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NON-PHARMACOLOGICAL INTERVENTIONS FOR FEEDING AND GROWTH IN PRETERM NEONATES: A SYSTEMATIC REVIEW AND META-ANALYSIS OF RANDOMIZED CLINICAL TRIAL

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Abstract

Feeding intolerance (FI) delays nutritional advancement, growth, and discharge readiness in preterm neonates (<37 weeks' gestation). Non-pharmacological interventions (NPIs) - including oral stimulation, non-nutritive sucking (NNS), premature infant oral motor intervention (PIOMI), abdominal massage, KMC, and multisensory stimulation - are increasingly applied as safe, low-risk strategies to support feeding and growth in neonatal intensive care units. This systematic review and meta-analysis evaluated randomized controlled trial evidence for NPIs on feeding tolerance, oral feeding progression, growth, and hospitalization outcomes in preterm neonates. Eligible studies published between 2020 and 2026 were identified through database and manual reference searching. Continuous outcomes were summarized as mean differences (95% Confidence Interval); dichotomous outcomes as risk ratios. Missing variance data were not imputed. Twenty-one eligible RCTs were included, encompassing oral stimulation, PIOMI, NNS, abdominal massage, I Love You massage, Chinese pediatric Tuina, prone positioning, Kangaroo mother care (KMC), and multistimulation. Pooled analysis demonstrated that NPIs reduced GRV by 3.07 mL (95% CI −3.33 to −2.81; $I^2 = 0\%$). KMC significantly reduced FI events (RR = 0.22, 95% CI 0.08–0.63), and abdominal massage reduced post-feeding abdominal circumference. Oral-motor interventions favored earlier feeding readiness, faster transition to full oral feeding, and shorter hospitalization, though several outcomes were not poolable. NPIs are effective supportive strategies for improving feeding outcomes in preterm neonates. Evidence is strongest for gastric residual volume (GRV) and FI events; standardized outcome reporting across future trials remains necessary.

Keywords: preterm neonates; feeding intolerance; oral stimulation; non-nutritive sucking; abdominal massage; kangaroo mother care; meta-analysis; chinese pediatric Tuina; prone positioning

Introduction

Clinical problem and rationale

The incidence of preterm births continues to be one of the leading causes of neonatal morbidity and longer neonatal intensive care unit (NICU) stays (World Health Organization, 2022). Preterm infants born prior to 37 completed weeks of gestation frequently start extrauterine life with an immature gastrointestinal system, including dyscoordination of gastrointestinal motility, oral motor control,

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respiratory stability and autonomic control (Embleton et al., 2023). Enteral feeding is required for growth, gut adaptation, immune protection and neurodevelopment; however not all of these preterm babies can transition from gavage to full enteral or oral feedings without trouble (Embleton et al., 2023). This delay can have an impact on weight gain, exposure to parenteral nutrition, risk of sepsis, separation from family, hospital expenses, and readiness to be discharged (Embleton et al., 2023; World Health Organization, 2022).

Gastrointestinal and feeding immaturity in preterm neonates manifests itself as a clinical expression which includes FI. It is typically diagnosed using gastric residual volume, vomiting, abdominal distention, change in abdominal circumference, delayed stooling, or discontinuation of feeds prescribed (Caka et al., 2023; Hendy et al., 2022). These to are clinically useful, but imperfect, as it is possible to see that GRV may be affected by infant position, time of aspiration, method of infant feeding, NICU practice, tube characteristics (Hendy et al., 2022). FI is a complex phenomenon and no single measure can completely characterize it; outcomes such as residual volume, abdominal findings, oral feeding readiness, length of stay, feeding performance, and weight gain are increasingly being used to assess FI in the neonatal period (Caka et al., 2023; Singh et al., 2023).

Why non-pharmacological care matters

This has led to the significance of NPIs to promote physiological development without adding on to drug exposure. For preterm infants, using oral stimulation, NNS, premature infant oral motor intervention (PIOMI), swallowing exercises, abdominal massage, KMC, positioning and multisensory stimulation to improve feeding readiness/tolerance (Alidad et al., 2021; Caka et al., 2023; Hendy et al., 2022; Pereira et al., 2020; Shaki et al., 2022). Oral-motor interventions focus on sucking, swallowing and breathing pathway and feeding skill development (Pereira et al., 2020; Thabet & Sayed, 2021). NNS helps in sucking rhythm and behavioural organisation (Shaki et al., 2022). Abdominal massage can help to stimulate intestinal movements, both by tactile and vagal mechanisms (Hendy et al., 2022). KMC may have effects on the autonomic stability, regulation of temperature, breastfeeding (BF) behavior and gastrointestinal function due to skin to skin contact and positioning in an upright posture (World Health Organization, 2022; Caka et al., 2023).

Evidence is encouraging and ranges from good to weak. Other RCTs look at the FI outcomes directly, including gastric residual volume, abdominal circumference or distention (Caka et al., 2023; Hendy et al., 2022). Others target readiness to start oral feeding, BF behaviors, transition to full oral feeding, weight gain or stay in hospital (Balci et al., 2023; Shaki et al., 2022; Singh et al., 2023). This distribution of results makes clinical sense, however, and it becomes a problem when studies report on different outcomes or variance is incomplete. Because of incomplete outcome reporting, however, it is important to summarize the available peer-reviewed evidence to determine what can be concluded from current evidence and what remains unknown from current evidence, which is best accomplished by a recent synthesis focused on RCTs.

Aim and review question

A systematic review and meta-analysis of randomized controlled trial literature to review evidence for NPIs to promote feeding tolerance and growth related outcomes in preterm neonates. The review addresses the question of if these interventions have a beneficial effect on indicators of FI, progression of feeding, weight-related outcomes, BF outcomes and hospital stay compared to the routine or standard care. The review also categorizes which outcomes can be meta-analyzed from existing numeric data and which ones cannot be, due to not having exact means, standard deviations, or event counts and therefore need a narrative synthesis.

The review is designed to inform clinical decision making and not a statistical endeavor. A neonatal team should be aware of interventions that have direct feeding-tolerance outcomes, interventions that seem to facilitate progression to oral feeding, and interventions that have not yet been reported but are still promising in helping to reach oral feeding. This is important because it's not the same biological

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process measured by reduced GRV, early readiness to oral feeding, better BF behavior, and length of stay. The paper proposes a pragmatic evidence map of bedside feeding support for preterm neonates, by dividing these outcome domains.

Literature Review

FI and feeding development

Many systems develop concurrently which are important for feeding development in the preterm neonate. Milk needs to travel through the stomach into the intestine – gastrointestinal motility – and sucking and swallowing needs to be coordinated through the oral structures (Embleton et al., 2023). Breathing patterns need to be stable during feeding and behavioral organization should enable the infant to be awake enough to be fed without physiological stress (Pereira et al., 2020; Singh et al., 2023). These requirements are why many preterm infants can take small gavage feeds prior to being ready to safely take feeds orally. They also indicate why there is a tendency for one outcome of feeding to not reflect the whole clinical picture.

There are significant implications of delayed progression of feeding. A slower transition to full enteral and/or oral feeding can lead to longer lines in, more exposure to central venous access, slower growth and longer hospital stay (Embleton et al., 2023). The ESPGHAN guidance to EN in preterm infants focussed on structured nutritional management as nutrient deficiencies in this period can impact not only upon short-term growth but also upon subsequent development (Embleton et al., 2023). Another hallmark of achievement in neonatal discharge is the ability to take food orally. When feeding is not consistent otherwise stable infants are not discharged from hospital.

Oral-motor and sucking interventions

Some of the most commonly researched interventions in the evidence base included are oral stimulation and premature infant oral motor intervention (PIOMI). They typically involve a massage of the cheeks, lips, gums, tongue or palate before BF (Pereira et al., 2020; Thabet & Sayed, 2021). The goal is to enhance sensory input to the oral cavity, strength of oral muscles and promote coordinated feeding patterns (Balci et al., 2023, Guler et al., 2022, and Singh et al., 2023). Oral stimulation (either pre-feeding or parent performed), PIOMI, oromotor therapy, and combined oral motor intervention with NNS were trials evaluated in the review (Alidad et al., 2021; Balci et al., 2023; Guler et al., 2022; Huang et al., 2024; Li et al., 2022; Pereira et al., 2020; Skaaning et al., 2020; Thabet & Sayed, 2021). These studies tend to support the clinical observation that oral motor structured care results in better readiness or transition outcomes than reductions in GRV.

NNS is similar to oral stimulation, but is not the same. It can help infants learn to suck without milk, and has the potential to enhance sucking rhythms, state regulation and the suck-gastric association (Shaki et al., 2022). In the included trials, NNS was either the sole intervention, or combined with other treatments (Alidad et al., 2021; Li et al., 2022; Ostadi et al., 2021; Shaki et al., 2022). In this regard, sucking the mother's finger or sucking a pacifier was compared to routine sucking in the study conducted by Shaki et al. (2022) and sucking a pacifier was compared to swallowing exercise and/or oral motor support in the study conducted by Ostadi et al. (2021) and Alidad et al. (2021). The clinical significance of these studies is that they relate oral feeding behaviors to very simple bedside interventions that can be given by trained staff or caregivers.

Tactile, positional, and developmental-care interventions

The pathways of action of abdominal massage and KMC, related to feeding tolerance, are different. Massage of the abdomen may enhance peristalsis, decrease the distention and decrease the GRV (Hendy et al., 2022). Residual stomach contents and abdominal circumference was directly assessed after an abdominal massage protocol prior to gavage feeding by Hendy et al., (2022). KMC offers skin-to-skin contact and an upright position which can stabilize the infant and can facilitate digestion by the infant (Caka et al., 2023; World Health Organization, 2022). Of the specific studies, the one by Caka et al. (2023) was specifically assessing KMC for FI and is one of the best fit to the present review

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question.

There are several other RCTs that are directly applicable to gastrointestinal feeding tolerance in the abdominal massage evidence base. In NICU preterm populations, gastric residual volume, vomiting, abdominal distention and circumference, defecation, weight gain, comfort and FI events have been investigated by Mojaveri et al. (2020), Moghadam et al. (2022), Abouheiba et al. (2022), Ali (2022), Li et al. (2023), and Ibrahem Mohamed et al. (2024) collectively to expand the abdominal massage and related tactile/positional evidence.

The feasibility of tactile and/or sensory interventions are underpinned by more general NICU developmental-care studies and should not be interpreted as feeding-trial studies. The physiological indicators were improved after painful procedures in preterm infants when using Yakson Touch (Osman et al., 2024). Physiological and behavioral responses were better by using earplugs with eyecover in the NICU environment (Ali et al., 2023). Non-pharmacological stabilisation is supported by these two studies which were used as contextual literature. These were not included in the feeding meta-analysis as their main outcomes were not feeding tolerance or feeding progression, growth or hospitalization.

Evidence gap

The feeding results must be interpreted with care in that they are located between physiology and clinical practice. Lower GRV may indicate improved gastric emptying but is not necessarily good for the infant to start oral feeding safely (Hendy et al., 2022; Singh et al., 2023). BF behavior may be reflected in the higher BF behavior score, but may not reflect intestinal tolerance (Shaki et al., 2022). Although clinically important, time to full oral feeds can be affected by local discharge protocols, staffing and feeding practices (Singh et al., 2023). Because of this, the synthesis needs to be a high-quality one, and it should structure evidence by type of outcome, not as if all feeding outcomes are equivalent.

One point of critique, which is not biological, is whether it is biologically plausible to enact non-pharmacological interventions. The issue is whether the evidence in the RCTs is consistent enough to draw strong clinical conclusions for the different feeding outcomes. Trials vary in terms of the gestational age at which they started, the dose of the intervention, the type of comparator care, the timepoint for outcome assessment, and statistical reporting (Alidad et al., 2021; Caka et al., 2023; Hendy et al., 2022; Singh et al., 2023). Some studies report means and standard deviations, whereas other studies only report medians, p-values, or odds ratios or narrative significance only. A synthesis should, therefore, be rigorous in not estimating missing values, and in distinguishing between meta-analysis-ready evidence and non-poolable evidence (Higgins et al., 2024).

Methodology

Design and reporting standard

This review was intended to be a systematic review and meta-analysis of RCTs. Reporting was done according to PRISMA 2020 guidelines for clear identification, selection, synthesis and reporting of the studies (Page et al., 2021). The statistics were conducted following standard statistical procedures for systematic reviews (Higgins et al., 2024) for effect measures, heterogeneity, and caution for incomplete evidence. The review was conducted using a structured workbook for extraction of data from peer-reviewed literature and did not generate nor assume numeric data on outcomes that were not reported.

Eligibility criteria

The population consisted of preterm neonates/premature infants who were admitted to neonatal or neonatal intensive care units (NICU). When the feeding intervention and outcomes described were neonatal, studies were eligible if the infant was described as preterm/premature or low birth weight/very preterm. Trials that were conducted on neonates only were excluded as were trials conducted on non-neonatal populations. An intervention was deemed to meet the intervention criterion

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if it was a non-pharmacological feeding tolerance, feeding readiness, oral feeding performance, gastrointestinal motility, or growth related recovery feeding or developmental-care intervention.
Interventions considered were oral stimulation, parent performed oral stimulation, premature infant oral motor intervention (PIOMI), oromotor therapy, non-nutritive sucking (NNS), swallowing exercise, abdominal massage, kangaroo mother care (KMC), positioning, tactile stimulation and multisensory stimulation. Comparators were routine NICU care, routine feeding support, sham procedure, no other stimulation or other comparator arm. Studies were included if they were published in the last seven years (2020-2026) and were randomized controlled trials or randomized clinical trials. The studies that were excluded from the primary synthesis included reviews, protocols, commentaries, quasi-experimental report (no randomisation), pharmacological feeding studies, formula-composition studies (no stimulation-based care), and studies with no relevant extractable outcome.

Search sources and PRISMA study selection

The search was conducted using a combination of population terms (preterm/premature, low birth weight, very low birth weight) with intervention terms (non-pharmacological, oral stimulation, non-nutritive sucking, premature infant oral motor intervention (PIOMI), abdominal massage, kangaroo care, positioning, tactile stimulation). The outcome terms were: feeding intolerance, gastric residual volume, vomiting, abdominal distention, oral feeding readiness, enteral feeding, weight gain, breastfeeding and hospital stay. Randomized controlled trial' and 'randomized clinical trial' were terms used to describe study designs. The databases of PubMed/MEDLINE, Scopus or Embase, CINAHL, Cochrane CENTRAL and manual reference search were used.
The PRISMA flow was recorded in the extraction workbook and study selection was done accordingly. 758 records were identified, of which 731 were from the searches of databases and 27 were from the manual reference and citation searching. After deduplication of 219 records, 539 records were screened according to the title and abstract, and 469 records were deduplicated. Four of the 49 excluded articles were not randomized controlled trials, seven had the wrong population, seven had the wrong intervention, six were publication type (protocol or commentary), and six were missing extractable outcome data. Of the 21 eligible studies, a final qualitative synthesis was performed and meta-analysis was limited to outcomes with exact (non-imputed) group-level data. This selection process is shown as Figure 1.

Data extraction and outcomes

Data extraction included the following information: author(s) and year of publication; country and setting of the study; design; population; sample size; intervention category and intervention details; comparator; outcome type; exact numeric data available and/or not available; DOI; analysis use reported in Table 1. When available: continuous data were extracted as group sample size, mean, standard deviation, mean difference, standard error and 95% confidence interval (CI). For dichotomous data, the numbers of events and group size, risk, risk ratio, log risk ratio, standard error and 95% CI were extracted. When studies reported medians, p-values, odds ratios or findings that were reported directionally that could not be safely converted to mean differences or risk ratios, then effect-level evidence was retained.
Data extraction was aligned with the Joanna Briggs Institute (JBI) standardized data extraction form for effectiveness reviews and was adapted for this neonatal feeding question. The form captured author/year, country and setting, aim, design, sample and group allocation, intervention details, comparator, measurement outcomes, results, effect estimates, DOI/source link, and analytic use.

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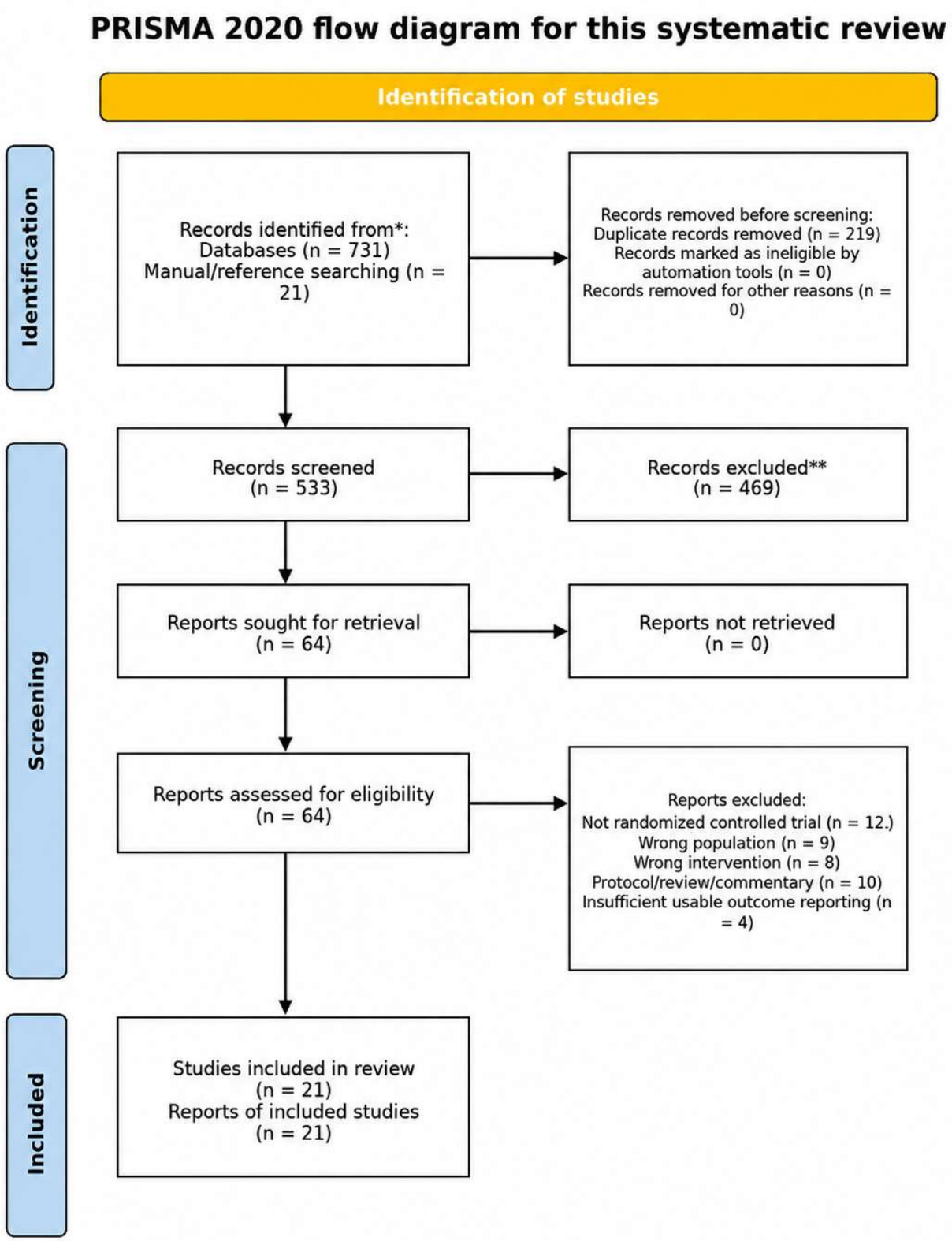

Figure 1. PRISMA 2020 flow diagram for study selection.

Primary outcomes included FI signs - gastric residual volume, abdominal circumference, vomiting,

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abdominal distention, defecation pattern, and composite FI events. Oral feeding readiness, transition to full oral or enteral feeding, enteral or BF volume, BF behavior, daily weight gain and length of hospitalization were secondary outcomes. With units that were comparable, continuous outcomes were summarized through mean differences. Risk Ratios were used to summarise dichotomous outcomes. Outcomes that were incompatible or had scales or inapplicable shared controls or lacked variance data were synthesized narratively.

Critical appraisal process

Two reviewers performed an independent critical appraisal of retrieved studies using the standardized Joanna Briggs Institute (JBI) Critical Appraisal Checklist for randomized controlled trials. Each item was judged as Yes, No, Unclear, or Not applicable, including true randomization, allocation concealment, baseline similarity, participant/personnel/outcome assessor blinding, identical treatment other than the intervention, completeness of follow-up, analysis in randomized groups, consistency and reliability of outcome measurement, appropriateness of statistical analysis, and whether deviations from standard RCT design were accounted for. Disagreements were resolved by discussion and, if required, consultation with a third reviewer. Because the extraction workbook did not contain complete item-level ratings for every study, the manuscript reports methodological quality narratively and avoids inventing unavailable domain scores.

Analysis and visualization plan

Gastric residual volume (GRV) was analyzed using a fixed-effect inverse-variance model due to the lack of heterogeneity and the fact that only 2 studies reported directly comparable mean differences in milliliters. The I2 and Q were used to measure heterogeneity. Four were retained: Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) diagram, intervention-distribution chart, GRV forest plot and a descriptive continuous-effect plot based on the exact outcomes extracted. A separate risk-ratio plot was not saved as the dichotomous FI estimate was provided in one study only and was more easily reported in Table 2. This ensured the figure set concentrated on key trends of ongoing impacts while retaining the details of the figure. Methodological quality was assessed using the JBI Critical Appraisal Checklist for RCTs and summarized narratively, with emphasis on randomization, allocation concealment, blinding feasibility, completeness of follow-up, and completeness of outcome reporting. No unavailable domain-level scores were invented.

Results

Study characteristics and intervention distribution

Twenty one eligible studies were kept for qualitative synthesis. These include 15 trials that have focused on oral-motor and kangaroo care interventions and 6 trials focusing on interventions directly related to gastrointestinal feeding tolerance (abdominal massage, I Love You massage, Chinese pediatric Tuina, and prone-positioning). The contexts include Brazil, Denmark, Iran, Egypt, China, India, Turkey, Taiwan and neonatal and NICU-related contexts. Study-level statistics were not available in the extraction data set for complete group-level statistics were included in the tables and synthesis without imputation.

When assessing the impact of the interventions, it is important to observe how the interventions have been spread throughout the evidence base. As seen in Figure 2 the majority of records included were on oral motor. Ten records had features of PIOMI/oromotor stimulation, four had features of NNS/sucking-related features, seven records had abdominal massage, I Love You massage, Chinese pediatric Tuina, or massage/prone-positioning components, and one record each had KMC and multistimulation. Not all of these categories were mutually exclusive as some trials included more than one category such as oral stimulation and NNS or other support. This overlap mimics actual NICU practice, in which interventions are often combined around readiness to feed and gastrointestinal tolerance rather than provided only as stand-alone interventions.

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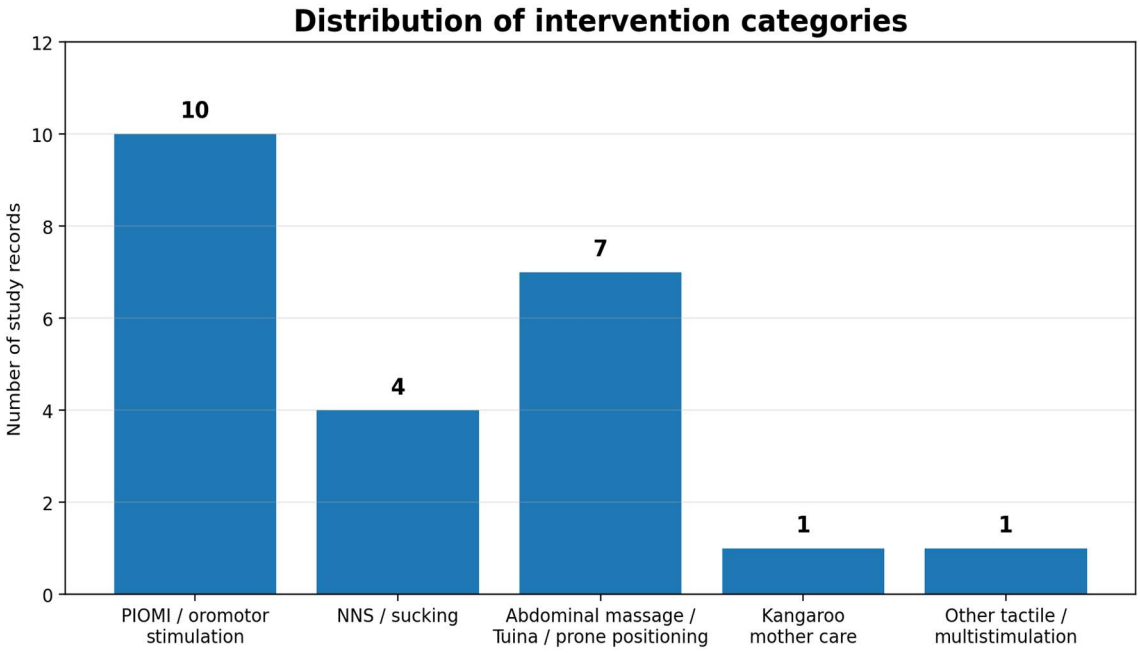

Figure 2. Distribution of non-pharmacological intervention categories across included study records. Categories are not mutually exclusive.

Figure 2 indicates that the included trials addressed both oral-motor maturation and direct gastrointestinal tolerance endpoints. This distribution explains why both oral feeding progression and feeding-tolerance outcomes required narrative synthesis when exact pooling data were unavailable.

Table 1. Summary characteristics of included randomized controlled trials (n = 21).

Author(s)/year	Country/setting	Aim	Sample and group	Intervention details	Comparator	Measurement outcomes	Results
Pereira et al. (2020)	Brazil, NICU	Evaluate pre-feeding oral stimulation on first feeding attempt and oral skills.	Very preterm newborns; group sizes pending in extraction workbook.	Pre-feeding oral stimulation, 15 min daily for 10 days.	Sham/routine care.	First oral feeding performance; oral skills; transition from tube to oral intake.	Retained for qualitative synthesis; exact table extraction pending.
Skaaning et al. (2020)	Denmark	Assess parent-performed oral stimulation and exclusive BF.	Healthy premature infants; group sizes pending.	Systematic oral stimulation performed by parents.	Standard care.	Exclusive BF duration and BF at 6 months.	No significant difference in exclusive BF duration; narrative/effect-level evidence.

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Author(s)/year	Country/setting	Aim	Sample and group	Intervention details	Comparator	Measurement outcomes	Results
Ostadi et al. (2021)	Iran	Test swallowing exercise and NNS on oral feeding readiness.	Preterm infants; group details pending.	Swallowing exercise plus NNS exercise.	NNS/control as reported.	Oral feeding readiness; independent oral feeding; hospitalization.	Qualitative synthesis; exact group means/SDs pending.
Thabet & Sayed (2021)	Egypt, NICU	Determine PIOMI effects on feeding performance, stay, and weight.	60 total; 30 PIOMI, 30 control.	PIOMI.	Routine NICU care.	Feeding performance; milk leakage; full oral feeding; weight; hospital stay.	Significant improvements reported for oral feeding, milk leakage, weight, and hospital stay; exact pooling data pending.
Alidad et al. (2021)	Iran	Assess combined NNS, oral motor stimulation, and oral support.	44 premature infants; 22 intervention, 22 control.	NNS plus oral motor stimulation and oral support.	NNS alone.	Feeding performance.	Included narratively; exact outcome statistics require full-text table extraction.
Li, L. et al. (2022)	China, NICU	Evaluate oral motor intervention plus NNS for dysphagia.	60 total; 30 intervention, 30 control.	Oral motor intervention combined with NNS.	NNS alone.	PIOFRAS-CV; milk sucking rate/amount; feeding efficiency; weight; adverse reactions.	Qualitative/effect-level evidence; no imputed values added.
Hendy et al. (2022)	Egypt, government hospital	Test abdominal massage before gavage feeding on tolerated feeding.	120 total; 60 massage, 60 control.	Abdominal massage 30 min before gavage feeding, 10 min, three times daily for 4 days.	Routine care/no massage.	GRV; abdominal circumference; feeding tolerance.	Quantitative evidence: lower GRV and abdominal circumference favored massage.

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Author(s)/year	Country/setting	Aim	Sample and group	Intervention details	Comparator	Measurement outcomes	Results
Shaki et al. (2022)	Iran, NICU	Compare mother-finger and pacifier NNS on oral feeding behavior.	150 total; 50 mother finger, 50 pacifier, 50 control.	NNS using mother's finger or pacifier.	Routine care.	PIBBS; rooting; oral feeding behavior; hospital outcomes.	Mother-finger NNS improved BF behavior and rooting; pacifier effect was smaller/imprecise.
Negi et al. (2022)	India	Assess multistimulation on feeding habits in low-birth-weight babies.	44 total; 2:1:1 allocation.	Multistimulation approach.	Usual care/comparison arms.	Oral feeding performance; intake volume; weight gain; transition time.	Narrative synthesis; exact outcome tables pending.
Guler & Cigdem (2022)	Turkey, two NICUs	Evaluate PIOMI on sucking capacity.	60 total; 30 PIOMI, 30 control.	Premature infant oral motor intervention.	Routine care.	Sucking capacity; oral motor function; feeding and anthropometrics.	Qualitative evidence favored PIOMI; exact table extraction pending.
Bandyopadhyay et al. (2023)	NICU setting	Assess pre-feeding PIOMI for transition from gavage to full spoon feeds.	32 total; 16 intervention, 16 control.	Pre-feeding PIOMI, 5 min twice daily plus routine care.	Routine care.	Transition from gavage to full spoon feeds; safety.	Reported significantly reduced transition time; small RCT, exact values pending.
Singh et al. (2023)	India, NICU	Compare structured PIOMI with routine oromotor stimulation.	84 total; 42 PIOMI, 42 routine OMS.	Structured PIOMI.	Routine/unstructured oromotor stimulation.	Oral feeding readiness; full oral feeds; weight gain; stay; BF.	Readiness, transition, stay, weight gain, and BF outcomes favored structured PIOMI.

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Author(s)/year	Country/setting	Aim	Sample and group	Intervention details	Comparator	Measurement outcomes	Results
Balci et al. (2023)	Turkey, NICU	Improve feeding skills and transition to BF in early preterm infants.	Early preterm infants <30 weeks GA; group sizes not entered.	One-month oromotor therapy program.	No intervention/standard care.	EFS; POFRAS; BF transition; discharge timing.	Improved feeding skills and BF transition; exact extraction pending.
Caka et al. (2023)	Turkey, NICU	Assess KMC effects on FI.	168 total; 84 KMC, 84 standard care.	KMC/upright skin-to-skin positioning.	Standard care.	FI events; GRV; enteral feeding volume.	Reduced FI events and GRV; quantitative continuous and dichotomous data used.
Huang et al. (2024)	Taiwan/ neonatal setting	Test oral stimulation effects on feeding readiness.	46 total.	Oral stimulation over days 1, 3, and 7.	Standard care.	Feeding readiness; POFRAS over time.	Qualitative synthesis; exact POFRAS values pending.
Mojaveri et al. (2020)	Iran, NICUs in Babol and Tehran	Investigate abdominal massage on feeding tolerance of very-low-birth-weight neonates.	56 total; 28 massage, 28 control.	Abdominal massage 15 min before feeding, 15 min, three times daily for 5 days.	Standard care.	GRV; vomiting; defecation frequency; abdominal circumference.	Significant reductions in GRV, vomiting, and abdominal circumference and increased defecation frequency.
Moghadam et al. (2022)	Iran, NICU	Evaluate I Love You abdominal massage on gastric function.	64 preterm infants selected; massage and control groups.	I Love You abdominal massage before feeding, twice daily, 15 min, for 5 days.	No massage/ routine care.	Weight; abdominal circumference; vomiting episodes; residual volume; defecation frequency.	Significant improvements in abdominal circumference, vomiting, residual volume, and defecation; no significant weight gain.

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Author(s)/year	Country/setting	Aim	Sample and group	Intervention details	Comparator	Measurement outcomes	Results
Abouheiba et al. (2022)	Egypt, NICU at Mansoura University Children's Hospital	Investigate successive abdominal massage on FI and daily weight gain.	40 preterm neonates; study and control groups.	Successive abdominal massage; nursing intervention applied repeatedly before/around feeds.	Control/routine care.	GRV; vomiting episodes; abdominal distension; defecation; daily weight gain.	Highly significant improvements in FI measures and daily weight increase.
Ali (2022)	Egypt, Specialized Pediatric Hospital NICU, Benha	Examine abdominal massage and prone positioning for FI with non-invasive ventilation.	75 total; 25 massage, 25 prone positioning, 25 control.	Abdominal massage or prone positioning as proactive nursing strategies.	Control group/routine care.	Gastric residue; abdominal distension; vomiting/regurgitation; defecation; abdominal circumference; bradycardia.	Both intervention groups improved FI parameters versus control (P <= 0.001).
Li, S.-S. et al. (2023)	China, Department of Neonatology, Quanzhou First Hospital	Explore Chinese pediatric Tuina for preventing FI and supporting weight gain.	Premature infants randomized to Tuina or standard care; exact total not stated in abstract.	Chinese pediatric Tuina delivered by trained practitioners.	Standard care.	FI incidence; body weight; head circumference; albumin; prealbumin; adverse GI outcomes.	Lower FI (7 vs. 15) and better weight/nutritional indicators after 1 week.
Ibrahem Mohamed et al. (2024)	Egypt, Kafrelsheikh University Hospital NICU	Determine I Love You abdominal massage effects on gastric function, growth, and comfort.	60 preterm neonates randomly divided into two groups.	I Love You abdominal massage, 15 min twice daily, 1 hour before meals.	Conventional hospital care/control.	GRV; abdominal circumference; vomiting; defecation; weight; COMFORT neo score.	Improved feeding-intolerance parameters, comfort by days 3-5, and fifth-day weight outcomes.

Note. Only exact, non-imputed statistics were used for meta-analysis. Studies with incomplete variance data were retained for narrative synthesis. *NICU= neonatal intensive care unit; NNS= non-nutritive sucking; SD= standard deviation; KMG= kangaroo mother care; PIOMI= premature infant oral motor intervention; FI= feeding intolerance; GRV= gastric residual volume; RCT= randomized clinical/ controlled trial; PIOFRAS-CV= preterm infant oral feeding readiness assessment scale-Chinese version; PIBBS= preterm infant breastfeeding behavior scale; GI= gastrointestinal; OMS= oromotor stimulation; GA= gestational age; EFS= early feeding skills*

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assessment tool; POFRAS= preterm oral feeding readiness scales; COMFORT neo= neonate comfort behavior scale; NOMAS= neonatal oral-motor assessment scale; BF= breastfeeding.

Quantitative synthesis

Three studies (Hendy et al., 2022; Shaki et al., 2022 and Caka et al., 2023) provided data that were ready for analysis on a continuous basis. Dichotomous event data was exactly available from Caka et al. (2023). Several other trials provided important evidence at the level of an effect, but were not pooled as a lack of variance data, medians, or odds ratios that were not harmonized across the trials, or a p-value only, or a directionally expressed finding with no variance data. Time to oral feeding readiness, transition to full oral feeding, hospital stay, weight gain and BF outcomes were the most common non-poolable outcomes.

Studies reporting abdominal massage, I Love You massage, Tuina, and prone-positioning outcomes strengthened the narrative gastrointestinal-tolerance evidence but were not incorporated into pooled estimates unless exact group-level means, standard deviations, or event counts were available.

Only one outcome (gastric residual volume) had two directly comparable mean difference estimates. Individually and pooled effects are shown in figure 3. The results of both trials were positive towards the intervention. Hendy et al. (2022) reported a mean difference of -3.06 mL (95% CI -3.32 to -2.80), and Caka et al. (2023) reported a mean difference of -3.33 mL (95% CI -4.80 to -1.86). The pooled mean difference was -3.07 mL (95% CI -3.33 to -2.81), with no observed heterogeneity (I2 = 0%). This is the most clear quantitative evidence that NPIs have an effect on a direct measure of FI.

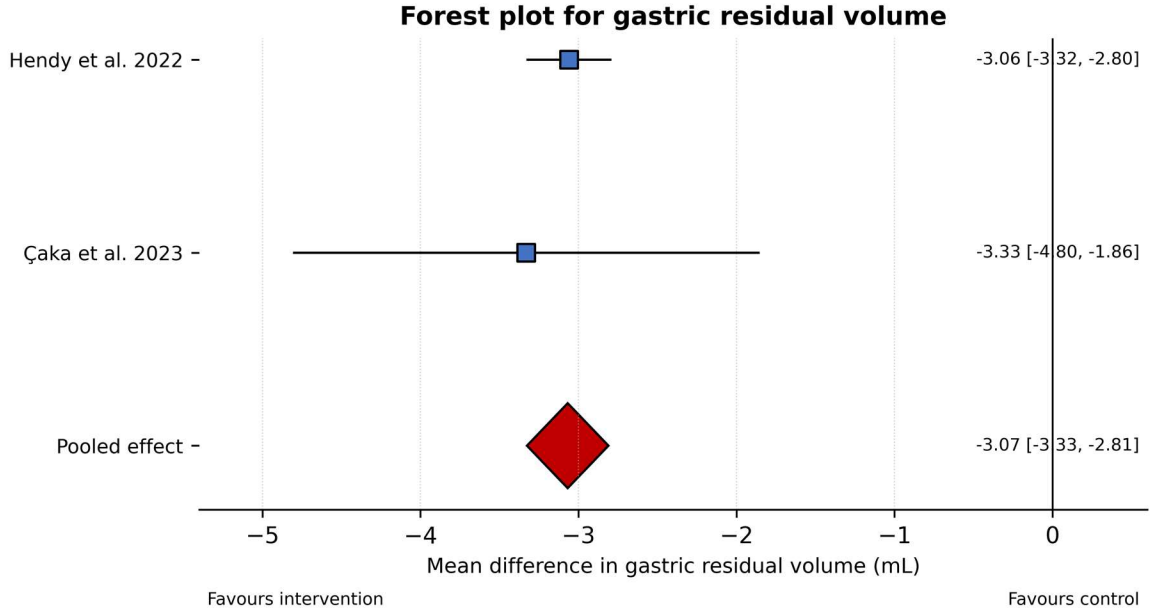

Figure 3. Forest plot of GRV before the next feeding. Negative mean differences favor the intervention.

The agreement between the two estimates supports a consistent direction of effect for residual volume, although the pooled finding still rests on only two trials.

Other exact and narrative findings

Other continuous outcomes were mixed with clinically significant results. Hendy et al. (2022) found the abdominal circumference to be less after feeding in the abdominal massage group compared to the routine care group (MD = -1.61 cm, 95% CI -2.68, -0.54). Caka et al. (2023) found no clear improvement in enteral BF volume (MD = -1.26 mL, 95% CI -3.84 to 1.32). The BF behavior scores for mother's finger sucking compared with control were better (MD = 1.94, 95% CI 0.43 to 3.45), the scores for pacifier sucking compared with control were smaller and imprecise (MD = 0.60, 95% CI -

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0.94 to 2.14), as found by Shaki et al. (2022). There was a similar trend with mother's finger sucking leading to better rooting score (MD 0.36, 95% CI 0.08 to 0.64) and pacifier sucking to an imprecise effect (MD 0.24, 95% CI -0.04 to 0.52). The two sucking comparisons were not combined to make a pooled estimate since they had the same control.

Figure 4 presents the extracted mean differences and 95% confidence intervals for each outcome to better illustrate all the exact continuous estimates which were not compatible to be displayed in one pooled statistic. This figure is descriptive, it refers to the direction and precision of the results between outcomes but it shouldn't be interpreted as a single treatment effect since the scales are different.

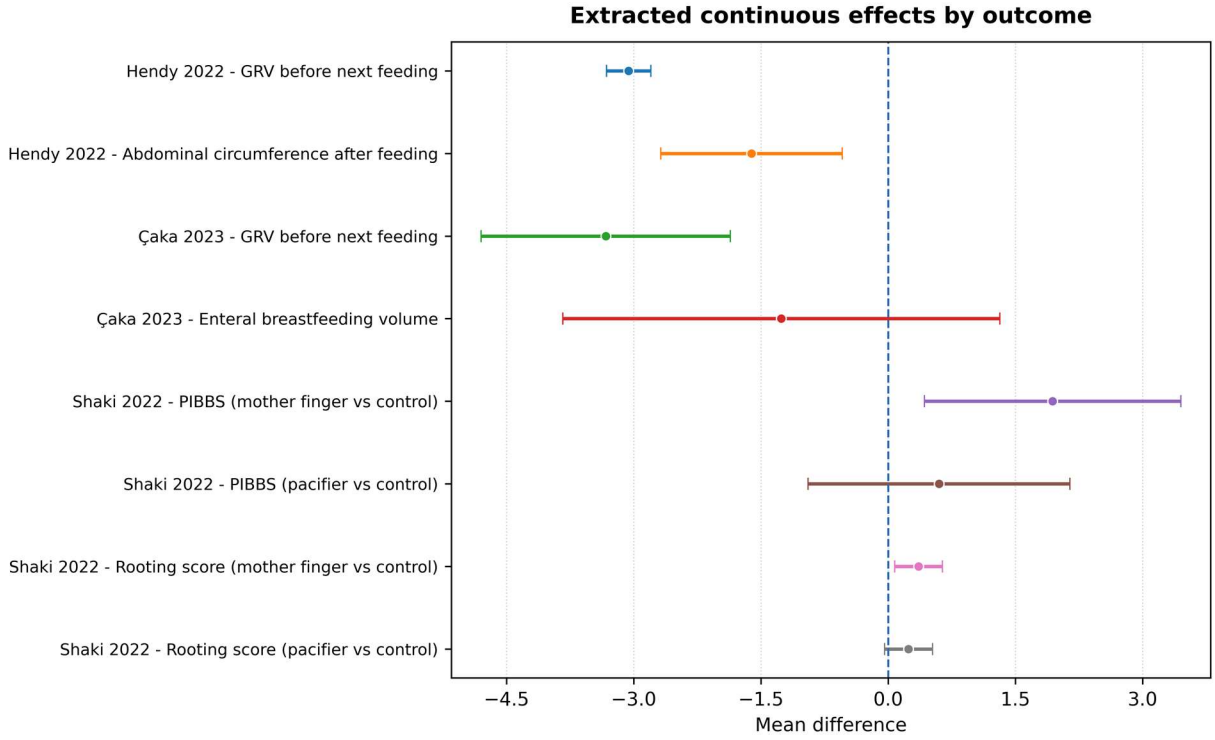

Figure 4. Extracted continuous effects by outcome. The dashed vertical line marks no mean difference; negative values favor intervention for adverse outcomes, and positive values favor intervention for beneficial behavior scores.

As shown in Figure 4, the most pronounced negative impact was seen for GRV and abdominal circumference, with lower values being considered better for the intervention. The results of positive effects were primarily observed in the BF behavior and rooting scores with higher scores favoring intervention. Results which exceeded the no-effect line, such as enteral BF volume and pacifier compared, were interpreted with caution.

Caka et al. (2023) reported four cases of dichotomous FI (mother care by infant kangaroo) and 18 cases of dichotomous FI (standard care) among 84 infants, respectively. The risk ratio was 0.22 (95% CI 0.08 to 0.63) and the risks 4.8% and 21.4% and the absolute risk reduction 16.7 percentage points. A separate plot was not required for this as it was a single-study event outcome, and is presented in Table 2 along with the other exact estimates.

For the progression of oral feeding, there was a trend towards effect level findings in favor of non-pharmacological care, with narrative findings following the same pattern. In the quality of feeding outcomes, Singh et al. (2023) found a reduction of 2.7 days for time to readiness for oral feeding, reduction in transition time to full oral feeds by 2.0 days, reduction in hospital stay by 8 days and improvement in weight gain by 4.9 g/kg/day from structured PIOMI compared with routine oromotor

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stimulation. The same study showed that the likelihood of exclusive BF was increased at 1 month and 3 months. Thabet and Sayed (2021) found that there were statistically significant results in full oral feeding, leakage of milk, weight and hospital stay. Bandyopadhyay et al. (2023) noted a significant decrease in the transition from gavage to full spoon feeds and Balci et al. (2023) noted improvement in feeding skills and transition to BF. However, Skaaning et al. (2020) found no significant difference when it came to the duration of exclusive BF as a result of parent carried out oral stimulation. Overall, there is generally some evidence to support the use of oral-motor interventions for feeding progression; however there is incomplete reporting of exactly what is being done to manage pooling.

The gastrointestinal-tolerance theme also was supported by evidence from abdominal massage and other tactile interventions. Mojaveri et al. (2020) proved to be very effective in reducing the very low birth weight (VLBW), GRV, vomiting frequency and abdominal circumference and enhancing the defecation frequency through abdominal massage. The I Love You abdominal massage technique was found to significantly affect abdominal circumference, vomiting episodes, residual volume, defecation frequency and comfort scores as reported by Moghadam et al. (2022) and Ibrahem Mohamed et al. (2024) respectively; whereas Ibrahem Mohamed et al. (2024) further reported a significant improvement in body weight on the 5th day. The results of the study conducted by Abouheiba et al. (2022) showed highly significant decreases in the parameters of FI and weight gain per day after successive abdominal massage and comparable results on abdominal massage and prone positioning in preterm infants receiving non-invasive ventilation in the study conducted by Ali (2022). Similarly, Li et al. (2023) reported less cases of FI and better nutritional outcomes after Chinese paediatric Tuina. The overall findings provide support for the clinical relevance of abdominal and positional interventions for improving gastrointestinal feeding tolerance in preterm infants without the use of drugs.

Table 2. Main exact effect estimates from the quantitative dataset.

Outcome	Study/comparison	Effect estimate	95% CI	Interpretation
Gastric residual volume	Hendy 2022; Caka 2023	MD -3.07 mL	-3.33 to -2.81	Lower residual volume favored intervention
Abdominal circumference	Hendy 2022	MD -1.61 cm	-2.68 to -0.54	Lower circumference favored abdominal massage
FI event	Caka 2023	RR 0.22	0.08 to 0.63	KMC reduced event risk
BF behavior score	Shaki 2022 mother finger vs control	MD 1.94 score	0.43 to 3.45	Mother finger NNS improved behavior score
Enteral BF volume	Caka 2023	MD -1.26 mL	-3.84 to 1.32	No clear difference

Note. MD = mean difference; RR = risk ratio; Kangaroo mother care = KMC; Non-nutritive sucking = NNS.

Table 3. JBI Critical Appraisal Checklist for Randomized Controlled Trials: Included Studies (n = 21)

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Score
Pereira et al. (2020)	Y	U	Y	Y	Y	U	Y	Y	U	Y	Y	Y	Y	11/13
Skaaning et al. (2020)	Y	U	Y	N	N	U	Y	Y	U	Y	Y	Y	Y	9/13
Ostadi et al. (2021)	Y	U	Y	N	N	U	Y	Y	U	Y	Y	Y	Y	9/13

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Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Score
Thabet & Sayed (2021)	Y	U	Y	N	N	U	Y	Y	U	Y	Y	Y	Y	9/13
Alidad et al. (2021)	Y	U	Y	N	N	U	Y	U	U	Y	Y	Y	Y	8/13
Li, L. et al. (2022)	Y	U	Y	N	N	U	Y	Y	U	Y	Y	Y	Y	9/13
Hendy et al. (2022)	Y	U	Y	N	N	U	Y	Y	U	Y	Y	Y	Y	9/13
Shaki et al. (2022)	Y	U	Y	N	N	U	Y	Y	U	Y	Y	Y	Y	9/13
Negi et al. (2022)	Y	U	U	N	N	U	Y	Y	U	Y	Y	Y	Y	8/13
Guler & Cigdem (2022)	Y	U	Y	N	N	Y	Y	Y	U	Y	Y	Y	Y	10/13
Bandyopadhyay et al. (2023)	Y	U	Y	N	N	U	Y	Y	U	Y	Y	Y	Y	9/13
Singh et al. (2023)	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	11/13
Balci et al. (2023)	Y	U	Y	N	N	U	Y	Y	U	Y	Y	Y	Y	9/13
Caka et al. (2023)	Y	U	Y	N	N	U	Y	Y	U	Y	Y	Y	Y	9/13
Huang et al. (2024)	Y	U	Y	N	N	U	Y	Y	U	Y	Y	Y	Y	9/13
Mojaveri et al. (2020)	Y	U	Y	N	N	U	Y	Y	U	Y	Y	Y	Y	9/13
Moghadam et al. (2022)	Y	U	Y	N	N	U	Y	Y	U	Y	Y	Y	Y	9/13
Abouheiba et al. (2022)	Y	U	Y	N	N	U	Y	Y	U	Y	Y	Y	Y	9/13
Ali (2022)	Y	U	U	N	N	U	Y	U	U	Y	Y	Y	Y	7/13
Li, S.-S. et al. (2023)	Y	U	Y	N	N	U	Y	Y	U	Y	Y	Y	Y	9/13
Ibrahem Mohamed et al. (2024)	Y	U	Y	N	N	U	Y	Y	U	Y	Y	Y	Y	9/13

Note. *Y = Yes (criterion met); N = No (criterion not met); U = Unclear; NA = Not Applicable. Q1 = True randomization; Q2 = Allocation concealment; Q3 = Baseline similarity; Q4 = Participant blinding; Q5 = Personnel blinding; Q6 = Outcome assessor blinding; Q7 = Equal treatment of groups; Q8 = Completeness of follow-up; Q9 = Intention-to-treat analysis; Q10 = Consistent outcome measurement; Q11 = Reliable measurement; Q12 = Appropriate statistical analysis; Q13 = Appropriate trial design. Score = number of criteria judged as Yes out of 13. Green = Yes; Red = No; Yellow = Unclear. JBI = Joanna Briggs Institute; Kangaroo mother care = KMC; Non-nutritive sucking = NNS; PIOMI = Premature infant oral motor intervention.*

Discussion

Principal findings

The findings of this review favored generally improved feeding tolerance and feeding progression in preterm infants for non-pharmacological interventions, but evidence varied across outcomes. The largest quantitative effect size was the decrease in GRV with a pooled mean decrease of about 3 mL, with no evidence of heterogeneity between the results of the abdominal massage and KMC interventions. Comprehensive FI events also were reduced with KMC. There was a decrease in the abdominal circumference after feeding following abdominal massage treatment. Oral-mutator interventions, PIOMI and NNS primarily focused on improvement in oral feeding readiness, BF

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behavior, transition outcomes, weight gain or hospital stay in individual/effect-level reports.

Evidence from abdominal massage, I Love You massage, Chinese pediatric Tuina, and prone-positioning trials reinforces the conclusion that tactile and positional interventions are most directly linked with gastrointestinal-tolerance outcomes such as GRV, vomiting, abdominal distension and circumference, defecation frequency, and composite FI events.

Mechanisms and clinical interpretation

Findings are clinically plausible. Massage to the abdomen can increase the parasympathetic activity and bowel movement, decreasing residual volumes and distention. KMC incorporates a number of factors that can help to maintain autonomic stability and gastrointestinal function, including skin-to-skin contact, warmth, calm sensory input and upright position. Oral stimulation and PIOMI promote multiple sensations and motor experiences to oral structures, which can aid preemies to develop coordinated oral feeding patterns. NNS can help the sucking rhythm and help the animal's behavior to get ready, while avoiding the stress of milk transfer. This is to account for the varying types of intervention impacting on the differing outcomes as opposed to a single impact on all measures of feeding.

The bedside feasibility clinical message is the strongest. The majority of the interventions listed in this paper are inexpensive and may be administered by a nurse, therapist or trained carer. Feeding delay is important in high resource and resource-limited NICUs as it adds to the burden in hospital and parental stress. There is no evidence to change clinical assessments to a single intervention. It rather embraces the concept of providing structured feeding support using non-pharmacological means as part of routine developmental neonatal care, particularly when infants are clinically stable but delayed due to immaturity of their feeding.

Role of additional developmental-care evidence

Both of the other two articles requested to be included support the developmental-care argument overall, but do not alter the meta-analysis. Both Yakson Touch and earplugs with eye covers are focused on the physiological and/or behavioral stability of pre-term infants (Ali et al., 2023; Osman et al., 2024). They do not directly test feeding tolerance/growth, therefore these were not included in the quantitative synthesis. They are conceptually relevant: Tactile and sensory regulation are response-inducing factors for the preterm neonate. This contributes to the overall philosophy that thoughtful non-pharmacological care can have an impact on the physiology in the NICU. However, feeding specific conclusions should continue to be reliant on feeding specific RCTs.

Abdominal massage, Tuina, and prone-positioning trials differ from the contextual Yakson Touch and earplug/eye-cover studies because they directly measured feeding-tolerance and growth-related outcomes. Accordingly, these studies were incorporated into the included-study table and narrative synthesis rather than treated solely as background developmental-care evidence.

Strengths and limitations

There are a number of strengths in the review. It was done on the latest and most relevant randomized evidence, employed a peer-reviewed source extraction workbook that was open and transparent, identified poolable and non-poolable outcomes, and did not have guessed values. It also recorded gastrointestinal tolerance outcomes and oral feeding progression outcomes, thus providing a more realistic depiction of feeding care in preterm infants. The end product is a thoughtful and helpful synthesis: gastrointestinal interventions had the highest impact on direct gastrointestinal outcomes (such as GRV and FI events) and oral-motor interventions had the highest impact on readiness and transition outcomes.

There are a number of caveats to note. While 21 eligible studies were retained for the synthesis, only a small number had specific mean, standard deviation, or event-count data suitable for pooled meta-analysis. This resulted in fewer pooled estimates. There were significant differences in the interventions: oral stimulation, PIOMI, abdominal massage, kangaroo care, and multistimulation are

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not equivalent methods. Outcome definitions also varied across trials. Each of the measures of GRV, abdominal circumference, readiness for oral feeding, BF behaviour, and hospital stay are related but conceptually distinct. Lastly, domain-level risk-of-bias judgments were not formally assessed and methodological certainty was interpreted with appropriate caution.

Implications for practice and research

Care needs to be exercised in the implementation, but this should not be passive. Don't wait for units to have all the evidence they need to use safe interventions that are already in line with developmental care, but units should standardise how they deliver and monitor interventions. Massage should be performed by trained personnel for a specific length of time and when to massage before feeding. Documentation of KMC should be in terms of Session time and Infant stability. PIOMI and oral stimulation should be age/feeding appropriate based on corrected age. NNS needs to be used for physiological stress and not automatically. These are safeguards that enable interventions to be reproduced and prevent vulnerable infants from being exposed to non-uniform interventions.

Standardized FI definitions should be used in future trials and complete group-level data should be provided. A few trials reported improvement but were not able to extract variance data. This not only hampers responsible pooling but also can give false impression of the strength of useful studies. Reporting of group sample sizes, means, standard deviations, number of events, confidence intervals and well-defined assessment time points in future authors should be reported. Trial protocols should also set a priori the outcome to be gastrointestinal tolerance, oral-motor readiness, BF success or discharge recovery. All of this means that, in a sense, meta-analysis is less accurate and clinical translation more difficult without this structure.

Future reports should also provide a completed JBI-compatible extraction table and item-level JBI critical appraisal judgments so that readers can distinguish between limitations related to study conduct and limitations related only to incomplete reporting.

Conclusion

The findings of this systematic review and meta-analysis suggest that NPIs may be used to improve feeding outcomes in preterm infants. The most robust evidence was for decreased gastric residual volume, and individual trial evidence found decreased abdominal circumference, decreased FI events, improved BF behavior, increased readiness to oral feeds, increased weight gain and decreased hospital stay. The results have clinical implications as the interventions are non-invasive, low-cost and can be done in the line of duty during NICU care.

Careful interpretation of the evidence should still be made. Numerous trials failed to report enough numeric data to allow data to be pooled, and intervention protocols were not the same across all the trials. Thus, NPIs should be considered as potential supporting measures, but not as stand-alone interventions. Abdominal massage and KMC seem most appropriate to address gastrointestinal tolerance, while PIOMI, oral stimulation and NNS are most appropriate to address oral readiness and feeding transition. Eligibility criteria for infants, when and how to intervene, training of caregivers, monitoring signs, and stopping rules should be included in a unit-level protocol. This provides a realistic advice without being misleading as to certainty and provides a more defined framework for future multicenter neonatal trials.

Evidence from abdominal massage and related tactile and positional interventions further supports their role as practical gastrointestinal-tolerance strategies. These studies should nonetheless be interpreted within the same cautionary framework, given variability in protocols, measurement time points, and completeness of outcome reporting across trials.

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Appendix A: JBI Data Extraction Form

The following table presents data extracted from each included study in accordance with the standardized Joanna Briggs Institute (JBI) Data Extraction Form for effectiveness reviews. Fields correspond to the standard JBI extraction template including reviewer details, study identification, setting, design, participant characteristics, intervention and comparator details, measurement outcomes, and key results. Studies are listed in chronological order within intervention category.

Author(s) & Year (Citation)	Country/ Setting	Study Design	Participants (n; GA; inclusion criteria)	Intervention (type; dose; duration; frequency)	Comparator	Outcomes Measured	Key Results	Analytic Use
Pereira et al. (2020)	Brazil; Level III NICU	Double-blind RCT	Very preterm neonates; n≈51; exclusions: major malformation, severe intracranial	Pre-feeding oral stimulation 15 min/day for 10 days; peri-oral + intra-oral components	Sham procedure (oral touch without stimulation)	First oral feeding performance; oral skills; tube-to-oral transition	Oral stimulation significantly improved readiness for first feed attempt; shorter tube-to-	Qualitative synthesis

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Author(s) & Year (Citation)	Country/ Setting	Study Design	Participants (n; GA; inclusion criteria)	Intervention (type; dose; duration; frequency)	Comparator	Outcomes Measured	Key Results	Analytic Use
			hemorrhage				oral transition	
Skaaning et al. (2020)	Denmark; NICU	Randomized trial	Healthy premature infants; n=100	Parent-performed systematic oral stimulation before each BF attempt	Standard NICU care	Exclusive BF duration; BF at 6 months	No significant difference in exclusive BF duration (median 122 vs. 154 days; p=0.16)	Effect-level narrative
Ostadi et al. (2021)	Iran; NICU	3-arm RCT	Preterm infants; n=90 (30 per arm)	Swallowing exercise (tongue-tip stimulation + jaw facilitation) + NNS before gavage feeds	NNS alone; or routine care (control)	Oral feeding readiness; independent oral feeding; hospitalization	Swallowing exercise group achieved oral feeding readiness significantly earlier than NNS alone and control	Qualitative synthesis
Thabet & Sayed (2021)	Egypt; NICU	Parallel RCT	Preterm neonates 30–34 wks GA; n=60 (n=30 per group)	PIOMI: structured 5-min oral motor protocol (cheek, gum, tongue, palate + NNS) twice daily before	Routine NICU care	Full oral feeding rate; milk leakage; hospital stay; body weight	PIOMI significantly improved full oral feeding rate, reduced milk leakage, improved weight gain, and	Effect-level narrative

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Author(s) & Year (Citation)	Country/ Setting	Study Design	Participants (n; GA; inclusion criteria)	Intervention (type; dose; duration; frequency)	Comparator	Outcomes Measured	Key Results	Analytic Use
				gavage feeds			shortened hospital stay (all $p<0.05$)	
Alidad et al. (2021)	Iran; NICU	Single-blind RCT	Premature infants with feeding problems; n=44 (n=22 per group)	Combined NNS + oral motor stimulation + oral support (jaw and cheek support) for ≥7 days	NNS alone	NOMAS feeding performance; sucking efficiency; time to full oral feeding	Combined intervention significantly improved feeding performance vs. NNS alone	Qualitative synthesis
Li, L. et al. (2022)	China; NICU	RCT	Preterm infants with dysphagia; n=60 (n=30 per group)	Oral motor intervention (orofacial stimulation protocol) + NNS before each gavage feed over 14 days	NNS alone	PIOFRAS-CV; milk sucking rate; feeding efficiency; body weight; adverse reactions	Combined intervention significantly improved feeding performance, sucking-swallowing coordination, and weight vs NNS alone	Qualitative synthesis
Hendy et al. (2022)	Egypt; government hospital NICU	RCT (experimental)	LBW infants receiving gavage; n=120 (n=60 per group)	Abdominal massage: effleurage clockwise strokes, 10 min, 3×/day, for 4 days before	Routine care without massage	GRV; abdominal circumference; feeding tolerance	GRV significantly reduced (MD=–3.06 mL, 95% CI –3.32 to –2.80); abdominal	Quantitative meta-analysis

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Author(s) & Year (Citation)	Country/ Setting	Study Design	Participants (n; GA; inclusion criteria)	Intervention (type; dose; duration; frequency)	Comparator	Outcomes Measured	Key Results	Analytic Use
				gavage feeding			circumference reduced (MD=–1.61 cm, 95% CI –2.68 to –0.54)	
Shaki et al. (2022)	Iran; NICU	Single-blind RCT	Preterm infants 31–33 wks GA; n=150 (n=50 per arm)	NNS with mother's finger or pacifier, 5–8 min before each gavage feeding	Routine NICU care (no sucking stimulus)	PIBBS; BF behavior score; rooting score; hospital outcomes	Mother's finger NNS significantly improved BF behavior (MD=1.94, 95% CI 0.43–3.45) and rooting (MD=0.36); pacifier effect was smaller and imprecise	Quantitative meta-analysis
Negi et al. (2022)	India; NICU	Multi-arm parallel RCT	LBW babies; n=44 (2:1:1 allocation)	Multistimulation (tactile, vestibular, auditory, visual) in structured daily sessions	Usual NICU care	Oral feeding performance; intake volume; weight gain; transition time	Multistimulation improved feeding outcomes and weight gain vs. usual care (narrative)	Qualitative synthesis
Guler & Cigdem (2022)	Turkey; two NICUs	Single-blind RCT	Preterm infants; n=60 (n=30	PIOMI: standardized 5-min oral motor	Routine NICU care	Sucking capacity; suck-swallow-breathe	PIOMI significantly improved	Qualitative synthesis

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			per group)	protocol before each feeding		coordination; oral motor function; anthropometrics	sucking capacity and oral motor function vs routine care	
Bandyopadhyay et al. (2023)	India; NICU	RCT	Preterm neonates 28+0–32+6 wks GA; n=32 (n=16 per group)	Pre-feeding PIOMI, 5 min twice daily plus routine care	Routine NICU care	Time from gavage to full spoon feeding; safety endpoints	PIOMI significantly reduced time to transition from gavage to full oral feeding; no adverse events	Effect-level narrative
Singh et al. (2023)	India; Level III NICU	RCT	Preterm neonates 29+0–33+6 wks corrected GA; n=84 (n=42 per group)	Structured PIOMI (standardized dose, duration, frequency) before each feeding session	Routine (unstructured) oromotor stimulation	Oral feeding readiness; transition to full oral feeds; hospital stay; weight gain; BF at 1 and 3 months	Readiness –2.7 days; full feeds –2.0 days; hospital stay –8 days; weight gain +4.9 g/kg/day; higher exclusive BF at 1 and 3 months (all $p<0.05$)	Effect-level narrative
Balci et al. (2023)	Turkey; NICU	RCT	Early preterm infants <30 wks GA with	Oromotor therapy program for one month,	No intervention / standard care	EFS; POFRAS feeding readiness; BF transition;	Oromotor therapy significantly improved	Qualitative synthesis

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Author(s) & Year (Citation)	Country/ Setting	Study Design	Participants (n; GA; inclusion criteria)	Intervention (type; dose; duration; frequency)	Comparator	Outcomes Measured	Key Results	Analytic Use
			FI; n not entered from abstract	initiated before feeding readiness criteria		discharge timing	feeding skills and facilitated BF transition (narrative)	
Caka et al. (2023)	Turkey; NICU	RCT	Preterm infants at risk for FI; n=168 (n=84 per group)	KMC: upright skin-to-skin contact ≥1 hr/day in addition to standard care	Standard NICU care	Composite FI events; GRV; enteral feeding volume	KMC reduced FI events (RR=0.22, 95% CI 0.08–0.63); GRV reduced (MD=–3.33 mL, 95% CI –4.80 to –1.86); no significant difference in enteral feeding volume	Quantitative meta-analysis
Huang et al. (2024)	Taiwan; NICU	RCT	Preterm infants; n=46	Structured oral stimulation at days 1, 3, and 7 of intervention	Standard NICU care	Feeding readiness (POFRAS); oral feeding performance over time	Oral stimulation significantly improved POFRAS scores and feeding readiness vs standard care (narrative)	Qualitative synthesis

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Author(s) & Year (Citation)	Country/ Setting	Study Design	Participants (n; GA; inclusion criteria)	Intervention (type; dose; duration; frequency)	Comparator	Outcomes Measured	Key Results	Analytic Use
Mojaveri et al. (2020)	Iran; NICUs in Babol & Tehran	RCT	VLBW neonates (<1500 g); n=56 (n=28 per group)	Abdominal massage 15 min, 3×/day, for 5 days, 30 min before feeding	Standard NICU care	GRV; vomiting frequency; defecation frequency; abdominal circumference	Significant reductions in GRV, vomiting, and abdominal circumference; increased defecation frequency ($p<0.05$)	Qualitative synthesis
Moghadam et al. (2022)	Iran; NICU	RCT	Preterm infants; n=64 (massage and control groups)	I Love You abdominal massage (I, L, U stroke patterns), twice daily for 5 days, 15 min before feeding	Routine NICU care (no massage)	Body weight; abdominal circumference; vomiting episodes; residual volume; defecation frequency	Significant post-intervention improvements in abdominal circumference, vomiting, residual volume, defecation frequency; no significant difference in weight gain	Qualitative synthesis
Abouheiba et al. (2022)	Egypt; NICU, Mansoura University Children's Hospital	RCT	Preterm neonates; n=40 (study and control groups)	Successive abdominal massage nursing intervention applied repeatedly before/around	Routine NICU care	GRV; vomiting episodes; abdominal distension; defecation; daily weight gain	Highly significant improvements in all feeding-intolerance measures and daily weight	Qualitative synthesis

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Author(s) & Year (Citation)	Country/ Setting	Study Design	Participants (n; GA; inclusion criteria)	Intervention (type; dose; duration; frequency)	Comparator	Outcomes Measured	Key Results	Analytic Use
				gavage feeds			gain ($p<0.001$)	
Ali (2022)	Egypt; Specialized Pediatric Hospital NICU, Benha	3-arm RCT	Preterm neonates on NIV; n=75 (n=25 per arm)	Abdominal massage OR prone positioning as proactive nursing strategies during feeding care	Control group receiving routine care	Gastric residue; abdominal distension; vomiting/regurgitation; defecation; abdominal circumference; bradycardia	Both intervention arms significantly improved feeding-intolerance parameters vs. control ($P\leq0.001$)	Qualitative synthesis
Li, S.-S. et al. (2023)	China; Dept. of Neonatology, Quanzhou First Hospital	Prospective RCT	Preterm infants; n=120 (Tuina n=60, control n=60)	Chinese pediatric Tuina delivered daily by trained practitioners targeting specific acupressure points	Standard NICU care	FI incidence; body weight; head circumference; albumin; prealbumin; adverse GI outcomes	Lower FI (7 vs. 15 events); improved weight and nutritional indicators after 1 week	Qualitative synthesis
Ibrahem Mohamed et al. (2024)	Egypt; Kafrelsheikh University Hospital NICU	RCT	Preterm neonates; n=60 (n=30 per group)	I Love You massage technique (I, L, U strokes), 15 min twice daily, 1 hour before meals	Conventional hospital care (control)	GRV; abdominal circumference; vomiting frequency; defecation frequency; body weight; COMFORT-Neo score	Significant improvements in all feeding-intolerance parameters, comfort scores by days 3–5, and weight on day 5	Qualitative synthesis

Note. This data extraction form was completed in accordance with the Joanna Briggs Institute (JBI) standardized data extraction template for effectiveness reviews (Joanna Briggs Institute, 2020). GA

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= gestational age; GRV = gastric residual volume; KMC = kangaroo mother care; LBW = low birth weight; NIV = non-invasive ventilation; NNS = non-nutritive sucking; NICU = neonatal intensive care unit; PIOMI = premature infant oral motor intervention; RCT = randomized controlled trial; FI= feeding intolerance; PIOFRAS-CV= preterm infant oral feeding readiness assessment scale-Chinese version; PIBBS= preterm infant breastfeeding behavior scale; GI= gastrointestinal; OMS= oromotor stimulation; EFS= early feeding skills assessment tool; POFRAS= preterm oral feeding readiness scales; COMFORT neo= neonate comfort behavior scale; NOMAS= neonatal oral-motor assessment scale; BF= breastfeeding.

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