Kangaroo Care (Skin Contact) Reduces Crying Response to Pain in Preterm Neonates: Pilot Results

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Abstract:

Crying commonly occurs in response to heel stick and adversely affects the infant's physiologic stability. Minimal crying in response to pain is desired. "Kangaroo Care," skin contact between mother and infant, reduces pain and may reduce crying in response to pain. The purpose of this pilot study was to test Kangaroo Care's effect on the preterm infant's audible and inaudible crying response to heel stick. Inaudible crying has not been previously studied. A prospective randomized cross-over study with 10 preterm infants 2-9 days old (30-32 weeks' postmenstrual age) was conducted. Infants were randomly assigned to two sequences (sequence A: day 1 heel stick in Kangaroo Care [after 30 min of prone skin contact upright between maternal breasts] and day 2 heel stick in incubator [inclined, nested and prone]; or sequence B: opposite of sequence A) was conducted. Videotapes of baseline, heel warming, heel stick, and recovery phases were scored for audible and inaudible crying times. Audible and inaudible crying times for each subject in each phase were summed and analyzed by repeated-measures analysis of variance. Subject characteristics did not differ between those in the two sequences. Crying time differed between the study phases on both days ($p \leq .001$). When in Kangaroo Care compared with the incubator, crying time was less during the heel stick ($p = .001$) and recovery ($p = .01$) phases, regardless of sequence. Because Kangaroo Care reduced crying in response to heel stick in medically stable preterm infants, a definitive study is merited before making recommendations.
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Crying is a common response to pain in infants (Efe & Ozer, 2007; Gibbins & Stevens, 2001) and is considered to be the most sensitive measure of pain (Franck, 2002; Craig, Gilbert-MacLeod, & Lilley, 2000; Stevens et al., 2006). Crying intensity increases with increasing pain in full-term infants undergoing heel stick (Bellieni, Sisto, Cordelli, et al., 2004). Crying has many adverse physiologic effects, such as elevated heart rate and blood pressure (Dinwiddie, Patel, Kumar, et al., 1979), shunting of unoxygenated blood (Dinwiddie, Pitcher-Wilmott, Schwartz, et al., 1979), and adverse brain effects, such as arteriovenous spasms causing cerebral blood flow changes (Hiraishi, Agata, Saito, et al., 1991) and cortical activation in both hemispheres (Bartoccie et al., 2006; Slater et al., 2006). The management of preterm infant pain is a high priority (Breau et al., 2006), and interventions to reduce pain and minimize adverse responses are needed (Bruce & Franck, 2005; D'Apolito, 2006). Specifically, interventions that may reduce the audible and inaudible crying response are needed. "Kangaroo Care" (KC) may be a useful pain management intervention, but its effectiveness has not been extensively studied and KC is not a part of routine practice (Cignacco et al., 2006), and its effect on inaudible crying is unknown. In fact, no studies of the inaudible cry response to pain could be found.

Infants in the neonatal intensive care unit (NICU) are routinely subjected to various diagnostic, surgical, or therapeutic procedures which can result in pain (Barker & Rutter, 1995; Evans, McCartney, Lawhon, & Galloway, 2005; Lago et al., 2005; Porter & Anand, 1998). Blood sampling from infants by lancing and squeezing the heel is one of the most frequently occurring acutely painful procedures (Simons et al., 2003). Premature infants have even more heel sticks: 56% of preterm infant invasive procedures are heel sticks (Grunau & Craig, 1987). The painful procedures in the early stages of development lead to long-term changes such as higher-level pain processing and pain-induced plasticity in the human brain (Anand et al., 2006; Slater et al., 2006; Taddio et al., 1995, 1997; Weaver, Diorio, & Meaney, 2007). Eighty percent of infants, either preterm or term, do not have effective pain relief from heel sticks (Schecter, 2006). Infants have more pain response, particularly the crying response, to heel sticks than to venipuncture for blood sampling (Ogawa et al., 2005). The use of heel stick as a pain stimulus greatly increases the probability that the resultant crying is due to pain.

Though many nonpharmacologic interventions have been studied to minimize preterm infant pain (Franck & Lawhon, 1998), none is yet widely nor routinely used. Kangaroo Care has been found to reduce hypothalamus-pituitary-adrenal activity in response to pain (Mooncey, Giannakoulopoulos, Glover, et al., 1997) and reduces infant heart rate and pain scores even in the absence of pain (Morelius, Theodorsson, & Nelson, 2005). Fifteen preterm infants given 20 minutes of KC immediately before a venipuncture in incubator had lower beta-endorphin levels than when lying in an incubator for 20 minutes before the venipuncture. Modi and Glover (1998) found a 74% reduction in beta-endorphin and a 66% reduction in plasma cortisol with 20 minutes of KC before incubator heel stick compared with lying in an incubator (Morelius, Theordorsson, & Nelson, 2005). Thirty minutes of KC before and during a heel stick was given to 74 healthy preterm infants (33.6 weeks' gestational age) and compared with incubator care before and during a heel stick (Johnston et al., 2003). Pain as measured by the Premature Infant Pain Profile was significantly lower after the KC heel stick than after the incubator heel stick. In another study, 3 hours of KC followed by a heel stick in KC produced lower peak heart rate and shorter duration of crying in response to heel stick pain than incubator care and incubator heel stick in 24 preterm infants who were 31.4 weeks' gestational age and 22 days old (Ludington-Hoe et al., 2005), findings confirmed in a randomized controlled trial of 15 minutes of KC versus no KC prior to a heel stick (Castral, Warnock, Leite, et al., in press). Even though "further investigation of KC as a potential source of analgesia in human neonates is most certainly warranted" (Stevens & Franck, 2001), most studies use scoring systems that only measure audible crying. Some preterm infants may not demonstrate an audible cry (Johnston et al., 1999), but our experience has shown that preterm infants can mount an inaudible cry in response to pain. Inaudible crying has been behaviorally measured for more than a decade using the Anderson Behavioral State Scoring System (Gill et al., 1988). Measurement of audible and inaudible crying responses to pain has not been previously reported even though brow bulge, facial grimace, and eye squeeze are some of the best recognized indicators of pain (Stevens et al., 2006), making this a unique feature of the present investigation with the inaudible crying results providing seminal information. Thus, a pilot study was conducted to determine the effect of 30 minutes of KC before and KC during a heel stick on audible and inaudible crying responses to pain. The hypothesis was that preterm infants would have less crying time (audible cry + inaudible cry) with a heel stick done in KC than with a heel stick done in the incubator.

MATERIALS AND METHODS

Design

A prospective cross-over design with random assignment to having the first heel stick either in KC, called a Kangaroo Care heel stick (KCH), or in the incubator, called incubator heel stick (IH), was conducted. Infants who had KCH first had a heel stick in the incubator 24 hours later. Infants who had the IH first had the KCH 24 hours later. All heel sticks were conducted at the same time each morning. Data were collected from facial videotapes taken throughout four phases: baseline (10 minutes before warming), heel warming (5 minutes), heel stick and squeezing (2-3 minutes), and recovery (20 minutes). The randomization was by permuted block design to ensure highest possible equivalence among infants (Chow & Liu, 1998). Independent scorers of the videotapes were blind to the purpose and cross-over design of the study. The study was approved by university and hospital Institutional Review Boards and written informed consent was obtained from both parents of each infant.

Setting

Infants were tested in a level II 13-bed NICU served by two neonatologists and two neonatal nurse practitioners. Noise and light levels were appropriately reduced at all times. A curtain was drawn around the infant during the study. On this unit routine care to minimize heelstick pain was nesting (use of rolled up blankets on all sides of infant); no other pain interventions were used when the study was conducted.

Sample

The ten infants reported here were one cohort in an NIH-funded multicohort pilot study measuring pain responses (Ludington, 2002). Twenty-six subjects were needed to detect moderate difference in crying time; however, funding permitted recruitment of only ten subjects. Therefore, the data reported here are pilot results only. Healthy mothers and healthy infants of singleton birth were recruited if infants met the following criteria: 30-32 weeks gestational age; within 2-9 days of birth [to control for hyperalgesia due to repeated heel sticks before study (Andrews & Fitzgerald, 1994, 1999; Fitzgerald, Millard, & MacIntosh, 1988]; no signs of heel tissue inflammation as measured by the Neonatal Skin Condition Score [to control for inflammation induced by tissue damage and inflammation's concomitant repetitive A-delta and C-fiber inputs activating the central neurons in the dorsal horn of the spinal cord and brainstem, causing them to respond to normal inputs in an exaggerated and extended manner (Woolf & Salter, 2000)]; either NPO or fed by bolus feed (one complete amount of feeding given over 20 minutes); and being cared-for in an incubator. Infants were not eligible if they had a known congenital anomaly; grade III or IV intraventricular hemorrhage; history of surgery; history of drug exposure; any tissue breakdown or inflammation of either heel; or any sedative or analgesic within 24 hours before the study. All mothers spoke English, and all mothers who were approached agreed to participate.

Conditions

Kangaroo Care was skin-to-skin, chest-to-chest, upright placement of the infant wearing only a diaper between maternal breasts, with a receiving blanket folded-in-fourths over the infant's back. Mothers reclined in a lounge chair behind a privacy curtain. Infants began KC 30 minutes before baseline measurement and were undisturbed throughout baseline period. After baseline measurement, the infant's foot was retracted from beneath the blanket for warming, and then the heel stick was conducted while the infant remained in KC. A band-aid was applied and the foot was placed back under the blanket for the 20-minutes recovery phase in KC.

Incubator care was placement of the diaper-clad infant prone and nested between rolled blankets on a mattress at a 30-40° incline in an Ohio IC double-walled incubator. Privacy curtains were drawn around the incubator for 30 minutes before baseline measurement and remained in place throughout warming, heel stick, and recovery phases. The incubator heel stick took place in the incubator without changing the baby's position; 20 minutes of recovery occurred in the same position in the incubator. Mothers were not present during IH.

Heel sticks were done by a consistent neonatal phlebotomist who used the National Association of Neonatal Nursing's standardized heel stick procedure (National Association of Neonatal Nurses, 1995) with a Tenderfoot™ spring-loaded lancet.

Outcome Variables

Some preterm and acutely ill infants may not cry during heel sticks and other painful procedures, which may be due to depleted energy reserves or because of the presence of an endotracheal tube (Johnston et al., 1999; McGrath, 1990). In the absence of crying (and with crying), the infant forms a "cry face" that is characteristic of pain, and the cry face is called a "silent cry." Thus, an audible cry alone may not be a reliable indicator for pain in preterm or acutely ill infants. Therefore, crying time was defined as the number of mean seconds of inaudible plus audible

crying time for each phase. Crying was measured in two ways: summing the total number of seconds of inaudible crying as measured by behavioral observation and the total number of seconds of audible crying as measured by infant vocalization of whimpering, crying, or hard crying. Inaudible crying behaviors have been found to be useful and important pain indicators in preterm infants (Stevens et al., 2006). Inaudible crying was scored using the Anderson Behavioral State Scoring System (Gill et al., 1988). The behaviors that characterize crying when no audible sounds are heard are facial grimacing, eye squeezing, and brow bulge. Infants were continuously observed throughout each phase. When behavioral criteria matching states 10 (fussy), 11 (crying), or 12 (hard crying) were observed in the absence of audible crying, stopwatch timing of the number of seconds of inaudible crying began. Stopwatch timing ended when the infant's behaviors ceased to characterize any one of the behaviors of the fussy, crying, and hard crying states. Inaudible crying was independently scored from full-face videotapes of nine subjects (one infant persistently turned his face away from the camera) by two research assistants whose inter-rater reliability was 0.82 using Kappa coefficient.

Audible crying was measured by stopwatches beginning when audible whimpering, crying, or hard crying were heard, providing the sum of seconds of all audible crying episodes within each phase. Two research assistants independently viewed the videotapes to score audible crying. Inter-rater reliability was 0.85 for audible crying time as measured by Kappa coefficient.

Instruments

Infants were videotaped using a Sony video camera (model TRV38; Tokyo, Japan) and recorder that were focused on the infant's face to record facial actions and vocalizations. The Anderson Behavioral State Scoring system has established concurrent validity and reliability between 0.71 and 0.95 (Gill et al., 1988; McCain, 1992). Stopwatches were Seiko digital stopwatch model WO73 that autocalibrated each time they were turned on and were used in the "stopwatch" mode. The Neonatal Skin Condition Score was assessed by one observer, and adequate reliability and criterion related validity have been established (Lund & Osborne, 2004).

Procedure

At 9:30 a.m. on the first day of study, infants were positioned in either KC or in the incubator depending on the sequence to which each had been randomized. Twenty minutes later, baseline data collection occurred. Then the heel warming phase took place, followed by heel stick to collect blood for lab tests required daily. A 0.5-mL blood sample was needed and generally required 1-2 minutes to obtain. Recovery phase began immediately after the heel stick site had been covered with a band-aid. At the end of recovery, all data collection ceased and the KC infant was placed back in the incubator. Infants assigned to IH were left in the incubator throughout all phases. On the second day, the procedure was the same except that infants who had been in KC on the first day were in the incubator on the second, and first-day incubator infants were in KC on the second day.

Statistical Analysis

The number of seconds of inaudible crying plus audible crying for each infant for each phase was totaled using the mean of the two research assistants' crying times for each subject. A mean of the subject means for all subjects in the same condition (KCH or IH on first and second days) was used in repeated measures-analysis of variance (ANOVA), with one factor being the four phases and the second factor being whether KCH was on the first or second day of the study. The repeated-measures ANOVA was the best test to analyze data across four phases. All assumptions for the repeated-measures ANOVA were met. Data were analyzed using SPSS version 13.0 (SPSS, 2005). Alpha was set at .05.

RESULTS

Subject Characteristics

Demographic characteristics of the mothers and their infants are presented in Table 1. The majority of the mothers were white (90%), were married (80%), and had delivered by cesarean section (80%). Infants were evenly distributed between genders. Infants were 32 weeks' gestation (60%) and a mean 6.00 days old (SD 2.00 days) on the first day of study, had a mean birth weight of 1,577 g (SD 327.00 g), and a mean of 22.00 (SD 6.00) prior painful experiences. No subjects were on ventilatory support or supplemental O_2 during testing nor did they have any other comorbidity. Eighty percent of the subjects had had previous KC experience. No significant differences were found in subject characteristics between infants who had KCH on Day 1 and those who had KCH on Day 2.

Analyses of Crying Time

Because inaudible crying was minimal in each phase (0.00-1.34 seconds) for both groups on both days, total crying times essentially reflect audible crying times. The means and standard deviations for total crying

TABLE 1.
Number, Percentage, Mean, and Standard Deviation (SD) of Maternal and Neonatal Characteristics

Characteristic	n	%	Mean	SD
Maternal Characteristics				
Marital status				
Married	7	70		
Single	2	20		
Divorced	1	10		
Employment				
Full time	3	30		
Part time	3	30		
Homemaker	2	20		
Student	2	20		
Education				
Completed graduate school	1	10		
Completed college	4	40		
Some college	2	20		
Completed high school	3	30		
Neonatal Characteristics				
Gestational age				
30 weeks	2	20		
31 weeks	2	20		
32 weeks	6	60		
Gender				
Male	5	50		
Female	5	50		
Race				
White	9	90		
American Indian	1	10		
Hispanic background				
Yes	2	20		
No	8	80		
Birth type				
Vaginal	2	20		
Cesarean section	8	80		
Pre-study KC experience				
Yes	8	80		
No	2	20		
Birth weight (g)			1,577	327
APGAR score				
1 min			7	1
5 min			8	1
Previous pain experiences (n)			22	6
Heel Skin Condition Score[a]				
Before KCH			4	1
Before IH			4	1

KCH = Kangaroo Care heel stick; IH = incubator heel stick.
[a]Neonatal Skin Condition Score (Lund & Osborne, 2004).

time during each phase on the first and second days are presented in Table 2. Combined crying was minimal before heel stick, increased during the heel stick, and declined during recovery, regardless of day of study. Significant difference in combined crying time between phases on both days [$F(1, 8) = 10.25$; $p < .001$] was present. The differences in combined crying time between KCH and IH did not occur during baseline and heel warming phases on either day, but did occur during heel stick and recovery phases. On the first day, infants in KCH had less crying during recovery (mean 5.83 seconds, SD 7.63 seconds) than infants in IH (mean 25.50 seconds, SD 41.93 seconds; Fig. 1). On the second day, KCH infants had significantly less crying time (mean 55.00 seconds, SD 55.53 seconds) during the heel stick phase than IH infants (mean 96.17 seconds, SD 92.42; $F(1,8) = 7.76$; $p = .001$; Fig. 2).

DISCUSSION

Two-to-nine day–old preterm infants exhibited less audible crying during and after a heel stick when in KC than in an incubator. Crying time was less in KC than in incubator regardless of which day KC occurred. The pilot data reported here suggest that KC is effective in reducing the crying response to heel stick pain in medically stable premature infants. A diminished pain response during a KC heel stick is similar to previous results with preterm (Castral et al., in press; Johnston et al., 2003; Ludington-Hoe, Hosseini, & Torowicz, 2005) and full-term infants (Gray, Watts, & Blass, 2000). Most of the preterm infants in the present study had previously experienced KC, so diminished pain response was anticipated, because pain behaviors diminish over repeated KC sessions (Morelius et al., 2005). Thus, the results of this study support earlier work showing that preterm infant pain responses change over repeated painful experiences (Grunau et al., 2005), but, also contribute new data suggesting that the changes may not always be negative. Nonetheless, a decrease in crying time to heel stick may only be expected when KC is simultaneously being given with the heel stick, because pain responses to immunization 5 and 13 months after KC had occurred did not differ between infants who had KC and those who did not (Miles et al., 2006). Yet, for acute procedural pain, KC appears to reduce pain reactivity. That pain reactivity, as evidenced by facial changes without audible crying, was negligible in both groups was unexpected, given that preterm infants who are not neurologically impaired usually demonstrate many more facial than physiologic indicators of pain (Stevens et al., 2007). Evaluating inaudible crying by the Neonatal Facial Coding System (NFCS) (Grunau & Craig, 1990) may provide better sensitivity to detect inaudible crying than the Anderson Behavioral State Scoring System because the qualifiers in the NFCS are quite detailed, eradicating uncertainty regarding observed behaviors.

Table 2.
Mean Combined Crying Time (mean ± SD) for Each Phase on the First and Second Days of Study

	Crying Time, 1st day		Crying Time, 2nd day	
Phase	**KCH**	**IH**	**IH**	**KCH**
Baseline	2.3 ± 3.8	1.0 ± 2.0	0.7 ± 1.2	1.3 ± 2.5
Warming	4.0 ± 3.7	2.3 ± 4.5	4.2 ± 5.9	4.5 ± 7.1
Heel Stick	84.3 ± 61.9	81.8 ± 97.4	96.2 ± 92.4	55.0 ± 55.5
Recovery	5.8 ± 7.6	25.5 ± 41.9	7.0 ± 9.9	2.8 ± 3.2

Kangaroo Care could have an analgesic effect in several ways. First, KC's continuous tactile stimulation may serve as a pain inhibitory system by activating endogenous pain-modulating systems. For example, by 23 weeks gestation, the human fetus and preterm infant can mount hormonal stress responses to painful stimuli (Giannakoulopoulos, Sepulveda, Kourtis, et al., 1994) and receive some analgesia through the endogenous endorphin system (Gibbins & Stevens, 2001). As little as 20 minutes of KC significantly alters cortisol and beta-endorphin release (Modi & Glover, 1998; Mooncey, et al., 1997). Second, KC's analgesic effect is thought to be due to blocking nociceptive transduction or transmission of afferent pathways, or activating descending inhibitory pathways (Carbajal, 2005; Carbajal, Gall, & Annequin, 2004). Because maternal holding is more analgesic than a pacifier in infants (Phillips, Chantry, Gallagher, et al., 2005), one may speculate that KC analgesia may inhibit stimulation of central pathways too. Future study of infant rats experiencing a heel stick during skin-to-skin contact, which occurs during natural infant rat huddling behavior with the mother (Farrell & Alberts, 2002), might clarify if KC analgesia is mediated through the dorsal horn only and if inhibition of central nociception pathways also occurs. Resolving the issue of central nociception activation/deactivation with KC is important because repeated experiences of KC analgesia may have the

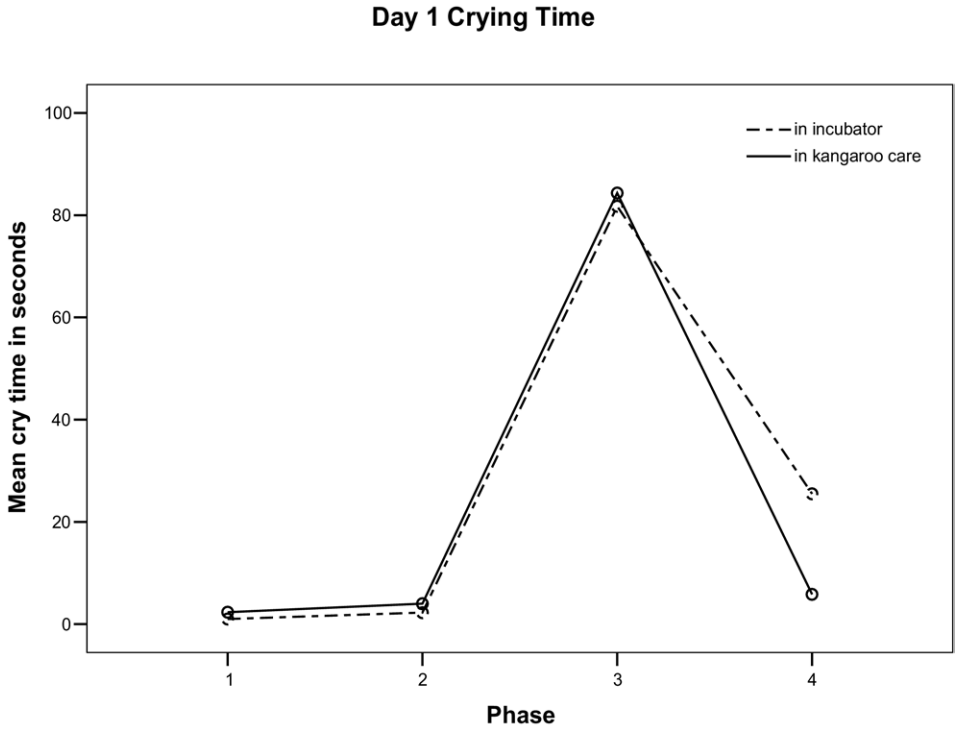


Figure 1. ■ Mean crying time in seconds on day 1 during Baseline (1), Warming (2), Heel Stick (3), and Recovery (4) phases for infants in Incubator and in Kangaroo Care.

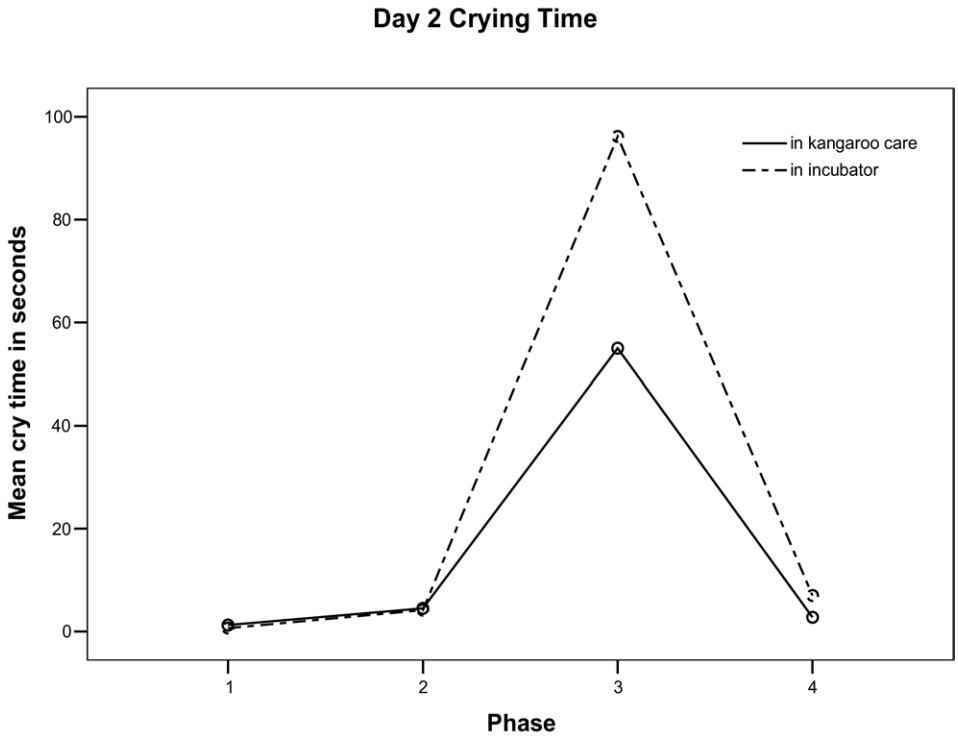


FIGURE 2. ■ Mean crying time in seconds on day 2 during Baseline (1), Warming (2), Heel Stick (3), and Recovery (4) phases for infants in Incubator and in Kangaroo Care.

remote potential of creating associative memory between KC and pain—memory that could thwart cuddling, closeness, and interaction between mother and infant though animal studies have dismissed the possibility (Ren, Blass, Zhou, et al., 1997). Third, KC's analgesic effects may be mediated through oxytocin. During skin-to-skin contact, oxytocin secretion increases in both infants and mothers (Uvnas-Moberg, 1998). Animal studies have examined the putative potential mechanism of oxytocin as an antinociceptive agent. For example, nonnoxious stimulation in infant rats increases oxytocin (Lund et al., 2002; Uvnas-Moberg et al., 1993). Oxytocin has both short- and long-term antinociceptive effects (Lund, et al., 2002) and does so in rats and mice by increasing the nociceptive threshold (Petersson et al., 1996; Lundeberg et al., 1994). Fourth, KC may indirectly reduce neonatal pain by decreasing the total amount of noxious stimuli to which neonates are exposed. Noxious environmental stimulation coupled with painful stimuli frequently increases pain response (Carbajal, Gall, & Annequin, 2004). During KC, infants fall deeply asleep and are less arousable to environmental events than when in incubators (Ludington-Hoe, Johnson, Morgan et al., 2006). Sleep has been found to minimize infant pain response (Slater et al., 2006; Stevens, Johnston, & Horton, 1994). A final mechanism may be the maternal presence, which includes the presence of maternal odor. Maternal odor provides a degree of analgesia (Carbajal, 2003). Infants who experience familiar maternal odor during a heel stick show no increase in crying compared with baseline crying levels (Goubet, Rattaz, Peirrat, et al., 2003). Maternal scent has reduced post–heel stick crying in full-term infants too (Rattaz, Goubet, & Bullinger, 2005), partially owing to newborn recognition of maternal scent from the womb (Marlier, Schaal, & Soussignan, 1998; Rangel & Leon, 1995). Future study with infants who only experience maternal presence by her proximity to the infant rather than having all of the holding, containment, skin contact, warmth, heart beat, and rhythmic chest movement elements that comprise KC would delineate the specific and numerous ways mothers contribute to their infant's pain management.

Crying differentiated the heel stick phase from any other phase, clearly showing a crying response to the acute painful stimulus. No differences were seen in crying time between the KCH and IH groups during baseline and heel warming phases, as one might have expected given that infants were undisturbed in their respective environments. Crying rarely occurred before the heel stick phase. Kangaroo Care calms infants, decreases their level of stress (Modi & Glover, 1998; Mooncey, et al., 1997; More-

lius, Theodorsson, & Nelson, 2005), decreases behavioral signs of discomfort (Morelius, Theodorsson, & Nelson, 2005), and is associated with very little crying (Ludington, 1990). Infants in incubators also cry little when undisturbed, so the low level of crying before the incubator heel stick was expected. Changes during the actual heel stick were expected, because even disinfecting skin area with an alcohol pad produces bilateral brain activation as a response to pain (Bartocci et al., 2006).

Limitations and Future Study

The study had many strengths: randomization of the infants, a narrow window of the two blood collections to control for intervening pain exposure, measuring the number of previous painful procedures, assigning a level of inflammation of the skin using the Neonatal Skin Condition score, and testing infants with a narrow gestational window to control for neurodevelopment influences on pain response. However, the results should be considered with caution because they are based on pilot work and limitations exist. One limitation was the lack of blinding to the study's conditions. For 6 months we tried to find a way to videotape just the infant's face during the heel stick so scorers could be blind to the incubator and KC condition. But blinding in this way was not possible because as an infant lies on his or her mother's chest, the head moves slightly in response to maternal breathing. Lack of similar head movement does not occur on the incubator mattress. Another limitation is that the results pertain only to infants who had no signs of inflammation at the heel stick site. Inflammation may change cry responses. Future study could include infants who demonstrate signs of inflammation using the Neonatal Skin Condition Score to determine inflammation's mediating effects. Future studies also need to be conducted with infants born at earlier gestational ages. Definitive studies with adequate sample sizes are needed to assure that KC minimizes the pain experience without creating memories associating mother's holding with painful stimuli.

Clinical Implications

The results reported here support those of earlier studies with preterm and full-term infants and contribute data on audible and inaudible crying times, with inaudible crying being practically non-existent, and thus, not a relevant clinical sign. The reduction in combined crying time suggests that less physiologic compromise may occur in response to pain, but physiologic parameters were not evaluated in this study. Less crying could also mean that heel stick pain was not perceived fully and, therefore, may be less likely to produce cortical patterns of hyperalgesia and pain memory during childhood. Given that preterm infants learn to anticipate pain when their leg is picked up once they have had 2 weeks of heel stick experience (Goubet, Clifton, & Shah, 2001), nonpharmacologic interventions to reduce pain should be in place during minor painful stimuli (Carbajal, 2006; Leslie & Marlow, 2006). Neonatal intensive care unit's staff need to educate on pain practice guidelines to improve neonatal pain management interventions (Carbajal, Gall, & Annequin, 2004). Kangaroo Care has been recommended as a nonpharmacologic pain management strategy (American Academy of Pediatrics, 2006; Golianu, Krane, Seybold, et al., 2007; Johnston, Filion, & Nuyt, 2007; Leslie & Marlow, 2006), but the evidence supporting its practice with preterm infants is still limited. Thus, the practice of KC during heel sticks should be monitored closely and variation in infant response anticipated.

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