International Journal of Biological and Pharmaceutical Sciences Archive

ISSN: 0799-6616 (Online)

Journal homepage: https://ijbpsa.com/

(REVIEW ARTICLE)

Methods and problems in the transition of premature infants to oral feeding: A review of the literature

Zaharoula Rigopoulou, Alexandros Mihopoulos and Pantelis Perdikaris *

Department of Nursing, School of Health Sciences, University of Peloponnese 28 Erythrou Stavrou & Karyotaki Str, 22131, Tripolis, Greece.

International Journal of Biological and Pharmaceutical Sciences Archive, 2023, 05(01), 001–016

Publication history: Received on 22 November 2022; revised on 15 January 2023; accepted on 18 January 2023

Article DOI: https://doi.org/10.53771/ijbpsa.2023.5.1.0106

Abstract

Introduction: Preterm infants are necessary to acquire safe and effective feeding skills as they are born without developed suck-swallow-respiration coordination skills. Various methods are used in premature infants in order to improve sucking skills and transit from gavage feeding to full oral feeding or breastfeeding safer and faster.

Aim: To research and evaluate all methods by which a premature infant will transit to oral feeding, as well as to report problems that is going to happen during the transition.

Methodology: A review of the literature was conducted in PubMed database from January 2022 to March 2022. The criteria for entering the review were the following: primary research studies, the language should be either English or Greek, the article should be published between 01/01/2012 to 31/12/2021 and studies that refer to preterm infants. The sort was done using the PRISMA 2009 method.

Results: A search in electronic database PubMed, applying specific eligibility criteria, resulted in 159 articles. Through identification, screening and eligibility procedures, resulted in 20 articles. The methods that identified were nonnutritive sucking with either a pacifier, the mother's breast, or a pacifier connected to a music player that heard the mother's voice, oro-motor stimulation, a combination of nonnutritive sucking oro-motor stimulation, responsive feeding to neonatal signs, cup and probiotics.

Conclusions: All these methods lead to earlier full oral feeding, reduce the length of hospital stay, and cause fewer side effects.

Keywords: Preterm infants; Transition; Full oral feeding; Non-nutritive sucking; Oro-motor stimulation; Cup feeding; Probiotics; cue-based feeding

1. Introduction

According to the World Health Organization, approximately 15 million infants are born prematurely each year, 8% to 10% of them in developed countries [1]. Premature infants may experience life-threatening medical conditions and develop chronic diseases associated with prematurity. Nutrition is an important element in the treatment of premature newborns, but there are several difficulties in meeting their nutritional needs. Healthy full-term neonates are born with coordinated sucking-swallowing-breathing skills that allow for safe oral feeding. Preterm infants develop these skills gradually as they transition from tube feeding to full oral feeding [2].

* Corresponding author: Pantelis Perdikaris

Feeding of premature newborns can be either enteral, parenteral, or a combination thereof. Very low birth weight neonates are fed only parenterally in the first few days after birth to provide all micro- and macro-nutrients and achieve growth, as during intrauterine life. In this way neurodevelopmental maturation is improved and developmental disorders often seen in low-birth-weight infants are prevented. However, prolonged parenteral nutrition is associated with cholestasis, thrombosis, infectious and metabolic risks, for these reasons it is necessary to start breast milk-based enteral feeding quickly. According to Wiechers et al., (2021) for the transition to enteral feeding, an examination can be performed to detect gastric residues, which, if found, may lead to suspension or delay of enteral feeding [3].

In general, in clinical practice, it is notable that there is difficulty in identifying the ideal moment to initiate the transition from tube feeding to oral feeding. The decision that a preterm neonate is ready for transition trials to oral feeding depends on several characteristics. Characteristics of readiness for oral feeding include: 1) physiological stability of heart and respiratory rate, oxygen saturation, skin color and temperature, 2) neurobehavioral status, i.e., being awake and alert, demonstrating flexion postures and visual focus on the caregiver and/or at the feeding source and 3) signs of readiness to feed or hunger, such as noise with crying before feeding, spontaneous growth and sucking (non-nutritive sucking) [4, 5]. In addition, important factors in the readiness of neonates to transition to oral feeding are the age of the neonate based on the mother's last menstrual period and feeding tolerance.

Methods commonly used to facilitate the transition to oral feeding include stimulation techniques based primarily on Beckman's Oral Motor Intervention (OMI), non-nutritive breastfeeding, cup feeding, responsive feeding, gloved finger, spoon, artificial nipples, and ‘paladai’ which is a traditional feeding device used in India for shorter duration breastfeeding [6]. OMI is the opening of the newborn's mouth for about 15 minutes and the stimulation of the perioral (cheeks, lips, jaw) and intraoral structures (upper palate, gums, tongue) [7]. Non-nutritive breastfeeding is stimulated with a gloved finger, a pacifier, or a nipple that is not producing milk. It is used during tube feeding and transition from tube feeding to oral feeding and is only recommended in the first 6 months of life [8]. It is defined as any “blind” repetitive activity on the nipple or nursing by the infant with a nipple that does not yield a wet stimulus [9]. With this method the newborn is encouraged to develop a "sucking" behavior and improves food digestion, while also having a calming effect on the newborn [10]. It also protects against aspiration by inhibiting ingestion [2, 11, 12]. Non-nutritive breastfeeding 5 minutes before feeding is associated with an increased level of alertness and leads to more food intake [12].

The goal of oral feeding transition interventions in the Neonatal Intensive Care Unit (NICU) is to help infants achieve the ability to fully orally feed, which is a key criterion for hospital discharge. Therefore, strategies to improve infants' oral motor skills are needed. The aim of the study was to research and evaluate all existing methods by which a premature infant will transit to oral feeding, as well as to report problems that might happen during the transition. Therefore, the following research questions arise: a) what are the existing methods by which a premature infant will transit to oral feeding? And b) what are the problems or side-effects that might be caused by these methods?

2. Methods

The type of study chosen was a literature review. The literature review was carried out following the guidelines of the recommended reporting elements for reporting systematic reviews and meta-analyses (PRISMA 2009). Based on this framework/proposal, in conducting the review, the suggested steps were followed. More specifically, having defined the research question and the determination of selection and exclusion criteria, a thorough search and selection of studies was carried out, continuing with the conduct of the data and the construction of a consolidated table of studies. This was followed by the detailed presentation of the results.

2.1. Searching bibliographic data

The literature search was carried out in the period from January 2022 to March 2022 in the online database PubMed (National Library of Medicine), by two researchers who worked independently, with the aim of searching and the evaluation of all the methods by which a premature newborn will transition to oral feeding, as well as highlighting the problems that arise during this transition. During the search, the following keywords were used: "premature infant", "oral feeding", "methods", "non-nutritive breastfeeding", "cue-based", "cup feeding", to search for studies published in Greek language while the keywords “premature infants”, “oral feeding”, “methods”, “nonnutritive sucking”, “cue-based”, “cup feeding”, directed the search for published articles in the English language, by searching for the words- of keys to be done on the basis of Boolean logic (AND/OR/NOT) and (AND/OR/NOT) respectively. The collection of articles was determined by the inclusion criteria decided upon. The selection of studies was carried out at two levels. The first level included titles and abstracts retrieved during the strategic database search in order to determine their inclusion in the

study according to the defined criteria. In the second level, the selected articles were screened according to the defined criteria to consider their final inclusion in the study.

2.2. Inclusion criteria

The inclusion criteria of the studies in this review included their publication in international scientific journals, provided they were written in English or Greek and related to human studies. Also, the studies had to be primary research, such as randomized control trials, cohort studies, cross-sectional studies, patient-control studies, prospective, as well as qualitative studies. The time interval for the review was from January 2012 to December 2021. Studies were included on the condition that they examined the methods and problems of preterm infants during the transition to oral feeding. Specifically, the target population was preterm infants aged 26 to 37 weeks from the day of gestation and involved both sexes. The specific age range was determined according to the definition given by the World Health Organization for premature newborns, where it is stated that premature is defined as a newborn born alive before the completion of the 37th week of pregnancy [1].

Conversely, studies that were outside the predefined time frame, as well as those that were not published in the default languages were rejected. At the same time, during the search and screening of the studies, those that appeared as duplicates and those that were literature reviews, meta-analyses or case studies were rejected. Studies that were incomplete or did not provide sufficient data, or authors had to be contacted to provide incomplete data, were not included in the review. Finally, articles that did not address the methods and problems of preterm infants during the transition to oral feeding were rejected. During screening, only the full articles found were collected and considered whether they met the selection/inclusion criteria.

2.3. Presentation of the results and construction of a summary table of studies

A more detailed description of the decision process according to the PRISMA 2009 flow chart was used to present the results. The flow chart is summarized in Figure 1. Full texts deemed suitable for inclusion in the study were analyzed using descriptive analysis and thematic analysis, in capital of the results. The presentation of the data extracted from the data analysis was done in the form of a table aiming to assess the degree of similarity between the studies. The summary table of studies includes general study characteristics (authors, year, and country of study), study sample characteristics (age, medical characteristics) and research tools, purpose and type of research, results and conclusions of studies that met the above inclusion criteria, as shown in Table 1.

3. Results

During the process of identifying the studies, through the search of the specified keywords in the electronic database PubMed, 1868 possible articles were found, based on the titles and abstracts they included. After applying the criteria, the research articles were narrowed down to 159, which were further explored during the screening process. Then, based on the screening of the titles, 69 potential articles were identified and further screening of their abstracts rejected 37 articles, while there were no duplicate articles. Finally, from the remaining full articles (n=32), those that did not meet the subject matter criteria of the research purpose were discarded after a full text review, resulting in 20 articles that were finally included in the review. The process of searching, screening and selection of the articles is summarized in Figure 1. Of these 20 studies, 2 were conducted in Europe, 11 in Asia and 7 in the Americas. Collectively, the sample of participants from all selected studies is estimated at almost 2000 preterm infants. In addition, the methods identified in the search based on the criteria selected involved non-nutritive breastfeeding either with a pacifier, with the mother's breast, or with a pacifier connected to a music player and the mother's voice was heard (5 studies) [13-17], oro-motor stimulation (6 studies) [18-23], the combination of non-nutritive sucking and oral motor stimulation (4 studies) [24-27], responsive feeding to the infant's hunger cues (3 studies) [28-30], the cup (1 study) [31] and probiotics (1 study) [32].

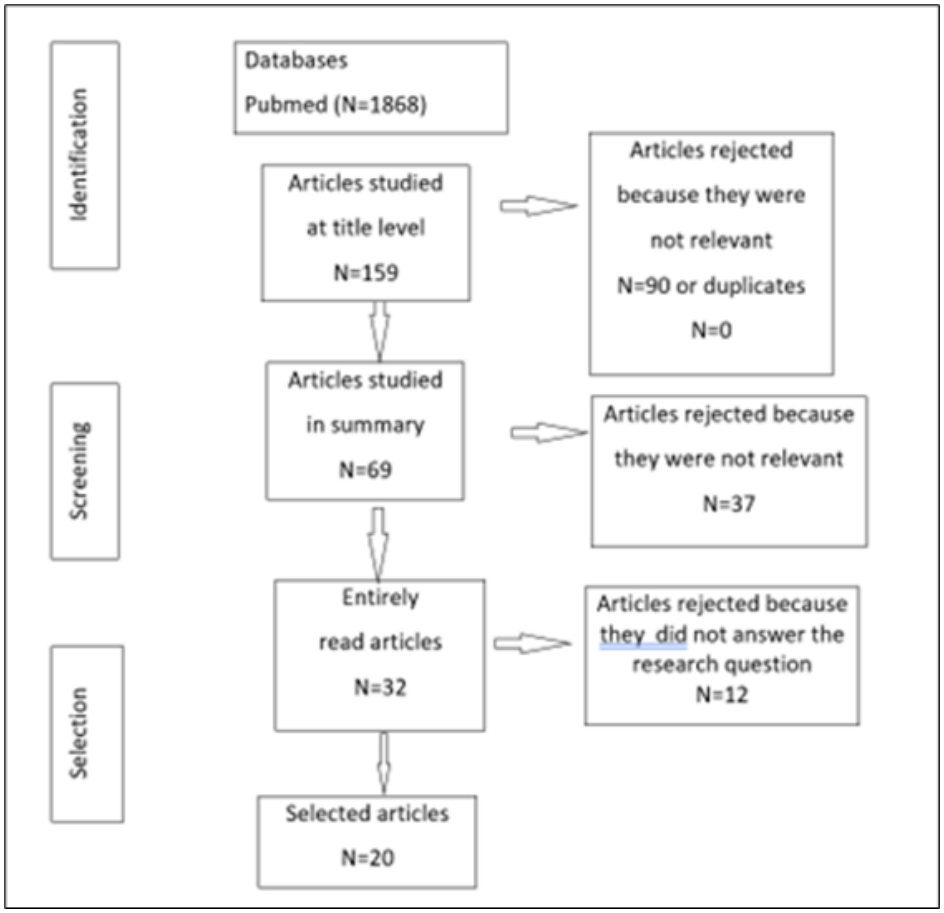

Figure 1 Flow chart according to the method-proposal PRISMA

Table 1 Summary of characteristics of studies used in the review.

Study	Population - tools	Purpose - type of research	Results	Conclusions
Non-nutritional breastfeeding				
Chorna et al., 2014 USA.	94 premature newborns, 34-35 weeks from the day of gestation, participated. Method: Allocation into 2 groups: 46 neonates in the intervention group where given a pacifier connected to a music player from which the mother's voice could be heard for 5 daily 15' sessions, and 48 neonates in the control group, where this device was not used. They recorded the mothers reading and singing to their newborns. Both groups received simple non-nutritive breastfeeding and	Aim: To assess whether the mother's voice heard through a music player connected to a pacifier during non-nutritive breastfeeding would improve the development of sucking skills and promote more effective oral feeding in preterm infants. Type of study: Randomized controlled trial.	The intervention group had significantly increased oral feeding rate (2.0 vs. 0.9 mL/min, $p<0.001$), oral food intake volume (91.1 vs. 48.1 mL/kg/day, $p=0.001$), oral feeds/day (6.5 vs. 4.0, $p<0.001$) and faster oral feeding (31 vs. 38 days, $p=0.04$) compared to the control group. The intervention group achieved full oral feeding an average of 7 days earlier than the control group. The reduction in length of hospital stay was not statistically significant ($p=0.07$).	A pacifier connected to a music player that played the mother's voice improved oral feeding skills in premature infants.

	maternal care. The intervention took place 30'-45' before feeding the newborns. If the pacifier came out of the mouth, the sound was not heard. No oral or tube feeding was attempted during the procedure.			
Kaya & Ayteki, 2017 Turkey.	70 premature newborns aged 30-34 weeks from the day of gestation, weighing ≥ 1000g, with an Apgar score >6 who did not use a pacifier, participated. Method: distribution in 2 groups: 34 newborns in the intervention group where a pacifier was used and 36 in the control group.	Aim: To determine the effect of pacifier use during the transition to full breastfeeding and the development of sucking abilities in premature infants. Type of study: Prospective, randomized controlled trial.	The transition time to full breastfeeding (123.06±66.56 hours) and the time to discharge (434.50±133.29 hours) in the intervention group were significantly shorter than in the control group (167.78±91.77 and 593.63±385.32 hours, respectively, p< 0.05). The sucking abilities of the newborns in the intervention group were at a better level 48 hours after the transition to full oral feeding and before discharge from the hospital compared to the control group (p<0.05).	The use of pacifiers in preterm infants helped during the transition to full oral feeding, improved sucking ability and reduced the time during the transition to full breastfeeding and at hospital discharge.
Say et al., 2018 Turkey.	90 preterm neonates 26-32 weeks from the day of gestation, weight ≥ 1500g, with stable clinical condition and full enteral feeding by catheter participated. Method: Allocation into 2 groups: 45 newborns in the intervention group where a pacifier was used for 15' before and after feeding (4 times a day in total), and 45 in the control group, where no pacifier was used.	Aim: To evaluate the effect of the pacifier in preterm infants on transition from tube to full oral feeding, time to discharge, weight gain and time to transition to full breastfeeding. Type of study: Prospective, randomized controlled trial.	The time to infant initiation of pacifier use in the intervention group averaged 29.64 days. Significant differences between the groups were found in the duration of tube feeding, time to transition to full breastfeeding and time to discharge (p<0.05). Time to transition to full oral feeding (38-19.2 days), time to transition to full breastfeeding (38.1-20 days) and time to discharge (48.4-19.2 days) in the pacifier group were shorter than the control group (49.8- 23.6, 49.1-22, 65.3-30.6 days, respectively, p<0.05). Side effects also in the pacifier group were less (n=6, 22%) than in the control group (n=21, 77.8%, p<0.05).	The use of a pacifier in preterm infants during intubation reduced the transition period to oral feeding and the length of hospital stay.
John et al., 2019 India.	9 preterm neonates 31-33 weeks from the day of gestation, weighing at least 1000g, with a stable clinical condition, who were fed by catheter, participated. Method: Allocation into 2 groups: 4 newborns in the intervention group where non-nutritive	Aim: To evaluate the effectiveness of non-nutritive sucking at the mother's breast in premature infants. To facilitate the performance of breastfeeding	No significant difference was found between the groups in relation to length of hospital stay. During the study, none of the neonates in the intervention group had an episode of apnea, aspiration, or feeding intolerance. A significant difference was found between the groups in the stages of non-nutritive breastfeeding, with the	Early initiation of non-nutritive sucking at the mother's breast in very preterm infants was safe. And effective intervention to facilitate maturation of

	breastfeeding was used at the mother's breast 3 times/day for 5' until nutritional breastfeeding started, and 5 in the control group. Both groups received non-nutritive finger-feeding during tube feeding.	and exclusive breastfeeding. Type of study: Single blind, randomized controlled trial.	intervention group having a more mature breastfeeding pattern. During the second week assessment (p=0.04) while showing an even more mature breastfeeding pattern at the third week assessment (p=0.05). There was no significant difference in its rates of exclusive breastfeeding between the groups at 6 weeks, 3 months and 6 months.	oral feeding and breastfeeding.
Dur & Gözen, 2020 Turkey.	72 preterm neonates 26-32 weeks from the day of gestation, weight ≥ 1500g, with stable clinical condition, initially fed orally, participated. Method: Allocation into 2 groups: 36 neonates in the intervention group where they were given a pacifier for 3' within 1 hour before feeding, and 36 in the control group. Vital signs were assessed before and after feeding in both groups.	Aim: To determine the effect of pre-feeding pacifier and feeding performance in preterm infants who were initially orally fed. Type of study: Randomized clinical trial.	Heart rates of preterm infants in the intervention group were statistically significantly lower (139.64±10.16) than the control group (149.31±8.40) (p<0.01) and oxygen saturation levels in the intervention group were higher (97.22±2.22) than the control group control (96.33±1.93, p<0.05). Effective feeding rates (1.94±1.19) and food intake rate (89.5±23.93) of preterm infants in the intervention group were significantly higher than the control group (0.69±0.34 and 70.86±27.41, respectively, p<0.01).	A pacifier given before feeding was effective in regulating vital signs and supporting feeding performance in preterm infants.
Oral Motor Stimulation				
Bache et al., 2014 Luxemburg.	Eighty preterm neonates, 26-33 weeks gestational age, with stable hemodynamic status and fed by tube were included. Method: Distribution in 2 groups: 40 neonates in the intervention group where oral stimulation was used when they reached 32 weeks from the day of gestation for 15' and for 10 days before feeding, and 46 in the control group, where only standard care was done. The intervention took place 15'-30' before feeding the newborns.	Aim: To evaluate the effect of early oral stimulation before initiation of oral feeding during the transition period, length of hospital stay and breastfeeding rate at discharge in preterm infants. Type of study: Prospective, randomized controlled clinical trial.	Breastfeeding rate was significantly higher in the intervention group than the control group (70% vs. 45.6%, p=0.02). There was no statistical difference between the 2 groups in the duration of the transition period and length of hospital stay.	Oral stimulation before feeding improved the rate of breastfeeding in preterm infants but did not reduce the transition period to full oral feeding or length of hospital stay.
Bala et al., 2016 India.	51 preterm infants aged 28-34 weeks from the day of gestation, with stable hemodynamic status and fed by tube, participated.	Aim: To evaluate the effect of oro-motor stimulation during the	The median transition time for neonates to reach partial and full oral feeding was less in the intervention group than in the control group. A greater number	Oral motor stimulation in preterm infants combined with non-nutritive

	Method: Allocation into 2 groups: 25 neonates in the intervention group where oral motor stimulation was used before feeding (total 5 times a day) and 26 in the control group, where only standard care was given. In both groups, non-nutritive breastfeeding was performed before feeding and "kangaroo" maternal care for 3-4 hours.	transition from tube to full oral feeding in preterm infants. Type of study: Randomized controlled pilot study.	of neonates in the intervention group were discharged with partial oral feeding compared to the control group. Mean spoon food intake (mL/kg/food) and rate of spoon food ingestion (mL/min) were higher in the intervention group (12-16 mL/kg and 0.9-1.4 mL/min) compared to the control group control (10-12 mL/kg and 0.8-1 mL/min), but not statistically significant. No adverse effects were observed.	breastfeeding and kangaroo mother care improved their feeding skills. Full oral feeding was achieved earlier in the intervention group and many neonates were discharged when they reached partial oral feeding.
Thakkar et al., 2018 India.	102 preterm neonates of 30-34 weeks of gestation, with stable hemodynamic status, who were fed by tube, participated. Method: Allocation into 2 groups: 51 neonates in the intervention group where oromotor stimulation was used for 15' before feeding (total 2 times a day), and 51 in the control group, where only standard care was given. In both groups, non-nutritive breastfeeding was performed before feeding and "kangaroo" maternal care for 8 hours.	Aim: To study the effects of an oral stimulation program for preterm infants on the feeding process, transition to full oral feeding, weight gain and length of hospital stay. Type of study: Randomized controlled trial.	In the intervention group, food intake volume (ml/kg/food) and milk transfer rate (ml/min) on the 5th day of intervention and when the pups reached full oral feeding were greater than in the control group ($p<0.001$). The intervention group had a shorter transition period to reach 4 oral feedings/day and 8 oral feedings/day compared to the control group ($p<0.001$). Finally, the intervention group had a shorter hospital stay [22.12 (1.88) days] than the control group [24.88 (2.09) days] ($p<0.001$). No adverse effects were observed.	Oral motor stimulation in preterm infants combined with non-nutritive breastfeeding and kangaroo mother care improved feeding performance, promoted earlier achievement of full oral feeding and resulted in shorter hospital stay.
Ghomi et al., 2019 Iran.	30 premature newborns of 26-29 weeks from the day of gestation, with a stable clinical condition, Apgar score 6 5' after birth participated. Method: Allocation into 2 groups: 15 newborns in the intervention group where oral motor stimulation was done for 5' 1 time/day for a total of 10 days, and 15 in the control group, where they received standard care.	Aim: To examine the effectiveness of oral motor intervention for premature infants in the development of feeding. Type of study: Double blind randomized clinical trial.	The intervention group reached the first oral feeding attempt (on average 7.2 days) and the eighth oral feeding attempt (on average 13.47 days) earlier than the control group. The length of hospital stay in the intervention group was significantly shorter than the control group ($p=0.03$).	Oro-motor stimulation has been an effective method for preterm infants and is recommended to be incorporated into feeding rehabilitation programs for preterm infants born at only 26-29 weeks' gestation.
Lessen Knoll et al., 2019 Thailand.	30 premature newborns, 26-34 weeks from the day of gestation, with stable clinical condition, Apgar score >4 5' after delivery, participated.	Aim: To evaluate the effect of oral motor intervention on feeding efficiency and rates of	The mean volume of oral intake was significantly greater in the experimental group versus the control group on all days of measurement. The mean volume consumed on Day 1 of oral feeding was 44.9% ± 7.33% in	Oral motor stimulation was an effective intervention in improving the effective feeding

	Method: Allocation into 2 groups: 15 neonates in the intervention group where oral motor stimulation was done for 5' 1 time/day for 7 days, and 15 neonates in the control group, where a sham intervention was used, i.e. the researcher touched the incubator but not the neonate, and standard care. The intervention took place 15'-30' before feeding the newborns.	improvement on days 1, 3, 5 in oral feeding. Type of study: Randomized controlled trial.	the experimental group versus 29.7% ± 9.55% in the control group (P<0.001), 53.9% ± 8.01% versus 30.4% ± 11.07% on Day 3 (P<0.001), and 61.7% ± 7.44% versus 34.8% ± 8.76 on Day 5 (P<0.001). An improvement was recorded in the intervention group as well.	of preterm infants.
Aguilar-Rodríguez et al., 2020 Spain.	47 premature neonates of 25-30 weeks of gestation, with stable hemodynamic status, who were fed by tube, participated. Method: Randomization into 2 groups. 24 neonates in the intervention group where oral stimulation was used for 10' over 2 weeks, with the exception of weekends, 2 times/day, and 23 in the control group where only standard care was given.	Aim: To investigate the effectiveness of an oral stimulation protocol in preterm infants compared to usual care to reduce the time to achieve safe and complete oral feeding. Type of study: Randomized controlled trial.	13 (54.17%) premature newborns presented mild bradycardia or desaturation during the implementation of the intervention. 11 neonates continued the protocol, while 2 had to discontinue it. The intervention group achieved full oral feeding 8.3 days earlier than the control group (p=0.013). The intervention group achieved 30% oral feeding in the first 5', 6.03 days earlier (p=0.019), and 100% oral feeding 5.88 days earlier (p=0.040). Finally, the intervention group stayed in the hospital 6.9 days less than the control group (p=0.028).	Oral stimulation in preterm infants significantly reduced the time to complete oral feeding and reduced the length of hospital stay.
Combination of non-nutritional breastfeeding and oral-motor stimulation				
Fucile et al., 2013 USA.	75 preterm neonates, 26-32 weeks gestational age, of appropriate weight for their age, who were fed by tube. Method: Allocation into 4 groups: one with oral motor interventions (O), one with tactile/kinesthetic sensorimotor interventions (T/C), one with a combination of these and a control group. In group O, sensorimotor stimulation was performed peri-orally for 7', intra-orally for 5' and non-nutritive breastfeeding with a pacifier for 3' (total 15' for 2 times/day). In the T/K	Aim: To investigate the effect of oral and non-oral sensorimotor interventions on breastfeeding-swallowing-breathing coordination. Type of study: Randomized clinical trial.	Group O had significantly higher levels of breastfeeding (divided into 1-2, 3-5 and 6-8 oral feedings/day) than the control group at 1–2 oral feedings/day (p<0.001), while there was no significant difference between groups at 3-5 oral feeds/day, but at 6-8 oral feeds/day group O had longer breastfeeding stages than all groups (p<0.039). The sucking/breastfeeding process was significantly longer in the O group compared to the control group and the combined group (p≤0.035). The O group had a significantly higher milk intake than the control and T/C groups (p≤0.026). All other group comparisons were not significant (p≥0.370). The T/K group over time had	Oral motor intervention improved nutritional breastfeeding skills, enhancing sucking-swallowing-breathing coordination. All three interventions reduced the occurrence of pause-breathe-pause, but only the T/K interventions and their combination resulted in a greater

	group, a body massage was performed starting from the head, neck, shoulders, back, legs and ending in the hands for 10', and passive range of motion of the arms and legs for 5' (total 15' 2 times/day). In the combined group, the intervention lasted 30' for 1 time/day. All interventions began 48 hours after discontinuation of continuous nasal positive airway pressure, were performed for 10 days within a 14-day period and took place 30' before feeding.		significantly less milk ingestion than the control group at 3-5 oral feedings/day (p=0.034) and the O, T/K and combined group had significantly greater milk ingestion than the control group at 6–8 oral feedings/day (p<0.003). There were no significant group, time, or group-by-time interactions for breast/swallow ratio (mean 1.1 [0.04]) and breast-swallow interval stability (mean 0.3 [0.2], p≥0.181). The 3 intervention groups had significantly fewer pause-breathe-pause patterns than the control group (p≤0.044), and the T/K and combined groups had significantly more occurrences of the breath-swallow-breathe pattern than the control group or O (p ≤0.03).	incidence of the breath-swallow-breathe pattern.
Zhang et al., 2014 China.	108 preterm infants aged 29-34 weeks from the day of gestation, with appropriate weight for their age, Apgar score ≥3 at 1' and ≥5 at 5' after delivery, who were fed by tube, participated. Method: Distribution in 4 groups: 25 newborns in the non-nutritive breastfeeding (NNS) group, where they used a pacifier for 5' 7-8 times/day, 27 in the oral stimulation group (OS), where peri- and intraoral structures were touched for 12' 1 time/day, 29 in the combined group, where both the above 2 interventions were done, and 27 in the control group. All interventions were done 30' before feeding.	Aim: To evaluate the effectiveness of non-nutritive breastfeeding and oral stimulation, applying the two techniques either separately or in combination to reduce the transition time from tube to full oral feeding. Type of study: Randomized controlled trial.	The transition time for the control group was significantly longer than that of the NNS group (p<0.001), the OS group (p<0.001) and the combined group (p<0.001). The combined group achieved full oral feeding at a significantly younger neonatal age based on maternal last menstrual period (p=0.004), lower birth weight (p=0.01) and few days (p=0.004) compared to the control group. No significant difference in length of hospital stay was observed between the NNS group (38.0±13.9 days), the OS group (40.4±13.9 days), the combined group (39.4±15.4 days) and the control group (41.4±12.9 days, p =0.416).	The combination of non-nutritive breastfeeding and oral stimulation reduced the transition time from initiation to full oral feeding and enhanced the rate of milk transfer.
Fucile et al., 2018 Canada.	31 tube-fed preterm neonate's ≤ 34 weeks gestational age, appropriate weight for their age, participated. Method: Allocation into 2 groups: 16 newborns in the intervention group	Aim: To evaluate the effectiveness of an oral sensorimotor intervention in the transition and maintenance of breastfeeding in	Newborns who received the oral sensorimotor intervention achieved full oral feeding 8 days earlier than the rest (p=0.01). More infants in the intervention group achieved immediate breastfeeding at hospital discharge than in the control	Oral sensorimotor intervention accelerated the achievement of full oral feeding and enhanced immediately the rate of

	where the perioral structures were touched for 5', tongue exercises for 5', and finally non-nutritive breastfeeding for another 5' (total 15' 1 time/day for 10 days), and 15 neonates in the control group, where sham intervention was used for the same duration.	premature infants. Type of study: Randomized controlled trial.	group (67% vs. 31%, p=0.049). There was no difference in breastfeeding abilities as evidenced by PIBBS score (12.7-2.5 vs 12.3-3.2, p=0.56) and length of hospital stay (33.0-15.7 vs 43.2-27.3, p=0.054) between the two groups. There was no statistical difference in PIBBS score, length of hospitalization and breastfeeding rates at 3 and 6 months after hospitalization between the two groups (p>0.32).	breastfeeding only at discharge from the hospital. This intervention was safe and low-cost and could increase breastfeeding rates in preterm infants.
da Rosa Pereira et al., 2020 Brazil.	74 premature newborns of 26-32 weeks from the day of gestation, with a stable clinical condition, participated. Method: Allocation into 2 groups: 37 newborns in the intervention group where they received an oral stimulation program consisting of 12' oral stimulation and 3' non-nutritive breastfeeding, therefore for 15' 1 time/day for a total of 10 days, and 37 newborns in the group control, where a sham intervention was used for the same duration.	Aim: To assess the effect of an oral stimulation program for preterm infants on first oral feeding performance, oral feeding skills and transition from tube to full oral feeding. Type of study: Double-blind, randomized clinical trial.	The difference between the groups remained until the 7th day of the transition period from tube to full oral feeding. In breastfed neonates, the transition time from tube feeding to full oral feeding was reduced (p<0.001). The mean gestational age at discharge (weeks) was 36.6±1.6 in the intervention group and 36.8±1.6 in the control group (p=0.792). Median length of hospital stay (days) was 20 (20-43) in the intervention group and 32 (25-41) in the control group (p=0.210), time to complete oral feeding was 4 (3-11) in the intervention group and 8 (7-13) in the control group (p=0.003). Full breastfeeding at discharge was achieved in 33 neonates (89.2%) in the intervention group and in 34 neonates (91.9%) in the control group (p=1.000), with no statistically significant differences between groups. The following side effects were observed: 1. Desaturation in 7 (18.9%) neonates of each group (p=1.000). 2. Bradycardia and vomiting in 1 premature neonate (2.7%) in the control group (p=1.000). 3. Drowning in 1 premature infant (2.7%) in the intervention group (p=1.000). 4. Reflex muscle contraction in 2 (5.4%) neonates in the intervention group (p=0.493).	The oral stimulation program used in the study resulted in stable oral feeding abilities in clinically stable preterm infants, promoting a faster and more efficient transition from tube feeding to oral feeding. Infants in the intervention group were more likely to achieve full (100%) oral feeding compared to those in the control group.

Signs of hunger				
McCain et al., 2012 USA.	86 premature newborns of 34 weeks from the day of gestation, with bronchopulmonary dysplasia, participated. Method: Allocation to 2 groups: 44 neonates in the intervention group where responsive feeding was done to the neonates' hunger cues and bottle feeding at 3-hour intervals if alert, and 42 in the control group where the neonates received standard care involving gradual increases on the rate of feedings from the tube to breastfeeding.	Aim: To test the hypothesis that preterm infants with bronchopulmonary dysplasia who transitioned from tube feeding to breast feeding using the hunger cue method would achieve earlier breastfeeding and discharge from the hospital earlier than control infants who received standard care. Type of study: Randomized controlled clinical trial.	The intervention group achieved full breastfeeding in a shorter time (M=5.9±0.7 days) compared to the control group (M=12.3±0.8 days, p<0.0001). Infant age based on maternal last menstrual period had no effect on days until breastfeeding was achieved. Length of hospital stay was not significantly different between the 2 groups. The intervention group was hospitalized for an average of 106.9±27.6 days and the control group for 115.9±39.4 days.	This method significantly reduced the time to breastfeed premature newborns with respiratory distress.
Davidson et al., 2013 USA.	115 premature newborns of 23-29 weeks from the day of gestation, with bronchopulmonary dysplasia, participated. Method: Allocation into 2 groups: 55 neonates in the intervention group where feeding was done in response to hunger cues and 60 in the control group where feeding was guided by the health professional.	Aim: To assess the efficacy and safety of feeding responsive to infant hunger cues versus healthcare professional-led feeding strategies. Type of study: Retrospective intervention study with a control group.	The intervention group had a shorter hospital stay than the control group. Also, the intervention group had achieved full oral feeding 10 days earlier than the control group (p<0.001).	Cue-based feeding of preterm neonates with bronchopulmonary dysplasia led to full oral feeding more quickly and reduced resource use by improving growth.
Wellington & Perlman, 2015 USA.	254 premature neonates between 28 and 33 weeks of gestation were included. Method: Neonates were divided into 2 groups: 101 in the intervention group where they received feeding guided by them, and 153 in the control group where they received feeding guided by the healthcare	Aim: To examine the benefits of feeding based on infant hunger cues or infant-guided feeding. Type of study: Randomized controlled clinical trial.	The age of the newborn based on the mother's last menstrual period at full breastfeeding and at the time of discharge was significantly lower in the intervention group than the control group. Neonates with a gestational age <28 weeks in the intervention group versus the control group reached full breastfeeding 17 days earlier (p=0.03), while there was no difference between the groups in	Neonatal-guided feeding reduced the time to full breastfeeding and to discharge, an effect that was more pronounced in neonates with gestational age >28 weeks.

	professional, and then each group was divided into 3 subgroups based on gestational age: <28, 28-32 and >32 weeks.		time to discharge (p=0.10). Neonates with a gestational age of 28-32 weeks reached breastfeeding 11 days earlier (p<0.001) and were discharged 9 days earlier (p<0.001) in the intervention group versus the control group. Neonates with gestational age >32 weeks reached full breastfeeding 3 days earlier (p=0.04) and were discharged 3 days earlier (p=0.048) in the intervention group versus the control group.	
Cup				
Yilmaz et al., 2014 Turkey.	They included 522 preterm infants 32-35 weeks gestational age, did not require supplemental oxygen and were fed only by tube. Method: Allocation into 2 groups: 254 neonates in the intervention group where feeding was done with a small plastic medical cup by touching their lower lip with its tip and 268 in the control group where feeding was done with a bottle.	Aim: To determine the effect of cup and bottle on the rate of exclusive breastfeeding at hospital discharge, as well as 3 and 6 months after discharge in borderline preterm infants. Type of study: Randomized controlled clinical trial.	Cup-fed infants were more likely to be exclusively breastfed at discharge (RR: 1.58, 95%CI: 1.36-1.83, p<0.0001), 3 months after discharge (RR: 1.64, 95%CI: 1.42-1.89, p<0.0001), and 6 months after discharge (RR: 1.36, 95%CI: 1.14-1.63, p<0.001). The mean weight gain in the first week and the mean feeding time on the seventh day did not differ between the 2 groups (16.8±1.5 g/d, control group and 16.7±1.5 g/d, intervention group). The mean length of stay of neonates also did not differ between groups (25.96 ± 2.20 days in the control group and 25.68 ± 2.22 days in the intervention group).	Cup feeding significantly increased the likelihood that preterm infants were exclusively breastfed at hospital discharge, as well as 3 and 6 months later. It also did not increase the length of hospital stay.
Probiotics				
Qiao et al., 2016 China.	60 premature newborns of 30-35 weeks from the day of gestation participated. Method: Distribution in 2 groups: 30 newborns in the intervention group where oral administration of a combination of lactobacillus and bifidobacterium (LCB) was used, and 30 in the control group, where lukewarm water was administered at the same dose. The intervention started on the second day after delivery with a dose of 0.5g 2 times/day for 2 weeks.	Aim: To evaluate the effect of early administration of probiotics on the gut microflora and on the effect of feeding premature infants. Type of study: Double blind randomized controlled clinical trial.	The rate of feeding intolerance in the intervention group was significantly lower than the control group (13.3% vs. 46.7%, p=0.013). There were no significant differences in daily weight gain between groups. In the first week, the amount of intestinal lactobacillus and bifidobacterium was higher in the intervention group than the control group (7.84±0.35 vs. 6.39±0.53, p=0.013 and 8.52±0.23 vs. 7.01±0.48, p=0.013 respectively), and in the second week was also higher in the intervention group (8.62±0.28 vs. 7.34±0.59, p=0.036 and 9.45±0.64 vs.	Probiotic supplementation of preterm infants in the first 2 weeks resulted in greater amounts of lactobacillus and bifidobacterium in the gut and thus a low rate of feeding intolerance.

			7.85±0.43, p=0.036 respectively).	

4. Discussion

The main purpose of this literature review was to search and evaluate all the methods by which a premature newborn will be able to transition to full oral feeding, as well as to report on the problems that will arise during this transition. Methods identified in the search based on the criteria selected were non-nutritive breastfeeding either with a pacifier, the mother's breast, or a pacifier connected to a music player and the mother's voice was heard, oro-motor stimulation, the combination of non-nutritive sucking and oro-motor stimulation, responsive feeding to the newborn's hunger cues, the cup and probiotics.

Regarding the use of non-nutritive breastfeeding with a pacifier, the results showed that it helped during the transition to full oral feeding, improved breastfeeding ability and reduced the time during the transition to full breastfeeding [14], while the use of pacifier during tube feeding reduced the transition period of neonates to oral feeding and the time to full breastfeeding [15]. Non-nutritive breastfeeding at the mother's breast was also shown to be effective in the maturation of oral feeding and breastfeeding [16]. In addition, using a pacifier connected to a music player and listening to the mother's voice improved oral feeding skills and achieved full oral feeding 7 days earlier. With the pacifier method, it was found that the length of stay of newborns in the hospital was reduced [14, 15], while there was no statistically significant difference by placing the newborn on the mother's chest and using a pacifier that was connected to music reproduction [13, 16]. Adverse events were only reported in the study of Say et al., (2018) but they were very few in relation to the sample size [15]. Additionally, using a pacifier before feeding newborns has been found to help regulate newborn vital signs. Specifically, it reduced heart rates and increased hemoglobin oxygen saturation levels [17].

Oral motor stimulation was found to achieve earlier the first and eighth oral feeding of preterm infants [21] and showed that there was an improvement in oral food intake from the first day compared to the third and fifth day and more generally over days [20], while it reduced the length of stay of newborns in the hospital [20, 21]. Oral motor stimulation combined with kangaroo mother care and non-nutritive breastfeeding also led to earlier complete oral feeding, improved feeding skills and reduced length of hospital stay [18, 19]. Simple oral stimulation in the study of Aguilar-Rodriguez et al., (2020) showed that full oral feeding was achieved 8 days earlier and reduced the length of hospital stay by 7 days [23], however in the study of Bache et al., (2014) there were not positive findings regarding the reduction of the transition period to full oral feeding or the length of hospital stay [22]. Moreover, with the oral stimulation method, adverse effects such as mild bradycardia and desaturation occurred [23].

However, the combined method of oro-motor stimulation and non-nutritive breastfeeding could lead to a faster and more efficient transition from tube feeding to oral feeding [25-27]. Furthermore, it was more likely to lead to immediate breastfeeding at hospital discharge [26, 27]. The combination of sensorimotor and oral stimuli together with non-nutritive breastfeeding reduced the occurrence of pause-breath-pause and led to a greater incidence of the breath-swallow-breath pattern [24]. With this method, adverse effects and complications were observed in newborns such as desaturation, bradycardia, vomiting, suffocation and reflex muscle contraction [27]. Finally, it did not have a significant effect on reducing the length of hospital stay of newborns [25-27].

In relation to feeding responsive to newborn hunger cues, it appeared to have a beneficial effect in reducing the time to transition to full breastfeeding of newborns. In the study of Welligton & Perlman (2015), full breastfeeding with responsive feeding was achieved earlier in all infants regardless of gestational age, while length of hospital stay was also reduced in all infants [30]. Finally, it was found that this method helped neonates with bronchopulmonary dysplasia to reduce the time to transition to full oral feeding and breastfeeding while also reducing the length of hospital stay [28, 29]. The cup-feeding method significantly increased the likelihood of preterm infants being exclusively breastfed at hospital discharge and beyond, while it did not increase length of hospital stay [31]. Finally, the administration of probiotic supplementation to preterm infants in the first 2 weeks resulted in higher amounts of lactobacillus and bifidobacterium in the intestine and at the same time a low rate of feeding intolerance [32].

Therefore, the results of the studies used in this review showed that all these methods/techniques could achieve an optimal and faster transition to oral feeding, although some studies reported problems and complications that occurred in neonates during this transition. Nevertheless, it appeared that the combination of sensorimotor and oral stimulation together with non-nutritive breastfeeding was the safest method for transitioning to oral feeding, as it enhanced the development of coordination of sucking, swallowing and breathing in preterm infants.

Limitations

The present review is characterized by some limitations. Initially, articles were searched in a single database and studies published in English and Greek during the last ten years (2012-2022) were included. This fact is probably due to the small number of articles that were related to the topic, while characteristically no study was found published in the Greek language. Therefore, studies published before the time period, which may contain important results, have been excluded from the review. Finally, an additional limitation of the review is the lack of assessment of the quality of the studies.

5. Conclusion

In newborns with a gestational age of 23-36 weeks, the transition from tube feeding to full oral feeding is not an easy task, as it requires them to learn to coordinate the ability to breastfeed, swallow and breathe. To achieve this goal, it has been established from the above studies that non-nutritive breastfeeding either with a pacifier, or on the mother's breast, or with a pacifier connected to a music player from which the mother's voice can be heard, oral motor stimulation, the combination of non-nutritive sucking and oro-motor stimulation, responsive feeding to the infant's hunger cues, the cup and probiotics. All these methods lead earlier and safely to complete oral feeding and breastfeeding, while also reducing the length of stay of newborns in the hospital. However, a more efficient method based on the results of the studies seems to be the combination of sensorimotor and oral stimulation together with non-nutritive breastfeeding, as it helps not only to reduce the occurrence of pause-breath-pause, but also to increase the frequency of the breath-swallow pattern-respiratory which is necessary for the newborn to develop proper coordination skills of breastfeeding, swallowing and breathing. Also, during the transition to oral feeding, problems such as bradycardia, desaturation or choking are possible, but the risk of their occurrence is very low. Therefore, it is important that health care providers implement these interventions in preterm infants so that they can transition quickly and safely to oral feeding.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest.

References

[1] World Health Organization. Preterm birth. [Internet]. Geneva: World Health Organization; © 2022 [cited 2022 Nov 14]. Available from https://www.who.int/en/news-room/fact-sheets/detail/preterm-birth.

[2] Crowe L, Chang A, Wallace K. Instruments for assessing readiness to commence suck feeds in preterm infants: effects on time to establish full oral feeding and duration of hospitalisation. Cochrane Database of Systematic Reviews. 2016 (8): CD005586.

[3] Wiechers C, Bernhard W, Goelz R, Poets CF, Franz AR. Optimizing early neonatal nutrition and dietary pattern in premature infants. International Journal of Environmental Research and Public Health. 2021 Jul 15;18(14):7544.

[4] Shaker CS. Feed me only when I'm cueing: Moving away from a volume-driven culture in the NICU. Neonatal Intensive Care: The Journal of Perinatology-neonatology. 2012 25(3):27-32.

[5] Korth K, Rendell L. Feeding intervention. In: CaseSmith J, O'Brien JC, (Eds.), Occupational therapy for children, St Louis MO: Mosby Elsevier; 2015. p. 389-415.

[6] Collins TC, Gillis J, McPhee JA, Suganuma H, Makrides M. Avoidance of bottles during the establishment of breast feeds in preterm infants. Cochrane Database of Systematic Reviews. 2016 Sep 30;9(9):CD005252. doi: 10.1002/14651858.CD005252.pub3.

[7] Beckman DA. Oral Motor Assessment and Intervention. Winter Park, Beckman FL, Associates, Inc; 2008.

[8] Sexton S, Natale R. Risks and benefits of pacifiers. American Family Physician. 2009 Apr 15;79(8):681-5.

[9] Wolff PH. The serial organization of sucking in the young infant. Pediatrics. 1968; 4-2(6):943-956.

[10] Kimble C. Nonnutritive sucking: adaptation and health for the neonate. Neonatal Network. 1992; 11:29-33.

[11] Foster PJ, Psaila K, Patterson T. Non-nutritive sucking for increasing physiologic stability and nutrition in preterm infants. Cochrane Database of Systematic Reviews. 2016; 10(10):CD001071.

[12] Lubbe W, Ten Ham-Baloyi W. When is the use of pacifiers justifiable in the baby-friendly hospital initiative context? A clinician's guide. BMC Pregnancy childbirth. 2017; 17(1):130.

[13] Chorna OD, Slaughter JC, Wang L, Stark AR, Maitre NL. A pacifier-activated music player with mother's voice improves oral feeding in preterm infants. Pediatrics. 2014 Mar;133(3):462-8. doi: 10.1542/peds.2013-2547.

[14] Kaya V, Aytekin A. Effects of pacifier use on transition to full breastfeeding and sucking skills in preterm infants: a randomized controlled trial. Journal of clinical nursing. 2017; 26(13-14):2055–2063.

[15] Say B, Simsek GK, Canpolat FE, Oguz SS. Effects of Pacifier Use on Transition Time from Gavage to Breastfeeding in Preterm Infants: A Randomized Controlled Trial. Breastfeeding medicine: the official journal of the Academy of Breastfeeding Medicine. 2018; 13(6):433–437.

[16] John HB, Suraj C, Padankatti SM, Sebastian T, Rajapadian E. Nonnutritive Sucking at the Mother's Breast Facilitates Oral Feeding Skills in Premature Infants: A Pilot Study. Advances in neonatal care: official journal of the National Association of Neonatal Nurses. 2019 Apr;19(2):110-117.

[17] Dur Ş, Gözen D. Nonnutritive Sucking Before Oral Feeding of Preterm Infants in Turkey: A Randomized Controlled Study. Journal of Pediatric Nursing. 2021 May-Jun;58:e37-e43.

[18] Bala P, Kaur R, Mukhopadhyay K, Kaur S. Oro-motor Stimulation for Transition from Gavage to Full Oral Feeding in Preterm Neonates: A Randomized controlled trial. Indian pediatrics. 2016; 53(1):36–38.

[19] Thakkar PA, Rohit HR, Ranjan Das R, Thakkar UP, Singh A. Effect of oral stimulation on feeding performance and weight gain in preterm neonates: a randomized controlled trial. Pediatrics and International Child Health. 2018 Aug;38(3):181-186.

[20] Lessen Knoll BS, Daramas T, Drake V. Randomized Controlled Trial of a Pre-feeding Oral Motor Therapy and Its Effect on Feeding Improvement in a Thai NICU. Journal of obstetric, gynecologic, and neonatal nursing: JOGNN. 2019; 48(2):176–188.

[21] Ghomi H, Yadegari F, Soleimani F, Knoll BL, Noroozi M, Mazouri A. The effects of premature infant oral motor intervention (PIOMI) on oral feeding of preterm infants: A randomized clinical trial. International Journal of Pediatric Otorhinolaryngology. 2019 May;120:202-209.

[22] Bache M, Pizon E, Jacobs J, Vaillant M, Lecomte A. Effects of pre-feeding oral stimulation on oral feeding in preterm infants: a randomized clinical trial. Early Human Development. 2014 Mar;90(3):125-9.

[23] Aguilar-Rodríguez M, León-Castro JC, Álvarez-Cerezo M, Aledón-Andújar N, Escrig-Fernández R, Rodríguez de Dios-Benlloch JL, Hervás-Marín D, Vento-Torres M. The Effectiveness of an Oral Sensorimotor Stimulation Protocol for the Early Achievement of Exclusive Oral Feeding in Premature Infants. A Randomized, Controlled Trial. Physical & Occupational Therapy in Pediatrics. 2020;40(4):371-383.

[24] Fucile S, McFarland DH, Gisel EG, Lau C. Oral and nonoral sensorimotor interventions facilitate suck-swallow-respiration functions and their coordination in preterm infants. Early Human Development. 2012; 88(6):345–350.

[25] Zhang Y, Lyu T, Hu X, Shi P, Cao Y, Latour JM. Effect of nonnutritive sucking and oral stimulation on feeding performance in preterm infants: a randomized controlled trial. Pediatric Critical Care Medicine. 2014 Sep;15(7):608-14.

[26] Fucile S, Milutinov M, Timmons K, Dow K. Oral Sensorimotor Intervention Enhances Breastfeeding Establishment in Preterm Infants. Breastfeeding Medicine. 2018;13(7):473–478.

[27] da Rosa Pereira K, Levy DS, Procianoy RS, Silveira RC. Impact of a pre-feeding oral stimulation program on first feed attempt in preterm infants: Double-blind controlled clinical trial. PloS One. 2020 Sep 9;15(9):e0237915.

[28] McCain GC, Del Moral T, Duncan RC, Fontaine JL, Pino LD. Transition from gavage to nipple feeding for preterm infants with bronchopulmonary dysplasia. Nursing Research. 2012 Nov-Dec;61(6):380-7.

[29] Davidson E, Hinton D, Ryan-Wenger N, Jadcherla S. Quality Improvement Study of Effectiveness of Cue-Based Feeding in Infants With Bronchopulmonary Dysplasia in the Neonatal Intensive Care Unit. Journal of Obstetric, Gynecologic & Neonatal Nursing. 2013; 42(6):629–640.

[30] Wellington A, Perlman JM. Infant-driven feeding in premature infants: a quality improvement project. Archives of Disease in Childhood - Fetal and Neonatal Edition. 2015; 100(6):F495–F500.

[31] Yilmaz G, Caylan N, Karacan CD, Bodur İ, Gokcay G. Effect of Cup Feeding and Bottle Feeding on Breastfeeding in Late Preterm Infants. Journal of Human Lactation. 2014 May;30(2):174-9.

[32] Qiao LX, Zhu WY, Zhang HY, Wang H. Effect of early administration of probiotics on gut microflora and feeding in pre-term infants: a randomized controlled trial. The journal of Maternal-fetal & Neonatal Medicine. 2017; 30(1):13–16