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Effect of aquatic physical therapy on pain and state of sleep and wakefulness among stable preterm newborns in neonatal intensive care units

Efeitos da fisioterapia aquática na dor e no estado de sono e vigília de recém-nascidos pré-termo estáveis internados em unidade de terapia intensiva neonatal

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Abstract

Objective: To evaluate the effects of aquatic physical therapy on pain and on the cycle of sleep and wakefulness among stable hospitalized premature infants. **Method:** This study was characterized as an uncontrolled clinical trial on a time series and included 12 clinically stable newborns of gestational age less than 36 weeks who were hospitalized in a neonatal intensive care unit (NICU). After selection, the newborns were placed in a liquid medium for aquatic physical therapy lasting 10 minutes. Movements to stimulate flexor posture and postural organization were performed. The sleep-wakefulness cycle was assessed using the adapted Brazelton (1973)* scale and pain was assessed by the occurrence of signs of pain according to the Neonatal Facial Coding System (NFCS) scale; and physiological parameters. **Results:** In relation to states of sleep and wakefulness, before the physical therapy, the newborns' behavior varied from fully awake with vigorous body movements to crying. After the physical therapy, the states of sleep ranged from light sleep with closed eyes to some body movement. These values presented statistically significant differences ($p<0.001$). The score on the pain assessment scale also decreased from 5.38±0.91 to 0.25±0.46, with $p < 0.001$ after the intervention. The vital signs remained stable. **Conclusion:** It is suggested that aquatic physical therapy can be a simple and effective method for reducing pain and improving sleep quality among preterm infants in NICUs. Controlled studies with larger numbers of subjects are needed in order to generalize the results.
Article registered of the Clinical Trials under the NCT00785837.

Key words: aquatic physical therapy, preterm, neonatology.

*Brazelton TB. Neonatal Behavioral Assessment Scale. London: Clinics in Developmental Medicine; 1973.

Resumo

Objetivos: Avaliar os efeitos da fisioterapia aquática na dor e no ciclo de sono e vigília de bebês prematuros estáveis hospitalizados. **Métodos:** A pesquisa caracterizou-se como ensaio clínico não controlado de séries temporais. Foram incluídos 12 recém-nascidos clinicamente estáveis com idade gestacional inferior a 36 semanas internados em unidade de terapia intensiva neonatal. Após serem selecionados, os recém-nascidos foram colocados no meio líquido, onde foi iniciada a fisioterapia aquática, com duração de 10 minutos, na qual foram realizados movimentos que estimulam as posturas flexoras e a organização postural. Foram avaliados os ciclos sono e vigília por meio da escala de avaliação do ciclo de sono e vigília adaptada de Brazelton, a presença de sinais de dor por meio da escala Sistema de Codificação da Atividade Facial Neonatal (NFCS), além de parâmetros fisiológicos. **Resultados:** Em relação aos estados de sono e vigília, antes da fisioterapia, os recém-nascidos apresentaram comportamentos que variaram entre totalmente acordados, com movimentos corporais vigorosos e choro. Após a fisioterapia, os estados de sono variaram entre sono leve com olhos fechados e algum movimento corporal. Esses valores apresentaram diferenças estatisticamente significativas ($p<0,001$). O escore da escala de avaliação de dor também diminuiu de 5,38±0,91 para 0,25±0,46 com $p<0,001$ após a intervenção. Os sinais vitais mantiveram-se estáveis. **Conclusão:** Sugere-se que a fisioterapia aquática pode ser um método simples e efetivo na redução da dor e na melhora da qualidade do sono de bebês prematuros em UTI Neonatal. Tornam-se necessários estudos controlados e com maior número de indivíduos para a generalização dos resultados.
Artigo registrado no Clinical Trials sob o número NCT00785837.

Palavras-chave: fisioterapia aquática; pré-termo; neonatologia.

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Introduction

According to Gaspardo, Linhares and Martinez[1], there is evidence that newborns, even preterm ones, have the neurological ability of feeling pain. Pain reduction among newborns avoids potential risks and waste of energy in an attempt to compensate the difficulty of adaptation to the extra-uterine environment. By studying pain among newborn infants, Anand[2] concluded that it is one important harmful factor of the extra-uterine environment. In addition, when pain is not treated, it can cause several deleterious effects, such as metabolic alterations, increase in the level of circulating hormones and in the susceptibility to infections, alterations of cerebral blood flow, hypoxia and modifications in the patterns of sleep and wakefulness, other than behavioral changes.

Procedures used to relieve pain can improve homeostasis and stability among newborns and are essential for the immature neonates' care and support[1]. Among the various pain relief procedures, the improvement in sleep cycles is essential for the subject's neurodevelopment, learning skills, memory and preservation of brain plasticity[2]. Studies indicate that bathing techniques can reduce crying and anguish and improve behavior and sleep quality[1]. The tactile-kinesthetic stimulation has shown itself to be effective in pain reduction[3].

Due to the complexity of neonatal intensive care units (NICUs), pain relief procedures and multidisciplinary therapy programs focusing on the newborns' comfort are necessary.

This study intends to assess the effects of aquatic physical therapy on the improvement of sleep quality and pain reduction among stable premature infants hospitalized in NICUs.

Methods

The study was an uncontrolled clinical trial on a time series, in which the participants acted as their own controls before undergoing the physical therapy intervention. The study sample was recruited by convenience through a consecutive selection of newborns that fulfilled the inclusion criteria.

The study was conducted at the NICU of the Hospital Luterano in Porto Alegre (RS) - Brazil, from July 2005 to June 2007. A sample of 12 subjects was estimated based on a previously performed pilot study, which considered a 0,99 effect size and standard deviation of 0.313 to provide an 80% power for detecting a difference in neonatal facial coding system (NFCS) scores after the therapeutic procedure (alpha of 0.05).

The inclusion criteria were: clinically stable premature newborns with gestational age of less than 36 weeks, who presented behavioral abnormalities and were given permission to bathe by the pediatrician. Examples of behavioral abnormalities included intolerance to touch, excessive crying, pain signs according to the NFCS scale and difficulty to change from a state of crying and agitation to deep sleep after 60 minutes or less. The presence of these abnormalities was assessed by pediatricians and physical therapists at the NICU. The exclusion criteria were: clinically unstable premature infants who presented temperature alterations, contraindications to immersion baths, neurological problems, or who needed ventilatory support, as well as those with signs of infectious process or facial congenital malformations that would derail the use of the NFCS assessment scale.

Some physiological parameters were assessed in this study, such as mean blood pressure (MBP), body temperature (TAX), cardiac frequency (CF), saturation of oxygen (O_2 SAT) and breathing frequency (BF). The NFCS, developed by Grunau & Craig, was used to assess pain[3]. Scores on the NFCS are determined by the presence or absence of eight facial movements: frowning, eyelid compression, deepening of the nasolabial furrow, open lips, vertical or horizontal mouth stretch, tense tongue and trembling of the chin (i.e. one point is assigned for each observed facial movement). The presence of pain is considered when the score exceeds three points (Appendix 1).

The neonatal behavioral assessment scale (NBAS), adapted from Brazelton[4], was used for the analysis of the newborns' behavior during sleep and wakefulness states. This scale provides a score for each state of sleep or wakefulness of the infant (Appendix 2).

To perform the aquatic physical therapy, a standard plastic cot was used. The cot was sterilized with a solution of chlorhexidine and 70% alcohol and placed next to the incubator. The water temperature was kept at 37 ºC by use of a water thermometer model zls-1270.

For the verification of the physiological variables (MBP, TAX, CF, O_2 SAT and BF), a Dixtal monitor with a pediatric adaptor was used. The researchers responsible for this procedure were specialists in neonatology who had received a 30-day training to follow the protocol of aquatic physical therapy and to use the assessment scales.

The infants who fulfilled the inclusion criteria were selected to receive the study intervention. Participants were wrapped in a towel with their bodies semi-inflected and then were gently placed in the liquid environment, where the physical therapy was applied for 10 minutes. The aquatic physical therapy included smooth and slow movements of the trunk and pelvis. The participant performed

sliding movements in the liquid environment, which also promoted tactile-kinesthetic stimulation and facilitated a flexed posture induced by buoyancy. At the end of the procedure, the participants were removed from the cot and, while maintaining their posture, they were wrapped in a towel and taken to the incubator. The variables related to pain, sleep quality and physiological parameters were registered at the following time-points: 15 minutes before treatment; during the aquatic physical therapy; immediately, 30 and 60 minutes after treatment.

In order to compare the mean pain assessed by the NFCS at the different time-points, a repeated measures analysis of variance (ANOVA) was performed. Using the same statistical test and time-points, the mean values of physiological variables were also evaluated. For the results of the NBAS, the Friedman test with correction for Kendall's coefficient of concordance was applied, due to its equivalence to the repeated measures ANOVA for categorical variables. For data analysis, the Statistical Package for the Social Sciences (SPSS) software was used.

The study was approved by the Research Ethics Committee of the Universidade Luterana do Brasil (ULBRA), Canoas, (RS), Brazil, in December 2006 (CEP-ULBRA 2006-397H). Newborns whose guardians read and signed the informed consent form were included in the study.

Table 1. Sample characteristics.

	Mean (sd) n=12	
GA	31.25±2.25	
DL	25.75±14.23	
Gender (%)	6F	6M
	F: 50%	M: 50%

GA=gestational age; DL=days of life; sd=standard deviation; F=female; M=male.

Table 2. Physiologic parameters during the study.

		Mean (sd)	P
MBP	Pre	56.63±8.03	-
	Pos	55.57±4.5	0.228
TAX	Pre	36.23±0.49	-
	Pos	36.57±0.19	0.076
CF	Pre	172.13±12.11	-
	Pos 30'	147.63±11.10	0.001
	Pos 60'	147±10.74	0.001
O_2 SAT	Pre	91%±3.66%	-
	Pos 30'	96.75%±3.15%	0.001
	Pos 60'	97.63%±2.38%	<0.001
BF	Pre	54±3.54	-
	Pos 30'	45.88±4.99	0.001
	Pos 60'	44.38±4.77	<0.001

sd=standard deviation; p=significance index; CI 95%=confidence interval of 95%; MBP Pre=mean blood pressure before the procedure; MBP Pos=mean blood pressure after the procedure; TAX Pre=body temperature before the procedure; TAX Pos=body temperature after procedure; CF Pre=cardiac frequency before the procedure; CF pos 30'=cardiac frequency after 30 minutes procedure; CF Pos 60'=cardiac frequency after 60 minutes of the procedure; O2 SAT Pre=saturation of oxygen before the procedure; O2 SAT 30'=saturation of oxygen after 30 minutes of the procedure; O2 SAT 60'=saturation of oxygen after 60 minutes of the procedure; BF Pre=breathing frequency before the procedure; BF Pos 30'=breathing frequency after 30 minutes of the procedure; BF Pos 60'=breathing frequency after 60 minutes of the procedure.

Results

The sample consisted of 12 premature newborns (six female and six male) with mean gestational age of 31.25 weeks (Table 1).

Physiological variables

Mean blood pressure

Before the aquatic physical therapy procedure, the MBP was 56.63±8.03. After aquatic physical therapy, a small decrease in the MBP was observed (55.57±4.5), but this difference was not significant (p=0.228) (Table 2).

Body temperature

The mean TX (measured in degrees Celsius) was 36.23 ± 0.49 before the aquatic physical therapy procedure, and 36.57±0.19 after the procedure. This difference was not significant (p=0.76) (Table 2).

Cardiac frequency

Before the aquatic physical therapy procedure, the mean CF (measured in heart beats per minute) was 172.13±12.12. The mean CF was decreased to 157.25±16.21 five minutes after the procedure (p=0.013), and to 147.63±1.10 30 minutes after the procedure (p=0.001) (Table 2).

Saturation of oxygen

The mean O_2 SAT was significantly increased from pre- to post-intervention until 60 minutes after the aquatic physical therapy procedure (p<0.001). The mean O_2 SAT was 91%±3.66% before the procedure and 95.75%±3.24% five minutes after the procedure (p=0.002) (Table 2).

Breathing frequency

A statistically significant reduction was observed in BF after the end of the aquatic physical therapy procedure (p<0.001). The mean BF (measured in respiratory movements per minute) was 54±3.54 before the procedure, 48.88±5.24 five minutes after the procedure (p=0.006), 45.88±4.99 30 minutes after the procedure (p=0.001) and 44.38±4.77 60 minutes after the procedure (p<0.001) (Table 2).

Neonatal behavioral assessment scale adapted from Brazelton[4] (NBAS)

Figure 1 describes the changes observed in median NBAS scores at the different time-points. Before the physical therapy procedure, the newborns' behavior varied from fully awake with vigorous body movements to crying (scores ranging from 5 to 6 points). During the procedure, the median NBAS score were reduced, with the most prevalent behaviors being a wakefulness state with eyes open and minimum body movements, followed by a state of sleep with eyes opening and closing (scores of 3 and 4). At the end of the procedure, the sleep states varied between light sleep with eyes closed and some body movement and deep sleep with no movement and regular breathing (scores of 1 and 2). These differences were statistically significant (p<0.001).

Neonatal facial coding system (NFCS)

The mean score on the NFCS was 5.38±0.916 before the physical therapy procedure. During the first minutes of physical therapy, the mean NFCS score decreased to 4±1.85. At the end of the procedure, the mean score was reduced to 1.38±1.18 (p<0.001) when compared to the mean pre-intervention score. Further reductions were observed 30 minutes (0.38±0.74; p<0.001) and 60 minutes (0.25±0.463; p<0.001) after the procedure (Table 3 and Figure 2).

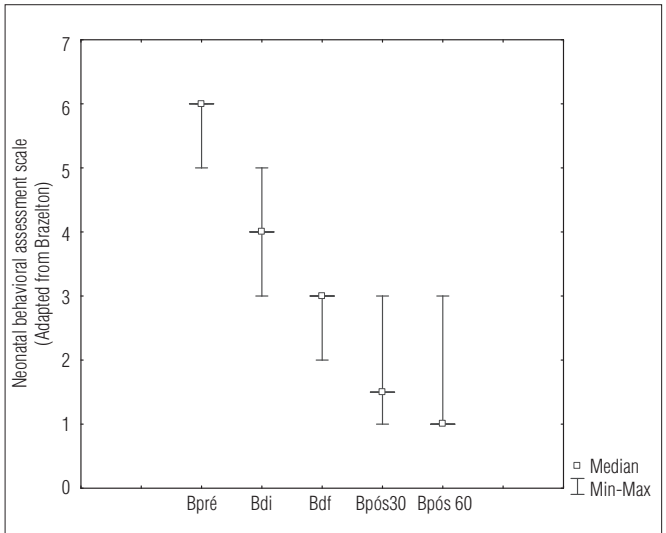
Discussion

During the physical therapy procedure, the newborns' behavior varied from a crying state to a wakefulness state with open eyes and organized body movements. This result is consistent with that found in Sweeney's study[5], which observed the maintenance of the alert and quiet state during hydrotherapy, as opposed to the sleep state demonstrated during immersion baths without body movements. After several procedures performed in newborns presenting changes in tonus, the same author observed an improvement in spasticity when the subjects underwent aquatic physical therapy. The newborns obtained, in a shorter period of time and with less effort, semi-flexed postures and improvements in the performance of spontaneous movements

Table 3. Comparisons between the average scores of the scale of pain (NFCS) during the protocol

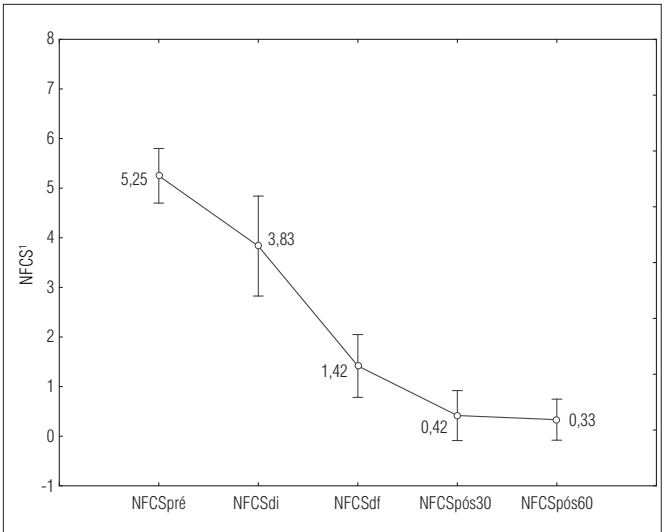
	Mean (sd)	*p*	Diference of the Means
NFCS Pré	5.25±0.87	-	-
NFCS Di	3.83±1.59	0.012	1.41±0.47
NFCS Df	1.33±1.07	<0.001	4±0.26
NFCS Pós-30'	0.42±0.79	<0.001	4.83±0.34
NFCS Pós-60'	0.33±0.65	<0.001	4.91±0.31

sd=Standard Deviation; NFCS Pré=Scale rating before the protocol; NFCS di=Scale rating during 5 minutes of the protocol; NFCS DF=Scale rating in the final of the protocol; NFCS Pós-30=Scale rating after 30 minutes of the protocol; NFCS Pós-60=Scale rating after 60 minutes of the protocol. Between the groups only the NFCS Pós 30' x NFCS 60' the difference (0.08±0.08) wasn't significant (p=0.34).



[1]Scale rating from 1 to 6 (Appendix B); Bpré=scale rating before the protocol; Bdi=Scale rating during 5 minutes of the protocol; Bdf=Scale rating in the final of the protocol; Bpós-30=Scale rating after 30 minutes of the protocol; Bpós-60=Scale rating after 60 minutes of the protocol; Friedman's test: Qui-square: 46.3; p<0.001; Kendall's coefficient of concordance=0.96.

Figure 1. Neonatal behavioral assessment scale (adapted from brazelton)[4] during the study.



[1]NFCS scale rating from 0 to 8; *Multivariate Tests Wilks' lambda (p<0,001); *Verticals Bars indicated 95% Confidence Interval. NFCSpré=Scale rating before the protocol; NFCSdi=Scale rating during 5 minutes of the protocol; NFCSdf=Scale rating in the final of the protocol; NFCSpós30=Scale rating after 30 minutes of the protocol; NFCSpós60=Scale rating after 60 minutes of the protocol.

Figure 2. Comparison between the average scores of the scale of pain (NFCS) during the study.

in a liquid environment[5]. Other studies investigating bathing techniques in newborns found reductions in crying and anguish and improvements in behavior[6]. According to Béziers and Hunsinger[7], the water environment facilitates the movement and also allows infants to recover the feeling of their fundamental movements and continue to develop their "motor coordination".

When it comes to sleep and wakefulness cycles, the REM and non-REM cycles are considered essential to the subject's neurodevelopment, learning skills, memory and preservation of brain plasticity[8]. Nedive[9] states that the facilitation and protection of sleep and sleep cycles are essential, in the long term, to learning skills and to cerebral development by the preservation of brain plasticity. In the present study, newborns' sleep and wakefulness cycles changed to a light sleep state with eyes closed and some body movement immediately after the aquatic physical therapy, and after some time, the newborns acquired a deep sleep state with regular breathing.

According to the NFCS scores, there was a significant decrease in pain after the aquatic physical therapy. The physiological effects of water cause pain relief and general muscle relaxation by the reduction of sensibility in nerve endings and the increase of peripheral circulation, which provides more blood to the muscles[10]. According to Sobrinho, Kreulish e Habib[11], as pain receptors are located in the skin, physical approaches to reduce pain are basically related to the spinal dorsal horn. The stimulation of larger afferents that deliver less harmful messages can reduce the impact of smaller afferents that deliver pain messages. Therefore, painless stimulus such as touch can be used to ease pain.

Aquatic physical therapy has shown to be safe when it comes to vital signs. In 1983, Sweeney[5] compared exercises in water with immersion only and found normal vital signs values during both procedures. However, the authors observed a decrease in mean blood pressure during the immersion procedure. The temperature was kept at normal values, without variations. This finding might be related to the water temperature, which was closer to the infants' body temperature. According to Masi[12], if the water is at the same temperature as the subject's body, the convection and conduction mechanisms are not operating in heat loss. These mechanisms, however, are very important for heat dissipation during aquatic exercises due to the great body surface in contact with water and the conduction capacity of the environment. According to Cloherty and Stark[13], loosely wrapping the infant in a warm wet cloth, as performed in this study, assists the child's relaxation and temperature stability.

Before the procedure, the infants demonstrated tachycardia, with CF of 172.13±12.11, probably due to crying and/or presence of pain. This finding matches the findings of Clohery and Stark's[13] study, where newborns' CF was increased during crying. Studies suggest that pain and stress aggravate the clinical instability of newborns in intensive care[14]. In the present study, after the physical therapy intervention, the subjects' CF decreased, especially 30 and 60 minutes after the intervention. This finding is in line with those of Sweeney et al.[5], who detected a decrease in heartbeats after hydrotherapy. Caromano et al.[10] observed that exercises in warm water could modify physiological responses such as CF, however this did not occur in the present study. It is suggested that the decrease in physiological responses is associated to changes in behavior (i.e. crying to deep sleep).

The BF was significantly reduced after the aquatic physical therapy, especially 60 minutes after the procedure. As previous studies demonstrate that tachypnoea can be a consequence of anxiety or pain[15], this finding might be related to pain reduction and the change in neonatal behavior to a deep sleep state.

Before the aquatic physical therapy, the infants were agitated and tearful, demonstrating a mean O_2 SAT of 91%±3.66%. After the aquatic physical therapy, there was a statistically significant increase in O_2 SAT. It is believed that this result is related to the decrease in the neonates' crying and pain. Authors report that the O_2 SAT decreases due to the stressful environment of the NICU[2]. According to Campion[16], the therapeutic effects of either exercising in warm water or simple immersion improve blood circulation and respiratory muscle functioning. Beziers[7], Getz, Hutzler and Vermer[17] also argue that the water environment increases vital capacity and reduces body weight, allowing the newborns to recover the movements performed during their fetal life.

The present study demonstrated that the aquatic physical therapy was safe for preterm newborns. However, the indication for this technique should be precise and follow well-established criteria in addition to the caution with water temperature, cot sterilization and observation of vital signs.

The present study has several limitations that need to be acknowledged. First, it is possible that the scores on the pain assessment scale may have been biased due to the difficulty in identifying and scoring the newborns' facial movements (i.e. observer bias). Second, the limited sample size makes it difficult to generalize the results (i.e. low external validity). A total of 14 and 24 patients would be required to provide 80% power and 90% power to detect important differences, respectively; whereas the actual

sample size (n=12) provided only 77.3% power with an alpha value of 0.05. The main limitation of this study was the absence of a control group. As such, the observed effects could have been due to factors other than the intervention provided (e.g. change in the environment conditions, effect of the time, oscillations of the circadian cycle, etc.). Based on the discussions that were raised and the limitations of this study, future controlled studies with larger sample sizes are needed to examine the presence of possible confounding factors that could interfere with the results.

Conclusions

The aquatic physical therapy was shown to be safe and effective in reducing pain and improving sleep quality among premature infants hospitalized in NICUs. This intervention, when well performed, can be used as a non-pharmacological method for pain relief and improvement in deep sleep quality and duration. As such, this procedure can contribute to the multidisciplinary principles of humanization in NICUs.

Pain is a sensory experience and can be managed by pharmacological or non-pharmacological procedures, or by the simultaneous use of both. Non-pharmacological interventions, such as tactile approaches, massages, non-nutritive sucking and immersion baths aim to prevent the aggravation of a painful process, disorganization of the neonates, stress and agitation; in other words, to minimize the pain repercussions. In the present study, the improvement in physiological parameters, pain and sleep quality after the intervention suggest that aquatic physical therapy can be beneficial to stable preterm newborns. This technique can contribute to the reduction of harmful effects among the infants, without depriving them of the tactile-kinesthetic stimulation necessary to their neurodevelopment. More controlled studies are necessary to prove these benefits.

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Appendix 1

Neonatal Facial Coding System (NFCS).

The Neonatal Facial Coding System (NFCS) is a scale based only in the evaluation of neonate facial expression and it is adapted to those born at term and also preterm.

Facial movement	0 Point	1 Point
Wrinkled foreheads	Absent	Present
Compressed palpebral fissures	Absent	Present
Deep nasolabial groove	Absent	Present
Half open lips	Absent	Present
Mouth vertical or horizontal outstretched	Absent	Present
Tense tongue	Absent	Present
Tongue protrusion	Absent	Present
Quivering of the chin	Absent	Present

Maximum score: eight points. It is considered the presence of pain when three or more facial movements appear in a consistent way during the evaluation of the presence of pain.

Appendix 2

Brazelton – Neonatal behavioral assessment scale.

State 1	Deep sleep, without movements, breathing regularly
State 2	Light sleep, closed eyes, some corporal movement
State 3	Sleepy, eyes opening and closing
State 4	Awake, opened eyes, minimum corporal movement
State 5	Completely awake, strong corporal movement
State 6	Cry