GLAND SURGERY

# THE EFFECT OF TACTILE-KINESTHETIC STIMULATION ON WEIGHT AND LENGTH OF HOSPITAL STAYS IN PRETERM NEONATES: A RANDOMIZED CLINICAL TRIAL

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## Abstract

**Background:** Preterm birth is a major cause of neonatal mortality and long-term neurodevelopmental impairment, while the stressful NICU environment negatively affects preterm neonates' growth, weight gain, and length of hospital stay (LOS). Although Tactile-Kinesthetic Stimulation (TKS) is an evidence-based, non-pharmacological intervention that may reduce these adverse effects, further high-quality evidence is needed to establish its effectiveness in improving growth and clinical outcomes among preterm neonates.

**Purpose:** This study evaluated the clinical efficacy of the TKS protocol on weight trajectories and the LOS among preterm neonates.

**Design and Method:** A parallel-group, randomized clinical trial design was utilized at the NICU of King Abdullah University Hospital in northern Jordan. A total of 69 stable preterm neonates (gestational age 34–37 weeks, birth weight 1500–2500 grams) were randomized to either the TKS group (n = 34) or the control group (n = 35). The study group received routine NICU care combined with a standardized 15-minute, skin-to-skin TKS protocol administered twice daily for 5 consecutive days, consisting of prone tactile stroking and supine passive range-of-motion exercises. The control group received only routine nursing care. Primary outcomes

included daily weight, discharge weight, and LOS. Data analyzed using the Statistical Package for the Social Sciences (SPSS) version 23.0.

**Result:** Independent samples t-tests revealed no statistically significant differences in raw mean absolute weights between the TKS and control groups at baseline (1986 ± 220 grams vs1972 ± 257 grams), post-intervention day five (2061 ± 224 grams vs 1983 ± 258 grams), or medical discharge (2117 ± 217 grams vs 2120 ± 223 grams). Daily weight velocity also lacked significant variations (9.46 ± 5.17 grams/day for the TKS group vs10.88 ± 24.9 grams/day for the control group, $p = 0.219$). Interestingly, the percentage of weight gain from day 5 to discharge was significantly higher in the control group than in the TKS group (5.5% ± 4.1% vs 2.31% ± 0.71%, $p = 0.031$). Preterm neonates in the TKS group experienced an average hospitalization duration of 14 ± 3 days compared to 12 ± 3 days in the control group, which was not statistically significant ($p = 0.143$). Linear regression modelling confirmed that TKS exposure did not serve as a statistically meaningful independent predictor of absolute discharge weight or length of hospital stay.

**Conclusion:** Although the TKS protocol did not achieve a statistically significant independent reduction in absolute discharge weights or hospital length of stay within this specific sample, it established positive directional trends in neonatal weight trajectories.

**Practical Implication:** TKS is a safe, non-invasive, and cost-effective intervention that can be integrated into routine neonatal nursing care to support early physiological stability in preterm neonates. Future large-scale, multicenter RCTs with long-term follow-up are needed to confirm its effectiveness and determine the optimal intervention dosage.

**Keywords:** Preterm neonates; Tactile-Kinesthetic Stimulation; weight; Length of hospital stay; Neonatal Intensive Care Unit.

## Introduction

Preterm birth, defined by the World Health Organization (WHO) as live births occurring before 37 completed weeks of gestation, remains a leading global driver of neonatal mortality and long-term neurodevelopmental morbidity (Vetter et al., 2025). The abrupt transition from a highly regulated, protective intrauterine environment to an extra-uterine setting forces physiologically immature neonates to cope with significant biological stressors. In the NICU, these neonates are routinely subjected to unavoidable, painful, noxious stimuli and prolonged sensory deprivation from maternal separation, which collectively disrupt natural neurodevelopmental pathways and metabolic homeostasis (Altit et al., 2024). This adverse sensory environment leads to chronic activation of the hypothalamic-pituitary-adrenal (HPA) axis, resulting in elevated cortisol levels and diverting metabolic reserves from growth to basic survival mechanisms (Altit et al., 2024).

During intermediate and intensive neonatal care, preterm neonates are consistently exposed to disruptive environmental stressors, including continuous auditory and visual stimuli and necessary but noxious medical handling (Boyar & Gennattasio, 2023). To mitigate these sensory disturbances, targeted environmental modifications such as earplugs and eye covers have been implemented to maintain physiological and behavioral stability (Ali et al., 2023). Additionally, specialized touch modalities, such as the Yakson touch technique, have shown clinical effectiveness in stabilizing vital physiological indicators during painful or invasive procedures (Ali et al., 2023; Osman et al., 2024). These cumulative stressors can significantly impair metabolic efficiency, sleep organization, and weight-gain trajectories in neonates. As a result, suboptimal weight gain persists as a major challenge in neonatal care, contributing to prolonged hospital stays, increased healthcare costs, and heightened susceptibility to secondary nosocomial infections (Embleton et al., 2022; Sibrecht, 2024). In response, current neonatal nursing frameworks prioritize implementing safe, non-invasive, and cost-effective interventions to stabilize physiological parameters and improve clinical outcomes (Reyes, 2026).

Tactile-Kinesthetic Stimulation (TKS) has emerged as an evidence-based, non-pharmacological supportive intervention to reduce physiological stress and developmental disruptions associated with premature birth (dos Anjos et al., 2022). This multi-sensory approach systematically combines gentle, rhythmic, moderate-pressure strokes across the neonate's skin with passive range-of-motion exercises of the upper and lower extremities to promote positive growth and neurodevelopmental responses (dos Anjos et al., 2022; Pramitha et al., 2026). Standardized clinical protocols specify the application of these tactile strokes to defined anatomical regions, including the limbs, back, hands, and feet (dos Anjos et al., 2022). Because premature delivery abruptly ends critical third-trimester intrauterine sensory inputs, such as continuous physical boundaries and kinesthetic



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feedback within the amniotic sac, the use of structured tactile and kinesthetic interventions is essential to replicate these stimuli, thereby supporting normal neurobehavioral maturation and preventing central nervous system developmental delays (Alimuddin, 2026; Monfared, 2024).

The application of structured TKS is heavily grounded in foundational neurodevelopmental and physiological theories, most notably the Vagal Tone and Gastrointestinal Maturation Theory pioneered by Field's stimulation frameworks (Parra Reyes, 2026). Under this framework, the application of moderate-pressure stroking activates peripheral mechanoreceptors, which stimulates the vagus nerve and shifts the neonate's autonomic balance toward a parasympathetic-dominant state (Yao et al., 2025). The resulting elevation in vagal tone increases the release of gastrointestinal hormones, such as gastrin and insulin, thereby enhancing gastric motility and accelerating peristalsis (Yao et al., 2025). This cascade improves nutrient absorption and metabolic efficiency, allowing a greater percentage of caloric intake to be allocated to growth rather than stress-induced thermogenesis (Parra Reyes, 2026).

The Kinesthetic Growth and Osteoblast Activation Theory further elucidates the effects of the physical movement component of TKS. Passive flexion and extension of the limbs mimic the resistance experienced by the fetus during late pregnancy when kicking against the uterine wall (Parra Reyes, 2026). This mechanical loading increases bone-specific alkaline phosphatase levels, stimulates osteoblast activity, and promotes cortical bone mineralization, which is directly associated with improvements in linear crown-to-heel length. Collectively, these mechanisms establish a comprehensive theoretical basis for employing touch to achieve measurable anthropometric changes (Parra Reyes, 2026).

The underlying mechanisms driving the efficacy of TKS are closely linked to this enhancement of vagal activity and the stimulation of cutaneous pressure receptors. This physiological cascade triggers the release of localized anabolic hormones, reduces behavioral and biochemical markers of stress, and preserves optimal thermoregulation (Monfared, 2024; Reyes, 2026). Recent randomized clinical trials demonstrate that structured sensorimotor stimulation plays a pivotal role in accelerating daily weight gain, improving gastric motility, and facilitating a more rapid transition to full oral feeding among low-birth-weight (LBW) and preterm neonates (Mahalakshmi et al., 2024; Reyes, 2026).

In addition to promoting immediate growth, clinical evidence demonstrates that structured tactile programs substantially enhance early parent-infant interaction, strengthen maternal attachment, and increase maternal self-confidence during neonatal hospitalization (Monfared, 2024; Pramitha et al., 2026). These combined physiological and neurobehavioral improvements contribute to greater clinical stability, resulting in shorter hospital stays and reduced healthcare costs (Alimuddin, 2026).

Suboptimal weight gain velocity and extended hospital stays among preterm neonates constitute significant global public health and clinical concerns. Although the safety, cost-effectiveness, and physiological benefits of TKS are well-established internationally (Mahalakshmi et al., 2024), there is a notable lack of empirical research examining its direct effects on growth parameters and hospitalization duration within Jordan's healthcare system. Middle Eastern NICU settings often face unique operational challenges, including variable nurse-to-patient ratios and distinct socio-cultural practices related to family-centered care and maternal involvement. To address this gap, the present randomized clinical trial evaluates the impact of a standardized TKS protocol on weight and hospital stay duration among preterm neonates in Jordan.

## Method

### Study Design and Setting

A parallel-group, randomized clinical trial design was utilized to evaluate the effect of TKS on weight and the LOS among preterm neonates. The study was conducted within the NICU King Abdullah University Hospital (KAUH)—a 683-bed tertiary teaching facility in northern Jordan (Al-Shamsi et al., 2025). Within this setting, the NICU operates with a baseline capacity of 30 incubators staffed by 60 registered nurses, accommodating an average of 516 neonatal admissions annually.

### Ethical Considerations

Ethical approval for this study was formally granted by the Institutional Review Board (IRB) of the Jordan University of Science and Technology (JUST) under approval number 46/139/202. Administrative clearance was also secured from the Director General of KAUH. Prior to recruitment, the NICU head nurse and staff nurses were provided with a brief overview of the study protocol to facilitate cooperation.



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Parents or legal guardians of eligible neonates were thoroughly informed regarding the study's objectives, potential benefits, risks, and ethical protections. Formally documented, voluntary written informed consent was obtained from each participant's parent or guardian prior to enrollment. Parents were explicitly informed of their right to decline participation or withdraw their neonate from the study at any stage without penalty or compromise to the medical and nursing care received.

### Participant Eligibility Criteria

The target population comprised all stable preterm neonates admitted to the NICU at KAUH. General admission indications for this population included respiratory distress, cardiac instability, risk of infection, prematurity, low Apgar scores following difficult deliveries, metabolic instability (e.g., hypoglycemia), or life-threatening congenital anomalies.

### Sample selection criteria

Neonates were included if they met the following criteria: a gestational age of 34–37 weeks; NICU admission within the first 48 hours of life; a birth weight of 1500–2500 grams; an Apgar score >7 at 1$^{st}$ and 5$^{th}$ minutes with no delivery room resuscitation; and tolerance of oral or gavage enteral feedings. Eligible neonates were also required to have an expected or actual hospital stay of at least 5 days post-enrollment and to have demonstrated physiological stability for 24 consecutive hours prior to enrollment. Exclusion criteria comprised physical contraindications to tactile stimulation (e.g., ulcers, burns, cutaneous or open skin lesions, ecchymosis, active rashes, fractures, tissue damage, generalized edema, or active localized dermatological infections). Neonates were also excluded for documented neonatal asphyxia; acute gastrointestinal pathologies such as necrotizing enterocolitis (NEC); requirement for invasive or non-invasive mechanical respiratory support (mechanical ventilation or CPAP); surgical intervention during hospitalization; sedative medication use within the preceding 48 hours; or diagnoses of intrauterine growth restriction (IUGR), active untreated clinical sepsis, major congenital or genetic abnormalities, intraventricular hemorrhage (IVH), or severe hyperbilirubinemia requiring therapies beyond phototherapy.

### Sample Size and Randomization

A priori power analysis based on Cohen's (1992) framework indicated that a minimum sample size of 26 neonates per group (N = 52) was required to detect a large effect size (d = 0.8) with 80% statistical power and a 5% significance level ($\alpha = 0.05$). To account for an anticipated 15% attrition rate and maximize statistical precision, the enrollment target was expanded. Convenience sampling was utilized to screen neonates daily via medical chart reviews, admission logs, and nursing shift reports until the expanded enrollment target was achieved. Simple randomization was performed using an automated generator to allocate eligible neonates in a 1:1 ratio to either the TKS group (n = 41) or the control group (n = 41).

### Study Groups and Interventions

The study group received routine NICU care in addition to a structured TKS protocol. To ensure intervention fidelity, the protocol was administered by a single, certified, and specially trained NICU registered nurse. Conversely, the control group received only routine NICU care. Routine nursing care consisted of scheduled diaper changes; mouth, nose, and eye care every 2 to 3 hours; routine bathing three days per week; and ongoing metabolic and infectious monitoring (e.g., blood glucose measurements and septic workups) as clinically indicated. Of the 82 randomized neonates, 69 completed the study (TKS group, n = 34; control group, n = 35). Thirteen neonates were lost to follow-up or excluded post-randomization. Reasons for attrition included parental withdrawal of consent (n = 8); early hospital discharge or transfer to a secondary facility prior to the 5-day observation window; acute clinical deterioration requiring mechanical respiratory or surgical support; or the development of adverse skin reactions during the intervention period (Figure 1).

### Pilot Study

Prior to the full-scale investigation, a pilot study was conducted with 12 preterm neonates (TKS group, n = 6; control group, n = 6) to evaluate the feasibility, safety, and logistical practicality of the TKS protocol and to estimate data collection time requirements. Because no modifications were made to the protocol or data extraction sheet after this pilot phase, these 12 neonates were included in the final analytical sample.

### Data Collection

Data collection spanned from August 1, 2025, to December 30, 2025. Following a comprehensive literature



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review, a Google Forms electronic data extraction sheet was developed to standardize data entry from physical and electronic medical records, alongside bedside nursing flow sheets. The primary data extraction sheet captured baseline demographic and clinical characteristics, including gender, birth location, chronological age at enrollment, gestational age, birth weight, and birth length. Additionally, data were collected on 1st- and 5th-minute Apgar scores, primary clinical diagnosis, delivery mode, fetal presentation, and the average number of daily feedings.

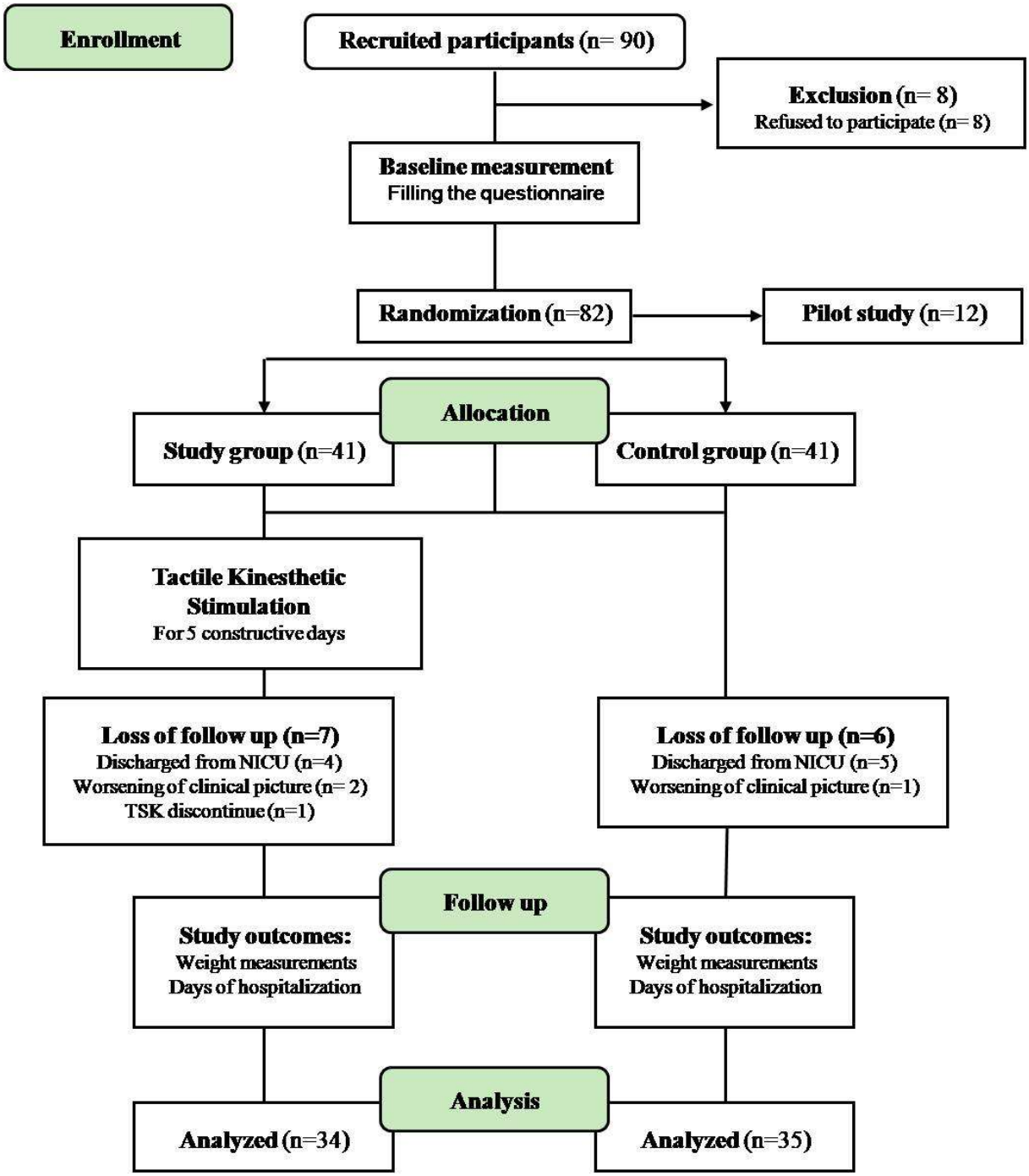


***Figure 1.*** *Procedure of our study.*

## Procedure and Intervention

### Nurse Training and Intervention Fidelity

To ensure fidelity, a single NICU registered nurse administered the TKS protocol. The nurse completed a 6-



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hour training curriculum under the supervision of a Certified Infant Massage Instructor from the International Association of Infant Massage (IAIM), covering mannequin calibration in a simulation lab and supervised clinical practice with preterm neonates. Regular investigator audits ensured ongoing protocol compliance. The nurse maintained a weekly caseload of 4 to 5 neonates. The 5-day intervention began following a 24-hour window of physiological stability (chronological age: 2–5 days) (dos Anjos et al., 2022). The intervention was based on the TKS protocol originally developed by Field et al. (2010) and adapted for infants born at greater than 30 weeks' gestation, with modifications limited to session frequency and duration. The nurse administered a 15-minute, skin-to-skin, bare-hand TKS session twice daily (morning and afternoon), 90–120 minutes after feeding, with a minimum inter-session interval of 2 hours (Reyes, 2026). Incubator access ports were used throughout the intervention to maintain a neutral thermal environment (31.0°C–33.0°C) (Reyes, 2026). Each 15-minute session consisted of three consecutive 5-minute phases, following the protocol described by Field et al. (2010): Phase 1, prone tactile stroking from the head to the lower extremities; Phase 2, supine passive range-of-motion exercises of the upper and lower extremities; and Phase 3, repeated prone tactile stroking. The control group received routine NICU care only, including daily weight measurements, bathing three times weekly, and hygiene care every 2–3 hours.

### Clinical Monitoring and Safety

The nurse remained silent, continuously monitoring the neonate for distress cues (crying, skin mottling, hiccups, gagging, apnea, or bradycardia); stroking continued if the neonate fell asleep without distress (Monfared, 2024). Vital signs—axillary temperature, SpO2, heart rate (HR), blood pressure (BP), and respiratory rate (RR)—were recorded 15 minutes pre-session, immediately post-session, and 15 minutes post-intervention.

Predefined clinical termination thresholds included: hypothermia (<36.5°C); desaturation (SpO2 < 90%); tachycardia (>180 bpm); severe distress (>200 bpm); bradycardia (<100 bpm); gestational-age adjusted hypo/hypertension (>95 percentile); or apnea (20 seconds or accompanied by bradycardia/desaturation). If HR exceeded 200 bpm, the session was paused for 15 seconds. If the neonate cried, showed distress, urinated, or defecated, stimulation was halted, and a stationary "resting hands" technique was applied until physiological and behavioral stabilization was restored (Monfared, 2024).

### Outcomes and Measurement

The primary clinical outcomes were daily weight, discharge weight, and LOS. Baseline body weight was measured within the first 24 hours of life, with follow-up measurements obtained on day 5 of the TKS protocol and on the day of physician-authorized hospital discharge.

To ensure measurement consistency and minimize potential sources of error, all weight assessments were performed under standardized conditions during the evening nursing shift, exactly 2 hours after the last feeding. Neonates were weighed naked, without clothing or diapers, using a calibrated electronic infant scale (Seca®, Germany) with a measurement precision of ±10 grams. Each neonate was positioned supine at the center of the scale, ensuring that no part of the body contacted surrounding surfaces. The scale was recalibrated before each measurement. Length of hospital stay was calculated as the total number of days from birth until hospital discharge.

### Data Analysis

Data analyzed using the Statistical Package for the Social Sciences (SPSS) version 23.0. Baseline characteristics were summarized using descriptive statistics (frequencies, percentages, means, and SD). Following normality testing, independent-samples t-tests and simple linear regression models were used to evaluate the predictive effect of TKS exposure (Yes/No) on neonatal weight and LOS, with significance set a priori at $\alpha = 0.05$.

## Result

### Demographic and Baseline Clinical Characteristics

The final analytical sample comprised 69 preterm neonates who completed the protocol: 34 in the TKS group and 35 in the control group. Baseline demographic and clinical characteristics for both groups are systematically detailed in Table 1. A higher prevalence of female neonates was observed in the study group (n = 24, 70.6%), whereas the control group demonstrated a relatively homogenous distribution between males (n = 18, 51.4%) and females (n = 17, 48.6%). At the time of study enrollment, the chronological age peaked at 5 days in the TKS group (n = 13, 38.2%) and at 4 days in the control group (n = 14, 40.0%). Minor baseline variations were



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noted in gestational age; the highest proportion of neonates in the study group was classified at 34 weeks of gestation (n = 15, 44.1%), whereas the 35-week classification was most frequent within the control group (n = 14, 40.0%). Baseline measures revealed baseline differences between the two allocations. Preterm neonates randomized to the TKS group exhibited a lower birth weight distribution than their control counterparts. Specifically, birth weights in the control group were primarily concentrated between 2001 and 2500 grams (n = 23, 65.5%), whereas the TKS group's birth weights were distributed equally between the 1500–2000 gram and 2001–2500 gram boundaries (n = 17, 50.0% for each). Primary clinical diagnoses and obstetric parameters completed the baseline neonatal profiles. Respiratory Distress Syndrome (RDS) was the most frequent primary diagnosis in the TKS group (n = 13, 38.2%), whereas clinical sepsis was the most frequent diagnosis among control neonates (n = 14, 40.0%). Nutritional baseline indices indicated that the majority of neonates in both the study group (n = 19, 55.9%) and the control group (n = 22, 62.9%) maintained a baseline feeding frequency of 5-8 feeds per day.

*Table 1. The preterm neonates' demographic characteristics (n = 69)*

| Baseline data | Total sample (n=69) | | | |
|---|---|---|---|---|
| | **Study group** | | **Control group** | |
| | **Frequency** | **Percentage** | **Frequency** | **Percentage** |
| Gender | | | | |
| Male | 10 | 29.4 | 18 | 51.4 |
| Female | 24 | 70.6 | 17 | 48.6 |
| Age when the study started in days: | | | | |
| 2 days | 2 | 5.9 | 1 | 2.9 |
| 3 days | 11 | 32.4 | 8 | 22.9 |
| 4 days | 8 | 23.5 | 14 | 40 |
| 5 days | 13 | 38.2 | 12 | 34.2 |
| Gestational age in weeks: | | | | |
| 34/+ weeks | 15 | 44.1 | 9 | 25.7 |
| 35/+ weeks | 10 | 29.4 | 14 | 40 |
| 36/+ weeks | 9 | 26.5 | 12 | 34.3 |
| Birth weight in grams: | | | | |
| Between 1500- 2000 grams | 17 | 50 | 12 | 34.5 |
| Between 2001- 2500 grams | 17 | 50 | 23 | 65.5 |
| Length in cm: | | | | |
| Less than 40 cm | 1 | 3.6 | 2 | 5.7 |
| 40- 45 cm | 13 | 39.3 | 9 | 25.7 |
| 46- 50 cm | 17 | 50 | 21 | 60 |
| Above 50 cm | 3 | 7.1 | 3 | 8.6 |
| Head circumference in cm: | | | | |
| Less than 28 cm | 0 | 0 | 3 | 8.6 |
| 28- 30 cm | 12 | 35.4 | 14 | 40 |
| 31- 33 cm | 14 | 41.1 | 7 | 20 |
| Above 34 cm | 8 | 23.5 | 11 | 31.4 |
| Apgar score 1st minute: | | | | |
| 4- 6 | 18 | 52.9 | 23 | 65.7 |
| 7- 10 | 16 | 47.1 | 12 | 34.3 |
| Apgar score 5th minute: | | | | |
| 4- 6 | 0 | 0 | 0 | 0 |
| 7- 10 | 34 | 100 | 35 | 100 |
| Diagnosis: | | | | |
| Respiratory Distress Syndrome (RDS) | 13 | 38.2 | 11 | 31.4 |
| Transient Tachypnea of Neonate (TTN) | | | 10 | 28.6 |
| Sepsis | 9 | 26.5 | 14 | 40 |
| | 12 | 35.3 | | |
| Mode of delivery: | | | | |
| Normal and not induced | 2 | 5.9 | 0 | 0 |
| Normal and induced | 9 | 26.5 | 5 | 14.3 |



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| | | | | |
|---|---|---|---|---|
| Breech delivery | 5 | 14.7 | 13 | 37.1 |
| Planned/ Elective cesarean | 10 | 29.4 | 9 | 25.7 |
| Unplanned or emergency cesarean | 2 | 5.9 | 6 | 17.1 |
| Vacuum-assisted birth | 2 | 5.9 | 0 | 0 |
| Forceps assisted birth | 4 | 11.8 | 2 | 5.7 |
| Presentation at delivery: | | | | |
| Cephalic | 19 | 55.9 | 11 | 31.4 |
| Breech | 15 | 44.1 | 24 | 68.6 |
| The number of daily feeds: | | | | |
| Satisfactory: 5- 8 times | 19 | 55.9 | 22 | 62.9 |
| Best: 9- 12 times | 15 | 44.1 | 13 | 37.1 |

### The Effect of Tactile-Kinesthetic Stimulation on Preterm Weight Trajectories

Neonatal weight was evaluated at three distinct operational milestones: baseline, five days into the intervention, and at the time of physician-ordered hospital discharge. As shown in Table 2, independent-samples t-tests revealed no statistically significant differences in raw mean absolute weight between the TKS and control groups at any assessment point. At baseline, the mean weight of the TKS group was 1986 ± 220 grams compared to 1972 ± 257 grams in the control group. Following five days of intervention, the TKS group reached a mean weight of 2061 ± 224 grams, while the control group averaged 1983 ± 258 grams. At medical discharge, mean weights stabilized symmetrically at 2117 ± 217 grams for the TKS group and 2120 ± 223 grams for the control group. Figure 2 illustrates changes in mean weight across the three assessment time points for both study groups.

*Table 2. Weight observation at different intervals among preterm neonates*

| Variable | Study group Mean ± SD (Min-Max) | Control group Mean ± SD (Min-Max) |
|---|---|---|
| Baseline weight | 1986 ± 220 (1565-2350) | 1972 ± 257 (1495-2425) |
| Day 5 of TKS | 2061 ± 224 (1630-2580) | 1983 ± 258 (1510-2375) |
| At the time of discharge | 2117 ± 217 (1670-2450) | 2120 ± 223 (1750-2510) |

*Note. TKS = Tactile Kinesthetic Stimulation; SD = standard deviation.*

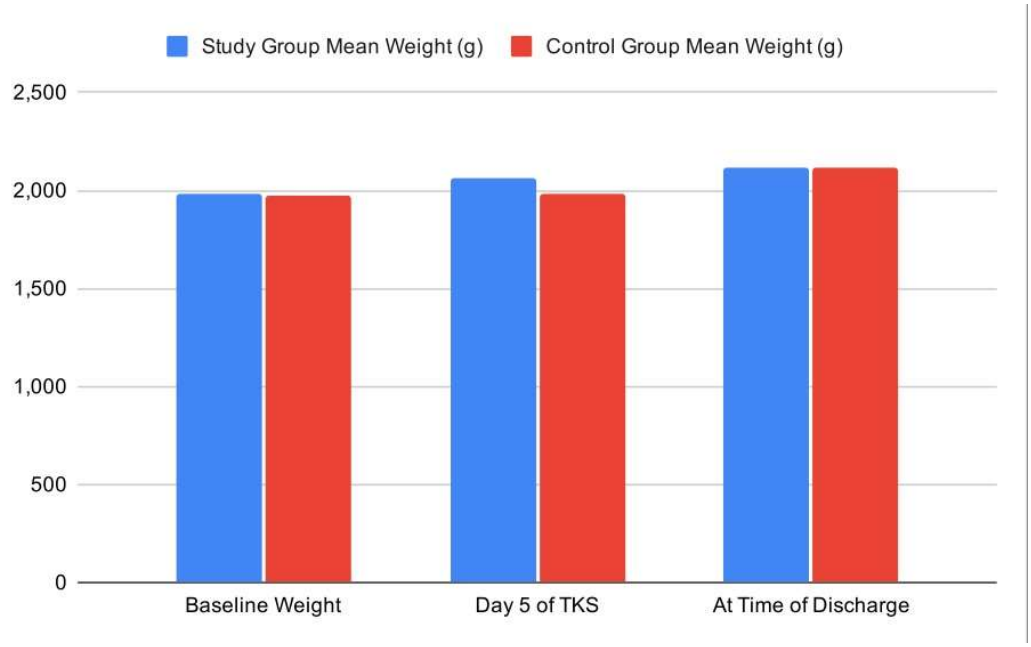




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*Figure 2. Variation of preterm mean weight over the study period*

Although absolute weight measurements remained statistically comparable between groups, differences emerged when weight gain was expressed as a percentage over specific time intervals (Table 3). From baseline to post-intervention day 5, the TKS group exhibited a greater percentage weight gain (2.1% ± 1.1%) than the control group (1.5% ± 0.6%); however, this difference was not statistically significant ($p = 0.780$). Conversely, the percentage of weight accumulated from day five to the date of hospital discharge was significantly higher in the control group than in the TKS group (5.5% ± 4.1% vs 2.31% ± 0.71%, $p = 0.031$). Mean weight gain from study enrollment to discharge (124.64 ± 117.39 grams vs 135.69 ± 129.44 grams, $p = 0.794$) and overall daily weight velocity (9.46 ± 5.17 grams/day vs 10.88 ± 24.9 grams/day, $p = 0.219$) did not exhibit statistically significant variations between the intervention and control groups.

*Table 3: Comparison of weight gain percentage between study and control groups (Mean± SD)*

| Variable | Study group (Mean ± SD) | Control group (Mean ± SD) | *p*-value |
|---|---|---|---|
| Day 5 of TKS compared to baseline | 2.1 ± 1.1 | 1.5 ± 0.6 | 0.780 |
| At the time of discharge compared to day 5 of TKS | 2.31 ± 0.71 | 5.5 ± 4.1 | 0.031 |
| The mean increase in weight from enrollment to the time of discharge | 124.64 ± 117.39 | 135.69 ± 129.436 | 0.794 |
| Mean weight gain (gram/day) | 9.46 ± 5.17 | 10.88 ± 24.9 | 0.219 |

*Note. Independent samples t-test; p-value significant at <0.05*

### The Effect of Tactile-Kinesthetic Stimulation on Length of Hospital Stay

The LOS demonstrated wide individual variation across the total sample. Preterm neonates enrolled in the TKS group experienced an average hospitalization duration of 14 ± 3 days, whereas neonates managed under routine care experienced an average duration of 12 ± 3 days. An independent samples t-test confirmed that this baseline difference in hospitalization duration did not cross the threshold for formal statistical significance ($p = 0.143$). Figure 3 illustrates the distribution of hospital length of stay across the TKS and control groups.

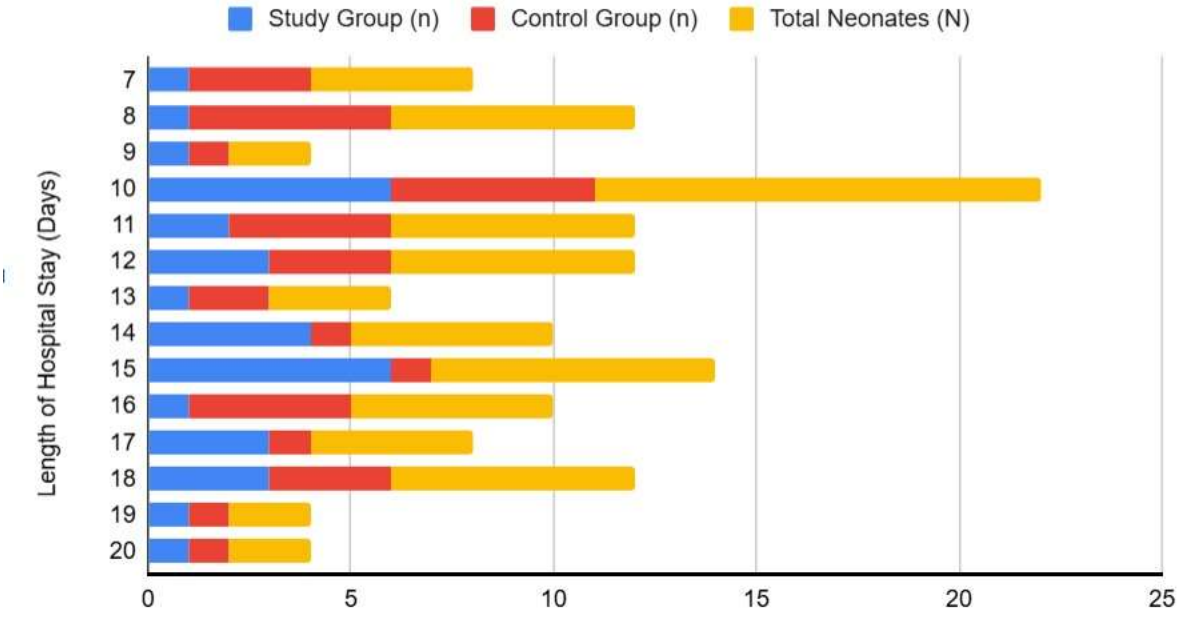


*Figure 3: The length of hospital stays among preterm neonates according to group*

### Predictors of Neonatal Outcomes: Simple Linear Regression Modelling



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To evaluate the isolated predictive value of the non-pharmacological intervention, simple linear regression models were constructed using TKS exposure as a dichotomous independent predictor against both neonatal discharge weight and hospital length of stay (Table 4). For weight at discharge, the unstandardized regression coefficient (β) was 3.071 (95% CI: 103 to 109), yielding a negligible standardized weight (β= 0.007). The test statistics (t = 0.058, $p$ = 0.954) indicated that TKS exposure was not a statistically meaningful or clinically independent predictor of absolute mass at medical discharge. Similarly, the linear regression model evaluating the duration of hospitalization revealed an unstandardized coefficient (β) of -1.303 (95% CI:-3.05 to 0.451). While the standardized coefficient (β= -0.178) implies a small, negative directional relationship—suggesting that TKS exposure was mathematically linked to an approximate 1.3-day reduction in hospitalization—the model failed to establish formal statistical significance (t = -1.483, $p$ = 0.143). Ultimately, the linear modelling confirms that the TKS protocol did not exert an independent statistical influence on absolute discharge weight or length of hospital stay within this study sample.

*Table 4. Simple Linear Regression Models for TKS Exposure Predicting Neonatal Outcomes*

| Variable | R | B | CI 95% | β | t | *$p$-value |
|---|---|---|---|---|---|---|
| Weight at the time of discharge | 0.007 | 3.071 | 103-109 | 0.007 | 0.058 | 0.954 |
| Length of the hospital stays | 0.178 | -1.303 | -3.05 – 0.451 | -0.178 | -1.483 | 0.143 |

*Note. *Simple linear regression analysis; p-value significant at <0.05*

## Discussion

### Sample Size Context and Baseline Comparability

The present clinical trial evaluated a comprehensive matrix of baseline clinical and demographic parameters to establish robust prognostic tracking, including gender, birth location, chronological age at enrollment, gestational age, birth weight, length, head circumference, primary clinical diagnoses, mode of delivery, fetal presentation, and daily feeding frequency. The final sample of 69 preterm neonates provided an adequate statistical basis and is comparable to, or larger than, the sample sizes used in several recent randomized trials evaluating touch-based interventions in preterm neonates. Whereas earlier studies often included only 20–40 participants, more recent neonatal RCTs have typically enrolled 60–80 neonates, balancing statistical rigor with the practical and ethical challenges of conducting research in neonatal intensive care settings (dos Anjos et al., 2022; Monfared, 2024).

### Growth and Weight Gain Velocities

A growing body of evidence indicates that structured tactile and kinesthetic interventions can improve metabolic efficiency and support growth in preterm neonates (Mahalakshmi et al., 2024; Reyes, 2026). In the present study, neonates in the TKS group had higher mean weights on post-intervention day 5 and at hospital discharge than those in the control group; however, these differences were not statistically significant. These findings are consistent with those of dos Anjos et al. (2022), who reported favorable trends in daily weight gain following a standardized 15-minute TKS protocol without significant between-group differences in absolute weight ($p$ = 0.43) during the intervention period.

The observed trend may be explained by the physiological effects of tactile stimulation, which activates cutaneous pressure receptors, enhances vagal tone, improves gastric motility, and facilitates feeding efficiency, thereby supporting postnatal growth (Mahalakshmi et al., 2024; Reyes, 2026). Despite these favorable trends, the control group demonstrated a significantly greater percentage weight gain between post-intervention day 5 and hospital discharge than the TKS group (5.5% vs 2.31%, $p$ = 0.031). This finding contrasts with previous studies, including Mahalakshmi et al. (2024), which reported significantly greater weight gain among infants receiving tactile and kinesthetic stimulation.

The discrepancy may reflect differences in clinical characteristics and hospitalization patterns rather than the intervention itself. For example, the TKS group had a higher prevalence of respiratory distress syndrome (38.2%), whereas the control group had a higher prevalence of neonatal sepsis (40.0%). In addition, variations in the duration of hospitalization may have influenced the calculation of percentage weight gain, contributing to differences in growth trajectories between groups.

### Length of Hospital Stay and Predictive Modelling

The mean length of hospital stay did not differ significantly between the TKS and control groups (14 ± 3 vs 12



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± 3 days, respectively; $p = 0.143$). Similarly, simple linear regression demonstrated a negative, but non-significant, association between TKS and length of hospital stay ($\beta = -1.303$, $p = 0.143$), suggesting a trend toward a reduction of approximately 1.3 hospitalization days among neonates who received the intervention.

Although previous studies have reported that tactile interventions may shorten hospitalization by promoting physiological stability, enhancing vagal activity, and improving feeding outcomes (Alimuddin, 2026), the present findings did not demonstrate a statistically significant effect. This may indicate that, within the current cohort, the duration of hospitalization was influenced more by the underlying clinical condition and severity of illness than by the TKS intervention alone.

## Limitations

Several methodological and environmental constraints should be taken into account when interpreting the findings of this clinical trial. First, the recruitment phase was notably protracted and complex due to the implementation of narrow, stringent inclusion and exclusion criteria designed to isolate medically stable neonates, which significantly restricted the overall pool of eligible neonates within the study window. Furthermore, by relying entirely on objective data extraction sheets and standardized physiological parameters, the study design lacked the capacity to capture broader, qualitative dimensions of neonatal development, such as behavioral self-regulation, infant state organization, and fine motor maturity.

Operationalizing a rigorous randomized controlled protocol within a highly acute NICU also introduced distinct logistical and human-centric challenges. Institutional friction was observed when eight families declined study enrollment due to unfamiliarity with the clinical benefits of therapeutic touch, while the daily protocol required extensive clinical coordination, which added significantly to the existing nursing workload. Finally, navigating the multi-layered administrative pathways required to secure ethical and institutional approvals extended the pre-implementation timeline, creating a substantial systemic barrier to scaling this protocol across diverse geographic regions and healthcare sectors within Jordan.

## Conclusion

This randomized clinical trial demonstrates that a safe, non-invasive, and highly cost-effective TKS protocol can be effectively integrated into routine neonatal intensive care nursing practice, promoting favorable trends in weight gain among preterm neonates. Although the intervention did not produce statistically significant independent effects on discharge weight or length of hospital stay within this sample, TKS remains a clinically feasible, supportive, non-pharmacological intervention that may contribute to early physiological stabilization (dos Anjos et al., 2022; Reyes, 2026).

To strengthen the evidence base, future randomized controlled trials should employ multi-center designs with larger and more diverse samples to improve statistical power and enhance the generalizability of findings. Extended longitudinal follow-up beyond hospital discharge is also needed to determine the long-term effects of early tactile stimulation on growth, neurodevelopment, and overall health outcomes (Alimuddin, 2026; Monfared, 2024). Furthermore, future studies should systematically evaluate different TKS dosing regimens, including variations in session frequency, duration, and overall intervention period, to identify the optimal protocol for maximizing clinical benefits in vulnerable preterm populations (Pramitha et al., 2026).

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