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Original Article

Non-nutritive sucking milestones of preterm infants in Indonesia: a descriptive study

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Abstract

Background Non-nutritive sucking (NNS) maturity has been used as one of the markers of oral feeding readiness in infants. Prematurity may hinder the attainment of NNS milestones. Depending on gestational age (GA) at birth, preterm infants may display various degrees of immaturity, potentially affecting the strength, coordination, and efficiency of skills required for NNS.

Objective To identify the progression of NNS patterns across gestational age groups of preterm infants in Indonesia by comparing NNS parameters between moderate-to-late preterm and very preterm infants.

Methods NNS evaluation was conducted in 120 preterm infants born at 28-34 weeks gestational age in five tertiary hospitals in Jakarta, Indonesia. Three aspects of NNS (suction pressure, number of suctions per burst, and time between bursts) were documented and arranged to present a descriptive overview. A suction pressure measurement device was used to record, identify, and analyze NNS parameters. We hypothesize that maturity, as determined by GA, positively affected the attainment of NNS milestones.

Results Moderate-to-late preterm infants (GA 32 to <37 weeks), compared to very preterm infants (GA 28 to <32 weeks), had higher mean NNS pressure (-79.8 *vs.* -72.7 mmHg, respectively, P=0.041) and shorter mean time between bursts (6.63 *vs.* 7.36 s, respectively, P=0.030). Mean number of suctions per burst were also significantly different between the two GA groups (8.90 *vs.* 8.99 sucks/burst, respectively, P=0.048).

Conclusion Maturity, as reflected by GA, had a positive effect on the attainment of NNS milestones in preterm infants in Indonesia. Significant differences in the three NNS parameters: number of suctions per burst, time between bursts, and suction pressure were found between moderate-to-late preterm and very preterm infants. **[Paediatr Indones. 2022;62:311-7; DOI: https://doi.org/10.14238/pi62.4.2022.311-7]**.

Keywords: preterm infants; gestational age; non-nutritive sucking milestone

Two forms of sucking in infants are distinguished into nutritive sucking (NS) and non-nutritive sucking (NNS).[1] Nutritive sucking is an infant's primary means to receive nutrition, while NNS is sucking in the absence of nutritional flow, with the aim of self-regulation, fulfilling the natural desire of sucking, and exploration.[2] NNS has been observed to begin as early as 15 weeks after conception during intrauterine life and become stable and well-patterned by 34 weeks gestational age.[3,4] Non-nutritive sucking consists of burst-pause patterns, in which there is a consistent pattern of NNS followed by a rest, and then a return to the pattern.[5] The maturity of NNS has been used as one of the markers of oral feeding readiness in infants.[2,6] All healthy, full-term infants can perform a stable burst-pause NNS pattern.[7,8] Degree of prematurity at birth may hinder the attainment of NNS milestones in the preterm

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population.[9] Depending on their gestational age (GA) at birth, preterm infants may display various degrees of immaturity of their nervous, anatomical, and physiological control systems, potentially affecting the strength, coordination, and efficiency of the skills required for NNS.[9-12] Assisted oral feeding is required for most preterm infants until they are able to achieve full oral feeding ability. Preterm infants must achieve early feeding milestones described by three aspects of NNS (suction pressure, number of suctions per burst, and time between bursts). Establishing consistent and well-patterned NNS is critical, because NNS is a precursor to oral feeding development.[13]

Standardized methods to measure NNS have not been established. A commonly used approach to assess NNS is to place one's little finger into the infant's mouth halfway covering the tongue.[1] However, this approach provides only a subjective and descriptive evaluation, is highly dependent upon the clinician's experience and tactile sensitivity, as well as how long the infant sucks on the finger.[14] This study used a suction pressure measurement device to objectively quantify NNS parameters in preterm infants (number of suctions per burst, time between bursts, and suction pressure).[15]

Previous studies have been done to quantify NNS in preterm infants.[5,7,16,17] However, to date, NNS milestones of preterm infants in Indonesia have not been documented. Such information is critical, as it can aid health care professionals working with this population to get a better understanding of NNS, since NNS is one of the markers of oral feeding readiness in infants.[13] Hence, we aimed to identify the progression of NNS patterns across gestational age (GA) groups of preterm infants in Indonesia by comparing NNS parameters between moderate-to-late preterm and very preterm infants. We hypothesized that maturity (determined by gestational age) would have a positive effect on the attainment of NNS milestones.

Methods

This descriptive, cross-sectional study was performed from August to November 2021 in five tertiary hospitals in Jakarta, Indonesia. A consecutive sample of 120 preterm infants born between 28-34 weeks of gestation were included. Exclusion criteria were craniomaxillofacial malformation, neonatal asphyxia with an initial Apgar score of <7, grade 3 and 4 intraventricular hemorrhage (IVH), and the use of an endotracheal tube at the time of assessment. NNS measurement was performed by general practitioners who had been trained to use a suction pressure measurement device in preterm infants. Written informed consent was obtained from the infants' mothers prior to examination. This study was approved by the Health Research Ethics Committee of the Universitas Indonesia Medical School.

The suction pressure measurement device was assembled (**Figure 1**) and evaluations were performed according to the method described by Wahyuni *et al.*[15] Measurement was carried out for 1 minute with the infant in a quiet-alert state and performed 30 minutes before the infant's feeding schedule. Subjects were classified by GA based on the *World Health Organization* (WHO) sub-category of prematurity.[18] According to the guideline, our subjects could be classified into two of the three sub-categories, namely very preterm (28 to <32 weeks GA) and moderate-to-late preterm infants (32 to <37 weeks GA). Since the highest GA in our inclusion criteria was 34 weeks, the cut-off GA for moderate-to-late preterm infants in our study was 34 weeks. Birth weight (BW) was categorized as follows: extremely low birth weight (ELBW) when BW was <1,000g, very low birth weight (VLBW) when BW was <1,000-1,499g, and low birth weight (LBW) when BW was 1,500 to <2,500g.[19]

Collected data were analyzed using *Microsoft Excel software* (*Microsoft Inc.*, Redmond, Washington). The NNS parameters examined were: (1) number of suctions per burst, (2) time between bursts, and (3) suction pressure. A burst was defined as the period of sucking between pauses, with one burst consisting of several suctions. Time between bursts is the sucking rest period (**Figure 2**). Suction pressure was the strength and compression of the tongue against the palate as well as the ability to form intra-oral pressure.[20] The NNS ability was interpreted as adequate if the infant was able to perform a strong and rhythmic NNS characterized by an average of 5-10 suctions/burst, an average time between bursts of 4-9 seconds, and an average suction pressure of -16.7 to -87mmHg.[2,21,22] **Figure 2** illustrates a graph of suction pressure measurement results. In the first burst, 19

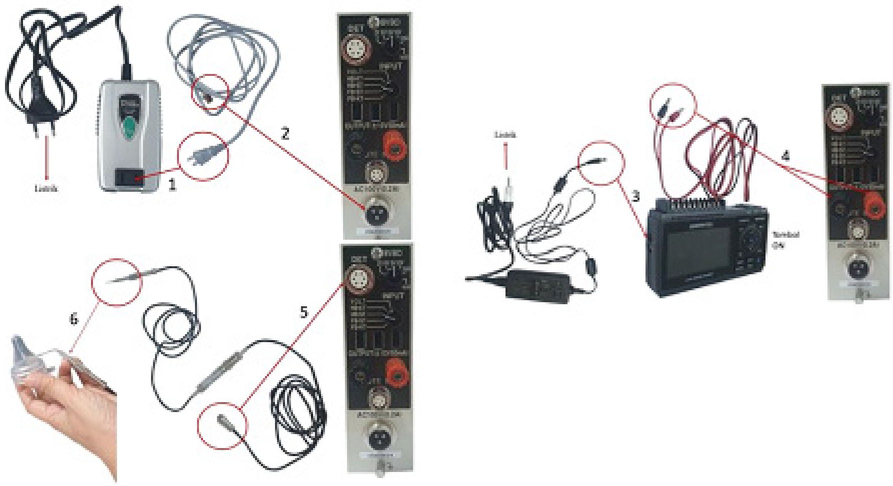
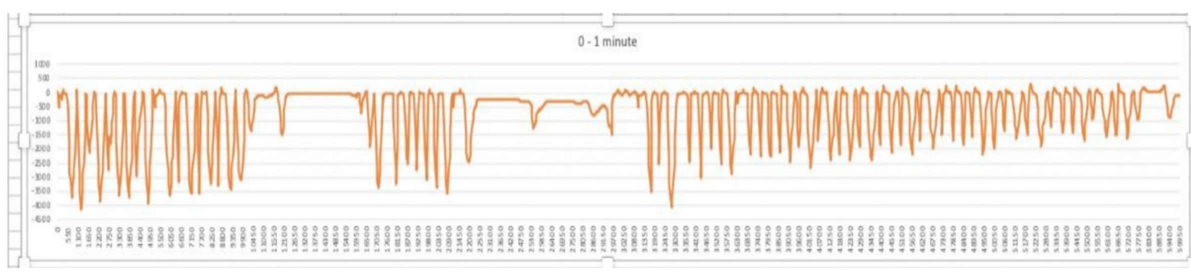


Figure 1. Assembly steps of sucking mechanism evaluation system tool: 1. The amplifier cable is connected to the adapter. 2. The other side of the same cable is connected to the amplifier, connecting the wires following the pattern on the amplifier. 3. The data logger adapter cable is connected to the data logger. 4. The black and red wires attached to the data logger are connected to the amplifier according to the color of the wires. Press the on button. 5. The sucking sensor cable is connected to the amplifier according to the pattern on the amplifier. 6. The sucking sensor cover is opened and connected to the pacifier. 7. Gain on the amplifier is adjusted at 100. Connect all tools to mains. 8. The data logger is calibrated by adjusting the amplifier using a screwdriver (-). The magnitude of the voltage is adjusted at +0.03.



	19	sucks/burst	10	sucks/burst	46	sucks/burst	**Mean sucks/burst**	**25**	**sucks/burst**
	3	bursts/min					**Number of burst/min**	**3**	**bursts/min**
Amplitude	-3195.2	V	-2698	V	-2015.86	V	**Mean amplitude**	**-2636.353**	**V**
Pause	3.3	seconds	8.65	seconds	11	seconds	**Mean pause**	**7.65**	**seconds**
Notes:	(blue)	= bursts							
	(yellow)	= time between bursts							
	(orange)	= suctions							

Figure 2. Suction pressure measurement results graph. The blue bar represents bursts, the yellow bar represents time between bursts, and the orange line represents suctions.

suctions were recorded, as shown by the number of peaks on the graph (**Figure 3**). The infant's suction pressure was determined by the average amplitude of the graph peaks in the bursts. Sucking pressure was presented in negative values to correspond to the negative sucking pressure. All data were saved under participants' ID numbers in an effort to avoid researcher bias during data analysis.

Data analysis was performed using *SPSS for Mac version 20.0 software* (IBM, Armonk, New York). Descriptive analysis was performed for all the variables. We compared gender and birth weight distribution in the two GA groups (very preterm and moderate-to-late preterm). Independent t-test was used to analyze differences in characteristics of NNS parameters (suction pressure, number of suctions per burst, and time between bursts) between the two GA groups. A P value of <0.05 was considered statistically significant, and we incorporated 95% confidence intervals.

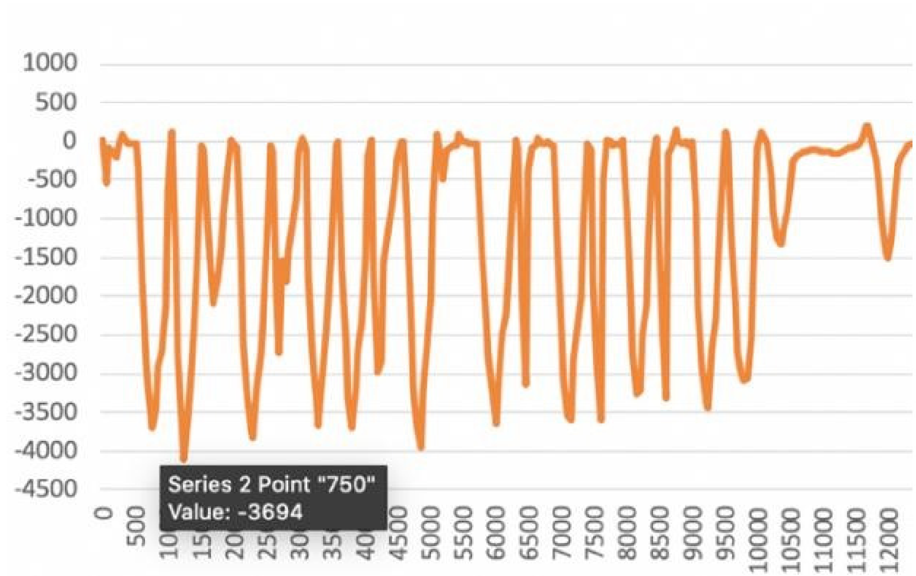


Figure 3. Burst description of the suction pressure measurement device. The X-axis represents time in milliseconds (ms); the Y-axis represents amplitude in mmHg. In this burst, 19 suctions were recorded, as shown by the number of peaks on the graph.

Results

Subjects were 120 preterm infants classified into either the moderate-to-late preterm (n=80) or very preterm (n=40) groups. Characteristics of subjects are described in **Table 1**. The very preterm group had more females than males (24 *vs.* 16, respectively), while the moderate-to-late preterm group had more males than females (46 *vs.* 34, respectively). Out of five ELBW infants, four were categorized as very preterm, and one was in the moderate-to-late preterm group. Among VLBW infants, the number of very preterm infants was higher compared to the number of moderate-to-late preterm infants (22 *vs.* 16, respectively). On the other hand, the number of LBW infants was higher in the moderate-to-late preterm group than in the very preterm group (63 *vs.* 14, respectively).

Parameters of NNS (suction pressure, number of suctions per burst, and time between bursts) were expressed as mean and standard deviation (SD). Mean suction pressure was higher in moderate-to-late preterm infants [-79.8 (SD 31.69) mmHg] compared to very preterm infants [-72.7 (SD 31.21) mmHg] (P=0.041). However, no significant difference was found in the number of suctions per burst between very preterm infants [8.99 (SD 2.62) suctions] compared to moderate-to-late preterm infants [8.90

Table 1. Characteristics of subjects

Characteristics	Gestational age: Very preterm (28 - < 32 weeks) (n=40)	Gestational age: Moderate-to-late preterm (32 - < 37 weeks) (n=80)	P value
Gender, n (%)			0.071
Male	16 (40)	46 (57.5)	
Female	24 (60)	34 (42.5)	
Birth weight (BW), n (%)			<0.001
Extremely low BW (n=5)	4	1	
Very low BW (n=38)	22	16	
Low BW(n=77)	14 (18.2)	63 (81.8)	

(SD 2.26) suctions] (P=0.048). Moderate-to-late preterm infants had shorter time between bursts [6.63 (SD 1.90) seconds] than very preterm infants [7.36 (SD 2.62) seconds] (P=0.030) (**Table 2**).

Discussion

Maturity of NNS reflects central nervous system integrity and has been used as a marker of oral feeding readiness and orofacial motor development in preterm infants.[23,24] Non-nutritive sucking is a precursor skill to oral feeding; however, oral feeding skills are far more complex as it requires the coordination between sucking, swallowing, and breathing.[22] Although NNS ability is not necessarily predictive of feeding success, stable cardiorespiratory function (breathing pattern, oxygen saturation) during NNS may indicate the infant's ability to manage oral feeding and represent hunger cues.[25] Quantitative measures of the NNS pattern can provide information related to the preterm infants' developmental status and progression of oromotor control systems.[26] It is often assumed that infants possess the skills necessary to feed by 34 weeks GA and will be able to maintain feeding before 37 weeks GA. However, to date, only a few studies have systematically investigated the age at which preterm infants attain essential early feeding milestones, or the factors that influence this important aspect of neonatal development.[27-30]

In our study, preterm infants in both gestational age groups demonstrated strong and rhythmic NNS pattern, characterized by an average of 5-10 suctions/burst, an average of 4-9 seconds of time between bursts, and an average suction pressure of -16.7 to -87 mmHg. These objective NNS characteristics represent the NNS ability in infants aged 32-36 weeks post-menstrual age.[2,21,22] However, moderate-to-late preterm infants showed higher NNS pressure, shorter time between bursts, and slightly higher number of suctions per burst compared to very preterm infants (**Table 2**). With increased maturation, we saw a significant gradual change towards a more intense sucking pressure (P=0.048) and shorter intervals (P=0.030).

Previous studies of NNS measurement in preterm infants have been reported.[5,16,21,22] Measurements showed improved sucking ability with maturation and age, and consistent sucking ability by 32-34 weeks post-menstrual age.[25] Medoff-Cooper found longer sucking episodes or bursts as infants mature.[31] Hafström and Kjellmer have also shown a more stable rhythm, faster pace and more intense sucking activity with longer bursts and shorter intervals with increased maturation.[5] These studies were consistent with our findings. A more stable rhythm of NNS is associated with maturity of general cerebral development as synaptogenesis and myelinization increase.[5]

There were several limitations that must be acknowledged in this study. First, infants may already have previous NNS experience on pacifiers prior the start of this study, and the exact amount has not been recorded. Therefore, future studies should control for prior pacifier use. Another limitation of this study was the small sample size and the study being conducted only in Jakarta, thus the results may not have been representative of other areas in Indonesia. Furthermore, suction pressure measurement devices are currently very limited in availability even in the capital region of Jakarta, and has not been widely used in Indonesia.

In conclusion, this study showed that maturity, as represented by GA, had a positive effect on the attainment of NNS milestones in preterm infants in Indonesia. Significant differences of the three NNS parameters of number of suctions per burst, time between bursts, and suction pressure were found between very preterm and moderate-to-late preterm

Table 2. Gestational age and NNS parameters

Variables	Very preterm (n=40)	Moderate-to-late preterm (n=80)	P value
Mean suction pressure (SD), mmHg	-72.7 (31.21)	-79.8 (31.69)	0.041*
Mean number of suctions /burst (SD)	8.99 (2.62)	8.90 (2.26)	0.048*
Mean time between bursts (SD), sec	7.36 (2.62)	6.63 (1.90)	0.030*

*P<0.05

infants. Further studies with larger sample size are needed in order to document NNS milestones across GA groups, from very late to full-term.

Conflict of interest

None declared.

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References

1. da Costa SP, Engel-Hoek LVD, Bos AF. Sucking and swallowing in infants and diagnostic tools. J Perinatol. 2008;28:247-57. DOI: https://doi.org/10.1038/sj.jp.7211924.
2. Wolf LS, Glass RP. Feeding and swallowing disorder in infancy : assessment and management. Pennsylvania State University: Therapy Skill Builders; 1992.
3. Nijhuis JG. Fetal behavior. Neurobiol Aging. 2003;24:S41-6. DOI: https://doi.org/10.1016/S0197-4580(03)00054-X.
4. Hack M, Estabrook MM, Robertson SS. Development of sucking rhythm in preterm infants. Early Hum Dev. 1985;11:133-40. DOI: https://doi.org/10.1016/0378-3782(85)90100-8.
5. Hafstrom M, Kjellmer I. Non-nutritive sucking in the healthy pre-term infant. Early Hum Dev. 2000;60:13-24. DOI: https://doi.org/10.1016/s0378-3782(00)00091-8.
6. Kish MZ. Improving preterm infant outcomes: Implementing an evidence-based oral feeding advancement protocol in the neonatal intensive care unit. Adv Neonatal Care. 2014;14:346-53. DOI: https://doi.org/10.1016/s0378-3782(00)00091-8.
7. Wolff PH. The serial organization of sucking in the young infant. Pediatrics. 1968;42:943-56. PMID: 4235770.
8. Hafström M, Lundquist C, Lindecrantz K, Larsson K, Kjellmer I. Recording non-nutritive sucking in the neonate. Description of an automatized system for analysis. Acta Paediatr. 1997;86:82-90. DOI: https://doi.org/10.1111/j.1651-2227.1997.tb08838.x.
9. Kenner C, McGrath J. Developmental care of newborns and neonates: a guide for health professionals. St. Louis: Mosby; 2004.
10. Lau C, Alagugurusamy R, Schanler RJ, Smith EO, Shulman RJ. Characterization of the developmental stages of sucking in preterm infants during bottle feeding. Acta Paediatr. 2000;89:846-52. PMID: 10943969.
11. Medoff-Cooper B, McGrath J, Bilker W. Nutritive sucking and neurobehavioral development in preterm infants from 34 weeks PCA to term. MCN Am J Matern Child Nurs. 2000;25:64-70. DOI: https://doi.org/10.1097/00005721-200003000-00004.
12. Martell M, Martinez G, Gonzalez M, Diaz Rossello JL. Suction patterns in preterm infants. J Perinat Med. 1993;21:363-9. DOI: https://doi.org/10.1515/jpme.1993.21.5.363 .
13. Eishima K. The analysis of sucking behaviour infants. Early Hum Dev. 1991;27:163-73. DOI: https://doi.org/10.1016/0378-3782(91)90192-6 .
14. Shandley S, Capilouto G, Tamilia E, Riley DM, Johnson YR, Papadelis C. Abnormal nutritive sucking as an indicator of neonatal brain injury. Front Pediatr. 2021;8:599633. DOI: https://doi.org/10.3389/fped.2020.599633.
15. Wahyuni LK, Mangunatmadja I, Kaban RK, Rachmawati EZK, Harini M, Laksmitasari B, *et al.* A comparison of objective and subjective measurements of non-nutritive sucking in preterm infants. Paediatr Indones. 2022;62:276-83. DOI: https://doi.org/10.14238/pi62.4.2022.276-83.
16. Medoff-Cooper B, Verklan T, Carlson S. The development of sucking patterns and physiologic correlates in very-low-birth-weight infants. Nurs Res. 1993;42:100-5. PMID: 8455984
17. Lau C, Kusnierczyk I. Quantitative evaluation of infant's nonnutritive and nutritive sucking. Dysphagia. 2001;16:58-67. DOI: https://doi.org/10.1007/s004550000043.
18. Howson CP, Kinney MV, Lawn JE. March of Dimes, PMNCH, Save the children, WHO. Born too soon: the global action report on preterm birth. Geneva: World Health Organization. 2012.
19. World Health Organization. ICD-10: International statistical classification of diseases and related health problems : tenth revision, 2nd ed. World Health Organization; 2004.
20. Gouna G, Rakza T, Kuissi E, Pennaforte T, Mur S, Storme L. Positioning effects on lung function and breathing pattern in premature newborns. J Pediatr. 2013;162:1133-7.e1. DOI: https://doi.org/10.1016/j.jpeds.2012.11.036.
21. Mizuno K, Ueda A. The maturation and coordination of sucking, swallowing, and respiration in preterm infants. J Pediatr. 2003;142:36-40. DOI: https://doi.org/10.1067/mpd.2003.12.
22. Pineda R, Dewey K, Jacobsen A, Smith J. Non-nutritive sucking in the preterm infant. Am J Perinatol. 2019;36:268-276. DOI: https://doi.org/10.1055/s-0038-1667289 .

23. Mizuno K, Ueda A. Neonatal feeding performance as a predictor of neurodevelopmental outcome at 18 months. Dev Med Child Neurol. 2005;47:299-304. DOI: https://doi.org/10.1017/s0012162205000587.
24. Lau C. Development of suck and swallow mechanism in infants. Ann Nutr Metab. 2015;66(suppl 5):7-14. DOI: https://doi.org/10.1159/000381361.
25. McGrath JM, Braescu AV. State of the science: feeding readiness in the preterm infant. J Perinat Neonatal Nurs. 2004;18(4):353-68. DOI: https://doi.org/10.1097/00005237-200410000-00006.
26. Barlow SM, Burch M, Venkatesan L, Harold M, Zimmerman E. Frequency modulation and spatiotemporal stability of the sCPG in preterm infants with RDS. Int J Pediatr. 2012;2012;581538. DOI: https://doi.org/10.1155/2012/581538..
27. Sidell EP, Froman RD. A national survey of neonatal intensive-care units: criteria used to determine readiness for oral feedings. J Obstet Gynecol Neonatal Nurs. 1994;23:783-9. DOI: https://doi.org/10.1111/j.1552-6909.1994.tb01953.x.
28. Eichenwald EC, Blackwell M, Lloyd JS, Tran T, Wilker RE, Richardson DK. Inter-neonatal intensive care unit variation in discharge timing: influence of apnea and feeding management. Pediatrics. 2001;108:928-33. DOI: https://doi.org/10.1111/j.1552-6909.1994.tb01953.x.
29. Blackwell MT, Eichenwald EC, McAlmon K, Petit K, Linton PT, McCormick MC, *et al.* Interneonatal intensive care unit variation in growth rates and feeding practices in healthy moderately premature infants. J Perinatol. 2005;25:478-85. DOI: https://doi.org/10.1038/sj.jp.7211302.
30. Pickler RH, Best AM, Reyna BA, Gutcher G, Wetzel PA. Predictors of nutritive sucking in preterm infants. J Perinatol. 2006;26:693-9. DOI: https://doi.org/10.1038/sj.jp.7211590
31. Medoff-Cooper B. Changes in nutritive sucking patterns with increasing gestational age. Nurs Res. 1991;40:235-7. PMID: 1857653.