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The Effectiveness of Prone and Supine Positions on Body Temperature of Premature Neonates Admitted to Neonatal Intensive Care Unit

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Abstract

Background

Neonates are the most vulnerable population in terms of temperature control. In general, neonates are not able to protect themselves against fluctuations in ambient temperature. We aimed to compare the effect of the prone and supine positions on temperature of premature neonates.

Materials and Methods: In this crossover clinical trial, a total of 22 premature neonates between 32-36 weeks of gestation admitted to the Neonatal Intensive Care Unit of Amir Kabir Hospital, Arak, Iran, were selected through purposive sampling technique, and were randomly assigned into groups 1 and 2. Newborns in group 1 were first placed in a prone position (i.e., the first period for 3 hours), and then in a supine position (i.e., the second period for an additional 3 hours). The reverse procedure was applied to the intervention group 2. A trained nurse measured body temperature every minute for three hours with a digital thermometer.

Results: Mean age of newborns was 10.38±9.69 days and mean birth weight was 2297.72±693.75 g. The mean temperature at various times in the prone position was significantly higher than the prone position (P<0.05). The mean of body temperature at 1st, 2nd and 3rd hours in the prone position was 36.66 (±0.30), 36.57 (±0.29), and 36.88 (±0.35) and in supine position was 37.18 (±0.09), 37.16 (±0.16), and 37.17 (±0.17), respectively and in all three times, the temperature difference between the two positions was statistically significant (P<0.01).

Conclusion

Based on the results, placing of premature neonates, admitted to the NICU, in the prone position reduced the body temperature of those with fever or hyperthermia in a non-invasive and non-pharmacological manner and minimized their thermal fluctuations.

Key Words: NICU, Premature Neonates, Prone Position, Supine Position, Temperature.

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1- INTRODUCTION

Prematurity is a major cause of neonatal mortality and morbidity in NICUs and is considered the second cause of neonatal mortality after congenital anomalies (1, 2). Every year, about 15 million premature neonates are born worldwide, their survival has been improved due to the enhancement of technology and special treatment and supportive cares (3). Over the world, the estimated number of neonatal deaths between 1990 and 2017 decreased from 5 million to 2.5 million (4). One of the nursing cares and important factors in neonatal intensive care unit (NICU) is specific attention to the positioning of premature neonates. Since the publication of the clinical guidance by American Academy of Pediatrics (AAP) for decreased risk of Sudden infant death syndrome (SIDS), the prone position has decreased from 70 to 13% in America. This recommendation has resulted in neglecting other positions (5).

The preterm infant requires support to facilitate and maintain postures that enhance motor control, physiological functioning and reduce stress (6). Nesting technique is an intervention to improve musculoskeletal and postural outcomes and promote physiological functioning, stability of vital signs and sleep states of premature infants (7). Placement of premature newborns in the suitable position is one of the most important nursing cares (8). The prone position has many favorable effects, including reduced heart rate changes, increased pulmonary volume, improved breathing and oxygenation, reduced gastroesophageal reflux, rapid gastric emptying, decreased activity and energy consumption, improved sleep, decreased temperature loss, and reduced stress. However, there are some problems associated with this position, such as improper observation of infants, lack of ability to use in the presence of umbilical line, possibility of change of head shape and probability of SIDS (9, 10). On the other hand, the supine position has favorable impacts, including the ability to observe neonates, better performing of cares, and reduced risk of SIDS. However, some of the adverse effects of this position are increased need for oxygen, inappropriate ventilation, increased possibility of aspiration, and delay in gastric emptying (9-12). In general, premature neonates are placed in a non-supine position at the time of recovery (12). Nevertheless, infants must be placed in the supine position at the time of discharge to reduce the risk of SIDS (10). American Academy of Pediatrics recommended that premature infants, who are maintained in a clinically stable condition, be placed in the supine position so that they are used to the position at the time of discharge. Generally, premature neonates spend a period of their hospitalization in a non-supine position due to physiological and evolutional reasons (13).

Each position of neonates has different effects on their vital signs, especially the neonatal body temperature. The history of body temperature measurement dates back to Socrates. The temperature measurement scale was created by Celsius and Fahrenheit in the 18th century. In the 100-degree scale (centigrade), zero is indicative of the freezing point and 100 is allocated to the boiling point of water. However, the Fahrenheit scale has the freezing point of water at 32° and the boiling point of water at 212°. The mercury thermometer was invented by Fahrenheit in 1714, which is widely used in the hospitals of the world due to its high accuracy, low cost, and easy application (14). Continuous control and monitoring of the body temperature of infants in the NICU help to maintain their health. Abnormal body temperature is one of the most important causes of mortality and diseases (15, 16). The WHO has introduced the regulation of body temperature as the biggest neonatal health threat in the world. Control of neonatal body temperature depends on other systems of the infants, including cardiovascular, neurological and metabolic systems. Creation of heat is caused by elevated metabolic activity. Lower heat levels are caused by the activities of other organs, such as liver, brain, heart and skeletal muscle. Some of the causes of rapid temperature reduction in extremely low birth weight (ELBW) infants and premature neonates, compared to term newborns, are the low level of brown fat, surface area-to-volume ratio, and higher permeability of the premature infant's skin (17). The body heat of the fetus reaches the embryo through the cord, placenta, and amniotic fluid, and the heat from the fetal body is excreted through the placenta and amniotic fluid (17).

Transmission and conduction of neonatal skin temperature are generally poorly and strongly affected by the blood flow in the skin (14). While cold stress simulates breathing and protects newborns from brain damages caused by hypoxia, the long-term version of this process could be associated with some complications, such as hypoglycemia, hypoxia, metabolic acidosis, respiratory distress, coagulation disorders, acute renal failure, necrotizing enterocolitis, failure to gain weight and increased growth of premature neonates. In total, 500 to 600 calories of heat is used to evaporate every one ml of water from the neonatal body. The normal body temperature of infants is 36.5-37.5℃. Moreover, their skin temperature is 0.5-1℃ below their deep tissue temperature (18, 19). There is consensus between AAP and American College of Obstetricians and Gynecologists (ACOG) on maintaining the body temperature of 36.5-37.5 ℃ for term infants and 36.3-36.9 ℃ for premature neonates (18-21). There is a clear relationship between hyperthermia and secretion of cytokines, which leads to hematologic complications, such as thrombosis, resulting in complications of neurological malignancy. Several studies have mentioned the relationship between hyperthermia and cerebral damages caused by ischemia along with or without the presence of hypoxia. Brain damages caused by hyperthermia lead to increased risk of neurological damages and metabolic needs, changes in blood flow to the brain, and elevated amount of enzymes, including caspase 3. Experimental methods have shown that hyperthermic shock clearly increases the prothrombin and partial thromboplastin times and decreases D-dimer and platelet time. These hematological changes cause intravascular coagulation disorders (22). Among the treatment methods for cerebral damages, hyperthermia, neuromotomy and hypothermia were used by Mishima et al. on patients with hypoxic ischemia (23). According to their results, hyperthermia intensified the complications of hypoxic ischemia, and increased body temperature was significantly associated with cerebral complications (23).

The relationship between neonatal body temperature and their survival rate is well documented in a way that the survival rate of infants with body temperature of 31.7 °C was 83.5%, compared to the survival rate of neonates with the temperature of below 28.9 °C, which was 68.1% (11, 12). Compared to the temperature inside the incubator, the survival statistics are completely different when compared to the neonatal weight condition (16). In a research by Chitty et al., neonates weighing 1250-1500 gr at temperature of 0.2±36 °C during the first 96 hours of life and newborns with the body temperature of 31-32.2 °C were compared, demonstrating that the survival rate of the first group was significantly higher, compared to the control group (79% vs. 54%) (16). Hyperthermia occurs much faster than hypothermia in infants and its complications are equal to hypothermia. In addition, the body temperature regulator of infants is not complete due to the low number of sweat glands. Therefore, they cannot maintain coldness similar to adults. On the other hand, their body gets warm three-five times faster than adults. As a result, they are significantly prone to hyperthermia. It was found that placing preterm infants in the prone or supine position has effects on physiological factors, such as cardiorespiratory function, thermoregulation, oxygen saturation, body temperature and arousal from sleep (24). Therefore, the current study aimed to compare the impact of the supine and prone positions on body temperature of preterm infants in NICU.

2- MATERIALS AND METHODS

2-1. Study design and population

This randomized crossover clinical trial was conducted on newborns admitted to the NICU of Amir Kabir Hospital, Arak, Iran. A total of 22 newborns (32-36 weeks of gestational age) meeting the inclusion criteria were recruited through the purposive sampling technique. The study population was assigned into intervention groups 1 and 2 through the randomized block method.

2-2. Sample size

In this research, sample size was estimated at 22 newborns in each group according to the mean comparison formula based on Ghorbani et al.'s study (24). (α=0.05, β=0.2, S1=15.04, S2=13.09, D=12, n=22)

2-3. Inclusion and exclusion criteria

The inclusion criteria were: 1) gestational age of 32-36 weeks, 2) chronological age of 2-28 days, 3) birth weight of $\geq$ 1000 g, 4) spontaneous respiration and absence of mechanical ventilation, 5) maximum oxygen of 5 L/min when using oxygen in an incubator or hood, 6) stable body temperature, 7) lack of congenital disorders or blood disorder, 8) hemoglobin level of $\geq$ 9 g/dL, 9) nonuse of narcotics, corticosteroids, or surfactants, and 10) nonumbilical catheter in place. The exclusion criteria were: 1) parental refusal to continue the study, 2) transferring from NICU, 3) cardiopulmonary resuscitation, 5) inotropic support of $\geq$ 5 µg/kg, 6) pneumothorax, 7) peripheral edema, and 8) insertion of an umbilical catheter.

2-4. Intervention

First, all the newborns were placed in a lateral position for 30 minutes, body temperature was measured and recorded during this period. Then, the newborns in group 1 were turned to a prone position, and group 2 were placed in a supine position (i.e., the first period of intervention). A nurse measured body temperature every minute for three hours. Afterward, the newborns were placed again in a lateral position for 30 min, and their studied parameters were recorded. Thereafter, the newborns' position was changed to the opposite position of the first period (i.e., prone to supine and supine to prone), and their body temperature was recorded again every 15 min for 3 hours (i.e., the second period of intervention). The newborns were placed in a nest during positioning.

2-5. Measuring

Data were collected using a questionnaire, including two sections. The first section entailed the newborns' demographic information, including diagnosis, gender, gestational age, chronological age, type of delivery, 5-minute Apgar score, birth weight and height, and height and weight at the time of study. In addition, the second section consisted of a checklist to record vital signs (i.e., HR and RR) and body temperature. A consistent and trained nurse measured body temperature with a digital thermometer (TAT-5000: Exergen Temporal Scanner TAT-5000 (Exergen, Watertown, Massachusetts, USA).). To control the validity of the central skin thermometer, the infants' temperature was randomly checked and compared with a digital thermometer each time.

2-6. Ethical consideration

The current study was approved by the Ethics Committee of Arak University of Medical Sciences (Code no. IR.ARAKMU.REC.1395.150, date: July 18, 2016). The newborns were enrolled in the study as soon as their parents signed the written informed consent form. The parents were free to withdraw their newborn from the study at any time. The ethical principles for medical research established by the Iranian Ministry of Health and Medical Education were considered by the researchers throughout the study. The study was registered in the Iranian Registry of Clinical Trials (ID-Code: IRCT2017041633471N1).

2-7. Data Analyses

The data were analyzed in SPSS software (version 21.0). The normality of the data was examined using Kolmogorov-Smirnov test. Descriptive (i.e., mean, standard error, and 95% confidence interval), and inferential statistics (i.e., independent t-test and repeated-measures analysis of variance) were used for analyzing the data.

3- RESULTS

In this research, 22 neonates were placed in the prone and supine positions. The most common cause of hospitalization was RDS (n=8, 36.4%), and mean age of the newborns was 10.38±9.69 days, which was within the age range of 1-28 days. The mean (SD) birth weight (g) of included newborns and their mean (SD) weight at the time of the study (g) was 297.72±693.75, and 2293.63±652.1, respectively (**Table.1**).

Table-1: Baseline characteristics of the newborns, n=22.

Variables	Sub-group	Percentage (number)
Gender	Male	45.5 (10)
	Female	54.5 (12)
Type of delivery	Cesarean section	40.9 (9)
	Natural vaginal delivery	59.1 (13)
Diagnosis	Respiratory distress syndrome	36.4 (8)
	Transient tachypnea of the newborn	18.2 (4)
	Hyperbilirubinemia	18.2 (4)
	Sepsis-induced hyperbilirubinemia	13.6 (3)
	Pneumonia	9.1 (2)
	Sepsis	4.5 (1)
Gestational age (week)	32-33	31.8 (7)
	33-34	18.2 (4)
	34-35	40.9 (9)
	35-36	9.1 (2)
5-min Apgar score	4	4.5 (1)
	5	9.1 (2)
	6	18.2 (4)
	7	31.8 (7)
	8	27.3 (6)
	9	9.1 (2)

At first, the effect of period and the interaction between period and the intervention were investigated for all variables under study, and no effects were seen (**Table.2**). The comparison of body temperature between the two positions revealed that the mean body temperature in the prone position (36.77±0.04) was lower than that in the supine position (37.13±0.02) (**Table.3, Figure.1**).

Table-2: Impact of intervention period and interaction between period and treatment.

Temperature	(Prone-supine), n=22		(Supine-prone) n=22		Independent t-test	
	Standard deviation	Mean	Standard deviation	Mean	Statistics	P-value
Effect of period	0.26	0.37	0.28	0.35	0.156	0.87
Treatment*period	0.08	36.96	0.08	36.94	0.597	0.55

Table-3: Comparison of the modified mean body temperature between the two positions.

Group	Mean	Standard deviation	Confidence interval of 95%		P-value t-test
			Upper Limit	Lower Limit	
Prone position	36.772	0.042	36.684	36.684	0.0001
Supine position	37.137	0.022	37.091	37.091	

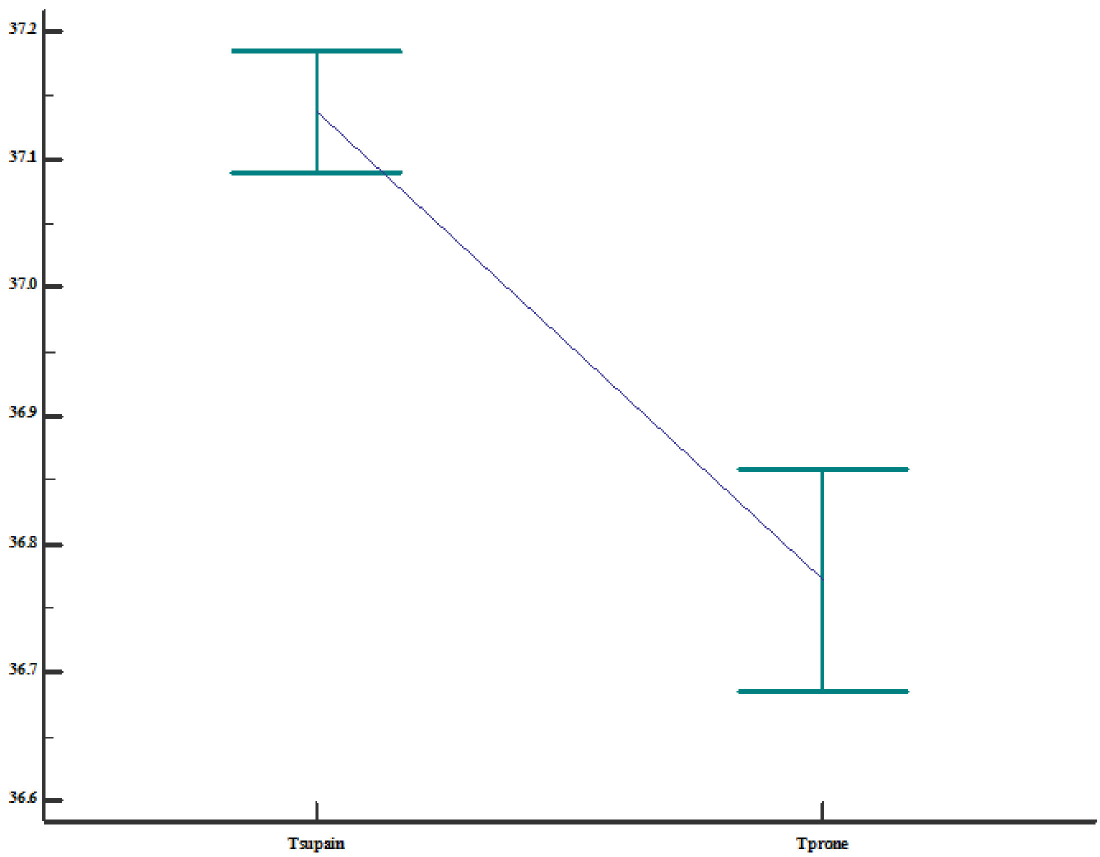

Fig.1: Comparison of the mean body temperature between the two positions.

It was also found that body temperature was significantly decreased over time in the prone position during both periods of the study (P<0.001; **Table.4**). According to **Table.4**, mean temperature in the supine position was significantly higher, compared to the prone position in each period after one hour. Moreover, changes in mean neonatal temperature had a decreasing trend in the prone position in both periods.

Table-4: Body temperature changes in both periods of the study at various times in two groups, n=22

Temperature	(Prone-supine)				P-value	(Supine-prone)				P-value
	Prone		Supine			Supine		Prone		
	Mean	Standard deviation	Mean	Standard deviation		Mean	Standard deviation	Mean	Standard deviation	
Before	37.13	0.15	37.38	0.47	0.1	36.72	0.32	36.65	0.58	0.72
15 minutes	37.11	0.19	37.01	0.16	0.19	37.14	0.32	37.14	0.22	0.999
30 minutes	36.94	0.17	37.04	0.15	0.15	37.15	0.21	37.1	0.12	0.5
45 minutes	36.95	0.26	37.08	0.13	0.15	37.17	0.16	37.009	0.16	0.02
One hour	36.85	0.26	37.18	0.09	0.0007	37.09	0.17	36.95	0.17	0.067
1:15 hours	36.66	0.3	37.14	0.14	0.0001	37.05	0.25	36.76	0.24	0.011
1:30 hours	36.64	0.26	37.09	0.19	0.0003	37.17	0.32	36.69	0.27	0.001
1:45 hours	36.66	0.38	37.08	0.24	0.0057	37.16	0.18	36.62	0.27	0.0001
Two hours	36.57	0.29	37.16	0.16	0.0001	37.16	0.15	36.71	0.31	0.0003
2:15 hours	36.65	0.37	37.24	0.14	0.0001	37.17	0.15	36.65	0.31	0.0001
2:30 hours	36.64	0.27	37.18	0.16	0.0001	37.19	0.14	36.58	0.33	0.0001
2:45 hours	36.58	0.34	37.2	0.18	0.0001	37.18	0.2	36.54	0.32	0.0001
Three hours	36.68	0.35	37.17	0.17	0.0005	37.19	0.23	36.5	0.34	0.0001
Repeated measured ANOVA	F=8.98 P=0.00001		F=2.564 P=0.067			F=5.09 P=0.003		F=9.047 P=0.0001		

4- DISCUSSION

This study aimed to evaluate the effect of prone and supine positions on body temperature in premature newborns. According to the results of the current research, mean body temperature was lower in the prone position in the nest, compared to the supine position. A premature neonate continues to grow outside the uterus in a way that the fastest duration of growth and cerebral development of neonates occurs during this time. On the other hand, there are some dangerous complications in this period, such as hyperthermia, which causes severe neural complications. Given the inability of premature newborns to maintain their body temperature at a normal and fixed range due to defects in their temperature regulation system, constant control of their body temperature is required (25). In a clinical trial by Van der Spek et al. (15), which was conducted on 26 very low birth weight neonates (520-1250 gr) with gestational age of 25-32 weeks, neonatal body temperature was measured every hour for 48 hours through rectal and skin methods. According to their results, mean skin temperature was 0.13 °C higher, compared to the mean rectal temperature (P<0.001). In addition, mean rectal and skin temperature was 37.05±0.41 and 37.18±0.5, respectively. In the aforementioned research, the difference between the rectal and skin temperature was -0.13. Given the lack of significant difference between the two techniques, the skin temperature method could be used as a safe technique to measure the temperature of neonates below 1,250 gr (15). The primary measures taken during the attachment of skin probe to the skin must avoid the placing of the probe on dry areas of the neonatal body (26, 27). Infants below 1750 gr must have a fixed skin temperature of 36.8, whereas infants with weights above 1750 gr must have a skin temperature maintained at 36.5. All infants below the gestational age of 32 weeks and weight below 1800 gr must be placed inside the incubator (28). The most common and safe method to control the temperature inside the incubator is servo control. Premature infants weighing more than 1800 gr with fixed axillary temperature of ≥36.5 °C in three consecutive rounds inside the incubator could be transferred to an open bed (29, 30).

In general, the conditions for transferring neonates from incubator to bed include weight above 1800 gr, fixed increase of weight, discontinued period of apnea and periodic bradycardia, being clinically and medically fixed, lack of need for long-term mechanical ventilation, decreased temperature of 0.5 °C inside the incubator every one hour until reaching the normal range, use of neonatal clothes, and ensuring of maintaining the axillary temperature of neonates every four hours and lack of fluctuations in the environment.

If the neonatal body temperature drops between 36.2-36.5 °C, more clothing or warm blankets must be used, if possible. Lack of fixed axillary temperature of neonates after one-hour of controls until three hours leads to the infants being placed inside a warm incubator (31, 32). It is noteworthy that premature neonates have no reaction to cold or to sweating reaction to warmth. Therefore, the best solution to measure their body temperature is constant control of body temperature in the ward. The central temperature receptors in the body are in hypothalamus, spinal cord, and abdominal organs (19). Some of the solutions for reducing neonatal body temperature higher than 37.5 °C include the evaluation and control of environmental factors, reducing the temperature of the bed about 0.5 °C every hour, control of axillary temperature of neonates every two hours until there are two consecutive rounds of temperature below 37.5 °C, and placing of neonates in the prone position (33). Therefore, placing infants in the prone position can be used as a safe and non-invasive method to maintain the body temperature of premature newborns within the range of 36.5-36.9 °C. This position also helps maintain a proper position for the infants. The aims of placing infants in nest are modifying positioning in the midline position, simulating fetal position in uterus in the form of flexion of body parts surrounded by the uterine wall and being placed in the middle line in the NICU.

The contact of hands of neonates with their face and mouth and sucking of fingers in this position leads to self-regulation and self-calming of infants. Another important cause of use of the nest is that generally, neonates understand gravity after birth and require help to perform their movements (flexion of body parts and self-calming). Given the fact that this inability is higher in premature neonates, they have to put more energy into this task. Therefore, it is recommended that the nest be applied in all stages of hospitalization in the NICU, whether in the prone, supine or side position.

4-1. Study Limitations

There are also limitations that must be considered while interpreting the results of the study. Some physicians were reluctant to include their patients in the study and this made the sampling process difficult. Also, gradients of surface temperature can be expected to parallel gradients in cutaneous blood flow but peripheral blood flow was not directly measured.

5- CONCLUSION

According to the results of the current research, the proper position for reducing and maintaining body temperature of premature neonates at the normal range along with fixing the vital signs is the prone position. Therefore, it is suggested that neonates admitted to the NICU be placed in the prone position if possible.

6- CONFLICT OF INTEREST

7- REFERENCES

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