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Back to the liquid environment: effects of aquatic physiotherapy intervention performed on preterm infants

De volta ao meio líquido: efeitos da intervenção de fisioterapia aquática realizada em prematuros

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Abstract – At birth, preterm newborns (PTNB) often require Neonatal-ICU hospitalization, which, despite being a care setting, also causes stress such as pain, sleep disturbances and wakefulness, and alterations of physiological parameters. The aim of this study was to analyze the effects of aquatic physiotherapy on pain, sleep disturbances and wakefulness, and physiological variables of PTNB in Neonatal-ICU. Pain, sleep disturbances and wakefulness, and alterations of physiological parameters were evaluated at three moments: 5 minutes before intervention, immediately after and 10 minutes after intervention. At intervention, participants were wrapped in soft fabric and immersed at shoulder level in warm water (36 ˚ C to 37.5 ˚ C). Sideways, forward, backward and rotational movements were performed. Twenty-two newborns participated in the study. The results obtained in relation to pain, sleep state and wakefulness showed significant improvements in reevaluations after intervention. Physiological variables also underwent significant changes and remained within normality parameters. The results indicate that aquatic physiotherapy is effective in reducing pain, improving sleep and wakefulness and physiological variables of PTNB in Neonatal-ICU.

Key words: Hydrotherapy; Infant premature; Intensive care units neonatal; Physical therapy modalities.

Resumo – *Ao nascer, o recém-nascido pré-termo (RNPT) frequentemente necessita internamento em UTI-Neonatal que, apesar de ser um ambiente de cuidados, também causa estresses ao RNPT como a dor, alterações de sono e vigília e de parâmetros fisiológicos. Objetivou-se analisar os efeitos da fisioterapia aquática sobre a dor, o estado de sono e vigília e variáveis fisiológicas de RNPT internados em UTI Neonatal. Avaliações sobre dor, estado de sono e vigília e das variáveis fisiológicas foram realizadas em três momentos: 5 minutos antes da intervenção, imediatamente após e 10 minutos após. Na intervenção, os participantes foram envoltos em tecidos macios e imersos, a nível do ombro, em água aquecida (36˚C a 37,5˚C). Foram realizados movimentos látero-laterais, ântero-posteriores e rotacionais. Participaram 22 RNPT. Os resultados obtidos em relação à dor e ao estado de sono e vigília mostram melhoras significativas nas reavaliações após a intervenção. As variáveis fisiológicas também sofreram mudanças significativas e mantiveram-se dentro dos parâmetros de normalidade. Esta pesquisa aponta que a fisioterapia aquática é efetiva na redução da dor, melhora do estado de sono e vigília e das variáveis fisiológicas de RNPT internados em UTI-Neonatal.*

Palavras-chave: *Hidroterapia; Modalidades de fisioterapia; Recém – nascido prematuro; Unidades de terapia intensiva neonatal.*

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INTRODUCTION

Preterm birth occurs before the 37th week of gestation. In Brazil, the prevalence of preterm birth is high and increasing. Between 1978 and 2004, the rate of preterm birth varied from 3.4 to 15% in the Southern and Southeastern regions of the country. In the Northeastern region, studies showed rates from 3.8 to 10.2% between 1984 and 1998[1]. There are several triggering factors, including gestational, environmental and physical, both of mother and infant[2]. It is known that at birth, the preterm newborn (PTNB) requires intensive care, being frequently admitted to Intensive Care Unit (ICU) to receive the necessary care through a multiprofessional team.

However, although it is a place for specific care, Neonatal ICU is a noisy environment with high lighting, in which infants are submitted to numerous daily manipulations as well as painful procedures such as venous punctures, laboratory tests, airway suctioning and tracheal intubation. These environmental characteristics may interfere with the clinical stability and neuropsychomotor development of PTNBs due to the stress caused by this environment[3]. It is estimated that a PTNB in a neonatal ICU receives, on average, 12 painful procedures per day and many of them are performed without analgesia[4]. Exposures to painful procedures may lead to hypoxia, altered blood flow, body temperature, and behavioral changes such as sleep disturbances and wakefulness[4].

Neonatal ICU professionals should be able to identify, evaluate and treat newborn pain in order to reduce it, in some cases, avoid the harmful effects of pain in these patients[5]. Pain relief procedures may increase their clinical stability. This type of procedure can contribute to the recovery and reorganization of these individuals in relation to pain, considered a stressful event[6]. These professionals also play an essential role of supporting PTNBs so that they can survive in this type of environment[7]. Sleep cycles are essential for neurodevelopment, memory, learning and preservation of brain plasticity[8]. During sleep, the nervous system adapts to changes in the environment conditions in which the individual is inserted, in this case, the Neonatal ICU[9].

Studies have shown that the neonate's contact with the liquid environment can reduce crying and pain due to the tactile and kinesthetic stimulation provided by water, and improve sleep behavior and quality[8]. In this context, the aim of this study was to analyze the effects of aquatic physiotherapy on pain, sleep and wakefulness and physiological variables, such as: body temperature, heart rate and oxygen saturation, through assessments of clinically stable PTNBs hospitalized at Neonatal ICU.

METHODOLOGICAL PROCEDURES

This is a study with a quasi-experimental clinical trial design[10] performed at the Neonatal ICU of a public university hospital, from April to June 2016, after approval by the Ethics Research Committee of the Federal

University of Paraná (under CAAE 50113315.2.0000.0096 and protocol number 1.374.002).

The study included PTNBs with corrected gestational age, on the day of intervention, from 30 to 37 weeks, clinically stable, that is, within expected heart rate (HR) and oxygen saturation ($SatO_2$) limits, which had participation authorized by parents or guardians by signing the informed consent form (TCLE). Newborns with corrected gestational age above 37 weeks, who underwent invasive mechanical ventilation (IMV) or non-invasive ventilation (NIV) with recent surgeries, those with central and / or peripheral venous accesses in places that prevented immersion in water were excluded.

Participants underwent evaluation to collect demographic, anthropometric, clinical data and were assessed for pain, sleep and wakefulness. Pain, sleep and wakefulness and physiological variables such as HR, $SatO_2$ and body temperature were assessed by the same criteria at three moments: 5 minutes before aquatic physiotherapy, immediately after and 10 minutes after intervention.

Pain was assessed using the Neonatal Facial Coding System – NFCS scale, valid and reliable to quantify facial expressions associated with pain. It can be used up to four months of life for both preterm and full term infants. Its indicators are: protruding forehead, narrowed eyelid fissure, deep nasolabial groove, open mouth, narrowed mouth (horizontal or vertical), tense tongue, tongue protrusion, chin tremor. The scale ranges from zero to nine points, and one point was assigned for each indicator, and totaling three points or more, it can be considered presence of pain. Due to its easy application and practicality, NFCS is the most recommended scale for clinical use[11].

To evaluate sleep state and wakefulness, the adapted Brazelton scale was used[12]. Through this scale, it is possible to analyze the behavior of premature infants in relation to sleep phases and wakefulness, and for each sleep phase or wakefulness, a score is selected. The scale has six states that range from deep sleep without movements with regular breathing (state 1) to crying (state 6)[12].

Physiological variables heart rate (HR) and oxygen saturation ($SatO_2$) were recorded by means of pulse oximetry. Dixtal monitor model DX 2405 was installed on the right lower limb. Physiological variable body temperature was recorded using G-Tech digital thermometer model THGTH150B.

After the initial evaluation, preterm infants were submitted to aquatic therapy intervention that was performed between breastfeeding periods in the afternoon. A standard plastic bucket, previously sanitized with peresal solution and 70% alcohol, was placed next to the incubator or cradle. The water temperature was maintained between 36 to 37.5°C using a waterproof digital thermometer. Preterm infants were wrapped in soft fabric with semi-flexed body and placed in the liquid environment beginning with the immersion by the lower limbs until water reached the level of shoulders. The support of the physiotherapist occurred in the cephalic region and aquatic physiotherapy lasted 10 minutes.

During immersion, sideways, antero-posterior and rotational movements were performed lightly and slowly, sliding the infant's body into the liquid environment. It was sought to promote body organization and comfort through the flexor posture provided by the wrapping of the body and fluctuation promoted by the thrust action [8]. At the end of intervention, preterm infants were removed from the liquid environment, dried and taken to the incubator or covered in their cradles in order to avoid loss of body temperature.

Statistical Package for the Social Sciences - version 22 (SPSS 22) was used to analyze data. Analysis of variance (ANOVA) for repeated measures was used to compare means for the assessment scales (NFCS and Sleep State and Wakefulness) and physiological variables at the three evaluation moments. Post-Hoc Bonferroni method after ANOVA was used in order to verify differences between evaluation moments. The GreenHouse-Geisser correction was applied in cases of non-sphericity ($p < 0.05$) in the Mauchly test. The effect size was calculated by Partial eta squared, and classified according to Cohen's d into small <0.2; medium $0.2 < d < 0.8$ and large $d < 0.8$[13].

RESULTS

During the data collection period, from April to June 2016, 114 newborns were admitted to the neonatal intensive care unit where the research was performed. Figure 1 shows in detail the sample selection process.

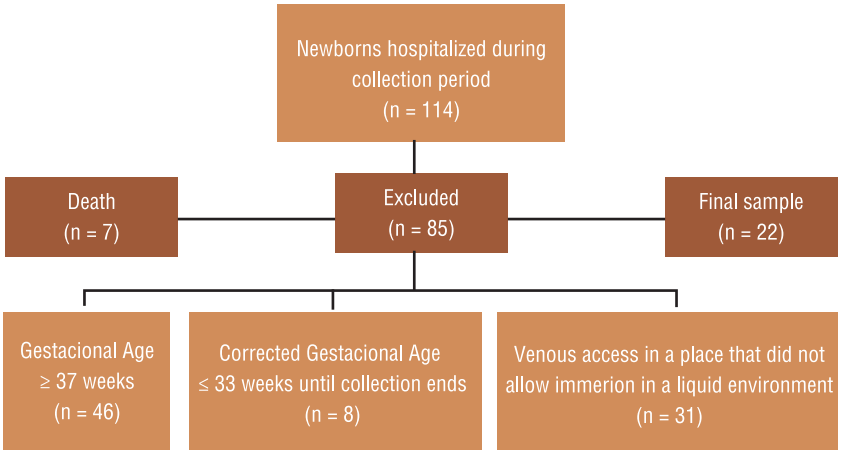

Figure 1. Sample selection process flowchart.

Of the 22 PTNBs participating in the study, 63.6% (14) were female. Patients had mean GA of 35.5 weeks (34-37) and mean weight of 1858.6 grams (± 165.4).

After aquatic physiotherapy intervention, a statistically significant pain reduction was observed when comparing the three evaluation moments ($p = <0.001$). As for sleep and wakefulness, a statistically significant improvement ($p = <0.05$) was also observed when results of the three evaluation moments were compared (Table 1). Before aquatic physiotherapy intervention, participants presented behavioral variation: from crying (state 6) or

totally awake with vigorous body movements (state 5) to light sleep, closed eyes, some body movement (state 2).

Regarding body temperature, a statistically significant change (p <0.01) from 36.52 ˚C ± 0.62 ˚C was observed in the first evaluation to 36.24 ± 0.07 ˚C after intervention (assessment 2). Temperature was maintained (36.22 ± 0.06 ˚C, p = 1.0) and did not show statistical difference 10 minutes after intervention (evaluation 3).

HR rates showed a significant decrease only from the first evaluation (before intervention), with average of 154.27 ± 2.6 bpm for the third evaluation (10 minutes after intervention), with mean of 143.72 ± 3.38 bpm (p = 0.003) (Table 2).

In relation to $SatO_2$, there was a significant increase (p = 0.001) when comparing the results of the mean difference between evaluation 1 (94.50% ± 0.60%) and evaluation 2 (97.31% ± 0.36%); these gains were maintained in evaluation 3 (97.86% ± 0.33%).

DISCUSSION

Preterm infants admitted to neonatal ICU, although clinically stable and without ventilatory support, are fragile patients, and the less they are handled, the better. Could aquatic physiotherapy intervention actually be beneficial for pain reduction, improving sleep and wakefulness, with maintenance of physiological variables for these patients? Based on the results obtained here, the answer is yes.

Table 1. Responses to intervention in relation to pain, sleep state and wakefulness

Variable	Pre-intervention	Immediately after intervention	10' after intervention	p	Effect size [b]
Pain (NFCS)[a]	3.68±0.25 (3.16 – 4.20)	1.04±0.12 (0.79 – 1.30)	0.40±0.12 (0.14 – 0.67)	<0.001	0.772
Sleep and wakefulness [a]	4.45±0.30 (3.83 – 5.07)	3.54±0.19 (3.14 – 3.95)	2.81±0.21 (2.37 – 3.26)	<0.001	0.545

Note. a. Values described as mean and standard deviation - Greenhouse-Geisser correction; b. Calculated by Partial eta squared.

Table 2. Comparison of the behavior of physiological variables during evaluation times

Variable	Evaluation	Mean of variables	Comparison of evaluations	Mean difference	Standard deviation	p	Effect size [a]
Temp.	1	36.5°C	Temp 1 and Temp 2	0.28	0.08	0.01*	0.448
	2	36.2°C	Temp 1 and Temp 3	0.30	0.07	0.001*	
	3	36.2°C	Temp 2 and Temp 3	0.02	0.60	1.0	
HR	1	154 bpm	HR 1 and HR 2	4.18	3.39	0.69	0.406
	2	150 bpm	HR 1 and HR 3	10.54	2.78	0.003*	
	3	144 bpm	HR 2 and HR 3	6.36	3.11	0.16	
$SatO_2$	1	94.5%	$SatO_2$ 1 and $SatO_2$ 2	-2.81	0.45	<0.001*	0.666
	2	97.3%	$SatO_2$ 1 and $SatO_2$ 3	-3.36	0.52	<0.001*	
	3	97.8%	$SatO_2$ 2 and $SatO_2$ 3	-0.54	0.33	0.3	

Note. P = confidence index; Temp = body temperature; HR = heart rate; SatO2 = oxygen saturation; 1 = pre-intervention evaluation; 2 = evaluation immediately after intervention; 3 = evaluation 10 minutes after intervention. * Statistical difference p = <0.05. a. Calculated by Partial eta squared.

It is known that a Neonatal ICU has a diversity of cases and that each one has its limitations and restrictions. However, this study showed the benefits of aquatic physiotherapy intervention in participants included in this study. The results presented here show that the proposed intervention was effective in reducing pain and improving sleep and wakefulness with significant data. Regarding the physiological variables analyzed, all remained within normality parameters, with an increase in $SatO_2$.

Significant pain reduction was observed in PTNB infants after aquatic physiotherapy, and this reduction had an effect of moderate magnitude[13]. A study that used immersion bath as a relaxation technique for newborns showed that the technique helped reduce pain, since newborns were more relaxed, without crying and some of them fell asleep during the immersion bath in properly heated water[14]. In the present study, it was observed that the relaxation remained within 10 minutes after intervention. Another research, in which the authors performed the aquatic physiotherapy modality with 12 preterm infants, obtained significant results regarding pain reduction[8]. It is believed that these results were due to the physiological effects of heated water and the fact that tactile stimuli arrive with greater velocity to the marrow, thus inhibiting fine fibers that stimulate pain, also promoting analgesia and general muscle relaxation[15,16].

During hospitalization in Neonatal ICU, PTNBs are vulnerable to pain because it is an adverse environment. Cignacco et al.[17] analyzed the exposure to painful process in 120 PTNBs in their first 14 days of life and found that each individual experiences, on average, 23 painful processes per day. The painful procedures experienced by these PTNBs, in addition to causing discomfort, can alter their quality of life and their neuropsychomotor development, as well as stress, alteration in the physiological variables and other reactions that contribute to homeostatic imbalance[18].

Regarding sleep and wakefulness evaluation, this study found significant changes between pre- and post-intervention moments with moderate magnitude effect. After intervention, most participants were sleepy with eyes opening and closing, light sleep with minimal body movements. This finding is consistent with the study by Vignochi et al.[8] and also the study by Sweeney[19], which found drowsiness state during the aquatic physiotherapy procedure.

The study conducted by Medeiros and Mascarenhas[20], in which 35 newborns were submitted to humanized bath technique, presented results that corroborate the findings of this study when reporting that after bathing, 97% of participants did not present signs of stress and of these, 3% presented light sleep. Such results are determined by physical properties and physiological and thermal effects of water. When immersed, the body experiences several responses, such as hydrostatic pressure that can work as a body "support", thrust, which allows the body to float and water temperature that, when heated, allows the relaxation that justifies vasodilation and reduction of body overload[14]. In addition, the liquid environment refers the PTNB to the uterine environment and thus, possibly, causes relaxation

due to the memory of this environment.

The newborn temperature is considered normal between 36.5 and 37 °C[20], values observed in all evaluations. The body temperature of participants of this study presented a significant decrease when evaluations in moments before and after aquatic physiotherapy were compared, but within normal temperature patterns[21], probably a response to the removal of the infant from immersion in heated water.

The research by Vignochi et al.[8] points out that, after aquatic physiotherapy intervention, there was no significant difference in body temperature of participants, which remained within normality, which corroborates the results of this study that, despite the significant decrease of body temperature, remained within normality parameters.

HR remained within normality parameters. There were no episodes of tachycardia or bradycardia in spite of the statistically significant decrease of this variable when compared to assessments before aquatic physiotherapy intervention (mean of 154.27 ± 2.6 bpm) and 10 minutes after intervention (mean of 143.72 ± 3.38 bpm). This finding is consistent with the study comparing bath in electric shower with the tummy tub technique, performed in plastic buckets, as used in this study, and resulted in calm newborns with normal physiological parameters when compared to electric shower bath[22].

A study performed with 30 PTNB infants submitted to a bucket bath also found HR reduction after intervention. This study points out that water heat and fluctuation may contribute to reduce heart rate. The effects of heated water are capable of causing a decrease in the hormones responsible for stress, reduction of muscle tension and, thus, can cause psychophysiological relaxation and, consequently, reduction in HR[23].

There was a significant increase in $SatO_2$ when the means of this variable before intervention and in both evaluations after intervention were compared. This result indicates that the effect was maintained even 10 minutes after intervention.

Neonatal ICU is considered a facilitating environment for the newborn instability. Nascimento and Maranhão[3] reported that noise, manipulation and excessive luminosity, as well as other factors, can cause negative impacts on the life of preterm newborns, such as changes in cardiorespiratory systems, with a consequent decrease in $SatO_2$.

A study that analyzed the effects of immersion in heated water on $SatO_2$ in PTNB also found a statistically significant increase in this variable. It is believed that this result is related to the relaxation offered by the aquatic environment, since the therapeutic effects of warm water immersion are able to generate improvement in the respiratory muscles in these individuals[8].

Few studies have been conducted to understand the well-being of PTNB infants hospitalized in neonatal intensive care units, but the main limitation of this study is the absence of a control group, which could generate other explanations such as the time and circadian cycle of evaluations. Despite the evaluator's experience, the difficulty in evaluating and scoring pain through the PTNB's facial movements may have been a study bias.

In literature, there are few studies that have investigated the effects of aquatic physiotherapy intervention on PTNB, impairing the proof of this technique based on scientific evidence, leaving a gap in literature, and allowing new studies related to the topic to be performed. This research demonstrates the effects of a low-cost resource that can be used in neonatal intensive care units. It is also possible to investigate the possible demands of ICUs, and if there is a shortage of professionals to meet this demand, since aquatic physiotherapy intervention requires a relatively long time to be prepared and performed.

CONCLUSION

Therefore, the results obtained from the aquatic physiotherapy intervention in PTNBs need to be diffused to show its possible benefits. Thus, this study demonstrated that aquatic physiotherapy intervention performed in PTNB infants hospitalized in neonatal ICU reduced pain and improved the sleep state and wakefulness of these patients, without compromising body temperature and HR, resulting in improvement in $SatO_2$.

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COMPLIANCE WITH ETHICAL STANDARDS

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Ethical approval
Ethical approval was obtained from the local Human Research Ethics Committee – Federal University of Paraná and the protocol was written in accordance with the standards set by the Declaration of Helsinki.

Conflict of interest statement
The authors have no conflict of interests to declare.

Author Contributions
Conceived and designed the experiments: K.R.M.N.; M.G.A.; V.L.I. Performed the experiments: K.R.M.N. Analyzed data: B.Y.; S. R. V. Contributed with reagents/materials/analysis tools: M.G.A. Wrote the paper: K.R.M.N.; B.Y.; S.R.V.

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