ARMY MEDICINE
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Biomedical Performance Optimization in Cold Environments

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The opinions or assertions contained herein are the private views of the author(s) and are not to be construed as official or as reflecting the views of the Army or the Department of Defense.

USARIEM

Outline

- USARIEM Research Mission, Organization, Capabilities
- Cold Injury Prevention Research Program Overview

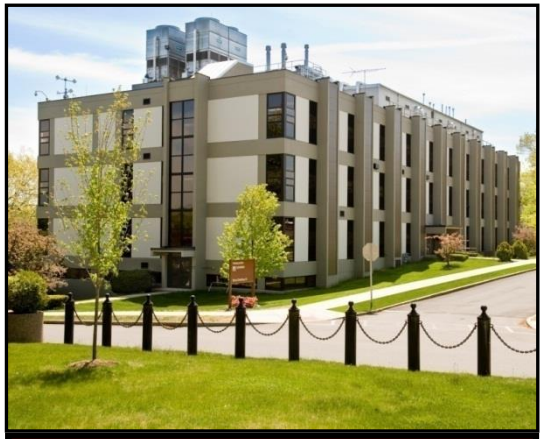
U.S. Army Research Institute of Environmental Medicine (USARIEM)

Mission:

Provide solutions to optimize Warfighter health & performance through medical research.

Organization:

Laboratory within the US Army Medical Research & Materiel Command (MRMC)

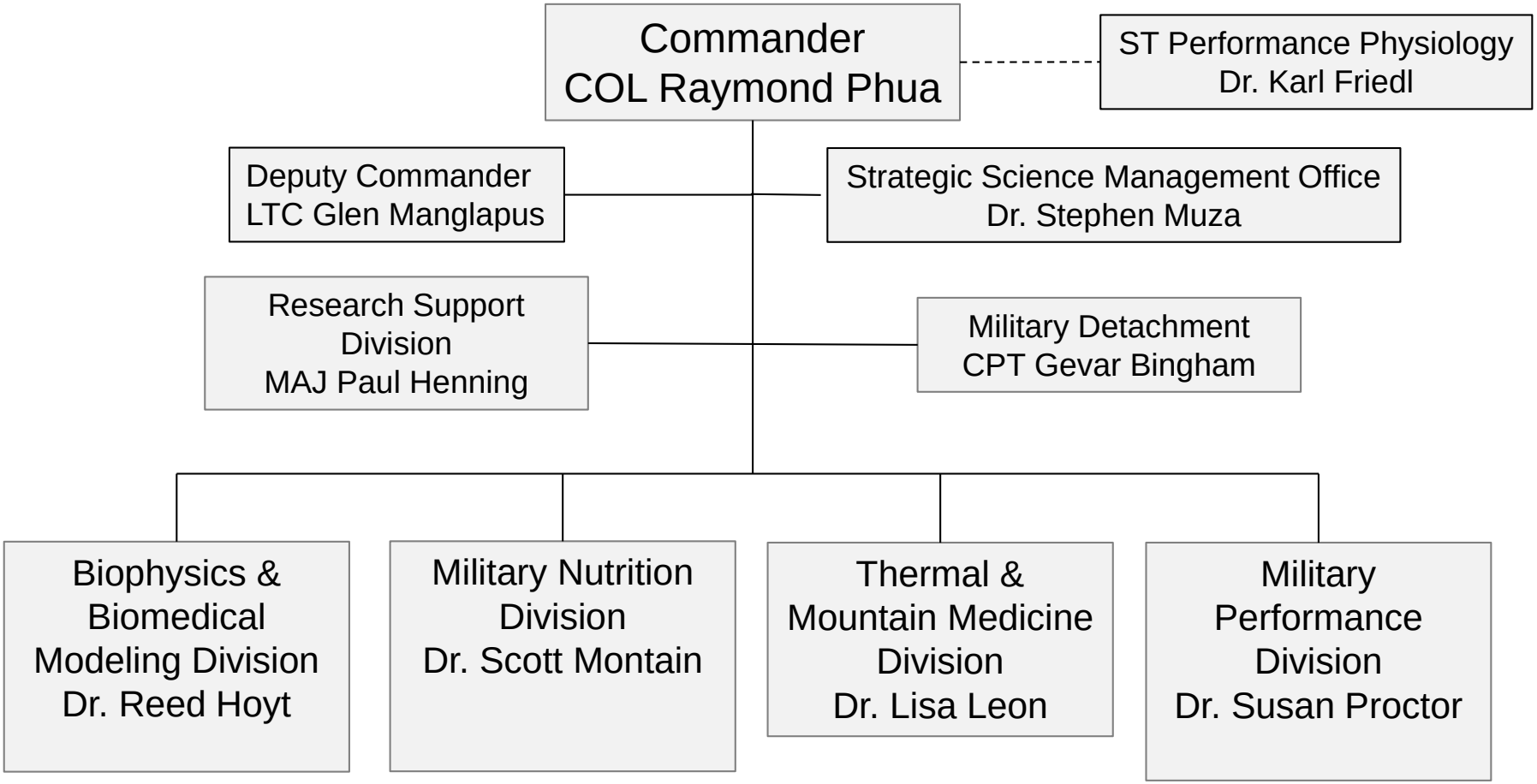


USARIEM

Locations:

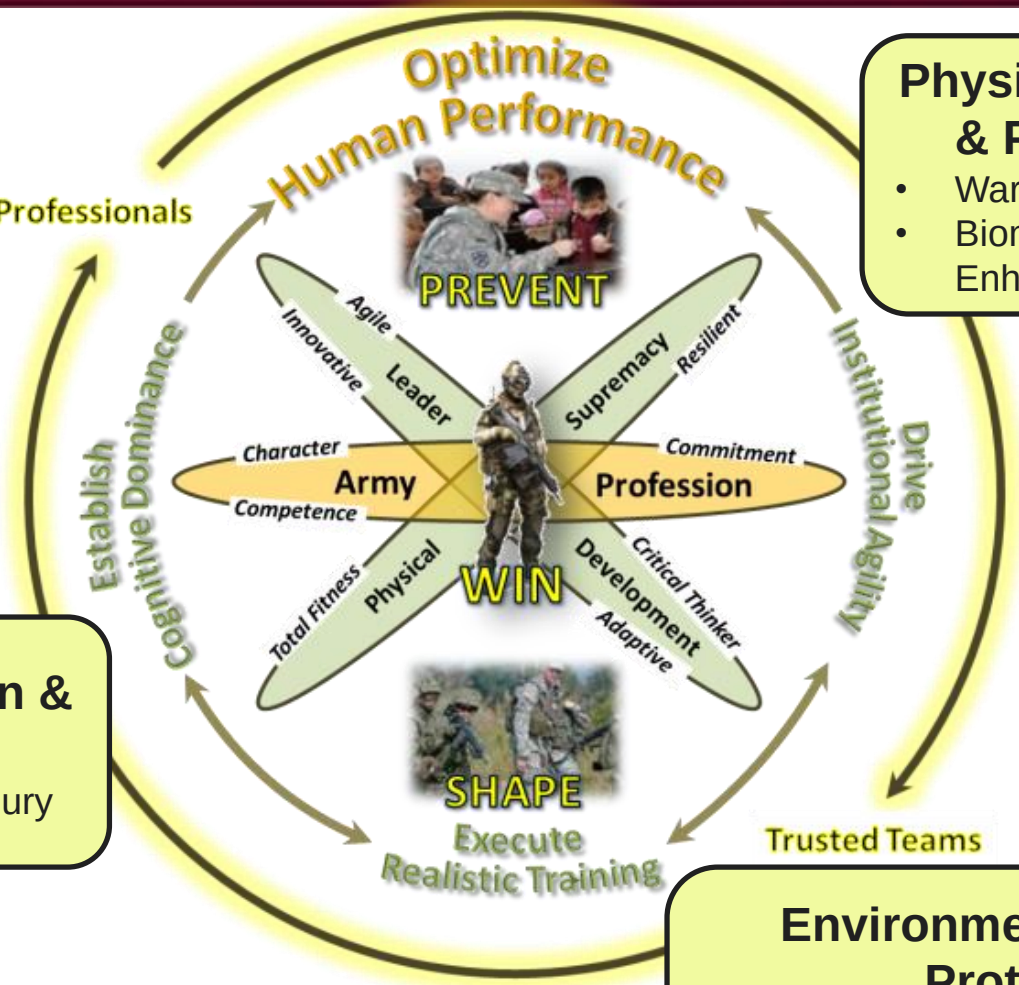
- Natick Soldier Systems Center, Natick, MA.
- High Altitude Research Laboratory, Pikes Peak, Colorado

USARIEM ORGANIZATION



Federal Civilian Personnel: 106
Military Personnel: 43
Interns, Contractors: 58

USARIEM's Roles in Military Operational Medicine



Physiological Health & Performance:

- Warfighter Nutrition
- Biomedical Performance Enhancement

Injury Prevention & Reduction:

- Musculoskeletal injury

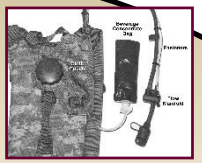
Environmental Health & Protection:

- Performance in extreme environments
- Real-time physiological status monitoring

Knowledge Products and Materiel Solutions to the Warfighter

Strategies to Enhance Warfighter Readiness & Resilience

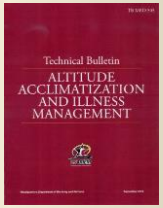
Occupational & Environmental Exposure Limits and Health Risk Prediction & Assessment Models



Biomedical Strategies to Sustain Performance in Continuous Operations

USARIEM research supports Warfighters and Army Medicine…every day

Interventions and tools for Soldiers and family members to attain and maintain fitness and healthy weight



Nutrient Specifications for Rations

Physiologically-Based Guidelines for Performance Optimization and Injury Prevention During Training & Operations

Biomedically-Based Design Criteria for Individual Protection Systems

USARIEM Research Divisions & Programs

Biophysics & Biomedical Modeling

- Biomedical Modeling
- Non-Combat Injury Prevention Modeling
- Physiological Monitoring
- Biomedical Sensors

Military Nutrition

- Nutritional Physiology & Metabolism
- Dietary Requirements
- Eating Behavior & Food Choices
- Nutritional Evaluation of Field Rations
- Dietary supplements

Thermal & Mountain Medicine

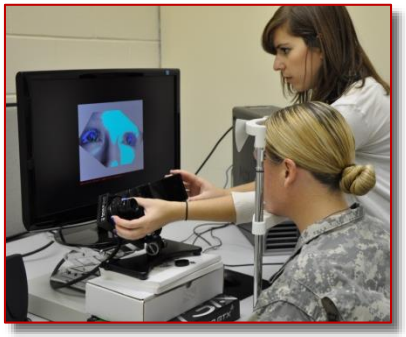
- Heat Stress Physiology
- Cold Stress Physiology
- Altitude and Hypoxia Stress
- Protective Equipment and Microenvironment
- Hydration

Military Performance

- Physical Performance Optimization
- Injury Reduction/Bone Health
- Military Biomechanics
- Cognitive/Neurological Performance
- Prevention of Injury Reoccurrence
- Injury Epidemiology

Research Capabilities

- Doriot Climatic Facility (Arctic & Tropic)
- Human & Animal Thermal Chambers
- Water Immersion Laboratory
- Human Performance Laboratories
- Nutrition Laboratory
- Manikins for Heat Transfer Biophysics
- Hypobaric Chambers (100 – 30,000 ft)
- High Altitude Research Laboratory (Pikes Peak, CO, 14,115 ft)
- Bone Health Laboratory
- Military Biomechanics Laboratory
- Cognitive Performance Laboratory
- Engagement Simulation Trainer Lab
- AAALAC Accredited Vivarium and Surgical Suite
- Biochemistry and Molecular Biology Labs



USARIEM Cold Research Facilities

Water Immersion Facility:

10x10x14 ft pool
5 to 41° C
2 adjustable depth platforms
Underwater treadmill, cycle ergometers

Thermal Manikins:

Thermal Chambers:

USARIEM Cold Research Facilities

Hypobaric Chamber Facility:

2 research chambers, 1 airlock
370 ft^2
0 – 9150 m altitude
-15 to 40°C
0 to 80% Rh

Doriot Chambers:

USARIEM Field Studies

USARIEM Cold Weather Guidance

TB MED 508

Prevention And Management Of Cold Weather Injuries

Department of the Army, 2005

www.usariem.army.mil

Prevention of Cold Injuries During Exercise

ACSM Position Statement

Castellani et al.,

Med. Sci. Sports Exerc., 38: 2012-2029, 2006.

Management of Heat and Cold Stress – Guidance to NATO Medical Personnel

Spitz et al.

USARIEM Technical Report T13-3, 2013

Focused Heating & Manual Dexterity

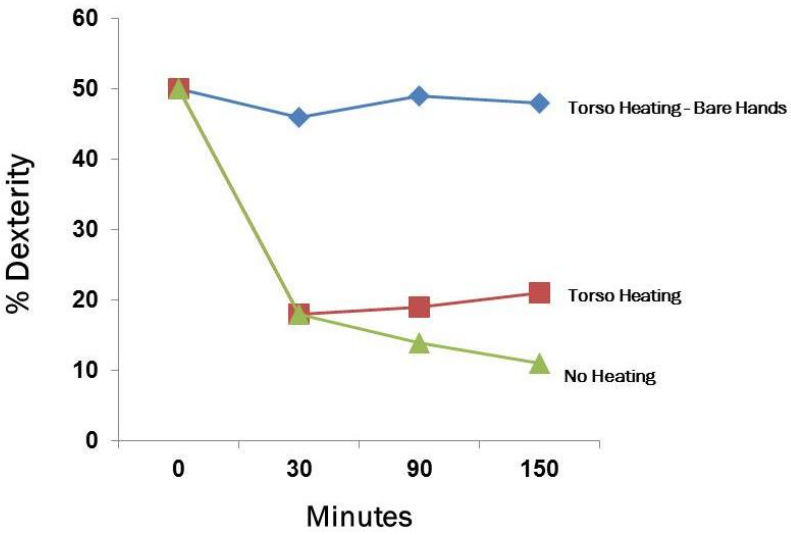
Thermal & Mountain Medicine Division

POC: John Castellani, Ph.D.
john.w.castellani.civ@mail.mil

Cold Exposure Effects

Acute problems:

- decreases manual dexterity
- gloves protect against injury, but 60-70% reduction in dexterity



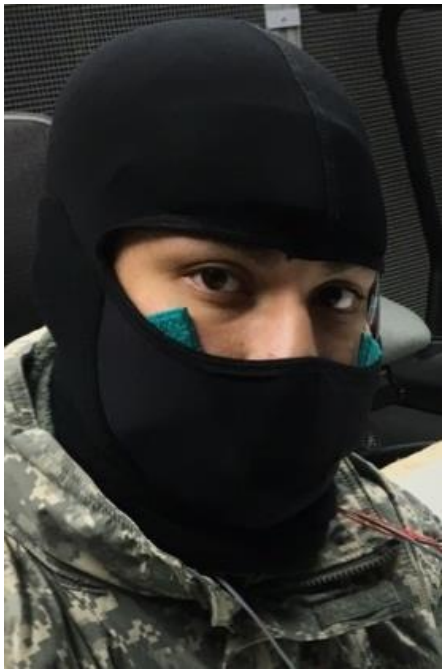
Focused Heating to Improve Dexterity

Methodology

Exploit Physiological Reflexes

Apply Direct Heating

Forehead
Cheeks



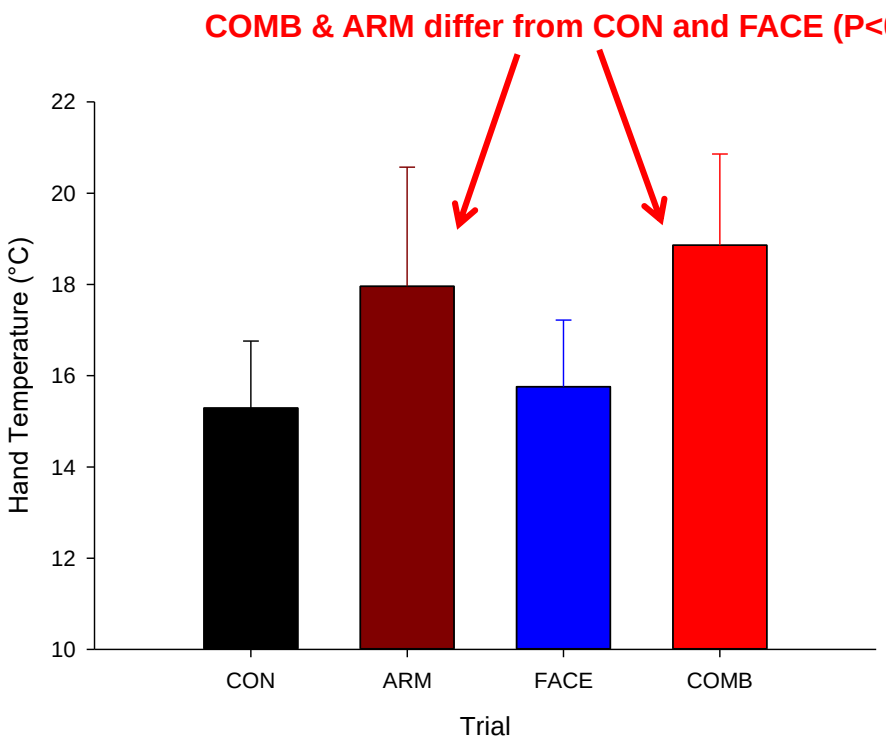
Forearm

Set point:
42°C

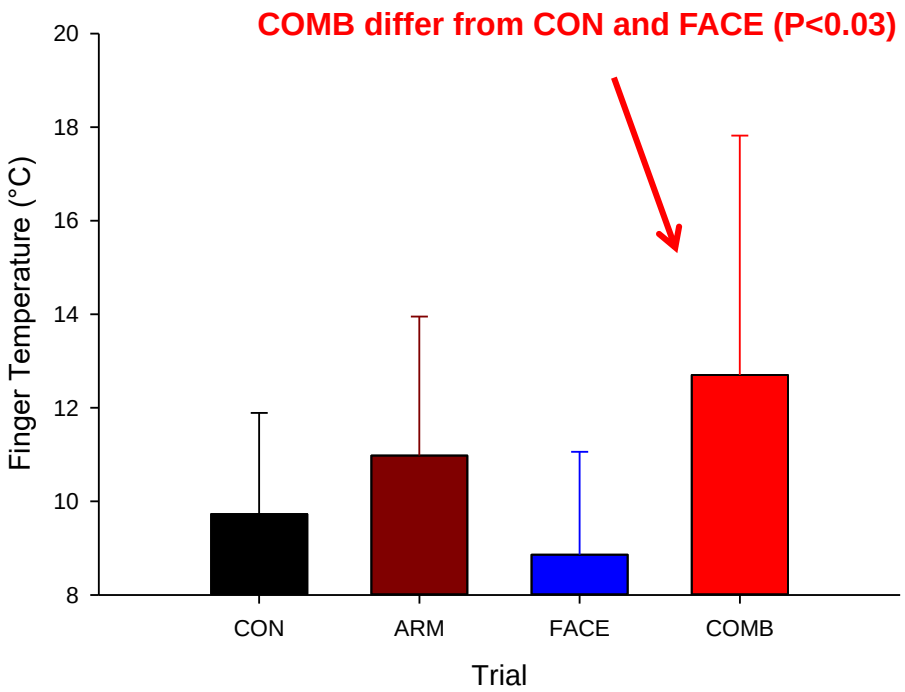
Results - Temperatures

Hand and finger temperatures at min 90

Hand Temperature



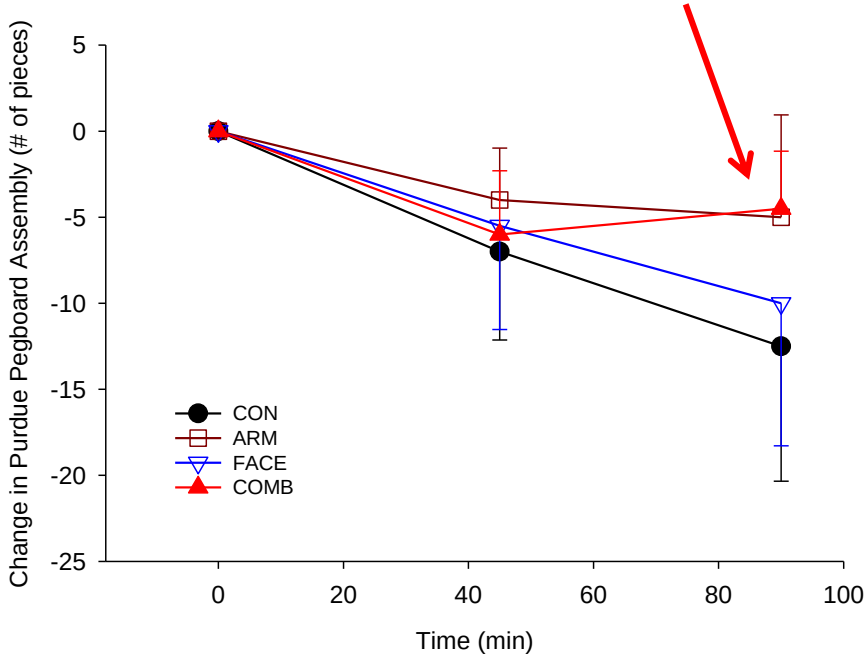
Finger Temperature



Results - Dexterity

Purdue Pegboard Assembly (# pieces)

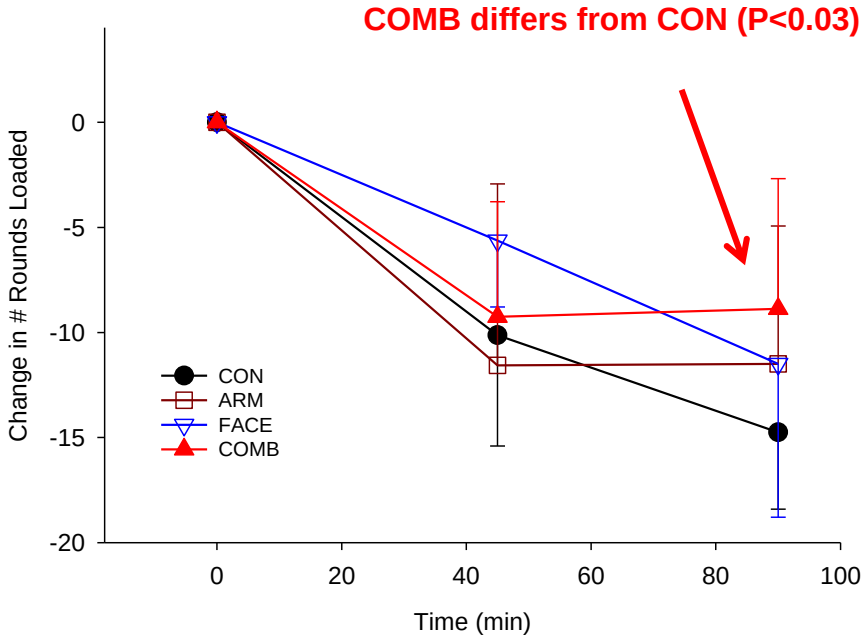
COMB & ARM differ from CON and FACE (P<0.04)



% change:
CON: -35 ± 20%
ARM: -14 ± 20%
FACE: -31 ± 27%
COMB: -14 ± 10%

Magazine Loading (# cartridges)

COMB differs from CON (P<0.03)



% change:
CON: -23 ± 5%
ARM: -17 ± 9%
FACE: -19 ± 13%
COMB: -14 ± 10%

Focused Heating to Improve Dexterity

Next Steps:

Laboratory and limited field testing of prototype forearm heating device currently being made at Edgewood Chemical and Biological Center

Thermal & Mountain Medicine Division

POC: John Castellani, Ph.D.
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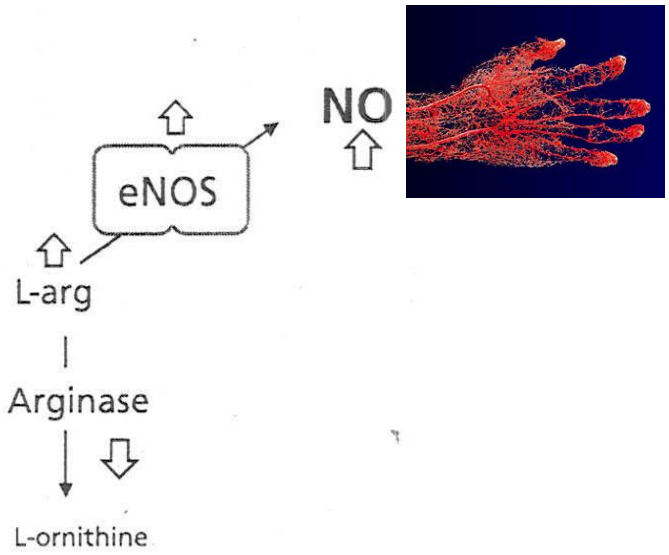
Nutraceutical Countermeasure

Are there countermeasures that can increase peripheral blood flow and overcome the effects of cold-induced vasoconstriction?

Bioflavanols?

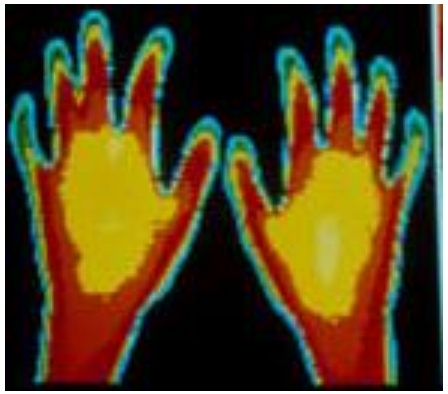


Heiss et al., 2003;
Fisher et al., 2003;
Heiss et al., 2005;
Schnoor et al., 2008;
Fraga et al., 2011

USARIEM POSTER

USARIEM Biomedical Research Efforts in Cold Environments

Expanded overview of USARIEM research projects and products to prevent injury and sustain performance in cold environments



Catherine O'Brien, M.S.
Thermal & Mountain Medicine Division

Performance Nutrition Research in the Arctic

Are combat rations effective when they are the only source of food during strenuous training in cold-weather environments?

What's more effective at preventing physiological and performance declines? More carbohydrate to offset the energy deficit?

Or, an equal amount of energy from protein to leverage the anabolic properties of amino acids?

Scott Montain, Ph.D.
Military Nutrition Division

USARIEM POSTER

Biophysical Evaluation of Four Military Cold-Weather Clothing Systems

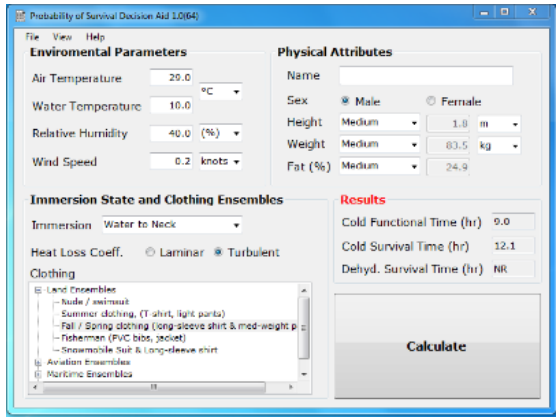
- Four clothing systems were evaluated by the Biophysics and Biomedical Modeling Division:
  - US Army's Extended Cold-Weather Clothing System (ECWCS)
  - US Marine Corps (USMC) cold-weather clothing system
  - Canadian military cold-weather clothing systems
  - Norwegian military cold-weather clothing systems
- Thermal and evaporative resistances were measured on a thermal manikin
  - Each individual garment in all four systems
  - Five or six ensemble configurations of each system
- First systematic study of military cold weather ensembles
  - Provides a comprehensive database on current clothing thermal properties
  - Helps improve current system and design next generation clothing

Timothy Rioux, B.S.
Biophysics & Biomedical Modeling Division

USARIEM POSTER

Science-Based Tools for Arctic Operations: Health Risk Prevention and Evaluation

- Extreme Arctic weather often creates health hazards during field operations
- Common cold injuries are frostbite and hypothermia
- Innovative and science-based tools have been developed to help manage these risks
  - **Cold Weather Ensemble Decision Aid**: assist in selecting appropriate clothing ensembles according to mission scenarios
  - **Probability of Survival Decision Aid**: estimate survival time during cold-water immersion to improve search & rescue operation effectiveness



Xiaojiang Xu, Ph.D.
Biophysics & Biomedical Modeling Division

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