Effect of Kangaroo Mother Care versus Hammock Positioning on Physiological Indices and Behavioral Organization among Preterm Neonates: A Humanized Nursing Approach

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Abstract:

Background: Preterm neonates are forced into extrauterine existence before the attainment of full development. Supportive developmental measures as kangaroo care and hammock positioning make preterm neonates feel as if they are in the womb, which promote their serenity, relaxation and deep sleep state. **Aim of the present study** was to investigate the comparative effect of kangaroo mother care versus hammock positioning on physiological indices and behavioral organization among preterm neonates. **Subjects and method:** A quasi-experimental, pre-posttests, research design was carried out at Neonatal Intensive Care Unit of Smouha Specialized University Hospital for Children in Alexandria, Egypt. A sample of 90 preterm neonates were randomly assigned into three equal groups. **Results**: A remarkable decline in preterm neonates' mean behavioral state was noticed after applying kangaroo mother care compared to hammock positioning group with significant statistical difference (P<0.001). Hence, majority of preterm neonates were in a sleepy state after receiving kangaroo care compared to nearly two-thirds of the hammock positioning group and about one-third of the control group with significant statistical difference (p<0.001). Moreover, kangaroo mother care and hammock positioning were effective in stabilizing the preterm neonates' physiological indices compared to the control group. **Conclusion and recommendations**: Both kangaroo mother care and hammock positioning were proved to be promising in enhancing the preterm neonates' physiological stability and behavioral organization; however, kangaroo care revealed a superior effect over hammock positioning. Accordingly, there is an immense need to incorporate supportive developmental measures into care protocols of neonatal intensive care units.

Keywords: Behavioral organization, Hammock positioning, Kangaroo mother care, Physiological indices, Preterm neonates.

Introduction

Prematurity is one of the significant high-risk problems affecting neonates as they are forced into extrauterine existence before attaining full-body systems' development. [(1)] Preterm neonates' life is threatened because their capability to maintain homeostasis and function at an optimum level is impaired. Prematurity is defined as all births that occur before 37 completed weeks of gestation. [(2)] Globally, the estimated preterm birth rate was 10.6%, equating to 14.84 million live preterm births in 2014. [(3)] In the United States (2019), the rate of preterm birth increased for the fifth straight year to 10.23%. [(4)] Whereas in Egypt (2017), Preterm birth complications accounts for 38% of neonatal deaths. [(5)]

In the last decades, advances in medical care have amplified the survival of neonates born preterm. Nevertheless, they have demanding tasks during the transitional period from intrauterine to extrauterine life. [(6)] They attempt to stabilize autonomic, sensory, and motor functions to conserve energy. Moreover, they utilize a wide range of behavioral states to avoid internal disorganization while interacting with the environment. [(7)] In this regard, preterm neonates require a supportive atmosphere as Neonatal Intensive Care Unit (NICU) to sustain their physiologic and neurobehavioral stability besides enhancing continuous development as if they are still in mothers' uterus. [(8)] However, they are quickly exhausted from continuous exposure to various external stimulus as excessive manipulations, bright lights, intense noise, painful procedures, and maternal separation. [(9)] These stimulations can trigger their clinical instability leading to further physiological, psychological, and behavioral sequelae. [(10)] So, the application of developmental supportive measures such as

Kangaroo Mother Care (KMC) and Hammock Positioning (HP) could be incorporated into the NICU care protocols to alleviate stress and enhance the neurobehavioral development among these vulnerable populations. [11, 12]

Kangaroo mother care was first established in Bogota, Columbia, where incubators shortage was compensated by keeping the preterm neonates warm in a natural incubator by skin-to-skin contact with mothers. [13] This alternative method entails holding naked preterm neonates in a prone upright position with flexed arms and legs as froglike while the head is turned sideways. Direct skin-to-skin contact between the neonate and mothers' bare breast is maintained in addition to covering the neonate's back with a blanket or mothers' clothing. [14] Early, prolonged and continuous KMC helps in improving the cerebral blood flow of preterm neonates; thus, it might promote brain development. [15] Furthermore, it improves behavioral organization and regular sleeping patterns, shortens duration to attain full enteral feeding, and thereby initiates exclusive breastfeeding earlier. [16] Concerning physiological indices, KMC boosts the neonates' body temperature by direct contact with the mother's skin. [17] It also guards against bradycardia, decreases apneic episodes, contributes to regular breathing patterns, and stabilizes the transcutaneous oxygen level. [11,18] Generally, KMC improves growth and development, enhances maternal-neonatal bonding, and contributes to better survival among preterm neonates. [19]

Hammock positioning is another simple innovative intervention for preterm neonates who require prolonged hospitalization in NICUs. [20] It refers to the placement of neonate in a fabric cotton blanket (hammock) that is fixed by ropes, passed through the circular openings of the incubator, and tied above it. Hammock positioning simulates the intrauterine position by keeping the neonate in a flexed posture. [20] It intends to promote the preterm neonates' containment, vestibular stimulus, sensory integration, and behavioral reorganization. So, such a position positively influences the sleep-wake cycle as well as reduces the noxious sensory stimulus and energy expenditure. [21] Moreover, it can minimize postural abnormalities and asymmetries related to prematurity. [12] So, it can be considered a strategy to humanize the care provided for preterm neonates. [20]

Neonatal nurses need to be well-versed with updated knowledge and skills to provide competent care for preterm neonates and respond to their cues rather than provide scheduled interventions. [22] Furthermore, neonatal nurses would better adopt evidence-based practices that focus on decreasing the neonates' stress as well as promoting their self-regulation and containment. They also play a crucial role in empowering mothers to participate in the care provided for their neonates. This will facilitate the gradual and smooth transition from conventional to continuous developmental care. [23] In this context, this study builds on and extends existing research to determine whether KMC or HP affect the physiological indices and behavioral organization of preterm neonates.

Aim of the present study

This study aimed to investigate the effect of kangaroo mother care versus hammock positioning on physiological indices and behavioral organization among preterm neonates

Research Hypotheses

- Preterm neonates who receive KMC exhibit more stable physiological indices and behavioral organization state than those who do not .
- Preterm neonates who receive HP exhibit more stable physiological indices and behavioral organization state than those who do not .
- Preterm neonates who receive KMC exhibit more stable physiological indices and behavioral organization state than those who receive HP.

Subject & Method

Design: A quasi-experimental, pre-posttests research design was used.

Setting: The study was carried out in the NICU of Smouha Specialized University Hospital for Children in Alexandria, Egypt. The unit is classified into three levels. Level I which deals with feeder and grower neonates, while neonates with some health problems of prematurity and respiratory assistance such as continuous positive airway pressure can be treated in level II. Whereas neonates who have complex disorders and receive intravenous fluids can be handled in level III. This study was conducted at Level I which includes 15 incubators and cribs.

Tools

Two tools were used for data collection.

Tool I: Neonates' Physiological Indices Assessment Tool

The researchers developed this tool after a review of relevant literature to assess Physiological Parameters of preterm neonates as Heart Rate (HR), Respiratory Rate (RR), oxygen saturation (SpO_2), and temperature. Characteristics and clinical data of preterm neonates such as; age, sex, gestational age, birth weight, current weight, mode of delivery, and diagnosis were attached to this tool.

Tool II: Anderson Behavioral State Scale

This scale was adopted from Anderson et al. (1990) to assess the behavioral organization of preterm neonates. [23] Neonates' behavioral states are assessed by observing their respiratory regularity, opening or closing of the eyes, limb and trunk activity, and the intensity of crying. Based on the observations, the scale will differentiate 12 behavioral states, including; regular quiet sleep (1), irregular quiet sleep (2), active sleep (3), very active sleep (4), drowsy (5), alert inactivity (6), quite awake (7), active awake (8), very active awake (9), fussing (10), crying (11) and hard crying (12). Scores from 1 to 5 indicate that the neonate is sleeping. Scores from 6 to 8 indicate that the neonate is awake and calm. Scores from 9 to 12 indicate that the neonate is in a state of restless activity or fussiness, which takes substantial energy. [23]

Participants:

Epi info program version 10 was used to estimate the sample size using the following parameters: population size of 99, Confidence coefficient of 97%, expected frequency of 50%, and acceptable error of 5%. The minimum sample size required was 82 preterm neonates. So, a convenient sample of 90 preterm neonates were included in this study, as illustrated in **Fig-1**. However, neonates who were attached to a mechanical ventilator or had pulmonary, cardiac, or neurological disorders such as intraventricular hemorrhage were excluded. Eligible neonates who fit the inclusion criteria and their guardians who agreed upon their participation were randomly assigned by researchers to three equal groups by simple random sampling technique using a random number generator program. Each group consisted of 30 preterm neonates as follows; the control group received the routine care of the NICU only. The second group received KMC in addition to the routine care whereas the third group were subjected to HP besides the routine care. Data were initially collected from the control group and then from the intervention groups (KMC and HP) alternately.

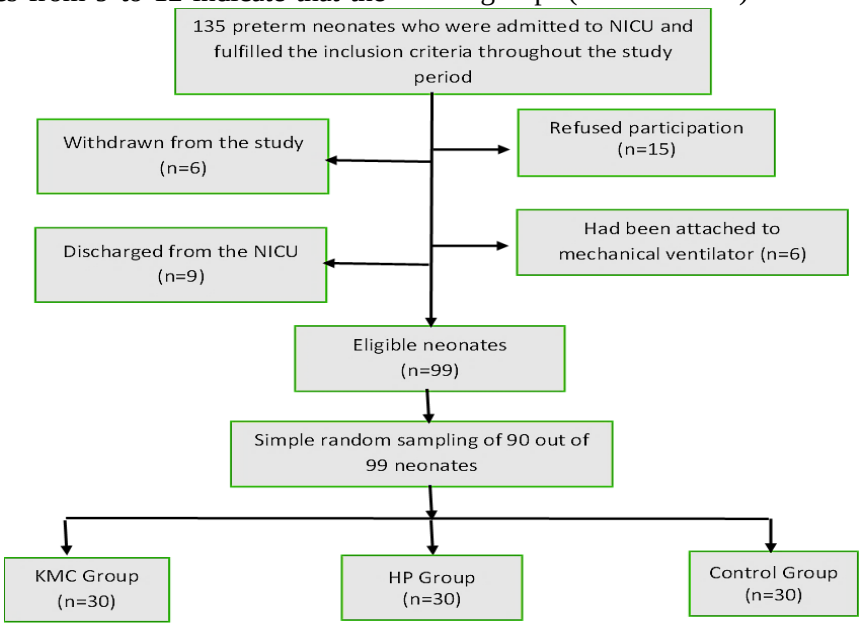

Fig-1: Flow chart of participants' recruitment process.

Ethical Considerations

An approval from the Ethical Research Committee review board of Faculty of Nursing, Alexandria University was obtained. Official permission for conducting the study was obtained from the director of the previously mentioned setting. The study protocol was approved and registered on U.S. National Library of ClinicalTrial.gov (NCT05165004). The researchers approached guardians of the neonates who matched the inclusion criteria. The aim of the study, benefits, and possible risk of participation were explained, and their free decision to voluntarily participate in the study was emphasized. The researchers also stressed their right to refuse participation or withdraw from the study. After their agreement, written informed consent was obtained from the neonates' guardians. Confidentiality of the obtained data was assured, and participants' anonymity was respected. Privacy also was maintained during the implementation of the study.

Method & Data collection

Tools I and II were tested for content validity by five experts in the field of Pediatric Nursing. A pilot study was conducted on nine neonates (10%) to test the research tools' clarity, feasibility, and applicability. These neonates were excluded from the total study subjects. The preterm neonates' characteristics and clinical data were extracted from their hospital records for the three groups. Baseline physiological indices and behavioral States were assessed and documented at a fixed time during the morning shift throughout three consecutive days of the study period for the three groups using tools I&II. Physiological indices were measured as follows; the HR and SpO_2 were monitored and documented with a multiparametric monitor by a sensor positioned on the outer side of neonate's foot. The RR was assessed by the researchers through visual inspection of the preterm neonate's chest and counting the respiratory cycles per minute. Body temperature was measured axillary by the researchers using the mercury temperature monitor.

The preterm neonates in **the control group** received the routine care of the NICU, which entails; encircling the neonate in a fetal position using a rolled towel inside the incubator.

Intervention groups:

For the kangaroo mother care group:

Researchers contacted the mother a day before applying KMC and advised her to take shower and abstain from using perfumes before attending to the NICU. On days of KMC application, the researchers asked the mother to remove the upper clothes in a private room and put on an open-front gown and mask. The mother was assisted to sit in a comfortable chair with a soft backrest and footrest to prevent fatigue. Then, the preterm neonate was carefully put naked except for the head and diaper area on the mothers' bare chest with flexed arms and legs as in froglike position, and the head was turned sideways. The researchers wrapped and secured the mother's gown and put a blanket on the neonates' back to ensure neonatal thermal insulation. The mother was instructed to support the neonate's bottom with the right hand while supporting the head and neck with the other hand.

For hammock positioning group:

Researchers made a hammock by using a rectangular cotton cloth with ropes that passed through the circular openings of the incubator and tied on the upper part of it. After one hour of feeding, the preterm neonate was placed in a supine fetal position in the hammock where the head was supported in a neutral midline position by using rolled towel without neck hyperflexion or hyperextension. Moreover, the spine of the preterm neonate was supported while arms and knees were flexed.

Kangaroo mother care and HP were performed in the morning shift for one hour from 10:00 am till 11:00 am on three consecutive days. Behavioral states of preterm neonates were assessed in the three groups three times during the intervention at fixed intervals in order to minimize the measurement errors due to fluctuations in their behavioral states. In case of incidental neonatal distress, the intervention was discontinued.

After applying KMC or HP, the preterm neonates were placed in the incubator as the routine NICU care. Finally, neonates' physiological indices and behavioral states in the three groups were recorded after 15 minutes from the intervention using tools I&II. Data were collected over 12 months

from March 2020 till the end of February 2021.

Data Analysis

The Statistical Package for Social Sciences (SPSS) version 23 was utilized for data analysis. **Descriptive statistics** included number, percentage, mean and standard deviation, were used to describe characteristics and clinical data, physiological indices, and behavioral States of preterm neonates. Kolmogorov-Smirnov test was used to check the normality of study variables, and it showed that they were not normally distributed. **In Analytical statistics**, a comparison between the neonates in the three study groups regarding their physiological indices was done by using Kruskal-Wallis tests. A Chi-square and Fisher Exact tests were used to compare between behavioural states of the three study groups. Comparison between the neonates in KMC and HP groups regarding their mean behavioral state was done by using Kruskal-Wallis tests. All of the statistical analyses were considered significant at $P < 0.05$.

Results

Table 1 illustrates preterm neonates' characteristics and clinical data. It was found that female preterm neonates constituted 56.70%, 56.70%, and 66.70% of the KMC, HP and control groups respectively. Moreover, 46.6% of preterm neonates in the KMC group were in the third week of life compared to 30.0% and 36.7% of HP and control groups. The weight of 60% of preterm neonates in the KMC and HP groups ranged from 2500 to less than 3000 grams compared to 50.0% of the control group. Furthermore, 53.3% of the KMC group and 46.7% of the HP group received oral feeding compared to 36.7% of the control group.

Table 2 reveals mean physiological indices of preterm neonates. A slight increase in the mean temperature among preterm neonates was observed after application of KMC and HP (36.80±0.12 ^{o}C and 36.61±0.13 ^{o}C respectively) compared to baseline temperature, which was 36.46±0.11 ^{o}C in each group. On the other hand, the mean temperature decreased among the control group from 36.80±0.12 ^{o}C to 36.52±0.12 ^{o}C. Regarding SpO_2, preterm neonates of the KMC group demonstrated more stabilized oxygen saturation after 1 hour of KMC (97.44±0.73) compared to 96.03±1.23 and 94.85±0.79 among HP and control groups, respectively. Concerning HR, it was decreased to 132.56±7.74 b/m after application of KMC compared to preterm neonates of HP and control groups) 138.19±4.47 b/m and 145.59±7.15 b/m, respectively). The RR also decreased among preterm neonates after one hour of KMC to 46.39±4.34 c/m compared to 49.09±5.63 c/m and 51.28±4.42 c/m among those in HP and control groups, respectively. There were statistical significant differences between the three groups regarding all physiological indices ($p<0.001$ for each).

Table 3 displays behavioral states of preterm neonates in the kangaroo mother care, hammock positioning, and control groups. The majority of preterm neonates in the KMC group (90%) were in a sleepy state after application of the intervention on the 1st day of the study period compared to 73.3% of the HP group and 53.3% of the control group. On the 2nd day of the study period, 80.0% of preterm neonates were in a sleepy state after one hour of KMC compared to 60.0% and 40.0% of HP and control groups, respectively. On the 3rd day of the study period, 66.7% of preterm neonates were in a sleepy state during the intervention of KMC compared to HP and control groups (46.7% and 43.3% respectively). After receiving one hour of KMC, it was observed that 83.3% of preterm neonates were in a sleepy state compared to 60.0% of the HP group and 30.0% of the control group. It is worth mentioning that none of the preterm neonates were in a restless activity and fussiness state after receiving KMC throughout the three days of the study period. Statistically significant differences were noticed between the three groups after the intervention in the three days ($p<0.001$)

Table 4 highlights comparison between mean behavioral states of kangaroo mother care and hammock positioning groups. Preterm neonates' mean behavioral state declined to 2.8±2.02 after KMC on the 1st day compared to 4.8±2.62 among preterm neonates who were placed in the hammock. On the 2nd of the study period, there was also decrease in the mean behavioral state of preterm neonates after receiving KMC (3.9±2.20) compared to HP group (5.2±2.78). Similarly, there was decrease in the mean behavioral state of preterm neonates during KMC on the 3rd day of the study period (4.53±2.21) compared to the HP group

(7.39±2.81) with significant statistically difference (P<0.001). A remarkable decline in preterm neonates' mean behavioral state was also noticed after applying KMC (3.03±2.25) compared to the HP group, which was 7.0±3.03. The differences between the two groups after applying the interventions were significant in the three days of the study period (p= 0.002, p<0.001, and p<0.001 respectively).

Table 1: Preterm Neonates' Characteristics and Clinical Data.

Characteristics and clinical data.		**KMC Group (n=30)**	**HP Group (n=30)**	**Control Group (n=30)**	**Significance**
Sex	Male	13(43.30)	13(43.30)	10(33.30)	X^2= 0.833
	Female	17(56.70)	17(56.70)	20(66.70)	p=0.761
Age/ days	1-	0(.0)	1(3.3)	0(.0)	F^{ET}=4.65
	7-	8(26.7)	12(40.0)	8(26.7)	p= 0.606
	14-	14(46.6)	9(30.0)	11(36.7)	
	21-28	8(26.7)	8(26.7)	11(36.7)	
	Mean±SD	17.27±5.681	15.57+6.004	17.9±6.194	$^{KW}\chi 2$ = 2.383 P=0.3.04
Current weight/ grams	1000-	2.0(6.7)	5(16.7)	7(23.3)	F^{ET}=3.55
	1500-	8(26.7)	5(16.7)	8(26.7)	p= 0.754
	2000-	2(6.6)	2(6.6)	0(0.0)	
	2500-3000	18(60.0)	18(60.0)	15(50.0)	
Gestational age/months	Very Preterm	1 (3.3)	2 (6.7)	3 (10.0)	F^{ET}= 4.28
	Moderate-Preterm	14 (46.7)	9 (30.0)	15 (50.0)	p= 0.373
	Late Preterm	15 (50.0)	19 (63.3)	12 (40.0)	
Birth weight	Normal birth weight	4(13.30)	4(13.30)	2(6.70)	F^{ET}=3.941
	Low birth weight	15(50.00)	16(53.30)	13(43.30)	p= 0.702
	Very low birth weight	9(30.00)	6(20.0)	9(30.0)	
	Extremely low birth weight	2(6.70)	4(13.30)	6(20.0)	
Diagnosis*	Hyaline membrane disease	10(33.3)	6(20.0)	8(26.7)	F^{ET}=17.71
	Hyperbilirubinemia	16(53.3)	10(33.3)	9(30.0)	p= 0.369
	Transient tachypnea of the newborn	14(46.7)	6(20.0)	13(43.30)	
	Congenital pneumonia	4(13.3)	2 (6.7)	4(13.3)	
	Small for gestational age	6(20.0)	4(13.3)	3 (10.0)	
	Neonatal sepsis	2(6.70)	3 (10.0)	4(13.3)	
Type of Feeding	Oral feeding	16(53.3)	14(46.7)	11(36.7)	X^2= 0.927
	Gavage feeding	10(33.3)	10(33.3)	10(33.3)	p=0.571
	Total Parenteral Nutrition	4(13.3)	6(20.0)	9(30.0)	

X^2: Chi-square Test F^{ET}: Fisher Exact Test $^{KW}\chi 2$ = Kruskal-Wallis tests
***Significant at P≤0.05**

Table 2: Mean Physiological Indices of Preterm Neonates

Physiological Indices	Before Mean±SD			Significance	After Mean±SD			Significance
	KMC Group (n=30)	HP Group (n=30)	Control Group (n=30)		KMC Group (n=30)	HP Group (n=30)	Control Group (n=30)	
- Temperature	36.46±0.11	36.46±0.11	36.80±0.12	$^{KW}\chi 2$ =5.62, p= 0.06, df =2	36.80±0.12	36.61±0.13	36.52±0.12	$^{KW}\chi 2$ =41.13, p<0.001[a], df =2
- Oxygen saturation (SpO_2)	95.13±0.81	95.27±1.46	95.41±1.08	$^{KW}\chi 2$ =0.419, p= 0.811, df =2	97.44±0.73	96.03±1.23	94.85±0.79	$^{KW}\chi 2$ =50.86, p<0.001[a], df =2
- Heart rate (b/m)	145.07±9.93	140.83±5.40	144.97±7.99	$^{KW}\chi 2$ =3.87, p= 0.144, df =2	132.56±7.74	138.19±4.47	145.59±7.15	$^{KW}\chi 2$ =37.09, p<0.001[a], df =2
- Respiratory rate (c/m)	51.50±4.64	51.53±6.35	50.33±4.33	$^{KW}\chi 2$ =0.421, p= 0.810, df =2	46.39±4.34	49.09±5.63	51.28±4.42	$^{KW}\chi 2$ =16.92, p<0.001[a], df =2

$^{KW}\chi 2$ = Kruskal-Wallis tests *Significant at [a]P< 0.001

Table 3: Behavioral States of Preterm Neonates in the Kangaroo Mother Care, Hammock Positioning, and Control Groups

Behavioral States	Before			During			After		
	KMC Group (n=30)	HP Group (n=30)	Control Group (n=30)	KMC Group (n=30)	HP Group (n=30)	Control Group (n=30)	KMC Group (n=30)	HP Group (n=30)	Control Group (n=30)
	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)
Day 1									
• Sleep state	14(46.7)	12(40.0)	17(56.7)	19(63.3)	16(53.3)	17(56.7)	27(90.0)	22 (73.3)	16(53.3)
• Awake and calm, State	12(40.0)	12(40.0)	11(36.7)	10(33.3)	9(30.0)	12(40.0)	3(10.0)	3 (10.0)	13(43.3)
• State of restless activity and fussiness	4(13.3)	6(20.0)	2(6.7)	1(3.3)	5(16.7)	1(3.3)	0(0.0)	5 (16.7)	1(3.3)
Significance	F^{ET}=2.90, p= 0.59			F^{ET}=4.37, p=0.37				F^{ET}=17.49	p<0.001[a]
Day 2									
• Sleep state	10(33.3)	10(33.3)	10(33.3)	17(56.7)	14(46.7)	12(40.0)	24(80.0)	18(60.0)	12(40.0)
• Awake and calm state	13(43.3)	11(36.7)	13(43.3)	10(33.3)	9(30.0)	12(40.0)	6(20.0)	7(23.3)	12(40.0)
• State of restless activity and fussiness	7(23.4)	9(30.0)	7(23.3)	3(10.0)	7(23.3)	6(20.0)	0(0.0)	5(16.7)	6 (20.0)
Significance	X^2=0.56, p=0.96			X^2= 2.96, p=0.56				F^{ET}= 15.51	p=0.003[b]
Day 3									
• Sleep state	16(53.4)	6(20.0)	12(40.0)	20(66.7)	14(46.7)	13(43.3)	25(83.3)	18(60.0)	9(30.0)
• Awake and calm state	7(23.3)	9(30.0)	8(26.7)	8(26.7)	9(30.0)	8(26.7)	5(16.7)	7(23.3)	6(20.0)
• State of restless activity and fussiness	7(23.3)	15(50.0)	10(33.3)	2(6.7)	7(23.3)	9(30.0)	0(0.0)	5(16.7)	15(50.0)
Significance	X^2= 7.78, p=0.100			X^2= 14.56, p=0.006[b]				X^2= 21.64, p<0.001[a]	

X^2: Chi-square Test F^{ET}: Fisher Exact Test *Significant at [b] P≤0.05 [a]P< 0.001

Table 4: Comparison between Mean Behavioral States of Kangaroo Mother Care and Hammock Positioning Groups

	Before			During			After		
Neonates' Mean Behavioral State	**KMC Group (n=30)**	**HP Group (n=30)**	**Significance**	**KMC Group (n=30)**	**HP Group (n=30)**	**Significance**	**KMC Group (n=30)**	**HP Group (n=30)**	**Significance**
	Mean±SD	**Mean±SD**		**Mean±SD**	**Mean±SD**		**Mean±SD**	**Mean±SD**	
Day 1	6.03±2.50	6.63±2.44	Z^{MW}=-0.55 P= 0.58	4.12±2.15	5.46±2.39	Z^{MW}=-2.15 P= 0.032 [b]	2.8±2.02	4.8±2.62	Z^{MW}=-3.09 P= 0.002 [b]
Day 2	7.0±2.12	6.93±2.69	Z^{MW}=-0.41 P= 0.68	5.13±2.19	5.88±2.62	Z^{MW}=-1.07 P= 0.286	3.9±2.20	5.2±2.78	Z^{MW}=-3.53 P<0.001 [a]
Day 3	6.43±2.34	8.57±2.92	Z^{MW}=-2.83 P= 0. 005 [b]	4.53±2.21	7.39±2.81	Z^{MW}=-3.82 P<0.001 [a]	3.03±2.25	7.0±3.03	Z^{MW}=-4.622 P<0.001 [a]

Z**: Mann Whitney Test** ⋆**Significant at** [b] **P≤0.05** [a]**P< 0.001**

Discussion

The premature infants in the NICU are exposed to an unfamiliar environment and subjected to repeated invasive procedures. [25] These various stressful procedures are associated with changes in their hemodynamic status and neurobehavioral organization, which trigger further clinical instability.[26] Thereafter, the application of developmentally supportive care provides a framework in which the neonatal environment and care processes are modified and structured to optimize the development and lessen the deleterious effects of prematurity.[20] It includes a broad category of nursing interventions such as positioning, sensory stimulation, and KMC which proved to be viable and promising for stress reduction and improvement of neurobehavioral development among such critically ill neonates. [26, 27]

Preterm neonates' responses to stimuli are non-specific and disorganized due to incomplete myelinization of the nervous system and the immature endogenous pain control systems that modulate pain. [21] Likewise, the environment of the NICU makes self-regulation of premature neonates extremely difficult. [28] Due to the diminished self-regulation of the autonomic nervous system, preterm neonates demonstrate disorganized behavior and amplified stress response, thus decreasing their ability to develop typically. [29] The current study results revealed that both KMC and HP yielded significant positive effects on behavioural organization among preterm neonates at the second and third days of the study period compared to the control group. Nevertheless, KMC revealed a superior effect compared to HP. Hence, most of the preterm neonates were sleepy after applying KMC in the three days of the study period, and none of them were in a state of restless activity and fussiness. The current study findings also demonstrated a significant decline in preterm neonates' mean behavioral score after applying one hour of KMC which denotes more stable and organized behaviors. The special effect of KMC could be explained in the light of specific facts. As soon as KMC begins, the oxytocin is released in the insular cortex, inducing a drop in stress hormones. This promotes calmness and relaxation of preterm neonates. [30] Simultaneously, KMC is associated with a substantial reduction in cortisol levels and autonomic reactivity. [31] Similarly, Bastani et al. (2017) and Kaffashi et al. (2013) reported that neonates who underwent KMC had experienced more organized sleep, leading to a more behavioral organization. [32, 33] Neu et al. (2013) also stated that preterm neonates who received KMC had better behavioral outcomes compared to the control group. [34]

Regarding HP, the positive effect of such intervention on the behavioral organization among preterm neonates in the present study could be attributed to the simulation of intrauterine containment and movement. Hence, it enables postural organization, harmonization of movements, as well as reduction of pain responses and energy expenditure. [21] Another explanation is that

HP provides a state of relaxation as most newborns evolve into a state of sleep that enhances brain maturity. [35] Hammock positioning also favors a more flexed posture and facilitates head alignment in relation to the body, contributing to proper neurobehavioral organization and development of preterm infants. [36] In this respect, Jesus et al. (2018) reported that preterm neonates who were positioned in hammocks evolved progressively into light or deep state of sleep. [20] Congruently, Sousa et al. (2021) cited that HP proved to be effective in reducing stress and improving the behavioral state of preterm neonates. [26]

Cardiopulmonary instabilities are common among preterm neonates due to their delayed development. [37] Kangaroo mother care and HP are humanized strategies that decrease stress associated with increased energy expenditure and cardio-pulmonary demands among preterm neonates. [12, 38] In this context, the current study results revealed that KMC and HP were effective in stabilizing the preterm neonates' physiological indices compared to the control group. Nevertheless, preterm neonates who received KMC demonstrated more stabilized SpO_2, RR, and HR. During KMC, the c-afferent nerves of the mother's and neonate's chest surfaces respond to the human touch and send the messages directly to the brain. Sequentially, oxytocin is released, which calms and stabilizes cardio-respiratory variables. Hence, the brain stem shifts from sympathetic control responsible for stress reaction and hyper-alertness to parasympathetic one responsible for relaxation and contentment. [39] Moreover, skin-to-skin contact with mothers is likely to be accompanied by less cry that means less stress, lower levels of cortisol, and more physiological stabilization. As well, placing the neonate in upright position, decreases the compression of the diaphragm, maximizes ventilation and perfusion resulting in improved respiratory function. [39] The current study results are consistent with Mohamed et al (2013), who concluded that KMC could effectively, and positively promote premature neonates' biological stability than those cared for by conventional care. [40] Similarly, Sarparast et al. (2015) reported that respiratory rate was significantly decreased to more stabilized level during KMC. [41] Cho et al. (2016), in contrast, stated that there were no significant differences between preterm neonates who received KMC and the control group regarding physiological parameters. [11]

In terms of the effect of HP on physiological indices, the current findings might be ascribed to a reduction in newborn cervical hyperflexion, which reduces the likelihood of apnea and a drop in SpO_2. [20] Hammock positioning also provides greater stability of the rib cage and more space for the diaphragmatic muscle fiber, which enhances its action. [12] Pereira et al. (2018) claimed that HP promotes a better relaxation of neonates, thus lowers the HR and RR to more stabilized levels. [38] Similarly, Costa et al. (2017) reported a statistically significant reduction of the heart and respiratory rates after HP. [36] On the contrary, Sousa et al. (2021) found no significant differences between HP and other study groups regarding HR or SpO_2. [26] Chiu et al. (2014) also did not identify any changes in SpO_2 among neonates who were placed in a hammock and those positioned in a crib. [30]

Maintaining a neutral thermal environment is a critical component of preterm neonates' nursing care, whether in the delivery room or during the subsequent care. [42] The present study illustrated an increment in the mean temperature after one hour of KMC relative to baseline temperature whereas the mean temperature of the control group declined. Heat conduction from mothers' warm bare chest to the preterm neonate's naked skin is sufficiently high to compensate for the heat loss. [43] Additionally, covering the preterm neonate's back with a blanket eliminates convective and radiative heat loss. [44] Correspondingly, Pramila and Vijay (2014) argued that early kangaroo care had a favorable effect on extrauterine temperature of low-birth-weight neonates as the assumed flexed position is more efficient in conserving heat by reducing the exposed skin area to the surrounding atmosphere. [45]

As a consequence of the advantages of KMC and HP in terms of cardio-pulmonary parameter stability and behavioral organization, it is thought that these interventions for preterm neonates have both short- and long-term benefits. Thus, it reduces stress, promotes relaxation, increases

muscle tone, as well as enhances breathing mechanics and gastric function. Besides, it has long term consequences on brain growth. (46)

Conclusion

Developmental supportive care represents a revolution in how nursing interventions are delivered in the NICU by stressing the humanity of the preterm neonates' care to achieve the greatest outcomes. In that sense, Both KMC and HP were proved to be promising in enhancing the preterm neonates' physiological stability and behavioral organization; however, KMC revealed a superior effect over HP.

Recommendations

In order to foster the behavioral stability of preterm newborns, there is an immense need to incorporate supportive developmental measures such as KMC and HP into NICUs protocol of care. Moreover, instructional programs are worthy of being conducted for NICU nurses and parents to increase their awareness regarding the benefits of such measures and mothers' capacity to engage in the care of their hospitalized preterm neonates.

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Conflict of Interest

The authors declare no conflict of interest concerning the research, authorship, and publication.

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