Original Article

Effects of nesting and swaddling on the sleep duration of premature infants hospitalized in neonatal intensive care units

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Abstract

Background: In neonatal intensive care unit (NICU), neonatal sleep is disrupted due to different factors. Due to the critical role of sleep in premature infants' brain development, this study aimed to investigate the effect of nesting and swaddling on the sleep duration of premature infants hospitalized in NICUs.

Materials and Methods: In a crossover clinical trial, 42 preterm infants who met the inclusion criteria were enrolled. They were randomly assigned to two groups of nest–swaddle and swaddle–nest. Sleep status was evaluated by observation and use of Prechtl's criteria. Then, durations of total sleep time (TST) and quiet sleep time (QST) were recorded. Data were analyzed using repeated measure analysis of variance (ANOVA).

Results: Mean values of TST and QST during nesting and also swaddling periods were significantly higher than in the control period in both groups ($P < 0.001$). Mean values of TST and QST in the swaddling period were higher than in the nesting period in both groups, However, these differences were not significant ($P = 0.245$).

Conclusions: Both swaddling and nesting could significantly increase the duration of TST and QST, compared to the control. There were no significant differences between the effects of these interventions on TST and QST. Therefore, using any of these methods is suggested to improve infants' quality of sleep in NICU, with respect to the ward policies.

Key words: Iran, nesting, premature neonate, sleep, swaddling

Introduction

Sleep is essential for the brain development in neonates.[1-7] Adequate sleep is of great importance in neonates as it affects the development of sensory system, the structure of hippocampus, pons, brainstem, middle brain, motor system, limbic, learning, long-term memory, thermoregulation, preservation of the capacity of coping with changes, and appropriate responses to environmental stimulations.[1-3,5] In neonates, the sleep cycle includes three stages of active, quiet, and undetermined sleep.

Active sleep (REM) is characterized by the presence of rapid eye movements, irregular breathing, facial and body movements, and a continuous EEG pattern. Quiet sleep (QS) is marked by the absence of REM and body movements, presence of regular respiration, and a discontinuous EEG pattern.

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Indeterminate sleep (IS) is a state in which the sleep characteristics are not clearly classifiable as QS or active sleep (AS). It is at the beginning of sleep and between QS and AS.[5,8]

During fetal life, with increase in gestational age, and also after birth, with brain development, the duration of active sleep time gradually decreases while that of QS increases.[9] The total time of a complete sleep cycle at 27–30 weeks of gestational age is about 40 min, and at 31–34 weeks, it is 50–70 min.[5] Active sleep is effective on the development of sensory system during both fetal period and neonatal period. QS has an important role in the development of long-term memory and learning ability. The preservation of capacity of adaptation with environmental changes, learning to respond to environmental experiences, and coping with new needs are affected by both stages of sleep.[3] In addition, growth hormone is secreted during quiet sleep time (QST).[10] In neonates, short time sleep deprivation leads to an increase in sympathetic tonicity, higher risk of obstructive apnea, and increase of pain perception. Hospitalization of the neonates in neonatal intensive care unit (NICU) and contact with various environmental stimulations leads to shortening of their sleep time or development of a sleep disorder.[5] In recent years, several studies have been conducted on the factors affecting neonates' sleep improvement. Some studies showed that neonates who are swaddled are less awake and have more sleep time. They also fall asleep more spontaneously and conveniently when they wake up.[11,12] Other studies have indicated the effect of nesting on neonates' sleep improvement. Nesting, as a component of developmental care, improves neonates' sleep quality through preservation of neonates' curved limb position and reduction of sudden movements as well as immobility of the arms and legs.[13,14] Bertelle *et al*. showed that administration of individualized developmental care (reduction of environmental light and noise, usage of head supports, supports for back and legs, swaddling the hands, non-nutritive sucking, grasping, reduction of parents' stressful interventions, and caring the infant through hugging) prolongs the duration of QS and active sleep times in premature infants and shortens the IS period.[15] Although in recent years, administration of individualized developmental care is of great consideration in NICUs worldwide, and is conducted well in some of them, but in Iran, preterm infants do not receive this model of care completely and in an organized manner in NICUs, and just some types of developmental care such as nesting are provided. In addition, swaddling is not routinely administered in the wards presently. With regard to the importance of sleep among infants and the role of developmental care administration for sleep promotion, it seems that application of a part of developmental care program can lead to infants' sleep improvement in the NICUs of Iran in the present conditions. The researcher did not find any study comparing the efficacy of the two care methods of nesting and swaddling. Therefore, the present study aimed to compare the effects of nesting and swaddling on the sleep duration of Iranian premature infants hospitalized in NICUs. The researchers decided to test two hypotheses:

- Usage of nesting or swaddling in neonatal care leads to an increase in duration of sleep time, compared to control period
- The effects of nesting and swaddling on infants' sleep are different.

Materials and Methods

This is a prospective clinical trial conducted in a crossover design to control the confounding factors of infants' sleep. Sampling was conducted from Oct 2013 to June 2014 in NICUs of hospitals affiliated to Isfahan University of Medical Sciences, after obtaining permission from the ethics committee of … University of Medical Sciences. The sample size was estimated as 39 based on sample size formula. Inclusion criteria were: Gestational age between 31 and 34 weeks (based on last menstrual period (LMP) and sonography), postnatal age of at least 2 days, spontaneous breathing with no need of assisting device, having no major congenital defects or abnormal neurologic findings including intraventricular hemorrhage more than grade two, no consumption of illicit narcotics or addictive substances by the mothers during pregnancy, infant not treated by sedatives 24 h prior to intervention, no possibility of administration of kangaroo mother care (KMC) for the infant or its limited usage for the infant due to mother's reluctance or her absenteeism, infant not having diarrhea, re-hospitalization of infant not done, infants' APGAR score over four, infants fed every 2 h, and administration of no phototherapy for the infant. Exclusion criteria were: An immediate need for administration of a specific intervention during the study or parents' decision to stop cooperating with the study. A total of 42 infants entered the study. During the study, three infants were excluded from the study: One due to phototherapy and the other two due to their parents' unwillingness to continue in the study. Sampling was done by random convenient method (drawing of lots) in such a way that every day, a subject was randomly selected (through tossing a coin) from the hospitalized infants meeting the inclusion criteria and evaluated, after obtaining an informed written consent from his/her parents. Infants' demographic information was extracted from their medical files.

As the feeding intervals are routinely every 2 h in the NICU and the sleep cycle of infants of gestational age 31–34 weeks is almost 45 min, in order to evaluate at least two sleep cycles in each period, each infant was firstly in control period for 2 h and then in swaddling or nesting period for 2 h,

based on random allocation. Next, he/she was in wash out period for 2 h, and finally, he/she was in the next intervention period for 2 h (nesting or swaddling). Therefore, the infants were put in two interventions of either swaddling–nesting or nesting–swaddling. Due to the ward being less crowded and fewer interventions being administered between 12 and 20 PM, the infants were evaluated within this time interval. Each period of evaluation started immediately after infants' feeding, and during any period of the study, any unnecessary interventions were avoided. In the period of swaddling, a light-colored, soft, thin cotton cloth was wrapped around the infant so as to cover his/her whole upper trunk and somehow restrict his/her hand movements [Figure 1]. In the nesting period, the infant was laid in a nest made of cotton cloth similar to its foreign equivalents. Its size was adaptable to the infants' body size through a strip of cloth attached to the nest [Figure 2]. Evaluation of the infants was conducted based on Prechtl's scale through observation by an experienced person every 30 s with a chronometer,[6,16] while the infants were in supine position wearing just a diaper.

Based on Prechtl's scale, existence of signs such as closed eyes, absence of rapid eye movements, absence of body movements, a regular pulse and respiration, and few short wakes was considered as QS. Closed eyes with rapid eye movements, existence of body movements, an irregular pulse and respiration, short time wakes, and existence of any movements were considered as active sleep. Heart rate was checked and recorded by pulse oximeter device GMSOT-701 attached to the infants' leg. Respiration regularity was observed visually. Presence of the criteria related to each sleep stage for at least 1 min was considered as the beginning of that stage and their complete stoppage for 1 min as the end of that stage. Whenever the signs were not classifiable as active or QS categories, whether during a stage or during the interval between two separate stages, the signs were considered as a part of the previous stage. However, if the criteria continued to be present for more than 10 min, the sleep time was considered as ended.[16] Finally, total sleep time (TST) and each of its stages was calculated during a 2 h interval. Data were analyzed by SPSS version 14. To compare the mean length of sleep and each stage of that in various periods, repeated measure analysis of variance (ANOVA) was used. To compare the variables of birth weight, gestational age, and birth age, independent *t*-test was adopted. Significance level was considered as $P < 0.05$.

Ethical considerations

All subjects were enrolled in the study after obtaining written Consent from the parents.

Results

Out of 39 infants in the study, 26 were female and 13 were male. They were evaluated in two groups of nesting–swaddling (N–S) and swaddling–nesting (S–N). There were 19 infants with a mean gestational age of 31.9 (0.94) weeks in N–S group and 20 infants with a mean gestational age of 31.6 (0.82) weeks in S–N group. Infants' postnatal age was 2–18 days with a means 8.26 (4.5) and 7.6 (4.8) days in N–S and S–N groups, respectively. Infants' birth weights were 1200–2300 g with means of 1663.2 (279.4) and 1711 (324.3) g in N–S and S–N groups, respectively. Independent *t*-test showed no significant difference in the mean of gestational age and infants' postnatal age, and also in their birth weights between the two groups ($P > 0.05$). Mean of TST is presented in Table 1 and shows that in N–S group, the mean of TST was 76.2 (24.3) min in the control period, 90.2 (18.2) in the nesting period (first intervention), and 96.7 (21.1) min in the swaddling period (second intervention). In the S–N group, the means of TST were 71.5 (32.2) min in the control period, 105.1 (19.9) min in the swaddling period (first intervention), and 100.5 (22.2) min in the nesting period (second intervention). Repeated measure analysis of covariance (ANCOVA) showed no significant

Figure 1: Swaddled infant

Figure 2: Nested infant

difference in the means of TST between swaddling and nesting periods in both groups ($P = 0.245$), but there was a significant difference in the means of TST between both swaddling and nesting periods and the control periods in both groups ($P < 0.001$).

ANCOVA showed that the effect of period was not significant ($P = 0.414$). In other words, the sequence of applied periods of swaddling and nesting was not effective on TST. Independent *t*-test showed that wash out period effect was not significant ($P = 0.133$). In other words, the length of wash out period was adequate for deletion of previous intervention effect.

With regard to quiet sleep time (QST), results showed that in the N–S group, QST was 29.7 (15.6) min in the control period, 39.7 (14.1) min in the nesting period (first intervention), and 53.5 (16.9) min in the swaddling period (second intervention). In the S–N group, the mean length of QST was 21.8 (13.5) min in the control period, 54.7 (19.4) min in the swaddling period (first intervention), and 47.9 (15.4) min in the nesting period (second intervention) [Table 2]. Repeated measure ANCOVA showed no significant difference in QST in periods of swaddling and nesting in the two groups ($P = 0.450$), but QST between both periods of swaddling and nesting and the control period was significantly different ($P < 0.001$). ANCOVA also showed that the effect of period was not significant ($P = 0.693$) and independent *t*-test showed that the effect of wash out period was not significant ($P = 0.312$).

Discussion

The results showed that in both groups of nesting–swaddling and swaddling–nesting, TST and QST in the swaddling period and also in the nesting period were significantly more than in the control period. Bertelle *et al*. evaluated sleep in premature infants by polysomnography and showed that individualized developmental care including reducing the direct light and environmental noise, use of supports for back and head, non-nutritive sucking, and swaddling with restriction of hands increased the length of total sleep and QST.[15] Kihara and Nakamura, in a study on the effect of swaddling and nesting on premature infants' behavioral conditions and sleep, concluded that infants in prone position, either in the nest or swaddled, had more prolong QST in them.[17] Also, Meyer and Erler showed that swaddling significantly increased the percentage of QST.[12] Franco *et al*., in a study on the effect of swaddling children less than 1 year on their sleep and wake periods, obtained results similar to previous studies, and showed that swaddling increased TST and QST.[18] In the present study, we adopted Prechtl's tool and observed the infants for their sleep evaluation and obtained results consistent with the four above-mentioned studies. Westrup *et al*. showed that administration of individualized developmental care had no effect on QST,[19] which is not in line with the present study. As the neonates' length of sleep cycle is affected by their gestational age, and in the present study, subjects with gestational age 31–34 weeks were selected, this could be the reason for the different results obtained by us. In addition, higher number of subjects in our study can be another probable reason. Berttele, *et al.* according to study of Backer et al say that administration of individualized developmental care had no effect on neonates' sleep.[15] The reason for the difference between their results and ours can be the duration of sleep evaluation, as we evaluated the infants in 2 h periods but they evaluated infants' sleep for duration of 18 min.

Results showed that the mean values of TST and QST were more when infants were swaddled than in the periods when were nested, although the difference was not significant. If

Table 1: Comparison of the mean total sleep time in each of the study periods in two groups (nest-swaddle and swaddle-nest)

Variable (statistical indexes) Group	TST_1 (min) (control)				TST_2 (min) (the first intervention)				Wash out time (120 min)	TST_3 (min) (the second intervention)			
	Max.	Min.	Mean	SD	Max.	Min.	Mean	SD		Max.	Min.	Mean	SD
Nest-swaddle	120	37	76.2	24.3	120	41	90.2	18.2		120	53.5	96.7	21.1
Swaddle-nest	120	31.5	71.5	32.2	120	65.5	105.1	19.9		120	67	100.5	22.2

Max.: Maximum, Min.: Minimum, SD: Standard deviation, TST: Total sleep time, N-S: Nest-swaddle, S-N: Swaddle-nest

Table 2: Comparison of the mean quiet sleep time in each of the study periods in the two groups (nest-swaddle and swaddle-nest)

Variable (statistical indexes) Group	QST_1 (min) (control)				QST_2 (min) (the first intervention)				Wash out time (120 min)	QST_3 (min) (the second intervention)			
	Max.	Min.	Mean	SD	Max.	Min.	Mean	SD		Max.	Min.	Mean	SD
Nest-swaddle	53.5	10	29.7	15.6	70	23.5	39.7	14.1		74.5	22	53.5	16.9
Swaddle-nest	52	4.5	21.8	13.5	86	23	54.7	19.4		75.5	22	47.9	15.4

Max.: Maximum, Min.: Minimum, SD: Standard deviation, QST: Quiet sleep time, N-S: Nest-swaddle, S-N: Swaddle-nest

the study had been conducted in more number of subjects, the difference could probably have been significant.

Literature review of the available studies showed that there are a limited number of studies on neonates' sleep, possibly due to difficulty in sleep investigation in neonates. In addition, we also found no study that compared the effects of two different care methods on neonates' sleep; therefore, the results of this study could not be compared with other studies. So, further studies are needed in this field.

Conclusion

Results showed that both swaddling and nesting care methods significantly increased the length of TST and QST in preterm infants. In addition, swaddling increased TST and QST more than nesting, although the increase was not significant. Therefore, considering the existing facilities and equipments in the ward and the economic conditions and policies of hospitals as well as neonates' condition, either nesting or swaddling method of care is used to improve neonates' sleep.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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