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Outdoor clothing: its relationship to geography, climate, behaviour and cold-related mortality in Europe

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Abstract It has been suggested, that the inhabitants of northern European regions, who experience little cold-related mortality, protect themselves outdoors by wearing more clothing, at the same temperature, than people living in southern regions where such mortality is high. Outdoor clothing data were collected in eight regions from 6583 people divided by sex and age group (50–59 and 65–74 years). Across Europe, the total clothing worn (as assessed by dry thermal insulation and numbers of items or layers) increased significantly with cold, wind, less physical activity and longer periods outdoors. Men wore 0.14 clo (1 clo=0.115 m^2 K W^{-1}) more than women and the older people wore 0.05 clo more than the younger group (both P<0.001). After allowance for these factors, regional differences in insulation and item number were correlated (r=–0.74, P=0.037; r=–0.74, P=0.036 respectively), but not those in clothing layers (r=–0.21; P=0.61), with indices of cold-related mortality. Cold weather most increased the wearing of gloves, scarves and hats. The geographical variation in the wearing of these three together items more closely matched that in cold-related mortality (r=–0.89, P=0.003). A possible explanation for this may be that they protect the head and hands, where stimulation by cold greatly increases peripheral vasoconstriction causing a rise in blood pressure that procedure haemoconcentration and raised cardiovascular risk.

Key words Cold · Winter mortality · Clothing

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Introduction

In western Europe, over a quarter of million deaths per year, mainly from cardiovascular and respiratory diseases, can be attributed to cold exposure (Keatinge et al. 1997), there being paradoxically less cold-related mortality in northern regions with colder winters (McKee 1989). Both Eurowinter (Keatinge et al. 1997) and other studies (Donaldson et al. 1998a, b) in some of the coldest inhabited parts of the former Soviet Union have suggested that ample outdoor clothing, together with adequate indoor heating, can prevent much of this excess winter mortality. The Eurowinter study did not, however, fully substantiate this suggestion as it did not report any significant association between the layers of clothing worn at a standard temperature of 7°C in eight different regions and indices of cold-related all-cause or cause-specific mortality. This may have been due to clothing layers poorly reflecting thermal insulation or to an absence of adjustment for wind speed or behaviour outdoors. We felt it important to provide public health advisors with more robust evidence on the benefits of increased outdoor clothing for reducing excess winter mortality. We have therefore re-examined the Eurowinter data to try to establish such a link, and to provide previously unpublished information on the relationship of specific items, and their combinations, to geography and temperature. Other studies in this field have been mainly laboratory-based and concerned with indoor dressing behaviour. These have shown it to be influenced by light intensity (Kim and Tokura 1995a) as well as diurnal and menstrual fluctuations in core temperature (Kim and Tokura 1994, 1995b). One field study has, however, shown that, in industries where workers are exposed to cold, there seems to be a practical upper limit to the thermal insulation of clothing which is not exceeded whatever the actual requirements (Aptel 1988).

Materials and methods

Data collection

Local market-survey companies collected data on outdoor clothing worn during the first excursion of the day lasting longer than 10 min. The data were available for 6583 individuals out of 8152 people who were interviewed at home after 5 p.m. between November 1994 (October in Finland) and February 1995 (18th March in north Italy); the remaining 1569 stayed indoors all day or went out for less than 10 min. The people were equally divided by gender and age group (50–59 and 65–74 years) and lived in eight regions of Europe (north Finland, south Finland, The Netherlands, Greater London, Baden-Wurttemberg, north Italy, Palermo and Athens). The age groups were selected to include either predominately working or retired individuals, so minimising bias due to differences in retirement age and associated activities in the different regions. Other reasons for the selection were that measurable cold-related mortality existed in each group and that sufficient individuals could be easily identified for the survey. In each region, interviewees were selected by a two-stage process. Primary sampling areas (typically 5% of the total), representative of population density, social composition and related factors (such as type of accomodation), were identified from census data. An interviewee was then selected in each area, and subsequent interviewees separated by at least four addresses, with the limitation that not more than two interviews should be conducted in the same street; apartment blocks were treated as streets.

Information was also collected on how long the subjects were in the open air or in unheated buildings or transport, to which they could reply 10–20, 21–30, 31–40, 41–50, 51–60 min or 1–1.25, 1.25–1.5, 1.5–2, >2 h. These durations were recoded to the midpoint of each interval, and expressed in hours. They were also asked if they stood for at least 2 min during the excursion and whether they shivered or not.

The daily mean temperature and wind speed were computed from 3-h values for stations in each region, supplied by the Meteorological Office, in north Finland (mean value for Oulu, Kuopio, and Vaas), south Finland (mean for Helsinki and Lahti), Baden-Wurttemberg (mean for Freiburg and Stuttgart), The Netherlands (Volkel), Greater London (Heathrow), Emilia-Romagna (Bologna), Athens and Palermo. Occasional missing readings were replaced by interpolation using the preceding or subsequent 3-h value and the change over the previous or following day; where more than one replacement was available these were averaged. Mean daily temperatures were linked to the survey data as the exact time of the first outdoor excursion during the preceding 24 h was not recorded.

The number of layers worn was calculated by adding together the body surface areas that each garment could generally be assumed to cover, and expressing this as a fraction of the total body surface area, taken as 1.90 m^2 for men and 1.62 m^2 for women; data on body segment surface area were obtained from Haywood and Keatinge (1981). The total dry insulation was also calculated from these garments (ISO 1994; Parsons 1993), an anorak being equivalent to 0.4 clo (1 clo=0.155 m^2 K W^{-1}), a bra 0.01, gloves 0.025, a hat 0.02, a jacket 0.30, a long dress 0.40, a long-sleeved vest 0.12, long underpants 0.10, a long-sleeved shirt 0.20, an overcoat 0.30, a scarf 0.02, socks 0.025, a short-sleeved shirt 0.15, a short-sleeved vest 0.09, a skirt 0.20, a short dress 0.20, a sweater 0.28, shoes 0.02, tights 0.02, trousers 0.24, underpants 0.03, an underskirt 0.03, and a waistcoat 0.12. These calculations took into account whether two of the same items were worn, for example two pairs of socks. For the analysis of specific clothing items, the data were coded into a binary format, e.g. wearing or not wearing socks.

Indices of cold-related mortality

The 1988–1992 figures for mortality (from all causes) per million of the population in the same geographical regions as the survey were obtained for both men and women age 50–59 and 65–74. These were regressed against 3-day lagged daily temperature below 18°C by means of generalised linear modelling for a Poisson distribution of the deaths, with the assumption of linearity, by specifying an identity link function. Indices of cold-related mortality were then estimated by expressing the regression coefficients as a percentage increase on estimates of the mortality at 18°C, thereby adjusting for differences in mortality between regions caused by non-climatic factors such as diet and smoking. These data have been previously published in Keatinge et al. (1997) and are reproduced in this paper in Table 1.

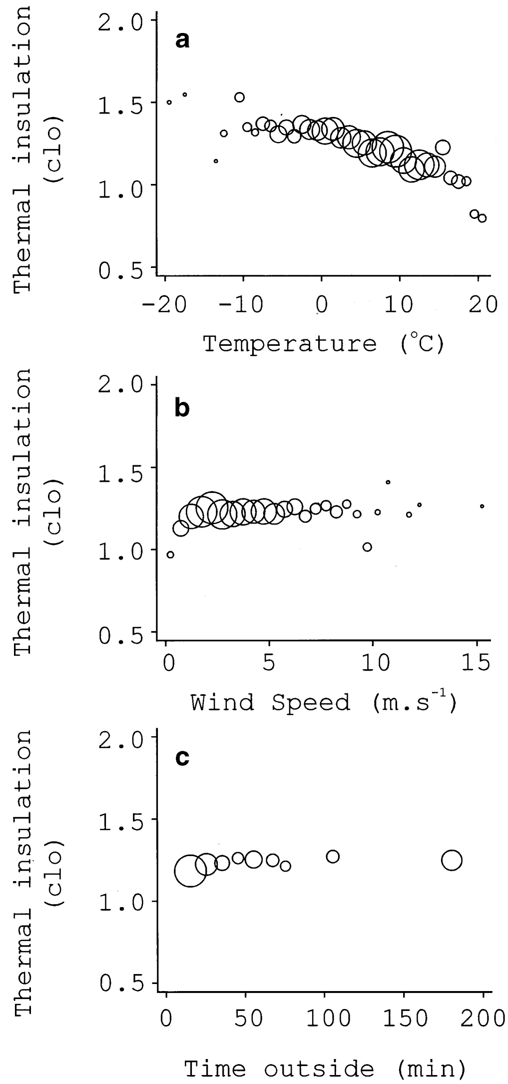

Fig. 1a–c Total dry thermal insulation, plotted against (**a**) temperature, (**b**) wind speed and (**c**) time outdoors; bubble size indicates the number of data comprising each point

Statistical analysis

Data for this study were analysed with Stata 5.0. Multiple analysis of covariance was used to determine the "main" effects of the seven independent factors (sex, age, region, outdoor temperature, wind speed, time outdoors and activity), separately on clothing layers, the number of items worn, thermal insulation and the incidence of shivering. Plots showed these, for the most part, to be linearly related to the continuous independent variables (see Fig. 1);

checks showed no sampling bias in either gender or age group during colder weather. A similar analysis of covariance was carried out for the simultaneous wearing of a hat, scarf and gloves. All first-order interactions were also tested. Following the analysis of covariance, the coefficients that represented the differences between regions, after adjustment for the other explanatory variables, were correlated (Pearson Product-Moment) with the indices of cold-related mortality.

Logit regression was used to determine the relationship between whether or not specific items of clothing were worn and temperature in each region separately, with allowance for the five other independent variables. The regression coefficients on temperature from the eight regions were then tested by *t*-test for significance from zero; mean values (±SD) are reported. Plots were also made of the proportion of people wearing specific items of clothing in each region after adjustment for other factors.

Results

In all eight regions, a total of 1827 men and 1680 women went outdoors on the day of interview in the group aged 50–59 years, and 1616 and 1461 respectively in the group aged 65–74 years. In each region, on average 823 people were interviewed with roughly equal numbers in each gender and age group (all non-significant in each region by χ^2-test). Table 1 shows the numbers interviewed, their average clothing and the climate on the survey days, and the cold-related mortality, in each region.

Table 2 shows the main independent effects of sex, age, region, temperature, wind speed, physical activity and excursion duration on clothing layers, clothing items, insulation and shivering. The percentages of the variance explained (r^2) for each were 24%, 26%, 37% and 3.3% respectively. Men wore 0.45 (0.48–0.42: 95% confidence interval) fewer layers of clothing and 0.43 (0.53–0.33) fewer items than women. The thermal insulation of these clothes was, however, higher than for women (0.14 clo; 0.13–0.15 clo) and the percentage of men who shivered outdoors was 3% (5%–2%) lower. The younger age group wore 0.21 (0.24–0.18) fewer layers or 0.58 fewer (0.68–0.48) items, with a lower total insulation of 0.05 clo (0.06–0.04 clo) than the older group, and shivered 3% more (4%–1%). Even after allowance for climate and journey characteristics, there were large variations between regions, most (3.38 layers)

Table 1 Characteristics of interviewees, clothing and climate in each region [mean (SD)]

Characteristic	N. Finland	S. Finland	Netherlands	G. London	B. Wurttem.	N. Italy	Palermo	Athens
Interviewees	827	909	718	793	746	918	857	815
Men	434	460	388	410	391	464	461	435
Aged 50–60 years	427	465	384	404	439	474	473	441
Surface area (layers)	3.0 (0.7)	2.8 (0.7)	2.6 (0.6)	2.5 (0.7)	3.0 (0.6)	3.1 (0.7)	2.8 (0.8)	2.4 (0.6)
Items	13.8 (2.5)	13.1 (2.8)	10.4 (2.1)	10.5 (2.1)	12.4 (2.4)	11.8 (2.1)	10.3 (1.8)	9.6 (1.4)
Insulation (clo)[a]	1.4 (0.3)	1.3 (0.3)	1.2 (0.2)	1.1 (0.3)	1.3 (0.2)	1.3 (0.2)	1.2 (0.3)	1.0 (.02)
Time outside (min)	58 (55)	55 (53)	41 (46)	68 (60)	46 (46)	47 (49)	77 (62)	54 (57)
Proportion stationary (%)	11	11	17	29	18	15	45	43
Temperature (°C)	–2.3 (5.0)	–0.9 (4.3)	6.6 (3.8)	8.9 (2.8)	5.0 (4.7)	6.8 (3.1)	14.5 (2.9)	11.1 (2.9)
Wind speed (m/s)	3.8 (1.5)	3.1 (1.3)	4.9 (2.5)	4.1 (1.5)	3.5 (2.2)	2.3 (1.1)	5.3 (3.1)	2.9 (1.9)
Increase in mortality for each 1°C fall from 18°C (%)	0.29	0.27	0.59	1.37	0.60	0.51	1.54	2.15

[a] 1 clo=0.155 m^2 K W^{-1}

Table 2 Analysis of covariance: main effects of sex, age, region, temperature, wind speed, activity and time outdoors on layers of clothing, insulation and shivering. 1 clo=0.155 m^2 K W^{-1}

Parameter	Clothing layers	Item Number	Insulation (clo)	Shivering (%)
Constant	2.98	11.0	1.03	18
Sex (men versus women)	–0.45**	–0.43**	0.14**	–3**
Age (young versus old)	–0.21**	–0.58**	–0.05**	3**
Region				
N. Finland	0.16**	2.37**	0.19**	–13**
S. Finland	0.04	1.95**	0.15**	–10**
The Netherlands	–0.05	0.05	0.11**	–6**
Greater London	–0.03	0.41*	0.09**	5**
Baden-Wurttemberg	0.40**	2.05**	0.22**	–3*
N. Italy	0.52**	1.62**	0.25**	2
S. Italy	0.37**	0.75**	0.16**	8**
Athens				
Temperature (°C)	–0.028**	–0.125**	–0.012**	–0.8**
Wind speed (m/s)	0.022**	0.081**	0.010**	0.5*
Activity (stationary versus active)	0.046*	0.137*	0.009	4.0**
Time outdoors (h)	0.029**	0.225**	0.022**	0.4

*P<0.05; **P<0.001

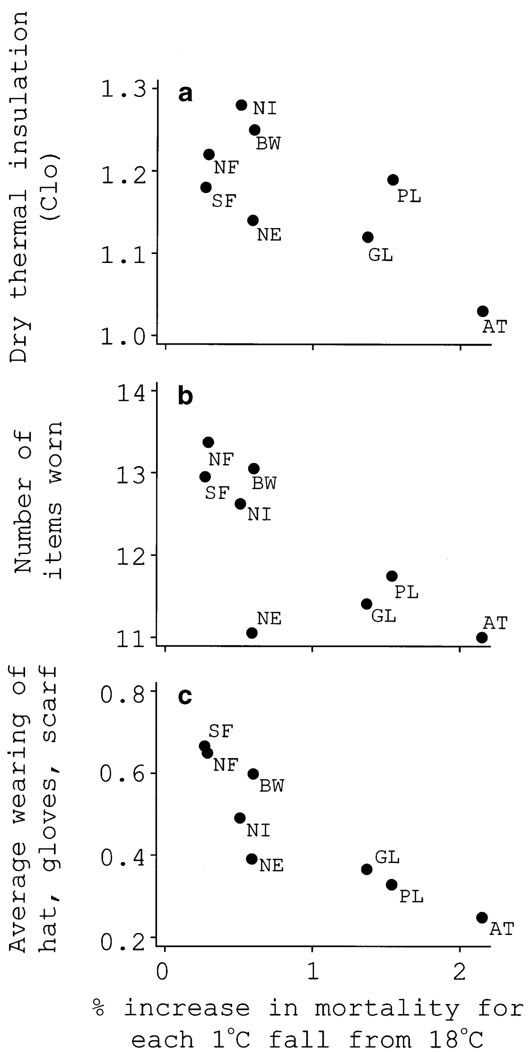

Fig. 2a–c Regional variations in (**a**) thermal insulation, (**b**) number of items and (**c**) the wearing of hat, gloves and scarves, plotted against regional indices of winter mortality after allowance for sex, age, temperature, wind speed, time outdoors and physical activity. Regions from *left* to *right*: *SF* south Finland, *NF* north Finland, *NI* north Italy, *NE* The Netherlands, *BW* Baden-Wurttemberg, *GL* Greater London, *PL* Palermo, *AT* Athens

of clothing being worn in north Italy and fewest (2.93 layers) in The Netherlands. These findings were not fully replicated in terms of total insulation, as the greatest amount worn was 1.28 clo in north Italy and the least 1.03 clo in Athens. These regional variations also did not match well those in shivering, after standardisation for difference in climate and excursion characteristics, with 26% of those outdoors shivering in Palermo but only 5% in north Finland.

Table 2 also shows that the wearing of layers, items and insulation independently increased by roughly 1% for every 1°C fall in temperature, from its value adjusted for the other factors (the constant in Table 2). An increase in wind speed of 1 m/s increased the clothing layers and items worn by 0.75% and increased insulation by 0.97%. However, these adjustments did not seem to prevent shivering, which increased by 4% for 1°C fall in temperature and by 3% for a 1 m/s increase in wind. People who were stationary for over 2 min whilst outdoors wore about 1.5% more layers and 1.2% more items, and 0.8% more insulation, but this lack of activity was associated with a 22% rise in shivering. Those people who spent longer outdoors increased their layers, items and insulation by 1%–2% for every hour spent outside, the incidence of shivering also increasing by about 2% per hour outside.

The results of the analysis, which included all 21 possible first-order interactions, were generally consistent for either clothing layers, insulation or the number of items. Inclusion of the interactions in the core model resulted in the main effects of wind speed, activity and time outside becoming non-significant (P>0.05). For all three models, 12 of the interactions were always non-significant, and 2 were significant with only one of the models. Of the remaining 9 possible interactions, 5 were with region (F and P values for thermal insulation are as follows: sex F=5.2, P<0.0001; temperature F=10.7, P<0.0001; wind speed F=6.9, P=0.0001; activity F=2.0, P=0.049; time outside F=11.4, P<0.0001) and 3 were with sex (age F=5.65, P=0.018; temperature F=0.08, NS; activity F=6.64, P=0.010), and the remaining interaction was that between temperature and wind speed (F=22.0, P<0.0001). For thermal insulation, the interaction between sex and age suggested that the difference between old and young men was greater than that between old and young women.

The regional differences in insulation or number of items, after allowance for the other explanatory variables (see Materials and methods), were significantly correlated with the indices of winter mortality (r=–0.74; P=0.037 and r=–0.74; P=0.036 respectively) but the clothing layers worn were not (r=–0.21; P=0.61) (see Fig. 2). Similar correlations between clothing measures and regional differences in shivering were all non-significant (insulation r=–0.14, items r=–0.53, layers r=0.23). Regional differences in layers and items worn were, however, correlated with insulation (r=0.80, P=0.018 and r=0.78, P=0.022 respectively).

Figure 3 shows the proportion of people wearing specific items of clothing in each region. Data on men and women have been combined, except in the case of female apparel (bra, skirts, underskirt, long or short dresses) where the graphs show the proportion of women wearing a particular item. There was large variation between regions in the wearing of gloves, hats, scarves, short and long-sleeved vests, underskirts and long underpants, skirts, jackets, anoraks and overcoats. Some items, in these age groups were nearly always worn (bras and shoes) and some seldom worn (short or long dresses, short-sleeved shirts). The variation in the wearing of trousers can be attributed to women as all the men wore trousers. For the eight regions, the lowest mean (±SD) logit regression coefficient for temperature, after adjustment for sex, age, wind speed, journey time and activity, was –0.23 (SD 0.1) for gloves. This mean regression co-

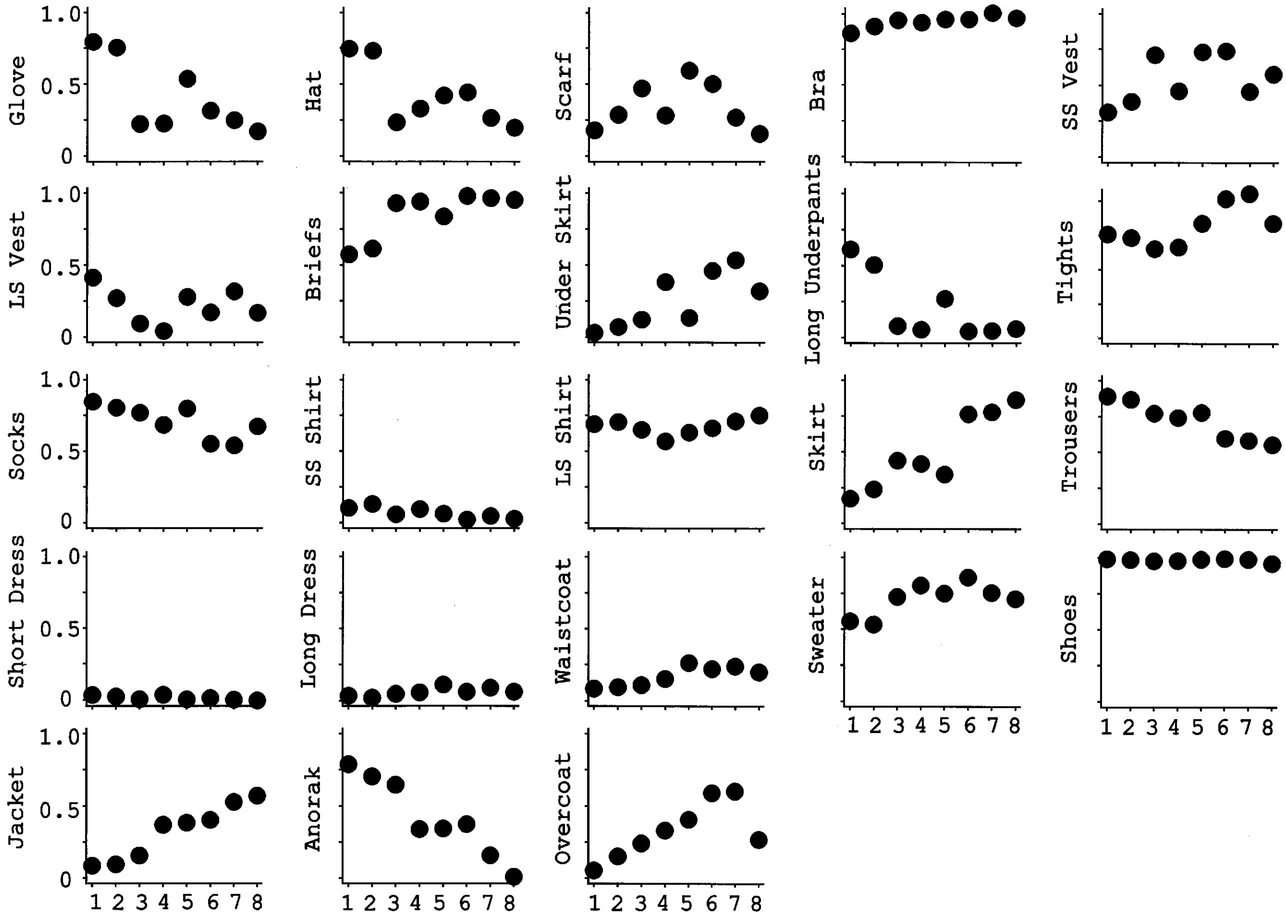

Fig. 3 Proportion of people wearing specific garments in each region, after adjustment for sex, age, temperature, wind speed, time outdoors, and physical activity. Regions: *1* north Finland, *2* south Finland, *3* The Netherlands, *4* Greater London, *5* Baden-Wurttemberg, *6* north Italy, *7* Palermo, *8* Athens

efficient is formally defined as a change in the logarithm of the odds of wearing gloves with every 1°C fall in temperature but, in simple terms, a negative value indicates an increased usage as the temperature falls. The next lowest coefficient was for scarves –0.14 (SD 0.11), then hats –0.12 (SD 0.05), long underpants –0.12 (SD 0.04), overcoats –0.10 (SD 0.12), long-sleeved vests –0.10 (SD 0.5), long dresses –0.08 (SD 0.09) and sweaters –0.07 (SD 0.04). Whereas colder weather resulted in less wearing of briefs 0.12 (SD 0.10), jackets 0.06 (SD 0.06), long-sleeved shirts 0.06 (SD 0.07) and short-sleeved vests 0.05 (SD 0.06). For all these, *t*-tests showed all the coefficients of the eight regions to be different from zero, indicating a significant effect of temperature ($P<0.05$); other items were not related to temperature. Regional variations in the average wearing together of a hat, scarf and gloves were significantly related to those in excess winter mortality ($r=-0.89$, $P=0.003$; see Fig. 2c) and to shivering ($r=-0.73$, $P=0.039$).

Of the 2678 people who wore a hat, 1936 (72%) also wore gloves and 1321 (49%) wore a scarf; 1042 (38%) wore all three. Of the 4883 people wearing trousers, 909 (19%) wore tights and 1386 (28%) wore long underpants. Of 1453 women wearing skirts, 1326 (91%) wore tights, 230 (16%) wore socks and 709 (49%) wore an underskirt. The wearing of jackets, anoraks and overcoats was generally mutually exclusive, with 5984 of 6583 people wearing one of these, 618 wearing both overcoat and jacket, 265 anorak and jacket, 9 overcoat and anorak, and 9 wearing all three.

Discussion

This interview-based study is the first to provide information on some of the complex factors, interactions and combination of clothes that determine what European outdoor clothing is worn. A strength of this study was that a large number of people living in regions with different cultures and climatic conditions were interviewed. A weakness was the lack of detailed information about the thermal insulation of the clothing. It was, however, impractical to make any measurements of the clothing or to assess its properties. The lack of such information might explain why no correlation was found between regional differences in clothing and shivering. Similarly we could not assess the precise reason for the outdoor excursion, which is likely to be another important factor in determining what was worn.

The major finding was that regional variations in thermal insulation and number of items worn, after allowance for differences in climate and behaviour, were associated with geographical differences in excess winter mortality. This has not been described before and it provides some scientific support for public health advice about wrapping-up well when going outdoors in the winter, particularly in southern European countries. It is unlikely that a lack of clothing is the sole cause of winter mortality, but there is evidence from the Eurowinter Study that links cold-related mortality to outdoor cold stress independently of home heating, as well as to home heating independently of outdoor cold stress.

Like the Eurowinter study, this study found no correlation between the number of layers of clothing worn and cold-related mortality, even after further adjustment for wind speed, time outdoors and activity. This suggests that it is a poor measure of thermal protection, particularly when there are large variations due to fashion, as suggested by the strong statistical interactions with sex and with region. The implication of this finding should be qualified, in that this type of ecological study can never indicate causality, but this is unlikely ever to be truly established because of the nature of the problem. Caution should also be exercised when extrapolating the results with respect to temperature, the reason being that the maximum and minimum amount of clothing worn will be limited by restriction to movement and decency.

The main subsidiary findings were that people in everyday life wear more clothing in colder or windier conditions, or during lengthy or less active excursions. These conclusions are fairly obvious, but have not, as far as we are aware, been previously reported. The surprising finding, which deserves further socio-behavioural research, was that these increases in clothing did not prevent increases in shivering, even though common sense suggests that people would wear more to avoid this. Results from the analysis of clothing combinations shows that there is a potential to increase clothing, particularly by wearing long underpants or tights with trousers, underskirts with skirts, jackets with overcoats, or all three of hat, scarf or gloves. The use of extra clothing would, however, have to be balanced against the practicalities of removing excess clothing when indoors. The choice of what outdoor clothing to wear was presumably based on anticipation of the day's events and climate since the subjects had not yet been outside. This could lead to subjects being over- or under-dressed, particularly when the weather changes rapidly. This phenomenon could, in part, explain the greater increase in mortality per 1°C fall in temperature in the autumn than in the spring (Spencer et al. 1998), since people may fail to dress appropriately as the weather gets colder and so expose themselves more to cold. Whereas, in the spring, they are reluctant to change out of their winter clothing and experience less cold stress.

For the three items (hat, scarf and gloves) that are most likely to be worn more as the weather becomes colder, there was a strong association between their use and the indices of winter mortality in the different regions. A possible explanation for the latter, not previously described, is that cooling of the head and hands elicits greater peripheral vasoconstriction than cooling of other body parts. Thus systemic blood pressure rises to a greater degree, so that more fluid is filtered out of the capillaries and, as a result, prothrombotic risk factors in the blood become concentrated thereby increasing cardiovascular risk and mortality (Keatinge et al. 1984; Rowell 1983).

In conclusion, outdoor dressing behaviour is determined by anticipation of climate and journey characteristics but fails to prevent shivering. The geographical variation in cold-related mortality may be explained by differences in the wearing of outdoor clothing. Of these, gloves, hat and scarves are the most important since they cover those areas of the body most involved in determining the blood pressure response to cold. Public health advice should emphasise the benefits of wearing more clothing in the winter.

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