

An Ergonomic Comparison of Wool and Polyester-Filled Quilts

Summary:

A comparison of wool and polyester-filled quilts (10.5 Tog), carried out at the Ergonomics Unit of the Polytechnic of Wales, found statistically significant differences in the physiological responses of subjects sleeping under the two quilts. Lower heart rates and more favourable microclimate (next-to-skin) conditions were observed for subjects sleeping under the wool-filled quilt.

Experimental evidence was obtained to verify that the quilts were within their respective comfort ranges at 16°C, before comparison of the physiological data was made.

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Introduction

This report is a continuation of a series of Technical Information Letters (TILs SP-13, SP-19) describing sponsored research projects to compare the comfort properties of wool and competitive fibres in different products.

This TIL summarizes work completed at the Polytechnic of Wales, Ergonomics Unit, in which wool and polyester-filled quilts of the same tog rating (10.5) were compared in sleep trials by volunteer subjects. Both subjective and objective evaluations were carried out in a conditioned environment at 16°C and 22°C and 50% relative humidity.

The advantage of the sleep experiment lies in the inclusion of the circadian rhythm effects - natural body rhythms - which are known to be different in the waking and sleeping states. Information on the thermal comfort of sleeping subjects is generally sparse, perhaps because of the difficulty in controlling the subject. The subject will tend to adopt the most comfortable sleeping condition. This may well involve a redistribution of the bedding which may invalidate the data collected if redistribution of the bedding which may invalidate the data if the deviation from the imposed text condition is too great. This study attempted to cope with this problem by including body movement and degree of coverage as responses in the experiment.

A pilot study suggested that 50% relative humidity, ambient temperature conditions of 16°C and 22°C would correspond to slightly too cold and slightly too warm for subjects using 10.5 Tog quilts.

2. Methodology

2.1 The Chamber and Furnishings

Each sleep experiment took place in a temperature and humidity controlled room (3.4m x 3.0m), which had been decorated to resemble a bedroom. Subjects slept on a standard single divan bed (1m x 2m). A low light level video camera was fixed in a top corner of the room, facing the bed, to monitor subject movement.

2.2 Bedding and Sleepwear

The details of the two quilts are given in Table 1.

Table 1. Details of quilts (100% cotton casings)

| Quilt Filling | Tog Value | Total Weight (g) | Thickness (mm) |
|---------------|-----------|------------------|----------------|
| Wool | 10.40 | 880 | 39.0 |
| Polyester | 10.20 | 840 | 53.0 |

Secondary bed covers of 50/50 polyester / cotton were used in all experiments. A foam rubber-filled mattress, covered with a bed sheet of 100% cotton was used together with feather-filled pillows, fitted with 100% cotton covers. All subjects used cotton shorts and cotton shirts which buttoned down the front.

2.3 Experimental Design

Two male and two female subjects were used. Each subject completed an adaptation of night and four experimental nights, using each possible combination of quilt type and temperature. The 16 trials were carried out in random order.

2.4 Experimental conditions

The subjects slept for up to 8 hours in the climatic chamber, described above under the following conditions, independent variables

- two different room temperatures of 16°C and 22°C and a constant relative humidity of 50%
- each subject tested one wool-filled quilt and one polyester-filled quilt at each temperature

2.5 Monitoring

The following subject responses were monitored

- subject heart rate
- microclimate (next to the skin) conditions;
 - temperature
 - relative humidity
 - major body movements
 - time completely covered by quilt
 - subjective assessment by questionnaire (see 2.6 below)

2.6 Questionnaire

A carefully designed questionnaire, which also tested to constancy of the subject's answers, was used to evaluate subjective assessment. For example:

Change in comfort desired was measured on a seven point scale, from -3 through 0 to +3 where - indicated a wish to be cooler and + indicated a wish to be warmer.

Analysis of Subject Movement

The video tapes taken during the sleep trials were analysed according to section 2.5 c), d) c) and e) and the values were summated for quilts and temperature to give the totals shown in the first part of the Table 2.

Table 2. Subject Movement Totals for Comparison of Quilts and Temperatures

| Totals | No. Movements | Time Exposed (minutes) | Limbs Completely Covered (minutes) |
|---------------------|---------------|------------------------|------------------------------------|
| a) Wool / 22°C | 192 | 292 | 785 |
| b) Polyester / 22°C | 126 | 687 | 666 |
| c) Wool / 16°C | 119 | 49 | 879 |
| d) Polyester / 16°C | 111 | 61 | 905 |
| e) Temp. 22°C | 318 | 979 | 1451 |
| f) Temp. 16°C | 230 | 110 | 1784 |

Relationships compared for significant difference

| Relationships compared for significant difference | Significant Level |
|---|--|
| a) wool / polyester at 22°C | More movement under wool 1% |
| b) wool / polyester at 16°C | No significant difference |
| c) 22°C / 16°C | More movement at 22°C (1%) |
| a) wool / polyester at 22°C | More limb exposure with polyester (1%) |
| b) wool / polyester at 16°C | No significant difference |
| c) 22°C / 16°C | More limb exposure at 22°C (0.1%) |
| a) wool / polyester at 22°C | More complete coverage with wool (1%) |
| b) wool / polyester at 16°C | No significant difference |
| c) 22°C / 16°C | More complete coverage at 16°C (1%) |

The pairings a), b) and c) for the three movement criteria were compared by statistical means and the result given in the second half of table 2. Were identified, all differences were highly significant.

- At 22°C there was significantly more movement under the wool quilt, indicative of greater restlessness. However, the limb exposure and coverage data strongly suggests that, although restless, the subjects were not discomforted enough to divest themselves of the wool quilt. Conversely it was apparent that the subjects tended to remove the polyester quilt, presumably because it became too uncomfortable, and thereby greatly modify the test condition imposed. These findings may be explained in terms of the comfort range of the two quilts. With respect to the degree of tolerance shown by the subjects it was likely that 22°C was just inside the comfort range for the wool quilt, but just outside the comfort range for the polyester quilt.

Because the subjects used the two quilts in different ways at 22°C it was inappropriate to use the physiological data collected to compare the quilts.

- b) At 16°C there was no significant difference between the quilts for any of the movement criteria. This finding was taken to indicate that the quilts were used in the same way and that a valid comparison of the quilts could be made using the physiological data.
- c) As may be expected there was more body movement, more limb exposure and less complete coverage at 22°C than at 16°C.

Comparison of the physiological data for the quilts at 16°C

- a) **heart rate**
The results for the two quilts averaged for the subjects are shown in Fig. 1. Clearly heart rate under the wool quilt was lower and statistically analysis revealed it to be significantly lower for 100% of the time. Lower heart rate infers a more rested condition.
- b) **Microclimate Relative Humidity**
The averaged results are shown in Fig. 2. Statistical analysis revealed that the humidity was significantly lower under the wool quilt for 71% of the time, inferring a more comfortable condition for the sleeper.
- c) **Microclimate temperature**
The averaged results are shown in Fig. 3. Bezinger et al (2) have identified 33°C as the temperature at which perspiration production typically becomes independent of skin temperature and Fanger (3) also suggested a similar temperature as optimum for comfort. This infers that as temperature deviates from this optimum temperature then the comfort of the subject decreases. Fig. 3 shows that the wool quilt was responsible for a smaller rise above 33°C than the polyester quilt (highly significant for about 80% of the time) suggesting that the wool quilt was potentially more comfortable.

Subjective assessment

Analysis of the subjective data, obtained by questionnaire when the subjects awoke after each trial, did not confirm the differences found in the physiological data of the two quilts at 16°C. However, it is likely that the answers given in the questionnaire were strongly influenced by the subjects' perception on waking, when differences in the physiological measurements were least (Figs. 1 and 3), and were not truly representative of the entire sleep period.

Conclusions

Body movement data confirmed the equivalent use of the two quilts at 16°C by the sleeping subjects.

The physiological data was statistically significantly different for the two quilts at 16°C. The lower heart rate and microclimate temperature and relative humidity were indicative of greater comfort under the wool-filled quilt.

References

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- b) T.H. Benzinger, C. Kitzinger and A.W. Pratt "The Human Thermostat" (ed. J.D. Hardy, Ref. 1).
- c) P.O. Fanger "Thermal Comfort: Analysis and Application in Environmental Engineering" McGraw-Hill, (1970).

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