Government of Canada / Gouvernement du Canada

Joint Federal Research Funding for Military Personnel and Veterans

Project Report Summary Template

Funding Opportunity
Biophysical assessment of Canadian Armed Forces clothing with a sweating thermal manikin
Brief Overview
The military ensembles have to shield the human body from the environment while providing wear comfort. The bulkiness and the weight of these ensembles, their moisture-tightness for chemical, biological, and foul weather protection, the manipulation of stiff textiles with low air and moisture permeability for mechanical and ballistic protection such as ballistic inserts and hard-plate body armor, as well as the adds-on such as load-carrying tactical vests and wearable sensors to bring the clothing to a certain level of functionality and protection, cause the protective performance of military ensembles to be often constructed with a certain thermo-physiological discomfort. Thermo-physiological discomfort is the physiological strains (e.g., hyperthermia and heat stress) caused by the impediment to transport heat and moisture (perspiration) from the skin to the environment and through garments. The thermo-physiological responses of the human body are predictable and can be calculated by measuring factors such as the thermal resistance of the clothing, the evaporative resistance of the clothing, clothing evaporative cooling and moisture management capabilities, climatic conditions, and the level of exercise. In this research, our team employed a sweating thermal manikin in a climatic chamber to predict the Canadian Armed Forces (CAF) clothing's capabilities to dissipate heat and moisture from the skin to the environment with the eventual aim of reducing the physiological strains in the CAF personnel.
What is this Research About? This research assessed the thermo-physiological properties of Canadian Armed Forces' clothing, illustrated in Tables 2 and 3. The proposed clothing underwent extensive laboratory experiments to measure the thermo-physiological comfort properties of the clothing using a sweating thermal manikin in a walk-in environmental chamber under the relevant environmental conditions. For this purpose, the military ensembles mentioned in Tables 1 and 2 were assessed for predicting thermal and evaporative resistances under steady-state conditions in accordance with Test Methods ASTM F1291 and ASTM F2370, respectively. In addition, the Canadian Armed Forces winter base layers' (Table 3) evaporative cooling and moisture management properties were assessed using the sweating manikin in accordance with ISO 18640-1 Standard Test Method. In this part of the research, the combined heat and moisture transfer through the ensemble mentioned in Table 3 were measured using a non-isothermal transient state to determine the dry heat loss, moisture-driven heat loss, evaporative cooling, and moisture management properties of the Canadian Armed Forces winter base layers during a simulated physical activity at a medium intensity (6 Met) for 30 minutes and a recovering phase (1 Met) after the physical activity. The results from these experiments will indicate the thermo-physiological comfort properties of these ensembles, which represent the ability of the clothing to dissipate heat and moisture transfer from the skin to the environment.

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What did the Research Do?

This research determines the thermo-physiological comfort properties of clothing ensembles and their contribution to the rating of the comfort of Canadian Armed Forces clothing.

What did the Research Find?

The results obtained from this research include:

Phase 1:

- Thermal resistance (insulation) of the air layer on the surface of the nude manikin
- Thermal resistance (insulation) of the clothing and surface air layer around the clothed manikin
- Intrinsic thermal resistance insulation of the clothing
- Manikin surface and local area
- Manikin average and zoned surface temperature (℃)
- Power required to heat the manikin (W)

Phase 2:

- Total (entire manikin) and local (individual zones) evaporative resistance of the air layer on the surface of the nude manikin
- Total (entire manikin) and local (individual zones) evaporative resistance of the clothing and surface air layer around the clothed manikin
- Total (entire manikin) and local (individual zones) evaporative resistance of the clothing
- Manikin surface and local area

Phase 3:

- CD: cooling delay (min)
- initial cooling (℃/h)
- sustained cooling (℃/h)
- post cooling (℃/h)
- evaporated moisture (g)
- moisture uptake (g)
- dripped moisture (g)
- drying time (min)

What does this Research Mean?

Thermo-physiological comfort properties of clothing ensembles measured in this research contribute to the rating of the comfort of Canadian Armed Forces clothing. Exploring the data obtained from this research and the interrelation of textile properties and structures from fiber, yarn, and garments provides information for understanding the heat and moisture phenomenon from the skin through these clothing and the environment. The findings of this research enable the engineering of textiles to design military ensembles with enhanced breathability and improved potential to dissipate heat and moisture without sacrificing their protective capabilities.

Sources

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