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Effect of Mothers' Heart Beats on Premature Infants' Physical and Physiological Parameters

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Abstract: Background: One of the developmental supportive care interventions introduced to NICUs is auditory and tactile stimulation. Early exposure to auditory stimulation especially with maternal heartbeats, represents a unique source of sensory stimulation for premature infants. **Purpose:** To determine the Effect of Mothers' Heartbeats on Premature Infants' physical and physiological parameters. **Research design**: A quasi-experimental research design (study and control groups) was used to complete this study. **Settings**: The study was conducted in the Neonatal Intensive Care Unit at Damanhur National Medical Institution (DMNI) and the Neonatal Intensive Care Unit at Kafr Eldwar General Hospital, at El Beheira Governorate-Egypt. **Sampling**: A purposive sample of 60 premature infants from the previously mentioned settings were selected. **Instruments**: Two Instruments were used to collect the necessary data. Instrument one: Characteristics and Medical History of Premature Infants Assessment Sheet and Instrument two: Premature Infants Physical and Physiological Parameters Assessment Tool. **Results**: The Heart Beats (HB) Group exhibited significantly lower heart and respiratory rates $p < 0.001$ and slightly lower temperatures $p = 0.002$ than the control group, with consistently higher oxygen saturation $p < 0.001$. Also, maternal heartbeat exposure significantly positively affected weight gain and mid-arm circumference in the HB Group, with highly statistically significant differences $p < 0.001$. **Conclusion**: Premature infants who heard their mothers' heartbeats had better physical and physiological parameters in the study group compared to control group. **Recommendations**: Auditory stimulation such as mothers' heartbeats needs to be incorporated into the care of premature infants in the NICU

Keywords: *Mothers' Heart Beats - Premature Infants' -physical parameters - physiological parameters*

Introduction

Premature birth remains a significant global health issue, affecting an estimated 15 million infants each year, and is a leading cause of mortality among children under five (World Health Organization [WHO], 2023). Premature infants, born before 37 weeks of gestation, often experience underdeveloped organs and a range of physiological and developmental challenges, such as respiratory distress, neurodevelopmental delays, and fragile immune systems. The sudden separation from the maternal environment exacerbates these vulnerabilities, leading to difficulties in self-regulation and increased susceptibility to environmental stressors. (Abd EL-Fatah, & Mahmoud 2023)

Regarding growth parameters, premature infants experience early postnatal weight loss of up to 15%, typically regained within 8–24 days. Once regained, they gain weight at a rate of 10–30 g/kg/day, similar to fetal growth in the third trimester. Length growth peaks between 31–34 weeks gestation at about 0.8–1.3 cm/week and reflects nutrient adequacy. Head circumference, which correlates with brain development, grows steadily, and mid-arm circumference, indicating fat and muscle mass, is also monitored. (Leifer, 2018). Premature birth disrupts organ system development, leading to complications. Immature lungs lack surfactant, causing respiratory distress syndrome, while an underdeveloped respiratory center results in apnea of prematurity. The cardiac system is affected by delayed circulatory transition and immature myocardium, which reduces cardiac energy stores and leads to hypotension. (Heikkilä K 2021)

Fetal auditory recognition does not begin by hearing sounds but rather by sensing sounds from internal, such as maternal heartbeats, voice, and bowel peristalsis. Hearing begins at approximately 25-26 weeks of gestation. Also, the fetus can perceive auditory and react to language, music, and meaningful environmental sounds at 29 weeks of gestation. Auditory stimulation benefits premature infants by improving physiological stability, feeding tolerance, and weight gain while promoting neurological, language, and immune system development. It fosters parent-infant bonding, reduces stress hormones, and enhances immune function. (Chorna et al., 2019).The mother’s heartbeat is the primary intrauterine auditory stimulus, heard by the fetus, providing a sense of security and fostering early attachment, which is crucial for healthy social and emotional development. This rhythmic sound serves as a predominant source of sensory stimulation, helping regulate the fetus's heart rate and promoting feeding tolerance. However, in the Neaonatal Intensive Care Unit NICU, premature infants lose exposure to this soothing stimulus due to unfiltered auditory stimuli, which can impact their development and stability. Reintroducing maternal heartbeat sounds can positively influence physiophysical parameters and provide

comfort to premature infants. (Hibiya-Motegi R,2020)

Nurses in NICU monitor infants' physiological parameters four times a day for all stable infants and at increased frequency for critically ill ones. Oxygen saturation level is maintained above 90% and supplemental oxygen is administered when levels fall below 85%. The respiration is monitored for fast breathing which is more than 60 breaths per minute for neonates and the presence of apnea episodes. A heart rate of 120-160 beats per minute is normal while temperature should be maintained at 36.5-37.5 ℃. The nurse employs measures to prevent hypothermia such as keeping incubator doors/portholes closed, using radiant warmers, wrapping neonates in a blanket when out of incubator, and encouraging kangaroo care for temperature stabilization. Auditory stimulation has been linked to cardio-respiratory stability which is critical for optimal outcomes for premature infants (Gallagher et al., 2017). Once premature infants are medically stable, the focus of nursing care shifts from survival to growth and development. Growth monitoring is another aspect of nurses' responsibilities in NICU. Nurses in NICU assess the weight and mid-upper arm circumference of premature infants to monitor physical growth and for early detection of deviations from normal (Lake et al., 2016).

Therefore, nurses in NICU have a dual role where the care provided should be distributed between premature infants and their families. They must have a passion for working with these infants and their families. Furthermore, nurses should tolerate the high-pressure, fast-paced environment in the NICU. They should provide care for vulnerable newborn infants who require intensive nurturing and round-the-clock attention. Nurses in NICU must be creative and have the talent to select the best safe strategy to improve premature infants' health conditions (Bry & Wigert, 2019). Thus, the current study aimed to Determine the Effect of Mothers' Heartbeats on Premature Infants' Physical and Physiological Parameters. The findings from this research may offer vital insights into the development of non-invasive, cost-effective interventions that support holistic health and neurodevelopmental trajectory of premature infants.

Purpose:

To determine the Effect of Mothers' Heart Beats on Premature Infants' Physical and Physiological Parameters

Research Hypotheses

1) Premature infants who listen to mothers' heartbeats are expected to exhibit more stability in Physical parameters than those who do not listen.

2) Premature infants who listen to mothers' heartbeats are expected to exhibit more stability in physiological parameters than those who do not listen.

Operational Definitions:

Physical Parameters:

Physical parameters include weight and mid-arm circumference of premature infants.

Physiological Parameters:

Physiological parameters are body temperature, heart rate, respiratory rate, and oxygen saturation.

Methods:

Research Design

A quasi-experimental research design (study and control groups) was used to complete this study.

Setting

The study was conducted at Damanhur National Medical Institution's Neonatal Intensive Care Unit (DMNI) and the Neonatal Intensive Care Unit in Kafr Eldwar General Hospital, at El Beheira Governorate- Egypt.

Sampling

A purposive sample of 60 premature infants from the previously mentioned settings who fulfilled the following criteria comprised the study subjects:

- 28 weeks to less than 37 weeks of gestation.
- Four days postnatal age.
- Critically ill and those on mechanical ventilators were excluded.
- Free from neonatal infections such as severe sepsis or necrotizing enterocolitis.
- Not on any sedatives.
- Free from cardiac congenital malformation and structural anomalies of GIT.
- Receiving enteral feeding.

Mothers' Heart Beats Group (Study group):

Thirty premature infants who listened to their mother's heartbeats in addition to the unit's regular care

Control group:

Thirty premature infants who received only the routine care of the unit.

Infants were randomly assigned to two equal groups: the mothers' heart beats group HB (study group) and the control group (each group consisted of 30 premature infants) as follows: 1st premature infant for the control group then the 2nd premature for mothers' heart beats group and so…. on

Calculation of sample size:

The studied sample was estimated based on Epi info program which is used to estimate the sample size using the following parameters:

- Total population approximately equals 100 neonates (representing the average number of children admitted to the previously mentioned setting in the last four months before data collection).
- Confidence level 95%
- Error level 5 %
- Expected frequency 50%
- The final sample size was 60 premature infants

Instruments

Two Instruments were used to collect the necessary data.

Instrument one: Characteristics and Medical History of Premature Infants Assessment Sheet

This tool was developed by researchers. It was divided into two parts:

- **Part1**: Biosociodemographic characteristics of premature infants as gestational age, gender, birth weight, and current weight.
- **Part 2**: Medical history of premature infants as admission date, type of delivery, ante and intrapartum problems of the mothers, and current diagnosis.

Instrument two: Premature Infants Physical and Physiological Parameters Assessment Tool

This tool was developed by the researchers based on WHO classification (World Health Organization [WHO], 2019) to assess premature infants' Physical and Physiological Parameters. It consisted of two parts:

- **Part one** : Premature infants' physical parameters as weight in grams and mid-arm circumference in centimeters
- **Part two**: Premature infants' physiological parameters included heart rate, respiratory rate, temperature, and oxygen saturation.

Pilot study:

A pilot study was carried out on 6 children (10% of the total sample size) to test the instruments' applicability and clarity. Those children were excluded from the study sample.

Reliability:

The reliability of instrument two was determined by measuring the internal consistency of its items using Cronbach's Alpha coefficient test and the result was 0.855 which was accepted .

Validity

Instruments one and two were developed and submitted to a jury of 5 experts in the field of pediatric nursing to assess content validity. Recommended changes were done. The Content validity value was 92%.

Ethical considerations

Approval from the Research Ethical Committee, Faculty of Nursing, Damanhur University (67-b 15/12/2022) was obtained. After explaining the purpose of the study and the infant's mother's right to participate voluntarily and withdraw from it at any time, each premature infant's mother was given written informed consent. The privacy of premature infants was considered, and the confidentiality of the data was assured.

Procedure

1) An official letter from the Faculty of Nursing was sent to appropriate authorities in the Neonatal intensive care unit at Damanhur National Medical Institution (DMNI) and the Neonatal intensive care unit in Kafr Eldwar General Hospital for permission to conduct the study after explaining the purpose of the study.

2) On the 4th postnatal day, the premature infants' physical and

physiological parameters were assessed for the two groups as base data.

a) Physical parameters were measured as follows: Weight: They were weighed naked before the first feed at 9 AM. The researcher used an electronic scale, which was disinfected by alcohol and calibrated at zero before each measure. Mid-arm circumference (MAC) was measured at the midpoint between the tip of the acromion and the olecranon processes on the posterior aspect of the arm while it was flexed 90 degrees at the elbow. The researcher placed the non-stretchable tape around the infant's arm without compression of soft tissues.

b) Physiological parameters included body temperature, apical pulse, respiration, and oxygen saturation. Body temperature was measured axillary using a digital thermometer and pulse was counted apically using a medical stethoscope. Respiratory rate was measured by counting breaths per full minute and oxygen saturation was measured using a portable pulse oximeter.

3) Study Group (mothers' heartbeats group): Inside the incubator, each premature infant heard the mother's heartbeats on record. Each premature baby's mother's heartbeat was recorded with a digital stethoscope.

4) The researchers put a premature infant in a supine position and the recorded mother's heartbeats played for 15 minutes once daily in the morning shift starting on day 4 of life up to day 14 of life (10 days). Recorded mother's heartbeats were played through a wireless JBL headphone, which has been validated for safety and feasibility. The decibel level was adjusted to 45 Db (Bozzette, 2008; van der Heijden et al., 2016) after consultation with a specialist using a TM-102 sound level meter.

5) The control group: Premature Infants in this group did not receive any specific stimulation; rather they received routine care in the NICU only.

6) All premature infants in the two groups were monitored for physical parameters after 7 (1st week), 14 (2nd week), 21 (3rd week), and 28 (4th week) days of the intervention.

7) Physiological parameters were monitored before and after the intervention for the study group and once for the control group during the ten days

8) Infection control measures were followed to prevent infection. They included hand washing, sanitizing hands using alcohol, and decontamination of the study instruments such as thermometers, measuring tape, stethoscopes, and headphones with alcohol swabs before and after each use.

9) The data were collected during a period of 4 months which started from January 2023 to April 2023.

Statistical Analysis

The raw data were coded and transformed into coding sheets. The results were checked. Then, the data were entered into SPSS system files (SPSS package version 20) using a personal computer. Output drafts were checked against the revised coded data for typing and spelling mistakes. Finally, analysis and interpretation of data were conducted. The following statistical measures were used. Descriptive statistical measures included numbers, and percentages (Minimum, Maximum, Arithmetic mean, and Standard deviation). Statistical analysis tests included Chi-square, student t-test, and paired t-test. The graphical presentation included bar charts for data visualization. The significance of the results was at the 5% level of significance.

Results:

Table1 illustrates the sociodemographic characteristics of premature infants. It revealed that the highest percentage of premature infants had gestational age ranged from 30 to less than 32 weeks of gestation for both of the studied groups (40% for the heartbeats group and 50% for the control group) with a mean gestational age 31.31±1.24 for those hearing mothers' heartbeats and 30.87±1.71 for the control group. The same table showed that the mean birth weights of the control group and premature newborns who listened to their mothers' heartbeats were 1179.1±121.34 and 1171.4±127.85, respectively.

The medical history of premature infants is shown in **Table 2**. It is clear from this table that the majority of infants who heard the heartbeat and the control group were diagnosed with prematurity (83.3%, 76.7%respectively). Concerning pregnancy problems, a high percentage of premature infant mothers in the two groups had pregnancy problems; representing 86.7% for those who heard heartbeats, and 83.3% for the control group. The majority of mothers in both groups didn't experience labor problems representing 70% of those who heard heartbeats, and 63.3% for the control group. Regarding the type of delivery, 60% of premature infants who heard heartbeats, and 63.3% of the control group were delivered by Caesarean Section.

Table 3 shows that there was no significant difference initially, but a statistically significant decrease was observed by the 14th day in relation to temperature. Heart rate and respiratory rate both showed marked reductions, with a significant decrease by the 14th day ($p<0.001$). Oxygen saturation improved significantly on both days, with near-maximum saturation observed by the 14th day.

Table 4 Clarifies that there were no statistically significant differences in temperature, heart rate, or respiratory rate between the heartbeats group (HB) and the control group on the 4th day. However, by the 14th day, the HB Group showed significantly lower heart rates and respiratory rates, and slightly lower temperatures, compared to the control group ($p<0.001$ for heart rate and respiratory rate). Oxygen

saturation was consistently higher in the HB Group on both days, with a perfect 99.7% saturation on the 14th day.

Table 5 illustrates the impact of mothers' heartbeats on the mean weight and mid-arm circumference of the HB group compared to the control group. The results demonstrated highly statistically significant differences between the HB Group and the Control Group for both physical parameters on day 7, day 14, day 21, and day 28 of the intervention ($P < 0.001$).

Table (1): Bio-sociodemographic Characteristics of Premature Infants

Characteristics	HB (study) Group		Control Group		Test of sig.	p
	No n=30	%	No. n=30	%		
Gestational Age/ weeks 28-	7	23.3	6	20.0		
30-	12	40.0	15	50.0	□□ = 0.610	0.373
32-34	11	36.7	9	30.0		
Mean ± SD	31.31±1.24		30.87±1.71		t= 1.141	0.258
Sex Male	15	50.0	13	43.3		
Female	15	50.0	17	56.7	□□ = 0.268	0.605
Birth weight/grams <1000	0	0.0	1	3.3		
1000-	9	30.0	5	16.7	3.402	MCp = 0.711
1100-	7	23.3	6	20.0		
1200-	9	30.0	13	43.3		
1300-	3	10.0	2	6.7		
1400-1500	2	6.7	3	10.0		
Mean ± SD	1171.4±127.85		1179.1±121.34		t= 0.239	0.811
Current weight/ grams <900	0	0.0	1	3.3		
900-	9	30.0	6	20.0	3.666	MCp = 0.665
1000-	12	40.0	10	33.4		
1100-	6	20.0	9	30.0		
1200-	2	6.7	1	3.3		
1300+	1	3.3	3	10.0		
Mean ± SD	1031.7±91.4		1042.6±112.6		t= 0.412	0.682

HB group: premature infants who heard their mothers' heartbeats.

Table (2): Medical History of Premature Infants and their Mothers

Medical History	HB(study) Group		Control Group		χ^2	p
	No. n=30	%	No. n=30	%		
Current Medical Diagnosis						
Prematurity	25	83.3	23	76.7		
Respiratory distress	5	16.7	7	23.3	0.417	0.519
Pregnancy Problems						
Yes	26	86.7	25	83.3		
No	4	13.3	5	16.7	0.131	0.718
Problems experienced in pregnancy	**n= 26**		**n= 25**			
Poor Coagulation	2	7.7	4	16.0		
Vaginitis	7	26.9	5	20.0		
Hemorrhage	2	7.7	2	8.0	2.097	0.894
Anemia	10	38.5	7	28.0		
Urinary infection	3	11.5	4	16.0		
Pre-eclampsia	2	7.7	3	12.0		
Labor problems	**n= 30**		**n= 30**			
Yes	9	30.0	11	36.7	0.300	0.584
No	21	70.0	19	63.3		
Problems experienced in labor	**n= 9**		**n= 11**			
Placenta abnormality	4	44.4	8	72.7	1.650	0.199
Apnea	5	55.6	3	27.3		
Delivery method	**n= 30**		**n= 30**			
Vaginal Delivery	12	40.0	11	36.7	0.071	0.791
A cesarean section	18	60.0	19	63.3		

Table (3): Effect of Hearing Mothers' Heart Beats on Mean Physiological Parameters of Premature Infants

Physiological Parameters	HB (study) Group		t	P
	Before n=30	After n=30		
Temperature				
4th day (Initial)				
Mean ±SD	37.59±0.31	37.46±0.52	1.428	0.164
Range	36.70–37.90	36.20-38.00		
14th day				
Mean ±SD	37.59±0.31	37.08±0.26	5.819	<0.001*
Range	36.3-37.90	36.70-37.60		
Heart rate				
4th day (Initial)				
Mean ±SD	168.1±12.8	162.7±17.3	1.905	0.067
Range	136.0–182.0	121.0-182.0		
14th day				
Mean ±SD	158.3±6.3	144.8±7.0	10.214	<0.001*
Range	142.0-171.0	130.0-156.0		
Respiratory Rate				
4th day (Initial)				
Mean ±SD	66.7±10.3	54.0±9.1	7.773	<0.001*
Range	44.0-86.0	38.0-72.0		
14th day				
Mean ±SD	56.2±6.4	49.1±5.8	6.866	<0.001*
Range	41.0-66.0	39.0-59.0		
Oxygen saturation				
4th day (Initial)				
Mean ±SD	95.7±2.0	98.9±1.3	10.770	<0.001*
Range	92.0-100.0	95.0-100.0		
14th day				
Mean ±SD	96.7±1.7	99.7±0.8	10.428*	<0.001*
Range	93.0-100.0	97.0-100.0		

t = Paired t test * Significant p at ≤0.05

Table (4): Mean of Physiological parameters of Premature Infants in the Study Group versus Control one

Physiological Parameters	HB (study) Group n=30	Control Group n=30	t	P
Temperature				
4th day (Initial)				
Mean ±SD	37.46±0.52	37.57±0.34	0.995	0.324
Range	36.20-38.00	36.70-37.80		
14th day				
Mean ±SD	37.08±0.26	37.32±0.30	3.324	0.002*
Range	36.70-37.60	36.80-37.80		
Heart rate				
4th day (Initial)				
Mean ±SD	162.7±17.3	162.1±20.7	0.122	0.903
Range	121.0-182.0	120.0-191.0		
14th day				
Mean ±SD	144.8±7.0	164.6±10.3	8.709	<0.001*
Range	130.0-156.0	141.0-181.0		
Respiratory Rate				
4th day (Initial)				
Mean ±SD	54.0±9.1	58.2±15.7	1.259	0.214
Range	38.0-72.0	30.0-80.0		
14th day				
Mean ±SD	49.1±5.8	64.6±7.7	8.775	<0.001*
Range	39.0-59.0	50.0-73.0		
Oxygen saturation				
4th day (Initial)				
Mean ±SD	98.9±1.3	95.3±2.2	7.758	<0.001*
Range	95.0-100.0	89.0-99.0		
14th day				
Mean ±SD	99.7±0.8	95.3±1.9	11.735	<0.001*
Range	97.0-100.0	92.0-99.0		

t = Student t test * Significant p at ≤0.05

Table (5) Mean of Physical Parameters of Premature Infants in the Study and Control Group

Physical parameters	HB (study)group n=30	Control group n=30	t	P
Weight\ gm				
4th day (Initial)				
Mean ±SD	1067.0±97.2	1083.0±118.4	0.573	0.569
Range	920.0-1320.0	900.0-1340.0		
7th day				
Mean ±SD	1247.5±85.6	1143.8±121.3	3.825*	<0.001*
Range	1100.0-1450.0	950.0-1400.0		
14th day				
Mean ±SD	1407.4±76.2	1224.8±129.4	6.662*	<0.001*
Range	1243.0-1570.0	984.0-1460.0		
21th day				
Mean ±SD	1533.7±270.5	1301.8±135.7	4.196*	<0.001*
Range	178.0-1810.0	1090.0-1550.0		
28th day				
Mean ±SD	1780.2±89.0	1390.8±131.1	13.457*	<0.001*
Range	1630.0-1960.0	1180.0-1655.0		
Mid- Arm Circumference\ cm				
4th day (Initial)				
Mean ±SD	5.89±0.57	5.82±0.62	0.455	0.651
Range	4.70–7.10	4.70–7.20		
7th day				
Mean ±SD	6.57±0.52	5.99±0.57	4.086*	<0.001*
Range	5.50-7.20	5.0-7.20		
14th day				
Mean ±SD	6.92±0.44	6.34±0.68	3.906*	<0.001*
Range	6.0-7.70	5.50-7.70		
21th day				
Mean ±SD	7.44±0.57	6.60±0.58	5.651*	<0.001*
Range	6.0-8.60	5.70-7.70		
28th day				
Mean ±SD	8.0±0.61	6.97±0.62	6.500*	<0.001*
Range	6.0-8.90	6.20-8.20		

t= Student t test * Significant p at ≤0.05

7thday: after 1week from intervention **14thday:** after 2weeks from intervention

21thday: after 3weeks from intervention **28thday**: after 4weeks from intervention

Discussion

Preterm newborns being separated from their mothers' voices is a serious problem. Because the fetus, which is exposed to loud noises in neonatal intensive care units (NICUs), depends on it for the development of its hearing sense. According to Krueger et al. (2010), the fetus is typically accustomed to bowel movements, blood flow sounds, the mother's voice, the sound of her heartbeat, uterine movements, and synchronized sounds. The noises in the NICU are very human-made. In addition to causing physiological changes including variations in blood pressure, heart rate, oxygen saturation level, and breathing rate, unwanted noise in the NICU also makes patients feel exhausted, stressed, and afraid. On the other hand, a good auditory stimulus keeps the baby busy and has a cognitive impact on pain management and physiological stability (Chen et al., 2009).

Physiological parameters of premature infants which are body temperature, oxygen saturation, heart, and respiratory rate are indicators for their general stability. A major problem of premature infants is their inability to regulate their physiological parameters. Therefore, all of them are nursed in incubators that can be adjusted to provide the ideal temperature as well as the perfect amount of oxygen, humidity, and light which in turn stabilize all physiological parameters (Das et al., 2020). The results of the present study showed that premature infants' temperature, pulse, respiratory rate, and oxygen saturation as physiological parameters of those who heard their mothers' heartbeats improved throughout the study period. It was shown that the means of body temperature in the studied and control groups were within normal. It may be due to the fact that all premature infants nursed in incubators which helped them to maintain their normal body temperature value. Over and above that, the mean value of body temperature among premature infants who heard their mothers' heartbeats was lower after hearing and reached to normal range during the study period. Moreover, the temperature of premature infants who heard their mothers' heartbeats was lower than those of the control group. Contrary to the current findings, Bozzette (2008) reported that the temperature of premature infants who heard their maternal voice was significantly higher after stimulation than before.

The current study findings reflected that the means of heart and respiratory rates of premature infants after hearing their mothers' heartbeats had decreased than before hearing throughout the study period. Furthermore, the means of heart rate and respiratory rate of premature infants who heard their mothers' heartbeats were less than those in the control group throughout the studied days. Also, The findings of the current study revealed that the means of oxygen saturation for premature infants had increased after they heard their mothers' heartbeats than before the study period. Moreover, the means of oxygen saturation were higher for premature

infants who heard their mothers' heartbeats than those in the control group. From the perspective of the researchers, For premature infants, the synthesis of the mother's heartbeat produces a sound that is comparable to the mother's intrauterine environment. This has the effect of stabilizing their physiological reaction, which lowers their heart rate. In this regard, similar findings have been reported by Zhang and He (2022), who found that hearing the mother's heartbeat in the NICU setting can improve the breathing, cardiac function, and feeding of premature infants. Similarly, Radwan et al. (2022), revealed that, with a statistically significant difference between the study and control groups, oxygen desaturation was not found in the majority of the preterm neonates in the study group compared to half of those in the control group. Also, the finding was supported by Erdoğan et al. (2020) who found that children who listened to their mothers' voices had a less increase in heart rate and a decline of SpO2.

Due to inadequate nutrition during the first few weeks of life, premature infants are at a heightened risk of experiencing a developmental delay. Risks persist because of metabolic and gastrointestinal immaturity, compromised immune systems, and other health problems of preterm infants, even with advancements in neonatal care. For preterm newborns, growth status and rate are critical health outcomes Joana et al., (2020). Establishing a stable development path in preterm newborns requires their body weight to return to normal as soon as possible after birth. The findings of the current study revealed that means of weight as well as mid-arm circumference were higher in premature infants who heard their mothers' heartbeats than those in the control group with significant differences between both groups during the study period. These findings could be justified by the fact that auditory stimulation improves the general stability and well-being of premature infants, promoting food digestion and absorption that enhances growth (Ranger et al., 2018). Premature infants who heard their mothers' heartbeats were in their mother's uterus for at least 7 months and they were used to hear their mothers' heartbeats so after birth hearing this familiar sound and rhythm enables them to remember their secure environment which in turn improves their physical growth. The effect of mothers' heartbeats on the physical findings of the current study is supported by France et al. (2018) who found that The calming sound of the mother's heartbeat lowers stress levels overall, improving the sleep/wake cycle and behavioral state, which helps infants store more energy and put on weight. On the contrary, this finding was in disagreement with Alemdar and Tüfekcİ (2018) who found no statistically significant difference in gestational age, birth weight, birth height, or head circumference between the control and intervention groups.

Conclusion

In light of the current study's findings, premature infants who heard their mothers' heartbeats had better physiological and physical parameters in the study period compared to the control group.

Recommendations:

The present study findings led to the following recommendations to be suggested:

1) Auditory stimulation such as mothers' heartbeats needs to be incorporated into the care of premature infants in NICU.

2) All NICU nurses should have access to in-service training programs that cover auditory stimulation and its advantages for premature infants.

3) Mothers of premature newborns and NICU nurses should have recourse to a condensed pamphlet or CD regarding auditory stimulation and its use.

4) Provision of recording devices and headphones for premature infants in NICU is necessary.

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