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The thermal environment in which 3–4 month old infants sleep at home

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SUMMARY The thermal insulation of clothing and wrapping (tog value), room temperature, and body temperature was measured for 3–4 month old infants sleeping in their home cots under conditions chosen freely by parents during a cold winter. We found that ambient temperature averaged 18·4°C when infants were put down, but fell by an average of 4·4°C during the night. Minimum room temperature correlated with outside temperature, but most rooms were heated to some degree; smaller babies were kept in warmer rooms. The tog value of clothing before putting the baby down averaged 5·1, supplemented by 9·6 tog units of wrapping in the cot—a 188% increase for a 4·4°C drop in temperature.

Total tog of clothing and wrapping correlated negatively with minimum room temperature; smaller born babies tended to be more heavily wrapped. Despite the large increase in insulation in the cot, most babies maintained normal body temperatures.

Over the last couple of decades there has been a substantial increase in the variety of items for clothing and wrapping of babies, and a rise in the number of homes with central heating. There are few reports, however, of the thermal consequences of the way in which parents now clothe and wrap their babies.[1]

Recent reports of raised core temperature in some sudden infant deaths,[2] and subsequent retrospective analysis of clothing and wrapping,[3] have suggested that 'over wrapping' may be a contributory factor, but is not clear how 'over wrapping' can be defined as we have no precise information about either the range of normal parental behaviour or how it affects infant thermoregulation.

In this study we report data on the room temperatures to which normal 4 month old infants were exposed at home during the night, the extent to which they were clothed and wrapped, and the factors that parents took into account in deciding the appropriate combination of room heating and coverings for sleeping babies during a cold British winter.

Subjects and methods

Information on a random sample of normal, full term, singleton babies was collected at birth, and permission obtained from parents for the body temperature to be monitored for one night during sleep between the ages of 3–4 months. At this time each child was visited at home, weighed, skin fold thickness measured, and information obtained on feeding pattern and the recent health of the baby. Three thermistor probes were securely attached to the baby: (a) at the centre of the forehead; (b) on the abdomen 3 cm to the left of the umbilicus; and (c) into the rectum 5 cm from the anal margin. A fourth probe was fixed at the cot side to measure room temperature. All probes were connected to a Grant Squirrel Data Logger that was set to make recordings at one minute intervals throughout the night from 2200 to 0700.

Parents were advised not to alter clothing, wrapping, and room heating practice, so that recording of normal conditions could be obtained.

The researchers noted the number and quality of each item of clothing and wrapping, and the thermal conductivity (tog value) calculated using the standard set at the Shirley Institute, Manchester[4] and from data provided by Clulow (E Clulow, personal communication) (table). For each baby a total tog value for clothing and wrapping was obtained, which could be related to the changes in body temperature. If wrappings were folded, allowance was made in the calculations. One tog unit is the thermal resistance of a fabric when the temperature difference between its faces is 0·1°C for a flow of heat equivalent to one watt per square metre.

Table *Standard tog values used to quantify the insulation on sleeping babies. Data supplied by the Shirley Institute, Manchester (E Clulow, personal communication)*

Garment or wrapping	*Tog value*
Vest	0·2
Babygro	1
Winter dress or pyjamas	2
Jumper, trousers	2
Cardigan	2
Nappy (disposable)	2 (less when very wet)
Sleeping suit	4
Baby Nest	4
Sheet	0·2
Old blanket	1·5
New blanket	2·0
Quilts	Manufacturers' figures: typically 9

A diary of the night's events was kept by the parents and recorded the time the baby was put to bed and any episodes of waking, crying, etc; the recordings commenced at bedtime. In all cases infants remained in the same clothing and wrapping throughout the recording period, with the occasional exception of a nappy change. All measurements were taken during December–March so that the widest variations in environmental and room temperatures would be obtained.

After monitoring, the computerised data on each baby was extracted to show a minute by minute record of all temperatures simultaneously, and scrutinised for inaccuracies or artefacts. Only unblemished recordings were analysed.

SUBJECTS

A total of 98 subjects were recruited to the study, but full recordings were made on only 74, as some infants were ill or unavailable at the proposed time of recording.

The subjects ranged in age from 9·5 to 19·5 weeks (standardised to a 40 week gestation) at the time of recording with a mean (SEM) of 14·81 (0·25) weeks. Only seven infants were outside the range of 12 to 18 weeks. The mean (SEM) body weight at monitoring was 6265 (80)g (range 4520–8100 g) and the birth weight 3257 (50)g (range 2360–4340 g). Mean (SEM) skin fold thickness at the time of recording was 10·58 (0·29) mm. Some infants suffered mild infections during the week before recording, but none were ill on the day, or became so within two days.

Results

ROOM TEMPERATURES

Of the 74 homes studied, 41 (55%) had central heating, 26 (35%) local heating in the bedroom, and seven (10%) no heating in the bedroom. A total of 19 (26%) kept the heating on all night and 45 (61%) part of the night, usually the late evening and early morning; the remainder provided no heat to the bedroom during the time of recording.

When the babies were put down, the mean (SEM) ambient temperature was 18·43 (0·42)°C. Fig 1 shows the changes over the following eight hours. Data were normalised to the time of putting down in order to maintain compatibility with measurements of rectal and skin temperature reported elsewhere.[5] Bedtime ranged from 1800 to 0100, with a median of 2115. In almost all cases, however, the rooms were heated until the baby was put down, and only then allowed to cool, so the normalisation procedure does accurately reflect the ambient temperature to which babies are exposed in various states of sleep or wakefulness.

By six hours after putting down, mean (SEM) ambient temperature had fallen to 14·0 (0·63)°C,

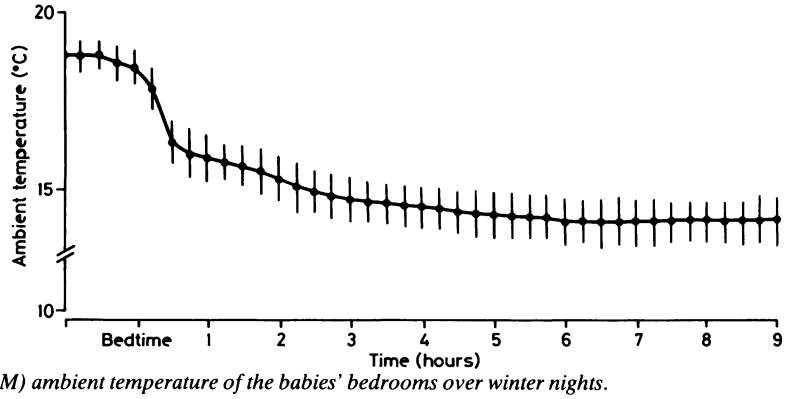

Fig 1 *Mean (SEM) ambient temperature of the babies' bedrooms over winter nights.*

but this mean disguised a considerable increase in range. In some cases temperature fell to below 7°C, in others it stayed above 22°C. Fig 2 shows the distribution of ambient temperature just before and six hours after putting down.

Minimum room temperature correlated positively with minimum outside temperature ($r=0{\cdot}31$, $p<0{\cdot}01$, $n=74$). The minimum outside temperature ranged from −9 to +6°C, with a mean of −0·2°C. At any given outside temperature, ambient temperature could range over many degrees. Other factors, including room heating, were significant.

Minimum room temperature correlated negatively with the weight of the infant at monitoring ($r=-0{\cdot}31$, $p<0{\cdot}01$, $n=74$), but did not correlate with age or skin fold thickness. Only 24 (32%) babies below median body weight were in rooms where temperature fell below median minimum ($\chi^2=9{\cdot}14$, with 1 df, $p<0{\cdot}01$). There was also a significant negative correlation between minimum temperature and birth weight ($r=-0{\cdot}22$, $p<0{\cdot}05$, $n=74$).

Smaller babies therefore slept in warmer rooms.

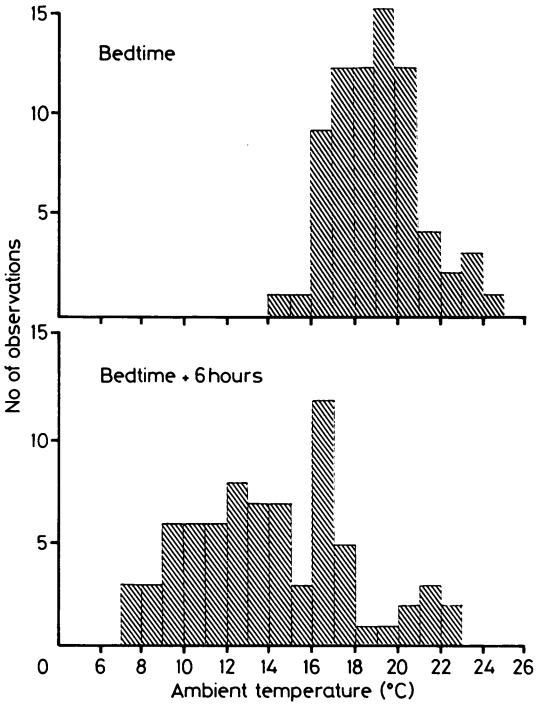

Fig 2 *Distribution of ambient temperature in the babies' bedrooms just before they were put down and six hours later.*

CLOTHING AND WRAPPING

The mean tog value of clothing worn before putting down was 5·1 with a range of 2·4 to 10·2. When placed in the cot, babies were wrapped, on average, with an additional 9·6 tog units (range 1·9 to 19·3). A 4·4°C drop in ambient temperature was therefore associated with a 188% increase in insulation, not taking into account the insulation afforded by a foam mattress.

Tog value of clothing and wrapping taken together correlated negatively with the minimum ambient temperature ($r=-0{\cdot}36$, $p<0{\cdot}01$, $n=74$) (fig 3), but did not correlate with room temperature at bedtime. Around 12% of parents seemed to apply much more wrapping than the others (see fig 3). There was a weak positive correlation between total tog value and body weight at monitoring ($r=0{\cdot}21$, $p<0{\cdot}15$, $n=74$), but a weak negative correlation between total tog value and birth weight ($r=-0{\cdot}16$, $p<0{\cdot}1$, $n=74$). While there was not a strong linear relation between body and birth weight and total tog value it was clear that lower birthweight babies were more heavily insulated. Only 24 (32%) of the babies above median birth weight had wrapping with tog values above median.

Tog value was, therefore, related to the minimum ambient temperature in the room, but this relation was modified to some degree by the birth weight of the baby.

Discussion

We have examined the conditions under which normal 4 month old infants sleep at home during a cold spell of a British winter. The data were collected as part of a larger study and appeared to parents as incidental to the main purpose of the investigation. Parents were also asked not to change their habits, and we have no evidence that they did, so we must assume that we are seeing normal parental behaviour.

In almost all cases, the infants' rooms were heated during the evening, so that at bedtime room temperatures fell within a narrow range, despite a considerable range of outside temperatures. During the study minimum outside air temperature ranged from −9 to +6°C.

In most cases room temperature then fell during the night; the extent of fall, though related to outside temperature, was not great. The fall appeared to be attenuated or prevented to a variable degree by room heating so that overall temperature fell, on average, by only 4·4°C.

The minimum room temperature reached during the night correlated negatively with the body weight and birth weight of the babies, suggesting that

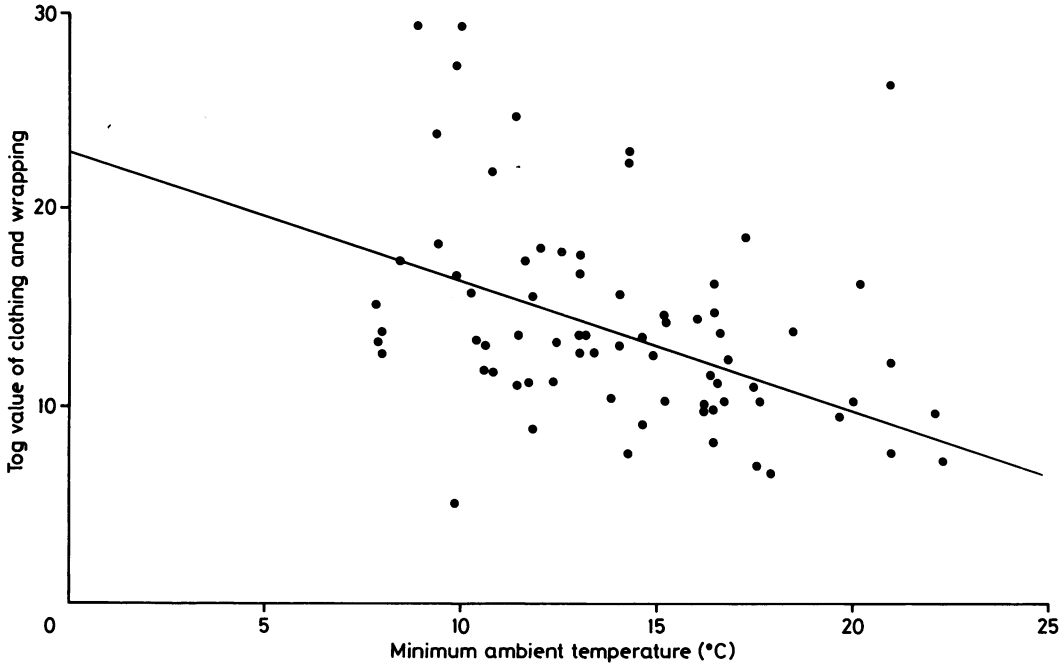

Fig 3 *Relation between the combined tog value of clothes and wrappings and minimum ambient temperature in the babies' bedrooms.*

parents are more likely to provide night time heating for smaller babies.

When infants are put down they are wrapped with considerable extra thermal insulation, which rises by 188%. Parents are presumably guarding against potential falls in body temperature. While the rooms do cool, they do not do so immediately, most reaching their minima after many hours, and in any case the overall fall in temperature is not great. Even allowing for an assumed drop of 30–40% or so in metabolic rate during sleep it is difficult to see the need for such a dramatic increase in insulation. Either infants are under insulated before putting down, or over insulated after, particularly during the first few hours of the night. Indeed Clulow (E Clulow, personal communication) has calculated, using the formula of Barton and Edholm,[6] that the appropriate tog value for the insulation of a sleeping baby at 16°C should be 8·8. The same formula yields a prediction of 10·5 tog for 14°C. As we report elsewhere,[5] however, most infants do appear capable of thermoregulation, and show a precisely controlled sequence of body temperature changes during the night.

The parental decision about clothing and wrapping is not a random one. Total thermal insulation is related to the minimum ambient temperature in the room, except for a small proportion of parents (12%) who wrapped much more heavily than others. Only one baby in the sample was much more lightly insulated than usual. Birth weight, though not age or current body weight, of the infants also appeared to exert a small influence on the extent of wrapping, in that at any given temperature smaller born babies appeared to be more heavily insulated.

Parents seem, therefore, to be working to a rough 'formula' relating insulation to perceived risk of hypothermia, taking into account how much the room temperature is expected to fall, and the vulnerability of the infant to that fall.

Two questions are immediately apparent. First, how is this formula established and second is it 'right' in the sense that it places infants in a thermal environment offering the least challenge to thermoregulation?

Parents receive advice on wrapping babies from a number of sources, other parents and health care workers being most obvious. We have no evidence that this advice is based upon objective estimates of what is best for babies, and in any case it is given mainly at the time of birth, and may set parental habits that become less appropriate as babies get

older. There are recommendations about room temperature for babies, but these do not appear to be tied to similar recommendations about the thermal insulation that should be used.

It is clear that most babies can thermoregulate in their cots, though they may have to work quite hard to keep the temperature down. Many seem to sweat, and as we report elsewhere, skin temperature is relatively high, suggesting some peripheral vasodilatation.[5] This is particularly obvious from the head temperatures, which suggest that some 85% of the heat loss from the baby is via the head. This will be examined in detail in another report. It is just possible that some vulnerable babies may not rise as effectively to the thermal challenge as others, and indeed in three babies who we studied, and who were well, body temperature rose after a while in the cot, and eventually reached levels well above the top end of the normal range.

It is clear that more work is needed to establish how parents decide the thermal environment of their babies, and that there is a need for some relatively objective statement about which combination of wrapping and room temperature is most appropriate.

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