

## A comparison of objective and subjective measurements of non-nutritive sucking in preterm infants

Luh Karunia Wahyuni<sup>1</sup>, Irawan Mangunatmadja<sup>2</sup>, Risma Kerina Kaban<sup>2</sup>,  
Elvie Zulka Kautzia Rachmawati<sup>3</sup>, Melinda Harini<sup>1</sup>, Budiati Laksmitasari<sup>1</sup>,  
Agatha Geraldine<sup>1</sup>, Inez Ayuwbowo Sangwidjojo<sup>1</sup>, Dini Prima Utami<sup>1</sup>,  
Victor Prasetyo Poernomo<sup>1</sup>, Adrian Prasetya Sudjono<sup>1</sup>

### Abstract

**Background** Of preterm infants born before 32 weeks of gestation, 40-70% have atypical and immature feeding skills, which could delay initiation of oral feeding. A formal objective measurement of non-nutritive sucking may increase the accuracy of determining the right time to initiate oral feeding, however, most hospital perinatology care units do not own a suction pressure measurement device to objectively measure non-nutritive sucking parameters.

**Objective** To compare objective and subjective non-nutritive sucking (NNS) based on sucking pressure, number of suctions per burst, and time between bursts.

**Methods** One hundred twenty preterm infants born at 28-34 weeks' gestation were evaluated for objective and subjective NNS. Data were collected from August to November 2021 at five hospitals in Jakarta. Objective NNS was measured by a suction pressure measurement device, while subjective NNS was clinically examined. Number of suctions per burst, sucking pressure, and time between bursts were analysed by Spearman's correlation test.

**Results** A positive and significant correlation between objective and subjective NNS was found in all parameters ( $P < 0.001$ ). The highest correlation was found in time between bursts ( $r = 0.74$ ;  $P < 0.001$ ), followed by number of suctions per burst ( $r = 0.60$ ;  $P < 0.001$ ), and sucking pressure ( $r = 0.58$ ;  $P < 0.001$ ).

**Conclusion** The correlation between objective and subjective NNS examination was moderate in preterm infants. Therefore, an objective NNS measurement is still required for optimizing the examination. [Paediatr Indones. 2022;62:274-81 DOI: 10.14238/pi62.4.2022.274-81].

**Keywords:** preterm infants; non-nutritive sucking

Full-term infants naturally obtain oral feeding ability, but preterm infants (<37 weeks gestation) often experience delays in feeding.<sup>1</sup> Around 40-70% of preterm infants have atypical and immature feeding skills.<sup>2</sup> Before they are able to safely feed orally, non-oral feeding methods are generally used,<sup>3</sup> resulting in delayed initiation of oral feeding.<sup>2</sup> Even after the transition from non-oral to oral feeding has been achieved, 80% of preterm infants with developmental delays were reported to still have difficulty feeding orally.<sup>4</sup>

Oral feeding difficulties experienced by preterm infants are generally caused by irregular, weak, and inefficient sucking, as well as problems in initiating sucking, difficulty in coordinating the process of suck-swallow-breathe, which causing infants to get tired quickly during oral feeding. These feeding difficulties

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From the Department of Physical Medicine & Rehabilitation<sup>1</sup>, Department of Child Health<sup>2</sup>, and Department of Ear, Nose, and Throat Clinic<sup>3</sup>, Universitas Indonesia Medical School/Dr. Cipto Mangunkusumo Hospital, Jakarta, Indonesia.

**Corresponding author:** Luh Karunia Wahyuni. Department of Physical Medicine and Rehabilitation, Faculty of Medicine Universitas Indonesia/ Cipto Mangunkusumo Hospital, Jl. Pangeran Diponegoro No.71, Senen, Jakarta Pusat 10430. Email: luhkwahyuni@gmail.com.

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may lead to negative impacts on nutritional status, hospital length of stay and cost, readmission to the neonatal intensive care unit, and further long-term feeding difficulties. Therefore, the ability to feed orally should be evaluated in preterm infants.<sup>3</sup>

Sucking is a process of putting liquid into the mouth, and moving it posteriorly to the back of the oral cavity, in order to be swallowed towards the larynx. Adequate sucking must be strong and rhythmic. The sucking process is assumed to be a vacuum system, because the liquid moves by use of negative pressure changes.<sup>5</sup> There are two main types of sucking in infants, namely, nutritive and non-nutritive sucking. Nutritive sucking (NS) is a process to obtain nutritional needs and provide early oral-motor experiences, which are important for oral sensorimotor skill development and mother-child bonding. Non-nutritive sucking (NNS) lacks of nutritional flow, and is done for self-regulation, fulfilling the natural desire to suck, and exploration.<sup>6</sup> Non-nutritive sucking has been used as an indicator of oral feeding readiness. This oral-rhythmic behavior begins to appear in infants at 28-33 weeks' gestation, and stabilizes by 34 weeks of gestation.<sup>7</sup>

The use of a formal objective measurement for oral feeding readiness is one of the ways to increase accuracy in determining the right time to initiate oral feeding.<sup>1</sup> Information obtained through objective instrument evaluation is necessary to help determine the etiology of feeding or swallowing difficulties. Examples of such instruments are video-fluoroscopy, fiberoptic endoscopic evaluations of swallowing (FEES), and suction pressure measurement device. Examinations with video-fluoroscopy and FEES are indicated for suspected problems in the pharyngeal phase of swallowing based on history and/or oral-motor observations. They are also indicated if the infant had a risk of aspiration, previous history of aspiration, pneumonia, impaired respiratory function, impaired phonation, or stridor at rest or during sucking.<sup>8</sup>

The suction pressure measurement is a non-invasive device that can be used to record, identify, and analyze suction characteristics such as the number of suctions per burst, time between bursts, and sucking pressure in infants. A burst is defined as the period of sucking between pauses, with 1 burst consisting of several sucks. Time between bursts is defined as the sucking rest period. Sucking pressure can be assessed by the strength and compression of the tongue against the

palate, as well as the ability to create intraoral pressure.<sup>9</sup> Non-nutritive sucking of post-menstrual, gestational age 32 to 36 weeks was interpreted as adequate, if the infant was able to suck with an average of 5 to 10 sucks/burst, average time between bursts of 4 to 9 seconds, and average sucking pressure of -16.7 to -87 mmHg.<sup>10-12</sup>

Most hospital perinatology care units do not own a suction pressure measurement device to measure non-nutritive sucking parameters objectively, thus, competent medical staff make subjective measurements by clinical evaluations. To our knowledge, there has been no previous comparison of objective NNS measurements with an instrument and subjective measurements by clinical evaluation. The objective of the study was to evaluate for possible correlations between objective and subjective measurements of NNS for several parameters including sucking pressure, number of suctions per burst, and time between bursts.

## Methods

This cross-sectional study was performed from August to November 2021 at five tertiary hospitals in Jakarta, Indonesia. A consecutive sampling of 120 preterm infants born at 28-34 weeks' gestation and admitted to perinatal facilities were included. Exclusion criteria were craniomaxillofacial malformations, neonatal asphyxia with APGAR score less than 7, grade 3 and 4 intraventricular hemorrhage, and use of an endotracheal tube at the time of assessment. Date of birth, gender, gestational age, birth weight, and comorbidity data were collected. Objective NNS measurement was done using a suction pressure measurement device by a trained general practitioner (**Figure 1**). Simultaneously, as the infant was sucking on a pacifier, another general practitioner subjectively assessed NNS by visually observing the movement of the cheeks and jaws, and by slightly pulling the pacifier to test the strength of the lip seal around the pacifier (**Figure 2**). Particular attention was placed on the sucking strength, number of suctions per burst, and time between bursts. The objective and subjective measurements were performed by different observers to avoid bias. Informed consent was obtained from subjects' mothers prior to examination. This study was approved by the Ethics Committee of the Universitas Indonesia Medical School.



**Figure 1.** Objective NNS measurement with suction pressure measurement device



**Figure 2.** Subjective NNS measurement

The suction pressure measurement device consisted of three parts: a data logger (GRAPTEC *midi* LOGGER GL240, JTEKT Corporation, Kariya, Japan), an amplifier (JTEKT PMS-5M2 50K, JTEKT Corporation, Kariya, Japan), and a pressure transducer (JTEKT PMS-5M2 50K, JTEKT Corporation, Kariya, Japan). The sensor was a PMS-5M-2 (50K) semiconductor transducer, with a detection range of -50 to +50 kPa, where 1 kPa is 7.5 mmHg. Thus, the sensor could detect +375 to -375 mmHg, which was an appropriate infant sucking pressure range. The tool could detect a minimum of 0.5% variations (0.25 kPa or 1.875 mmHg). A preemie care pacifier (Pigeon™, Pigeon Corporation, Tokyo, Japan) was attached to the transducer. The pressure signal was a pressure change effect that occurred when the infant's lips and tongue pressed against the air contained in the pacifier. The pressure change was also generated when negative intraoral pressure was transmitted to the transducer, which was set at a frequency of 150Hz. The signal amplifier was A/D-converted, recorded, and analyzed by Microsoft Excel for Mac version 16.16.27.<sup>10</sup>

Before performing the evaluation, tools were sterilized, and researchers used level 2 personal protective equipment (PPE) as well as appropriate handwashing protocol. When the device was set up according to the manufacturer's instruction, an infant was swaddled in a physiologically flexed position. While performing the examination, the infant's head and neck were supported in semi-upright position. The pacifier was placed on the infant's lower lip and on the top of the tongue to stimulate the sucking reflex. The NNS measurement was recorded for 1-min period.

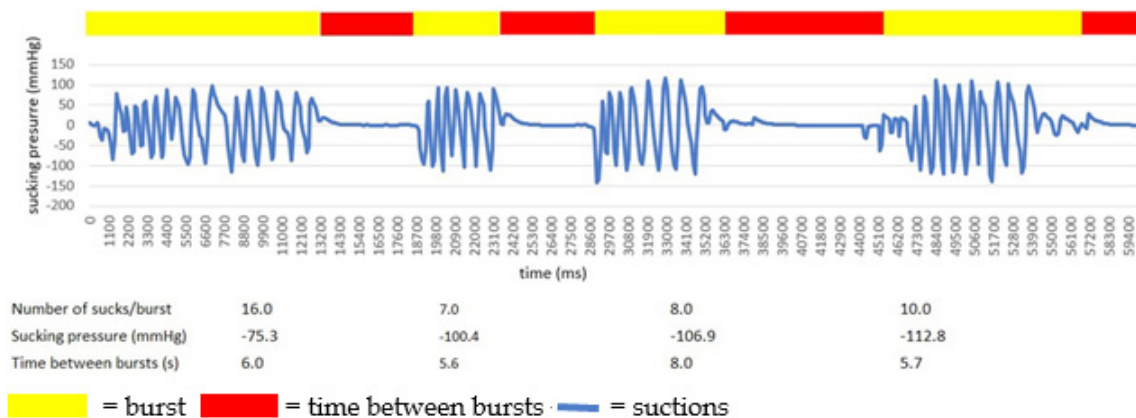
The recorded data were then exported and analyzed. The examination was performed for 30 minutes before the infant's feeding schedule.

The parameters of non-nutritive sucking measured included: 1) number of suctions per burst, 2) time between bursts, and 3) sucking pressure. As presented in **Figure 3**, the yellow bar represents bursts, the red bar represents time between bursts, and the blue line represents suctions. In the first burst, 16 suctions were obtained according to the number of the bottom points of the graph. The amplitude that describes the sucking pressure was the distance between the upper and lower limits of the graph peak in 1 suction.

Data analysis was carried out with *Statistical Package for the Social Sciences (SPSS) for Macintosh version 20.0*. Results with P values <0.05 were considered to be statistically significant. The objective and subjective measurements of three non-nutritive sucking parameters were analyzed by Spearman's correlation test. Intraclass correlation coefficient was used to measure the level of correlation (**Table 1**).

**Table 1.** Interpretation of correlation coefficient<sup>13</sup>

Intraclass correlation coefficient	Correlation level
<0.50	Low
0.50-0.74	Medium
0.74-0.90	High
>0.90	Very high



**Figure 3.** Suction pressure measurement's results graph

## Results

Subjects' characteristics are shown in **Table 2**. Of 120 preterm infants, 62 (51.6%) were males. From the objective NNS measurement, female infants tended to have higher mean sucking pressure (-79.0 vs. -72.6 mmHg, respectively,  $P=0.113$ ) and greater mean number of suctions per burst (9.5 vs. 8.4, respectively,  $P=0.565$ ) than male infants, although no significant difference were found. Similar results were also reflected in the subjective NNS examination, with more females than males having strong NNS (49 vs. 45%, respectively,  $P=0.105$ ). Females also had greater mean number of suctions per burst compared to male infants (10.0 vs. 8.0, respectively,  $P=0.620$ ). However, mean time between bursts were similar in both the objective (6.8 vs. 6.6 s, respectively,  $P=0.20$ ) and subjective evaluations (5.0 vs. 5.0 s, respectively,  $P<0.001$ ).

Moderate to late preterm infants had a higher mean objective sucking pressure and more infants in this category had strong sucking strength compared to very preterm infants (-79.0 vs. -68.0 mmHg, respectively; 63 vs. 31%, respectively,  $P=0.375$  and  $P=0.580$ ). The objective measurement revealed similar mean number of suctions per burst (8.9) and time between bursts for both gestational age groups and (6.7s). However, the subjective NNS evaluation yielded a slightly higher number of suctions per burst (9.5 vs. 9.0, respectively,  $P=0.297$ ) and shorter time between bursts (5.0 vs. 6.0s, respectively) in moderate to late preterm infants compared to very preterm infants.

Low birth weight infants had the strongest NNS sucking pressure (-78.3 vs. -74.3 vs. -66.4 mmHg, respectively) and shortest time between bursts (6.2 vs. 7.0 vs. 8.7s, respectively) compared to very low birth weight and extremely low birth weight infants in the objective NNS. Similarly, the subjective NNS revealed that the number of low birthweight infants with strong sucking strength was the highest (59 vs. 32 vs. 3%, respectively) compared to very low birth weight and extremely low birth weight infants, and they had the shortest time between bursts (5.0 vs. 5.5 vs. 7.0 s, respectively). In subjective NNS examination, the number of suctions per burst gradually decreased as the birth weight increased (10.0 vs. 9.5 vs. 9.0, respectively), however the number of suctions per burst fluctuated in objective NNS measurement. Intraventricular hemorrhage (17 infants) and patent ductus arteriosus

(14 infants) were the most common comorbidities among our subjects.

Positive correlations were observed between objective and subjective NNS. The level of correlations was moderate, but significant for all parameters (**Table 3**). The lowest correlation was found in sucking pressure [Spearman's coefficient ( $r$ )=0.58;  $P<0.001$ ], followed by number of suctions per burst ( $r=0.60$ ;  $P<0.001$ ). The highest correlation was found in time between bursts ( $r=0.74$ ;  $P<0.001$ ).

## Discussion

Our objective and subjective NNS findings revealed that female preterm infants had a higher sucking pressure and number of suctions per burst compared to male infants, which contributed to better NNS performance, although no significant difference were found. This finding was consistent with a widely accepted concept in neonatal medicine called "male disadvantage."<sup>14</sup> Male infants tend to be less stable than female infants and have more difficulties adjusting to the external environment after birth.<sup>15,16</sup> A study also confirmed that males were more likely to suffer from a major neonatal outcome and remain at a higher risk of respiratory and gastrointestinal complications, which makes them more prone to mechanical ventilation.<sup>17</sup> Also, prolonged duration of mechanical ventilation or other respiratory support for respiratory compromise led to reduced NNS performance.<sup>12,18</sup> Additionally, another study reported that preterm female infants showed significantly higher sucking frequencies and larger amplitudes than preterm male infants.<sup>19</sup>

The quality of NNS continues to improve with age, as rates of maturation and coordination are greatly influenced by infant gestational age (GA) and postmenstrual age (PMA).<sup>20</sup> Compared to full-term infants, preterm infants showed a significantly shorter sucking cycle time (measured from the peak of one sucking pattern to the peak of the next sucking pattern),<sup>21</sup> smaller intensity of sucking pressure,<sup>21</sup> shorter length of time between sucks,<sup>20,22</sup> decreased number of sucking bursts,<sup>20,22</sup> and lower sucking frequency (number of suctions per minute).<sup>23</sup> These previous findings were in agreement with our results, in which moderate to late preterm infants exhibited a higher sucking pressure, higher number of suctions

**Table 2.** Subjects' characteristics (N=120)

Characteristics	Objective NNS				Subjective NNS		
	n, (%)	Sucking pressure, mmHg	Number of suctions/burst	Time between bursts, s	Sucking strength		Time between bursts, s
					Weak, n (%)	Strong, n (%)	
Gender							
Male	62 (51.6)	-72.6	8.4	6.6	17 (27.4)	45 (72.6)	5.0
Female	58 (48.4)	-79.0	9.5	6.8	9 (15.5)	49 (84.5)	5.0
Gestational age							
Very preterm (28-31 weeks)	40 (33.3)	-68.0	8.9	6.7	9 (22.5)	31 (77.5)	6.0
Moderate to late preterm (32-34 weeks)	80 (66.7)	-79.9	8.9	6.7	17 (21.3)	63 (78.7)	5.0
Birth weight							
Extremely low (<1,000 g)	5 (4.2)	-66.4	8.8	8.7	2 (40)	3 (60)	7.0
Very low (1,000 - 1,499g)	38 (31.6)	-74.3	9.0	7.0	6 (15.8)	32 (84.2)	5.5
Low (1,500 - <2,500g)	77 (64.2)	-78.3	8.8	6.2	18 (23.4)	59 (76.6)	5.0
Comorbidities							
BPD	7 (5.8)	-85.8	10.3	7.3	1 (14.3)	6 (85.7)	7.0
NEC	7 (5.8)	-72.7	9.0	7.0	3 (42.9)	4 (57.1)	5.0
IVH	17 (14.1)	-72.7	10.0	6.2	5 (29.4)	12 (70.6)	6.0
AOP	5 (4.1)	-72.7	6.6	7.0	3 (60)	2 (40)	8.0
PDA	14 (11.6)	-65.9	8.9	6.6	3 (21.4)	11 (78.6)	6.0

BPD=bronchopulmonary dysplasia; NEC=necrotizing enterocolitis; IVH=intraventricular hemorrhage; AOP=apnea of prematurity; PDA=patent ductus arteriosus

**Table 3.** Correlation between objective and subjective NNS parameters

NNS parameters	r	P value
Number of suctions per burst	0.60	<0.001
Time between burst	0.74	<0.001
Sucking pressure	0.58	<0.001

\*Spearman's correlation test

per burst, and shorter time between bursts in the subjective examination. However, the number of suctions per burst and time between bursts did not differ between the two gestational age groups in the objective measurement. This observation might have been caused by a smaller sample size of very preterm infants (40 subjects) compared to moderate to late preterm infants (80 subjects).

Our study demonstrated a positive correlation between birth weight and sucking pressure, i.e., preterm infants with higher birth weight had the highest sucking pressure. On the other hand, a negative correlation was found between birth weight and time between bursts. A previous study showed that higher birth weight was significantly associated with more coordinated breath, suck, and swallow cycles.<sup>24</sup> A previous study reported that very low birth weight infants exhibited a significantly shorter sucking cycle length (amount of time from the peak of 1 suck to the peak of the next suck) and lower sucking pressures compared to full-term infants.<sup>21</sup> The activity to develop sucking began during the prenatal period.<sup>25</sup> Lower birth weight infants have less time to practice sucking skills in utero and, as a consequence, have lower ability to suck, compared to full term infants.<sup>21</sup> Our results were consistent with those of other studies indicating that birth weight also influences NNS in preterm infants.

We found positive and significant correlations between objective and subjective NNS examinations in preterm infants. The strongest correlation was found in time between bursts ( $r=0.74$ , a moderate correlation). Number of suctions per burst ( $r=0.60$ ) and sucking pressure ( $r=0.58$ ) parameters also had moderate correlations. There could be several reasons for the lack of strong correlations between the objective and subjective results. The subjective NNS was conducted by observing infants' sucking pattern through a pacifier, so this approach only provides qualitative and imprecise data. Another reason could

be that this type of subjective NNS examination had not been standardized and it did not match the infants' actual NNS performance. In addition, the observer needs to be highly skilled in order to note all the desired measures, e.g., number of suctions per burst, time between bursts, and sucking strength in the subjective NNS evaluation. To our knowledge, our study is the first to investigate possible correlations between objective and subjective NNS in preterm infants. Lau *et al.*<sup>26</sup> developed a finger pressure device that allows quantification of specific measures for non-nutritive sucking because the conventional gloved-finger sucking evaluation only proposed subjective, less detailed, and less accurate information on the infant's non-nutritive sucking skills. Moreover, the assessor was not able to differentiate the suction/expression component when using the routine gloved-finger test. Thus, they concluded that the finger pressure device offered more detailed and reliable information than the gloved-finger test. Likewise, subjective NNS examinations still could not replace the role of objective NNS measurements.<sup>26</sup>

The shortcomings of this study were the small sample size, and that our study was conducted only in Jakarta. Thus, the results may not be representative of other areas in Indonesia. The suction pressure measurement device is still not readily available in Jakarta, let alone the rest of Indonesia.

In conclusion, the correlation between objective and subjective NNS examinations was moderate, but significant, in preterm infants. Given that the correlation is not strong, ideally, an objective device should still be used to optimize the examination. However, further diagnostic study needs to be conducted in order to determine the validity and reliability of subjective vs. objective NNS, since not all health services offer the objective NNS.

## Conflict of interest

None declared.

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## References

1. Kish MZ. Oral feeding readiness in preterm infants: a concept analysis. *Adv Neonatal Care*. 2013;13:230-7. DOI: 10.1097/ANC.0b013e318281e04e.
2. Capilouto GJ, Cunningham TJ, Giannone PJ, Grider D. A comparison of the nutritive sucking performance of full term and preterm neonates at hospital discharge: a prospective study. *Early Hum Dev*. 2019;134:26-30. DOI: 10.1016/j.earlhumdev.2019.05.007.
3. Einarsson-Backes LM, Deitz J, Price R, Glass R, Hays R. The effect of oral support on sucking efficiency in preterm infants. *Am J Occup Ther*. 2017;48:490-8. DOI: 10.5014/ajot.48.6.490.
4. Lau C. Development of suck and swallow mechanisms in infants. *Ann Nutr Metab*. 2015;66 Suppl 5:7-14. DOI: 10.1159/000381361.
5. Lau C, Hurst N. Oral feeding in infants. *Curr Probl Pediatr*. 1999;29:105-24. DOI: 10.1016/s0045-9380(99)80052-8.
6. Wolf LS, Glass RP. Feeding and swallowing disorder in infancy: assessment and management. Tucson: Therapy Skill Builders; 1992. p.181.
7. Thoyre SM, Carlson JR. Preterm infants' behavioural indicators of oxygen decline during bottle feeding. *J Adv Nurs*. 2003;43:631-41. DOI: 10.1046/j.1365-2648.2003.02762.x.
8. Comrie JD, Helm JM. Common feeding problems in the intensive care nursery: maturation, organization, evaluation, and management strategies. *Semin Speech Lang*. 1997;18:239-60. DOI: 10.1055/s-2008-1064075.
9. 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: 10.1016/j.jpeds.2012.11.036.
10. Wolff PH. The serial organization of sucking in the young infant. *Pediatrics*. 1968;42:943-56. PMID: 4235770.
11. Mizuno K, Ueda A. The maturation and coordination of sucking, swallowing, and respiration in preterm infants. *J Pediatr*. 2003;142:36-40. DOI: 10.1067/mpd.2003.mpd0312.
12. Pineda R, Dewey K, Jacobsen A, Smith J. Non-nutritive sucking in the preterm infant. *Am J Perinatol*. 2019;36:268-76. DOI: 10.1055/s-0038-1667289.
13. Koo TK, Li MY. A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *J Chiropr Med*. 2016;15:155-63. DOI: 10.1016/j.jcm.2016.02.012.
14. Naeye R, Burt L, Wright D, Blanc W, Tatter D. Neonatal mortality, the male disadvantage. *Pediatrics*. 1971;48:902-6. PMID: 5129451.
15. Brothwood M, Wolke D, Gamsu H, Benson J, Cooper D. Prognosis of the very low birthweight baby in relation to gender. *Arch Dis Child*. 1986;61:559-64. DOI: 10.1136/adc.61.6.559.
16. Stevenson DK, Verter J, Fanaroff AA, Oh W, Ehrenkranz RA, Shankaran S, et al. Sex differences in outcomes of very low birthweight infants: the newborn male disadvantage. *Arch Dis Child Fetal Neonatal Ed*. 2000;83:F182-5. DOI: 10.1136/fn.83.3.f182.
17. Masato I, Tamura M, Namba F. Role of sex in morbidity and mortality of very premature neonates. *Pediatr Int*. 2017;59:898-905. DOI: 10.1111/ped.13320.
18. Estep M, Barlow SM, Vantipalli R, Finan D, Lee J. Non-nutritive suck parameters in preterm infants with RDS. *J Neonatal Nurs*. 2008;14:28-34. DOI: 10.1016/j.jnn.2007.12.005.
19. Hafstrom M, Kjellmer I. Non-nutritive sucking in the healthy pre-term infant. *Early Hum Dev*. 2000;60:13-24. DOI: 10.1016/s0378-3782(00)00091-8.
20. Medoff-Cooper B, Verklan T, Carlson S. The development of sucking patterns and physiologic correlates in very-low-birthweight infants. *Nurs Res*. 1993;42:100-5. PMID: 8455984.
21. Matsubara M, Tamura Y, Ruchala P. Analysis of nutritive sucking function in very low and extremely low birthweight infants in Japan: a pilot study. *Japan J Nurs Sci*. 2005;2:3-7. DOI: 10.1111/j.1742-7924.2005.00026.x.
22. Medoff-Cooper B. Changes in nutritive sucking patterns with increasing gestational age. *Nurs Res*. 1991;40:235-7. PMID: 1857653.
23. Lau C, Smith E, Schanler R. Coordination of suck-swallow and swallow respiration in preterm infants. *Acta Paediatr*. 2003;92:721-7. DOI: 10.1080/08035250310002407.
24. Reynolds EW, Grider D, Caldwell R, Capilouto G, Vijaygopal P, Patwardhan A, et al. Swallow – breath interaction and phase of respiration with swallow during nonnutritive suck among low-risk preterm infants. *Am J Perinatol*. 2010;27:831-40. DOI: 10.1055/s-0030-1262504.
25. Prechtl HF. Qualitative changes of spontaneous movements in fetus and preterm infant are a marker of neurological dysfunction. *Early Hum Dev*. 1990;23:151-8. DOI: 10.1016/0378-3782(90)90011-7.
26. Lau C, Kusnierczyk I. Quantitative evaluation of infant's nonnutritive and nutritive sucking. *Dysphagia*. 2001;16:58-67. DOI: 10.1007/s004550000043.