

Sucking Behavior Differences Between Directly Breast-fed and Bottle-fed Infants: A Rapid Review

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Abstract

Breastfeeding is an important activity that has a long-term influence on neonatal growth and development. Different coordination of sucking behavior can occur between directly breastfed and bottle-fed. The anatomy between the nipple and the bottle nipple affects sucking behavior. This study was conducted to determine the differences in sucking behavior in infants who directly breastfed and bottle-fed.

A Rapid Review was conducted in this research using PRISMA with keywords and conjunctions "AND" according to the Boolean operator method from 4 databases (PubMed, Science direct, springer, and nature) that match the inclusion and exclusions criteria.

After reviewing 597 articles, four articles were included. The study contained four articles that compared sucking behavior among infants who directly breastfed and bottle-fed. The sucking behavior shows a greater result in infants who directly breastfed. Various types of teats may influence the study's results.

Sucking behavior between breast-fed and bottle-fed infants shows insignificant differences in the mouth's angles and jaw movement. The sucking quantity, duration of the pause between sucks, and sucking pressure show varying results in each article. The results of significant and insignificant differences are presented in several articles.

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Introduction

Breastfeeding is an essential neonatal nutrition fulfilment activity with a long-term influence on neonatal growth and development. This activity affects the child's sensory processes, motor functions, and nutritional intake, which can encourage brain growth and development.¹ According to a report published by the Ministry of Health of the Republic of Indonesia in 2020, the percentage of babies who have been exclusively breastfed for less than 6 months is 66,1%, above the target of 40% set for 2020. Following the World Health Organization (WHO), exclusively breastfeeding occurs when infants are fed exclusively with breast milk from birth to 6

months, with no additional foods or fluids other than vitamins, medicines, or minerals.²

WHO, United Nations Children's Emergency Fund (UNICEF), and the American Academy of Paediatrics (AAP) recommend exclusive breastfeeding in infants aged 0-6 months. Breast milk has benefits for children's systemic health. Breast-fed also promotes balanced craniofacial growth.³⁻⁶ In 2018, WHO revealed that only 41% of infants were exclusively breast-fed, below the global target of 70% by 2030.⁷ This can occur as a consequence of early breast-fed cessation for several reasons, including infants with medical conditions such as metabolic disorders, working mothers, and mothers with medical issues.^{5,8,9,10}

Bottle feeding is a solution to substitute direct breastfeeding, but bottle feeding can provide different functional stimuli, thereby endangering the oral motor development, position, and strength of the stomatognathic structure.¹¹ Peres et al.¹² suggest that a long duration of bottle-fed may contribute to inadequate mandibular development. WHO

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stated that 57% of infants worldwide in 2018 were given formula milk using a bottle in the 1st hour of birth. The findings of the Republic of Indonesia's Basic Health Research (*Riset Kesehatan Dasar/Riskesdsas*) revealed a 7,3% rise in the provision of formula milk to infants aged 0-6 months, from 55,4% in 2013 to 62,7% in 2018.¹³

Due to the difference between the nipple and the artificial teats, different coordination develops in sucking behavior in directly breast-fed with bottle-fed.^{3,8} These differences occur in the base's shape, the shaft's compressibility, and the milk's flow rate make it difficult for infants who are used to bottle feeding to suck effectively at the breast.^{8,9} This causes differences in the angle of the mouth, jaw movement, sucking quantity, duration of pause between sucks, and sucking pressure from directly breast-fed to bottle-fed.^{8,9,14,15} When compared to bottle-fed, directly breast-fed normally involves wider mandibular movements, a higher frequency of sucking, and more rhythmic sucking movements.¹⁶ Aizawa et al.⁸ state that the infant's mouth opens wider to grasp the mother's areola during direct breastfeeding than when feeding with a bottle. According to Moral et al.¹⁴, the sucking and pausing movements, as well as the duration of the pause, were shorter during bottle-fed than during direct breastfed, and Segami et al.⁹ explained that there is a difference between the structure of the nipple and the bottle's artificial teats that affects the tongue movements during sucking.

Based on the explanation, it encourages the author to conduct a literature review in the form of a *rapid review*. This study aims to determine the differences of sucking behavior in directly breast-fed and bottle-fed infants. This study was conducted with the hopes of providing public knowledge about these differences, especially in the dental science field, and also serves as a reference for future study.

Materials and methods

A rapid review, a variation of a systematic review with simplified methods and an accelerated process, was used to perform the study. Simplification was done by analysing the literature with a single reviewer, using at least 2 or more databases, by limiting the year of publication, language, and study design.¹⁷ The

research procedure establishes research characteristics, inclusion and exclusion criteria, and PRISMA (*Preferred reporting items for systematic review and meta-analyses*) analysis as comprehensive and detailed steps to increase transparency in conducting a literature review.¹⁷

The Boolean operator was used for data search, which is a search strategy using keywords with "AND" and/or "OR". In this study, only the conjunction "AND" was applied. The stages of screening and study selection were carried out by searching for scientific articles using a combination of keyword in the PubMed, Science Direct, Springer, and Nature databases, namely, "Breastfeeding" AND "Bottle feeding" AND "Sucking behavior" and "Breastfeeding" AND "Bottle feeding" AND "Sucking behavior" AND "Nutritive sucking". The article included in this study is an article that discussed sucking behavior in infants aged 1 to 8 months who directly breast-fed and bottle-fed, published in 2007-2022, full-text, in English, and has a study design in the form of systematic reviews, cross-sectional, cohort, and randomized control trials. Articles with samples of special needs children and study design in the form of narrative reviews, case reports, and case series were excluded from this study. Qualitative analysis was used to analysed the data. Subjectivity assessment in each article uses the *Joanna Briggs Institute (JBI) critical appraisal*. The study was conducted from January to February 2022. The PRISMA flow diagram can be seen in Figure 1.

Results

The results of the study selection with PRISMA analysis obtained as many as 4 articles that will be studied. All 4 articles have the same design study which is cross-sectional. The study contained 4 articles^{9,14,18,19} that compared sucking behavior among infants who suckle breast milk directly over bottle-fed. The sucking behavior shows a greater result in directly breast-fed infants. The differences that occur are not all significantly different. The total number of infants participated in this study was 457. Participants in the 4 articles^{9,14,18,19} had to meet inclusion criteria, including being born at the appropriate age and having no congenital disease or other abnormal conditions that interfered with sucking, such as cleft palate or ankyloglossia. The weight of the infants studied was set at ≥2500 grams in the 3

articles reviewed.²⁰⁻²² According to 1 article⁹, mothers of participating infants must be between the ages of 28 to 37 years. The research in the articles was conducted in several nations, especially Japan^{9,18}, Spain¹⁴, and Western Australia¹⁹. Table 2 below presents the results of data extraction from the 4 articles.

Subjectivity Risk Assessment

The JBI was used to assess bias risk in 4 articles^{9,14,18,19} with a cross-sectional design study. The assessment was completed by answering 8 questions with 4 assessment criteria: yes, no, unclear, and not applicable. The bias determination criteria are as follows: 1-3 yes for *high bias*, 4-6 yes for *moderate bias*, and 7-8 yes for *low bias*. The assessment findings show that all articles^{9,14,18,19} that all articles have a low bias value. Table 1 below present the results of subjectivity risk assessment from the 4 articles.

Discussion

Feeding is a complex process to provide nutrition for neonates that involve efficient coordination between the ability to suck, swallow, and breath.¹⁴ Unlike bottle teat, the breast nipple may transform to fit the shape, size, and positioning of the infant's mouth.²³ The results showed a non-significant difference in the angle of the mouth and jaw movement.⁹ Sucking behavior, as measured by the sucking quantity, the duration of the pause between sucks, and the sucking pressure had carrying results in each article, with some articles showing significant and insignificant results.^{9,14,18,19}

In all 3 article studies, the sucking quantity in directly breast-fed is higher than bottle-fed.^{9,14,18} Segami et al⁹ compared the sucking behavior of infants who suckled breast milk directly against bottle feeding with a modified experimental teat. This modified teat provides a wider base to prevent teat release and support a more open attachment, as well as a valve on the base to ensure the milk flow occurs only when the infant is under negative pressure. Modification to this experimental teat led to insignificant differences in the result of the sucking quantity. The same results were also found in the Moral et al¹⁴ study, however, the infants participated in this study were already accustomed to both feeding techniques so that the difference was not clearly visible. In contrast to Taki et al¹⁸ study, which found a significant difference in results in infants

aged 1 and 3 months but not in infants aged 6 months. The difference in sucking quantity could be mainly due to non-nutritive sucking during milk ejection reflect (MER) or also called let down reflex. Directly breast-fed infants will not get milk if there is no MER.¹⁸ The different types of bottle teats used, cause differences in the results achieved in each article. From 4 articles, a total of 2 articles^{9,19} use modified experimental teats and the other two; Taki et al¹⁸ use Pigeon brand teats, whereas Moral et al¹⁴ use NUK teats. The conventional teats Taki et al¹⁸ employed in the study resulted in a significant difference in the sucking quantity. Use of conventional teats will result in poor coordination of sucking, swallowing, and breathing.⁹ Age, hunger, infant's mouth position on the breast, sucking time and pressure, fatigue and satiation, and milk flow all have an influence on the infant's rhythm of sucking and pauses during breastfeeding.¹⁴

Segami et al's⁹ study presented that the use of modified experimental bottle teats resulted in insignificant differences in mouth angle compared to direct breast milk. In contrast to the results of Aizawa et al's⁸ study comparing the angle of the mouth between directly breast-fed and conventional bottle-fed infants revealed a significantly different outcomes. This demonstrates how the breast nipple's size and form can already be seen in the components of the modified experimental bottle teats. The angle formed by the mouth when feeding can affect the movement of the jaw and throat. The large angle of the mouth induce minor jaw and throat movements. In order to achieve a greater mouth angle closer to the angle when directly breast-fed, the bottle nipple must have a shape and material that are close to the breast.⁸

According to Segami et al's⁹ study using the modified experimental bottle teats in directly breast-fed infants resulted in much larger jaw movement. Jaw movement has a direct relationship with the angled formed by the mouth as in Segami et al⁹ study. According to Aizawa et al⁸, the significant angle of the mouth during direct breast-fed contributes to the minor jaw movement since the jaw movement is limited. The oral muscles, mastication muscles, and extrinsic tongue muscles all play a part in the perioral movement.²⁴ Gomes et al²⁵ state that the sucking movements performed in directly breast-fed infants is different compared with bottle-fed infants. This difference causes significant

changes in the muscles involved. The masseter muscle's function and activity is reduced in bottle-fed infants, resulting in changes to the stomatognathic system, swallowing, breathing, and chewing.

The difference in sucking pressure in directly breast-fed and bottle-fed was significant in the 2 articles^{9,19}, while the other article¹⁸ was not significant with results showing that directly breast-fed puts more pressure than bottle-fed does. There is a physiological disparity between directly breast-fed and bottle-fed because the ejection of breast milk from the breast is a combination of negative pressure provided by the infant and positive pressure of milk ejection.¹⁹ Segami *et al*'s⁹ research using a modified experimental teat revealed that there was a hold pressure during bottle-fed, which is typically only present during directly breast-fed, although the findings achieved are still significantly lower than directly breast-fed infants. Hold pressure is an activity in which the infant retains negative pressure in his mouth to prevent the intraoral pressure from returning to air pressure. There was no hold pressure found in bottle-fed using a conventional teat because the teat shape prevented a strong attachment. Taki *et al*¹⁸ studied infants at 3 different ages-1, 3, and 6 months, so that we could examine the variations in growth and development in this article. Increasing the amount of milk consumed by infants at 1,3, and 6 months did not result in a substantial increase in sucking pressure at each feeding. Geddes *et al*¹⁹ stated that sucking pressure was significantly greater in infants who were directly breast-fed than bottle-fed. Baseline vacuum also referred to as maximum pressure, is required to elongate the nipple until it is positioned optimally for milk ejection and the mother's comfort. Baseline vacuum performed by bottle-fed infants with experimental teat showed significant differenced due to breast nipple being more flexible than bottle teat, allowing them to extend 7-8 mm beyond the confluence of hard and soft palate.

The duration of the pause between suck demonstrates how the outcomes in the 2 articles differ.^{14,18} In both articles, directly breast-fed resulted in longer pause duration than bottle-fed. This is as a result of the different types of bottle teat used. A coordination movement is required because the infant takes pauses in between sucks, which are helpful for the swallowing

process. In order to ensure that the infant can continue suckle without interruption, the central nervous system will determine the right moment to swallow and breath.²³ Goldfield *et al*'s²³ study on sucking patterns and breathing in infants who were directly breast-fed and bottle-fed showed significant differences. Oxygen saturation was significantly higher in directly breast-fed infants compared with bottle-fed infants. The general breastfeeding mechanism has a role in this distinction. When an infant is directly breast-fed, tongue movements in the form of peristalsis make swallowing a repetitive action, however, when an infant is fed through a bottle, tongue movements such as pistons make it harder to identify chances to swallow. According to Sakalidis *et al*²⁶, bottle-fed can interfere with coordination between sucking, swallowing, and breathing due to the rapid flow of the milk. The milk flow, teat hole size, and compressibility of each type of bottle vary according to its use, which affects the coordination of sucking, swallowing, and breathing. Geddes *et al*²⁷ stated that excessive milk flow from conventional teat may lead to decrease oxygen saturation, changes in respiratory rate, and bradycardia in infants.

The angle of the mouth, jaw movement, sucking quantity, duration of the pause between sucks, and suck pressure differ between directly breast-fed and bottle-fed infants. The differences that occur are not all significantly different. Improvements in the bottle teat and technological advancements have minimized these differences since they have a shape and material that is near to the nipple of the breast. The difference in the techniques of feeding milk to the infant, according to Lopes *et al*³, may contribute to parafunctional behaviors such as non-nutritive sucking but are not directly related to the occurrence of malocclusion. Corkins *et al*²⁸ declared that adequate nutrition plays an important role in optimal brain development. Babies obtain their nutrition from their mothers, hence it is essential for the mother to consume nutritious food to ensure that the baby receives all the nutrients they need.

This study's limitations include the limited number of articles that passed screening with the lack of research type variation, the wide range of bottle teat types used in each article, and the small number of samples participating.

Conclusions

The findings of all cross-sectional articles showed differences in sucking behavior between directly breast-fed and bottle-fed infants. The angles of the mouth and the movement of the jaws reflect insignificant differences. The sucking quantity, duration of the pause between sucks, and suction pressure show varying results in each article. The results of significant and insignificant differences are presented in several articles.

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Declaration of Interest

The authors report no conflict of interest.

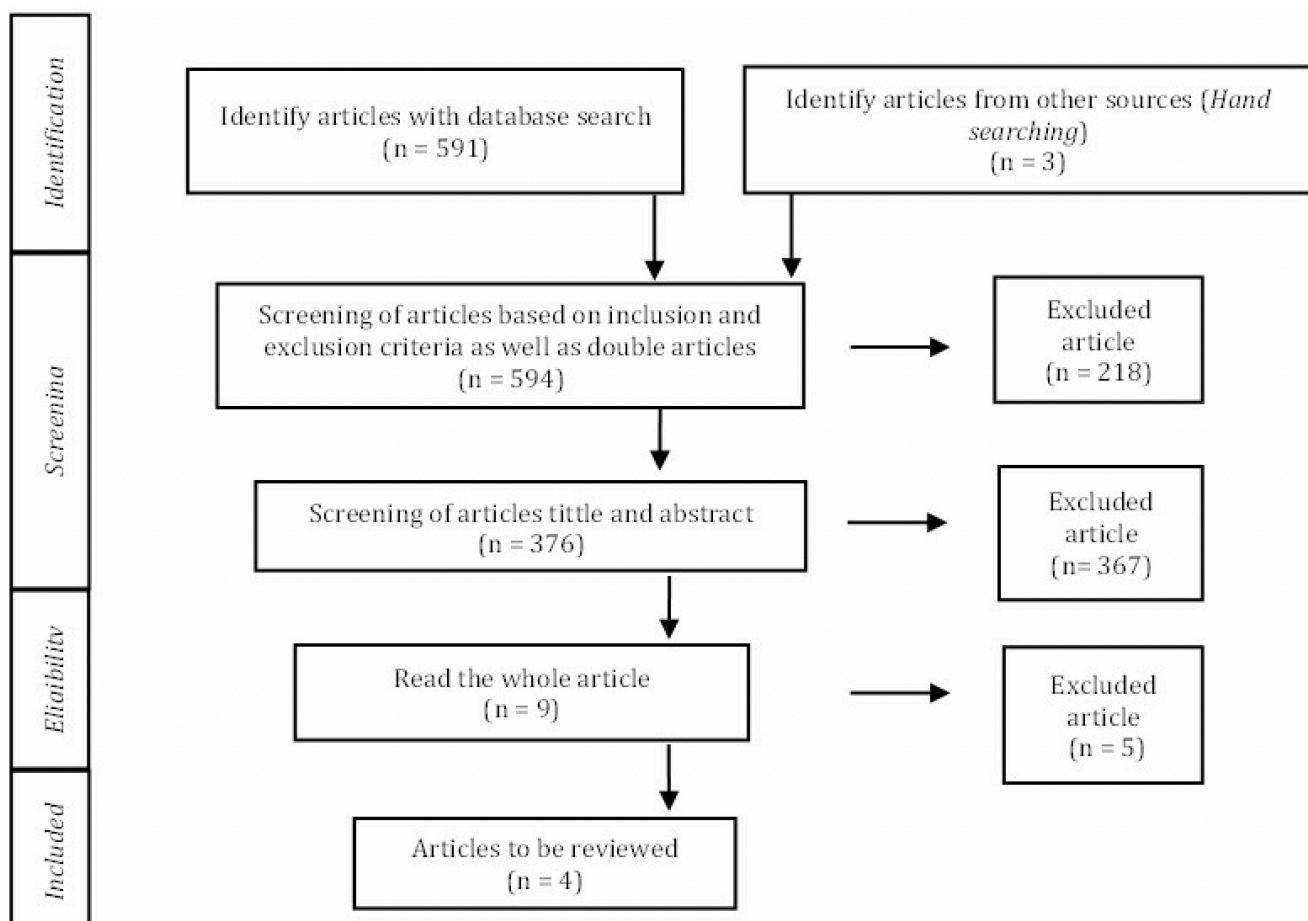


Figure 1. PRISMA Flow.

Author, Year of Publication	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Risk
Moral et al, 2010	v	v	v	v	v	v	v	v	Low
Taki et al, 2010	v	v	v	v	v	v	v	v	Low
Segami et al, 2013	v	v	v	v	v	v	v	v	Low
Geddes et al, 2012	v	v	v	v	v	v	v	v	Low

Table 1. Subjectivity Risk Assessment.

Title (Author, Year of Publication)	Study Design	Sample	Sucking Behavior		Results	Conclusions
<i>Mechanics of sucking: comparison between bottle feeding and breastfeeding (Moral et al, 2010)</i>	Cross-Sectional	Total sample: 395 infants consisting of infants aged 21-28 days who were exclusively breast-fed, infants aged 21-28 days who were exclusively bottle-fed, and infants aged 3-5 months who were mixed feeding.	1. Sucking quantity per minute. 2. Pause duration per minute.	per	Age 3-5 months mixed feeding Sucking quantity per minute Breast-fed: $\pm 42,9$ sucks/minute Bottle-fed: $\pm 42,6$ sucks/minute NOT SIGNIFICANT Pause duration per minute Breast-fed: $\pm 23,2$ second/minute Bottle-fed: $\pm 19,7$ second/minute NOT SIGNIFICANT	1. There are no significant differences in sucking behavior between directly breast-fed and bottle-fed infants. 2. Sucking quantity and pause duration in bottle-fed infants is less than in directly breast-fed infants.
<i>Maturational changes in the feeding behavior of infants - a comparison between breast-feeding and bottle-feeding (Taki et al, 2010)</i>	Cross-sectional	Total sample: 24 infants aged 1,3, and 6 months consisting of 16 directly breast-fed infants and 8 bottle-fed infants.	1. Sucking quantity burst. 2. Sucking quantity. 3. Pause duration feed. 4. Sucking pressure.	per	Sucking quantity per burst 1 month Breast-fed: $17,8 \pm 8,8$ times Bottle-fed: $37,7 \pm 12,2$ times SIGNIFICANT 3 months Breast-fed: $23,8 \pm 8,3$ times Bottle-fed: $43,3 \pm 7,4$ times SIGNIFICANT 6 months Breast-fed: $32,4 \pm 15,3$ times Bottle-fed: $82,3 \pm 22,0$ times SIGNIFICANT Sucking quantity per feed 1 month Breastf-fed: 585 ± 288 times Bottle-fed: 290 ± 111 times SIGNIFICANT	1. Total sucking quantity and sucking pressure per feed did not differ among ages. 2. The increase in the amount of ingested milk with maturation resulted from an increase in bolus volume per suck as well as more continuous suck for both breast- and bottle-fed infants.

<i>Perioral movements and sucking pattern during bottle feeding with a novel, experimental teat are similar to breastfeeding (Segami et al, 2013)</i>	<i>Cross-sectional</i>	Total sample: 20 infants aged 1-8 months consisting of 11 males and 9 females.	<ol style="list-style-type: none"> 1. Jaw movements). 2. Angle of the mouth. 3. Sucking quantity per burst. 4. Peak pressure. 5. Hold pressure. 	Breast-fed: -155 ± 76 mmHg Bottle-fed: -126 ± 24 mmHg NOT SIGNIFICANT	3 months Breast-fed: -122 ± 50 mmHg Bottle-fed: -137 ± 10 mmHg NOT SIGNIFICANT	6 months Breast-fed: -131 ± 60 mmHg Bottle-fed: -143 ± 15 mmHg NOT SIGNIFICANT	1. There were no significant differences in perioral movements and feeding behavior between breast-fed and bottle-fed infants.	
				Jaw movement (mean) Breast-fed: 2,6 cm Bottle-fed: 2,5 cm NOT SIGNIFICANT	Sucking quantity (mean) Breast-fed: 20,3 times. Bottle-fed 18,8 times NOT SIGNIFICANT	Angle of the mouth (mean) Breast-fed: 145,5° Bottle-fed: 140,6° NOT SIGNIFICANT		
				Peak pressure (Mean) Breast-fed: -141,2 mmHg Bottle-fed: -111,5 mmHg SIGNIFICANT	Hold pressure (mean) Breast-fed: -43,4 mmHg	Bottle-fed: -24,2 mmHg SIGNIFICANT		
				Minimum intraoral pressure Breast-fed: -122 mmHg Bottle-fed: -67 mmHg SIGNIFICANT	Maximum intraoral pressure Breast-fed: -31 mmHg Bottle-fed: -12 mmHg SIGNIFICANT			
				1. Minimum intraoral pressure. 2. Maximum intraoral pressure.				
	<i>Cross-sectional</i>	Total sample: 18 infants consist of 10 males and 8 females aged 49,4- 56 days.		1. Minimum intraoral pressure. 2. Maximum intraoral pressure.	Minimum intraoral pressure Breast-fed: -122 mmHg Bottle-fed: -67 mmHg SIGNIFICANT	1. Sucking pressure and tongue movement in directly breast-fed and bottle-fed infants are the same.		
					Maximum intraoral pressure Breast-fed: -31 mmHg Bottle-fed: -12 mmHg SIGNIFICANT			

Table 2. Data Extraction.

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