

RESEARCH PAPER (ORIGINAL)

Cardiorespiratory effects of maternal sounds in infants born between 26 and 33 weeks of gestation

Os efeitos cardiorrespiratórios dos sons maternos no recém-nascido das 26 às 33 semanas de idade gestacional

Los efectos cardiorrespiratorios de los sonidos maternos en el recién nacido de las 26 a las 33 semanas de edad gestacional

Crisanta Maria Gomes da Silva Leopoldo Portugal*; Luís Octávio de Sá**; Maria Hercília Ferreira Guimarães Pereira Areias***

Abstract

Background: Care delivery to preterm infants is one of the health areas that have made most progress in recent decades, leading to more interventionist and innovative obstetrical and neonatal practices. Environmental and behavioral factors in neonatal intensive care units (NICUs) have been studied in order to analyze and identify their impact on PTIs.

Objectives: To identify the effects of maternal sounds in the cardiorespiratory parameters of PTIs admitted to an NICU.

Methodology: An experimental randomized study was conducted with 18 PTIs who were randomly distributed into 2 groups, in order to compare the effects of maternal sounds with the effects of the usual sounds at a NICU.

Results: PTIs exposed to maternal sounds had a more stable heart rate ($p = .000$), higher respiratory rate ($p = .000$), and higher oxygen saturation ($p = .000$) than PTIs exposed to the usual sounds at a NICU.

Conclusion: The results show the benefit of exposure to maternal sounds, leading to greater physiological and clinical stability of PTIs.

Keywords: auditory stimulation; premature infant; heart rate; respiratory rate; pulse oximetry

Resumo

Enquadramento: A assistência ao recém-nascido prematuro (RNP) é uma das áreas da saúde com maiores progressos nas últimas décadas, determinando condutas obstétricas e neonatais mais intervencionistas e inovadoras.

Os fatores ambientais e comportamentais, existentes nas unidades de cuidados intensivos neonatais (UCINs), têm sido estudados para analisar e determinar quais os seus efeitos nos RNPs.

Objetivos: Determinar quais os efeitos dos sons maternos nos parâmetros cardiorrespiratórios dos RNPs internados numa UCINs?

Metodologia: Efetuou-se um estudo experimental randomizado com 18 RNPs, distribuídos aleatoriamente em 2 grupos, de modo a comparar os efeitos dos sons maternos com os efeitos dos sons habituais de uma UCIN.

Resultados: Os RNPs expostos aos sons maternos apresentaram valores mais estáveis de frequência cardíaca ($p = 0,000$), frequência respiratória mais elevada ($p = 0,000$) e saturações de oxigénio superiores ($p = 0,000$) quando comparados com os RNP expostos aos sons habituais de uma UCIN.

Conclusão: Os resultados obtidos demonstram o benefício da exposição aos sons maternos, conduzindo a uma maior estabilidade fisiológica e clínica dos RNPs.

Palavras-chave: estimulação auditiva; recém-nascido prematuro; frequência cardíaca; frequência respiratória; oximetria de pulso

Resumen

Marco contextual: La asistencia al recién nacido prematuro (RNP) es una de las áreas de la salud con mayores progresos en las últimas décadas, y determina conductas obstétricas y neonatales más intervencionistas e innovadoras.

Se han estudiado los factores ambientales y comportamentales, existentes en las unidades de cuidados intensivos neonatales (UCINs), para analizar y determinar cuáles son sus efectos en los RNPs.

Objetivos: determinar cuáles son los efectos de los sonidos maternos en los parámetros cardiorrespiratorios de los RNPs internados en una UCIN.

Metodología: se realizó un estudio experimental aleatorizado con 18 RNPs, distribuidos aleatoriamente en 2 grupos, con el objetivo de comparar los efectos de los sonidos maternos con los efectos de los sonidos habituales de una UCIN.

Resultados: Los RNP expuestos a los sonidos maternos presentaron valores más estables de frecuencia cardíaca ($p = 0,000$), frecuencia respiratoria más elevada ($p = 0,000$) y saturaciones de oxígeno superiores ($p = 0,000$) cuando se compararon con los RNP expuestos a los sonidos habituales de una UCIN.

Conclusión: Los resultados obtenidos demuestran el beneficio de la exposición a los sonidos maternos, lo que lleva a una mayor estabilidad fisiológica y clínica de los RNPs.

Palabras-chave: estimulación auditiva; recién nacido prematuro; frecuencia cardíaca; frecuencia respiratoria; oximetría de pulso

*MSc., Adjunct Professor, Santa Maria Health School, 4049-024, Porto, Portugal [crisanta.portugal@sapo.pt]. Contribution to the article: literature search, data collection, treatment, and statistical assessment, data analysis and discussion, article writing. Address for correspondence: Praceta Fernão de Magalhães, 101, 10.º, Vila Nova de Gaia, 4049-024, Porto, Portugal.

**Ph.D., Assistant Professor, Universidade Católica Portuguesa-Porto, 4700-072, Porto, Portugal [lsa@porto.ucp.pt]. Contribution to the article: supervision of the research process, article writing.

***Aggregation, Invited Full Professor/Director of the Neonatology Unit, Department of Pediatrics, Faculty of Medicine, University of Porto, 4200-319, Porto, Portugal. [herciliaguimaraes@gmail.com] Contribution to the article: supervision of the research process and selection of the best evidence in the field, collaboration in article writing.

Received for publication: 08.11.16

Accepted for publication: 17.01.17

Introduction

Preterm birth is not a natural event for the human being. Preterm infants are an extremely vulnerable and heterogeneous group, which includes infants born between 24 and 37 weeks of gestation with a birth weight as low as 500g. Although preterm births represent a small part of the total number of live births, they account for a significant proportion of perinatal problems in Portugal. They are responsible for around 50% of neonatal deaths and a significant number of future citizens with sequelae (Machado et al., 2002). However, preterm infant care is one of the health-related areas that showed a greater scientific advance in recent decades, leading to more active and innovative obstetric and neonatal practices (Guimarães, 2008). Between 2009 and 2014, the percentage of low-birth-weight infants (weighting less than 2,500g) decreased, corresponding to 8.7% of the total live births in 2014. This phenomenon is particularly common in mothers aged under 20 years and over 34 years (Instituto Nacional de Estatística [INE], 2015). In the same period, the percentage of preterm live births (less than 37 weeks of gestation) also decreased from 8.7% to 7.7% (INE, 2015). This problem raises questions about health professionals' role in care delivery at neonatal intensive care units. How can these professionals, namely nurses, contribute to the motor and cognitive development of preterm infants through the provision of adequate sensory stimulation? The scientific research conducted in neonatal care on preterm infant care supports optimal care, which would lead to gains not only in preterm infants' health but also in the family, social, and, economic areas. These studies involve not only auditory stimulation (with different features and methodologies), but also the modification of procedures (noise and light reduction) and innovation of practices, such as care individualization – for example, the Newborn Individualized Developmental Care and Assessment Program (NIDCAP). This study aims at identifying the cardiorespiratory effects of maternal sounds in preterm infants born between 26 and 33 weeks of gestation, when compared to the usual sounds at a neonatal intensive care unit (NICU). There-

fore, we intend to produce knowledge that supports the improvement and innovation of nursing practices in neonatal care for the benefit of preterm infants and their families.

Background

Advances in neonatal medicine have allowed for the increasing survival of preterm infants. However, many newborns face morbidity and changes in their psychomotor development. Preterm infants' survival depends on two key factors: the time and the place of birth. There has been a slow but steady increase in the survival rate of preterm infants without an associated increase in the number of sequelae (Guimarães, 2008). These sequelae range from severe cerebral palsy and mental disability to a broad spectrum of behavioral and learning deficits (Hack et al., 2009; Schreuder, McDonnell, Gaffney, Johnson, & Hope, 2002). In order to better understand the effects of external conditions at NICUs in the development of sequelae in preterm infants, various environmental and behavioral factors have been studied, namely the physical structure of neonatal care units (Milford, Zapalo, & Davis, 2008), the lighting conditions (Lee, Malakooti, & Lotas, 2005), and newborn care provision (Als et al., 2004; Aucott, Donohue, Atkins, & Allen, 2002). Some studies have suggested the need not only to change care practices at NICUs, but also to choose low-noise equipment (Glass, 1999; Thomas & Uran, 2007) in order to create a more appropriate acoustic environment. In general, cardiorespiratory parameters are influenced by multiple factors, particularly during the neonatal period of preterm infants when heart and respiratory rate variability is extremely complex. These depend not only on the infant's gestational age (neurological and physiological maturity) and gender (Krueger, Van Oostrom, & Schuster, 2010; Nakamura, Horio, Miyashita, & Chiba, 2006; Nakamura, Horio, Miyashita, Chiba, & Sato, 2005) but also on the influence of environmental factors in NICUs. Studies and new therapeutic options are needed to continue reducing noise levels and

replace them by more *soothing* sounds that are capable of promoting preterm infants' healthy development and growth. NICUs practices are changing and improving in terms of noise and light reduction, as well as in care delivery itself. The results obtained with the use of so-called soothing sounds have proved to be promising (Doheny, Morey, Ringer, & Lahav, 2012; Rand & Lahav, 2014; Webb, Heller, Benson, & Lahav, 2015); however, the use of maternal sounds as an alternative to music has not yet reached a consensus, thus requiring further in-depth research.

Hypothesis

This study aims to identify the effects of the mother's voice and other maternal sounds in the cardiorespiratory parameters of preterm infants hospitalized in a NICU. This study compares the effects of soothing maternal sounds *versus* the effects of usual sounds at neonatal units in the following parameters: heart rate, respiratory rate, and oxygen saturation. We have formulated the following hypothesis: Preterm infants who listen to recorded maternal sounds present a more rapid and consistent heart rate stabilization, higher respiratory rate, and higher oxygen saturation than preterm infants who are exposed to the usual sounds at a NICU.

Methodology

We conducted an experimental randomized controlled study (pre- and post-test) at the Neonatology Unit of Hospital of São João – Porto for a period of 24 months following the CONSolidated Standards of Reporting Trials (CONSORT 2010). Methodologically, this study was based on the guidance from other studies of the Harvard University, through one of its researchers, who provided us with the logistics for the recordings, within the scope of the Harvard Medical School Portugal program, and the Brigham and Women's Hospital, in Boston. All requirements to initiate a study/research with newborns at a

hospital setting were met. We requested permission to the Director of the Autonomous Unit of Women and Child Management as well as to the Ethics Committee of the Hospital of São João. A guide was prepared for the children's parents with information about the study, an informed consent form, and a declaration of consent for participants in the autonomy-deprived condition provided by the Ethics Committee of the Hospital of São João. The participants' privacy was respected as well as the possibility of withdrawing from the study at any time without penalty. Infants were selected according to the following inclusion criteria: newborns, admitted to the Neonatology Unit of the Hospital of São João, with gestational age between ≥ 26 and ≤ 33 weeks confirmed by ultrasound. The following exclusion criteria were applied: newborn infants with major congenital or chromosomal abnormalities (Down syndrome, Turner syndrome, and Klinefelter syndrome), congenital infections (HIV, TORCH), significant brain damage, with prenatal diagnosis (e.g., neonatal asphyxia), uncontrolled maternal disease, maternal history of tobacco, alcohol, and illicit drug consumption, history of significant maternal nutrient deprivation or malnutrition. After verification of the compliance with the inclusion and exclusion criteria, parents were contacted and explained in person about the purpose of the study and given the guide for clarification and the informed consent. After two days of reflection, if the parents agreed to participate in the study, the selected infants were randomly assigned to one of the groups using the Random Allocation Software, version 1.0: control group (CG) and experimental group (EG). Of the 867 infants admitted to the Neonatology Unit of the Hospital of São João for the duration of the study (24 months), 849 were excluded. Of these, 775 did not meet the inclusion criteria, seven of the parents declined to participate, and the remaining 67 were excluded for various reasons, from linguistic barriers, logistical difficulties (unavailability of monitors, unavailability of recording material, improvement works at the unit). The CONSORT 2010 flow diagram is shown below (Figure 1).

CONSORT 2010 Flow Diagram

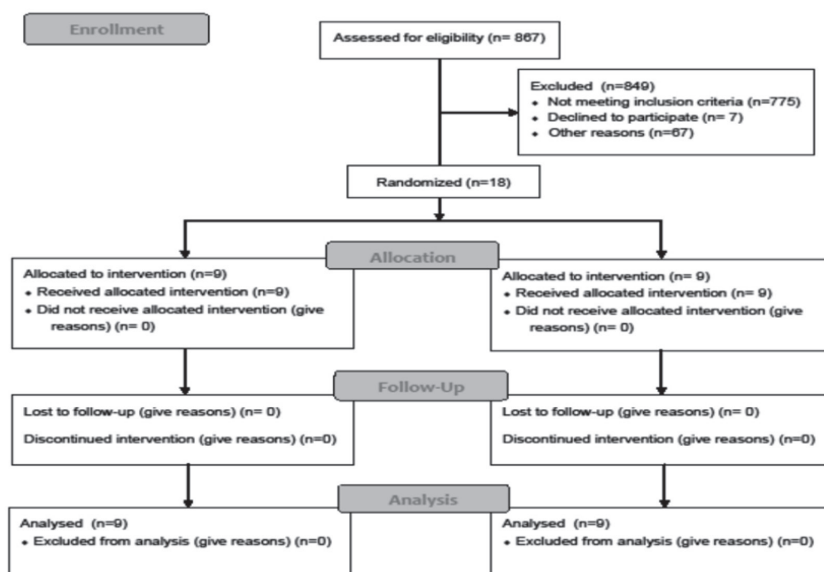


Figure 1. CONSORT 2010 Flow Diagram.

In this study, we used the nursing intervention: stimulation of child and associated activity: talk and sing to child (Dochterman & Bulechek, 2008). This intervention would not be possible because the preterm infant is in an incubator, so an audio technology was developed to allow the newborn to listen to maternal sounds. The study was conducted as follows: in the EG, during hospitalization, newborns listened to the mother's recorded voice and heartbeats. In the CG, newborns listened to the usual sounds in a NICU. If the newborn was included in the group of maternal sounds (EG) between the third and fourth day after birth, the mother's voice and heartbeats were recorded in a room with acoustic isolation in the Hospital of São João. During the voice recording, the mother would (i) talk spontaneously with the newborn, (ii) read a letter or a text with a special meaning, and (iii) sing. The mother's heartbeats were recorded using a digital stethoscope, provided by the Harvard University. The 15-min recording was sent to Amir Lahav's laboratory and then transformed into a 45-min audio track in which the moth-

er's voice was overlaid on the mother's heartbeats. The sound level emitted by the audio track did not exceed 60 decibels, and the peaks above this value were toned down. After the audio track was sent, an audio playing device - MP3 SanDisk® player (sansa® clip) - was placed outside the incubator together with two speakers (iHome iHM79 Rechargeable Mini Speakers) on an acrylic support specifically designed for this purpose, in the headboard inside the incubator. The audio track was transferred to the MP3 and the audio was played through both speakers placed inside the incubator for 45 minutes, four times per day. The decision to play the audio track was made by the nurse responsible for the infant's care plan. A key condition was that newborns were placed inside the nest for sleeping after being fed. The audio track was played at a sound pressure level equivalent to normal conversation (60-65 dB) in accordance with the guidelines of previous studies (Standley, 2002). A sound level meter was used at the beginning of the study to ensure that the sound did not exceed the 65dB (EXTECH USB Sound Level

Datalogger 407760). In the EG, the intervention started (X) when the audio started being played, i.e. when the infant was placed in the nest for sleeping after being fed. In the CG, the moment to consider for comparison was also the moment when newborns were placed in the nest for sleeping after being fed. Any interference (medical exams, nursing care, clinical examinations or procedures) would result in the elimination of any records of the vital signs. Newborns' vital signs were recorded using permanent monitoring - MP30 (Philips MP30 Patient Monitor) - for 45 minutes before, 45 minutes during, and 45 minutes after the intervention. The data for analysis were collected during the newborns' hospitalization until they were transferred to the cradle or discharged. Data were analyzed using the statistical analysis software SPSS (Statistical Package for the Social Sciences), version 20, and the confidence interval was set at 95%.

Results

Both groups were initially analyzed and compared in terms of characteristics at birth and of morbidity. This analysis is essential for group comparison in experimental studies, in which homogeneity should be as consistent as possible. The t-test or Mann-Whitney U test were used to compare both groups. The following table shows the newborns' characteristics, including gender, Apgar scores at 1 and 5 minutes, gestational age, birth weight, antenatal corticosteroid therapy, administration of surfactant and caffeine, otoacoustic emissions, and days in the study, as well as data on morbidity: sepsis, chronic pulmonary disease, intraventricular hemorrhage, and necrotizing enterocolitis. No statistically significant differences were found between the groups regarding their characterization (Table 1).

Table 1
Newborns' demographic, perinatal, and neonatal data

Parameters	Experimental Group (EG) <i>n</i> = 9	Control Group (CG) <i>n</i> = 9	<i>p</i> ^a
Male, <i>n</i> (%)	3 (33.3)	1 (11.1)	
Female, <i>n</i> (%)	6 (66.7)	8 (88.9)	.576
Apgar 1 min.	7.0 ± 1.2	6.4 ± 2.1	.615
Apgar 5 min.	8.0 ± 1.2	8.0 ± 1.0	.847
Gestational age (weeks)	28.7 ± 1.6	29.4 ± 2.0	.499
Birth weight (gr.)	1.153 ± 334	1.128 ± 462	.691
Antenatal corticosteroid therapy (%)	8 (88.9)	8 (88.9)	1.000
Caffeine, <i>n</i> (%)	9 (100)	9 (100)	1.000
Surfactant, <i>n</i> (%)	9 (100)	9 (100)	1.000
Standard otoacoustic emissions	9 (100)	9(100)	1.000
Days in the study	37.3 ± 21.2	37.6 ± 20.6	.929
Morbidity			
Sepsis, <i>n</i> (%)	5 (55.6)	4 (44.4)	.696
Chronic pulmonary disease, <i>n</i> (%)	1 (11.1)	1 (11.1)	1.000
Intraventricular hemorrhage (grade I/II), <i>n</i> (%)	4 (44.4)	2 (22.2)	.286
Necrotizing enterocolitis, <i>n</i> (%)	0 (0)	0 (0)	1.000

Note. Mean scores and Standard deviation (±) are shown. a *p* value results from the application of the t-test or the Mann-Whitney U test for comparison between groups. *p* > .05 n.s. (non-significant).

On average, the CG infants stayed in the study for about 37.6 ± 20.6 (M \pm SD) and the EG infants for about 37.3 ± 21.2 days. No statistically significant difference was found ($p = .931$).

After the statistical analysis of the characteristics of the sampled newborns, we proceeded to the statistical analysis of the different cardiorespiratory parameters measured in both groups: heart rate, respiratory rate, and oxygen saturation.

On average, throughout the seven weeks of observation, the distance in the mean heart rate (bpm) becomes more evident between groups. In the first week, mean scores were quite close: CG with 152.6 ± 13.6 (M \pm SD) and EG with 152.4 ± 11.3 , with no significant difference between both groups ($p =$

.073). After the first week, the distance between the mean scores of each groups increased, with highly statistically significant differences throughout the weeks. Mean scores and standard deviation were as follows: 2nd week - CG with 154.5 ± 12.9 and EG with 152.8 ± 10.7 ($p = .000^{***}$); 3rd week - CG with 154.5 ± 12.9 and EG with 152.8 ± 10.7 ($p = .000^{***}$); 4th week - CG with 161.3 ± 13.9 and EG with 148.7 ± 11.9 ($p = .000^{***}$); 5th week - CG with 158.4 ± 15.4 and EG with 150.8 ± 11 ; ($p = .000^{***}$); 6th week - CG with 164.1 ± 11.4 and EG with 150.7 ± 12.1 ($p = .000^{***}$), and 7th week - CG with 161.7 ± 12.2 and EG with 149.8 ± 13 ($p = .000^{***}$). We present the results in the Figure 2 below for better visualization ($^{***}p < .001$ - highly significant).

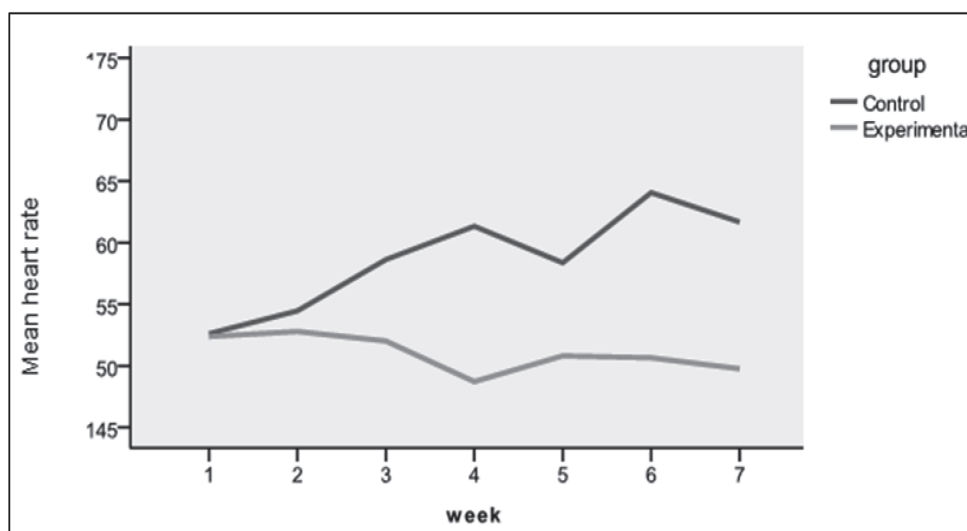


Figure 2. Evolution of newborns' mean heart rate during the first 7 weeks.

With regard to the respiratory rate over the first seven weeks, between the third and fourth week, the mean respiratory rate (br/min.) became closer between groups. After the fourth week, the mean scores deviate and the distance increased, with statistically significant differences between both groups in every week. Mean scores and standard deviation were as follows: 1st week - CG with 45.5 ± 12.8 and EG with 48.7 ± 13 ($p = .000^{***}$); 2nd week - CG with 44.2 ± 11.8 and EG with 48 ± 12.1

($p = .000^{***}$); 3rd week - CG with 48 ± 12.1 and EG with 46.6 ± 12 ($p = .000^{***}$); 4th week - CG with 46.5 ± 11.9 and EG with 47 ± 12.3 ($p = .002^{**}$); 5th week - CG with 45.7 ± 12.8 and EG with 47.2 ± 11.9 ($p = .000^{***}$); 6th week - CG with 48.2 ± 13.9 and EG with 50.4 ± 12.6 ($p = .000^{***}$), and 7th week - CG with 49.7 ± 12.4 and EG with 52.4 ± 12.1 ($p = .000^{***}$). We present the results in the Figure 3 below for better visualization ($^{***}p < .001$ - highly significant; $^{**}p < .01$ - very significant).

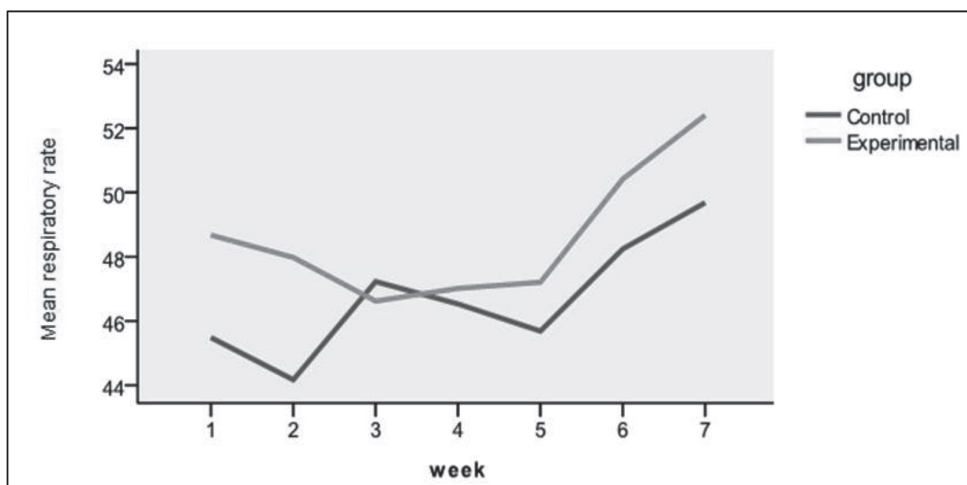


Figure 3. Evolution of newborns' mean respiratory rate during the first 7 weeks.

Throughout the seven weeks, with the exception of the first week, mean O₂ saturation (%) was always higher in the EG, and significant differences were found between both groups in all weeks. Mean scores and standard deviation were as follows: 1st week - CG with 97.1 ± 3.4 and EG with 96.6 ± 3.7 ($p = .000^{***}$); 2nd week - CG with 95.9 ± 4.3 and EG with 96.9 ± 3.8 ($p = .000^{***}$); 3rd week - CG with 95.9 ± 4 and EG with 98

± 2.7 ($p = .000^{***}$); 4th week - CG with 96.2 ± 3.9 and EG with 98 ± 2.7 ($p = .000^{***}$); 5th week - CG with 96.3 ± 3.8 and EG with 98.2 ± 2.4 ($p = .000^{***}$); 6th week - CG with 95.6 ± 4.1 and EG with 98.1 ± 2.1 ($p = 0.000^{***}$); and 7th week - CG with 95.5 ± 4.1 and EG with 98.7 ± 1.8 ($p = .000^{***}$). We present the results in the Figure 4 below for better visualization ($p < .001$ - highly significant).

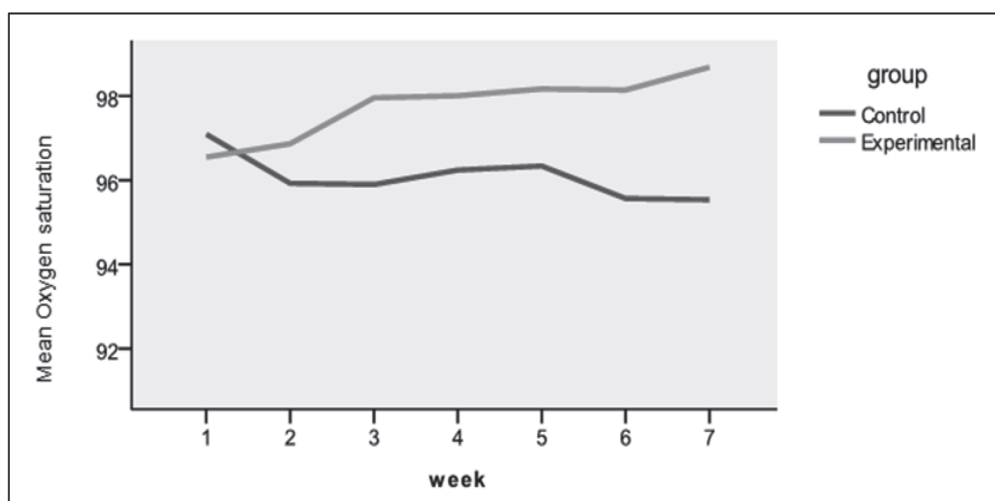


Figure 4. Evolution of newborns' mean oxygen saturation during the first 7 weeks.

Discussion

The comparison between both groups revealed highly significant differences ($p = .000$) in terms of heart rate, respiratory rate, and oxy-

gen saturation.

With regard to the heart rate, significant differences were found between groups, with the EG having lower scores, without major fluctuations throughout the study period. This effect

was consistent during the 7 weeks, demonstrating an homogeneous response in all newborns exposed to maternal sounds. Variability was very limited in this group, but the CG newborns had higher heart rates throughout the study period, with greater variations. With regard to the respiratory rate, the CG always had lower mean scores than the EG (except in the third and fourth weeks, when scores came closer), and the statistical differences were highly significant. It should be noted that a higher respiratory rate in the EG may mean that, when stimulated with maternal sounds, newborns have greater physiological ability for self-regulation, keeping the breath in stable and high levels, which reduce the likelihood of apnea or hypoxia. This regulation is influenced by providing external stimulation to newborns (Martin & Wilson, 2009).

With regard to the oxygen levels, the EG had higher mean scores (by 2-3%) than the CG in all weeks after the first week. The most significant difference was found in the seventh week, with values of 95.5 ± 4.1 in the CG and 98.7 ± 1.8 in the EG. It should be emphasized that oxygen saturation levels should be as close to 98-99% as possible in order to reduce the number of sequelae. Once more, we can infer that auditory stimulation using maternal sounds had an extremely beneficial effect in the newborns of the EG, although the values of the CG are within normal limits. Oxygen saturation levels below 90% are responsible for severe situations with a real impact on morbidity and mortality. This situation did not occur in any of the groups.

These observations about the parameters assessed in this study are reported in other studies (Doheny et al., 2012; Rand & Lahav, 2014; Webb et al., 2012), in which the results are very similar to ours, thus confirming the hypothesis that maternal sounds have a very positive impact on preterm infants' development. Given the sample size, both in our study and in the above-mentioned studies, the results, despite being very promising, cannot be generalized and should be carefully analyzed. We conclude that maternal sounds have a soothing and beneficial effect in preterm infants.

Opposite to other studies, maternal sounds were used for long periods (45-min) rather than for very short periods (1-2 min.), and

in infants with a long hospital length-of-stay. Based on this, we believe that newborns' physiological response (heart rate, respiratory rate, and oxygen saturation) is not merely an immediate response to a sudden and isolated stimulus, but rather a sustained and consistent response, leading us to believe that preterm infants have the ability to recognize and react to surrounding sounds. The consistent reduction in heart rate, along with the increase in respiratory rate and oxygen saturation, to more stable levels as a response to stimulation using maternal sounds leads us to consider further interventions and procedures in nursing care delivery to preterm infants.

Conclusion

Sensory stimulation through maternal sounds has a positive impact on preterm infants' development so it is of utmost importance that the study be replicated in other similar NICUs. Although the study sample was composed of 18 preterm infants, these conclusions are substantiated by the significant differences found between both groups. Auditory stimulation using maternal sounds was found to be very important for cardiorespiratory stabilization. The development of a technology that parents and nurses can easily use to enable exposure to maternal sounds should be considered. We suggest that this auditory stimulation technique should be implemented by nurses and integrated into incubators, thus reducing the number of neurological, physiological, and psychological complications in these children.

References

- Als, H., Duffy, F. H., McAnulty, G. B., Rivkin, M. J., Vajapeyam, S., Mulkern, R. V., ... Eichenwald, E. C. (2004). Early experience alters brain function and structure. *Pediatrics*, 113(4), 846-857.
- Aucott, S., Donohue, P. K., Atkins, E., & Allen, M. C. (2002). Neurodevelopmental care in the NICU. *Mental Retardation Developmental Disabilities Research Reviews*, 8(4), 298-308. doi:10.1002/mrdd.10040
- Dochterman, J. M., & Bulechek, G. M. (2008). *Classificação das intervenções de enfermagem* (4.^a ed.). Porto

- Alegre, Brasil: Artemed.
- Doheny, L., Morey, J. A., Ringer, S. A., & Lahav, A. (2012). Reduced frequency of apnea and bradycardia episodes caused by exposure to biological maternal sounds. *Pediatrics International*, 54(2), e1-3. doi:10.1111/j.1442-200X.2012.03575.x
- Glass, P. (1999). The vulnerable neonate and the neonatal intensive care environment. In G. B. Avery, M. A. Fletcher & M. MacDonald (Eds.), *Neonatology pathophysiology and management of the newborn* (5^a ed., pp. 91-108). Philadelphia, USA: Lippincott Williams & Wilkins.
- Guimarães, H. (2008). Viver um dia de cada vez: Nascer prematuro: Limites e riscos. In A.S. Carvalho (Coord.), *Bioética e vulnerabilidade* (pp. 129-136). Coimbra, Portugal: Almedina.
- Hack, M., Taylor, H. G., Schluchter, M., Andreias, L., Drotar, D., & Klein N. (2009). Behavioral outcomes of extremely low birth weight children at age 8 years. *Journal Of Developmental and Behavioral Pediatrics*, 30(2), 122-130. doi:10.1097/DBP.0b013e31819e6a16
- Instituto Nacional de Estatística. (2015). *Estatísticas demográficas 2014*. Lisboa, Portugal: Autor.
- Krueger, C., van Oostrom, J. H., & Shuster, J. (2010). A longitudinal description of heart rate variability in 28-34 week-old preterm infants. *Biological Research for Nursing*, 11(3), 261-268. doi:10.1177/1099800409341175
- Lee, Y. H., Malakooti, N., & Lotas, M. (2005). A comparison of the light-reduction capacity of commonly used incubator covers. *Neonatal Network*, 24(2), 37-44. doi:10.1891/0730-0832.24.2.37
- Machado, M. C., Neto, M. T., Guimarães, H., Tomé, T., Martins, V., Virella, D., ... Peixoto, J. C. (2002). *Nascer prematuro em Portugal: Estudo multicêntrico nacional 1996-2000*. doi:10.13140/2.1.3716.6086
- Martin, R. J., & Wilson, C. G. (2009). What to do about apnea of prematurity?. *Journal of Applied Physiology*, 107(4), 1015-1016.
- Milford, C. A., Zapalo, B. J., & Davis, G. (2008). NICU design: Process and outcome measures. *Neonatal Network*, 26(5), 299-305.
- Nakamura, T., Horio, H., Miyashita, S., & Chiba, Y. (2006). Local holder exponent analysis of heart rate variability in preterm infants. *IEEE Transactions on Biomedical Engineering*, 53(1), 83-88. doi:10.1109/TBME.2005.859796
- Nakamura, T., Horio, H., Miyashita, S., Chiba, Y., & Sato, S. (2005). Identification of development and autonomic nerve activity from heart rate variability in preterm infants. *Biosystems*, 79(1-3), 117-124. DOI: 10.1016/j.biosystems.2004.09.006
- Rand, K., & Lahav, A. (2014). Maternal sounds elicit lower heart rate in preterm newborns in the first month of life. *Early Human Development*, 90(10), 679-683. doi:10.1016/j.earlhumdev.2014.07.016
- Schreuder, A. M., McDonnell, M., Gaffney, G., Johnson, A., & Hope, P. L. (2002). Outcome at school age following antenatal detection of absent or reversed end diastolic flow velocity in the umbilical artery. *Archives of Disease in Childhood Fetal and Neonatal Edition*, 86(2), F108-F114. doi:10.1136/fn.86.2.F108
- Standley, J. M. (2002). A meta-analysis of the efficacy of music therapy for premature infants. *Journal of Pediatric Nursing*, 17(2), 107-113. doi:10.1053/jpdn.2002.124128
- Thomas, K. A., & Uran, A. (2007). How the NICU environment sounds to a preterm infant. *MCN The American Journal of Maternal Child Nursing*, 32(4), 250-253. doi:10.1097/01.NMC.0000281966.23034.e9
- Webb, A. R., Heller, H. T., Benson, C. B., & Lahav, A. (2015). Mother's voice and heartbeat sounds elicit auditory plasticity in the human brain before full gestation. *Proceedings of the National Academy Science of the United States of America*, 112(10), 3152-3157. doi: 10.1073/pnas.1414924112

