COLD PROTECTION OF HEAD BY LIGHT AND HEAVY HEADGEAR

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INTRODUCTION

The head is protected against heavy cooling by strong blood circulation except the outermost parts like nose and chin. Protection of the head is however necessary for minimizing the heat loss of the whole body. Heat loss of the unprotected head can be as much as 80 % of the total heat production of the body at temperature of -20 °C (1). The purpose of the study was to evaluate the meaning of headgear on heat loss in cold conditions.

METHODS

Thermal insulation of two different kind of winter fur headgears was determined in the laboratory using four test persons and two different metabolic rates. Total insulation, Itot was calculated by formula (1)

(1) Itot = (Theadgr-Ta)/HFheadgr, where

Theadgr = mean skin temperature under the headgear,
Ta = ambient temperature of laboratory (-15 °C)
HFheadgr = mean heat flux under the headgear.

We measured the mean skin temperature at 15 sites and the mean skin temperature under the headgear was measured at 4 sites with thermistors of YSI 400 series for which the accuracy is about ±0.1 °C. The corresponding heat fluxes were measured using sensors HA-13-18-10 P(C), with the accuracy about 10 %. The insulation of the material of the headgear, Imat was determined the same way by measuring temperatures of the lower surface and the upper surface of headgear and the heat flux under the headgear.

Experiments were conducted in an environmental chamber maintained at -15 °C. Subjects exercised on a cycle ergometer at two different work rates for 120 minutes. The lower metabolic rate (150 W) was selected so that the calculated DLE- time (Duration Limited Exposure) (2) was 60 minutes. The other metabolic rate was selected at 525 W in order to initiate sweating during the tests. According to the Sprague Munson formula (3) the calculated thermal insulation of the clothings was 2.7 clo. The sweat rate was measured by weighting headgear, clothing and subjects. The results were checked by measurements in the field and by measurements with a sweating skin model (4) in the laboratory.

RESULTS

Table 1 shows the measured thermal insulations of the headgears. The heat losses by sweating and by respiration were different, 15 W and 90 W at the two levels of metabolic rate. Both headgears had the same change in weight as a consequence of the condensation (0 ±1 g and 28±18 g) at the different metabolic rates.

Table 1. The total thermal insulation and the insulation of the material of headgears

Headgear	Itot clo	Imat clo	N
1	2.5 ±0.5	1.4 ±0.1	8
2	1.6 ±0.2	0.8 ±0.1	8

Table 2 presents the measured temperatures and heat fluxes with two metabolic rates of 150 W and 525 W.

Table 2. The measured total insulation of headgears, Itot, the rectal temperatures, Trec, the mean skin temperatures,Tsk , the mean temperatures under the headgear, Theadgr , the mean heat fluxes from skin , HFsk, the mean heat fluxes from the head, HFhead and the mean heat fluxes under the headgears, HFheadgr. with two metabolic rates.

Head-gear	Metabolic rate W	Itot clo	Trect °C	Tsk °C	Theadgr °C	HFsk W/m^2	HFhead $W m^2$	HFheadgr W/m^2	N
1	150	2.5±0.5	37.0±0.4	29.9±1.0	33.3±0.4	116±10	196±21	128±25	4
2	150	1.7±0.2	36.9±0.1	29.5±0.6	31.2±0.4	122±5	236±12	174±16	4
1	525	2.6±0.5	38.0±0.1	34.4±0.1	35.5±0.6	145±11	262±19	120±19	4
2	525	1.6±0.2	37.8±0.2	34.5±0.5	34.6±1.2	148±13	305±37	193±7	4

CONCLUSIONS

Two headgear.s were tested in laboratory at -15 °C temperature. The individual differences between test persons were significant. The headgear with the insulation of 2.5 clo had the same thermal insulation as the rest of the clothing. It showed that this thermal insulation was too small for lower metabolic rate (150 W). The calculated IREQ- index was 4.3 clo for the conditions tested. On the other hand at the higher metabolic rate (525 W) both headgears had too high thermal insulations for those conditions. The metabolic rate and sweating did not effect the measured thermal insulation (p= 0.25, N=18). The results were the same when headgears were tested in the field and when the materials were tested in the laboratory.

For the used conditions (Ta = -15 °C and metabolic rate 150-525 W) the calculated thermal insulation should be 1.3- 4.5 clo. For this reason the easy adjustment of the thermal insulation is an important property of the headgear. The headgear should also protect against the facial frostbites. Therefore it should cover the head as well as possible (70 %) . Adjustment should also made by adding an extra hood over the headgear for the prolonged exposure time. In general, we found out that the insulation of the selected headgears were too high. That caused extra sweating and uncomfortable conditions afterwards.

The heat loss from the head was 13 ±1.6 % of the total body heat loss. It changed only 1% with different metabolic rates and with different headgears although the heat flux through the skin under the headgear changed about 50 %.

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