Effects of Covering Newborn's Head after Bath on Body Temperature, Heart Rate and Arterial Oxygen Saturation

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Purpose: In this study changes were observed in body temperature, heart rate and arterial oxygen saturation (SaO2) of newborns after bathing and to determine the effects of covering their heads with cotton hats after bathing. **Methods:** Participants were 58 newborn infants, 31 in the experimental group had their heads covered with cotton hats after their bath while 27 in the control group did not. Body temperature, arterial oxygen saturation and heart rate were measured at 8 consecutive times after bathing. Data were analyzed using t-test and repeated measures ANOVA. **Results:** Body temperature declined shortly after bathing. The experimental group showed faster recovery ($p<.001$). Heart rate increased after bathing in both groups. Heart rate in the experimental group decreased for 120 minutes and gradually increased to baseline ($p<.001$). In the control group, heart rate decreased for 180 minutes and then increased but did not reach the baseline ($p<.001$). Arterial oxygen saturation decreased shortly after bathing and recovery to the baseline was more rapid in the experimental group (30 minutes vs. 60 minutes) ($p<.001$). **Conclusion:** With significant changes observed in newborns' body temperature, arterial oxygen saturation and heart rate, covering the head right after bathing is effective in stabilizing infants' physiological system.

Key words: Newborn, Body temperature, Heart rate, Oxygen, Baths

INTRODUCTION

Infants lose their body temperature easily due to large surface area and a thin layer of subcutaneous fat in relation to body weight. Heat loss in infants proceeds through various mechanisms such as convection, conduction, radiation and evaporation (Knobel & Holditch-Davis, 2007). The loss caused by evaporation usually happens due to wet amniotic fluid on the skin surface immediately after birth (Hammarlund, Nilsson, öBerg, & Sedin, 1980) and, similarly, evaporation could also occur after taking a bath. To compensate, infants increase their basal metabolism, secrete norepinephrine leading to vasoconstriction, and produce heat by making brown adipose tissues via dividing triglyceride into fatty acids (Davis, 1980) while consuming more oxygen to accommodate to the heat loss (Gomella, Cunningham, & Eyal, 2009).

Maintaining appropriate body temperature is one of the key practices to prevent neonatal death (Darmstadt et al., 2005). Major interventions to maintain the newborn's body temperature through preventing heat loss include: using an incubator, minimizing ventilation around a warming instrument, using a heat cover and wearing a hat or socks (Gomella et al., 2009). Among the various prevention methods, covering the head could be considered effective and simple because an infant's head size is relatively large, one fourth of their length, larger than chest circumference and occupying around 40% of their total volume (Oski, 1994). Concurrently, maintaining appropriate surrounding temperature and humidity, and evaluating the heart rate, respiratory rate, oxygen consumption and glucose level of an infant are also considered essential ways to assess their body temperature (Oski, 1994).

Regardless, hypothermia is critical in newborn infants and they

주요어: 신생아, 체온, 심박동수, 산소, 목욕

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are often exposed to risky environments which cause evaporation from their wet skin and lead to decreased body temperature. There have been only few studies on influence of bath on body temperature and their physiological system.

Thus, the purpose of this study was to observe the changes of body temperature, heart rate and arterial oxygen saturation of full term newborn infants in regular interval after bathing, and to determine whether covering the head with a cotton hat shortly after bathing could exert positive effects on these changes. This study provides evidence for covering head for infants as an effective nursing intervention for infants, at risk for hypothermia.

METHODS

Participants

Fifty eight full-term infants born in a University-affiliated hospital were recruited between October 2006 and March 2007. The subjects were divided into an experimental group (31 infants) and a control group (27 infants) with a randomized method using a coin. Sample size was estimated using a power analysis. It showed that 21 babies in each group were sufficient for repeated measures ANOVA, at a significance level of .05, effect size of .15, and power of 80%. We recruited 58 to accommodate possible mortality. Infants in the experimental group wore hats while infants in the control group did not. Their gestational period was greater than 37 weeks and their birth weight was between 3.0 and 4.0 kg (6.6-8.8 pounds). The subjects were full-term infants whose mothers and health care providers understood the purpose of this study and mothers provided written consent for their infants to participate in the study.

There were no significant differences in gender, birth delivery type and birth weight between experimental and control groups (Table 1). Infants' body temperature, arterial oxygen saturation and heart rate showed no difference and they were in the normal range before the intervention (Table 2).

Table 1. General Characteristics of the Experiment and Control Groups

Variables		Exp. (n=31)	Cont. (n=27)	*p*
		Mean ± SD	Mean ± SD	
Gender				.266*
	Male	15 (48.39)	17 (62.96)	
	Female	16 (51.61)	10 (37.04)	
Delivery type				.940†
	NSD	24 (77.42)	20 (76.08)	
	C/S	7 (22.58)	7 (23.92)	
Weight (gram)		3,380 ± 270	3,470 ± 240	.205‡

*Chi-Square test; †Fisher's Exact test; ‡t-tests.
Exp. = experiment group; Cont. = control group; NSD = normal spontaneous delivery; C/S = caesarean section.

Measures

An infra-red TM thermometer (IRT-4520, Braun GmbH, Frankfurter, Germany) was used to measure the body temperature and its measurement error range was ± 0.1℃ (34-42.2℃). Its accuracy was examined by the department of biomedical engineering. A monitoring instrument (N1205A, Boeblingen GmbH, Boeblingen, Germany) was used to evaluate the heart rate. Its error range was ± 1 bpm. Lastly, arterial oxygen saturation was measured with a pulse oximeter (N-560, Nellcor Puritan Bennett Inc., Seoul, Korea), a non-invasive instrument that could measure oxygen saturation safely and easily from the skin by attaching a sensor on the side of a sole. Its error range was ± 1% (35-100%).

Interventions

Infants in the experimental group wore hats which were made with pure cotton, smooth, and elastic with 30-35 cm in diameter. Its size was determined to fit infants who weigh between 2.5 kg and 4 kg. Infants were covered with hats above the eyebrows and ears for 4 hours shortly after bathing.

Room temperature was measured before bathing and maintained at 24℃, and water temperature for the bath was set at 40℃ before bathing. Bath time was pre-determined as 3 minutes and was consistently maintained for all infants. Bath duration was determined by observing the daily bath schedule in the nursery. Baths were given by nurses in the nursery with over 3 years of clinical experience.

Procedures for collecting data

This study was approved by the pertinent Institutional Review Board (SCUMC01OT089). Each infant was laid supine and temperature from an eardrum was measured. After undressing an infant, a pulse oximeter was attached and heart rate and arterial ox-

Table 2. The Body Temperature, Heart Rate and Oxygen Saturation at Baseline

Variable	Exp. (n=31)	Cont. (n=27)	t	*p*
	Mean ± SD	Mean ± SD		
Body temperature (℃)	36.75 ± 0.18	36.72 ± 0.17	0.21	.844
Heart rate (beat/minute)	132.32 ± 13.52	129.07 ± 13.65	0.29	.784
Oxygen saturation (%)	98.19 ± 1.80	98.19 ± 1.60	0.10	.926

Exp. = experiment group; Cont. = control group.

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ygen saturation were measured. We bathed infants with warm water of 40℃ for 3 minutes. For the experimental group, infants wore hats covering above the eyebrows and ears after bathing. Then, temperature, heart rate and arterial oxygen saturation were measured again immediately after bathing, and at 30, 60, 90, 120, 180, and 240 minutes afterward. For the control group, the same procedure was used but without hats after bathing. Temperature, heart rate and arterial oxygen saturation were measured following the same protocol with the experimental group.

Statistical analysis

General characteristics, body temperature, arterial oxygen saturation and heart rate of the two groups were analyzed with descriptive statistics, χ^2-test and t-test and the serial changes of temperature, heart rate and arterial oxygen saturation were analyzed with repeated measures ANOVA.

RESULTS

Temperature

The mean body temperature of the experimental group was 36.75 ± 0.18℃ before bathing (baseline) and decreased to 36.20 ± 0.19℃ shortly after bathing. It was restored to 36.81 ± 0.20℃ at 90 minutes after bathing. In the control group, the baseline body temperature was 36.72 ± 0.17℃ and it went down to 36.07 ± 0.20℃ after bathing. However, their body temperature did not return to baseline until 180 minutes after bathing (36.73 ± 0.19℃) (Table 3).

The pattern of body temperature changes was similar in both groups, showing sharp decreases shortly after bathing and then a gradual recovery. However, the body temperature of the experimental group was significantly higher than the control group. The temperature recovery to the baseline level was more rapid in the experimental group. The temperature and temperature by time between groups showed a significant difference (t = 42.80, $p < .001$, F = 175.12, $p < .001$ respectively) and the interaction between group and measuring time was also significant (F = 5.41, $p < .001$).

Heart rate

Heart rate increased after bathing, 146 ± 14.34 for the experimental group and 138.78 ± 12.97 for the control group, and then decreased to baseline 30 minutes after bathing in the experimental group (132.52 ± 10.76). However, it continually decreased until 180 minutes after bathing in the control group. The control groups showed decreased heart rate at 30 minutes after bathing (124.26 ± 12.34) and subsequently (Table 4). They displayed decreased heart rate throughout the observation and only the experimental

Table 3. Comparison of Body Temperature between Experiment and Control Groups

	T1	T2	T3	T4	T5	T6	T7	T8
	Mean ± SD							
Exp. (n = 31)	36.75 ± 0.18	36.20 ± 0.19	36.47 ± 0.25	36.65 ± 0.18	36.81 ± 0.20	36.89 ± 0.20	37.00 ± 0.14	37.06 ± 0.14
Cont. (n = 27)	36.72 ± 0.17	36.07 ± 0.20	36.14 ± 0.32	36.39 ± 0.19	36.54 ± 0.27	36.65 ± 0.15	36.73 ± 0.19	36.79 ± 0.15
	Group				Time		Group*Time	
	F		42.80		175.12		5.41	
	p		< .001		< .001		< .001	

T1: base line, T2: shortly after bath, T3: 30 minutes after bath, T4: 60 minutes after bath. T5: 90 minutes. after bath, T6: 120 minutes after bath, T7: 180 minutes after bath, T8: 240 minutes after bath.
Exp. = experiment group; Cont. = control group.

Table 4. Comparison of Heart Rate between Experiment and Control Groups

	T1	T2	T3	T4	T5	T6	T7	T8
	Mean ± SD							
Exp. (n = 31)	132.32 ± 13.52	146.90 ± 14.34	132.52 ± 10.76	131.94 ± 11.27	130.19 ± 9.94	129.48 ± 11.72	129.55 ± 12.85	132.94 ± 11.63
Cont. (n = 27)	129.07 ± 13.65	138.78 ± 12.97	124.26 ± 12.34	125.04 ± 10.80	122.37 ± 15.78	122.15 ± 11.62	120.63 ± 8.14	123.26 ± 12.07
	Group				Time		Group*Time	
	F		18.98		16.28		0.47	
	p		< .001		< .001		.855	

T1: base line, T2: shortly after bath, T3: 30 minutes after bath, T4: 60 minutes after bath. T5: 90 minutes after bath, T6: 120 minutes after bath, T7: 180 minutes after bath, T8: 240 minutes after bath.
Exp. = experiment group; Cont. = control group.

Table 5. Comparison of SaO_2 between Experiment and Control Groups

	T1	T2	T3	T4	T5	T6	T7	T8
	Mean ± SD							
Exp. (n=31)	98.19 ± 1.80	95.29 ± 2.58	98.23 ± 1.52	98.58 ± 1.29	98.77 ± 1.31	98.77 ± 1.31	98.55 ± 1.46	99.03 ± 1.08
Cont. (n=27)	95.29 ± 2.58	96.96 ± 1.43	97.78 ± 1.63	98.30 ± 1.81	98.48 ± 1.60	98.67 ± 2.00	98.56 ± 1.55	98.56 ± 1.40
	Group				Time		Group*Time	
F	0.00				21.31		3.41	
p	.97				<.001		.001	

T1: base line, T2: shortly after bath, T3: 30 minutes after bath, T4: 60 minutes after bath. T5: 90 minutes after bath, T6: 120 minutes after bath, T7: 180 minutes after bath, T8: 240 minutes. after bath.
Exp. = experiment group; Cont. = control group.

group recovered to the baseline heart rate in 240 minutes, whereas the control group did not. There was a significant difference in heart rates between the groups (t = 18.98, $p < .001$) and by time (F = 16.28, $p < .001$). However, the interaction between groups and the measuring time was not significant (F = 0.47, $p = .855$).

Arterial oxygen saturation

Arterial oxygen saturation of the two groups was not significantly different (t = 0.00, $p = .975$). Both groups showed a significant difference in arterial oxygen saturation by time (F = 21.31, $p < .001$) and there was significant interaction between the group and the measuring time (F = 3.41, $p = .001$). The saturation decreased significantly after bathing and it returned to the level of baseline at 30 minutes after bathing in the experimental group (98.23 ± 1.52) and at 60 minutes in the control group (98.30 ± 1.81) (Table 5).

DISCUSSION

Newborn infants go through diverse environmental changes. While they are trying to adapt to an extrauterine environment, they are likely to experience mild or severe metabolic acidosis due to imbalance between oxygen consumption and supply, which could lead to hypothermia. Moreover, relatively low temperature of the delivery room aggravates cold stress for newborn infants. Hypothermia is a critical issue, especially in infants and it can result hypoglycemia, respiratory crisis, bradycardia and metabolic acidosis (Green & Wilkinson, 2004; Oski, 1994). However, the risk of hypothermia is not only present at birth; infants are exposed to a similar situation when they are taking a bath. Thus, this study, which investigated the influence of bathing on infants' temperature and related physiological symptoms, would add knowledge to the current status of science.

While bathing has positive effects such as keeping their body clean, providing developmentally appropriate stimuli and enabling observation of any congenital malformations (Sarkar, Basu, Agrawal, & Gupta, 2010), it could lead to heat loss. In particular, many studies suggested that bathing could destabilize their physiological system (Albers, Riksen-Walraven, Sweep, & de Weerth, 2008; Behring, Vezeau, & Fink, 2003; Liaw, Yang, Yuh, & Yin, 2006; Medves & O'Brien, 2004). It is critical to prevent hypothermia in infants (Osborn, 2005) because the compensation mechanism for the infants has not been fully developed when they are exposed to a cold environment (Oski, 1994).

In the current study, infants showed decreased body temperature right after the bath and it took an average of 90 minutes to return to original body temperature for the experimental group and 180 minutes for the control group. Infants' initial body temperatures were lower than the previous study but showed similar results of decrease by 0.5-0.7℃ after bathing and a similar recovery trajectory (Medves & O'Brien, 2004). Saturated oxygen level of infants dropped after bathing as well, and recovered within 30 minutes after bathing for both groups. Heart rate increased immediately after bathing in both groups and it took an average of 30 minutes to restore for the experimental group. It was a contradictory result considering the fact that hypothermia leads to bradycardia (Davies & Maconochie, 2009; Green & Wilkinson, 2004; Knobel & Holditch-Davis, 2007). Inevitably, they started to show decreased heart rates 30 minutes after taking a bath and it took almost 240 minutes to recover for the experimental group, whereas the control did not recover even after 240 minutes. It is possible that the initial elevation in heart rate might have been caused by infants' response to sudden stimuli with bathing. Then, their cold stress eventually influenced their physiological system, and produced symptoms such as decreasing heart rate.

As bathing could easily induce heat loss caused by evaporation, hypothermia and subsequent physiological burdens on infants should be cautiously assessed. In this study, the intervention to re-

duce heat loss of infants was performed by blocking the process of evaporation and immediately covering the head of infants. To prevent heat loss by evaporation, interventions including drying immediately after taking a bath and minimizing exposure of the body during bathing were used and a cotton hat was used to keep them warm. In this study, infants' body temperature after bathing returned to the baseline after 90 minutes in the experimental group. The recovery was faster compared to that of the control group whose temperature came back to the baseline at 180 minutes after bathing. Therefore, it could be considered that keeping infants' heads warm was helpful to maintain their body temperature. This result was consistent with the previous study reporting that stockinet cap helped body temperature of infants to improve (Roberts, 1981).

Arterial oxygen saturation was not significantly different between the groups but it showed a significant difference by time after bath and interaction between the group and measuring time was also found to be significant. It decreased significantly after bathing in both groups and recovered to the baseline at 30 minutes after bathing in the experiment group and at 60 minutes in the control group. This result suggested that keeping infants' heads warm helped oxygen saturation stabilize more rapidly. As the decrease of oxygen saturation indicates diminished oxygen supply to the tissues in major organs such as the brain, heart and lung in infants, prompt recovery of oxygen saturation is essential. Although arterial oxygen saturation by time was in normal range, the result supported significance of keeping the head warm.

Heart rate showed a significant difference between the two groups and by time in this study. It increased immediately after bathing, followed by a decrease, and recovered to baseline at 240 minutes after bathing in the experimental group. Due to the lack of previous studies, this result was not feasible for comparison. However, heart rate escalation shortly after the bath and initial recovery to the baseline should be carefully evaluated because it continuously decreased even after the heart rate reached the baseline. This result suggests comprehensive and unremitting attention to the infants when any physiological changes are present.

Although this study showed a significant influence of bathing to infants' body temperature and physiological system and an effect of keeping infants' heads warm using a cotton hat, there are some limitations. Since this study was conducted with only full-term infants and with a limited sample size, further investigation should be taken into consideration when applying this result to pre-term infants.

CONCLUSION

While bathing has been considered as routine care for newborn infants and has shown advantages, there are several things which need to be considered especially for newborn infants. In this study, it was found that bathing affected the infants' body temperature, arterial oxygen saturation and heart rate. Bathing lowered the body temperature, decreased arterial oxygen saturation and initially increased and then decreased heart rate. Their recovery was more rapid in the group with a cotton hat on. Thus, it is concluded that wearing hats for infants was an effective and simple method to keep their body temperature, oxygen saturation and heart rate stable as it prevented heat loss. It is strongly recommended that there should be comprehensive observation for infants with any physiological changes for an extended time. Some hospital does not even covering head after bath on the newborn yet. Hope through this study is that they will be changed.

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