



Effects of combined use of non-nutritive sucking, oral sucrose, and facilitated tucking on infant behavioural states across heel-stick procedures: A prospective, randomised controlled trial

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ABSTRACT

Background: Pain and stress agitate preterm infants, interrupting their sleep. Frequent high arousal states may affect infants' brain development and illness recovery. Preserving infants' sleep and relieving their pain during painful procedures are both important for their health.

Objectives: To compare the effectiveness of different combinations of non-nutritive sucking (sucking), oral sucrose, and facilitated tucking (tucking) with routine care on infants' sleep–wake states before, during, and after heel-stick procedures.

Design: Prospective, randomised controlled trial.

Setting: Level III Neonatal Intensive Care Unit in Taipei.

Method: A convenience sample of 110 infants (gestational age 26.4–37 weeks) needing heel sticks were randomly assigned to five combinations of non-pharmacological treatments: sucking–oral sucrose–tucking; sucking–oral sucrose; oral sucrose–tucking; sucking–tucking; and routine care. Infant states, measured by a state-coding scheme, included quiet sleep, active sleep, transition, quiet awake, active awake, and fussing or crying. All states were recorded at 1-min intervals during four phases: baseline, intervention, heel-stick procedures, and recovery.

Results: Infants receiving sucking–oral sucrose–tucking or sucking–oral sucrose experienced 52.8% ($p=0.023$) and 42.6% ($p=0.063$) more quiet-sleep occurrences than those receiving routine care after adjusting for phase, baseline states, non-treatment sucking during baseline and recovery, positioning, and infants' characteristics. Infants receiving oral sucrose–tucking, sucking–oral sucrose, sucking–oral sucrose–tucking, and sucking–tucking experienced 77.3% ($p<0.001$), 72.1% ($p=0.008$), 51.5% ($p=0.017$), and 33.0% ($p=0.105$) fewer occurrences of fussing or crying, respectively, than those receiving routine care after adjusting for related factors.

Conclusions: The four treatment combinations differentially reduced infants' high arousal across heel-stick procedures. The combined use of oral sucrose–tucking, sucking–oral sucrose, and sucking–oral sucrose–tucking more effectively reduced occurrences of infant

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fussing or crying than routine care. Treatment combinations of sucking–oral sucrose–tucking and sucking–oral sucrose also better facilitated infants' sleep than routine care. To preserve infants' sleep, clinicians should use combinations of non-nutritive sucking, oral sucrose, and facilitated tucking to reduce agitation during painful procedures.

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What is already known about the topic?

- Preterm infants undergo repeated painful procedures during hospitalisation. Heel stick, one of the most frequent painful procedures, often causes pain and stress that interrupt infant sleep.
- Oral sucrose, non-nutritive sucking, and facilitating tucking more effectively relieve pain during short painful procedures than routine care.
- Preterm infants' rapid eye movement (REM) sleep during the first hour after nursing care was significantly lower and non-REM sleep was higher after receiving oxycodone than after receiving tucking, oral glucose, or placebo.
- Developmental care (decreasing environmental noise and light, supportive positioning, swaddling, non-nutritive sucking, or grasping) reduced preterm infants' state changes and increased their total sleep time.

What this paper adds

- Combined treatments of non-nutritive sucking, oral sucrose, and facilitated tucking more effectively reduced infants' fussing or crying than routine care across heel-stick procedures.
- Infants receiving non-nutritive sucking + oral sucrose + facilitated tucking, or non-nutritive sucking + oral sucrose experienced more occurrences of quiet sleep than those receiving routine care.
- Infants receiving oral sucrose + facilitated tucking experienced more occurrences of transition state than those receiving routine care across heel-stick procedures.
- Across heel-stick procedures, infants in the lateral position experienced more occurrences of quiet sleep than those in the supine position.

1. Introduction

Preterm births comprise about 12.5% of all live births in the United States (Martin et al., 2010), and 8.5–8.9% in Taiwan (Shu, 2010). In both Taiwan and western countries, this high incidence rate motivates clinicians to consider ways to promote these infants' health and development, especially during their early life. Because they are immature, preterm infants need to stay in a neonatal intensive or special care unit to survive and continue their development. During hospitalisation, these infants are repeatedly exposed to painful caregiving procedures needed for their survival (Cameron et al., 2007; Newnham et al., 2009), but such procedures may agitate infants (Porter et al., 1999), interrupt sleep (Brandon et al., 1999; Liaw et al., 2012b), and cause physiological and behavioural instability (Liaw et al., 2012c; Holsti et al., 2005).

Previous studies mostly used pain scores to evaluate the effects of pain-relief interventions (Axelin et al., 2006; Stevens et al., 2010). However, sleep structure may be a more objective measure than current pain assessments for the prolonged effects of pain and its management (Axelin et al., 2010). Indeed, sleep is a basic physiological need in humans, like respiration and feeding (Maslow, 1943). Humans cannot survive without sleep (Bertelle et al., 2007). Preserving infants' sleep and relieving their pain during painful procedures are both important for their health. However, clinicians tend to disregard preterm infants' sleep needs because they cannot verbalise their need for sleep. Instead, clinicians should provide preterm infants with interventions to relieve pain and preserve sleep organisation. Relieving pain with pharmacological interventions like opioids can, however, decrease the amount of REM sleep, which has been hypothesised to harm preterm infants' brain development (Axelin et al., 2010). Thus, clinicians urgently need effective non-pharmacological interventions that preserve infants' sleep. However, interventions using facilitated tucking (FT) or glucose alone did not effectively protect preterm infants' sleep compared to placebo (Axelin et al., 2010). Therefore, this study focused on examining the effects of combined non-pharmacological interventions on preterm infants' sleep–wake states during painful procedures.

Sleep organisation is thought to provide a foundation for physiological development and neurological maturation, arousal regulation, and cognitive growth (Arditi-Babchuk et al., 2009; Holditch-Davis and Thoman, 1987; Scher, 2005) and is an important determinant of infants' developmental outcomes (O'Callaghan et al., 2010; Weisman et al., 2011). Disrupting sleep and sleep cycles interferes with illness recovery (Bertelle et al., 2007), and the early process of infants' sensory and brain development (Dang-Vu et al., 2006), which has led to adverse neurodevelopmental outcomes (O'Callaghan et al., 2010; Weisman et al., 2011). Preterm infants exhibit more attention and learning disorders, behaviour problems, emotional dysregulation, and poor cognitive functioning during later life than full-term infants (O'Callaghan et al., 2010; Sun et al., 2009). The link between disrupted sleep organisation and later life outcomes motivated the authors to consider ways to facilitate preterm infants' sleep organisation during hospitalisation.

Infant behavioural states, defined by eye opening, body and limb movement, muscle tone, eye movement, and respiration, are categorised into quiet sleep, active sleep, quiet awake, active awake, transition, and fussing or crying (Holditch-Davis et al., 2004). Quiet sleep has been associated with energy maintenance, increased protein synthesis, and release of growth hormone, and is crucial to creating long-term memories and learning (Dang-Vu et al.,

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