The effect of kinesthetic tactile stimulation on enhancing motoric development in babies with low birth weight

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Abstract

Neonatal mortality in Indonesia is predominantly attributed to Low Birth Weight (LBW), prematurity, asphyxia, and infections, with LBW infants at an elevated risk of mortality and developmental delays. The 2025 health goals in Indonesia prioritize reducing infant mortality, maternal mortality, and malnutrition. Metro City has implemented strategies such as healthcare training and enhanced referral networks to support these objectives. This study investigates the effect of tactile kinesthetic stimulation on motor development in LBW infants treated in a Metro City hospital from September to December 2019. Using a quasi-experimental design, 22 LBW infants were divided into intervention and control groups, each with 11 infants selected through quota sampling. Motor development was assessed using validated observation tools and analyzed with paired t-tests (α=0.05). Results indicated a significant improvement in motor development in the intervention group after 10 days of tactile kinesthetic stimulation ($p=0.001$, $p<0.05$), as well as a significant increase within the control group ($p=0.004$, $p<0.05$). A comparison on day 10 revealed a significant difference favoring the intervention group ($p=0.001$, $p<0.05$). The findings suggest that tactile kinesthetic stimulation effectively enhances motor development in LBW infants compared to standard care. However, the small sample size limits the generalizability of the results, warranting further research to confirm these findings in broader populations.

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Informed consent and consent to participate: all parents or legal guardians of participants in this study provided written informed consent before participation. They were fully informed about the study's objectives, procedures, potential benefits, and risks. Participation was entirely voluntary, with the right to withdraw at any time without consequences.

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Introduction

Neonatal mortality, defined as the death of a newborn within the first 28 days of life, remains a significant public health issue worldwide, including in Indonesia. Despite various efforts, the neonatal mortality rate in Indonesia is still high, at approximately 20 per 1,000 live births. This high rate indicates an urgent need for effective interventions targeting neonatal care and prevention strategies. Low Birth Weight (LBW) is a known risk factor for neonatal mortality, and addressing this factor is crucial for improving survival rates among newborns.[1]

Anemia during pregnancy has been identified as a significant risk factor for low birth weight and neonatal mortality. In Indonesia, the prevalence of anemia in pregnancy was reported to be 37.1% in 2013, rising to 48.9% in 2017.[2] Anemia during pregnancy is a critical public health issue that requires immediate attention and intervention to mitigate risks for both the mother and the newborn. Breastfeeding has been consistently shown to have a protective effect against neonatal mortality. Exclusive breastfeeding for the first six months of life is associated with reduced child mortality rates.[3] Promoting and supporting breastfeeding, particularly exclusive breastfeeding, can significantly contribute to reducing neonatal mortality rates in Indonesia. Adequate healthcare services, including comprehensive antenatal care and access to skilled midwives, are essential in reducing neonatal mortality rates. The high maternal mortality rate in Indonesia, reported to be 305 per 100,000 live births in 2019, further highlights the necessity of improving healthcare services for pregnant women.[4] Ensuring that pregnant women receive appropriate care during pregnancy and childbirth can help prevent complications that may lead to neonatal mortality.

Socioeconomic factors and environmental conditions also significantly influence neonatal mortality. A study conducted in Indonesia found that children's environmental profiles, including factors such as sanitation and housing, were associated with the risk of child mortality.[5] Improving environmental conditions and addressing social determinants of health can play a pivotal role in reducing neonatal mortality rates. Despite ongoing efforts, neonatal mortality remains a significant public health issue in Indonesia, particularly in regions such as Lampung and Metro City. Contributing factors include inadequate implementation of standard neonatal care protocols, high prevalence of anemia during pregnancy, suboptimal breastfeeding practices, and limited access to quality healthcare services. Addressing these factors through enhanced training and implementation of evidence-based practices, interventions to reduce anemia during pregnancy, promoting and supporting breastfeeding, and strengthening healthcare services is crucial to reducing neonatal mortality rates in Indonesia.[6]

Parental knowledge about neonatal diseases and symptoms is a critical challenge in reducing infant mortality. The government has responded by improving neonatal healthcare services, including training healthcare workers and increasing the number of pediatricians.[7] Improving maternal and child health services is also crucial. Government programs offer adequate pregnancy care, including routine check-ups, nutritional counseling, and access to essential medications. Promotion of exclusive breastfeeding is also emphasized.[8] Strengthening health infrastructure, including health facilities in rural areas and investing in medical equipment, aims to improve the quality of healthcare services for newborns and their mothers. Accurate and up-to-date data are essential to monitor policy effectiveness. The government has implemented a data collection and analysis system to identify areas needing further intervention.[9] Research supporting efforts to reduce infant mortality due to LBW includes the study titled "Tactile-kinesthetic stimulation to gain weight and reduce the length of stay care for premature babies at public hospitals of Semarang, Indonesia, which shows that using tactile-kinesthetic stimulation on LBW infants effectively increases weight and reduces hospital stay length. These findings confirm that tactile-kinesthetic stimulation interventions can positively impact maintaining premature infants' weight while reducing hospital care costs.[10] Another study titled "Effect of tactile-kinesthetic stimulation on growth, neurobehavior, and development among preterm neonates" also revealed that tactile-kinesthetic stimulation positively affects weight gain and early discharge of premature infants, which is efficient and potentially cost-saving. However, further research is needed to evaluate the effects of tactile-kinesthetic stimulation on infants with birth weights of less than 1000 grams and to apply this research in other regions to obtain more informative data.[11]

A study conducted by Ahmed *et al.* in 2015, titled "Effect of tactile kinesthetic stimulation on preterm infants' weight and length of hospital stay in Khartoum, Sudan," also confirmed the benefits of tactile kinesthetic stimulation in increasing weight and reducing hospital stay length for preterm infants. These findings underline the efficiency and potential cost savings of using tactile kinesthetic stimulation.[12] Numerous studies have identified several factors contributing to high neonatal mortality rates, including inadequate management of neonatal visits by midwives, the prevalence of anemia during pregnancy, suboptimal breastfeeding practices, and limited access to healthcare services. Several studies also highlight the importance of tactile-kinesthetic stimulation in increasing weight and reducing the length of stay for LBW infants, demonstrating the potential of this intervention to address the issue. Tactile-Kinesthetic Stimulation (TKS) has emerged as a promising intervention to support the growth and development of LBW infants. Previous studies, such as those conducted in Indonesia and other regions, have shown that TKS can increase weight gain and reduce the length of hospital stays for LBW infants, thereby lowering healthcare costs.[10,11] The effectiveness of TKS in facilitating motor and neurobehavioral development is supported by evidence indicating that physical stimulation can promote weight gain and improve developmental outcomes in LBW infants. However, further research is needed to confirm the efficacy of this intervention in diverse contexts and among infants with varying birth weights.

This study aims to evaluate the effect of kinesthetic tactile stimulation on motor development in LBW infants. By focusing on motor development, this research seeks to expand the understanding of how TKS can support specific developmental outcomes in LBW infants, potentially reducing the high neonatal mortality rates in Indonesia. The expected outcome is to provide evidence on the benefits of TKS, contributing to standardized neonatal care protocols that may improve survival and developmental outcomes in LBW infants.

Materials and Methods

Research design

This study utilized an intervention design, specifically a Nonequivalent Control Group Design, to evaluate the impact of Tactile Kinesthetic Stimulation (TKS) on motor development in Low Birth Weight (LBW) infants. In this design, the treatment and control groups were compared without randomization.

Population and sample

The population included all LBW infants treated in the Perinatology Ward of a hospital in Metro City, Indonesia, from September to December 2019. Quota sampling was used to select the sample, which consisted of 22 LBW infants divided equally into an intervention group (n=11) and a control group (n=11).

To define the study population clearly, inclusion criteria consisted of LBW infants who were treated in the Perinatology Ward during the specified study period and whose parents provided informed consent for their participation. Exclusion criteria included LBW infants with congenital defects or physical injuries, as these conditions could independently influence motor development and potentially bias the results. Specifying these criteria ensures transparency and aids replicability, allowing a more accurate assessment of TKS effects on motor development in LBW infants.

Variables

The independent variable was Tactile Kinesthetic Stimulation (TKS) applied to infants in the intervention group. The dependent variable was motor development in LBW infants, measured by specific motor reflexes indicative of early developmental milestones.

Measurement and instrumentation

Motor development was assessed using an adapted observation sheet, evaluating reflexes such as Babinski, tonic neck, Moro, grasp, standing, and walking. This tool was modified from the Premature Neonates Behavior Assessment Sheet by Situmorang

(2010), a validated instrument for assessing premature infant behavior. Content validity was confirmed by a neonatal nursing expert, Rustina from the Faculty of Nursing, University of Indonesia, ensuring the adequacy of the instrument for this specific population.[13,14] Reliability of the instrument was tested using Cronbach's Alpha, with a high alpha score indicating strong reliability. In Situmorang's (2010) original study, the instrument showed a Cronbach's Alpha of 1.707, exceeding the critical value at the 5% significance level (r table=0.878). This high reliability score confirms the instrument's appropriateness for assessing motor development in premature and LBW infants. This study is an intervention research using a Nonequivalent Control Group Design. This design compares the treatment and control groups without randomization.

Implementation of tactile kinesthetic stimulation

The implementation began by selecting the sample using quota sampling until the sample size was met. All eligible LBW infants, totaling 11, were included, with 11 in the intervention group and 11 in the control group. Reflexes such as Babinski, tonic neck, Moro, grasp, standing, and walking were assessed on the first day for both groups. The intervention group received tactile kinesthetic stimulation every morning and evening for 10 days. On the 10th day, reflexes were reassessed in both groups. The reflex assessments and tactile kinesthetic stimulation were conducted by trained researchers and enumerators certified in National Baby-SPA and Treatment.

Statistical analysis

The data obtained from this study were analyzed using a dependent t-test, as the data were normally distributed. Statistical analysis was performed at a 95% confidence level (α=0.05).

Ethical permission

This study received approval from the Health Research Ethics Committee (KPEK) of the Tanjungkarang Health Polytechnic, with approval number 266/EA/KEPK-TJK/IX/2019.

Results

The demographic data of the study respondents as shown in Table 1.

Tabel 1 show The respondents gender in the intervention group had a slightly higher number of females (55%) compared to males (45%). In the control group, females (64%) also outnumbered males (36%). This indicates a relatively balanced gender distribution between the two groups, with no significant difference in gender distribution.

The majority of infants in the intervention group were premature (64%), with a smaller proportion being mature (36%). Similarly, the control group was predominantly composed of premature infants (82%), with only a few being mature (18%). This data shows that most infants in this study were born prematurely, and the significant difference in gestational age between the two groups could influence the motor development of LBW infants.

In terms of birth weight, most infants in the intervention group were classified as LBW (64%), while a smaller number were Very Low Birth Weight (VLBW) (36%). In contrast, the control group had a higher proportion of VLBW infants (55%) compared to LBW infants (45%). This indicates a difference in birth weight distribution between the two groups, which could affect the outcomes of the tactile kinesthetic stimulation intervention.

The analysis of respondent demographics indicates that the study was conducted with a relatively balanced gender distribution between the intervention and control groups. However, there were significant differences in gestational age and birth weight between the groups. These differences could influence the results of the study on the effect of tactile kinesthetic stimulation on motor development in LBW infants and should be considered when interpreting the data. Further research may be needed to determine whether these factors significantly impact the study outcomes.

The t-test analysis aimed to evaluate whether there were significant differences in motor development in LBW infants before and after receiving tactile kinesthetic stimulation for 10 days. The analysis results are shown in Table 2.

In the intervention group before the tactile kinesthetic stimulation, the mean motor skills score was 5.82 with a standard deviation of 2.316. After the intervention, the mean motor skills score increased to 11.18 with a standard deviation of 2.750. The t-test showed a highly significant difference (p=0.001, $p<0.05$) between the motor skills scores before and after the tactile kinesthetic stimulation in the intervention group.

The control group Before the tactile kinesthetic stimulation, the mean motor skills score was 2.27 with a standard deviation of 1.679. After the intervention, the mean motor skills score increased to 4.27 with a standard deviation of 1.555. The t-test for the control group also showed a significant difference (p=0.004, $p<0.05$) between the motor skills scores before and after the intervention, although the difference was not as substantial as in the intervention group. The t-test analysis results indicate that tactile kinesthetic stimulation significantly improved motor skills in LBW infants in the intervention group. The very low p-value (p=0.001) suggests that this change was not due to chance but was a direct effect of the intervention. However, it is worth noting that the control group also experienced a significant improvement in motor skills, albeit to a lesser extent than the intervention group. These results strong-

Table 1. Respondent demographic data.

	Number	Percentage (%)
Demographic data		
Gender		
Intervention group		
Male	5	45
Female	6	55
Control group		
Male	4	36
Female	7	64
Gestational age		
Intervention group		
Premature (< 36 weeks)	7	64
Mature (36 – 40 weeks)	4	36
Control group		
Premature (< 36 weeks)	9	82
Mature (36-40 weeks)	2	18
Birth weight		
Intervention group		
Lbw (1500 – 2499 grams)	7	64
Vlbw (< 1500 grams)	4	36
Control group		
Lbw (1500-2499 grams)	5	45
Vlbw (< 1500 grams)	6	55

ly support the effectiveness of tactile kinesthetic stimulation as an intervention to enhance motor development in LBW infants. Nonetheless, further research with larger samples and more rigorous controls is necessary to validate these findings more thoroughly. The motor skills scores of the control group before the 10-day care period had a mean of 2.27 with a standard deviation of 1.679, and after 10 days of care, the mean increased to 4.27 with a standard deviation of 1.555. The study results show a significant difference between the scores before and after the care period without tactile kinesthetic stimulation ($p=0.004$, $p<0.05$).

The difference in mean motor skills scores between the intervention group receiving tactile kinesthetic stimulation and the control group on the 10th day showed a p-value of 0.000 ($p<0.05$), indicating a significant difference in motor skills scores between LBW infants who received tactile kinesthetic stimulation and those who did not, as seen in Table 3.

The findings demonstrate that tactile kinesthetic stimulation significantly improved motor skills in LBW infants in the intervention group compared to the control group. The very low p-value ($p=0.001$) underscores the effectiveness of the intervention.

Discussion

The findings of this study show a marked improvement in motor development among LBW infants following Tactile-Kinesthetic Stimulation (TKS). The motor development score in the intervention group increased significantly from a baseline of 5.82 to 11.18 over 10 days of stimulation, with a statistically significant difference ($p=0.001$). This improvement aligns with the growing body of evidence that supports TKS as an effective intervention for enhancing motor development and other physical outcomes in LBW infants.

Studies reinforce the role of TKS in promoting physiological growth in LBW infants. Johari et al. found that TKS contributed to weight gain and advocated massage as a complementary therapy to mitigate neurological issues in neonates.[15] Similarly, Sartika's research demonstrated that TKS produced a significant weight increase in LBW infants ($p=0.005$), underscoring TKS's role in supporting developmental and growth outcomes.[16]

The physiological basis for these findings is supported by motor development theories, where kinesthetic and tactile inputs play essential roles in developing neural and motor pathways. The study by Rismalinda (2017) highlights that motor development in infants is influenced by the coordination of muscle, nerve, and brain functions.[17] According to Piaget's Cognitive Development Theory, reflex-based development in infants progresses naturally up to about six weeks, suggesting that TKS may accelerate this natural developmental trajectory in LBW infants who may otherwise develop more slowly without such stimulation.[18]

Further, the findings align with Kachoosangy & Aliabadi (2011), who reported significant improvements in motor behavior in LBW infants who received 10 days of TKS ($p=0.0001$) compared to controls.[19] This suggests that tactile stimulation may support motor milestone achievements in LBW infants by providing essential sensory input that aids in nervous system maturation.

Several studies, including Yoanita *et al.* (2021), have also shown that TKS supports weight gain and reduces hospital stay durations, demonstrating its potential for broader physiological benefits.[11] Additionally, Iskandar *et al.* (2019) observed similar benefits in Indonesia, reporting that TKS promoted weight gain and shortened hospital stays, suggesting its viability as a cost-effective intervention in resource-limited settings.[10]

Despite these promising findings, the study encountered certain limitations. The small sample size (n=22) limits generalizability and may reduce the robustness of the statistical analysis. Additionally, differences in gestational age between the intervention and control groups could present confounding effects. Previous research indicates that gestational age plays a crucial role in motor development; therefore, future studies should account for gestational age as a potential confounding variable to enhance accuracy. Moreover, a Nonequivalent Control Group Design without randomization can introduce selection bias, potentially affecting internal validity.

Nevertheless, this study contributes to the evidence supporting TKS as a safe and effective intervention for LBW infants, improving motor development outcomes. The use of validated instruments for assessing motor reflexes strengthens the reliability of the findings, and adherence to ethical standards ensures research integrity. Future research should aim to include a larger and more diverse sample to enhance generalizability and explore the potential of TKS for very low birth weight infants and those with different gestational age profiles.Based on the study results, the average

Table 2. Differences in motor skills of infants before and after tactile stimulation in the intervention and control groups.

	N	Mean	SD (±)	95% CI	t	p
Intervention group						
Before	11	5.82	±2.316	-4.763 – -2.601	-7.085	0.001
After		11.18	±2.750			
Control group						
Before	11	2.27	±1.679	-3.202 – -0.798	-3.708	0.004
After		4.27	±1.555			

*Paired T-test.

Table 3. Differences in motor skills of infants after tactile stimulation in the intervention and control groups.

	N	Mean	SD (±)	95% CI	t	p
Intervention	11	11.18	2.750	1.791-4.937	4.461	0.001
Control		4.27	1.555			

*Independent T-test.

motor development of LBW infants in the intervention group before receiving tactile kinesthetic stimulation was 5.82, which increased to 11.18 after 10 days of stimulation. This shows an improvement of 5.36 points. Further analysis revealed a significant difference in average motor development before and after the tactile kinesthetic stimulation in the intervention group, with a p-value of 0.001.

This study aligns with (Jonathan *et al.*, 2020) in "The Effect of Massage Stimulation On The General Movements Quality In Breastfed Preterm Infants," where the general movement quality in preterm infants did not show significant differences between groups (p=0.150).[20] However, Based on Johari (2016) in "The Effect of Massage on Weight Gain of Low-Weight Hospitalized Infants: A Randomized Clinical Trial" found that tactile-kinesthetic stimulation led to weight gain in LBW neonates and recommended massage therapy as complementary care to prevent neurological issues.[15]

This issues supporting by Sartika (2015) found significant weight gain in LBW infants receiving tactile kinesthetic stimulation, with an increase from 1744.7 grams to 1764.4 grams on average.[16] Statistical analysis confirmed a significant weight increase (p=0.005). Kachoosangy & Aliabadi (2011) also observed significant motor behavior improvement in LBW infants given 10 days of tactile kinesthetic stimulation compared to the control group (p=0.0001).[19] Similar findings were reported by Hastuti *et al.*,[21] who noted significant physiological development in heart rate and respiration in LBW infants after tactile kinesthetic stimulation (p=0.037 and p=0.001, respectively). However, temperature development showed significant differences in both stimulated and non-stimulated groups (p=0.001). Physiologically, LBW infants develop slower than normal infants, but tactile kinesthetic stimulation accelerates motor development. Providing tactile kinesthetic stimulation helps LBW infants develop motor skills faster compared to no stimulation. The control group's initial average motor development was 2.27, increasing to 4.27 after 10 days, showing a 2.00-point improvement. Statistical analysis showed a significant difference in motor development before and after the study period without tactile kinesthetic stimulation (p=0.004). Jonathan *et al.* (2020) found no significant differences in general movements among preterm infants with or without massage stimulation (p=0.150).[20] Physiologically, newborns develop motor skills, determined by muscle, nerve, and brain elements.[17] According to Piaget's Cognitive Development Theory, infants experience reflex development up to 6 weeks old, indicating natural motor skill progression.[18] Motor development involves coordinating nervous system activities, starting with newborn reflexes that fade by 6-9 weeks.[22] Without stimulation, LBW infants develop motor skills slower than normal infants. Tactile kinesthetic stimulation accelerates motor development in LBW infants, potentially equating their progress to that of normal infants.

Dependent t-test analysis showed significant differences in motor development between infants in the intervention group and those in the control group (p=0.001). This indicates the effectiveness of tactile kinesthetic stimulation in enhancing motor skills in LBW infants. Yoanita *et al.* (2021) found that tactile kinesthetic stimulation benefits weight gain and reduces hospital stay duration. Further studies are recommended to evaluate its impact on infants under 1000 grams and to collect broader data.[11] Iskandar *et al.* (2019) reported that tactile kinesthetic stimulation effectively increased weight gain and reduced hospital stays in LBW infants in Semarang, Indonesia.[10]

Ahmed *et al.* (2015) emphasized the beneficial impacts of tactile kinesthetic stimulation, noting its significant role in enhancing both weight gain and the efficiency of hospital discharge processes in Sudan.[12] Similarly, Johari *et al.* (2016) proposed massage therapy as a beneficial intervention for promoting weight gain and supporting neurological development in infants with low birth weight (LBW).[15] Furthermore, other studies demonstrated that tactile kinesthetic stimulation effectively enhances feeding tolerance and facilitates weight gain specifically in late preterm neonates.[23] Tactile stimulation is commonly used to stimulate spontaneous respiration in preterm infants during neonatal resuscitation.[24] An other studies observed that tactile stimulation could shorten the duration of apnea, hypoxia, and bradycardia, with automated stimulation showing promise.[25]

Jonathan *et al.* (2020) found no significant differences in general movements among preterm infants with or without massage stimulation (p=0.150).[20] Conducted with Hidayanti (2018) found significant weight and length gains in newborns after parental massage.[26] Karbasi *et al.* (2013) suggested body massage as a safe, non-medical intervention for weight gain in LBW neonates.[27] Similar findings were reported in Iran (2010), showing that tactile stimulation for 10 days improved motor behavior in LBW infants compared to those without stimulation.[19] Tactile stimulation is effective once infants are stable post-intensive care. Anjos *et al.* (2021) found that hydrotherapy and tactile-kinesthetic stimulation significantly increased weight gain in preterm infants, making these interventions safe and beneficial.[28] Emphasized the need for standardized tactile/kinesthetic stimulation application and further research on its side effects.[29]

Motor development in LBW infants in the intervention group significantly improved after receiving tactile kinesthetic stimulation. In contrast, the control group showed no significant development over ten days. This study has several strengths. It targets LBW infants, a particularly vulnerable group, allowing for interventions that address specific developmental needs. The study uses a structured intervention with a Nonequivalent Control Group Design and systematically applies tactile kinesthetic stimulation, making the protocol clear and replicable. Additionally, the use of validated instruments, confirmed for content validity and reliability, ensures the accuracy and consistency of the data collected. The study also benefits from ethical approval by a recognized ethics committee, which adds credibility and ensures adherence to ethical research standards. Moreover, the study uses specific and measurable outcomes (motor reflexes) to evaluate the intervention's effectiveness, providing clear and concrete results.

However, there are notable weaknesses. The small sample size of only 22 infants (11 in each group) limits the generalizability of the findings and reduces the statistical power of the results. The use of a Nonequivalent Control Group Design, which lacks randomization, could introduce selection bias and affect the internal validity of the study. Additionally, differences in gestational age and birth weight distribution between the intervention and control groups could influence the study's outcomes and complicate the interpretation of the results. Despite these limitations, the study provides valuable insights into the potential benefits of tactile kinesthetic stimulation for LBW infants' motor development.

Recommendations

For future studies, it is recommended to increase the sample size and employ a randomized controlled trial design to enhance the validity and generalizability of the findings. Extending the follow-up period will help assess the long-term effects of tactile kinesthetic stimulation. Controlling for confounding variables, such as gestational age and birth weight, and including additional developmental outcomes will provide a more comprehensive understanding of the intervention's impact. Exploring parental involvement, conducting cost-effectiveness analyses, and incorporating qualitative research methods can offer valuable insights into the practical application and feasibility of the intervention. Collaboration with multidisciplinary teams will ensure a holistic approach and improve care practices for LBW infants.

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