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The effects of skin-to-skin contact during acute pain in preterm newborns

Thaila C. Castral [a,*], Fay Warnock [b], Adriana M. Leite [c], Vanderlei J. Haas [d], Carmen G.S. Scochi [c]

[a] *University of Sao Paulo at Ribeirao Preto College of Nursing, WHO Collaborating Centre for Nursing Research Development, Av. Bandeirantes 3900, Ribeirao Preto – SP, CEP: 14040-902, Brazil*
[b] *British Columbia University – School of Nursing, Vancouver, British Columbia, Canada*
[c] *University of Sao Paulo at Ribeirao Preto College of Nursing – Department of Maternal-Child and Public Health, WHO Collaborating Centre for Nursing Research Development, Brazil*
[d] *Brazilian Coordination for the Improvement of Higher Education Personnel, Department of General and Specialized Nursing, WHO Collaborating Centre for Nursing Research Development, Brazil*

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Abstract

Background and purpose: Several promising non-pharmacological interventions have been developed to reduce acute pain in preterm infants including skin-to-skin contact between a mother and her infant. However, variability in physiological outcomes of existing studies on skin-to-skin makes it difficult to determine treatment effects of this naturalistic approach for the preterm infant. The aim of this study was to test the efficacy of mother and infant skin-to-skin contact during heel prick in premature infants.
Method: Fifty nine stable preterm infants (born at least 30 weeks gestational age) who were undergoing routine heel lance were randomly assigned to either 15 min of skin-to-skin contact before, during and following heel prick ($n = 31$, treatment group), or to regular care ($n = 28$, control group). Throughout the heel lance procedure, all infants were assessed for change in facial action (NFCS), behavioral state, crying, and heart rate.
Results: Statistically significant differences were noted between the treatment and control groups during the puncture, heel squeeze and the post phases of heel prick. Infants who received skin-to-skin contact were more likely to show lower NFCS scores throughout the procedure. Both groups of infants cried and showed increased heart rate during puncture and heel squeeze although changes in these measures were less for the treated infants.
Conclusions: Skin-to-skin contact promoted reduction in behavioral measures and less physiological increase during procedure. It is recommended that skin-to-skin contact be used as a non-pharmacologic intervention to relieve acute pain in stable premature infants born 30 weeks gestational age or older.

Keywords: Pain; Premature; Skin-to-skin contact; Heel prick; Neonatal nursing

1. Introduction

Early exposure to significant pain and stress is now known to cause immediate and long lasting changes to the structure and function of the preterm infant's brain (Fitzgerald and Beggs, 2001). However, despite this

* Corresponding author. Tel.: +55 16 36306674(home)/36023411(off.); fax: +55 16 36333271.
E-mail addresses: thailacastral@usp.br, thailacastral@bol.com.br (T.C. Castral).

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knowledge, many newborns (NBs) still do not receive adequate pain treatment for routine painful procedures (Prestes et al., 2005).

According to Als et al. (1982) synactive theory, instability in multiple subsystems occurs when a baby is exposed to early stressors. Stress induced instability in autonomic system results in alterations to neonatal heart rate, breathing, and temperature and instability in motor subsystem results when the baby makes uncoordinated limb movements in response to pain. Disturbance to the sleep–wake subsystem causes changes in sleep cycles, and handling together with vestibular manipulations, may cause apnic episodes and may impact on maternal-infant interaction. Pain relief helps stabilize the preterm infant's subsystem response to pain and stress (Als et al., 1982).

Non-pharmacological interventions to alleviate procedural NB pain such as providing the baby glucose and sucrose (Deshmukh and Udani, 2002) and breastfeeding (Shah et al., 2006; Leite, 2005), or mothers' milk (Blass, 1997), skin-to-skin contact (Johnston et al., 2003), and non-nutritive sucking (Blass and Watt, 1999) have been developed. Findings from a systematic review of 2 meta-analyses and 13 randomized controlled trials suggest that swaddling, facilitated tucking, and non-nutritive sucking have pain–relieving effects (Cignacco et al., 2007). In that review, lack in using standardized interventions, validated pain assessment tools and ambiguity in study measures were cited as possible reasons for failure to detect treatment effects in some studies. Of particular interest was the finding of significantly lower pain scores (using the composite Premature Infant Pain Profile, PIPP), in preterm infants ($n = 75$) who received skin-to-skin contact (Johnston et al., 2003). In that study, when the pain indices were examined individually, no differences were noted in heart rate (HR) or in oxygen saturation between contact and crib conditions. Interestingly, facial action contributed significantly to the total PIPP score with infants in the contact condition exhibiting a 20% decrease in facial pain

Pain behavior and HR were also assessed in two other skin-to-skin interventions: one involving full-term NBs ($n = 30$) (Gray et al., 2000), and the other involving preterm NBs ($n = 24$) (Ludington-Hoe et al., 2005). Both studies reported reductions in pain behavior, but only the latter study reported statistically significant differences in HR. The inability to detect consistent change in HR across studies may be due to loose associations between behavioral and physiological or the manner in which the pain indices were measured (combined vs. separate). To add to the science, the purpose of this current study was to test the efficacy of skin-to-skin in reducing acute pain reactivity between a treatment group and a control group of stable premature NBs (30 weeks of gestational age and older) during routine heel prick for Phenylketonuria (PKU) screening. We hypothesized that NBs who received skin-to-skin before and during heel prick would exhibit a lower pain response, and a quicker return to baseline compared to infant controls.

2. Methods

2.1. Subjects

This study consisted of a total of 59 premature NBs. This sample represented the entire number of available eligible NBs who were born between September 2005 and May 2006 and recruited from the intermediary neonatal care unit of the Clinics Hospital at the Ribeirão Preto School of Medicine, University of São Paulo (HCFMRP-USP), Brazil. Included were NBs with gestational age $\geqslant 30$ weeks and $\geqslant 36$ weeks plus 6 days and who had an Apgar score of 6 at 5 min. Excluded were infants who were on assisted ventilation or who had intraventricular hemorrhage, congenital nervous system diseases; malformation or neurological damage or who were receiving analgesics opioids. Hence, the 59 study NBs were in stable clinical state, although 62% had received intensive care prior to them being transferred to the intermediary neonatal care unit.

Of the 62 mothers initially approached, three infants were not entered into the study because two mothers declined participation and another mother was under treatment for tuberculosis. The remaining 59 infants who met the inclusion criteria and whose parent agreed to their infant's or to their infant's and their own participation were randomly assigned into two study groups: skin-to-skin ($n = 31$) or to regular crib/incubator care ($n = 28$). Randomization was achieved using a sequence of random numbers from a computer generated sequence according to Beller et al. (2002). Ethical approval to conduct this study was obtained from the hospital ethical committee and informed consent was obtained from all of the 59 mothers prior to their infant's heel prick.

2.2. Study measures, coding procedure and analyses

In this study, infant pain reactivity was measured in terms of change in facial action (NFCS), sleep–wake (behavioral state), infant cry and heart rate (HR). We chose to include both behavioral and physiological infant pain indicators and to measure them separately to help clarify the preterm infant's complex pain response to the skin-to-skin intervention. As can be seen in Table 1, the heel prick event was broken down into seven data collection time points during which all of the four study measures were collected: baseline (2 min), treatment (15 min), heel cleaning (20 s), heel prick (20 s), heel squeeze (time enough to blood collection), wound compression (20 s) and recovery (2 min).

Table 1
The seven phases of PKU test

	Duration (seconds)
Baseline (BL)	120
Treatment (T)	120
Heel cleaning (HC)	20
Heel prick (HP)	20
Heel squeezing (HS)	Time enough to collect blood sample
Wound compression (WC)	20
Recovery (R)	120

The Neonatal facial coding system (NFCS) (Grunau and Craig, 1987) was selected, because it is considered the most salient behavioral indicator of infant pain (AAP et al., 2006). Although this scale was developed for research purposes, the NFCS has been shown to be feasible for use at the bedside (Grunau et al., 1998; Harrison et al., 2002) and its validity and reliability in assessing acute pain has been demonstrated in both full-term (Pereira et al., 1999) and preterm infants (Johnston et al., 1995; Guinsburg et al., 2003).

Two trained coders, who were blinded to the purpose of the study, coded for change in facial action following protocols established by Grunau and Craig (1987).This involved coding the nine facial actions comprising the NFCS (brow bulge, eye squeeze, naso-labial furrow, open lips, vertical mouth stretch, horizontal month, lip purse, taut tongue and chin quiver) every two seconds for the first 20 s of each of the seven study phases for each videotaped infant case. Inter-rater reliability, in this study, was 0.97 based on 30% of the infant sample size and the conservative formula proposed by Grunau and Craig (1987).

The two trained coders also coded infant behavioral state and infant cry at each 20 s interval using the states described by Precthel (1974). In this study, crying was defined as any audible vocalization lasting more than five seconds and with intervals of up to 20 s (Bilgen et al., 2001). Infant behavioral state was coded continuously from baseline to recovery and infant cry was coded for the full duration of each infant's heel cleaning, heel prick, heel squeeze and wound compression. The variable cry duration represented the total sum score for those sub-phases of infant heel prick. Heart rate (HR) was measured by a cardiac monitor (Nellcor model N5000-ENS) and recorded by hand every minute for the duration of each of the seven sub-phases except when a phase took less than one minute, HR was then recorded at least once for that phase (e.g. heel cleaning and puncture). The mean HR value was calculated by summing HR values for each full minute as indicated above and dividing by the seven study phases. Risk was considered if HR values differed from normal range, i.e. 110–160 bpm (beats per minute) (Fletcher, 1999).

Background characteristics of the infants (e.g. gestational age, birth weight, sex) were analyzed using descriptive statistics and Mann–Whitney non-parametric test for two independent variables or Chi-Square. A repeated-measures ANOVA was performed to compare NFCS scores and average HR within subjects and between groups. Mann–Whitney non-parametric test was used to compare behavioral state between groups on each phase. To compare NFCS during heel prick and squeezing phases, a one-way ANCOVA (GLM) was performed controlling for corrected and post-conception infant age and for the number of previous exposure to invasive procedures. Bonferroni method was used as adjustment for multiple comparisons, with $\alpha = 0.05$. Infant gender (sex) was stratified.

2.3. Procedure

The study took place in the neonatal care unit. Two trained nurses conducted all of the heel pricks using a standardized protocol. None of the 59 study infants were breast-feed for at least 30 min before their heel prick, and none received any analgesic or comfort measure during their heel prick except for the treatment group of infants who received the skin-to-skin contact.

The skin-to-skin protocol used in this study for the treatment group is based on the works of Johnston et al. (2003) and Gray et al. (2000). Mothers wore front opening hospital gowns and infants wore only diapers. To provide maximum skin-to-skin contact and to maintain infant temperature, the infants were held by their mothers in an elevated prone position, at approximately 60° across mothers' chest while mothers' hands remained around babies' backs, hidden under blankets. During the baseline, treatment and recovery study phases, mothers remained seated on a chair to perform skin-to-skin contact but they stood with their babies in the skin-to-skin position to facilitate blood collection during the heel cleaning, heel prick, heel squeeze and wound compression phases.

For the duration of the seven study phases, the infant controls were placed in a lateral decubitus position with their heads raised by a cloth diaper in their cribs or incubators, wearing only diapers and rolled-up in blankets. Although positioning of infants in the two study groups differed and this may influence infant outcomes, current studies show no evidence that differing positioning of the infant has any direct pain–relieving effect (Grunau et al., 2004; Stevens et al., 1999). The mothers of the control infants were invited to remain with their infants, but they were instructed not to touch or talk to their babies.

For all infants, data collection commenced when the researcher placed electrodes on the chest of the infants to gather continuous measures of HR. The faces of all of the infants were continuously video-recorded throughout the seven study phases to capture change in facial action. After the full two minutes baseline,

infants in the treatment group were given to their mothers to receive the 15 min skin-to-skin contact intervention while the control infants remained in their crib or incubator with no handling. Thus, in contrast to the intervention group, the infant controls received no handling for 15 min except handling associated with infant heel prick. The heels of infants were then cleansed (20 s) and lanced (20 s) by the nurse followed by heel squeezing to obtain the required amount of blood sample and then compressed (20 s). During the 2 min recovery period, the treatment group continued in skin-to-skin contact while the control group remained in their cribs or incubators.

3. Results

Mean birth weight was 1748.8 g for the treatment group and 1846.2 g for the control group. Infants who received skin-to-skin had lower average Apgar scores at 1st min (6.5) than the infant controls (7.1). On the day of blood collection, mean postmenstrual age was 254.4 days in the control group compared to 248.3 in the treatment group. Mann–Whitney Test results showed that birth weight ($p = .320$), Apgar ($p = .337$), and NBs' postmenstrual age ($p = .105$) did not differ significantly between the infant groups.

There were more boys ($n = 18$, 58%) than girls ($n = 13$, 42%) in the treatment group but more girls ($n = 16$, 57%) than boys ($n = 12$, 43%) in the control group. Six mothers (19.4%) in the treatment group, and two (7.1%) in the control group had previous experience with skin-to-skin. Fisher's Exact Test showed no statistically significant group differences in terms of previous skin-to-skin experience ($p = .259$). Although all NBs in this study had experienced several daily painful procedures as part of their neonatal care, the two infant groups did not statistically differ on the number of invasive procedures performed 24 h before blood collection ($p = .832$) or in the number of punctures performed during heel lance ($p = .099$). Table 2 illustrates the number of punctures by infant group during PKU exam.

The duration of heel puncture (heel cleaning to wound compression) was significantly shorter for the treatment group than it was for the control group ($p = .014$). The shortest collection time in the treatment group was 1.95 min, compared to 2.48 min in the control group. Two NBs (one from the treatment group and the other from the control group) received four punctures, and collection time lasted 16.22 and 17.25 min, respectively.

The mean NFCS scores for the seven coded study phases were lower for the treatment group than they were for the control group. Both groups showed a marked increase in mean NFCS scores from heel cleaning to puncture. However, in the treatment group, there was a progressive decline in NFCS pain scores from

Table 2
Number of heel punctures during PKU test by infant group

Number of heel punctures	Treatment group		Control group	
	No.	%	No.	%
1	22	71	14	50
2	7	22.6	10	35.7
3	1	3.2	3	10.71
4	1	3.2	1	3.6

Table 3
Multiple comparison of mean NFCS scores between infant groups for each of the seven study phases

Study phase	Study group	Mean	Mean difference (Treatment-control)	Std. Error	Sig. (a)	95% Confidence interval for difference (a)	
						Lower bound	Upper bound
1	Treatment	.47	−.322	.398	.422	−1.119	.475
	Control	.79				−0.475	1.119
2	Treatment	.32	−.641	.340	.064	−1.322	.039
	Control	.96				−.039	1.322
3	Treatment	1.07	−.340	.480	.482	−1.300	.621
	Control	1.41				−.621	1.300
4	Treatment	2.47	−1.140 (a)	.486	.023	−2.114	−.166
	Control	3.61				.166	2.114
5	Treatment	2.37	−1.872 (a)	.530	.001	−2.933	−.811
	Control	4.24				.811	2.933
6	Treatment	1.16	−.917	.504	.074	−1.926	.092
	Control	2.08				−.092	1.926
7	Treatment	.94	−.483	.486	.325	−1.456	.491
	Control	1.42				−.491	1.456

Based on estimated marginal means; Mean differences in neonatal facial action system (NFCS) score between infant treatment (skin-to-skin) and infant control groups; (a) = the mean difference is significant at $p < .05$ based on adjustments for multiple comparisons: Bonferroni 1 = baseline; 2 = treatment; 3 = heel cleaning; 4 = heel prick; 5 = heel squeezing; 6 = wound compression; 7 = recovery.

puncture to recovery, whereas the control group showed decline in pain scores only after heel squeezing. There was a reduction of 1.14 in puncture and 1.87 in heel squeezing in mean NFCS scores for the treatment group compared to the control group.

Table 3 shows infants receiving skin-to-skin were more likely than infant controls to have significant lower NFCS scores for heel prick ($p = .023$) and for heel squeeze ($p = .001$). The mean difference in NFCS scores between groups for these phases were still significant after controlling for corrected ($p = .043$; $p = .003$) and chronological age ($p = .024$; $p = .001$), and after controlling for previous pain experience ($p = .019$; $p = .001$). The mean NFCS score were also lower in treatment group, whether the NBs were male or female.

Fig. 1 shows average prevailing behavioral state values for each of the seven study phases by infant group. During baseline, most of the infants in both groups (67.7% treatment; 64.3% control) were sleeping. When the heel was cleaned, NBs in the treatment group remained in deep sleep (32.3%), active sleep (19.4%) or were drowsy (9.7%) while in control group, infants were in active sleep (42.9%) or deep sleep (17.9%). During heel prick and heel squeeze, crying was the most common sleep–wake state for both treatment and control groups (51.6% vs. 57.1%; 58.1% vs. 85.7%, respectively). Immediately after heel squeeze and during compression, 29 NBs in the treatment group (38.7%) were in deep sleep, whereas nine NBs in the control group (32.1%) remained crying. During recovery, most NBs (71.0%) in the treatment group were in deep sleep compared to six NBs (21.4%) in the control group. Mann–Whitney Test revealed statistically significant differences between groups for infant behavioral state during recovery ($p = .000$), using Bonferroni correction factor. As can be seen in Fig. 2, average cry duration during heel prick in the treatment group was 2.5 min compared to 4.8 min in the control group ($p = .024$). There was a 37.41% reduction in mean cry duration in the group with skin-to-skin contact.

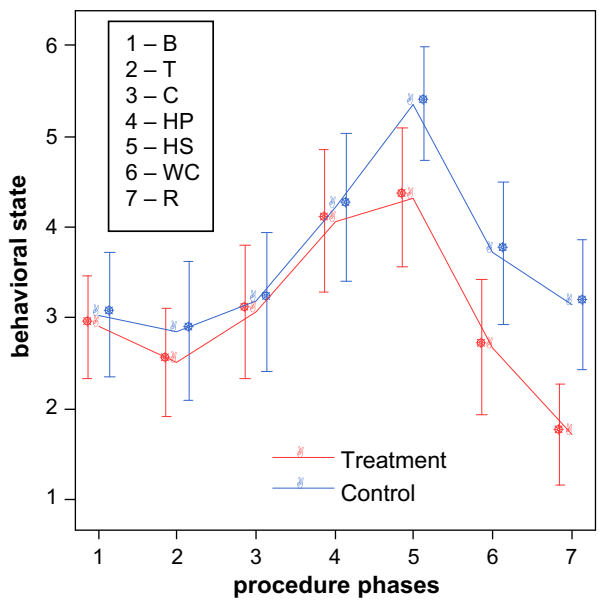

Fig. 1. Average prevailing behavioral state values for each phase of the data procedure (B = Baseline, T = treatment, C = heel cleaning, HP = heel prick, S = heel squeeze, WC = wound compression, R = recovery as per Figure 1) by infant group. Behavioral states: 1 = deep sleep, 2 = active sleep, 3 = drowsy, 4 = quiet alert, 5 = active alert, 6 = cry.

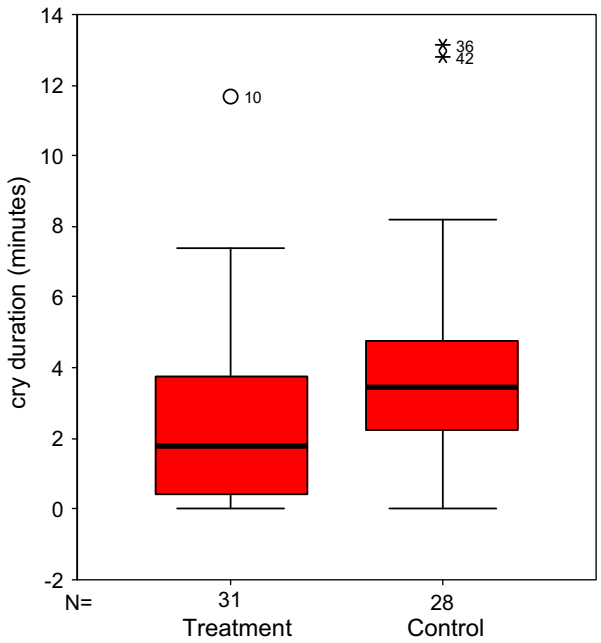

Fig. 2. Cry duration during heel prick (cleaning, heel prick, heel squeeze and wound compression) for each group.

In terms of HR, most of NBs in this study showed risk values for HR above 160 bpm (beats per minute) during heel cleaning (58%), heel prick (71%), heel squeeze (93%) and wound compression (71%). After blood collection, 49% of the infants had HR values above 160 bpm. Skin-to-skin contact reduced average HR values during the treatment period. After that, HR increased markedly until puncture and remained the same during heel squeezing. HR then decreased during recovery until close to baseline values were approached.

In the control group, there was a sharp increase in HR with heel squeezing. HR values then decreased during compression and recovery, but remained tachycardiac with values above 160 bpm. There was an average increase of 19 bpm from baseline to heel puncture and squeezing in treatment group compared to an average increase value of 23 bpm during puncture and 34 bpm during heel squeezing, in control group. During recovery, there was a reduction of 19 bpm after handling in the treatment group, compared to 11 bpm in the control group.

Table 4
Multiple comparison of mean HR between groups for each of the seven study phases

Study phase	Study group	Mean	Mean difference (Treatment-control)	Std. Error	Sig. (a)	95% Confidence interval for difference (a)	
						Lower bound	Upper bound
1 B	Treatment	156.3	5.538	6.046	.364	−6.569	17.645
	Control	150.8				−17.645	6.569
2T	Treatment	150.8	−6.003	5.083	.243	−16.182	4.175
	Control	156.8				−4.175	16.182
3HC	Treatment	164.7	−.365	6.824	.958	−14.030	13.299
	Control	165.1				−13.299	14.030
4HP	Treatment	175.5	2.234	7.046	.752	−11.875	16.343
	Control	173.2				−16.343	11.875
5HS	Treatment	175.7	−8.428	5.246	.114	−18.933	2.076
	Control	184.1				−2.076	18.933
6WC	Treatment	178.9	.721	8.007	.929	−15.313	16.755
	Control	178.2				−16.755	15.313
7 R	Treatment	159.5	−.661	5.888	.198	−19.452	4.129
	Control	167.2				−4.129	19.452

Based on estimated marginal means; Mean differences in Heart Rate between infant treatment (skin-to-skin) and infant control groups; (a) = the mean difference is significant at $p < .05$ based on adjustments for multiple comparisons: Bonferroni 1 = baseline; 2 = treatment; 3 = heel cleaning; 4 = heel prick; 5 = heel squeezing; 6 = wound compression; 7 = recovery.

Table 4 presents repeated-measures ANOVA results for average HR values between infant groups for each of the seven study phases. As per Table 3, mean HR values were lower on average for the treated infants than they were for the control infants, but there were no statistically significant differences in HR values between the groups for any of the seven study phases.

4. Discussion

In this study, skin-to-skin contact 15 min before, during, and after heel prick resulted in diminished acute pain response in stable premature infants born 30 weeks gestational age or older. This study represents one of the first skin-to-skin studies in the preterm infant population to have measured, separately, common physiological and behavioral indices of NB pain and it made use of control measures and comparative infant groups with randomization. The advantage in obtaining separate measures is that data representing each indictor of the preterm infant's complex response to pain can be closely examined. In using a composite pain scale, understanding the nuances or contributions of the behavioral and the physiological responses may be obscured since those scales yield a total pain score. The majority of skin-to-skin studies employ a cross over within subject study design. Those designs are important because they help remove the effects of prior pain experience which is important for the preterm infant (Ludington-Hoe et al., 2005). Conversely, the value in utilizing an infant group comparative design with randomization is that it enables a direct approach to assessing the effects of the intervention.

Consistent with previous findings, the pain–relieving effect of the skin-to-skin intervention, in this study, was evidenced by statistically significant fewer pain scores throughout the heel prick event (Johnston et al., 2003) and shorter cry duration during recovery (Gray et al., 2000). Similar to the findings reported by Ludington-Hoe et al. (2005), most of the treated study NBs fell into deep sleep during recovery and they appeared calmer and more organized during wound compression and recovery than did the infant controls. Also, consistent with Johnston et al. (2003) and Gray et al. (2000), HR levels were lower for infants who received skin-to-skin contact and similarly we did not detect statistically significant group differences in HR. Statistically significant reductions in HR were, however, reported in the Ludington-Hoe et al. (2005) study. The Ludington-Hoe et al. (2005) findings likely arose because the skin-to-skin intervention lasted 3 h. The prolonged duration of the intervention likely increased infant exposure to the added potent antinociceptive and comfort effects of breastfeeding. Taken together, the preceding findings suggest that skin-to-skin contact has stress reducing benefits. Decrease in infant cry could represent a 13% reduction in energy costs which may further suggest skin-to-skin as an important protective factor for preterm NBs (Rao et al., 1993).

In this study, duration of the heel prick event lasted longer for the infant control group than it did for the treated group and this may have influenced study findings. In existing skin-to-skin studies, we found little information about duration of heel lance between infant groups or between study treatment or control conditions, and this makes it difficult to compare our findings. In this study, measures were taken to minimize factors

that could have led to group differences in duration. The same two trained nurses conducted all of the heel pricks using a standardized protocol and we found no statistically significant group differences in the number of heel pricks. It is, however, possible that elevated prone positioning of the treated NBs may have facilitated blood flow to the infants' heel, and that skin-to-skin contact helped relax the NBs.

We do not believe group differences in duration stood as a confounder to the NFCS study findings. This is because for both study groups, NFCS scores were coded for only the first 20 s of each of the seven study phases. It is, however, possible that duration impacted on the cry, behavioral state and HR outcomes because those measures were collected for the natural duration of the heel prick event which lasted longer for the control group. Future studies will need to report duration of the heel prick event as this will further insight on the meaning and impact of duration differences. An alternative approach would be to equalize the groups on duration prior to data analysis. However, if this is done, it may be important to avoid setting the offset time too close to the timing of the pain stimulus as this may negate understanding of the preterm infant's recovery from pain relative to the treatment.

Our inability to detect statistically significant group differences in HR may have been due to immaturity in preterm infant's cardiac modulation systems (Morison et al., 2001) and/or due to the manner in which HR is measured. Newborns less than 36 weeks postconceptual age often exhibit reduced biological response capacity since the magnitude of their physiological responses will differ depending on degree of prematurity at birth (Oberlander and Saul, 2002). Future studies may therefore benefit from ensuring baseline values in HR between study groups, carefully selecting HR epochs relative to effects of the treatment, and interpreting HR spectral peaks rather than autonomic tone (Oberlander and Saul, 2002). Another reason may be related to study power. In this study, NBs were sampled during an 8 month time block and sample size calculations were guided by the Gray et al. (2000) study that also employed a comparative infant group design. However, our sample size of 59 NBs may have been insufficient to obtain the power needed, particularly to detect statistically significant differences in HR. Hence, similarly designed future studies may also benefit from multisite trials as this may help obtain sufficient sample size based on aprori power calculations for HR.

In this study, outcomes between the physiological and behavioral indicators of neonatal pain varied. Inconsistency between these measures may be due to loose association or dissociation (Johnston and Stevens, 1996; Barr, 1998) or due to factors associated with the measures themselves and/or individual differences in infant expression of those measures. As Barr (1998) explains, HR and SpO_2, are covert measures while behaviors such as cry, facial and body movements are overt. The author also suggests that dissociation may be related to neonates' individual characteristics (e.g. robustness). Thus in response to painful events, some babies may exhibit overt behaviors with indistinct manifestations in HR while other babies may not exhibit overt behaviors but they show significant change in HR.

To illustrate, Morison et al. (2001) investigated relations between physiologic (HR variability) and behavioral pain reactivity (NFCS, finger splay, and sleep/wake state) in preterm neonates at 32 weeks postconceptual age. Although NFCS scores and measures of infant state were moderately correlated with change in HR, associations between NFCS, infant state and HR variability were much lower and not significant. In that study, some neonates displayed a strong behavioral response to pain with a low physiologic reaction, while other neonates exhibited a high internal response with minimal external reaction. Those findings highlight the value in obtaining separate measures of the indicators of neonatal pain since it seems that behavioral and physiological responses in the preterm infant are regulated and manifested differently.

The systems involved in the nociceptive, comfort and stress regulative properties of skin-to-skin contact are explained in clinical and comparative animal studies. Physical proximity to the infant enables the mother to provide her baby with containment, maternal heart beat sound, rhythmic movement with maternal breathing, warmth, prone position (Lundington-Hoe and Swinth, 1996) and maternal odor (Goubet et al., 2003). It is also suggested that maternal contact serves as a powerful source of comfort to non-human offspring and the simultaneously putative sensory-altering pathways that characterize normative interactions between a mother and her baby help the infant to conserve energy (Blass et al., 1995; Blass, 1997). Also, there is evidence that touch-based interventions may be regulated by cholecystokinin and opioids, with other neuropeptides, such as oxytocin, and classical neurotransmitters; playing an important role in infant stress and emotion regulation development (Weller and Feldman, 2003).

This study has a number of limitations. Group differences in duration of the PKU event may have posed as a confounder. As well, coders could not be blinded to study group due to the nature of the intervention. In this study, the sample size may have reduced the power of the study and ability to prevent Type II error especially to detect group differences in HR. Recommendations for future infant group comparative studies were made to increase infant sample size and to employ different approaches to measurement in HR.

In conclusion, assessing the effects of non-pharmacological pain interventions in the preterm NB is challenging and further work is required especially with respect

to physiological measures. Data from this controlled study add to existing evidence and provide the basis for recommending skin-to-skin contact to relieve acute pain in stable premature infants born 30 weeks gestational age or older. This is in recognition of the primary regulative role that maternal caregiving plays in helping the fragile preterm infant to respond to everyday stressors including pain (Als et al., 1982).

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