Novelty Journals

ISSN 2394-7330

International Journal of Novel Research in Healthcare and Nursing
Vol. 7, Issue 1, pp: (702-716), Month: January - April 2020, Available at: www.noveltyjournals.com

Effect of Sensory-Motor Interventions on Feeding Outcomes and Weight-Gain among Preterm Neonates after Weaning from Non-invasive Mechanical Ventilation

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Abstract: **Feeding difficulties of preterm neonates remain a challenge and consequently leads to prolonged hospital stay. Early sensory-motor interventions improve oral feeding abilities and facilitate sucking-swallowing-respiration coordination in preterm neonates with delayed feeding. Objective: The aim of this studyis to identify the effect of sensory-motor interventions on feeding outcomes and weight gain among preterm neonates after weaning from non-invasive mechanical ventilation. Research Design: A quasi-experimental research design was used. Setting: The study was conducted in the Neonatal Intensive Care Unit of (NICU) at Specialized Somouha University Hospital in Alexandria, Egypt. Subjects: A convenience sampling of 60 preterm neonates who had homodynamicstability and weaned from nasal CPAP for 48hours.Tools: Three tools were used to collect necessary data namely;preterm neonates' feeding outcomes assessment, non-nutritive sucking pattern of preterm neonates and preterm neonates' oral feeding efficacy and weight gainassessment. Result: Significant statistical differences were found between the study and control groups regarding their ability to organize oral-motor functioning, remain engaged in feeding and coordinate swallowing and breathing (P=0.000) as well as their ability to maintain physiologic stability during feeding (P=0.008). Moreover, the mean of volume transfer per feeding session at the 10th day of interventions was 82.90 ml ±14.12 for the neonates in the study group compared to 71.33 ml ±16.96. The rate of milk for the neonates in the study group was 1.97±0.34 ml/minute compared to 1.06±0.32 ml/minute for the control one. The mean body weight of preterm neonates of the study group was 1495±5.13 compared to 1371±5.15 of the preterm neonates of control group at 10th day.Conclusion: It can be concluded that applyingsensory-motor intervention improve the preterm neonates' feeding abilities,non-nutritive sucking pattern, feeding efficacy and weight gain after weaning from non-invasive mechanical ventilation. Recommendations: educational programs should be provided for neonatal nurses about the Sensory-motor interventions to improve feeding outcomes among preterm neonates.**

Keywords: **sensory-motor interventions, preterm neonates' oral feeding, preterm neonates.**

1. INTRODUCTION

Prematurity is now the most important cause of death in the first month of life. It was estimated that 15 million neonates were prematurely born worldwide and more than 1millon of them die because of prematurity.Neonatal period is a highly vulnerable time for neonates**(Hockenberry et al., 2013 and World Health Organization, 2015)**.During this period, significant physiological changes occur to help neonates to adjust theextrauterineenvironment.Transition from dependence on placental gas exchange to spontaneous air breathing and pulmonary gas exchange occurs smoothly without difficulty in most of neonates. However, lungs of the preterm neonates are immature and unable to maintain normal

oxygen saturation. Multiple respiratory problems such asrespiratory distress syndrome, pneumoniaand apnea are affecting preterm neonates. In these circumstances, it is often necessary to provide ventilatory support either through invasive or noninvasive mechanical ventilation.However, the trend in the neonatal intensive care units is to use the less traumatic non-invasive ventilation whenever possible**(Steinhornet al., 2008 &Anderson 2011)**.

Using of non-invasive respiratory support is an appropriate method fortreating preterm neonates with respiratory problems. The application of nasal continuous positive airway pressure (NCPAP) is becoming one of the most popular non-invasive modes of this type of respiratory support**(Goldsmith et al ., 2010)**. Continuous positive airway pressure (CPAP), is a way of making continuous positive airway pressure through the neonatal airway with spontaneous breathing during the respiratory cycle**(Chan 2010 &Bonner 2007)**. Nasal prong is the most common interface actions in CPAP. It provides a better view of the neonate's face and mouth and the neonateis able to move easily without reducing the pharyngeal pressure. Unfortunately, using of NCPAP can lead to air leakage, trauma to the nose, stomach distention, nasal obstruction by secretions, nasopharyngeal prong kinking and the pressure loss through the open mouth. Since nutritional problems are one of the major difficulties preterm neonates experience after weaning from NCPAP. Moreover, evaluation of the factors associated with initiation of independent oral feeding would be beneficial**(Kamhawy et al., 2014&Kacho, 2017).**

Oral feeding is a complex task for preterm neonates where it requires precise coordination between sucking, swallowing and breathing that does not develop before 32–34 weeks of gestation**(Smith et al ., 2010&Fucile 2013)**. In addition, the function of gastrointestinal tract among preterm neonates is impaired related early interruption of gestation. Poor muscle tone, immature oral-motor control, and weak feeding reflexes are definitely hinder oral feeding process among preterm neonates**(Fucile et al., 2013&Greene, 2013).** Failure to achieve adequate extra-uterine growth is common phenomenon among preterm neonates. Moreover, preterm neonates appear to develop a severe caloric deficicy in the first few weeks of life that manifests in failed weight gain, which continues for long time. Besides, the unstable respiratory status and the attachment of preterm neonates to non-invasive ventilation require delay in oral feedings.Such delay may also cause lack of gastrointestinal tract stimulation**(Hwang etal., 2010).**

Providing adequate and safe nutrition for preterm neonates with respiratory problems is a great challenge for neonatal nurses. Those neonates are generally need a period of parenteral nutrition followed by a period offull gavage feeding and then oral feeding isinitiated gradually when they became hemodynamically stable**(Hwang et al ., 2010).**At the initial stage of independent oral feedingthe majority of them areunable to suck all prescribed formula. In order to improve the preterm neonates' sucking, oral feeding skills and efficacy, the neonatal nurse can apply a wide variety of oralsensory-motor interventions. Such interventionsshould be started earlyduring the transition period from tube feeding to full oral feedingand for at least 10 days**(Arvedsonet al ., 2013).**

Preterm neonates in NICUrequire an additional high level of technical and observational medical care. Many current interventions to improve sucking, swallowing, and their coordination with respiration focus on promoting the neural maturation of these processes.Early sensory-motor interventions may improve oral feeding abilities and facilitate coordination of sucking-swallowing-respiration in preterm neonates with delayed feeding. The sensory stimulation or manipulated actions of the lips, jaw, tongue, soft palatebefore or during either nutritive or nonnutritive sucking, intended to influence the oropha-ryngeal and respiratory sensory-motor mechanisms in order to improve function for sucking and feeding in preterm neonates.Basically, sensory-motor interventionscan also increase the volume of the consumed expressed or formula milk that consequently result in more weight gain among preterm neonates. However, empirical evidence for the effectiveness of the prefeeding intervention is scant inpreterm neonates' growth**(Salem et al ., 2016 & Khalessi,2015).**

Aim of the Study

This study aimed to determine effect of sensory-motor interventions on feeding outcomes and weight gain among preterm neonates after weaning from non-invasive ventilation.

Operational definition

In this study, feeding outcomes refers to the progress of the neonates' readiness for oral feeding, oral feeding abilities, non-nutritive sucking pattern, the volume of consumed milk, physiologic stability during oral feeding and behavioral state after feeding.

Novelty Journals

ISSN 2394-7330

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Research Hypothesis

1. Preterm neonates who receive sensory-motor interventions exhibit better feeding outcomes than those who do not.
2. Preterm neonates who receive sensory-motor interventions exhibit increase in body weight than those who do not.

2. MATERIALS AND METHOD

Materials

Research Design:

A quasi-experimental design was used to accomplish this study.

Setting:

This study was conducted at the Neonatal Intensive Care Unit (NICU) at Specialized Somouha University Hospital in Alexandria.

Subjects

Epi Info program was used to estimate the sample size using the following parameters

- Population size = 150 preterm neonates.
- Expected frequency = 50%.
- Acceptable error = 10%.
- Confidence coefficient = 95%.
- Minimum sample size =59 preterm neonates.

A convenience sampling of 60 preterm neonates who fulfilled the following inclusion criteria comprised the study subjects:

- Had homodynamic and physiological stability.
- Weaned from nasal CPAP since 48hours.

The preterm neonates who fulfilled the inclusion criteria were randomly assigned into two equal groups where one neonate was assigned to the study group and the next neonate was assigned to the control group alternatively.

- **Study Group**: consisted of 30 preterm neonates received sensory-motor interventions.
- **Control Group**: consisted of 30 preterm neonates received the routine NICU care.

Tools

Three tools were used to collect the needed data.

The tools for data collection were developed by the researchers after thorough review of related literature. They comprised the following:

Tool I: preterm neonates' Feeding Performance Assessment Tool:

This tool was developed by the researchers after thorough review of literature to assess feeding skills of preterm neonates **(Thoyreet al. 2005)**. It includes four parts as follow:

Part One: Characteristics of Preterm Neonates:

It entailed preterm neonates' characteristics such as sex, birth weight, type of delivery and diagnosison admission.

Part Two: Preterm Neonates' Readiness for Oral Feeding

It included body flexion, awake state, respiratory rate, and temperature and oxygen saturation.

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Part Three: Preterm Neonates' Oral Feeding Abilities

It included assessment of the following:

- Ability to organize oral-motor functioning
- Ability to remain engaged in feeding
- Ability to coordinate swallowing and breathing
- Ability to maintain physiologic stability during feeding

The presence of the sign in the readiness and feeding abilities categories is scored one while the absence is scored zero.

Part Four: Preterm neonates' behavioral state after oral feeding

It entitled neonates' behavior state such as quiet, alert, sleep and cry.

Tool II: Non-nutritive Sucking Pattern of preterm neonates Assessment Tool:

This tool was developed by the researchers after review of related literature to assess non- nutritive sucking pattern of preterm neonates **(Bahgatet al. 2017)**It included seven parameters, which are tongue movement, cupping, and jaw movement, sucking strain, sucking pause, rhythm and alert state.

- The presence of the sign is scored one while the absence is scored as zero.

Tool III: Preterm Neonates' Oral Feeding Efficacy and Weight gain Assessment Tool:

This tool was developed by the researchers after thorough review of literature to assess oral feeding efficacy of preterm neonates **(Lauet al. 2015 and Lau2011).**It included the following:

It included volume of transfers i.e. a percentage of the consumed milk volume relative to the prescribed volume and rate of transfers i.e. the volume of milk consumed relative to the duration of the oral feeding session [mL/min] and weight gain in grams.

Method

1. An official approval for conducting the study was obtained from the responsible administrative personnel after explaining the aim of the study.

2. The three tools of the study were developed after thorough review of the related literature.

3. Tools were submitted to a jury of five experts in pediatric nursing field for their content validity. Based on their comments; necessary modifications were done. The validity was 95% for Tool I and 98% for both Tool II and 94% for Tool III.

4. The reliability of Tool I, II and III were ascertained by measuring the internal consistency of their items using Cronbach alpha coefficient. The three tools were reliable as $\alpha = 0.87$ for Tool I, $\alpha = 0.86$ for Tool II and $\alpha = 0.90$ for Tool III.

5. A pilot study was carried out on six neonates to test the feasibility and applicability and clarity of the tools. Those preterm neonates were excluded from the study.

6. Initially, data concerning characteristics, readiness for oral feeding, oral feeding abilities of ,physiologic stability during oral feeding and behavioral state after oral feeding of every preterm neonate in the study and control groups were assessed at first day of interventions (after 48 hour from weaning from nasal CPAP) using tool I.

7. Pattern of non-nutritive sucking, oral feeding efficacy and weight gain of preterm neonates were also assessed at first day for the two groups using tool II and tool III.

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8. For the study group

- The sensory-motor interventions were performed once per day for 10 consecutive days for the preterm neonates.
- The preterm neonates were positioned on semi-sitting position.
- sensory-motor interventions were performed for 15-minutes, whereby the first 12minutes involved stroking the cheeks, lips, gums, and tongue, and the last 3minutes consisted of non- nutritive sucking with apacifier. These interventions were based on Fucile (2002) ( ) principle as follows:

a. Placing index finger at the base of the nose, compressing the **outer** tissues of **cheeks** while moving finger toward the ear, then down and toward the corner of the lip (ie, C pattern) and repeated the step4 times for each check.

b. Placing finger at **inner corner of lips while** compressing the **internal** tissue of cheeks then moving fingers back toward the molars and return to corner of lip. Repeated the step 2 times for each check.

c. Moving index finger in a circular motion, from the **lip** corner toward the center and to the other corner and repeated the step 4 times for each lip

d. Applying a sustained pressure with index finger at center of **lip curl**, then stretched it downward toward the midline, and repeated the step 2 times for upper and lower lipcurl.

e. Applied sustained pressure with index finger at the center of the **gum**, then slowly moving toward the back of the mouth and returning to the center of the mouth. Repeated the step 2 times for each side of the **upper and lower gum**.

f. Placing finger at the level of the molar between the **sideborders blade of the tongue** and the lower gum. Moving the finger toward midline and pushing the tongue towards the opposite direction. Immediately move the finger toward the cheek, stretching it. . Repeated the step 2 times for each side

g. Applying downward pressure on the tongue. Then, moving the finger a way toward the cheek and stretching it. Repeated the step 2 times for each side.

h. Applying a sustained pressure with index finger at into the hard palate for3 seconds. Then, move the finger down to induce a firm pressure on the tongue. Then, moving the finger back to the hard palate and repeated the step 4 times.

i. Placing the gloved finger at the midline, center of the **palate**, gently stroke the palate to elicit a suck, then introduced pacifier in mouth.

9. For the Control group: The preterm neonates received routine care of the NICU as no intervention was used before feeding just only inducing rooting reflex.

10. Every neonate in both groups was reassessed for their oral feeding readiness, oral feeding abilities, physiologic stability during feeding and behavioral state after feeding at the tenth day of interventions using tool I as well as non-nutritive sucking pattern and oral feeding efficacy and weight gain were reassessed using tool II and tool III.

11. Comparison between study and control groups regarding the feeding outcomes and weight gain among preterm neonates at completion of the study was done.

12. Data were collected over a period of eight months, started from the beginning of February to the end of October 2019.

13. Ethical considerations were considered all over the study phases included the following:

- Written informed consents were obtained from the neonates' guardians after explaining the aim of the study and their right to refuse to participate in the study or to withdraw at any time.
- Neonates ‘confidentiality of the collected data and privacy were maintained during implementation of the study.

The following statistical measures were used:

1. Descriptive Statistics:

1. Number and percentage were used for describing and summarizing qualitative data.
2. Minimum and maximum were used for describing and summarizing quantitative data.

3. Mean (□) was used to measure central tendency in statistical tests of significance.

4. Standard deviation (**SD**) is an average of the deviations from the mean. It was used for measuring the degree of variability in a set of scores.

2. Analytical Statistics:

1. Kolmogorov – Smirnov test was used to examine the normality of data distribution

2. Chi-square test, and Monte Carlo test were used to test the significance of results of qualitative variables

3. Comparison between means using either t-test for normally distributed quantitative variables or Mann-Whitney Test (**Z**) for abnormally distributed quantitative variables.

4. The 0.05 level was used as the cut off value for statistical significance (e.g. significant at P≤0.05).

3. RESULTS

Table (1) presents the demographic characteristics of the preterm neonates. It is revealed from the table that more than three quarters of the preterm neonates in the study group and two thirds of neonates in control group were in the first week of life (80.0% and 66.7% respectively).The mean age of the neonates in the study group was 4.1±2.81 days and 6.23±3.10 days in the control group with no significant statistical difference between the two groups. Moreover, 60% and 46.7% of the preterm neonates of both groups were males respectively. Regarding neonates' gestational age, it is observed that 80.0% of the neonates in the study group and 73.3% of the neonates of control group were very preterm. It is clear from the same table that 76.7% of the neonates in the study group and 66.7% of those in the control group had very low birth weight. Moreover, the majority of neonates 90.0% and 86.7% in both groups were delivered by caesarian section respectively.

Table 1: Demographic Characteristics of Preterm Neonates

Characteristics	Study Group		Control Group		Significance
	N n=30	%	N n=30	%	
Age/ days					X^2=1.36 P=0. 24
▪ 1-7	24	80.0	20	66.7	
▪ 8-14	6	20.0	10	33.3	
Min-Max	1-11		1-12		t= -2.87 P=0. 007
Mean±SD	4.1±2.81		6.23±3.10		
Sex					X^2=1.07 P=0. .301
▪ Male	18	60.0	14	46.7	
▪ Female	12	40.0	16	53.3	
Gestational age					
▪ Extreme Preterm	0	0.0	1	3.3	^{MC}P=0. 869
▪ Very Preterm	24	80.0	22	73.3	
▪ Moderate Preterm	4	13.3	7	23.3	
▪ Late Preterm	2	6.7	1	3.3	
Birth weight					
▪ Low birth weight	4	13.3	7	23.3	^{MC}P=0.599
▪ Very low birth weight	23	76.7	20	66.7	
▪ Extremely low birth weight	3	10.0	3	10.0	
Type of delivery					^{MC}P=1. 00
▪ Cs	27	90.0	26	86.7	
▪ NVD	3	10.0	4	13.3	

X^2: Chi-square Test t : Independent Samples Test P: Monte Carlo Test *Significant at P≤0.05

Effect of sensory-motor intervention on preterm neonates' readiness for oral feeding among preterm neonates is presented in Table (2). It is clear from the table that only 20% of preterm neonates among the study group and 16.7% of preterm

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ISSN 2394-7330

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neonates among the control group were able to maintain muscle tone and body flexion before feeding in the first day of interventions. On the 10th day, nearly one half of preterm neonates of both groups were able to maintain their muscle tone (53.3% for study group and 50% for the control one). Similarly, a very small percentage of preterm neonates in both groups (13.3% for study group and 20% for the control group) had a wake state during feeding as well as they had open eyes that is directed toward feeding (13.3% for the study group and 6.7% of preterm neonates in the control group in both signs) at the first day of interventions. These signs of readiness for oral feeding were improved at the 10th day where 60% of preterm neonates in the study group and 46.7% of the neonates in the control groupmaintained their wakefulness and opened eyes during oral feeding.

Physiologic parameters such as respiratory condition, body temperature and O_2 saturation also reflect the neonates' readiness for oral feeding. The same table shows that approximately half (50% and 56%) of the preterm neonates in both groups had stable physiologic parameters at the 1st day of interventions respectively. This stability of the physiologic parameters was increased at the 10th day of interventions.

The mean score of the preterm neonates' readiness for oral feeding at the first day was 2.40±1.73 for the study and 1.93±1.42 for the control one. While, the total score was 4.53±1.38 for the study group and 2.166±1.47 for the control group and significant statistical difference was observed between preterm neonates of both groups regarding their readiness for oral feeding at the 10th day where (P= 0000).

Table 2: Effect of Sensory-motor Interventions on Preterm Neonates' Readiness for Oral Feeding

Oral Feeding Readiness	1st day				Sig.	10th day				Sig.
	Study Group		Control Group			Study Group		Control Group		
	No	%	No	%		No	%	No	%	
1. Maintains muscle tone and body flexion before feeding	6	20.0	5	16.7	^{MC}P=0.326	16	53.3	15	50.0	**^{MC}P=0.034***
2. Had awake state	4	13.3	6	20.0		18	60.0	14	46.7	
3. Eyes are opened and directed toward feeding	4	13.3	2	6.7		18	60.0	14	46.7	
4. Respiratory rate less than 60 c/m	15	50.0	17	56.7		24	80.0	19	63.3	
5. Axillary temperature more than 36.5 C^O	17	56.7	17	56.7		23	76.7	20	66.7	
6. Baseline oxygen saturation >95%	18	60.0	20	66.7		28	93.3	25	83.3	
Mean score ± S.D	2.40±1.73		1.93±1.42		Z^{MW}= -0.717 P=0. 474	4.53±1.38		2.166±1.47		**Z^{MW}= -5.549 P=0 .000***

^{MC}P: Mont Carlo Exact Probability test Z^{MW}: Mann Whitney Test *Significant at *P≤0.5 **P< 0.001 ***P< 0.0001.

Table (3) illustrates Effect of sensory-motor intervention on preterm neonates' oral feeding abilities among preterm neonates at 1st and 10th days of interventions. It is clear from the table that all of the neonates of both groups had decreased feeding abilities at the first day of interventions while the study group showed a dramatic improvement in their oral feeding abilities than the control one.

Regarding the preterm neonates' ability to organize oral-motor functioning, it is observed that less than one quarter of the neonates in both study and control groups were able to open their mouths promptly when lips are stroked at feeding onsets (23.3% for each).At the 10th day, the majority of the preterm neonates in the study group (80.0%) were able to open their mouths promptly when lips are stroked at feeding onsets compared to only 30% of the neonates in the control group. Furthermore, very small percentages of the preterm neonates in both groups were able to maintain a smooth, rhythmic pattern of suckingonce feeding is under way at 1st day (10.0% for the study group and 13.3% for the control group). On

Novelty Journals

ISSN 2394-7330

International Journal of Novel Research in Healthcare and Nursing
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the other hand the majority of the preterm neonates in the study group were able to maintain the same skill (90.0% compared to only 40% of those neonates in the control group. In the same manner, 1:1 suck-swallow ratio and stable suck-swallow interval were maintained among 80% and 70.0% of the preterm neonates in the study group at the 10th day compared to only 43.0% and 40.0% of preterm neonates in the control group respectively.

The preterm neonates' ability to remain engaged in feeding is also shown in same table. It is clear that only 20.0% of preterm neonates in the study group and 16.7% of those in the control one were able to maintain flexed body position with arms toward midline during feeding at the first day of interventions. Meanwhile, 63.3% of the preterm neonates in the study group developed the skill compared to 33.3% of neonates in the control group at the 10th day.

The ability to coordinate swallowing and breathing is assessed through two skills. First, 16.7% of the preterm neonates in the study group were able to engage in long sucking bursts (7–10 sucks) without behavioral stress signs or an adverse or negative cardiorespiratory response at 1st day of interventions compared to 40.0% of neonates in the control group. This skill undergone an obvious improvement among the preterm neonates in the study group (67.7%) compared to less improvement among neonates in the control group (53.3%). Similarly, 80.0% of the neonates in the study group did not stop sucking to breath at the 10th day of interventions compared to only 46.7% of preterm neonates in the control one.

The mean score of the oral feeding abilities among preterm neonates was 3.38±1.80 for the study group and 2.16±1.17 for the control group at the 10th day, where high significant statistical difference was found (P =0.000).

Table 3: Effect of Sensory-motor Interventions on Preterm Neonates' Oral Feeding Abilities

Oral Feeding Abilities	1st day				Sig.	10th day				Sig.
	Study Group		Control Group			Study Group		Control Group		
	No	%	No	%		No	%	No	%	
● ***Ability to Organize Oral-Motor Functioning***					MCP=0.43					MCP= 0.000***
1. Opens mouth promptly when lips are stroked at feeding onsets	7	23.3	7	23.3		24	80.0	9	30.0	
2. Once feeding is under way, maintains a smooth, rhythmic pattern of sucking	3	10.0	4	13.3		27	90.0	12	40.0	
3. Maintains 1:1 suck-swallow ratio	4	13.3	5	16.7		24	80.0	13	43.3	
4. Maintains a stable suck-swallow interval	8	26.7	7	23.3		21	70.0	12	40.0	
● ***Ability to Remain Engaged in Feeding***										
5. Maintains flexed body position with arms toward midline during feeding	6	20.0	5	16.7		19	63.3	10	33.3	
● ***Ability to Coordinate Swallowing and Breathing***										
6. Able to engage in long sucking bursts (7–10 sucks) without behavioral stress signs or an adverse or negative cardiorespiratory response	5	16.7	12	40.0		23	76.7	16	53.3	
7. Don't stop sucking to breath	6	20.0	8	26.7		24	80.0	14	46.7	
Mean score ± S.D	1.66±1.88		1.00±1.28		ZMW= -1.686 P=0. 092	3.38±1.80		2.16±1.17		ZMW= -5.209 P=0 .000***

MCP: Mont Carlo Exact Probability test ZMW: Mann Whitney Test *Significant at *P≤0.5 **P< 0.001 ***P< 0.0001.

Table (4) illustrates the Effect of sensory-motor intervention on preterm neonates' ability to maintain physiologic stability during feeding. It is obvious that half of the preterm neonates (50.0% and 53.3%) in both the study and control groups maintained their O_2 saturation above 90% during feeding at the first day of intervention . The percentage of preterm neonates who maintained their O_2 saturation above 90% increased at the 10th day of interventions to 86.7% compared to 63.3% of the neonates in the control group. Similarly, the preterm neonates in the study group showed greater physiologic stability during oral feeding at the 10th day of interventions where 83.3% of them did not experience increase in their heart rate 15 b/m above their base line, no use accessory muscles/grunting (86.7%), no colour change (93.3%) or apnea (93.3%) compared to 73.3%, 56.7%, 70.0% and 73.3% among preterm neonates in the control group respectively with high significant statistical difference between the two groups in relation to their physiologic stability during feeding (p= 0.008).

Table 4: Effect of Sensory-motor Interventions on Preterm Neonates' Ability to maintain Physiologic stability during feeding

Physiologic state during feeding	1st day				Sig.	10th day				Sig.
	Study Group		Control Group			Study Group		Control Group		
	No	%	No	%		No	%	No	%	
1. O_2 saturation is maintained above 90%	16	53.3	15	50.0	MCP=0.21	26	86.7	19	63.3	MCP=0.008**
2. No raise in heart rate (15 b/m above base line)	13	43.3	12	40.0		25	83.3	22	73.3	
3. No use accessory muscles / grunting	11	36.7	13	43.3		26	86.7	17	56.7	
4. No colour change	16	53.3	16	53.3		28	93.3	21	70.0	
5. Noapnea	15	50.0	16	53.3		28	93.3	22	73.3	
Mean score ± S.D	2.36±1.29		2.40±1.47		ZMW= -0.303 P=0 .762	4.43±0.68		3.36±1.37		ZMW= -3.275 P=0 .001**

MCP: Mont Carlo Exact Probability test **ZMW: Mann Whitney Test** ***Significant at *P≤0.5 **P< 0.001 ***P< 0.0001.**

Table (5) highlights effect of sensory-motor interventions on preterm neonates' behavioral state during the first five minutes after oral feeding. It is clear from the table that almost two thirds of the neonates (66.7% and 70.0%) in both the study and control groups were fussy or cried after feeding at the first day of interventions respectively. On the other hand, 63.3% of the preterm neonates in the study group slept after feeding compared to only 20% of those neonates in the control group. While, one quarter of the neonates in both groups were quiet and alert (26.7% for each group).Furthermore, more than half of the preterm neonates (53.3%) in the control group remain fussy or cried during the first five minutes after feeding compared to only 10% of preterm neonate of the study group. Highly significant statistical difference was found between the two groups regarding the behavioral state after feeding (p= 0.000)

Table 5: Effect of Sensory-motor Interventions on Preterm Neonates' Behavioral State during the First Five Minutes after oral feeding

Behavioral State after Oral feeding	1st day				Sig.	10th day				Sig.
	Study Group		Control Group			Study Group		Control Group		
	No	%	No	%		No	%	No	%	
▪ Fussy/Cry	20	66.7	21	70.0	MCP=0.854	3	10.0	16	53.3	X2= 15.65 P=0.000***
▪ Quiet /Alert	8	26.7	6	20.0		8	26.7	8	26.7	
▪ Sleep	2	6.7	3	10.0		19	63.3	6	20.0	

MCP: Mont Carlo Exact Probability test ***Significant at** *****P< 0.0001.**

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ISSN 2394-7330

International Journal of Novel Research in Healthcare and Nursing
Vol. 7, Issue 1, pp: (702-716), Month: January - April 2020, Available at: www.noveltyjournals.com

Table (6) shows effect of sensory-motor interventions on preterm neonates' non-nutritive sucking pattern. It is obvious that there is dramatic improvement of non-nutritive sucking pattern among the preterm neonates in the study group. The table reveals that tongue movement was observed among only 26.7% of the preterm neonates in the study group and 20% of those neonates in the control group at the first day of interventions. On the other hand, at the 10th day of interventions, tongue movement during non- nutritive sucking was observed among 80% of the neonates in the study group compared to only 46.7% of neonates in control group. Moreover, 16.7% of preterm neonates who had cupping of the tongue during feeding at the first day among study group increased to 90% at the tenth day. Meanwhile, 13.3% of preterm neonate among control group increased to 50% at the tenth day.

The same table also illustrates that, at the first day of interventions 16.7% of the neonates in the study group had sucking pause less than 5 seconds and 20% of them maintained rhythmic sucking compared to 10% and 26.7% of the neonates in the control group. At the 10th day of interventions, sucking pause was observed among 73.3% of neonates in the control group as well as 76.7% of them maintained rhythmic sucking compared to 53.3% and 50.0% of the neonates in the control respectively. Significant statistical difference between the study and control groups regarding non-nutritive sucking pattern (p= 0.001).

Table 6: Effect of Sensory-motor Interventions on Preterm Neonates' Non-Nutritive Pattern of Sucking.

Non-Nutritive Sucking Pattern	1st day				Sig.	10th day				Sig.
	Study Group		Control Group			Study Group		Control Group		
	No	%	No	%		No	%	No	%	
1. Presence of tongue Movement	8	26.7	6	20.0	MCP= 0.359	24	80.0	14	46.7	MCP= 0.001**
2. Presence of tongue cupping during feeding	5	16.7	4	13.3		27	90.0	15	50.0	
3. Presence of jaw Movement	11	36.7	10	33.3		24	80.0	16	53.3	
4. Presence of sucking Strain	5	16.7	3	10.0		22	73.3	13	43.3	
5. Presence of sucking Pause less <5 sec	6	20.0	8	26.7		22	73.3	16	53.3	
6. Maintenance of Rhythm of sucking	6	20.0	9	30.0		23	76.7	15	50.0	
Mean score ± S.D	1.36±1.63		1.33±1.446		ZMW= -.100 P= 0. 920	4.73±1.14		2.96±1.47		ZMW= -4.347 P= 0.000***

MCP: Mont Carlo Exact Probability test ZMW: Mann Whitney Test *Significant at **P< 0.001 ***P< 0.0001.

The effect sensorimotor intervention on preterm neonates' oral feeding efficacy is illustrated in table (7). It is observed that almost two thirds of the neonates (66.7% and 63.3%) in both study and control group consumed less than 30% to less than 50% of milk volume relative to the prescribed volume at the first day respectively. At the 10th day of interventions, more than one third of the neonates in the study group (36.7%) consumed more than 90% of the milk volume relative to the prescribed volume compared to only 10% of the neonates in the control group. Furthermore, the mean of volume transfer was 44.33±1.52 for the study group compared to 43.36±1.52 of neonates in the control group at the first day while the mean of volume transfer was 82.90±14.12 for the neonates in the study group compared to 71.33±16.96 and the difference between the two groups was statistically significant (p= 0.006).

The same table also shows that the mean volume of milk consumed relative to the duration of the oral feeding session for the neonates in the study group at the 10thday of intervention was 1.97±0.34 ml/minute compared to 1.06±0.32 ml/minute for the neonates in the control one. Significant statistical difference was found between the study and control groups regarding the rate of transfer (p= 0.000).

Novelty Journals

ISSN 2394-7330

International Journal of Novel Research in Healthcare and Nursing
Vol. 7, Issue 1, pp: (702-716), Month: January - April 2020, Available at: www.noveltyjournals.com

Table 7: Effect of Sensory-motor Interventions on Preterm Neonates' Oral Feeding Efficacy

Milk transfer	1st day				Sig.	10th day				Sig.
	Study Group		Control Group			Study Group		Control Group		
	No	%	No	%		No	%	No	%	
#The volume transfers [%].										
▪ **Less than 30%**	3	10.0	4	13.3	MCP=0.77	0.0	0.0	0.0	0.0	MCP=0.02*
▪ **30%-**	20	66.7	19	63.3		1	3.3	5	16.7	
▪ **50%-**	3	10.0	5	16.7		4	13.3	10	33.3	
▪ **70%-**	4	13.3	2	6.7		14	46.7	12	40.0	
▪ **90%-**	0.0	0.0	0.0	0.0		11	36.7	3	10.0	
Min-Max	21-77		19-71		t= 0.73 P=0. 47	40-100		35-100		t= 2.87 P=0. 006**
Mean ± S.D	44.33±1.52		43.36±1.52			82.90±14.12		71.33±16.96		
Rate of transfer: [mL/min].										
Min-Max	0.22-0.97		0.21-0.99		t= 0.27 P=0.79	0.92-2.2		0.64-1.80		t= 5.28 P=0. 000***
Mean ± S.D	0.42±0.197		0.41±0.189			1.97±0.34		1.06±0.32		

MCP: **Mont Carlo Exact Probability test t= Independent Samples Test *Significant at *P≤0.5 * **P< 0.0001**

#The volume transfers: a percentage of the consumed milk volume relative to the prescribed volume and rate of transfers [%].

Rate of transfer: The volume of milk consumed relative to the duration of the oral feeding session [mL/min].

Table (8) presents effect of sensory-motor interventionson preterm nneonates'' weight gain. At the first day, it was found that the mean body weight among the neonates of both groups were 1115±5.23 and 1121±5.16 respectively. On the other hand, the mean body weight of preterm neonates of the study group was 1495±5.13 compared to 1371±5.15 of the preterm neonates of control group at 10th day and the difference was statistically significant (p=0.000).

Table 8: Effect Sensory-motor Interventions on Preterm Neonates' Weight Gain

Milk transfer	1st day		Sig.	10th day		Sig.
	Study Group	Control Group		Study Group	Control Group	
Min-Max	1034-1235	1028-1139	t=- 0.42 P=0.67	1420-1585	1272-1458	t= 4.35
Mean ± S.D	1115±5.23	1121±5.16		1495±5.13	1371±5.15	p=0. 000***

t= Independent Samples Test *Significant at *P≤0.5 * **P< 0.0001

4. DISCUSSION

Oral feeding is a complex process, which involves suck-swallow-breathe coordination, cardiorespiratory stability, behavioral state organization and neuromuscular support **(Song, 2019).** Skills that needed for full oral feeding of preterm neonates are challenging, especially those who are born at an extremely low gestational age (GA) (**Khan et al., 2019**). Interventions as oral sensory-motor simulation are needed and vitally important to improve the feeding performance among preterm neonates. Therefore, the current study investigated the effect of sensory-motor interventions on feeding outcomes and weight-gain among preterm neonates after weaning from non-invasive mechanical ventilation.

Criteria to determine when to best initiate oral feeding among preterm neonates are still unclear (**Osman et al., 2019)**. So, readiness for oral feeding among neonates should be assessed as indicators for transition from enteral tube to oral feeding(**Prade et al., 2016).**In this context, the current study assessed the readiness for oral feeding among studied groups by maintaining muscle tone and body flexion before feeding, physiologic stability and use accessory muscles/grunting. The results revealed that preterm neonates in both groups are almost equal in maintaining muscle tone and body flexion before feeding after the intervention while, preterm neonates in the study group were improved at the 10^{th} day after the intervention in all physiologic parameters such as respiratory condition, body temperature and O_2 saturation. Furthermore, there was greater physiologic stability during oral feeding at the 10th day of interventions in preterm neonates in study group compared with those in the control group such as did not experience increase in their heart rate 15 b/m above their base line, did not use accessory muscles/grunting, did not have color change or apnea. These results could be attributed to the positive impact of the sensory-motor interventions on muscle maturation and stability of physiologic parameters of preterm neonates as indicators of readiness for oral feeding.

The results of the current study confirmed the significant effect of sensory-motor interventions on improvement of oral feeding abilities such as ability to organize oral-motor functioning, ability to remain engaged in feeding, ability to coordinate swallowing and breathing and don't stop sucking to breath were investigated. These findings are supported by the development of structures, including the lips, tongue, palate, jaw, pharynx, larynx and oesophagus as contributing factors to improve the preterm neonate's feeding ability **(Khan et al.,2019).** So, the current results may be contributed to the effect of sensory-motor interventions on the strengthened the oral motor structures and its significant effect in providing the experience of sucking. These findings are congruent with a study done by **Greene et al.,(2016), i**n his study, the preterm infants who received oral sensory motor stimulation achieved independent oral feeding and oromotor coordination earlier two weeks compared with those in control group. In addition, **Song (2019)** found that oral stimulation improves feeding development in pretermneonates. Furthermore, **Lima et al. (2015)** concluded that oral sensory motor stimulation decrease the period of transition to full oral feeding system among preterm neonates.

It is obvious from the current study that there is dramatic improvement of sucking pattern among the preterm neonates in the study group compared with control group. Significant statistical difference between the study and control groups regarding non-nutritive sucking pattern was found.These results are in agreement with **Younesian et al. (2015)** who found that oral sensory motor stimulation have strengthened the oral motor structures which have a significant role in adequate sucking. In addition, **Hima et al. (2019)** investigated the effect of nonnutritive sucking: The infants in the intervention group had longer sucking bursts during breastfeeding and showed faster transition to mature stages of nonnutritive sucking than those in the control group.

Furthermore, it is clear from the current results that preterm neonates in the study group experienced more sleep and less crying compared with preterm neonates in the control group. In addition, there was highly significant statistical difference between the two groups regarding the behavioral state after feeding. These results are in congruence with the findings of **Rosen (2008)30** who concluded that feeding has a profound effect on sleep pattern of neonates. These results could be attributed to the effect of sensory-motor interventions on improvement of oral feeding abilities and efficacy that consequently leads to more sleep and less crying among preterm neonates in the study group. These results are in the same line with **Griffith et al. (2017)** who found positive relationship between behavioral states and oral feeding efficiency in preterm infants

Variables such as oral feeding proficiency, milk transfer rate have also been used as important quantitative indicators and predictors of successful oral feeding skills **(Prade et al., (2016).**Initially, the results of the present study revealed that almost two thirds of the neonates in both groups consumed less than 30% to less than 50% of milk volume relative to the prescribed volume at the first day. These results could be justified in the light of the fact that preterm neonates have less developed sucking and swallowing mechanisms. Numerous factors could also contribute in poor feeding abilities among preterm neonates such as, neurological immaturity, poor muscle tone, depressed rooting, sucking and gaging reflexes. Moreover, the existence of several co-morbidities e.g. respiratory disease can deteriorate the condition. These can deprive the neonate from adequate oral feeding intake and weight gain. **(Salem et al., 2016)**.On the other hand, The results of the current study revealed that the percent of preterm neonates who consumed milk volume relative to the prescribed volume was increased on the 10^{th} day of the study group compared to those in the control group. Also, the mean volume of milk consumed relative to the duration of the oral feeding session for the neonates in the study group at the 10^{th} day of

intervention was significantly more than that of the control group. These results could be related to the improvement of the neonate's readiness to oral feeding, physiologic stability as well as feeding abilities, sucking pattern and sucking-swallowing-breathing coordination. This is supported by the findings of **White-Traut et al. (2005)** who reported that feeding efficiency may be predicted by the increased frequency of feeding readiness immediately prior to feeding. These results are similar to the results of study by **Younesian et al. (2015)** who found that oral sensory motor stimulation had a direct positive impact on speeding up the maturation of their infants' oral feeding performances. The findings of the present study are congruent with a study done by **Zhang et. al (2014)**who reported that oral sensory motor stimulation improves feeding proficiency. Moreover, these findings are in the same line with **Lyu et al. (2014)** who conducted a similar study in China and found that oral stimulation had benefits feeding efficiency upon reaching successful oral feedings among the experimental group when compared to the control group. Furthermore, the results of the present study are in agreement with a meta-analysis done by **Tian et al (2015)** to evaluate the effectiveness of oral motor intervention in improving the status of oral feeding in preterm infants using 11 randomized controlled trials (RCTs).The results of the meta-analysis revealed that oral motor intervention is associated with the reduced transition time, shorten hospital stays and increased feeding efficiency.

Regarding the weight gain, the present study findings revealed that the mean body weight of preterm neonates of the study group was increased significantly compared to those of the control group at 10th day of the intervention. These results could be attributed to the fact that improved feeding ability, volume and rate of milk transfer consequently associated with weight gain among preterm neonates. Similarly, **Tian et al (2015)** concluded that oral motor intervention is associated with improved feeding efficiency rather than weight gain. On contrary, **Lyu et al. (2014)** reported no difference in weight at the initiation of oral feeding, while the experimental group had significantly lower weight than the control group upon reaching independent oral feeding and discharge from the hospital. The current findings are also contradicted with **Khodagholi etal. (2018)** who reported that nonnutritive sucking had no effects on their daily weight gain.

5. CONCLUSION

Based on the findings of the current study, it can be concluded that preterm neonates who received sensory-motor interventions exhibited better readiness for oral feeding, oral feeding abilities, sucking pattern, and physiologic stability during oral feeding. Moreover, applying of sensory-motor intervention was effective in enhancement of the consumed milk volume, and weight gain.

6. RECOMMENDATIONS

Based on the findings of the current study, the following recommendations were suggested:

- Educational programs should be provided for neonatal nurses about the Sensory-motor interventions to improve feeding outcomes among preterm neonates.
- The sensory-motor interventions should be included in the policies, protocols and procedures of the written guidelines for caring of the preterm neonates.

ACKNOWLEDGMENT

We are grateful to all mothers who participated in this study. In addition, we thank all the staff of the in the Neonatal Intensive Care Unit of at Specialized Somouha University Hospital for their cooperation during the study.

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