Skin to skin care:heat balance

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Abstract

Skin to skin care has been practised in primitive and high technology cultures for body temperature preservation in neonates. Regional skin temperature and heat flow was measured in moderately hypothermic term neonates to quantitate the heat transfer occurring during one hour of skin to skin care.

Nine healthy newborns with a mean rectal temperature of 36.3°C were placed skin to skin on their mothers' chests. The mean (SD) rectal temperature increased by 0.7 (0.4)°C to 37.0°C. The heat loss was high (70 Wm⁻²) from the unprotected skin of the head to the surrounding air. Minute heat losses occurred from covered areas; and heat was initially gained from areas in contact with the mother's skin. The total dry heat loss during skin to skin care corresponded to heat loss during incubator care at 32-32.5°C.

The reduced heat loss, and to a minor extent, the initial heat flux from the mothers allowed heat to be conserved, leading to rewarming.

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Rewarming of moderately hypothermic neonates can be achieved by incubator care or with a heated mattress¹ in combination with increased insulation to the surrounding air. The "kangaroo care" or skin to skin care method was evaluated for low birthweight babies born into primitive conditions.² The model permits maintenance of body temperature both in term and preterm neonates.³⁻⁵

Rewarming during skin to skin care has not been quantitatively evaluated, as far as we are aware. Clinical experience both under primitive and "high tech" conditions indicate that temperature maintenance can be achieved by placing newborn babies on their mothers' chests with additional covering fabrics. From a theoretical point of view, skin to skin care represents a complex thermal situation. The newborn baby is in a non-steady state thermal situation and is exposed to a constantly changing environment.

Regional skin temperature and dry heat flow measurements permit evaluation of heat fluxes for regions exposed to different microclimates and also estimation of total heat loss.⁶⁻⁸

We used regional temperature and heat flow measurements to achieve quantitative data on the regional and total heat transfer between the mother and the neonate, and the effect on rec-

Table 1 Demographic data as mean (SD)

Birthweight (kg)	3.1 (0.7)
Gestational age (weeks)	39 (2)
Age (days)	1.1 (0.8)

tal temperature of one hour of skin to skin care in term neonates.

Methods

Dry heat loss (convective, radiative, and conductive heat loss), skin temperature, rectal temperature, and activity were studied in nine healthy term neonates (two neonates were small for gestational age) with a mean (SD) rectal temperature of 36.3 (0.3)°C (table 1).

The mothers were lying supine on an ordinary hospital bed, but able to adjust the head-end level to a comfortable position. All neonates were naked except for a disposable nappy with an insulation value of 0.44 m²°C W⁻¹. They were placed skin to skin on their mothers' chests. The mothers covered the back and sides of their babies' trunks with their hands and wrists. The trunk and extremities of the baby, and the chest and arms of the mother, were covered with a double layer of terry cloth towelling with an insulation value of 0.037 m²°C W⁻¹ for a single layer.

After about 10 minutes a first set of recordings from the neonate was made, without removing the terry cloth towel covering the baby. Rectal temperature, regional skin temperature, and heat flow was measured at 10 sites. The mothers' skin temperatures at the right subclavicular region were measured as well as the environmental operative temperature and the humidity under the terry cloth towel. Measurements were repeated after one hour.

ENVIRONMENTAL CONDITIONS

The study was undertaken in an air-conditioned room. The operative temperature of the room (T_{op}) was measured with a 3 cm black globe thermometer.^{9 10} The black globe thermometer was placed at the head-end of the bed less than one metre from the baby. To reduce differences in radiative heat losses, the single window of the examining room was covered by a curtain.

Air flow velocity close to the head of the neonate was measured by a hot wire thermoanemometer (ATD 81 SWEMA, Danderyd, Sweden) with an accuracy of 0.005 m/s.

The relative humidity between the neonate and the covering terry cloth towel was measured with a hair hygrometer (Fischer, Germany) regularly calibrated against 100% humidity.⁶

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Table 2 Environmental conditions at 10 and 70 minutes as mean (SD)

	10 minutes	70 minutes
T _{op} room °C	23.6 (1.3)	23.8 (1.5)
T _{skin} mother °C	34.5 (0.6)	34.5 (0.6)
Relative humidity %	46 (11)	47 (10)

REGIONAL HEAT FLOW MEASUREMENTS

Regional dry heat flow was recorded using a commercial heat flow sensor (WS 22 HT Technisch Fysische Dienst TNO-Th, Delfts, The Netherlands). The heat flow sensor had a diameter of 23 mm and a thickness of 2 mm with an approximately 0.5 mm thick silicone coat. The emission of the sensor was 0.95 and the thermal resistance $0.013 \text{ m}^2\text{°C W}^{-1}$.

The added thermal insulation to air due to the thermal resistance of the sensor will change the total insulation by about 7%.^{11 12} This was compensated for by increasing the measured skin to air dry heat losses by 7%.

For measurements from skin contact areas, the heat flow sensor was placed between the mothers' and the infants' skins; for measurements from skin in contact with air, the sensor was gently placed on the skin.

SKIN AND RECTAL TEMPERATURE MEASUREMENTS

Skin temperatures were measured using modified Craft temperature sensors (Astra Tech, Mölndal, Sweden), as described before.⁶ The sensors have a small thermal mass and short response time and an absolute temperature accuracy of $\pm 0.1^\circ\text{C}$.¹³ Ten skin temperature thermistors were attached to the skin (number of measuring spots for each location in parentheses): head (n=2), trunk (n=3), arm (n=2), leg (n=2), foot (n=1).

Rectal temperature was measured using an Exacon MC8700, probe RR-2, with an accuracy of $\pm 0.1^\circ\text{C}$ (Exacon Scientific Instrument, Taastrup, Denmark). The probe was inserted to a depth of at least 5 cm from the anus.

CALCULATION OF TOTAL HEAT LOSS AND MEAN SKIN TEMPERATURE

Total dry heat loss was estimated by weighting together the regional dry heat losses and the relative size of the corresponding body regions. The relative size of body regions according to Klein and Scammon¹⁴ were used (head 21%, trunk 32%, arms 17%, legs 26% and feet 4%). About 10% of the area of the head was in contact with the skin of the mother (estimated by placing neonates on a transparent board and measuring the area in contact with the board).

The neonates were continuously observed during the measuring period. The activity was assessed when starting each measuring period and was divided into three categories: sleeping, awake but calm, and active with vigorous movements.

All results are given as mean (SD). Statistical evaluation of differences between the results obtained at the start and end of the skin to skin care period were made using Student's *t* test, paired samples. A *P* value of < 0.05 was considered significant.

This study was approved by the Ethics Committee of the Medical Faculty and informed consent was obtained from the parents of the babies.

Results

The environmental conditions for the neonates were stable during the study period with no significant changes in operative temperature (T_{op} 23.6–23.8°C). An air velocity of 0.15–0.20 m/s and a relative humidity of 46–47% was measured throughout the study period. The subclavicular skin temperature of the mother was also constant at 34.5°C (table 2).

Regional dry heat flow from the different body regions are shown in fig 1. The heat loss from the head to the surrounding air (head_{skin-air}) was very high. At the first measuring period after 10 minutes the dry heat loss from this region was 70 Wm^{-2} , compared with the result from the skin area of the head in contact with the mother (head_{skin-skin}) where a heat gain of 5 Wm^{-2} to the baby was measured. For other regions heat loss from the arm only was shown. The largest transfer of heat per unit area from the mother to the neonate (25 Wm^{-2}) was recorded for the foot.

At 70 minutes the large dry heat loss from the head to the surrounding air (head_{skin-air}) had not changed from the first recording at 10 minutes. A mean heat gain of 2 Wm^{-2} from the mother's chest to the neonate's trunk at 10 minutes changed to a heat loss of 6 Wm^{-2} at 70 minutes, a mean (SD) increase in dry heat loss of $8 (4) \text{ Wm}^{-2}$ ($P < 0.001$). Heat flow changes for other regions were insignificant.

The total net dry heat loss from the neonates increased by $6 (6) \text{ Wm}^{-2}$ ($P < 0.05$), from 11 Wm^{-2} at 10 minutes, to 17 Wm^{-2} at 70 minutes.

During the study period an increase in skin temperature was recorded for all body regions, the calculated mean (SD) skin temperature increasing by $0.6 (0.3)^\circ\text{C}$ ($P < 0.01$) from 34.1°C at 10 minutes to 34.7°C at 70 minutes. The rectal temperature also increased in all neonates. The mean (SD) rectal temperature increase was $0.7 (0.4)^\circ\text{C}$ ($P < 0.001$) from 36.3°C to 37.0°C (table 3).

The two neonates who were small for gestational age did not differ from the other neonates with respect to skin temperature, rectal temperature, or dry heat loss. All neonates were asleep at 10 minutes and remained asleep throughout the study period.

Figure 1 Regional dry heat loss for different regions at the start and end of the skin to skin care period. *** $P < 0.001$ compared with measurement at 10 minutes.

Table 3 Mean (SD) rectal temperature, skin temperature and dry heat loss at the start and finish of the skin to skin contact

	10 minutes	70 minutes	$\Delta(^{\circ}\text{C})/(\text{Wm}^{-2})$
$T_{\text{rectal}}^{\circ}\text{C}$	36.3 (0.3)	37.0 (0.2)	0.7 (0.4)***
Mean $T_{\text{skin}}^{\circ}\text{C}$	34.1 (0.4)	34.7 (0.4)	0.6 (0.3)**
$T_{\text{head skin-air}}^{\circ}\text{C}$	32.9 (1.0)	33.7 (1.0)	0.8 (0.7)*
Mean $T_{\text{skin other areas}}^{\circ}\text{C}$	34.9 (0.4)	35.4 (0.5)	0.5 (0.3)**
Total dry heat loss Wm^{-2}	11 (5)	17 (4)	6 (6)*
Head _{skin-air} dry heat loss Wm^{-2}	70 (13)	70 (10)	1 (11)
Mean heat loss other areas Wm^{-2}	-2 (5)	4 (4)	6 (5)*

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

Discussion

Skin to skin care during one hour resulted in a significant increase in rectal temperature in term neonates studied after the immediate postnatal period. As practised in this study, skin to skin care resulted in a net heat loss of 11-17 Wm^{-2} , comparable with an external temperature gradient of about 2°C .⁷ Heat flow from mothers to their neonates could initially be measured over skin to skin contact areas. Although this warming was large per unit area for the foot, its net contribution to the heat balance was minute.

Neutral environmental temperature for a term neonate after the immediate postnatal period represents a dry heat loss of about 25 Wm^{-2} .^{7, 15} The mean heat loss during skin to skin care would permit heat conservation even at minimal metabolic rate. As oxygen consumption was not measured, the possibility of an increase in metabolism caused by partial cold exposure to the face and airways cannot be ruled out.¹⁶

Regional dry heat loss from the skin area of the head exposed to room air was 70 Wm^{-2} which indicates an external temperature gradient of $9.5\text{--}10^{\circ}\text{C}$. These losses from the uncovered area of the head represented 94% and 74% of all heat losses at 10 and 70 minutes, respectively.

The study only included measurement of dry heat losses, which, for term neonates after the immediate postnatal period, represents virtually all the heat loss. For the defined environmental conditions, an evaporative heat loss of around 3 Wm^{-2} can be assumed.¹⁷

No signs of apnoea or any other negative event were noticed during the study period. All neonates fell asleep and stayed asleep. A tendency towards more sleeping and less crying if cared for, skin to skin, has been observed by others.^{5, 18}

In conclusion, the regional heat flow measurements allowed the mechanism behind the increase in rectal temperature to be measured during skin to skin care. Reduction of heat loss from areas in contact with the mother's skin or those covered by an insulating towel was the main cause for heat conservation. Actual heat transfer from the mother to the neonate was a minor contribution to the net heat balance. The heat loss from the area left exposed to room air was considerable.

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