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RESEARCH

Polysomnography assessment of sleep and wakefulness in premature newborns

Avaliação polissonográfica do sono e vigília de recém-nascidos prematuros

Evaluación polisomnografíca del sueño y vigilia de bebés prematuros

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ABSTRACT

Objective: to describe the total sleep time and its stages, total wake time, heart rate values and oxygen saturation shown by premature infants, and the influence of the periods of the day on sleep and physiological parameters. **Method:** a descriptive study was conducted of 13 hospitalized premature infants. Data collection was performed using polysomnography and unstructured observation for 24 uninterrupted hours. **Results:** the newborns remained asleep for 59.6% of the day, predominantly in quiet sleep, with a higher mean heart rate during wakefulness ($p < 0.001$). No difference was found between the variables related to sleep, physiological parameters and periods of the day, but in the morning a predominance of quiet sleep was observed ($p = 0.002$). **Conclusion:** the preterm newborn presented more total sleep time than wakefulness; quiet sleep was the predominant stage, and heart rate was higher during wakefulness.

Key words: Sleep; Newborn; Neonatal Nursing.

RESUMO

Objetivos: descrever o tempo total de sono e seus respectivos estágios, o tempo total de vigília, os valores da frequência cardíaca, de saturação de oxigênio apresentados pelos recém-nascidos prematuros; verificar a influência dos períodos do dia sobre o sono e os parâmetros fisiológicos. **Método:** estudo descritivo, conduzido com 13 recém-nascidos prematuros hospitalizados. A coleta de dados foi realizada pelo polissonígrafo e a observação não estruturada, durante 24 horas ininterruptas. **Resultados:** os recém-nascidos permaneceram 59,6% do dia dormindo, predominantemente em sono quieto, apresentando maior média de frequência cardíaca durante a vigília ($p < 0,001$). Não foi evidenciada diferença entre as variáveis relativas ao sono, parâmetros fisiológicos e os períodos do dia. No período matutino houve predominância do sono quieto ($p = 0,002$). **Conclusão:** os prematuros tiveram maior tempo total de sono do que vigília, o sono quieto foi o estágio predominante e a frequência cardíaca apresentou-se mais elevada durante a vigília.

Descritores: Sono; Recém-Nascido; Enfermagem Neonatal.

RESUMEN

Objectivo: describir el tiempo total de sueño y sus estagios, el tiempo total de vigilia, los valores de frecuencia cardiaca y saturación de oxígeno presentado por los bebés prematuros, y la influencia de los períodos del día sobre el sueño y los parámetros fisiológicos. **Método:** estudio descriptivo, realizado con 13 recien nacidos prematuros hospitalizados. La recolección de datos se realizó mediante polisomnografía y la observación no estructurada durante 24 horas, ininterrumpidamente. **Resultados:** se encontró que los recién nacidos permanecían 59,6% del día durmiendo, predominantemente en el sueño tranquilo, con una mayor frecuencia cardíaca media mientras estaba despierto ($p < 0,001$). No se encontró diferencia entre las variables relacionadas con el sueño, los parámetros fisiológicos y períodos del día, pero por la mañana hubo un predominio de sueño

tranquilo (p = 0,002). **Conclusión:** el prematuros tuvieran más tiempo de sueño total que vigilia, el sueño tranquilo fue el estagio predominante y la frecuencia cardíaca fue mayor durante la vigília.
Palabras clave: Sueño; Recíen-Nacido; Enfermería Neonatal.

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INTRODUCTION

The survival of premature infants (PI) in neonatal units has significantly increased due to scientific and technological progress achieved in recent decades[1-2]. However, this advance did not prevent the occurrence of possible developmental sequelae in the hospitalized infants, since the inherent characteristics of immaturity may be associated with adverse effects of care, the unit environment, and equipment use[3]. In this sense, researchers and health care professionals have focused on the development of preterm infants, as the early birth interrupts the maturational events, making them more vulnerable[1].

Sleep is an important basic human need, essential for homeostasis of the premature infants, and needs to be protected and promoted during hospitalization[2,4]. It is defined as a cyclic physiological condition, characterized by different stages, based on the electroencephalogram (EEG) pattern and the presence or absence of rapid eye movement[5]. During pregnancy, the cycles of activity and fetal rest, which can already be identified from the 28th to 32nd week, evolve to differentiated behavioral states as the neural mechanisms are developed, becoming sleep patterns and wakefulness[2,6].

Sleep, in the neonatal period, is classified into three stages: active sleep (AS) also known as rapid eye movement (REM); quiet sleep (QS), commonly described as non-REM sleep; and indeterminate or transitional sleep[7]. The total time, as well as the duration of the stages of sleep, are important for the development of preterm infants, because, while sleeping significant neurological and physiological activities occur that are related to cardiorespiratory parameters, which vary with sleep and wakefulness[2,8-9].

During hospitalization in the neonatal unit, preterm infants are often exposed to excessive environmental stimuli and/or nursing care[10-11]. These stimuli can lead to sleep deprivation, which is defined as the lack of sleep in a given period or which also can be interpreted by the time spent in each pattern[4,12].

Because of the lack of studies on the sleep of premature infants hospitalized in neonatal units, the premise of likely sleep deprivation of preterm infants in the intermediate care nursery (ICN), and the relationship between sleep and the cardiorespiratory function, it is important to know about the sleep of hospitalized infants. This study may contribute to development of care protocols to protect and promote the sleep of newborns in neonatal units in order to provide safe care.

In this context, this study aimed to describe the total sleep time and its stages, total wakefulness time, heart rate values (HR), and percutaneous arterial oxygen saturation (SpO2) values presented by hospitalized preterm infants, and to verify the influence of the periods of the day on sleep, wakefulness, and physiological parameters.

METHOD

This was a descriptive study conducted with preterm newborns hospitalized in the ICN of a public teaching hospital in São Paulo, which provides care to the users of the Unified Health System. The care provided to the newborns is not guided by developmental care, and includes a multidisciplinary team of nurses, technicians and nursing assistants, physicians, a speech therapist, social worker, physical therapist, nutritionist, and faculty, undergraduate and graduate students of nursing and medicine courses, among others. In the routine of the institution studied there is no preventive maintenance of incubators and other equipment. All preterm infants remained inside of incubators (model 1186 A - FANEM®). The incubators remained partially covered by fabric, throughout data collection, in order to minimize the incidence of light inside the equipment.

Inclusion and exclusion criteria were established for eligibility of individuals, in order to prevent the influence of possible pathological and therapeutic factors on the variables investigated in this study. The study included clinically stable preterm infants in incubators, weighing 1200-2000 grams, and showing positive transient evoked otoacoustic emissions, performed by the speech therapist of the unit. The exclusion criteria consisted of infants using phototherapy or noninvasive mechanical ventilation; presence of a congenital malformation or periventricular hemorrhage, grades II, III and IV; newborns treated with corticosteroids or central nervous system (CNS) depressants 24 hours prior to the data collection; and, those whose mothers had a history of any illicit drug use during pregnancy.

The variables investigated to characterize the preterm infants were: sex, birth and current weight, gestational age according to the last menstrual period (LMP), corrected and chronological age. The dependent variables related to sleep were measured in relation to total sleep time and wakefulness; length of QS, AS and IS; SpO2 and HR readings[8-9].

Data analysis was performed in four different periods of the day, to verify the influence on dependent variables. Thus, the periods were categorized as: morning (7:01am to 1pm); afternoon (1:01 - 7pm); night I (7:01pm -1am), and night II (1:01 -7 am).

All the national and international standards of ethics in research involving humans were met.

The Alice 5 (Respironics®) polysomnograph model and unstructured observation were used for data collection. The polysomnograph was installed by technicians specialized in polysomnography from the Sleep Institute / Association for Research Incentive Fund, and the devices of that instrument were placed with the newborns in the afternoon period and removed the next day. The polysomnographic recordings of 24 uninterrupted hours were obtained, and included the

monitoring of the EEG and electrocardiogram (EKG), thoracic and abdominal movements involving respiratory rate (RR) and SpO_2. So, this instrument, which is considered to be the gold standard for assessment of sleep in children[13], provided the data for sleep analysis, wakefulness, and the HR and SpO_2 readings of the investigated premature infants.

The evaluation of the records generated by the polysomnograph was performed by a pediatric neurologist, a specialist in Sleep Medicine of the Sleep Institute / Association for Research Incentive Fund, and conformed to the guidelines recommended by the American Academy of Sleep Medicine (AASM)[14]. An unstructured observation during the 24 uninterrupted hours was performed by two nurses previously trained by the researcher, concomitantly with the polysomnograph recordings. Each observer followed a script that only indicated the variables that should be recorded. Recordings were made only as changes occurred. To help the sleep specialist in the interpretation of recordings generated by the polysomnograph, the observers recorded the time and described the changes in the infant behavior. From the moment and tracing obtained by polysomnograph, the neurologist could interpret the data, relating the characteristics presented to the behavioral records obtained at that particular moment as: open/closed eyes, presence or absence of crying, eye movements, upper and lower limb movements, as recommended by the AASM. The observers also registered the hour and the environmental changes in the unit, such as the presence of noise, professionals, students around the incubator, lighting. In addition, the manipulation of premature infant by professionals, families and students was registered, to provide support to the researchers for the interpretation of the results of some dependent variables proposed for the study.

After evaluation of the polysomnograph, data were compiled in a spreadsheet and analyzed using the Statistical Package for the Social Sciences (SPSS) software, version 17.0. The descriptive analysis of quantitative variables was performed using mean, standard deviation, median, quartiles, and interquartiles, minimum and maximum. The paired t-test was used to perform the statistical analysis of some variables such as: total sleep time and its respective patterns, heart rate and SpO_2 readings at different times, namely in the morning, afternoon, night I and II periods. The comparison between the median times for sleep, and its respective stages, as well as wakefulness, HR and SpO_2 readings was performed using the non-parametric Friedman test, as each preterm infant was analyzed in four periods.

The same test was used for comparing the median values of HR and SpO_2 readings between the different sleep patterns for each period, as these variables were evaluated in the same infant. In both cases, the choice of the Friedman's test was due to this dependency and the sample size.

RESULTS

Due to time and resources available for the research, the non-probability sample consisted of 13 preterm infants. The premature infants were predominantly male, classified as late preterm according to gestational age by LMP, and adjusted, with a mean chronological age of 9.9 days, low birth and current weight, and mean of HR and SpO_2 during the 24 hours of 145.7 beats per minute (bpm) and 95.6%, respectively (Table 1).

Regarding the analysis of the 1440 minutes of recordings, Table 2 show the mean values of total sleep time, wakefulness, and the duration of the different sleep patterns, heart rate and SpO_2 of the investigated newborns.

The preterm infants remained longest in QS, followed by the AS and IS. Regarding the proportion of total sleep time of the 24 hours analyzed, this value represents 14.3 (59.6%) hours, of the obtained recordings.

In order to evaluate whether the care routines at different periods of the day had influence on sleep and physiological parameters of premature infants, Table 3 shows the median and interquartile ranges of total sleep time, sleep patterns and wakefulness, HR and SpO_2 in the morning, afternoon, night I and II periods.

Table 3 shows no statistically significant difference between the four periods of the day and the total sleep time, the different patterns, and the wakefulness, as well as HR and SpO_2. However, the highest median values of total sleep time of the premature infants occurred in the morning and night II periods. Regarding the different sleep patterns exhibited by the premature infants, the major median total time of AS was presented during the

Table 1 - Characteristics of preterm infants, São Paulo, São Paulo, Brazil, 2013

Variables	Values
Sex (%)	
Female	5(38.5)
Male	8(61.5)
Birth weight (grams)	
Mean ± SD	1742.3 ± 223.6
Minimum-Maximum	1290-2030
Current weight (grams)	
Mean ± SD	1760 ± 166.6
Minimum-Maximum	1315-1965
Gestational age by LMP (weeks)	
Mean ± SD	34.2 ± 2.8
Minimum-Maximum	29.6-36.4
Adjusted gestational age (weeks)	
Mean ± SD	34.6 ± 2.0
Minimum-Maximum	32-36.5
Chronological age (days)	
Mean ± SD	9.9 ± 6.1
Minimum-Maximum	2-20
HR* (beats per minute)	
Mean ± SD	145.7 ± 13.5
Minimum-Maximum	108.0-173.0
SpO_2** (%)	
Mean ± SD	95.6 ± 1.5
Minimum-Maximum	91-98

*Notes:*HR – Heart rate; **SpO_2 – Peripheral capillary oxygen saturation.*

afternoon and night I periods. The IS pattern was higher during night I, and QS prevailed during the morning shift.

Table 4 shows the results of the supplementary analysis of the sleep patterns of the preterm infants in different periods of the day.

During the morning shift, a predominance of QS in preterm infants was observed, and a statistically significant difference was identified when comparing to other patterns. In relation to the other periods of the day, there was no difference in the three sleep patterns of the newborns studied.

Relating the physiological parameters studied to the sleep and wakefulness of the premature infants, a significant difference in the HR mean ($p < 0.001$) was identified. The highest mean occurred during wakefulness (155.44 ± 13.1), compared to sleep (142.7 ± 14.3). A differences was also identified when comparing the HR with the sleep of preterm infants in the four periods of the day ($p = 0.012$), being the highest median value found during the night II (148.63). No statistically significant difference with respect to SpO_2 ($p = 0.247$) was found.

Table 2 - Mean values of premature newborns for total sleep time, patterns of sleep and wakefulness, in minutes, heart rate and oxygen saturation, São Paulo, São Paulo, Brazil, 2013

Variables	Mean ± SD	Minimum-Maximum
Total sleep time	860.7 ± 131.1	730.5-1149.5
Total AS+ time	275.6 ± 83.9	129.5-436
Total QS++ time	359.0 ± 167.0	222.0-835.5
Total IS+++ time	222.0 ± 79.4	51.0-293.5
Total wakefulness time	577.1 ± 129.8	290.0-709.5

Notes: +SA – Active sleep; ++QS – Quiet sleep; +++IS – Indeterminate sleep.

Table 3 - Comparison of the medians of total sleep time, total time of active sleep, quiet and indeterminate sleep and wakefulness, in minutes, heart rate and oxygen saturation presented by premature infants, according to the different periods of the day, São Paulo, São Paulo, Brazil, 2013

Variables	Morning Median (II)	Afternoon Median (II)	Night I Median (II)	Night II Median (II)	Friedman P value
Total sleep time	227.0 (59.3)	211.0 (68.5)	202.0 (79.0)	216.0 (86.8)	0.748
Total AS# time	55.5 (47.5)	70.5 (28.0)	71.0 (50.3)	65.5 (57.5)	0.801
Total QS## time	83.5 (50.3)	74.5 (58.3)	63.5 (35.8)	70.5 (69.0)	0.070
Total IS### time	59.0 (35.8)	57.0 (22.3)	66.5 (19.3)	51.5 (43.8)	0.595
Total wakefulness time	133.0 (59.3)	149.0 (68.5)	143.5 (87.5)	144.0 (86.8)	0.845
HR#### (bpm)	148.9 (14.56)	147.03 (19.0)	144.1 (15.69)	147.85 (16.95)	0.338
SpO_2##### (%)	96.5 (3.0)	96.0 (1.88)	96.0 (2.50)	96.0 (1.75)	0.992

Notes: II – Interquartil range; #AS – Active Sleep; ##QS – Quiet Sleep; ###IS – Indeterminate sleep; ####HR – Heart Rate; #####SpO_2 – Peripheral capillary oxygen saturation.

Table 4 - Comparison of median total time of sleeping patterns presented by premature infants in minutes, according to periods of day, São Paulo, São Paulo, Brazil, 2013

Variables	Total AS§ time Median (II)	Total QS§§ time Median (II)	Total IS§§§ time Median (II)	Friedman P value
Morning	55.5 (47.5)	83.5 (50.3)	59.0 (35.8)	0.002
Afternoon	70.5 (28.0)	74.5 (58.2)	57.0 (22.2)	0.412
Night I	71.0 (50.2)	63.5 (35.7)	66.5 (19.2)	0.165
Night II	65.5 (57.50)	70.5 (69.0)	51.5 (43.7)	1.000

Notes: II – Interquartil range; §AS – Active Sleep; §§QS – Quiet Sleep; §§§IS – Indeterminate sleep.

DISCUSSION

The results show that premature newborns had a sleep time less than that described in the literature. One study indicated that preterm infants need 22 hours of sleep/day, while another research study suggested a mean of 17 hours per day[2,15]. These findings becomes alarming, as the recordings were made for 24 uninterrupted hours, and sleep is characterized as the predominant behavioral state of premature newborns and is required to meet their developmental demands.

Sleep deprivation in preterm infants can change the HR, increase pain perception and apneic events[4]. Moreover, it can trigger infectious processes, increasing metabolic rate and leading to consequent weight loss; it can also cause stress, irritability, crying, with consequent increased intracranial pressure, bleeding and delay of discharge[10,16]. The relationship of long-term sleep deprivation with psychomotor, cognitive and personality development is not clearly understood in human beings[17].

The absence of routines in the NICU that promote individualized care of newborns may have contributed, in part, to the sleep deprivation of premature newborns; a high level of noise and excessive numbers of professionals and students around the incubators was identified, including several manipulations of the newborns by professionals, families and students for cares, performing procedures and also to interact with the child.

Research that aimed to evaluate the sleep of hospitalized newborns demonstrated that, by implementing some care actions with a focus on developmental care, such as reducing the noise level, protecting the newborn from direct lighting, and promotion of twilight periods, showed that newborns slept longer[18-19]. Thus, it is imperative to rethink the philosophy of care and actual routines in order to promote sleep, and therefore protect the newborn, through actions based on care protocols involving continuing education for the multidisciplinary team.

Quiet sleep was the predominant pattern in the investigated period. During QS, the basal metabolism that favors the replenishment of energy reserves decreases, preparing the body for AS, and also for awakening, and promotion of cell repair[6,20]. The prevalence of QS in this study may be related to the maturation of premature infants evaluated, as the mean gestational age was 34.2 weeks, which is considered late prematurity.

In general, studies indicate that the premature newborn should sleep about 80% of the total time in AS, decreasing as his gestational age increases; during this sleep pattern, brain activation occurs, which is essential for the structural maturation of the CNS[2,6,19,21]. There are numerous cellular activities in the brain during AS, which favor the development of the sensorineural system, the process of learning, memory and preservation of brain plasticity[21]. In this sense, the literature states the importance of nursing care in terms of negative or positive effects upon the states of sleep and wakefulness of the newborn, which may favor the more rapid decline of the AS in neonates[22].

Although the researchers recognize the different health care demands of morning, afternoon, night I and II periods of the unit where the study was conducted, the results indicate little difference between the median values of total sleep time of the premature infant when the four periods of the day were compared. Thus, this result does not discard the necessity of the multidisciplinary team to focus its attention on sleeping protection of newborns hospitalized in the neonatal unit, based on their behavioral states, favoring sleep organization, as the premature newborns are in critical periods of development, particularly cerebral[22].

The analysis of sleep and wakefulness of preterm infants demonstrated an influence on HR. Our findings confirm those of other studies that demonstrated the influence of sleep on cardiorespiratory parameters[8-9,23]. The HR showed a significant decrease in sleep as compared to the wakeful state. Thus, this result is expected, since during periods of wakefulness most spontaneous activity of the newborns was verified, as well as episodes of crying related to manipulation.

Significant differences were also observed in HR in preterm newborns during sleep in the four periods analyzed. This result indicates the need for further studies, as a lack of information is observed in the literature and may be related to the types of care for newborns on different shifts.

In this study, no significant difference was identified between the SpO2 readings of the premature infants in relation to sleep and wakefulness; during sleep, however, it was observed that this reading was higher during sleep. Studies indicate an elevation of SpO_2 in QS as compared to AS, demonstrating that with increased brain activity there is a greater oxygen consumption[8,24]. These results can be explained by the anatomical and physiological structure of premature infants. The acinar region of the lungs of these newborns is not fully developed, and depending upon their gestational age, the amount of surfactant and true alveoli responsible for gas exchange are insufficient. These aspects trigger areas of residual atelectasis, resulting in a ventilation-perfusion imbalance during periods of increased activity in the premature infants. Thus, changes in tissue oxygenation of preterm infants can be identified through pulse oximetry[8].

The fact that the variables of sleep and wakefulness were not jointly evaluated along with those related to the NICU environment and the handling of the infants can be considered limitations of the study. The sample size can be considered another limitation; however, the records were analyzed during 24 uninterrupted hours, which reveals an unprecedented characteristic of research regarding the evaluation of sleep and wakefulness of hospitalized preterm infants in the neonatal unit.

CONCLUSION

Premature newborns had a higher total sleep time than wakefulness; QS was the predominant pattern, especially in the morning, and HR was higher during wakefulness. As the results indicated a sleep time lower than that recommended by the literature, the development and use of care protocols aimed at the promotion and protection of sleep are imperative. Further studies are needed to assess sleep and wakefulness of hospitalized newborns, concurrent with the environmental aspects of the NICU and the handling of these infants.

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