days). Independent oral feeding: achieved independent feeding earlier. Early hospital discharge: shorter average hospital stay (16.5±3.9; control group 19.4±4.08 days).	PIOMI had positive effects on the readiness for oral feeding as well as on the progression to full oral feeding and subsequently, the improvements in oral feeding led to a reduction in the length/days of hospital stay, making it suitable for premature newborns.	Strong

Aguilar-Rodríguez *et al.*,[28]	Double-blind randomized clinical trial	46 premature newborns	Experimental group (n=24): oral sensorimotor stimulation (10 minutes for 2 weeks). Control group (n=22): Standard neonatal care (no stimulation).	Time to start oral feeding: The control group's first oral intake took 5.88 days longer. Control group took 8.3 days longer to achieve full oral feeding Control group took 6.03 days longer. Early hospital discharge: The control group took 6.9 days longer to be discharged from hospital.	Oral sensorimotor stimulation speeds up the achievement of full oral feeding, as well as the achievement of first oral intake and first full oral intake, resulting in a significant reduction in hospitalization days.	Strong
Ostadi *et al.*,[24]	Double-blind randomized clinical trial	40 premature newborns	Experimental group I (n=13): Non-nutritive sucking (for 10 days). Experimental group II (n=14): swallowing exercises + non-nutritive sucking (for 10 days). Control group III (n=13): Standard neonatal care (no stimulation)	Feeding performance/sucking pattern: Compared to the control group, both intervention groups showed an increase in the Preterm Oral Feeding Readiness Scale (POFRAS) in improving readiness for oral feeding, but no statistically significant differences between the two. Time to initiation of oral feeding and independent oral feeding: Compared to group III, more babies in group II were discharged without tube feeding (78.6% *vs* 30.8%). Between group I and II, there were no differences in the number of babies discharged without tube feeding.	Although the interventions studied had no effect on the functional outcomes examined, both were superior to routine care in improving the readiness for oral feeding of premature infants based on the POFRAS score. The combined program of non-nutritive sucking together with swallowing exercises may be more effective in transferring tube feeding to oral feeding than non-nutritive sucking exercises alone.	Strong
Kore and Mathew[21]	Estudo quase experimental com grupo de controle não aleatorizado	40 premature newborns	Experimental group (n=20): Oral sensorimotor stimulation (5 minutes for 5 days). Control group (n=20): Standard neonatal care (no stimulation).	Feeding performance/sucking pattern: In the pre-assessment, in the control group, 70% were in the reasonable category and 30% in the good category with regard to feeding performance. In the experimental group, 75% were in the reasonable category and 25% were in the good category. After the intervention, 95% of the participants in the experimental group were in the good category and in the control group only 75% were in the good category in terms of eating performance.	Oral stimulation was effective in reducing feeding problems, improving feeding performance and having a positive impact on the development of oral motor skills.	Weak

POFRAS= Preterm Oral Feeding Readiness Scale; PIOMI= Premature Infant Oral Motor Intervention.

Table 3

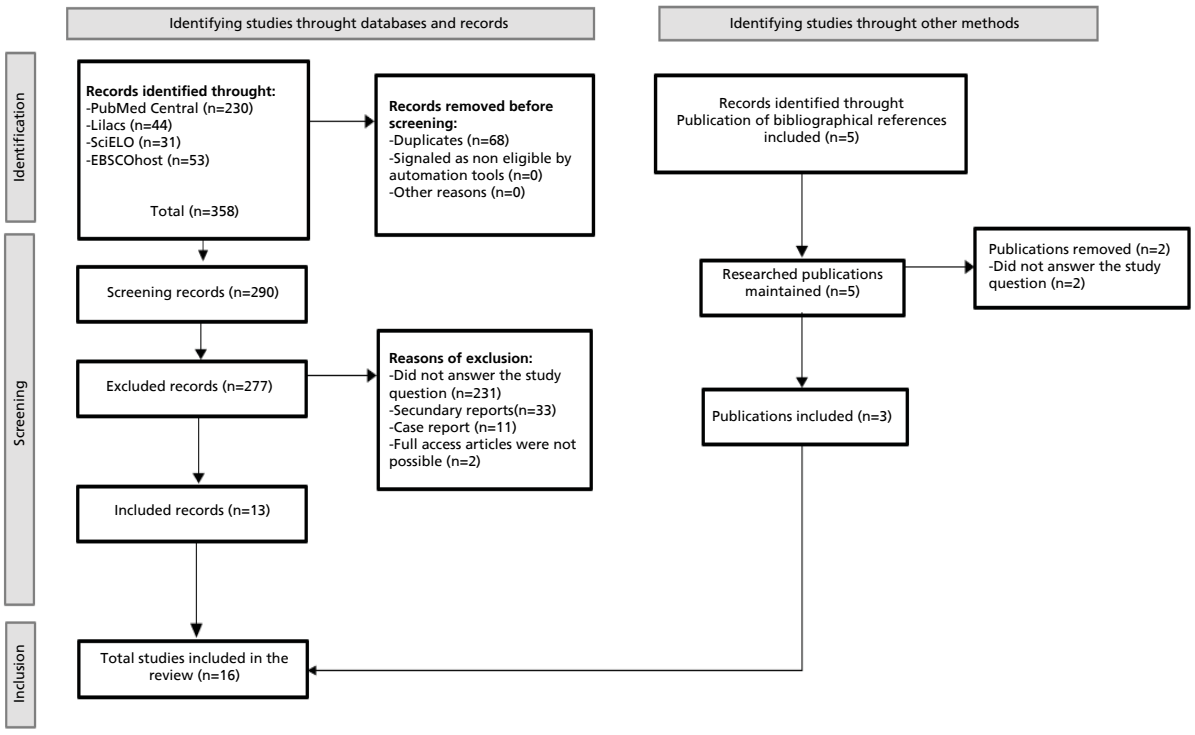
Summary of the outcomes of the integrated studies.

	Outcomes						
Reference	**Milk transfer rate**	**Volume of overall milk intake**	**Feeding performance/ sucking pattern**	**Time to initiation of oral feeding**	**Independent oral feeding**	**Breastfeeding**	**Early hospital discharge**
Fucile *et al.*,[9]	+	+	+	—	+	—	X
Fucile *et al.*,[15]	+	+	+	—	+	—	—
Rocha *et al.*,[17]	—	—	X	+	+	—	+
Costa *et al.*,[18]	X	X	—	—	X	—	—
Lessen[11]	—	—	—	—	+	—	+
Bache *et al.*,[25]	—	—	+	—	X	+	X
Lyu *et al.*,[26]	X	—	+	—	+	—	X
Arora *et al.*,[19]	—	—	+	—	+	—	+
Fucile *et al.*,[16]	—	—	—	—	+	+	+
Thakkar *et al.*,[20]	X	+	+	—	+	—	+
Ghomi *et al.*,[22]	—	—	+	+	+	—	+
Lessen *et al.*,[27]	—	+	+	+	—	—	—
Mahmoodi *et al.*,[23]	—	—	—	+	+	—	+
Aguilar-Rodríguez *et al.*,[28]	—	—	—	+	+	—	+
Ostadi *et al.*,[24]	—	—	+	+	+	—	—
Kore e Mathew[21]	—	—	+	—	—	—	—

(+) - proven outcome; (X) - unproven outcome; (—) - outcome not studied.

Figure 1

Flowchart of results based on PRISMA guidelines.[13]



PRISMA=Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

Discussion

Considering that this study aimed to study the importance of oral stimulation in the sucking/feeding process of premature newborns, it should be noted that the vast majority of the articles included showed that the oral stimulation program,[10] non-nutritive sucking[8] and PIOMI[11] had a beneficial effect not only on the feeding performance of premature newborns, but also on independent oral feeding. The studies by Fucile *et al*.,[9] Fucile *et al*.,[15] Rocha *et al*.,[17] and Lyu *et al*.[26] showed positive effects through the oral stimulation program[10] and non-nutritive sucking. With the intervention of the oral stimulation program alone, the studies by Bache *et al*.,[25] Fucile *et al*.,[16] Aguilar-Rodríguez *et al*.,[28] and Kore and Mathew[21] proved that the application of this program brings benefits to premature newborns. Through the implementation of PIOMI, the studies by Lessen,[11] Arora *et al*.,[19] Thakkar *et al*.,[20] Ghomi *et al*.,[22] Lessen *et al*.,[27] and Mahmoodi *et al*.,[23] demonstrated significant improvements with the use of this program. When interpreting the results of the studies analyzed, more outcomes were visible that are directly related to the programs under study. Thus, in addition to the outcomes initially studied (i.e. improved feeding performance and feeding independence of premature babies), the rate and volume of milk ingested, time to first feeding, breastfeeding rate and early hospital discharge were also analyzed. Therefore, these outcomes will be considered for this discussion.

i)Milk transfer rate

With regard to the milk transfer rate (i.e. the volume of milk ingested in relation to the duration of oral feeding session), one of the results found in the studies by Fucile *et al*.,[9] Fucile *et al*.,[15] showed that the oral stimulation program and non-nutritive sucking had a beneficial effect, causing these newborns to have a higher milk transfer rate precisely because of the improved sucking pattern. On the other hand, in the studies by Costa *et al*.,[18] Lyu *et al*.[26] and Thakkar *et al*.,[20] this same effect could not be observed and there was no increase in the milk transfer rate. Regarding this relationship, the literature has shown that there is an increase in the rate of milk transfer in newborns who undergo an oral stimulation program, suggesting that these babies are better able to suck more effectively.[29] These findings are congruent with the studies by Fucile *et al*.,[9] Fucile *et al*.,[15] which point to a benefit of these techniques.

ii)Volume of milk swallowed

Regarding the increase in the volume of milk swallowed (i.e. the volume consumed as a percentage of the prescribed volume) by premature newborns, the studies by Fucile *et al*.,[9] Fucile *et al*.,[15] Thakkar *et al*.,[20] and Lessen *et al*.,[27] showed favorable results, with a greater amount of milk volume swallowed by babies who received the stimulation program. However, the study by Costa *et al*.[18] did not show any changes in the volume of milk swallowed by the babies, which may be due to the fact that the experimental group weighed less at the different assessment times than the control group. The literature also attests to the positive relationship between the oral stimulation program and the increase in the volume of milk swallowed by these newborns, which is justified by the improvement in the sucking pattern, allowing the babies to swallow more milk due to stronger and more effective sucking.[30] This is in line with the studies by Fucile *et al*.,[9] Fucile *et al*.,[15] Thakkar *et al*.,[20] and Lessen *et al*.,[27] analyzed in this study.

iii)Feeding performance/sucking pattern

With regard to feeding performance/sucking pattern, one of the outcomes to be studied in this study, the studies by Fucile *et al*.,[9] Fucile *et al*.,[15] Rocha *et al*.,[17] Bache *et al*.,[25] Lyu *et al*.,[26] Arora *et al*.,[19] Thakkar *et al*.,[20] Ghomi *et al*.,[22] Lessen *et al*.,[27] Ostadi *et al*.[24] and Kore and Mathew[21] have shown that an oral stimulation program has promising results in relation to the feeding performance and sucking pattern of premature babies. According to the information found in other studies, it was possible to conclude that the feeding performance of these babies improved because the techniques used helped to coordinate the sucking-breathing-deglutition pattern during the different sucks, providing a maturation of the different structures.[31] This information is in line with the results obtained in the studies by Fucile *et al*.,[9] Fucile *et al*.,[15] Rocha *et al*.,[17] Bache *et al*.,[25] Lyu *et al*.,[26] Arora *et al*.,[19] Thakkar *et al*.,[20] Ghomi *et al*.,[22] Lessen *et al*.,[27] Ostadi *et al*.[24] and Kore and Mathew[21] demonstrating that the stimulation program effectively shows beneficial results in relation to the feeding performance of these premature infants.

iv)Time to start oral feeding

With regard to the time taken to start oral feeding, the studies by Rocha *et al*.,[17] Ghomi *et al*.,[22] Lessen *et al*.,[27] *Mahmoodi et al*.[23] and Aguilar-Rodríguez *et al*.[28] and Ostadi *et al*.[24] showed that the stimulation program reduced the time normally required for premature newborns to start oral feeding. This information is in line with the results found in the literature, in particular in the study by Neiva and Leone[32] which aimed to investigate and analyze the effects of non-nutritive sucking stimulation on the age of onset of oral feeding in premature newborns, and showed that this technique

accelerated the process of starting the first oral feeding. These results are similar to those obtained in the studies by Rocha *et al*.,[17] Ghomi *et al*.,[22] Lessen *et al*.,[27] Mahmoodi *et al*.,[23] Aguilar-Rodríguez *et al*.[28] and Ostadi *et al*.,[24] which show that the stimulation program plays an important role in anticipating the first oral feeding of premature babies without the presence of a feeding tube.

v)Independent oral feeding

Independent oral feeding was studied by the authors Fucile *et al*.,[9] Fucile *et al*.,[15] Rocha *et al*.,[17] Costa *et al*.,[18] Lessen,[11] Bache *et al*.,[25] Lyu *et al*.,[26] Fucile *et al*.,[16] Thakkar *et al*.,[20] Ghomi *et al*.,[22] Mahmoodi *et al*.[23] and Aguilar-Rodríguez *et al*.[28] who obtained the results of earlier total oral feeding by premature newborns who benefited from the stimulation program. However, Costa *et al*.[18] and Bache *et al*.[25] who also studied this factor, obtained different results, and there were no differences in the time needed to transition from tube feeding to independent oral feeding. According to the literature, as can be seen in the study by Pereira *et al*.[33] which aimed to assess the effect of the oral stimulation program on oral feeding performance and the transition time from the tube to total oral intake, this program showed important results with regard to the time needed to make the transition from the tube to independent oral feeding, with a reduction in time having been demonstrated in this study. In this way, the studies by Fucile *et al*.,[9] Fucile *et al*.,[15] Rocha *et al*.,[17] Lessen,[11] Lyu *et al*.,[26] Fucile *et al*.,[16] Thakkar *et al*.,[20] Ghomi *et al*.,[22] Mahmoodi *et al*.,[23] and Aguilar-Rodríguez *et al*.[28] are supported by the results obtained in the research by Pereira *et al*.[33] in which the oral stimulation program revealed that babies who were submitted to this technique showed a reduction in the transition time between the feeding tube and independent oral feeding. This may be related to the improvement in the sucking pattern of premature newborns which, because it is more efficient, allows babies to make the transition from the feeding tube to independent oral feeding sooner.

vi)Breastfeeding rates

With regard to breastfeeding rates, Bache *et al*.[25] and Fucile *et al*.[16] found that the oral stimulation program helped to improve breastfeeding rates. In this context, the study by Balci *et al*.[34] which aimed to understand the benefits of oromotor stimulation in relation to the transition to breastfeeding, concluded that the oral stimulation program has beneficial effects on feeding skills and the transition to breastfeeding in premature newborns. These data are in line with the results obtained in the studies by Bache *et al*.[25] and Fucile *et al*.,[16] demonstrating once again that oral stimulation of babies provides a number of benefits.

vii) Early hospital discharge

Early hospital discharge was one of the outcomes studied in the different studies analyzed in this investigation. It should be noted that this result is linked to the different results studied so far, since hospital discharge is directly related to oral feeding independence and also to feeding performance.In this way, different authors have studied this factor, Rocha *et al*.,[17] Arora *et al*.,[19] Fucile *et al*.,[16] Thakkar *et al*.,[20] Ghomi *et al*.,[22] Mahmoodi *et al*.[23] and Aguilar-Rodríguez *et al*.[28] showing that the oral stimulation program has positive effects on hospital discharge, and where the newborns studied were discharged earlier than those who were not subjected to this technique. Authors such as Song *et al*.[35] reported that newborns who had the oral stimulation program as an intervention had fewer days in hospital than the control group who did not have any type of intervention. However, in the studies by Fucile *et al*.,[9] Bache *et al*.[25] and Lyu *et al*.[26] the same results were not found, showing that babies who underwent the oral stimulation program had no differences in the length of stay until hospital discharge. These results may be due to the fact that the experimental group studied had a lower birth weight, which may have biased the effects.According to Medeiros *et al*.,[36] more premature newborns with lower birth weights stay in hospital longer because they need more care and specific interventions.

Thus, after analyzing the results and comparing them with the literature, we can highlight a beneficial effect of the oral stimulation program in improving the feeding performance of premature newborns and the early transition between tube and total oral feeding, information that answers the initial question of this research. Newborns submitted to this program show improvements related to feeding, which is decisive for their development and growth.

Study limitations

It is important to recognize some limitations regarding this work, especially those inherent to primary studies. Some methodological weaknesses (i.e. small samples, variability in the type of control group) influenced the analysis of the evidence. In addition, there were difficulties related to the heterogeneity of the studies which made it difficult to synthesize the data, especially

as the analysis measures varied significantly. As an example of this factor, it can be seen that the sample size varied from 19 to 112 premature newborns and their characteristics were not homogeneous, namely in terms of gestational age and birth weight. Another limitation observed was the time and frequency of administration of the different stimulation techniques. In some studies it was administered for five minutes once a day, while in others it was administered more times a day. In some studies, the intervention was carried out for seven days, while in others, it was prolonged until the baby began to feed himself or herself orally. It should also be noted that when interpreting the outcomes of the studies, the technique used was not always the same, and it was possible to verify the use of oral stimulation, PIOMI and non-nutritive sucking. This heterogeneity made it difficult to carry out a more comprehensive analysis and generalize the results found. There were no studies excluded because they were in a language not mastered by the researchers, so it is considered that there was no risk of language bias.

Conclusion

The literature supports the notion that oral sensorimotor stimulation has beneficial effects on the feeding process of premature newborns. This study underlines its relevance to clinical practice by demonstrating that oral sensorimotor stimulation is associated with an improvement in feeding patterns and promotes autonomy in newborns, which supports the recommendation to implement it in neonatal units. In addition, the results indicate a trend towards a reduction in the length of stay, which could contribute to a reduction in the costs associated with managing neonatal care services. The combination of different techniques could enhance the therapeutic effect in terms of the feeding transition, but more studies are needed to consolidate this statement.

Authors' contribution

Figueiredo IF: conceptualization, data collection and analysis, research, visualization and writing of the manuscript. Grilo M: supervision, validation and revision of the manuscript. Campos SG: data collection and analysis, revision of the manuscript. Rodrigues IT: project management, methodology, supervision, validation and revision of the manuscript. All the authors have approved the final version of the article and declare no conflict of interest.

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Appendice I

PRISMA - checklist (with indication of the page on which the information for each item is found).[13]

Section and topic	Item	Item check	Page where item is found
		TITLE	
Title	1	Identifies the publication as a systematic review	1
		SUMMARY	
Summary	2	Summary of the study.	2-3
		INTRODUCTION	
Rationale	3	Grounds the review in the context of existing knowledge	4-5
Objectives	4	Explicitly presents the objective(s) or question(s) concerning the review	5
		METHODS	
Eligibility criteria	5	Specifies the inclusion and exclusion criteria for the review and how the studies were grouped for the syntheses.	6-8
Information sources	6	Specifies all databases, registers, websites, organizations, reference lists and other sources searched or consulted to identify the studies.	6
Research strategy	7	Shows the complete research strategies for all databases, registers and websites, including all filters and limits used.	7
Selection process	8	Specifies the methods used to decide whether a study meets the review's inclusion criteria, including how many reviewers screened each record and publication selected, whether they worked independently and, if applicable, details of automation tools used in the process automatIzation	7-8
Data collection process	9	Specifies the methods used to collect data from the publications, including how many reviewers collected the information from each publication, whether they worked independently, any processes for obtaining or confirming data by the study researchers and, if applicable, details of automation tools used.	7-8
Data items	10a	List and define all outcomes for which data was searched. Specify whether all outcomes compatible with each outcome were searched for in each study (e.g. for all measures, time points, analyses) and, if not, specify the methods used to decide which outcomes to collect.	6
	10b	List and define all the other variables for which data were researched (e.g. characteristics of participants and interventions, funding sources). Describes the assumptions made about missing or unclear information.	8
Assessment of the risk of bias in the studies	11	Specifies the methods used to assess the risk of bias of the included studies, including details of the instrument(s) used, how many reviewers assessed each study and whether they worked independently and also, if applicable, details of automation tools used in the process.	7-8
Measures of the effect	12	Specify for each outcome the measure(s) of effect (e.g. relative risk and mean difference) used in the synthesis or presentation of the results.	10
Synthesis method	13a	Describes the processes used to decide the studies selected for each synthesis (e.g. present the characteristics of the intervention presented in the study and compare with the groups planned for each synthesis.	6-7-8
	13b	Describes all necessary methods of preparing data for presentation or synthesis, such as dealing with missing data in the summary statistics, or data conversions.	—
	13c	Describes all the methods used to present or display the individual results of studies and syntheses.	8
	13d	Describe all the methods used to summarize the results and provide a justification for the choice(s). If a meta-analysis was carried out, describe the model(s) and method(s) for identifying the presence and extent of statistical heterogeneity, and software used.	7-8
	13e	Describe all methods used to explore possible causes of heterogeneity between study results (e.g. subgroup analysis, meta-regression).	—
	13f	Describe all the sensitivity analyses carried out to assess the robustness of the results.	—
Assessment of reported bias	14	Describes all methods used to assess the risk of bias due to missing results in a synthesis (due to information bias).	—
Assessment of the degree of confidence	15	Describes all the methods used to assess the certainty (or confidence) in the body of evidence of a result.	7-8

		RESULTS	
Study selection	16a	Describes the results of the research and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flowchart.	8-9
	16b	Cite studies that appear to meet the inclusion criteria but were excluded, and explain the reasons for the exclusion.	8-9
Characteristics of the studies	17	It cites each included study and presents its characteristics	8-9
Risk of bias in the studies	18	Presents the risk of bias assessment for each included study.	10
Individual results in the study	19	For all the results of each study, it presents: (a) summary statistics for each group (where appropriate) and (b) an estimate of the effect and its precision (e.g. confidence/credibility interval), ideally using structured tables or graphs.t cites each included study and presents its characteristics.	10
Results of syntheses	20a	For each synthesis, a summary of the characteristics and risk of bias among the selected studies.	10
	20b	Present the results of all the statistical syntheses carried out. If a meta-analysis was carried out, for each result, a summary of the estimate and its precision (e.g. confidence/credibility interval) and measures of statistical heterogeneity. If groups were compared, describe the direction of the effect.	10
	20c	Presents the results of all investigations into possible causes of heterogeneity between study results.	8-9
	20d	Presents the results of all sensitivity analyses carried out to assess the robustness of the synthesized results.	—
Biases reported	21	Presents the assessment of the risk of bias due to missing results (resulting from information bias) for each synthesis assessed.	10
Significance level	22	Presents the assessment of certainty (or confidence) in the body of evidence for each result assessed.	—
		DISCUSSION	
Discussion	23a	Provides a general interpretation of the results in the context of other evidence.	10-14
	23b	Discusses all the limitations of the evidence included in the review.	15-16
	23c	Discusses all the limitations of the review processes used.	15-16
	23d	Discusses the implications of the findings for practice, policy and future research.	15-16
		OTHER INFORMATION	
Protocol record	24a	Provides information on the record of the review, including the name and record number, or states that the review is not recorded.	—
	24b	Indicates place of access to the review protocol, or states that the protocol has not been prepared.	—
	24c	Describes and explains any changes to the information provided in the records or protocol.	—
Support	25	Describes the sources of funding or non-funding support that underpin the review, and the role of the funders or sponsors of the review.	1
Conflict of interest	26	Declare any conflicts of interest of the authors of the review.	1
Availability of data, codes and other materials	27	Report which of the following materials are publicly accessible and where they can be found model data collection forms extracted from the included studies, data used for analysis; analytical code, any other material used in the review.	—