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# PHYSIOLOGICAL RESPONSES WHILE WEARING MILITARY CLOTHING AND HANDWEAR IN COLD ENVIRONMENTS

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Cold environments impact on selection of clothing, footwear and handwear which increase thermal insulation to minimize metabolic heat **loss.** Extremity cooling limits a worker's ability to complete a given occupational task a **loss** of manual dexterity and a subsequent performance decrement result if the hands are only slightly cooled.

Six male subjects each wore a light-duty work glove (LD.thermal resistance $R_c[m^2 \cdot K \cdot W^{-1}]=0.13$), a heavy-duty work glove (HD. $R_c=0.16$) and an Arctic mitten (AM, $R_c=0.23$). They wore an extended cold weather clothing system (ECWCS. $R_c=0.56$, water vapor resistance. $R_e[m^2 \cdot mbar \cdot W^{-1}]=0.820$) comprised of polypropylene underwear. polyester/cotton fatigues, polyester-insulated liners. balaclava. vapor-barrier boots and polytetrafluoroethylene (PTFE)-lined outer garments (wt=10.1 kg). Testing took place in a climatic chamber at $T_a=0^0$ C. $-20^0$ C, $-30^0$ C, RH=20% and $V_a=1.34\ m \cdot s^{-1}$ while the subjects were sitting (SIT, $M[W \cdot m^{-2}]=71$) on a bench or treadmill walking (WLK. M=171) at 0.98 $m \cdot s^{-1}$. Endurance time (ET. max=120 min) was dependent on exposure responses and by pre-set safety criteria (PSC). Rectal ($T_{re}$), middle finger ($T_{mf}$), and mean skin temperature ($\bar{T}_{sk}$, 10 sites) were monitored every minute. $\dot{V}O_2$ and heart rate (HR) were measured periodically. Total body weight **loss** ($\dot{m}_b$) was determined before and after the experiment.

When SIT and WLK at $0^0$ C (n=36), ET was near maximum ($\overline{ET}$=116.5 min) for all three gloves. At $-20^0$, SIT (n=17), $\overline{ET}$=68.3 min (LD=62, HD=62, AM=81 min) and when WLK (n=12), $\overline{ET}$=115.5 min (LD=111, HD=120 min). At $-30^0$ C, SIT (n=11), $\overline{ET}$=35.5 min (LD=25, HD=46 min) and when WLK (n=10), $\overline{ET}$=75.0 min (HD=71, AM=79 min). $\bar{T}_{re}$ did not vary significantly between the three environments or handwear and the overall increase due to WLK was slight ($0.57^0$ C). $T_{mf} \leq 5^0$ C **PSC** (31%) and voluntary subject withdrawal due to hand discomfort (60%) were the primary causes of premature ET. $\bar{T}_{sk}$ at $-30^0$ C ($29.4^0$ C) revealed considerable subject discomfort. At $0^0$ C. $\bar{T}_{sk}$ ($32.5^0$ C) resulted in numerous instances of profuse sweating during WLK. Ventilation of the ECWCS via zippers, closures. etc. was not allowed. Metabolic rates due to shivering were minimal for both activity modes at $0^0$ C. AM. SIT ($\bar{M}$=62) and $0^0$ C, LD. WLK ($\bar{M}$=162). Maximal rates occurred at $-30^0$ C. LD. SIT ($\bar{M}$=88) and $-30^0$ C, AM. WLK ($\bar{M}$=176). WLK HR responses were elevated 26% above SIT values across all handwear and temperature groups but did not approach PSC ($180b \cdot min^{-1}$). $\dot{m}_b$ values **showed** changes from either shivering or sweating while SIT or WLK at all temperatures. Maximal $m_b$. SIT occurred at $-30^0$ C ($\dot{m}_b=210g \cdot hr^{-1}$) and WLK at $0^0$ C ($\dot{m}_b=280g \cdot hr^{-1}$).

In summary. the LD. HD. and AM provided hand protection and overall cold tolerance relative to the intrinsic insulation *of* each glove. *55, 59.* and 63% of subjects completed a full ET while wearing the LD, HD. and AM. respectively. This is the first study to employ the ECWCS **over** an extended exposure and activity mode. $\bar{T}_{sk}$ and $T_{re}$ responses indicate that the ECWCS offers protection through a wide temperature range which would allow extension into more temperate climates when ventilation and removal of layers is an option during strenuous exercise.