Preventing Hypothermia in Combat Casualties: An Evaluation of Alternative Systems to Enhance Thermoregulation

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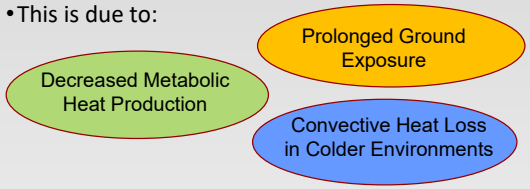
Introduction

- Soldiers injured in combat have an increased vulnerability to hypothermia, which can increase mortality rates.
- Trauma induced hypothermia is a persistent problem affecting military casualties and can occur independent of ambient temperature (Bennett and Holcomb, 2017).
- This is due to:



- Casualties arriving at forward-positioned medical treatment facilities are often in a hypothermic state (Committee on Tactical Combat Casualty Care, 2017).
- Battlefield systems need to prevent heat loss via
  - Conduction
  - Convection
  - Radiation
  - Evaporation
- Currently fielded Reflective Shell System (the Hypothermia Prevention and Mitigation Kit, North American Rescue), is comprised of:
  - Heat reflective shell that wraps around the body
  - Blanket placed on the chest with active warming heat cells (generate heat upon exposure to oxygen) provides heat up to 10 hours.

- Prior work using in-vitro models has s subtle differences after 120 minutes (et al., 2010)
  - No in-vivo studies

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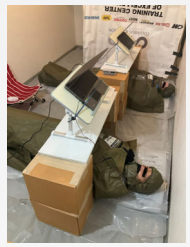
Disclosure: Simon Pennells works for Kingfisher Medical Inc., the company that is developing Xtract system. He was not involved in the data collection and analysis.

Study Objectives:

- To evaluate the benefit of possible alternatives to the currently fielded Reflective Shell System during an in-vivo sampling of participants enduring cold exposure.
- Specifically, this study compared the Reflective Shell System with:
  - Reflective Shell + an inflatable mattress pad
  - An Insulating Enclosure System (The Xtract Heatsaver System, Kingfisher Medical), which comprised of an insulating shell + an inflatable mattress pad.



Methods

Experimental Design

- Repeated Measures Design –
  - Each participant used each of the three hypothermia prevention systems
  - Randomized sequence
  - Only one condition per day
- Cold Exposure
  - Thermal Chamber – 1.7 deg C (35 deg F)
  - Session length: 3 hours
  - Clothing: shorts, t-shirt, socks & gloves.

Study Measures

- Core Temperature – measured rectally every 2 min. using DataThem II
  - Core temp changes: 55, 110, 165 minutes
- Thermal Discomfort – Every 30 minutes using Glickman-Weiss et al. (1994) scale.

Rating	Thermal Sensation
*	Unbearably Cold
10	Very, Very Cold
9	
8	
7	Very Cold
6	
5	Cold
4	Somewhat Cold
3	Very, Very, Cool
2	Very Cool
1	Cool
0.5	Moderately Cool
0	Nothing at all

Participants

- 11 participants: 7 male / 4 female
- Ages 18 – 61 / BMI <= 30
- All signed IRB approved informed consent

Procedure

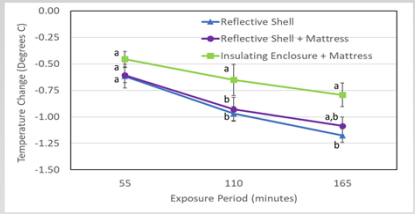
- After probe insertion baseline temp obtained
- Enter chamber – 15 minutes on lawn chair
- Placed in system along with Ready-Heat™ cells for 165 minutes.

Results

Core Temperatures

Table 1. Statistical results for the changes in core temperature readings relative to the starting value at the three time points.

Change in Core Temperature	F	df	p-value
55 minutes	1.35	2, 20	0.282
110 minutes	4.20	2, 20	**0.030**
165 minutes	3.95	2, 20	**0.036**

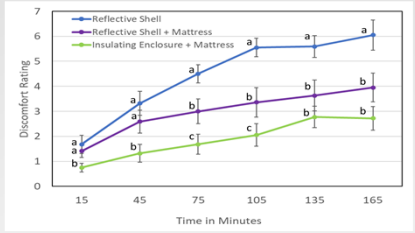


In both charts, conditions at each time points with the different letters are statistically different (p<.05)

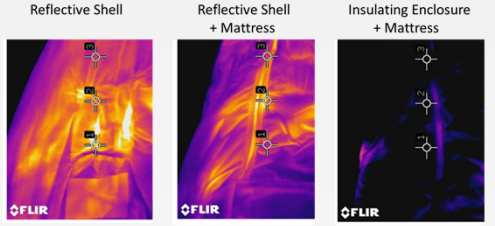
Thermal Discomfort

Table 2. Statistical results for the changes in the thermal discomfort ratings.

Thermal Discomfort Ratings	F	df	p-value
Condition	21.15	2, 20	<.001
Time	36.34	5, 50	<.001
Condition *Time	3.56	10, 100	<.001



Forward Looking InfraRed (FLIR) – 1 subject



Brighter colors indicate warmer temperatures → Greater heat loss experienced by the participant.

Conclusions

- These data support the need to move towards hypothermia protection systems that provide good quality insulation between the combat casualty and the ground.
- They also support the use of more insulating body wraps.
- Fielded systems need to be able to address all significant routes of heat loss affecting the combat casualty by using a sufficient combination of insulation and active warming to prevent environmental heat loss. They must also be easy to carry and easy to effectively implement.