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The Supported Diagonal Flexion Kangaroo Position Supports Physiological Stability in Premature Infants Through a Randomized Controlled Trial

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Background: Physiological parameters are vital indicators of neonatal health, particularly in premature and low birth weight (LBW) infants. **Specific Background:** Kangaroo Mother Care (KMC) enhances neonatal outcomes, yet optimal positioning—such as the recently introduced Supported Diagonal Flexion (SDF) position—requires further validation. **Knowledge Gap:** Limited evidence exists on whether SDF positioning offers physiological advantages over the conventional upright kangaroo position. **Aims:** This study aimed to determine the effect of SDF positioning on physiological stability in premature and LBW infants during KMC. **Method:** A randomized crossover trial was conducted involving 31 mother-infant dyads. Each infant experienced both SDF and upright kangaroo positions in two sessions, with at least one hour per session. Physiological parameters—body temperature, heart rate, and oxygen saturation—were measured at baseline and post-intervention, analyzed using General Linear Model Repeated Measures and Mann-Whitney tests. **Results:** No statistically significant differences were observed across parameters: temperature ($p=0.370$), heart rate ($p=0.956$), and oxygen saturation ($p=0.373$). **Novelty:** This is among the first trials comparing SDF and upright KMC positions in a crossover design. **Implications:** Although physiological differences were not significant, SDF positioning demonstrated safety and maintained stability, supporting its use as an alternative in KMC practices for premature and LBW infants.

Highlights:

- Highlights the safety and stability of SDF positioning in KMC.
- Uses a robust crossover design for internal control.
- Supports clinical application despite non-significant differences.

Keywords: Kangaroo Mother Care, Supported Diagonal Flexion, Premature Infants, Physiological Stability, Randomized Crossover Trial

Introduction

Mortality in premature infants is one of the global health problems that requires prevention efforts. Prematurity (gestational age <37 weeks) and low birth weight infants (<2500 grams) play an important role in the incidence of infant mortality and long-term neurodevelopmental disability [1]. Preterm birth and low birth weight, which contribute greatly to newborn mortality, occur in low- and lower-middle-income countries [2] [3]. About 45% of all children under the age of five who die are newborns, and 60-80% of newborns who die are premature and/or small babies of gestational age [4].

Treated premature infants/LBW are also exposed to several stress factors such as invasive procedures, bright light, and noise from medical equipment [5] [6]. Complications also often occur including breathing problems, hypoglycemia, sepsis, hyperbilirubinemia, thermoregulation problems, feeding problems, ICH, and even death [7] [8]. Useful interventions are indispensable for optimizing physiological and behavioral responses in premature infants [9] [10].

WHO states that three-quarters of mortality rates in premature infants can be prevented with current, cost-effective interventions. One of the 3 focus areas recommended by WHO to deal with mortality is through kangaroo mother care (KMC). The mortality rate in premature infants with KMC is 36% lower when compared to conventional treatment [11].

There have been slight changes and modifications in KMC positioning guidelines between 2003 and 2010 that are physiologically justified but have not been associated with any effect/benefit on communication patterns between mothers and infants. Buil et al. (2016) provide alternatives to modifying the position of SDF kangaroos to facilitate further benefits of giving kangaroo positions to communication patterns between mothers and infants. This SDF position is given with a half-leaning position diagonally on the mother's chest, related to the flexion posture around the mother's nipple, and following the baby's natural posture namely the asymmetrical tonic neck posture.

In the upright position, eye contact between mother and baby is only possible if the baby's head position is hyperextended, which can interfere with postures such as opisthotonos posture, and orthopedic abnormalities of the feet [12]. Such postures are known to harm muscle and orthopedic development [13] [14] [15]. SDF positioning shows modest changes in skin-to-skin contact positioning that have immediate and tangible benefits to maternal communicative behavior directed at infants and are thought to have a long-term positive impact on infants' psychomotor development [12] [16].

Optimal vital signs in premature neonates are very important concerning neonatal health indicators [17]. Vital signs monitors provide information about the baby's state and are important information in making a care plan [18]. KMC is an essential developmental care to ensure neonatal vital signs remain within normal limits through providing relaxation, reducing stress, increasing comfort, and supporting intervention and treatment for neonates [18].

There has been a lot of evidence from both experimental and quasi-experimental studies that review the effect of KMC on the vertical positioning of physiological parameters of premature infants [19] [20] [21]. However, not many studies have been found regarding the effect of SDF kangaroo positioning on the physiological function of premature infants/LBW. Research related to this position is also still rare and very little is applied in Indonesia.

The results of the meta-analysis of [22] stated that the average respiratory rate in premature infants / low birth weight performed by KMC was lower than infants who received conventional treatment and statistically meaningful, but not significant for heart rate, oxygen saturation, and temperature parameters. In line with the study [12] on SDF positioning that showed a significant decrease in breath frequency during skin-to-skin contact sessions.

This study then aims to determine the difference in the effect between diagonal kangaroo positioning and vertical/upright position on physiological parameters (temperature, heart rate, and oxygen saturation) in premature infants/LBW undergoing KMC. It is known that the effect of applying the kangaroo position will later be an intervention option, as well as an alternative in supporting the stability of the physiological function of premature infants/LBW.

Method

This study used a randomized control trial design with a crossover type, where respondents become controls for themselves. The study was conducted in two type B hospitals in Lampung Province. The population in this study

was mothers and premature infants/LBW who were undergoing treatment in the perinatology room. The sample was determined by consecutive sampling techniques from July to September 2023. Inclusion criteria were set out in this study: (1) premature infants/low birth weight with gestational age < 37 weeks or with a birth weight of < 2500 grams, as well as mothers who are willing to participate in the study; (2) the baby is in stable condition and has been allowed to do KMC; (3) infants do not have congenital genetic disorders, progressive neurological diseases, and malformed diseases; (4) the mother has no physical or psychological abnormalities and can read and write. The exclusion criteria are (1) premature infants experience shortness of breath, decreased oxygen saturation, tachypnea, or bradipnea; (2) uncooperative mother or family member. The total sample involved amounted to 31 respondents (each group). Randomization of samples based on randomization of blocks that have been compiled by researchers.

Consists of two group variables, namely the control group and the intervention group. The control group got KMC in an upright position, while the treatment/intervention group got a diagonal position. The intervention protocol for SDF kangaroo positioning in this study is based on the research of Buil et al. [23] [24] [25].In this study, a sling modification was carried out with a type of fabric 4 meters long and 40 cm wide, made of stretchy (elastic spandex) which allows stretching in all directions. The same type of sling is applied to both types of kangaroo positions in both SDF and upright positions. How to use a long cloth sling is with the Pocket Wrap Cross Carry (PWCC) wrap technique. The use of this long cloth sling aims to support and maintain the baby's posture and make it easier for the mother. The data collection instruments used were observation sheets, monitoring physiological functions of infants, and questionnaires of respondents' demographic data.

The study involved mother and infant in two types of kangaroo positioning methods (figure 1,2). In each group, mothers and babies will do KMC for at least 1 hour per session (as many as 2 sessions). A washout period of at least 3 hours is given between the two types of groups to avoid the influence of the first intervention on subsequent interventions (cross-over). During the KMC session, the nurse will collect data related to the results of measuring the baby's physiological parameters including temperature, heart rate, and oxygen saturation. Three measurements of results were carried out, namely at the beginning, after 1 hour session 1, and after 1 hour session 2 in each group. Researchers are assisted by enumerators/research assistants in providing KMC interventions and collecting observational data on the physiological parameters of premature infants/LBW. Enumerators are PK III nurses who have work experience in the perinatology room and/or have KMC training certificates.

Figure 1. Sling and Diagonal Kangaroo Position Model

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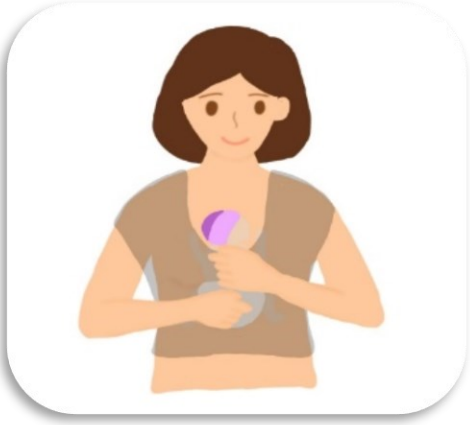

Figure 2. Sling and Upright Kangaroo Position Model

Statistical analysis of research data was carried out with the SPSS program. The characteristic variables of maternal and infant respondents, and the results of observations of physiological functions of infants, are presented in the form of frequency distributions or central tendencies in the form of mean, standard deviation, minimum, maximum, and median. Bivariate analysis of infant physiological function comparison based on the results of initial measurements, measurements after 1-hour session 1, and measurements after 1-hour session 2 were carried out with repeated ANOVA tests, as well as multivariate tests between intervention groups using General Linear Model Repeated Measure (GLM RM). If the data normality test is obtained, and the distribution of data is abnormal, then the Friedman test and the repeated Mann-Whitney test are used.

Ethical approval was obtained from the research ethics committee of the Tanjungkarang Poltekkes with No. 173/KEPK-TJK/III/2023 and from the KEPK of Imanuel Hospital Bandar Lampung with No. 1157/SDM/RSIM/VIII/2023.

Results and Discussion

A. Result

1. Respondent Demographics

A total of 31 study respondents became controls for themselves. The characteristics of research respondents are divided into two, namely infant respondents and maternal respondents.

No	Variable	Mean	SD
Infant Characteristics			
1	Gestational age	33,48	3,335
2	Birth weight	1928,06	343,855
3	Weight during research	1886,77	301,437
4	Long treatment	13,52	6,260
		Median	**Min-Mak**
5	Cronological age	12	4-37
		Frequency	**Percentage**
6	Gender	19	61,3
	a. *ale*	12	38,7
	b. *emale*		

		Frequency	Percentage
Mother's characteristics			
7	Education *a. lementary school* *b. unior High School* *c. enior High School* d. *ollege*	 4 9 17 1	 12,9 29 54,8 3,2
8	Job *a. other does not work* b. *other works*	 29 2	 93,5 6,5
9	Parity status *a. Multipara* b. *Primipara*	20 11 **Mean**	64,5 35,5 **SD**
10	Mother's age	29,29	6,28

Table 1. Characteristics of Infant and Maternal Respondents (n=31)

Respondents of premature infants/low birth weight are almost balanced between males (61.3%) and females (38.7%). The respondents were premature infants with an average gestational age of 33.48 weeks and a low birth weight with an average birth weight of 1928.06 grams. The average weight of infants when carried out in this study was 1886.77 grams, with an average length of days of infant care of 13.52 days, and a chronological age of 12 days when KMC was carried out.

Based on Table 1 on maternal respondents, it is also known that the average age of mothers who gave birth to premature infants/LBW in the two hospitals where the study was 29.29 years, with the lowest age of childbirth being 16 years and the highest 45 years. Based on the distribution of education levels, it is known that the most are mothers with a high school education, which is 54.8% while for universities it is only 3.2%. It is also known that the majority of mothers who have premature infants/LBW are non-working mothers with a percentage of 93.5%, and 64.5% are mothers with a history of previous childbirth (multipara).

2. Parameters of physiological functioning of premature infants

Variable	**Treatment Group (n=31)** Mean/Median (Min-Mak)	**Control Group (n=31)** Mean/Median (Min-Mak)
Temperature		
Initial	36,46 (36,30-36,70)	36,47(36,30-36,70)
After 1 hour session 1	36,56 (36,30-36,70)	36,61(36,30-36,90)
After 1 hour session 2	36,55 (36,40-36,80)	36,56(36,30-36,80)

P value	< 0,001*	< 0,001*
Heart Rate		
Initial	154 (148-158)	154 (148-158)
After 1 hour session 1	153 (146-156)	152 (150-157)
After 1 hour session 2	153 (146-156)	152 (148-157)
P value	0,001**	0,230**
Oxygen Saturation		
Initial	95,10 (93-97)	94,90 (93-97)
After 1 hour session 1	94,68 (93-96)	94,84 (93-98)
After 1 hour session 2	94,61 (93-98)	94,84 (93-97)
P value	0,06*	0,95*

*Repeated ANOVA. Post hoc position SDF temperature: initial vs. session 1(P<0.001); initial vs. session 2 (P 0.012). Post hoc vertical position temperature: initial vs. session 1 (P<0.001); initial vs. session 2 (P 0.003).
**Mann-Whitney. Post hoc Wilcoxon SDF position heart rate: baseline vs. session 1 (0.001); Initial vs Session 2(0.004)

Table 2. Comparison of Initial Physiological Parameters and During the KMC Session of Each Group

The physiological functions of premature infants/LBW measured in this study are temperature, pulse, and oxygen saturation. The results of the analysis proved that statistically there was a significant difference in the average body temperature of infants between the first, second, and third measurements in each group (p-value <0.001). Infant body temperature measurements during the study, both in the treatment group and the control group had a higher average when compared to the initial temperature.

The results of the analysis proved that statistically there was a significant difference in average heart rate between the first, second, and third measurements in the treatment group (SDF position) (p-value 0.001), but not significant for the upright position group. The average initial heart rate at the SDF position was slightly higher than the heart rate during KMC which tended to be stable between session 1 and session 2.

The results of oxygen saturation analysis in the treatment group (P value 0.06) and control group (P value 0.95) showed that there was no difference in oxygen saturation between the initial measurement, session 1, and session 2. The average value of oxygen saturation was almost the same between all measurement sessions, with the highest average saturation value being 95.10% for the initial measurement in the SDF position treatment group, and the lowest value of 94.61% after 1 hour session 2 of the SDF position treatment group.

Variable	**Treatment Group (n=31)** Mean (SD)	**Control Group (n=31)** Mean (SD)	***P value***
Temperature			
Initial	36,46 (0,105)	36,47 (0,101)	
After 1 hour session 1	36,56 (0,095)	36,61 (0,158)	0,370
After 1 hour session 2	36,55 (0,129)	36,56 (0,131)	
Heart Rate			
Initial	154 (2,863)	154 (3,462)	

After 1 hour session 1	153 (2,965)	152 (2,262)	0,956
After 1 hour session 2	152 (2,991)	152 (2,521)	
Oxygen Saturation			
Initial	95,10 (1,012)	94,90 (0,944)	
After 1 hour session 1	94,68 (0,791)	94,84 (1,068)	0,373
After 1 hour session 2	94,61 (1,145)	94,84 (1,036)	

Table 3. Comparison of the Physiological Parameters of Infants Between Groups While Doing KMC

3. General Linear Model Repeated Measure (GLM-RM)

The results of the multivariate test analysis showed that there was no significant difference in the average body temperature, heart rate, and oxygen saturation of infants on all measurements (initial, after 1-hour session 1, and after 1-hour session 2) between the SDF position treatment group compared to the control group who received routine treatment using an upright/vertical position with p value 0.370, 0.956 and 0.373 respectively. [26] recommends that infant clinical conditions such as heart rate, breathing, skin color, temperature, and oxygen saturation (if possible) should be monitored during KMC.

B. Discussion

1. Respondent Demographics

a. Baby Characteristics

Infants born with a body weight between 1200-1799 grams are usually accompanied by some health problems so it takes several days for stabilization in the special care room of neonates [27]. Infants with higher gestational age and birth weight can develop KMC faster than infants with gestational age and smaller birth weight. [28] states that currently, studies have proven that many benefits are obtained from starting KMC immediately, including reducing mortality, hypothermia, the incidence of infection, and increasing infant weight.

KMC is a simple and cost-effective intervention and can reduce mortality and the risk of infection in premature infants/LBW [29]. The results of a systematic review conducted by [25] stated that KMC should be started immediately within 24 hours after birth and given at least 8 hours every day. This is in line with WHO's latest recommendations for the care of premature infants/LBW [26].

In 2015, WHO recommended initiation of KMC in low birth weight infants (< 2000 grams) after the infant is clinically stable [30]. Stabilization of premature/low birth weight infants can take anywhere from a few hours to a few days, depending on gestational age, birth weight, and conditions at birth. The average age of the onset of KMC varies from 3 to 24 days [3]. Recent recommendations from WHO state that intermittent KMC can be started in healthcare facilities immediately before the baby is clinically stable, except in infants who cannot breathe spontaneously after resuscitation, go into shock, or require mechanical ventilation assistance [26].

b. Maternal Characteristics

One factor that can reduce the incidence of premature/LBW birth is pregnancy and childbirth at the ideal age (30). In this study, several respondents aged more than 35 years and less than 20 years were found to be one of the risk factors for premature birth [31] and is associated with maturity and decreased physiological function of the female reproductive organs [32].

Research by [33] states that the higher the mother's education level, the lower the incidence of low birth weight. The higher the mother's education level, the more mothers will get information about low birth weight, so that mothers will gain better knowledge to prevent low birth weight and make decisions related to the health of mothers and infants [34].

Low education is correlated with poor nutrition of pregnant women due to low family income and ability to choose food menu (eg milk consumption), and late/rare antenatal examination. However, the study by [34] stated that there

was no relationship between the education level of mothers, the majority of whom were in high school (37.5%), and the readiness of mothers to care for LBW. This is possible through the knowledge, information, and education provided to mothers that can prepare mothers to be able to care for premature infants/LBW including kangaroo mother care.

Primigravida mothers also have a risk of giving birth to premature infants/LBW, although this parity factor does not stand alone but is supported by other factors [32]. Other risk factors that also contribute to low birth weight include smoking, young age, low socioeconomic status, poor health information about pregnancy, and inadequate nutrition in pregnant women.

Similarly, occupation is associated with one of the socio-economic predictors that are important determinants in determining birth weight in a population, although the study of [35] found no meaningful relationship between maternal work and the birth of premature infants (P 0.077). However, mothers who do not work will benefit more from having more time to care for their infants.

2. Parameters of Physiological Functioning of Premature Infants

Based on Table 2, it is known that there is a significant difference in the average body temperature of infants in both the treatment and control groups and the infant's body temperature during the study has a higher average when compared to the initial temperature. Similar results are found in many studies that state KMC as an alternative incubator treatment and is recommended as one of the routine care interventions in premature infants that have a positive effect on the stability of the infant's body temperature and supports the physical health status of premature infants [37]. In KMC, there is direct contact between the infant's skin and the mother's skin (skin-to-skin contact). The mother's body acts as a thermoregulator to activate the infant through the process of heat transfer by conduction.

The results also showed that there was a significant difference in average heart rate in the treatment group (SDF position), but not significant for the upright position group. The average initial heart rate at the SDF position was slightly higher than the heart rate during KMC which tended to be stable between session 1 and session 2. [36] in their study stated that skin-to-skin contact in the implementation of KMC resulted in short-term improvements in cardiorespiratory stress, compared to conventional incubator treatment. Similar results were found in a study by [37] which states that KMC can reduce neonatal crying, improve physiological function, and stabilize the neonatal heart and blood vessel system. Although in the findings of the meta-analysis, [38] concluded that there is not enough evidence to state that KMC affects heart rate/pulse.

The results of oxygen saturation analysis showed no difference in oxygen saturation between the initial measurements, session 1 and session 2 in each group. The average value of oxygen saturation was almost the same between all measurement sessions, with the highest mean value of 95.10% being in the initial measurement results of the treatment group/SDF, and the lowest mean value of 94.61% after 1 hour of the 2nd session of the SDF group.

The results of this study are slightly different from the results of the study of [39] which showed that the physiological function status of oxygen saturation increased significantly during the intervention. In general, the value of oxygen saturation (SPO2) in the KMC group provides a positive picture and effect [18]. Oxygen saturation increases due to brain activity when the infant sleeps [40]. Premature infants/LBW who are treated by the kangaroo mother care become more relaxed so that oxygen saturation and the infant's pulse become more stable. This period of relaxation results in less energy expenditure in the infant.

In premature infants, the recommended oxygen saturation range based on the results of the study by [40] is 87% to 94%, while the oxygen saturation range of 85% to 89% can increase mortality and 91% to 95% can cause hyperoxia and adverse effects on infants. Pulse oximetry is good at measuring oxygen saturation and pulse, but some SpO2 monitors allow for bias in SpO2 assessment [42].

Based on Table 3, although there were no significant differences between groups in all measurements (initial, after 1-hour session 1, and after1 hour session 2) parameters of temperature, pulse, and oxygen saturation, these findings suggest that KMC in both diagonal and upright positions contributes to clinical stability in premature infants/low birth weight. A meta-analysis by [41] states that variations in temperature and oxygen saturation during the duration of the intervention do not cause any negative effects on infants, even in very premature infants. Many studies show

no statistically significant differences in the physiological function variables of premature infants, possibly due to sample size and control for other factors.

Physiologically, the diagonal kangaroo positioning in this study was safe and did not cause adverse effects, comparable to the upright positioning. There is very little evidence to suggest that KMC harms the physiological parameters of stress in premature infants, even in the most fragile infants [38]. KMC has an amending effect on the vital signs of premature neonates [18].

Similar results were found in a study [42] which stated that when compared to KMC upright position, in the application of KMC with SDF/diagonal position there were no negative effects related to the physiological function of premature infants. KMC supports neurobehavioral development in premature infants through the facilitation of the infant's natural posture (asymmetric tonic neck posture), and the elimination of environmental stressors that can cause physiological and behavioral disorders in infants.

SDF kangaroo positioning in 20 very premature infants during skin-to-skin contact sessions supported more restful sleep; evidence of less disorganized movement, negative vocalizations, and drowsiness; and no awake or active wakefulness status was found [43]. Skin-to-skin contact in KMC can also reduce cortisol levels, thereby reducing pain in the infant [44].

Conclusion

KMC is a developmental care practice that is essential in ensuring that neonatal vital signs are maintained within normal limits, as well as the diagonal kangaroo position in this study supports the creation of stable physiological function and safety in premature infants/LBW. Further research concerning other factors that allow bias to occur is needed to reinforce these findings.

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