THE EFFECT OF AUXILIARY HEATING OF HANDS AND BODY DURING COLD EXPOSURE ON SOLDIER MARKSMANSHIP OF ANTI-ARMOUR WEAPONS (TOW) UNDER FIELD CONDITIONS

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INTRODUCTION

There seem to be situations when it will be impossible for cold-weather clothing to protect the extremities sufficiently (1), and in these situations, particularly if manual dexterity is required, auxiliary heating can provide a solution. Operating weapon systems as the anti-armour weapon TOW (Tube-launched, Optically tracked, Wire-command link guided missile), where the users are directly exposed to the cold environment, is such a situation.

The problem of keeping the hands warm in a cold environment, is due to the geometry of the fingers (thin cylinders) and the difficulty of maintaining the blood supply to the fingers of a generally peripheral vasoconstricted man. The hands cannot be kept warm in cold environments except by maintaining the blood circulation by exercise, by withdrawing the hand into the parka, or by artificial heat *(2)*. The purpose of this study was first to determine the effectiveness of the NDRE developed heater-system of applying heat to the body, primarily to the hands. The second purpose was to examine the effect of this heater-system on marksmanship performance during cold exposure under field conditions.

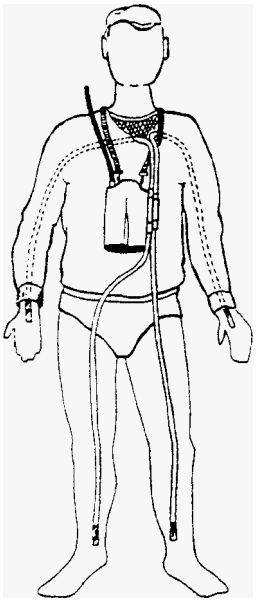

Figure 1. The illustration shows how the heater and the four distribution tubes were placed on the subject before he was dressed in the Norwegian military winter clothing.

METHOD

The marksmanship was measured by operating a BT-52 simulator for the anti-armour weapon TOW. The subjects shot on a target at about 2200 m range and the shot group tightness (SGT) was calculated based on five successive shots. SGT was calculated as the area (m^2) of the shot group; i.e., the maximum horizontal distance (X axis) multiplied by the maximum vertical distance (Y axis) between shots **(3).** During these shots the target was either moving at a speed of 10-20 km/h (horizontal left or right) or it was static. The shooting took place on two consecutive days. The ambient temperature ranged from -6 to -12°C, and the wind was below 2 m/s. Each subject had four to five series of five shots on a static target and five to seven on a moving target during the two days. The day before, the subjects had about 20 shots to familiarise themselves with the weapon simulator. Twelve soldiers divided into two groups were alternately operating the simulator followed by 30 min rest during a period of 2-4 hours. The subjects were lying on an insulated mat on the ground during the resting period. One of the groups had the benefit of the heater the first day; the other group on the following day.

The heat was applied to the body by using the NDRE developed Heatpac® (4), a charcoal-fuelled portable hot-air generator with four heat distribution tubes weighing 1.1 kg. This distribution unit was designed by Odd Halsnes NDRE (1993) to supply mainly the hands but also the legs with warm air from the heater at an amount of about 120 l/min. The corrugated tubes were made of 1 mm thick thermoplastic elastomer with perforation only at the far end. The heater was placed on the chest under the clothing as shown on Figure 1. Clothing worn while shooting was: cap; headover; undershirt; undershirt, cold weather, shirt; sweater; coat, combat; parka, snow camouflage; mittens, knitted; mittens, cloth; drawers, cold weather; drawers, extreme cold weather; trousers, combat; trousers, snow camouflage; socks, wool/synthetic; socks, stretch; boots, combat; overboots. Rectal and skin temperatures were recorded continuously by Squirrel loggers for 10 of the 12 subjects.

RESULTS

The mean skin temperature of the middle finger was considerably higher, above 10°C, with the heater than without after 2 hours of cold exposure (Table 1). The skin temperatures of the thigh, the leg and the chest were

also significantly increased by the heater, but more modest. The chest temperature, however, was increased more than 5°C by the heater, to a temperature above the rectal temperature. This is a result of measurements being made on the skin just beneath the heater. The rectal temperature and the skin temperature of the back and of the lower and the upper arm did not change significantly.

Table 1. Effect of heating on rectal and skin temperatures after two hours of cold exposure.

Temperature locus	n*	With heaters "C	Without heaters "C	t-test‡ p<
Rectal	8	36.82 ± 0.20	36.96 ± 0.21	n.s.†
Chest	9	39.6 ± 2.1	34.6 ± 0.6	0.001
Back	6	33.8 ± 0.6	33.9 ± 1.0	n.s.
Thigh	9	32.1 ± 1.3	30.9 ± 0.8	0.05
Leg	9	33.1 ± 2.5	30.6 ± 1.8	0.005
Upper arm	9	31.7 ± 1.7	31.0 ± 1.3	n.s.
Lower arm	9	31.2 ± 1.1	30.6 ± 1.7	n.s.
Foot	8	20.4 ± 2.6	20.6 ± 3.4	n.s.
Finger	8	24.8 ± 6.2	13.3 ± 4.5	0.01

* Number of subjects, § Means values ± SD, ‡ Student's t-test paired, † Not significant.

The marksmanship after 1-4 hours of cold exposure measured by the SGT value, was somewhat improved by using the heater system for a static target, but not significantly (Table 2). With a moving target there was no difference.

Table 2. Effect of heating on marksmanship measured by the SGT, for a static and a moving target.

Target	With heaters m^2	Without heaters m^2	t-test‡ p<
Static	0.40 ± 0.63 (n=26)*	0.93 ± 1.79 (n=26)	n.s.†
Moving	1.94 ± 2.37 (n=35)	1.73 ± 1.53 (n=34)	n.s.

* Number of SGT values, § Means values ± SD, ‡ Student's t-test unpaired, † Not significant.

CONCLUSIONS

The application of auxiliary heat by a Heatpac® system increases the temperature of the hands significantly from about 13 to 25°C under cold field conditions. This should improve the manual performance since the critical local skin temperature for fine motor tasks of the hands (finger dexterity) is about 15°C *(5)*. However, no significantly improved TOW shooting performance was observed. One possible explanation may be that the temperatures of the upper and lower arm are more relevant than the temperature of the finger for the shooting performance for this weapon, and these temperatures were not significantly altered by the heater. Another explanation may be that one day of shooting training is not enough to eliminate the effect of learning.

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