J. Hyg., Camb. (1975), **74**, 339
Printed in Great Britain

Warmth and comfort in the subtropical winter: a study in Brisbane schools

By A. AULICIEMS
Department of Geography, University of Queensland

(*Received* 31 *October* 1974)

SUMMARY

Winter thermal sensations of secondary and primary school-children in Queensland are related to air temperature. Neutrality is estimated by regression analysis of over 6000 assessments and a lower comfort limit is suggested to include 80% of the children. Cold discomfort is seen as the main problem, and comparison is made to an earlier study in England.

INTRODUCTION

In comparison with the numbers of researches into adult thermal experiences, the needs of children have been largely neglected. The present report deals with the thermal sensations of both secondary and primary schoolchildren during winter in subtropical Queensland. The study was designed to enable direct comparison with earlier work carried out with a similar sample in the climatically different circumstances of England.

METHOD

Collection of data was identical with that previously reported for English schoolchildren (Auliciems, 1969), but using pupils from all grades (ages approximately 12–17) in three secondary and grades 4–7 (ages approximately 8–12) in four primary state schools in Brisbane.

Atmospheric measurement was restricted to air temperature and humidity (Assmann psychrometer), while subjective thermal sensations were gained on prepared slips of paper showing a seven-point scale (see Table 1). The data were collected during the mornings (9.30–11.30 hours) May–August in 1973, and analysed in terms of two measures of ambient warmth: dry-bulb temperature and effective temperature (E.T.).

RESULTS

As found earlier in the English study (Auliciems, 1969), windows were rarely open providing minimal ventilation rates. Since heat stress was not encountered during the period of data collection, correlations of thermal sensations with effective temperature (based on a constant minimum air movement) were as

Table 1. *Scale of thermal sensations*

Sensation	Numerical value used by children	Numerical value used in analysis
Much too warm	1	+3
Too warm	2	+2
Comfortably warm	3	+1
Comfortable (neither warm nor cool)	4	0
Comfortably cool	5	−1
Too cool	6	−2
Much too cool	7	−3

expected lower than those with dry-bulb temperature. Consequently the following results and discussion are only concerned with the dry-bulb temperature.

The distribution of thermal sensations appears in Tables 2 and 3 together with various degrees of warmth and percentage comfort. Graphical representation of the sensation means against temperature is shown in Fig. 1. Regression analysis has been applied separately for the secondary- and primary-school samples to individual scores and equations expressed in the form $Y = ax+b$, where Y is the predicted thermal sensation, a and b constants and x thermal measure. The regression constants, the product moment correlation coefficients and predicted neutrality (when $Y = 0$ or 'comfortable') are shown in Table 4. For comparative purposes the values obtained in England are also included.

To determine acceptable upper and lower limits for comfort the data have been classified into three categories within which the children may be considered as feeling comfortable (values +1, 0, −1), too warm (values +3, +2) and too cool (values −2, −3). Percentages were determined for the three categories for each interval of temperature (Tables 2, 3) and the percentages comfortable appear in Fig. 2.

DISCUSSION

Comment may be needed on three aspects of Table 4. Firstly, the correlations in the present study appear to be considerably lower than that in the earlier one. This may not be so much an indication of decreased thermal sensitivity of the Australian sample as merely the relative scarcity of data under stress conditions. Secondly, the large difference between neutrality temperatures was to have been expected in view of differences in clothing and degrees of thermal acclimatization. Thirdly, the remarkable similarity between the regressions of the secondary and primary schools in the present study is as puzzling as the earlier finding in England that age differences appear to play a small part in thermal sensations under everyday conditions.

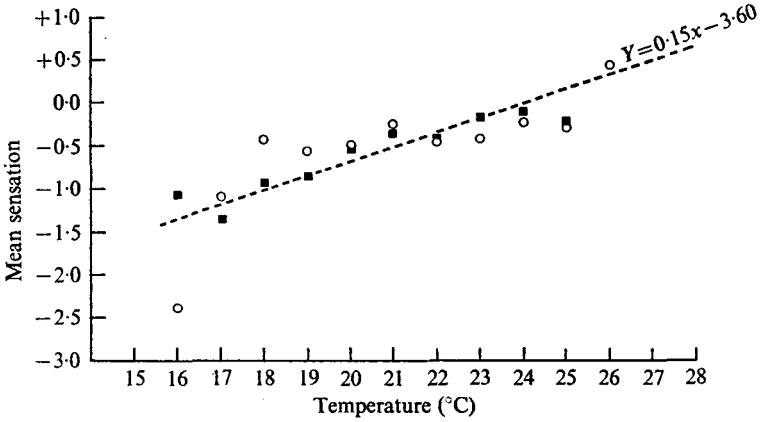
While some provision for heating is made in certain country areas, Brisbane winters are regarded as being too mild (during the sampling period outside temperature average was 19·8° C. with a standard deviation of 2·3° C.) to require any appliances in schools. With the lightweight customary clothing worn, excessive indoor temperatures do not occur and only cold discomfort need be considered. In

Table 2. *Distribution of sensations in relation to dry-bulb temperatures, primary schools*

Dry-bulb (°C)	Frequency of observations	Frequency of sensations							Total	Mean sensation	Percentage		
		+3	+2	+1	0	−1	−2	−3			Heat discomfort	Comfort	Cold discomfort
25·5–26·4	2	1	8	20	17	7	3	0	56	+0·46	16	79	5
24·5–25·4	7	3	4	33	63	66	13	3	185	−0·28	4	88	8
23·5–24·4	3	1	9	17	49	28	10	5	119	−0·21	8	79	13
22·5–23·4	12	2	6	50	92	105	32	5	292	−0·40	3	85	12
21·5–22·4	31	13	35	101	238	287	97	31	802	−0·45	6	78	16
20·5–21·4	34	23	28	186	355	343	82	27	1044	−0·27	5	85	10
19·5–20·4	17	10	12	64	135	140	62	26	449	−0·49	5	75	20
18·5–19·4	9	4	3	21	68	79	30	7	212	−0·57	3	79	18
17·5–18·4	5	4	2	19	35	48	14	4	126	−0·42	5	81	14
16·5–17·4	4	2	1	12	17	19	12	25	88	−1·11	3	55	42
15·5–16·4	3	—	1	1	4	10	24	68	108	−2·40	1	14	85
Total	127	63	109	524	1073	1132	379	201	3481	−0·45	5	78	17

Table 3. *Distribution of sensations in relation to dry-bulb temperatures, secondary schools*

Dry-bulb (°C)	Frequency of observations	Frequency of sensations							Total	Mean sensation	Percentage		
		+3	+2	+1	0	−1	−2	−3			Heat discomfort	Comfort	Cold discomfort
24·5–25·4	7	1	9	30	81	78	10	—	209	−0·22	5	90	·5
23·5–24·4	12	2	23	63	106	86	24	4	308	−0·10	8	83	9
22·5–23·4	17	2	26	86	178	137	38	5	472	−0·18	6	85	9
21·5–22·4	26	2	20	76	192	259	53	9	611	−0·44	4	86	10
20·5–21·4	22	6	11	101	208	207	51	10	594	−0·36	3	87	10
19·5–20·4	20	4	9	89	125	199	81	13	520	−0·54	3	79	18
18·5–19·4	7	1	1	18	43	77	53	4	197	−0·87	1	70	29
17·5–18·4	8	—	6	22	46	81	52	21	228	−0·94	3	65	32
16·5–17·4	5	—	1	5	14	36	31	16	103	−1·35	1	53	46
15·5–16·4	1	—	—	2	5	19	7	2	35	−1·06	0	74	26
Total	125	18	106	492	998	1179	400	84	3277	−0·45	4	81	15



°C	■	○
26		+0·46
25	−0·22	−0·28
24	−0·10	−0·21
23	−0·18	−0·40
22	−0·44	−0·45
21	−0·36	−0·27
20	−0·54	−0·49
19	−0·87	−0·57
18	−0·94	−0·42
17	−1·35	−1·11
16	−1·06	−2·40

Fig. 1. Mean sensation against temperature. ○, Primary schools; ■ secondary schools.

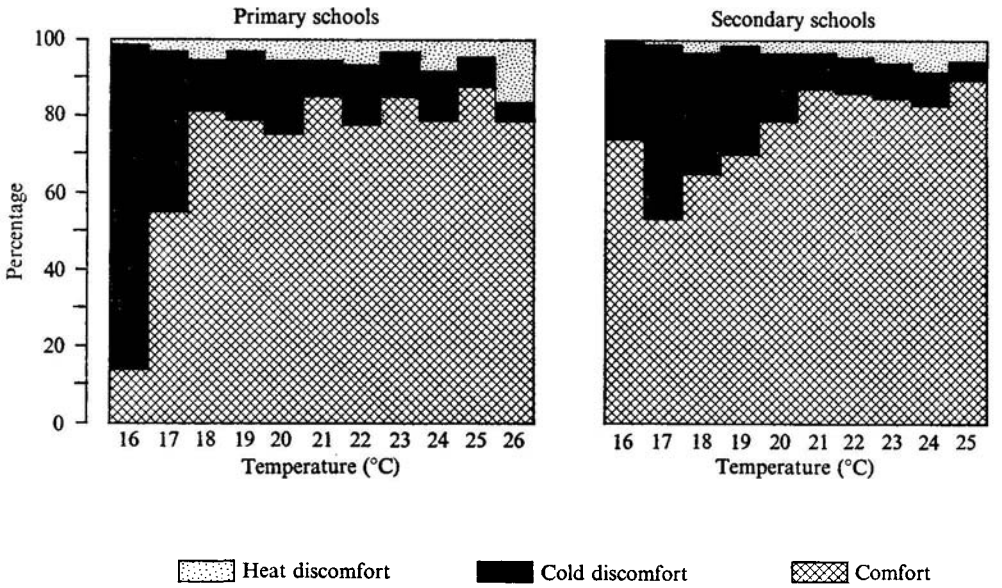


Fig. 2. Percentage comfort against temperature.

both secondary and primary schools neutrality was observed at 24–25° C., and cold discomfort could be reduced to a minimum (less than 20 %) if a lower limit was set at 20·5° C.

The delineation of comfort zones is arbitrary and in the English study a low 60 % comfort level had to be employed to produce a zone of some 6° C. (11° F.). Here heat discomfort had proved to be the problem with needlessly excessive temperatures occurring on 26 of the 109 (24 %) days sampled. Given that the wasteful habit of overheating could have been fairly easily rectified, the reduction of heat stress to a minimum would have achieved comfort to fully 98 % of the sample.

In conclusion it should be noted that in both Queensland and England school-

https://doi.org/10.1017/S0022172400046854 Published online by Cambridge University Press

Table 4. *Correlation coefficients, regression constants and neutrality*

	Correlation coefficient	Constant *a*	Constant *b*	Neutrality °C	Neutrality (°F)
Primary schools	+0·25	0·147	−3·56	24·2	(75·6)
Secondary schools					
Queensland	+0·27	0·147	−3.60	24·5	(76·1)
England (Auliciems, 1969)	+0·37	0·209	−3·56	17·1	(62·7)

children constitute by far the largest group of people engaged in similar work. For that reason alone, provision of optimum thermal conditions in schools should be a particular concern. Paradoxically, at present learning conditions in the mid-latitude English winter tend to produce heat stress, while those in subtropical south-east Queensland cold stress. This generalization probably is applicable to considerably broader geographical areas in both countries.

This study was sponsored by the Australian Research Grants Committee. I am grateful to the Director of Education of the Queensland Education Department for permission to carry out the data collection in the schools. Particular thanks is also given to Miss Susan Algate and Mrs Nancy de Freitas.

REFERENCE

Auliciems, A. (1969). Thermal requirements of secondary schoolchildren in winter. *Journal of Hygiene* **67**, 59.