Augmentation Technologies for Enhanced Physical Performance

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Natick Soldier Research, Development & Engineering Center
Natick Soldier RD&E Center

The Soldier's RDEC - Assuring Dominance through Superior Scientific & Engineering Expertise.

Providing the Army with Innovative Science & Technology Solutions to Optimize the Performance of Our Soldiers.
Natick Soldier Systems Center

- 78 Acres
- 459,000 Sq. Ft. of Lab Space
- Total 174 Acres (including 75 Family Housing units)

NSSC Partners

Research & Technology Collaborators

Product/Project Managers Development Partners

Only Active Army Installation in New England
Birthplace of the Army
Mission Areas

- Performance Nutrition
- Joint Foodservice equipment
- Mission-tailored rations

- Small Unit Sustainment Systems
- Airbeam Shelters
- Force Provider Subsystems

- Clothing & Individual Equipment
- Body Armor
- Helmets
- Boots
- Human Sciences

- JPADS
- Helicopter Sling Load
- T-11 Engineering Support

Joint Service Combat Feeding

Warfighter Protection, Survivability, and Optimization

Soldier Systems Engineering

Airdrop/ Aerial Delivery

Expeditionary Basing/Collective Protection
Leading the Research, Development, Test and Evaluation to understand, assess and characterize the impacts that the Clothing and Individual Equipment (gear) and mission tasks have on the Soldier and Squad's physical and cognitive performance.

Diverse scientific fields united by a common focus on optimizing the Soldier as a system, encompassing mind, body, and equipment.

Unclassified
Human Augmentation for Military Use
Developed a better appreciation of the challenge: The human body is very efficient at what it does and is much more complex and elegant than synthetic counterparts.
What does success look like?

Depends...
Example of Methods for Assessing HA Technologies

- Assessment of fit and sizing schemes
  - Measurements made of body and device dimensions and their relationships
- Repeated Measures Design: with and without devices, walking at controlled speeds on the level and up and down grades carrying various load weights for periods ranging from ~15 min to ~120 min
- Measurements made of energy cost, heart rate, ground reaction force, gait parameters (e.g., stride length and rate), body angles (e.g., forward lean of the trunk)
- Monitoring of device operation
  - Power usage, power production
- Administration of questionnaires and structured interviews
  - Acquire opinions on positive and negative features of device, acceptability for military use, mission scenarios in which the device might help or hinder operations, suggested modifications and improvements.
Inertial properties (mass, moment of inertia, center of mass) of the device and load (if attached) must be taken into consideration
  • Affects user’s balance, dynamic stability, and gait mechanics.
• Strive to maintain natural gait mechanics and accommodate gait transitions and dynamic movements out of the sagittal plane
  • Standing to walking, walking to running, cutting to the left or right, etc.
• Reduce metabolic cost and muscular fatigue as compared to carrying loads, performing mission/task without the device
• Limit discomfort at attachment/load transfer points
  • Chaffing, hot spots, pressure points, etc.
• Should not substantially increase the user’s thermal burden
• **Should include safety mechanisms**
  • Hard stops at joints to prevent hyperextension
  • Fail-safe mode in the event of power failure or other device malfunction such that the weight of the device and load attached to it is not transferred to the user in a harmful way
Military Specific Design Considerations

- Fit Soldier-user population and ranges of body dimensions
- Device must operate under austere conditions (MOS dependent)
- Basic military movements must be preserved
  - Running, jumping, weapon firing, assuming prone position, kneeling, etc.
- Must be compatible with clothing and individual equipment and military vehicles
  - Useable with body armor and load-carriage gear
  - No interference (i.e., EMI) that may impede the use of electronics/radios
  - Minimize noise signature
  - Don, adjust, and doff the device quickly and easily, ideally without assistance
  - No snag hazards – exposed cables and structure of device itself
  - User interfaces should be easy to use and intuitive
- Training & Maintenance
  - Time to train up a user
  - Most effective training methods (SOP)
  - Wear and tear and repair
The Current View

1) Human Augmentation is a broad and evolving area that is more encompassing than exoskeletons. Common discipline terminology and taxonomy have not yet been defined.

2) Technical challenges are complex and center on actuation, sensing, energy sources, materials, control strategies, user interface and the integration thereof.

3) Human factors, kinesiology, physiology, and biomechanics must be considered in parallel with technical system development and there is limited data on long term use.

4) Initial success will come in niche applications, focusing on specific tasks in specific environments.
Where do we go from here?

- Determine device performance requirements based on military mission scenarios/task and user MOSs
- Establish a collaborative effort between engineers, biomechanists, human factors specialists, anthropologists, and the user community
- Identify the appropriate joints to actuate, the magnitude of actuation and the timing of the actuation needed for a given task to optimize human performance
- Develop control strategies that can detect user intention, transitional states (e.g., walk to run) and other non steady-state movements (moving over difficult terrain)
- Enhance/develop better modeling and simulation tools to aid with the design and development of wearable exoskeletons
- Develop standardized methodologies and performance metrics to access HA technologies for military (TPA with ARL-HRED)
- Understand the long-term implications of using HA systems
  - Does HA reduce injuries over the long term
  - Prescribed use to maintain strength yet reduce likelihood of injury
Thank You