NAVAL HEALTH RESEARCH CENTER

# Quantification of cervical and lumbar spine kinematics and muscle physiology in swift boat combatant crewman

**Applied Translational Exercise and Metabolic Physiology Team (ATEAM) Department of Warfighter Performance**

**PI: Dr. Karen Kelly**
**Naval Health Research Center, San Diego, CA**

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The study protocol was approved by the Naval Health Research Center Institutional Review Board in compliance with all applicable Federal regulations governing the protection of human subjects. Research data were derived from an approved Institutional Review Board protocol, number NHRC.2021.0005.

# Background

- Special warfare combatant craft crewman (CCC) operate high-performance crafts on missions aimed at unconventional warfare, special reconnaissance, direct action, and counterterrorism.
- CCC are frequently exposed to various sea states and gravitational forces on a non-stable platform.
- High frequency and magnitude loads experienced by CCC during transit impact musculoskeletal structure, increasing risk of injury and decreased physicality.

*Photo courtesy of US DoD*

# Background

- Anecdotal reports from operators complain of lower limb and back pain.

- Shock mitigation seats were implemented to mitigate the effects of high frequency and magnitude of loading.
  - Reports from operators indicate that the design of the seat when donning a helmet moves the head forward, resulting in unusual posture and loading on the neck, causing reports of pain and injury in the cervical spine.

*Photo courtesy of US DoD*

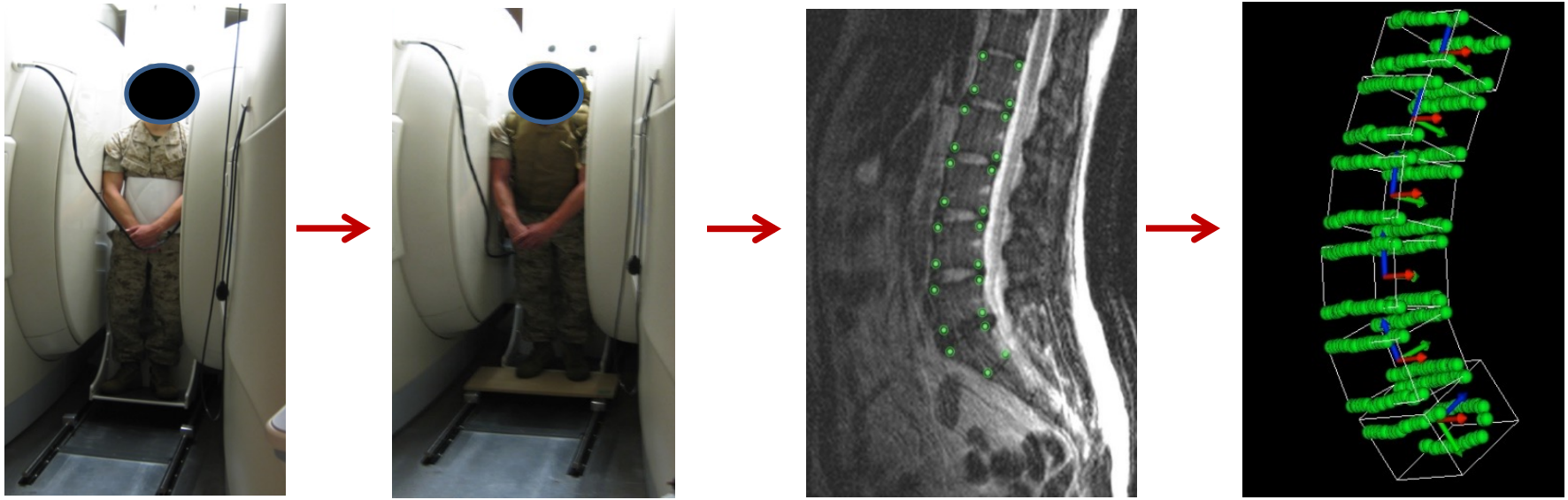
# Background

- Former efforts evaluated the effects of load on lumbar spine injuries in Marines.
- Developed vertical MRI protocol for lumbar spine:
  - Quantified kinematics of spine under load
  - Quantified muscular adaptation from chronic load
  - Effect of load placement
- Evaluated the effect of operational position on spine.

*Photo courtesy of US DoD*

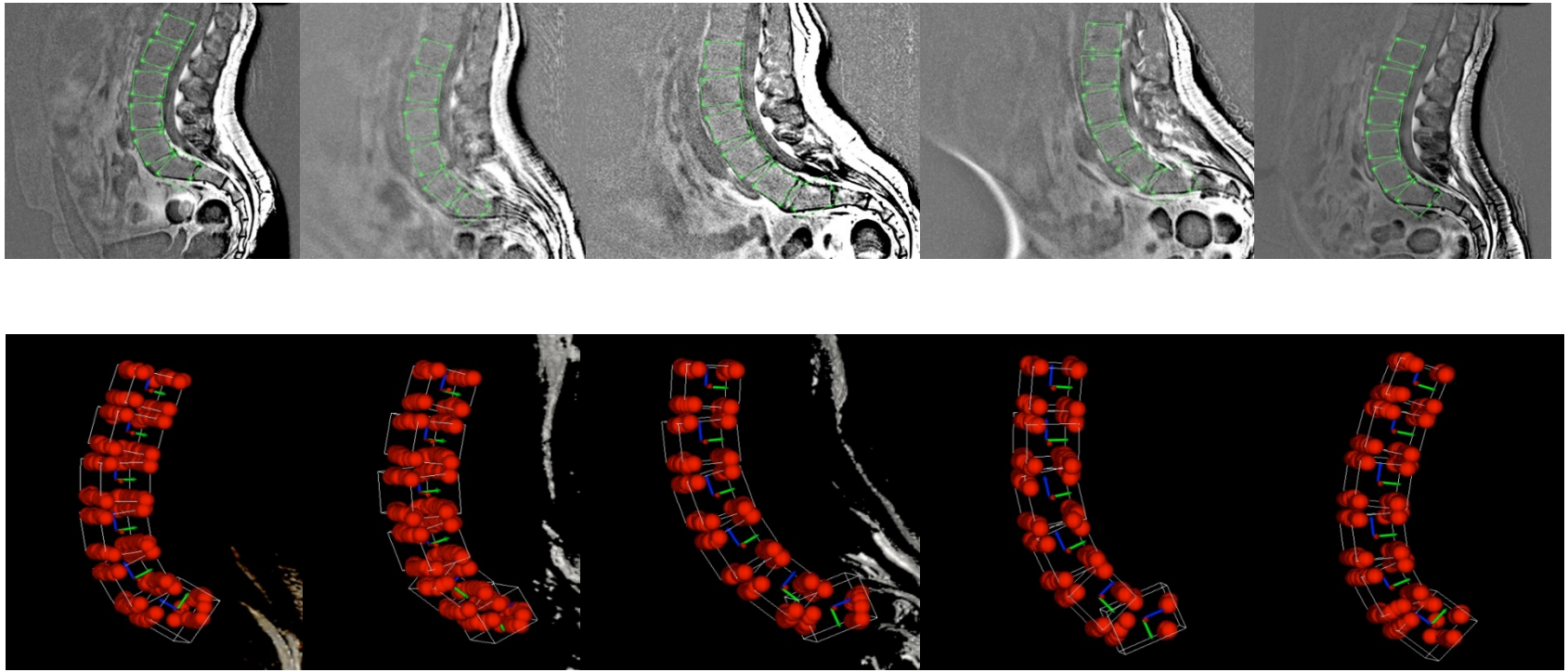
## **Model development**:

- Standing unloaded vs. loaded
- Operational positions



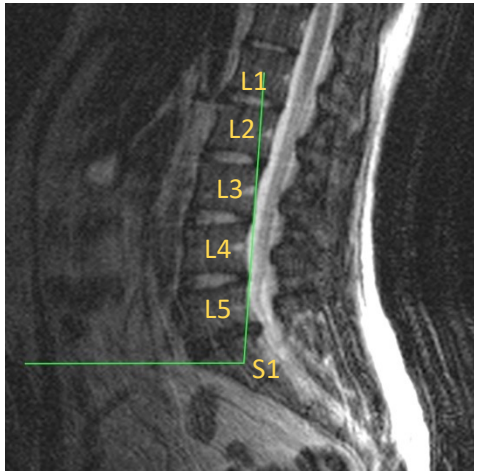
*Photos courtesy of NHRC*

Unloaded Loaded Loaded 45 Walking 45 Side-lying 45

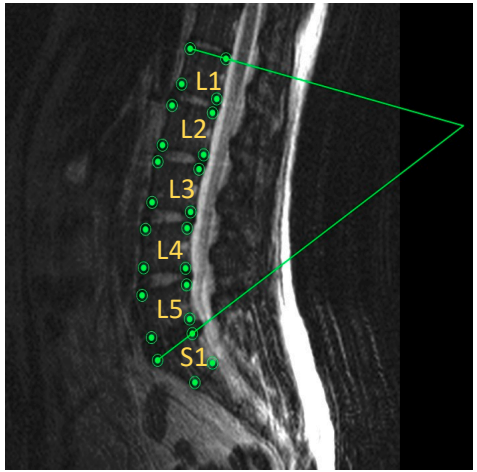


*Photos courtesy of NHRC*

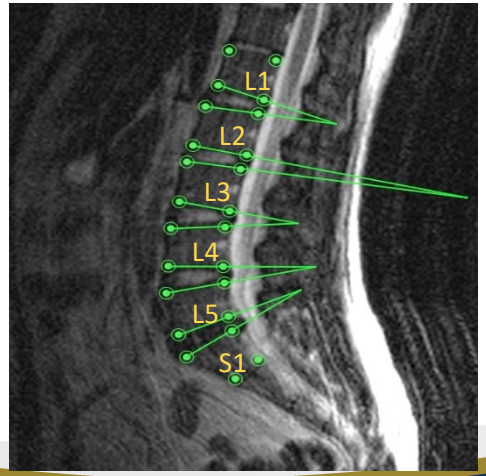
Horizontal Angle



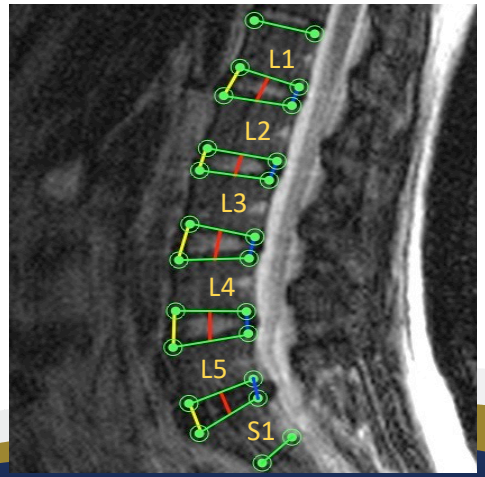

Cobb Angle



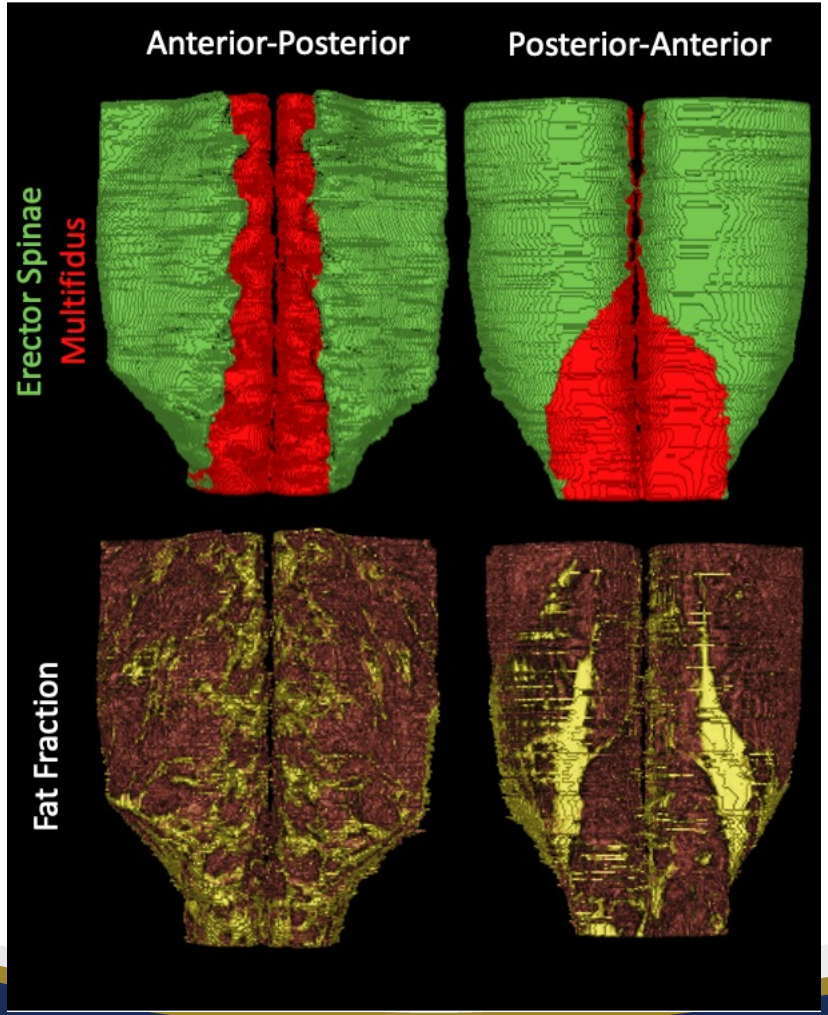

Intervertebral Angle




Intervertebral Distance

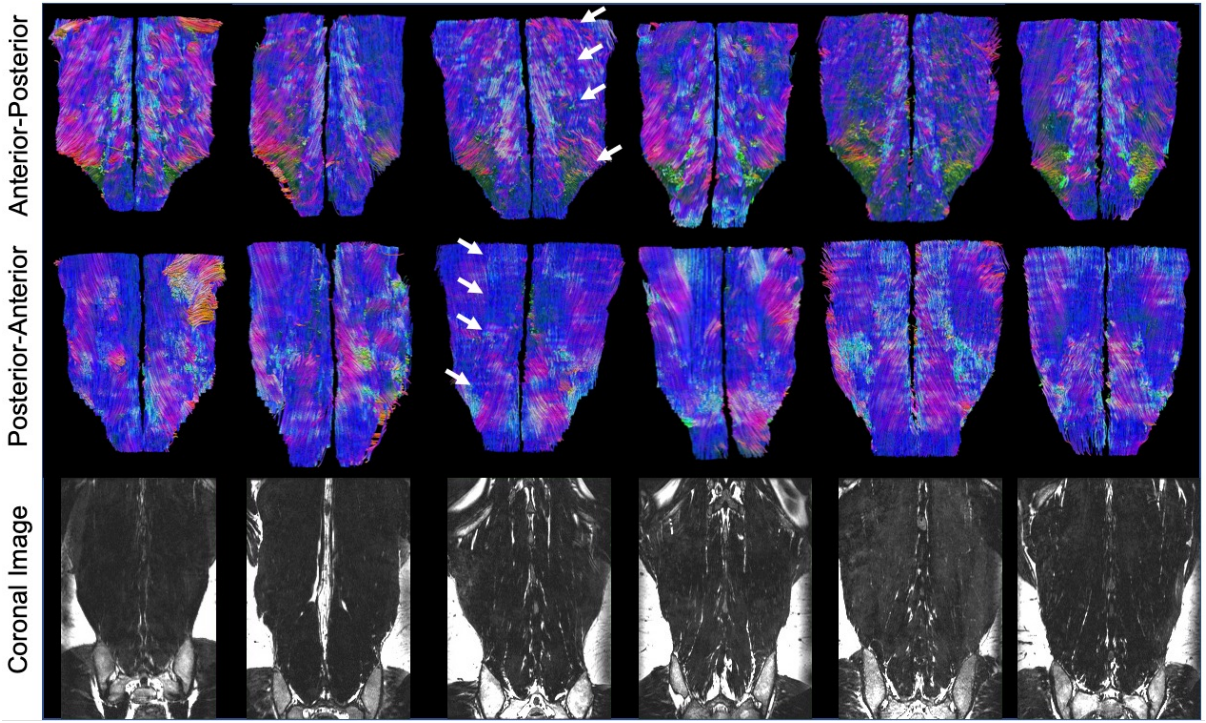



*Photos courtesy of NHRC*




3D reconstructions of muscle volume (top) and fat signal fraction (bottom) of the lumbar spine muscles from L1-S1

*Photo courtesy of NHRC*




These images demonstrate subject-to-subject variation in lumbar muscle size and fiber orientation. The border between the iliocostalis and longissimus muscles is highlighted by white arrows for one subject.

*Photo courtesy of NHRC*

Representative tractography images of the lumbar spine from 6 Marines (Top, middle rows) with corresponding high resolution reformatted coronal anatomical MRIs (bottom row). Colors in the tractography scans indicate direction of the tracked fibers (blue – superior/inferior; red – medial/lateral; green - anterior/posterior).

# Goals

1. Expand on previous work to quantify impact of high-speed boat operations on lumbar and cervical spine.

2. Develop mitigation strategies through “pre-hab” based upon data acquired coupled to PT assessments.

3. Rest-work cycles to allow for recovery

*Photo courtesy of NHRC*

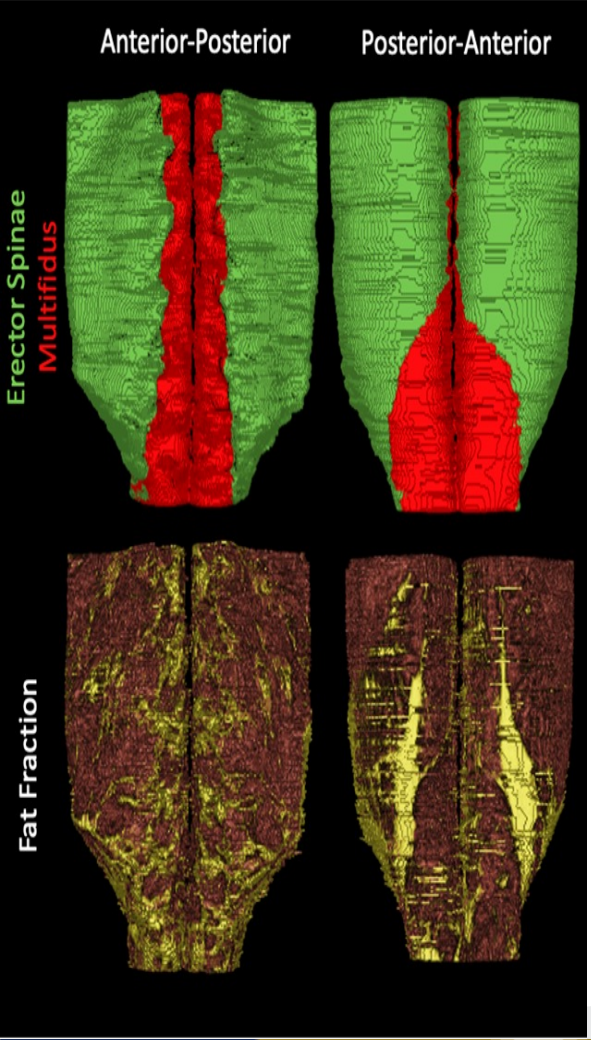
# Aims

1. To understand lumbar spine and lumbar disc kinematics between the two primary crafts (CCA and CCM).

2. To understand the influence of muscle structure and physiology on lumbar and cervical spine kinematics under simulated operational conditions.

3. To measure structural changes over time (2-3 years).

*Photo courtesy of NHRC*




# Methods

Aims 1 and 2:

- Acquire both supine and vertical MRI in various operational positions.
- Representative sample of CCA and CCM operators with varying degrees of time of service.
- Representation of 5 primary CCM positions.
- Instrument the boats and operators with monitor to capture whiplash and impacts over a training cycle.

*Photo courtesy of NHRC*

# Methods

Aim 3:

- Image immediately upon graduation prior to going to first operational unit.
- Image 1x per year for 2-3 years depending on when they start.
- Need 20 complete data sets, so aim to recruit 30 new operators.
- Issue subjects a wearable accelerometer to track daily exposure to rapid changes in g-forces and loading.

*Photo courtesy of NHRC*

# Risk and Benefit

**Risk:**

- None to participant
- May find spinal issue but will direct to Navy Medical provider

**Benefit:**

- Determination of impact of occupation on cervical and lumbar spine
- Understanding of how spine adapts to impacts and changes in muscle structure and physiology
- Target specific muscle groups as well as accessory muscles to stabilize spine
- Training implications, prehab from PT perspective
- Educating operators on potential impacts
  - Longevity of operator
- Understanding impact to possibly modify training schedule
  - "crew rest"

*Photo courtesy of NSW*

# Questions

*Photo courtesy of NHRC*