Ointments are traditionally used in Finland for protection against facial frostbite. Recent epidemiological reports showed unexpectedly, however, that the use of ointments is a statistically considerable risk factor for frostbite of the face and ears. The effects of 4 different emollients on facial temperature were studied in 46 acute cold exposures. The voluntary test persons sat in a cold chamber after emollients were applied thickly on half of the face, while the other half acted as an untreated control. Thermistors and an infrared scanner were used to measure skin temperature of symmetrical areas of the face. The thermal sensations on the corresponding sites were also recorded. Test emollients more often had an objectively cooling than a warming effect on facial skin. However, white petrolatum often produced a subjectively warming skin sensation. “Protective” ointments may cause a false sensation of safety, leading to increased risk of frostbite due to neglect of other protective measures. Key words: creams; ointments; frostbite; cold injury.

Material and methods

Test subjects and cold exposure

Acute cold exposures were carried out in a climatic chamber (~15°C, 3 m/s wind against the face). After obtaining informed consent, 24 voluntary and healthy male test persons (mean age 26 years, range 19–48 years), mostly medical students, sat in the chamber in each test for 25–30 min. Test subjects wore a Finnish army winter cap with the ears covered and warm clothing (thermal insulation 2.7 clothing units =~ 0.42 m^2K/W). The ambient temperature and wind speed were registered during each test. During cold exposure the facial skin temperature decreased from +32–34°C to around +10°C. The same test persons were not used for experiments until at least 48 h after the previous test.

Ointments and their application

Four emollients were studied: an oil-in-water (o/w) emulsion cream A (Aqualan L^1^, Orion Pharma, Espoo, Finland) containing vegetable oils, 4.25% glycerol and 63% water, a water-in-oil (w/o) emulsion cream B (Neribase^2^, Leiras Co., Turku, Finland) containing white beeswax, liquid paraffin, white petrolatum, no humectant and 30% of water and 2 different waterless ointments, C and D; C (Ceridal^3^ lipogel, Rhone-Poulenc Rorer Co., Helsinki, Finland) containing synthetic long chain hydrocarbons with cyclosiloxan, and D consisting totally of a mineral grease, white petrolatum (vaselineum album), manufactured ad modum Pharmaca Nordica in local pharmacy, Oulu, Finland. These non-medicated emollients were tested in 46 cold exposures (A in 16, of which 3 were started “late” =1 h from its application, B in 9, C in 10 and D in 11 exposures). In addition, 6 tests were performed with no emollient on either side of the face, in order to obtain a quantitative estimation of normal thermal asymmetry of face and to validate the test arrangement.

Two vasodilative liniments (Trafuril^4^, Ciba-Geigy, Helsinki and Muskelen^5^, Lääkefarmos, Turku, Finland) with 1% nicotinate as the pharmacologically active agent were studied in 3 tests. Four tests were performed with strong topical corticosteroid creams; 2 with 0.05% clobetasol-17-propionate (Dermovat^6^, Glaxo, Helsinki, Finland) and 2 with 0.1% halcinonide (Halocort^7^, Orion Pharma, Espoo, Finland). Corticosteroids are known to have vasoconstrictive properties (7, 8).

Emollients and topical preparations were applied at room temperature on half the face. The other half was left untreated as a control. Left and right facial halves were used equally for application and control to avoid bias caused by possible asymmetry of the test conditions. The amount of application was 1 g/half face, approximately 50 g/m^2. This intentionally exceeds by about threefold the

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average application of 16 g/m² used in topical therapy (9, 10) to
demonstrate even a small thermal effect. In a majority of experiments
the test persons entered the cold chamber 2 min after the application
of the emollient. Application was performed 1 h before the cold
exposure in 3 tests with o/w cream A to let its water content evaporate
at room temperature. This has been shown to occur in about 20 min
(11). Vasodilator liniments were applied 4 min before entering the
cold chamber. In tests with corticosteroids the cold exposure was
started 4 h after first application in 1 test and 2.5 – 3 h after the last of
repeated (once daily) applications on 2 – 3 days in 3 tests in order to
quantify their effect when the vasoconstrictive influence was expected
to be present (7, 8).

Measurement of skin temperature

The skin temperature of 4 symmetrical locations on the forehead and
cheeks was measured once a minute by using thermistors (YSI 400
series, Yellow Springs Instruments Inc., Yellow Springs, USA) with
an accuracy of about 0.1 °C. The location of the sensors is presented
in Fig. 1. The sensors were attached to the skin with a small strip of
adhesive tape (Transpore®, 3M, USA) before the emollient was
applied. All sensors were connected to a portable Squirrel 1200 data
logger in the lap of the test subject. Thermal difference between facial
halves was calculated (i) by summarizing the temperature compar-
isons on the left and right sides of the forehead and cheeks at 5, 10,
15, 20 and 25 min after the application, and (ii) by comparing the
average temperatures on the applied side with the untreated side of
the forehead and cheeks during time period 13 – 23 min, when the
decreasing temperature curve was moving into a plateau phase.

In the first 7 tests there were no thermistors on the cheeks. The
criteria for abandoning temperature values for sensor detachment or
electrical contact failure were no reading at all or 0 °C. The changes in
facial temperature were also measured continuously using a thermal
infra-red (IR) scanner (Inframetrics 600, Inframetrics Inc., Billerica,
Massachusetts, USA). The scanner was adjusted to 0.93 emittance
and −15 °C background. The visual temperature scale consisted of 20
colours. During cold exposure the range of the scale was usually
widened from 10 to 20 °C. Therefore the resolution of the colour
differences was either 1.0 or 0.5 °C. The temperature region was
regulated downwards to sustain its ability to discern temperatures
(best discernible in the middle area of the scale) while the skin
temperature lowered. The scanner measured the temperature of
pointed areas or spots with an accuracy of 0.1 °C. Thermographic
results were recorded on VHS videotape for further analysis. IR
results were achieved by combining the face-half comparisons in 3
modes of observations (see also Fig. 1): (i) IR image was frozen at
5 min intervals from the application (at the same moments when
thermistor results were used for comparison) to "still pictures", and
the skin temperatures on symmetrical square areas (about 2 × 2 cm)
on the forehead and cheeks were compared simultaneously, (ii) temperature differences between face halves (visible areas of the
forehead and cheeks in frontal image) were compared visually by 1 of
the authors (E.L.) in infra-red videotape recordings from the same
still pictures, and (iii) temperature levels of horizontal graphs on the
forehead and cheeks were recorded on both sides and compared from
these same still pictures.

Subjective thermal sensation

Test subjects were asked of their subjective thermal sensations in
different facial locations. The perception of temperature difference
between face halves was registered in the beginning, middle and at the
end of each cold exposure (5, 15 and 25 min after the application).
The location of the sensed difference was recorded.

Validation of methodology by tests without application

In the IR area registrations of 6 tests without application the mean
thermal difference of the face halves was 0.7 °C (0 – 2.2 °C) on the
forehead and 0.8 °C (0 – 2.2 °C) on the cheeks. In addition to 2 total detachments
or electrical contact failures of thermistors, the half differences in 2
thermistor measurements on the cheeks were so high that they
lead the researchers to suspect partial sensor detachments on the
cooler half. These numbers also had a remarkable influence on the
average half difference.

A difference in skin temperature between face halves was sensed
subjectively in 2/18 of comparisons without application. These 2
observations were both in the same test, only on cheeks, and the right
side was cooler.

Statistics

For all proportions of summed results in Table I, a 95% confidence
interval (95% CI) was calculated based on an assumption of a
binomial distribution. The agreement of observed and expected
distributions in proportion of cooling and warming effects of
individual emollients was tested by using χ² test statistics.

RESULTS

Non-medicated emollients

Thermistor results. The detachment or electrical contact fail-
ure of 1 or both thermistors caused a rejection of 7/59

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Fig. 1. The locations of thermistors, infra-red (IR) areas and hori-
zontal graphs in the measurement of facial skin temperature.
comparisons on the forehead and 9/52 on cheeks, altogether. The different calculations of thermistor results are shown in Table I. In comparison between facial halves the application of tested emollients caused a cooling effect more often (in 49 -- 51%) than a warming effect (in 28 -- 32%). According to 95% CI values this indicates a significant finding. Different emollients showed variability in thermal responses, although this was not significant ($\chi^2 = 5.85$; degree of freedom = 8; $p > 0.50$). The cooling effect was most evident with emulsion cream B (12/17 of observations showed a cooling effect and 4/17 a warming effect) and A (11/24 a cooling effect and 6/24 a warming effect) in measurements at 5 min intervals. Lipogel C (6/15 cooling, 5/15 warming) and waterless white petrolatum D (9/19 cooling, 6/19 warming) were noted to have more thermoneutral effects, although still more often cooling than warming. After the water content of cream A had evaporated, it acted as thermoneutral (2/5 both cooling and warming). The comparisons of effects by individual emollients also showed consistent results in the second mode of calculation (average temperatures at period 13 -- 23 min).

IR scanner results. The results of 2 modes of IR registrations are also shown in Table I. The skin temperature on the applied half was significantly more often cooler (41 -- 62%) than on the untreated half (12 -- 16%) following the results in thermistor registrations. Also this difference was significant when assessed by 95% CI values. In comparisons of horizontal graphs the applied half was cooler in 29/88 (33%) and warmer in 6/88 (7%). Creams A (15/32 of observations showed a cooling effect and 2/32 a warming effect) and B (7/18 cooling, 2/18 warming) together with lipogel C (9/20 cooling and 3/20 warming) had a cooling effect in a clear majority of comparisons in IR area measurements. White petrolatum D (7/22 cooling, 4/22 warming) had somewhat more thermoneutral effect (Fig. 2). Cream A acted still as cooling (3/6 cooling, 0/6 warming) after the evaporation of its water. The inter-emollient difference was not significant ($\chi^2 = 3.11$; degree of freedom = 8; $p > 0.50$). The responses of individual emollients were also similar in overall IR estimations and horizontal graphs.

Subjective thermal sensations. The thermal sensations of test subjects are specified with individual emollients in Table II. Test persons felt no thermal difference between facial halves in 51% of the tests. In the other half of the tests, the applied side of the face was sensed as often as warmer as cooler. Cream A caused a cooler sensation much more often than a warming feeling, as well before as after the evaporation of its water content. White petrolatum differed significantly from the almost neutral effects of emollients B and C by causing a warming sensation more than twice as often as a cooling sensation. The inter-emollient difference was statistically almost significant ($\chi^2 = 18.1$; degree of freedom = 8; $p = 0.058$).

Pharmaceuticals

The pharmacologically active vasodilative liniments had a distinctive warming effect in IR area tests with an average difference of 3.8°C (0.4 -- 5.6°C) on the forehead and 8.1°C (2.0 -- 15.7°C) on cheeks between facial halves. Temporally the difference was maximal (6.2°C on average on the forehead and 13.7°C on cheeks) at 10 min after the application showing a diminishing tendency after that period. The warming effect of vasodilators was distinctly sensed by all test subjects. Topical corticosteroids lowered the skin temperature in IR-area comparisons on the average by 1.1°C on the cheeks, but

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**Table I. Effect of all test emollients on facial skin temperature (T) in cold. Comparison of the applied half of the forehead and cheeks with the untreated half. Values $\geq 0.7°C$ were considered as thermal difference. Ambient temperature $-15°C$, wind 3 m/s against the face**

<table>
<thead>
<tr>
<th>Method</th>
<th>Effect (sum of emollients A – D)</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cooling n (%; 95% CI)</td>
<td></td>
</tr>
<tr>
<td>Thermistors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T at 5, 10, 15, 20 and 25 min</td>
<td>38 (51, 40 – 62)</td>
<td>75</td>
</tr>
<tr>
<td>Average T during period 13 -- 23 min</td>
<td>37 (49, 38 – 60)</td>
<td>75</td>
</tr>
<tr>
<td>Infra-red scanner</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area T at 5, 10, 15, 20 and 25 min</td>
<td>38 (41, 31 – 51)</td>
<td>92</td>
</tr>
<tr>
<td>Overall estimation at 5, 10, 15, 20 and 25 min</td>
<td>57 (62, 52 – 72)</td>
<td>92</td>
</tr>
</tbody>
</table>

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**Fig. 2.** The median skin temperatures on the applied (emollient D) and untreated halves of the forehead and cheeks during the acute cold exposures ($n = 11$) measured by infra-red scanner on symmetrical areas of about 2 x 2 cm. Ambient temperature $-15°C$, 3 m/s wind against the face.**

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*Acta Derm Venereol 80*
DISCUSSION

The thermal effects of ointments in the cold can theoretically be based either on physical or physiological mechanisms. In a recent experimental study in vitro, emollients A–D did not physically show significant thermal protective effects even in a 10 times thicker layer than ordinarily used in topical therapy (11). The physiological effects of emollients could still influence the temperature of the living skin, e.g. by adjusting water permeability of the epidermis, blood circulation in the dermis, etc. If there is a real thermal effect on the skin, it should lead to a temperature difference between the applied and untreated symmetrical skin areas, as tested in this study. The experimental conditions resembled true conditions of cold injury, but were not continued to an actual risk of frostbite. Moisturizing of dry winter skin with emollients should lead to a temperature difference between the applied and untreated face halves at 5, 15 and 25 min after the application. Corticosteroid creams caused a subjectively cooling sensation in 6/12 and a warming feeling in 2/12 of observations.

Table II. The effect of individual test emollients A–D on the subjective sensation of facial skin temperature in cold. Comparison of the applied and untreated face halves at 5, 15 and 25 min after the application. Ambient temperature –15°C, wind 3 m/s against the face. Emollients were applied 2 min before cold exposure, except in tests marked A* in which cold exposure was started 1 h after the application to let the water content of cream A to evaporate first.

<table>
<thead>
<tr>
<th>Emollient</th>
<th>Effect</th>
<th>Neutral (n)</th>
<th>Warming (n)</th>
<th>Total no. of observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Cooling (n)</td>
<td>12</td>
<td>22</td>
<td>5</td>
</tr>
<tr>
<td>A*</td>
<td></td>
<td>5</td>
<td>–</td>
<td>7</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td>5</td>
<td>15</td>
<td>7</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td>7</td>
<td>16</td>
<td>7</td>
</tr>
<tr>
<td>D</td>
<td></td>
<td>6</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>All</td>
<td></td>
<td>34</td>
<td>70</td>
<td>34</td>
</tr>
</tbody>
</table>

had no significant effect on the forehead. In IR-area comparisons including both the cheeks and forehead the applied half was cooler in 3/8 and warmer in 2/8. Corticosteroid creams caused a subjectively cooling sensation in 6/12 and a warming feeling in 2/12 of observations.

CONCLUSION

Tradition and subjective experience obtained from erroneous skin sensation seem to have formed the basis for the use of waterless commercial sports ointments, often consisting of petrolatum together with minor other ingredients, in prevention of facial cold injury. This sensation may lead to neglect of other preventive measures. The results of this study indicate that the emollients tested do not delay the cooling of facial skin temperature in cold. Together with epidemiological evidence of increased risk of frostbite in connection with emollient use (1, 2) and in vitro results of their lack of thermal insulation against cold even in thick application layers (11), the results in this study lead to a recommendation that the long-lived tradition to use “protective” ointments should be discouraged when cold exposure causes an actual risk of frostbite. Moisturizing of dry winter skin with emollients
should be left to temperatures at which the risk of frostbite is absent, and preferably indoors.

ACKNOWLEDGEMENTS

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