Kangaroo Mother Care as an Effective Strategy to Reduce Pain Responses in Neonates Undergoing Blood Sampling for Congenital Hypothyroidism Screening

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ABSTRACT
The collection of blood samples for Congenital Hypothyroidism Screening (CHS) is a routine neonatal procedure that induces moderate pain, thereby requiring effective interventions to reduce discomfort. This study aimed to examine the effect of the kangaroo method on neonatal pain scores during CHS blood sampling. A quasi-experimental design with a posttest-only control group approach was employed, involving 56 neonates selected through quota sampling at Garuda and Ibrahim Adjie Primary Health Centers in Bandung. Pain intensity was assessed using the Neonatal Infant Pain Scale (NIPS) and analyzed with an independent sample t-test. The findings demonstrated a significant difference between groups, with the intervention group showing a mean pain score of 2.83 compared to 5.79 in the control group. Statistical analysis confirmed a significant effect of the kangaroo method in reducing neonatal pain scores ($p = 0.000$; $p < 0.05$). The analgesic mechanism of the kangaroo method operates through the modulation of dual neural pathways that inhibit pain impulses, thereby decreasing neonatal pain responses. These results indicate that the kangaroo method is an effective, practical, and safe non-pharmacological intervention for reducing neonatal pain during CHS blood sampling and can be recommended for routine pain management in neonatal care.
Keywords: kangaroo method; pain; congenital hypothyroidism screening

INTRODUCTION
Congenital Hypothyroidism Screening (CHS) represents a critical early detection strategy aimed at identifying thyroid dysfunction in newborns as early as possible, thereby preventing delays in diagnosis and subsequent management [1-5]. This screening procedure is typically performed through neonatal blood sampling. Although the procedure is brief and routinely conducted, blood sampling remains a painful stimulus for neonates. Pain during the neonatal period should not be underestimated, as it can influence both physiological and behavioral responses and may lead to short- and long-term adverse consequences if not appropriately managed.

Blood sampling is recognized as a painful procedure routinely performed in newborns [6]. This is supported by the pain hierarchy described by Lissauer and Fanaroff, which categorizes heel-prick or venous puncture for CHS as a moderate pain stimulus [7]. Such procedures elicit distinct physiological and behavioral responses in neonates, including tachypnea, distressed facial expressions (such as brow bulging and furrowing), uncoordinated motor activity, and vocalizations in the form of crying [8]. Preliminary observations conducted in the field similarly demonstrated these characteristic responses. Due to the neonate's limited capacity for verbal communication, pain in this population is frequently underrecognized and undertreated [9].

Given these concerns, various strategies must be implemented to alleviate neonatal pain [6]. The American Academy of Pediatrics (AAP), in its policy statement, emphasizes that preventive and procedural pain management in neonates constitutes an essential standard of care for all pediatric practitioners [10]. The literature indicates that simple, low-cost non-pharmacological interventions have been shown to effectively reduce procedural pain in newborns [6]. AAP-recommended non-pharmacological measures include specific holding techniques, non-nutritive sucking, direct breastfeeding or expressed breast milk administration, and skin-to-skin contact, all of which have demonstrated efficacy in reducing pain during short procedures that induce mild to moderate discomfort [11].

However, findings from Rebecca et al. highlight that although non-nutritive sucking, specific holding methods, and swaddling can reduce pain in both preterm and term infants, these interventions may also be associated with adverse events such as vomiting, abdominal distension, transient skin reactions, decreased oxygen saturation, infant distress, and even septicemia [12]. Other studies examining breastfeeding, glucose administration, and non-nutritive sucking have not conclusively identified which non-pharmacological method is most effective for reducing neonatal procedural pain [6].

Considering that pain is one of the primary concerns among parents [13], parental involvement in neonatal pain management becomes an important source of support and should be integrated into care practices. Nevertheless, the implementation of neonatal pain management frequently encounters systemic barriers, including time constraints, insufficient knowledge among healthcare providers, skepticism regarding pain assessment tools, and inconsistent clinical approaches across practitioners [14][15].

The Kangaroo Method (KM), or skin-to-skin contact, is a non-pharmacological therapeutic approach in which the newborn is placed directly on the parent's chest, allowing continuous skin contact [16]. Evidence from Indriayani's study demonstrated a statistically significant reduction in pain intensity among preterm neonates in the NICU who received KM for 15 minutes prior to a procedure, with mean pain scores ranging from 4.53 to 5.26 compared to 5.38 to 10.23 in the control group [17]. Similar benefits were observed during intramuscular injection procedures in newborns, where the intervention group exhibited moderate pain while the control group experienced severe pain [18].

The analgesic mechanism of KM involves activation of the body's endogenous pain-modulation system through simultaneous multisensory stimulation, including tactile, proprioceptive, vestibular, olfactory, auditory, visual, and thermal inputs [19]. Effective KM duration ranges from 10 to 180 minutes before or during the procedure to achieve optimal analgesic effects. Its mechanism operates through inhibition of pain signal transmission prior to reaching the sensory cortex, consistent with the gate control theory of pain modulation [20]. Additionally, KM stimulates the release of endorphins and oxytocin, both of which contribute to natural analgesia [19]. Physiological and behavioral stress responses—such as motor dysregulation and increased heart rate—are significantly reduced, with clinical manifestations including decreased crying and faster recovery times [21].

KM also provides dual benefits by reducing maternal stress through decreased cortisol levels [22], increased oxytocin release [19], anxiolytic effects, enhanced maternal–infant bonding [23], and improved breastfeeding self-efficacy.

Given the complex phenomena described above, there is a clear need to further explore the effectiveness of the Kangaroo Method as a non-pharmacological intervention for managing procedural pain during CHS. Specifically, it is essential to determine whether KM can significantly modulate neonatal pain responses during blood sampling for Congenital Hypothyroidism Screening.

METHODS

The present study employed a quantitative quasi-experimental design using a post-test only control group structure. The research was conducted at two primary health centers in Bandung, namely Garuda Health Center, which served as the intervention site, and Ibrahim Adjie Health Center, which served as the control site. The selection of these sites was determined through simple random sampling. The study population consisted of all neonates scheduled to undergo Congenital Hypothyroidism Screening (CHS). Sample selection was carried out using a quota sampling technique, resulting in 28 neonates assigned to the kangaroo method intervention group and 28 neonates assigned to the control group, who underwent standard blood sampling procedures without the intervention.

The inclusion criteria for participation were: (i) gestational age between 37–40 weeks, (ii) birth weight between 2500–4000 grams, and (iii) neonates and mothers without medical conditions requiring referral to higher-level healthcare facilities, which would otherwise prevent CHS procedures from being conducted at the primary health center. The exclusion criteria consisted of neonates and mothers presenting with medical conditions requiring advanced care, thereby making CHS procedures at the primary health center unfeasible.

Neonatal pain scores were assessed using the Neonatal Infant Pain Scale (NIPS). Data collection was conducted through direct observation using a structured checklist for the kangaroo method and the NIPS instrument. The data collection procedure included several steps: screening of eligible respondents based on inclusion and exclusion criteria; obtaining informed consent from parents; providing maternal education regarding the kangaroo method; implementing the kangaroo method for 15 minutes prior to and during the CHS blood sampling procedure; and observing and recording neonatal pain scores during the blood sampling process.

Data analysis was performed using SPSS version 26. Bivariate analysis employed the Independent Sample t-test to compare mean pain scores between the intervention and control groups. Prior to hypothesis testing, data normality was assessed using the Kolmogorov–Smirnov test, which demonstrated a normal distribution ($p = 0.200$).

RESULTS

Table 1. Pain scores in the intervention group

Pain score	Frequency	Percentage
1	2	7.14
2	8	28.5
3	11	39.2
4	7	25
5	1	3.57

Based on Table 1, which presents the distribution of neonatal pain scores in the intervention group, it can be observed that the 28 neonates exhibited varying levels of pain during the CHS blood sampling procedure. The highest proportion of neonates experienced a pain score of 3, recorded in 11 infants (39.29%), indicating that nearly two-fifths of the intervention group demonstrated a moderate pain response. This was followed by a pain score of 2, reported in 8 neonates (28.57%), suggesting that more than one-quarter of the infants experienced relatively mild discomfort. A pain score of 4 was observed in 7 neonates (25%), while the lowest frequency was found at a pain score of 1, recorded in only 2 neonates (7.14%). A single neonate (3.57%) experienced a pain score of 5.

Overall, the distribution pattern indicates that the majority of neonates in the intervention group clustered within the lower to moderate pain categories (scores 2–4). This pattern reflects the potential analgesic effect of the kangaroo method, which appears to modulate pain responses and reduce the likelihood of higher pain scores during the procedure.

Table 2. Pain scores in the control group

Pain Score	Frequency	Percentage
4	2	7.14
5	7	25
6	14	50
7	5	17.86

Table 2 illustrates the distribution of pain scores among neonates in the control group, who underwent standard CHS blood sampling without the kangaroo method. The distribution demonstrates a markedly different pattern compared to the intervention group. The highest frequency was observed at a pain score of 6, reported in 14 neonates (50%), indicating that half of the infants experienced substantial pain during the procedure. This was followed by a pain score of 7 in 5 neonates (17.86%) and a pain score of 5 in 7 neonates (25%). The lowest frequency was recorded at a pain score of 4, observed in only 2 neonates (7.14%).

The distribution clearly shows that the majority of neonates in the control group experienced higher pain scores, particularly within the range of 6–7, which collectively accounted for 21 neonates (75%). This concentration of higher pain scores suggests that the absence of the kangaroo method is associated with increased pain intensity during CHS blood sampling.

Table 3. Effect of the kangaroo method on neonatal pain scores during congenital hypothyroidism screening blood sampling

Study group	Mean score	SD	p-value
Intervention	2.83	0.93	0.000
Control	5.79	0.86	

The normality test conducted using the Kolmogorov–Smirnov method yielded a significance value of 0.200 ($p > 0.05$), indicating that the data were normally distributed. Consequently, the comparison of mean pain scores between the two groups was appropriately analyzed using the Independent Sample t-test.

The results demonstrate that the mean pain score in the intervention group was 2.83 (SD = 0.93), whereas the control group exhibited a substantially higher mean pain score of 5.79 (SD = 0.86). The Independent Sample t-test produced a p-value of 0.000, which is below the threshold of 0.05, indicating a statistically significant difference between the two groups at the 95% confidence level. Thus, H_0 is rejected and H_a is accepted.

These findings confirm that the kangaroo method had a significant effect on reducing neonatal pain during CHS blood sampling. Neonates in the intervention group, who received kangaroo care prior to and during the procedure, exhibited markedly lower pain scores compared to those in the control group, who underwent standard operational procedures without the intervention. This result reinforces the analgesic benefits of the kangaroo method and supports its implementation as a non-pharmacological strategy for neonatal pain management in primary healthcare settings.

DISCUSSION

Pain score distribution in the control group

Based on Table 1, which presents the distribution of neonatal pain scores in the intervention group, the findings demonstrate a clear variation in pain intensity among the 28 neonates who received the kangaroo method prior to and during the CHS blood sampling procedure. The highest proportion of neonates experienced a pain score of 3, accounting for 39.29% of the sample, indicating that nearly two-fifths of the infants exhibited

a moderate pain response. This was followed by a pain score of 2, reported in 28.57% of neonates, suggesting that more than one-quarter of the infants experienced mild discomfort. A pain score of 4 was observed in 25% of neonates, while the lowest proportion was recorded at a pain score of 1, representing 7.14% of the sample. Only 3.57% of neonates demonstrated a pain score of 5, indicating that higher pain responses were relatively uncommon in the intervention group.

The distribution pattern suggests that the kangaroo method effectively modulated neonatal pain responses, as the majority of infants clustered within the lower to moderate pain categories. This aligns with the theoretical framework of neonatal pain physiology, wherein the kangaroo method may attenuate nociceptive transmission and reduce the likelihood of higher pain scores.

Physiological mechanisms of neonatal pain during blood sampling

The pain experienced by neonates during CHS blood sampling originates from the fundamental neurophysiological process of nociception. Pain perception begins with transduction, during which noxious stimuli are converted into electrical impulses by nociceptors located in the skin, muscles, and visceral tissues [24]. These nociceptors consist primarily of unmyelinated C-fibers and lightly myelinated A-delta fibers, both of which serve as primary receptors for painful stimuli [25]. The generated impulses are then transmitted via primary afferent fibers to the spinal cord through the dorsal root [24].

Within the spinal cord, the first synaptic relay occurs in the dorsal horn (cornu dorsalis), which serves as the initial processing center for nociceptive input [24]. Anatomically, the dorsal horn is organized into six Rexed laminae (I–VI), with laminae I and II—collectively known as the substantia gelatinosa—acting as the principal termination sites for nociceptive fibers [26]. From this point, pain signals ascend through two major pathways. The spinothalamic tract comprises two components: the lateral spinothalamic tract, which conveys discriminative aspects of pain (location, intensity, quality) to the ventral posterolateral (VPL) nucleus of the thalamus, and the anterior spinothalamic tract, which transmits affective dimensions of pain to the intralaminar thalamic nuclei [Slater et al., 2019]. The second pathway, the spinoreticular tract, projects to the reticular formation, particularly the nucleus raphe magnus and the periaqueductal gray (PAG) [27].

At the thalamic level, nociceptive signals undergo further processing in distinct nuclei [28]. The VPL nucleus relays sensory-discriminative information to the primary somatosensory cortex (S1) [29], while the intralaminar nuclei—including the central lateral and parafascicular nuclei—project to the anterior cingulate cortex and prefrontal cortex, mediating the affective-motivational dimensions of pain [28].

Neonatal physiological responses to pain involve multiple organ systems. The cardiovascular system responds with increased heart rate and blood pressure due to sympathetic activation. The respiratory system may exhibit altered breathing patterns and reduced oxygen saturation (SpO_2). The autonomic nervous system triggers increased muscle tone, pupil dilation, and palmar sweating as part of the sympathetic stress response [30].

Pain score distribution in the control group

Based on Table 2, the distribution of pain scores in the control group—who underwent standard CHS blood sampling without the kangaroo method—reveals a markedly different pattern. The highest proportion of neonates experienced a pain score of 6, representing 50% of the sample, indicating that half of the infants exhibited substantial pain. This was followed by a pain score of 7 in 17.86% of neonates and a pain score of 5 in 25% of the sample. The lowest proportion was recorded at a pain score of 4, representing 7.14% of neonates.

The concentration of neonates within the higher pain score range (scores 6–7), which collectively accounted for 75% of the sample, suggests that the absence of the kangaroo method was associated with significantly greater pain intensity. This distribution contrasts sharply with the intervention group, where pain scores were predominantly clustered within the lower to moderate range.

Physiological and behavioral modulation through the kangaroo method

The kangaroo method has been shown to stabilize neonatal cardiovascular and respiratory parameters during invasive procedures, enhance maternal responsiveness, and create a supportive sensory environment that mitigates pain responses [31]. Physiologically, kangaroo care promotes stabilization of heart rate and respiratory rate, prevents oxygen desaturation, and reduces episodes of bradycardia or tachycardia commonly observed during painful procedures [32]. Optimal thermoregulation is also achieved through maternal heat transfer, reducing metabolic stress in neonates [19].

Kangaroo Mother Care (KMC) is recognized as an effective non-pharmacological intervention for reducing neonatal pain during invasive procedures. Evidence indicates that administering KMC for 15 minutes prior to a procedure significantly reduces stress responses, particularly in preterm neonates above 32 weeks of gestational age [33]. The multisensory stimulation provided by KMC—including maternal warmth, heartbeat sounds, and maternal scent—collectively contributes to a complex analgesic effect [17].

The analgesic mechanism of KMC is consistent with the gate control theory of pain, which posits that non-painful sensory input can inhibit the transmission of painful stimuli to the central nervous system by "closing the gate" at the spinal level [34]. This mechanism occurs in the substantia gelatinosa of the dorsal horn, where interneurons modulate synaptic transmission between primary afferent neurons and ascending nociceptive pathways [35]. Skin-to-skin contact activates large, myelinated Aβ fibers, which stimulate inhibitory interneurons in the substantia gelatinosa, thereby reducing nociceptive transmission [20].

KMC also triggers the release of oxytocin [19], a hormone with well-established analgesic properties [36]. Oxytocin activates descending inhibitory pathways originating from the periaqueductal gray (PAG), projecting to the rostral ventromedial medulla (RVM), and subsequently to the dorsal horn, where serotonin and norepinephrine release stimulates interneurons to secrete enkephalins—endogenous opioids that suppress pain transmission [36].

Pain score interpretation and comparative analysis

The NIPS indicators in this study demonstrated improvement across all behavioral and physiological domains in the intervention group. Neonates exhibited more relaxed facial expressions, reduced crying, stable respiratory patterns, normal limb positioning without excessive flexion, optimal alertness, and improved consolability [12]. These findings reinforce the analgesic benefits of the kangaroo method during CHS blood sampling. The mean pain score in the intervention group was 2.83 (SD = 0.93), whereas the control group demonstrated a substantially higher mean score of 5.79 (SD = 0.86). The difference of 2.96 points on the NIPS scale reflects a clinically meaningful reduction in pain intensity attributable to the kangaroo method.

These findings are consistent with previous studies demonstrating the significant analgesic effects of KMC during invasive neonatal procedures (U = 241.00, p = 0.014) [37][38]. A meta-analysis of six studies further confirmed the statistical superiority of KMC over standard care in reducing procedural pain (p = 0.01, mean difference = −2.04, 95% CI: −3.65 to −0.43), despite high heterogeneity (I^2 = 93%) [21]. Additional studies have shown that KMC significantly reduces COMFORTneo scores, crying duration, perceived pain, and procedural stress in neonates undergoing invasive procedures [12].

Study limitation

A notable limitation of this study is that CHS blood sampling was conducted in two different primary health centers by two different healthcare providers. Although both providers adhered to standardized operating procedures, variations in technique or interpersonal interaction may have introduced potential bias.

CONCLUSION

The kangaroo method was shown to be effective in reducing neonatal pain intensity during congenital hypothyroidism screening blood sampling. This significant reduction indicates that kangaroo care functions as a reliable non-pharmacological intervention for managing pain during invasive neonatal procedures. Its clinical application has the potential to enhance the overall quality of neonatal care by minimizing procedural trauma, strengthening maternal–infant bonding, and supporting a more humanistic and evidence-based model of practice. The findings of this study contribute meaningfully to the development of neonatal and midwifery care standards that are more responsive to infant needs, and they provide a foundation for future research that may incorporate environmental factors, provider consistency, and broader implementation strategies.

Ethical consideration, competing interest and source of funding

-This study received ethical approval from the Ethics Committee of Poltekkes Kemenkes Bandung under approval number 51/KEPK/EC/II/2024. All ethical principles were upheld, including informed consent, data privacy, justice, and the balance of risks and benefits.
-There is no conflict of interest related to this publication.
-Source of funding is authors.

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