Law Enforcement Officer Body Armor Research Program
Assessing impact of current and next generation armor designs on law enforcement officers

NIJ Body Armor: The Next Generation

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Overview

- Human Factors @ Mississippi State
- Body Armor Issues
- Phase 1 Study
- Phase 2 Study
Human Factors @Mississippi State

- **Mission**
  - Maximize Performance; Improve Health and Safety
  - Encompass physical and cognitive aspects of human task performance

- **Use combination of traditional analysis tools as well as state-of-the-art tools**

- **Multidisciplinary research engineering group**
  - human factors, ergonomics, cognitive science, kinesiology, physiology, biomedical engineering, virtual environments and digital human modeling

- **8 Faculty, 1 Lab Manager, 10+ active students**
Human Performance Lab

- Motion capture facility
  - 14 cameras, up to 4 participants @500 FPS
  - 2D and 3D, static and dynamic analysis tools
- EMG measurement
- Portable eye tracker
- 8-camera video recording
- Thermography
- CorTemp core body temperature
- BioHarness HR, BR, skin temp
- Cortisol stress hormone analysis
Driving Simulation Lab

- Nissan Maxima
- 6 DoF motion base
- 180 front screen
- LCD side mirrors
- Rear screen visible in rear mirror
- Fully programmable physics-based drive simulation software
- Integrated data collection (audio/video, driver performance, vehicle stats, eye tracking data, etc)
Human Factors Research Areas

- Law Enforcement
- Industrial Ergonomics
- Driving Simulation
- Sports Performance
- Digital Human Models

Mississippi State University

CAVS
Overview

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Benefits of Current Body Armor

- 3000+ lives saved (IACP/Dupont Survivors Club)
  - Ballistic and non-ballistic incidents
- High level of threat protection (.06)
  - IIA: 9mm FMJ RN, .40 S&W FMJ
  - II: 9mm FMJ RN, .357 Magnum JSP
  - IIIA: .357 SIG FMJ FN, .44 Magnum SJHP
  - III: 7.62mm FMJ (M80)
  - IV: .30 cal AP (M2AP)
- Lightweight and flexible materials
- Durable and wearable constructions
Potential Weaknesses

- Selection and Application Guide to Personal Body Armor – NIJ Guide 100–01
  - Coverage
    - Armor Panels
    - Proper Fit
  - Comfort
LEO Injuries and Fatalities in Assaults with Firearm

- ~200 Injuries per Year
- ~49 Fatalities per Year

FBI UCR LEOKA Firearms Fatalities and Injuries

![Graph showing firearms fatalities and injuries from 2000 to 2009. The graph has a y-axis labeled 'Number of Officers' ranging from 0 to 250, and an x-axis labeled with years from 2000 to 2009. The graph displays two lines: one for firearm deaths (red) and one for firearm injuries (gold).]
FBI UCR LEOKA Statistics

- 2003–2009 LEO Firearm Fatalities
  - Total (N = 331)
    - 58% fatal head wound
    - 40% fatal torso wound
    - 2% below waist
  - Wearing Armor (N = 214)
    - 67% fatal head wound
    - 32% fatal torso wound
    - 1% below waist
2003–2009 LEO Firearm Injuries

- 1964 Total Reported Injuries
- 592 Detailed Incident Reports
- 520 Officers Wearing Armor
  - 55% injuries off-torso
  - 17% injuries stopped by armor
  - 21% injuries off-vest torso
  - 52% of torso hits were not stopped by armor
Armor Coverage and LEO Torso Injury

Entry Point of Off-Armor Torso Fatal and Non-fatal GSWs
(FBI UCR LEOKA Data 2003-2009)
Additional Research Data

- Dr. Marianne Wilhelm
  - News reports (N = 110)
  - Direct contact with survivors (N = 18)

Off-vest Torso Injury Location (by Study)

![Bar chart showing injury locations and study data]

- News Report Cases
- Wilhelm Cases
- Weighted Average

Legend:
- Side Panels
- Armhole/Shoulder
- Above Vest
- Below Vest

*Reported injuries excluding those coded as not applicable.
Potential Weaknesses

- Coverage
- Comfort
  - Mobility
  - Weight Distribution
  - Thermal Discomfort
  - Task Performance
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MSU Armor Study Phase 1

20 Participants

14 Tasks
- Range of Motion
- Sit
- Kneel
- Slow Ingress
- Slow Egress
- Fast Ingress
- Fast Egress
- Egress and Fire
- Egress Move and Fire
- Tactical Walk
- Duck and Run
- Weapon Draw
- Weapon Reload
- Suspect Restraint

7 Measurements
- Center of Pressure
- Heart Rate
- Skin Temperature
- Tympanic Temperature
- Task Completion Time
- Range of Motion
- User Perception
Example Tasks
Concealable Body Armor Results

- No Impact on Sit/Kneel Posture
- No Impact on Heart Rate
- No Impact on Skin or Ear Temperature
- Time to complete all 13 timed tasks ~3 seconds longer
- Reduces range of motion:
  - Back Left/Right Lateral Bending
  - 2-arm adduction (weapon stance)
  - Shoulder abduction
- Officers *perceive* slight impact on:
  - Bending backwards and forwards
  - Reaching handcuffs
  - Restraining suspects
  - Moving the upper torso

1. 2. 3. 4. 5.
External Body Armor Results

- No impact on sit/kneel posture
- Increased Heart Rate
- No impact on skin/ear temperature
- Time to complete all 13 timed tasks ~3 seconds longer
- Range of Motion reduced:
  - All shoulder RoM
  - Back bending and rotating
  - Neck rotation

- Officers *perceive* slight to moderate impact:
  - *All measures*
Impact of Shoulder Pads

- Quick and dirty side-study
  - 6 student participants
  - Shoulder RoM in tactical body armor
    - With shoulder protection
    - Without shoulder protection
  - Results
    - All shoulder RoM except internal rotation reduced when wearing shoulder protection
Phase 1 Results

- Very minimal impact of concealable body armor
- Identified a sensitive battery of mobility tests
- Subjective Impact > Objective Impact
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MSU Armor Study Phase 2

2 Experiments:
  Concealable vs Novel Design
  Concealable vs External Carrier Design

20–30 Participants per Experiment

7 Tasks
- Range of Motion
- Sit
- Kneel
- Egress Move and Fire
- Duck and Run
- Weapon Draw and Load
- Suspect Restraint

7 Measurements
- Heart Rate
- Skin Temperature
- Core Body Temperature
- Task Completion Time
- Range of Motion
- User Perception
Extended Coverage

Off-vest Torso Injury Location (by Study)

Data Source
Novel Armor Design

- 2 Ballistic Insert Panels
  - Shoulder Ballistic Insert (Deltoid Pad)
  - Side Panel Ballistic Insert (Rib Pad)

- Concerns
  - EBA Shoulder Pauldrons significantly reduce range of motion
  - Existing side panels impact left/right lateral bending
  - High side panels are reportedly uncomfortable
  - Small to medium sized inserts may not be sufficient for ballistic protection
External Carrier Design

- Commercially Available Carrier
- Significant interest in the LEO community in external carriers
Phase 2 Results

- Data Collection: Summer 2011
- Results by October 2011
- Final Report in December 2011
Acknowledgements

- Debra Stoe, Program Manager
  - Special thanks to the NIJ for providing support for the body armor research program (Grant #: NIJ 2007-DE-BX-K011)
- Many graduate and undergraduate students at Mississippi State University Industrial Engineering and CAVS
- Starkville Police Department and other local departments and their officers for their assistance and willingness to participate in our studies
- Dr. Marianne Wilhelm
Thank You!

Questaions?

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