New Frontiers in Wearable Technology

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About Me

Assistant Professor – Apparel Design (2016-present)

Dept. of Design, Housing, & Apparel (DHA)

College of Design – UMN Twin Cities

- Co-Director, Wearable Technology Lab (WTL)
- Director of Graduate Studies (DGS), Human Factors and Ergonomics (HFE) Program
- Affiliate appts: Product Design, Human Factors, Aerospace Engineering & Mechanics, MnDRIVE RSAM, MN Robotics Institute

Education: MIT (2003-2014)

- SB ’07 -- Aerospace Engineering
- SM ’10 -- Aeronautics and Astronautics
- SM ’10 – Tech. and Policy
- PhD ’14 -- Aerospace Biomedical Engineering
- Man-Vehicle Lab (MVL)
- NASA Space Technology Research Fellow (NSTRF)
  - 2011-2014

About the UMN Wearable Technology Lab

- Founded by Dr. Lucy Dunne in 2009
- Three lab facilities:
  - 322, 340, 344 McNeal Hall
  - UMN St. Paul Campus
- 8 graduate students, 3 undergrads

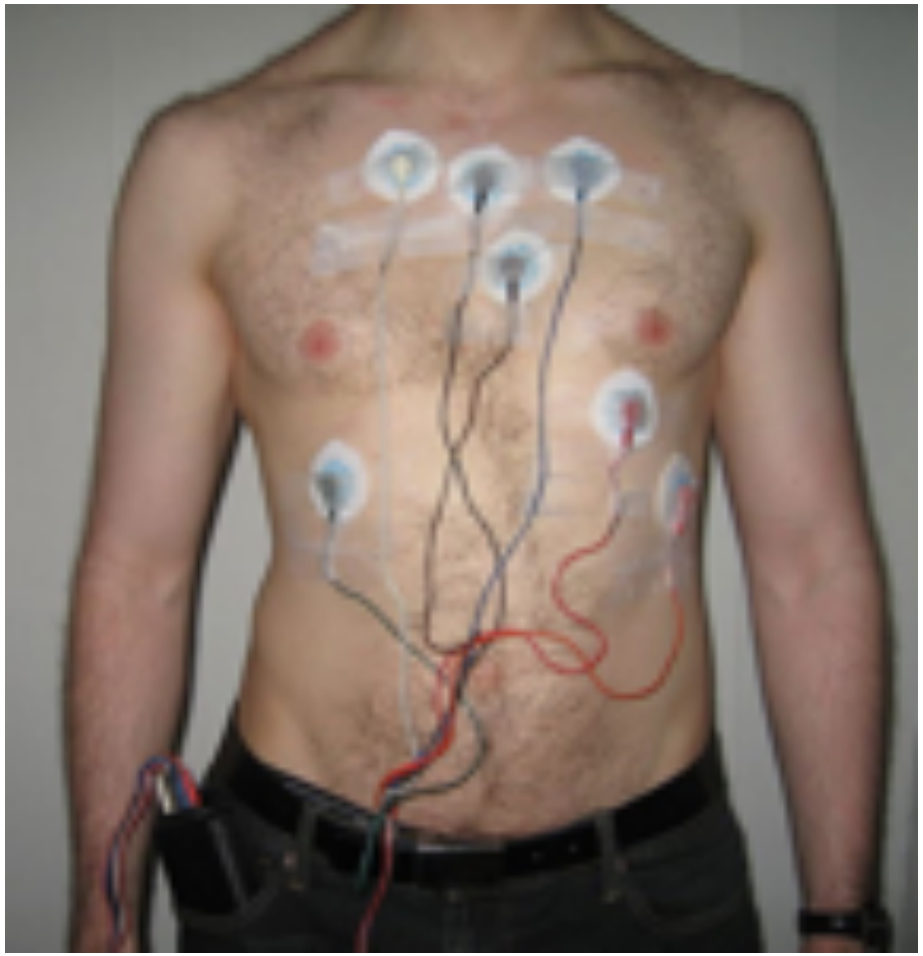
Facilities include:

- Cyberquins Running Mannequin
- BTS SMART-E optical motion capture system
- Biopac biological data acquisition system
- BMR Clinical electrical muscle stimulators
- 4-channel Thermoprobe
- Foam cutter
- Laundry facilities
- Instron tensile tester with environmental chamber
- Tekscan Pressure Measurement System
- Taz 5 3D printer
- 16-spool braiding machine
- Carbolite LHT Box Furnace

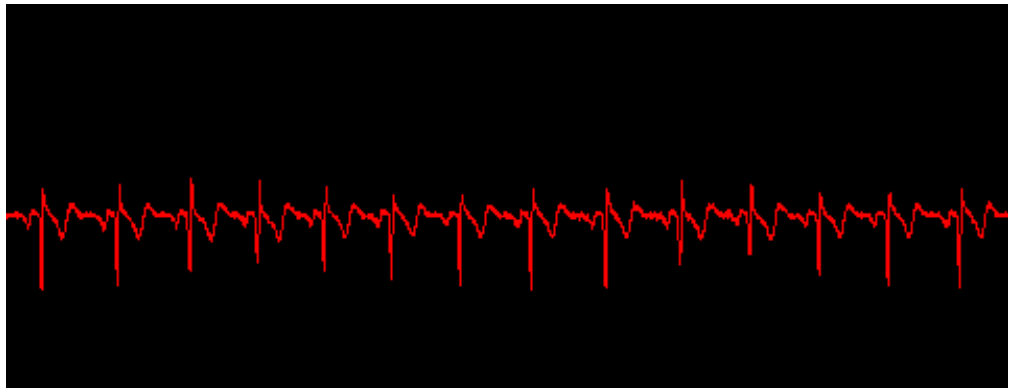
wtl.umn.edu

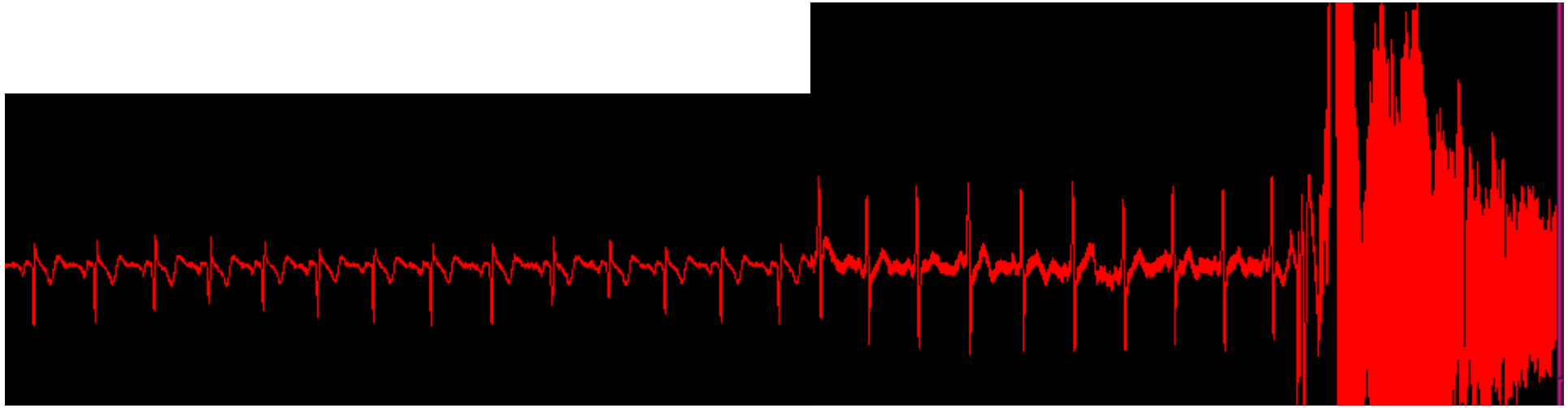
vs.

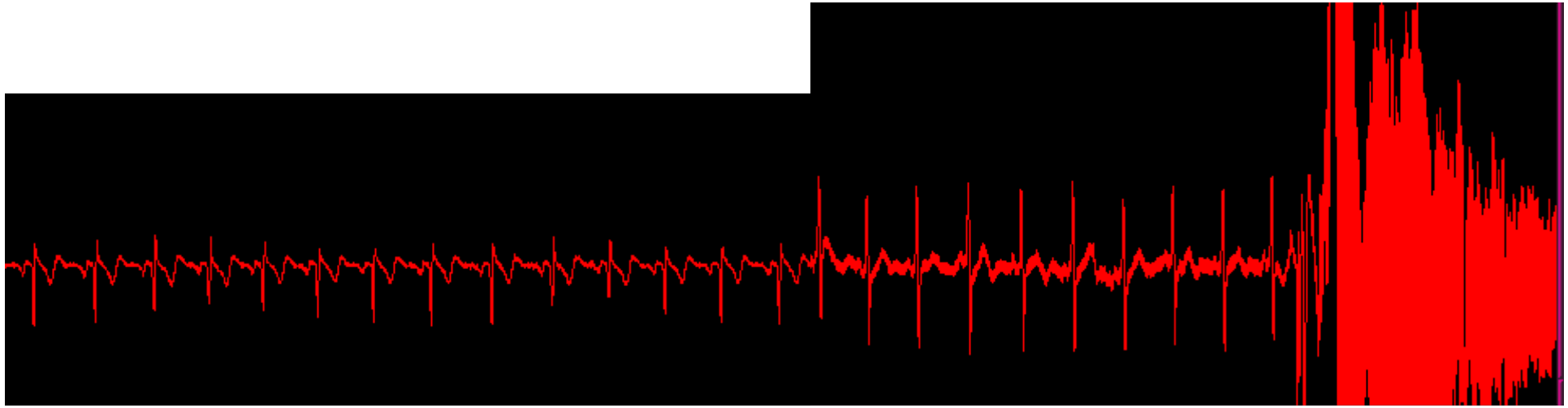
Challenges of Wearable Sensing

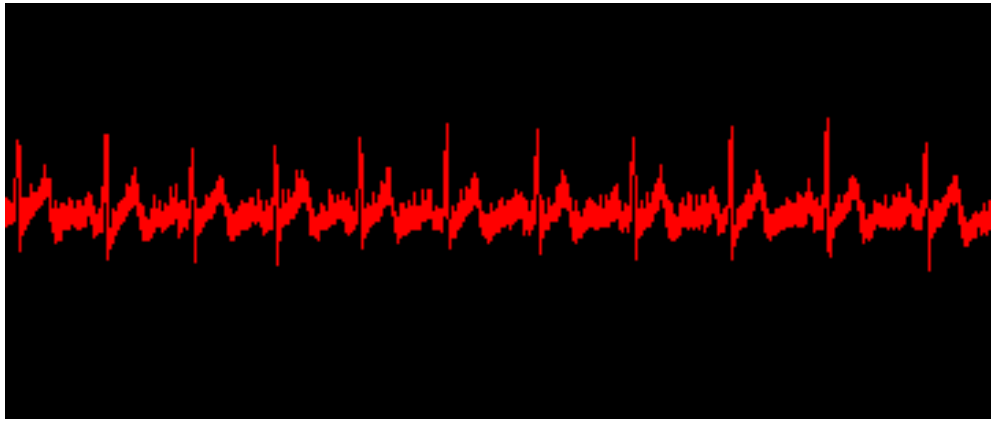


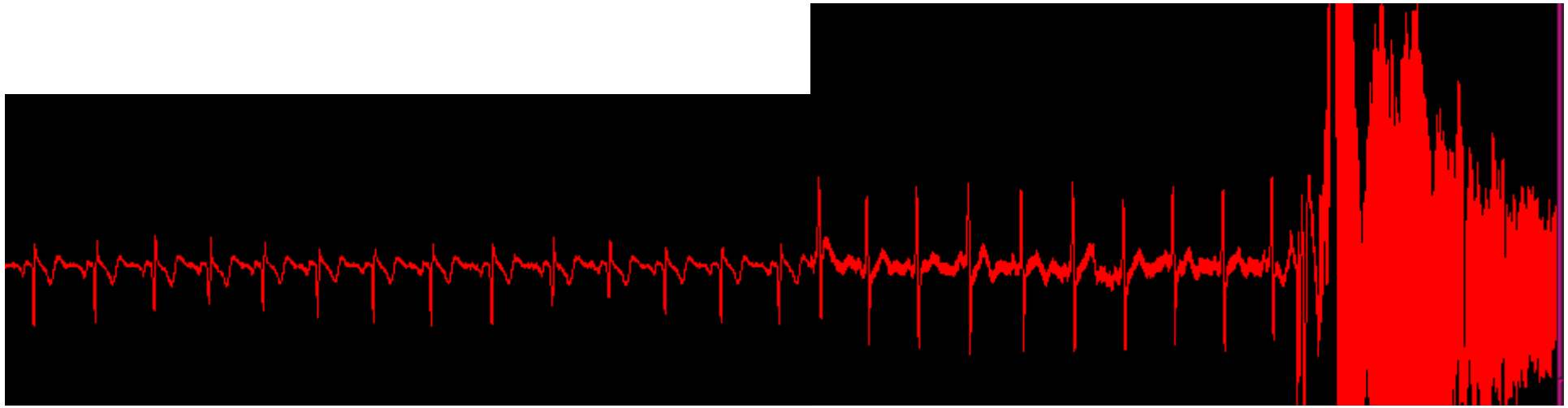

ECG Electrodes
EMG Electrodes

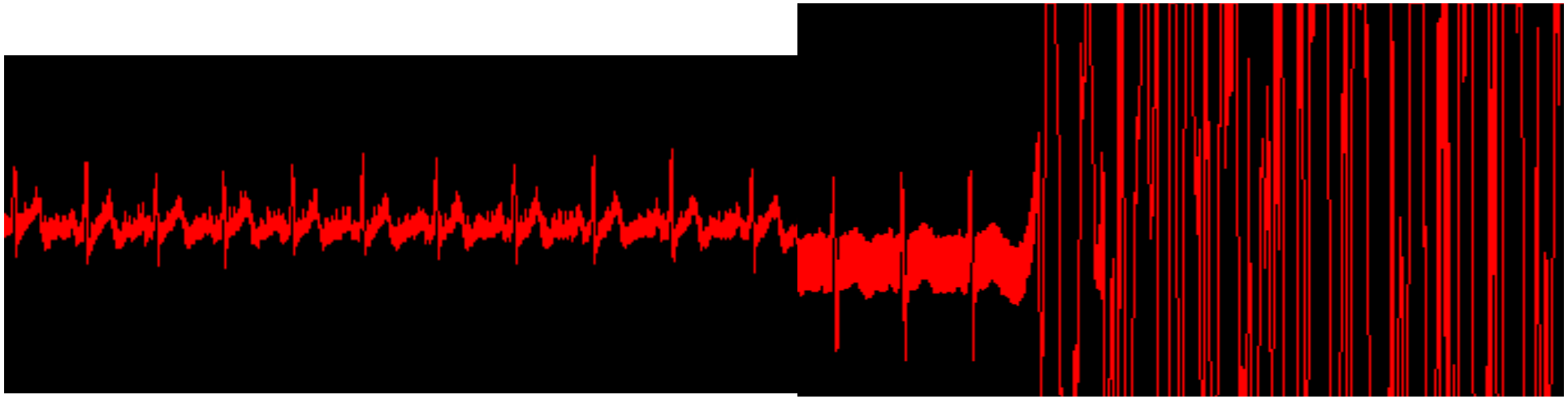


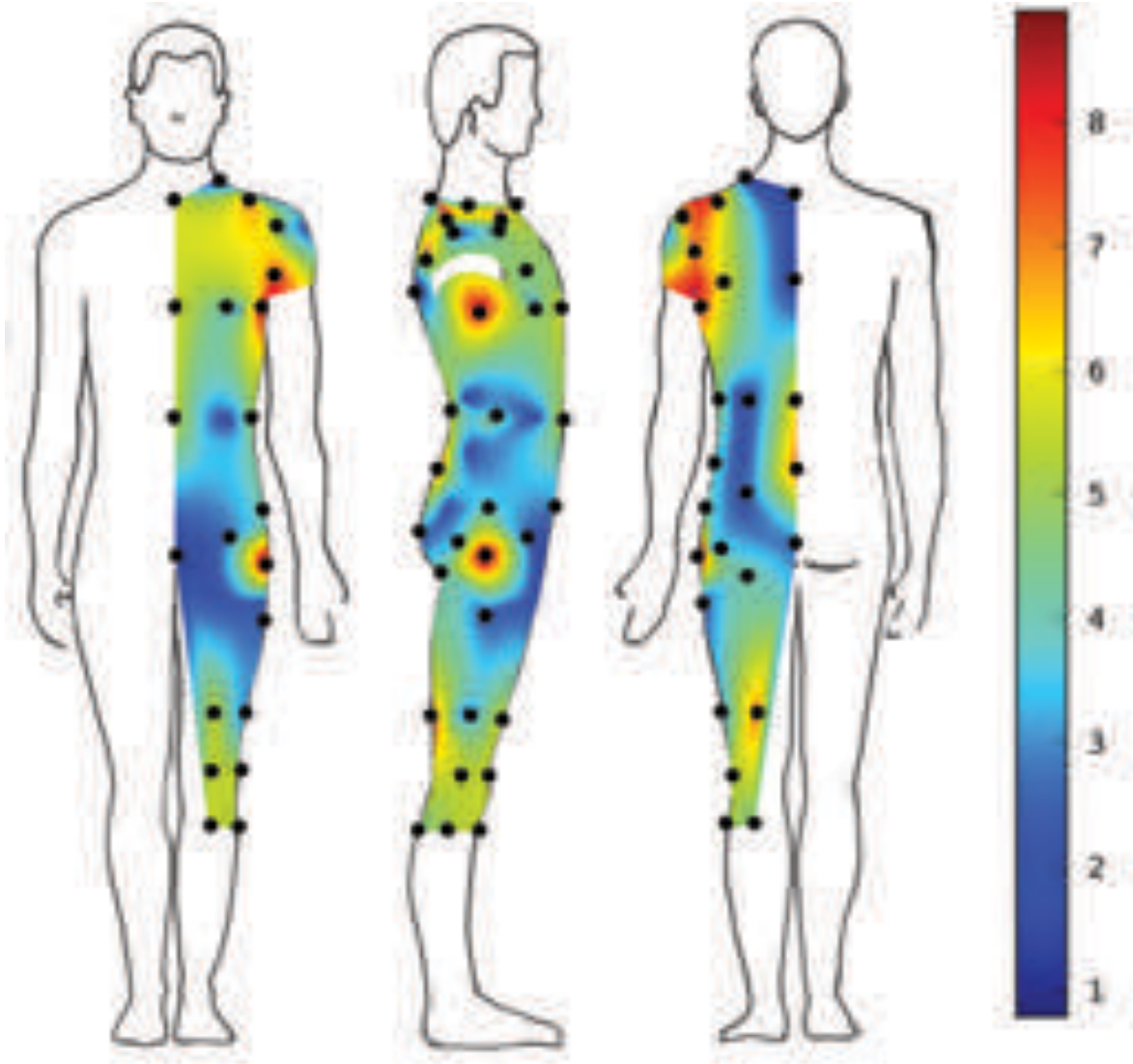




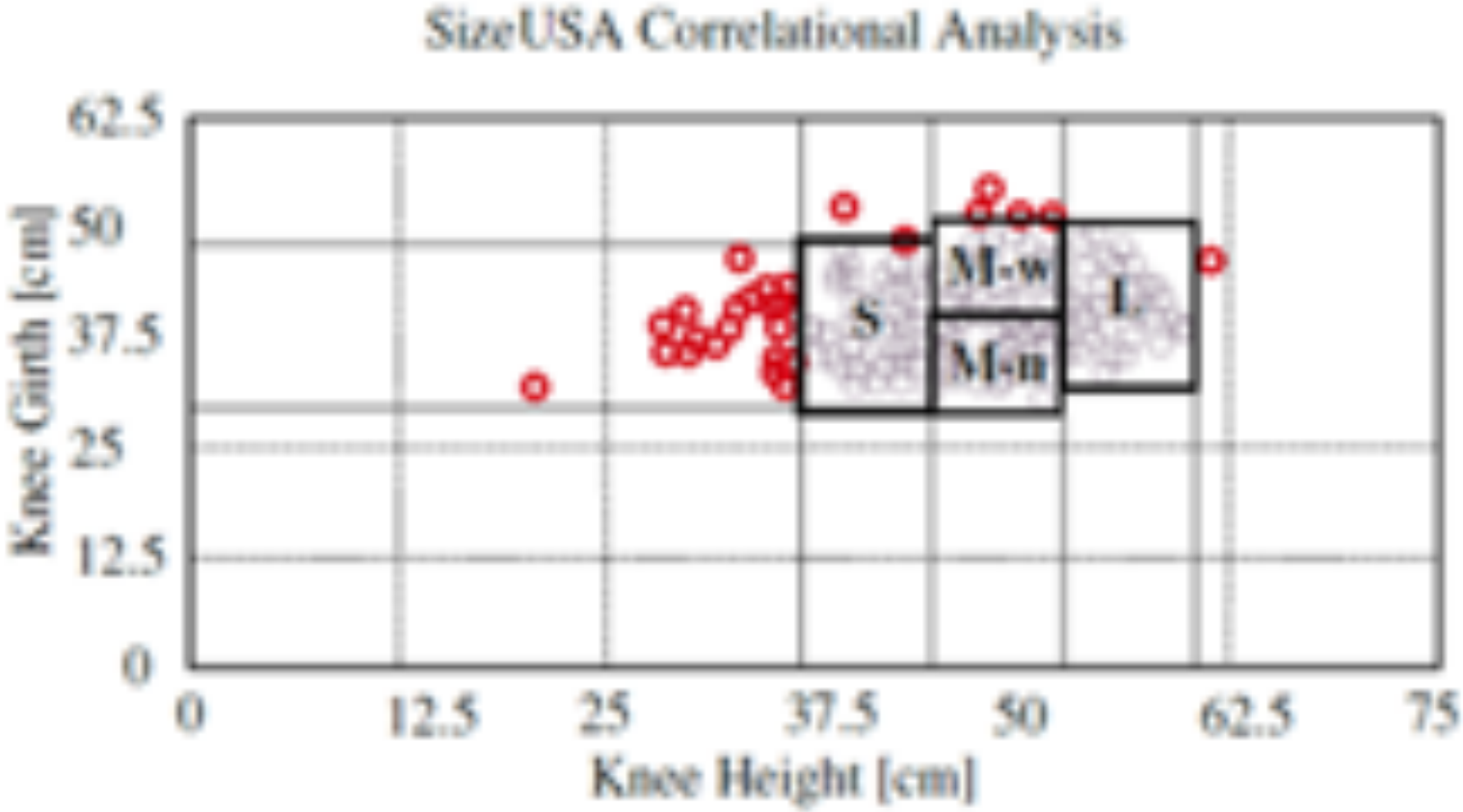








Movement of a Skin-Tight Bodysuit (mm)


SizeUSA Correlational Analysis
62.5
50
37.5
25
12.5
0
Knee Girth [cm]
S
M-w
M-n
L
0
12.5
25
37.5
50
62.5
75
Knee Height [cm]

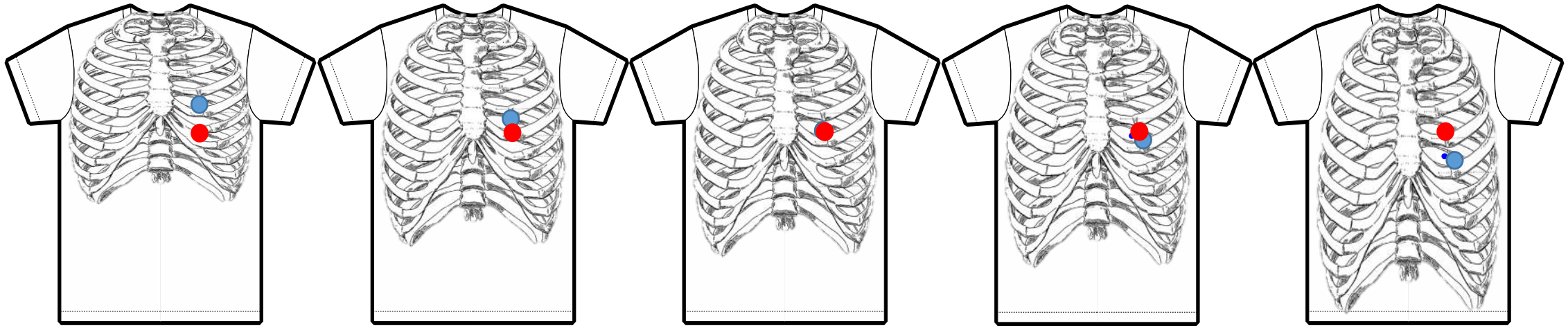
Min Suprasternale to 10th rib length

Q1: Suprasternale to 10th rib length

Mean Suprasternale to 10th rib length, placement of electrode in between 4th and 5th ribs.

Q3: Suprasternale to 10th rib length

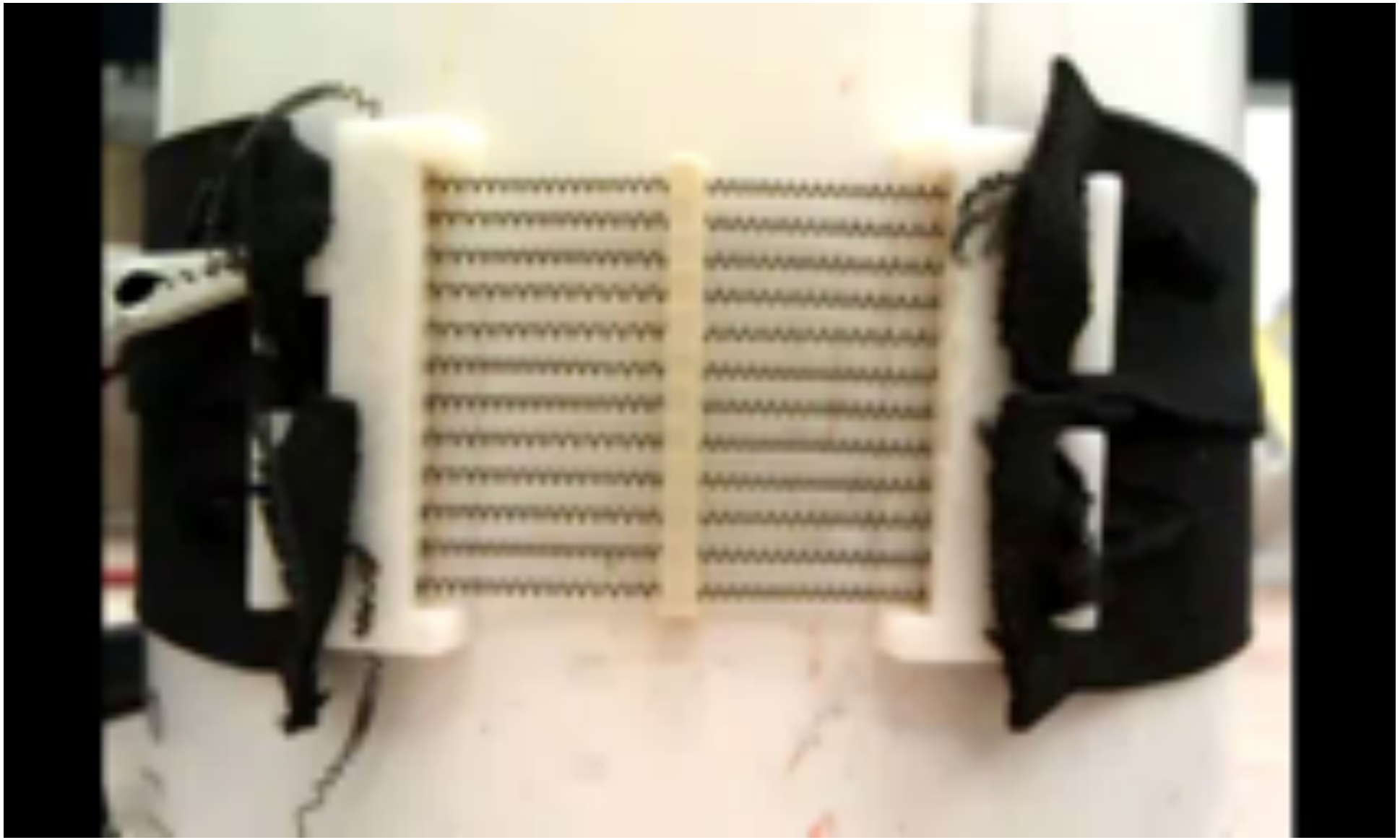
Max Suprasternale to 10th rib length

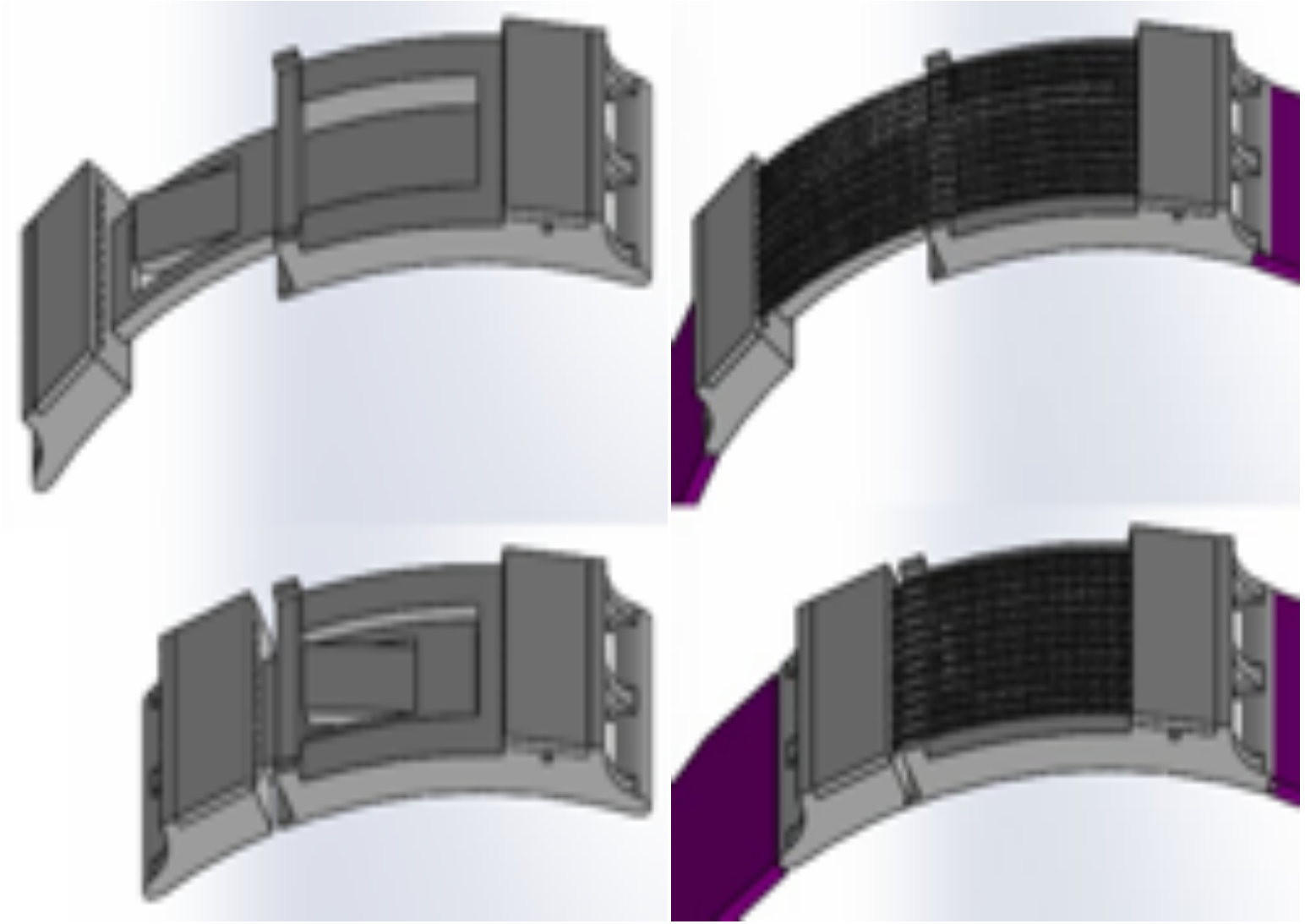


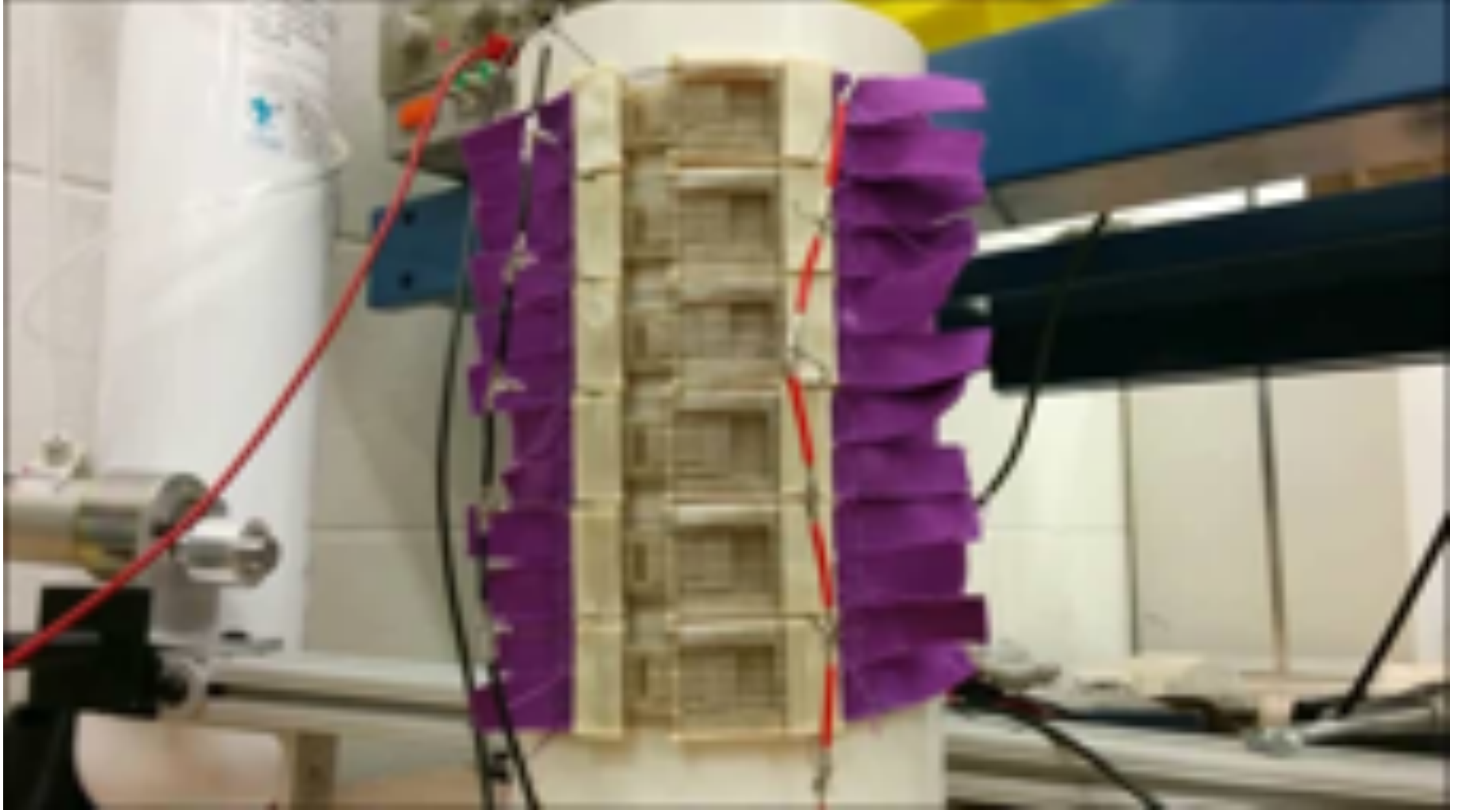
Challenges of Wearable Actuation

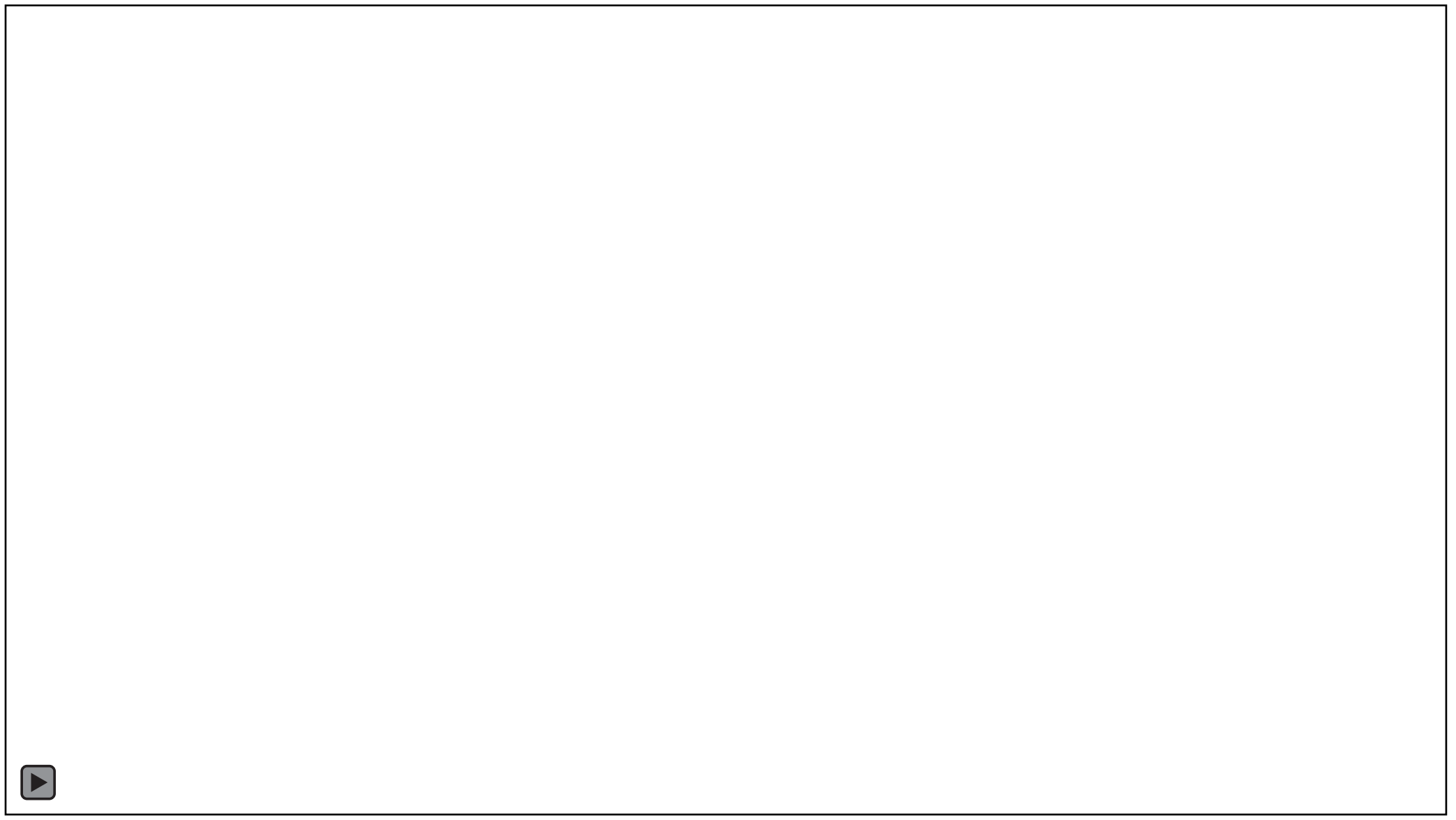
http://www.33rdsquare.com/2013/09/researchers-develop-super-strong-robot.html


BEND
SPLIT
THUMB ROTATE

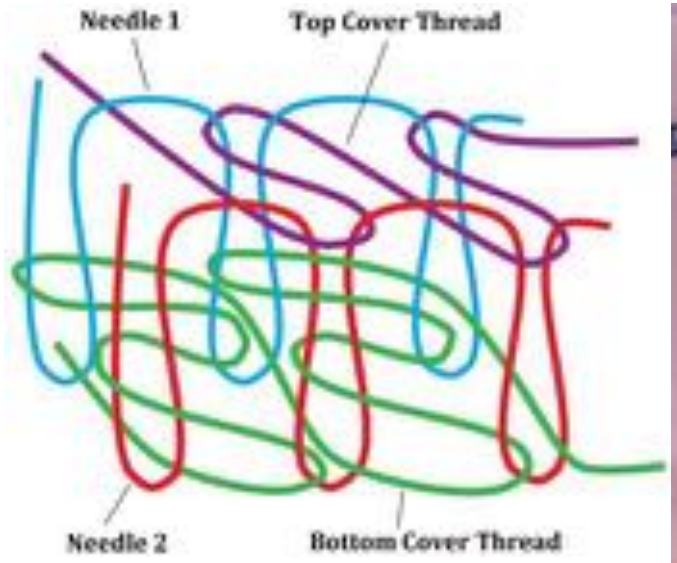


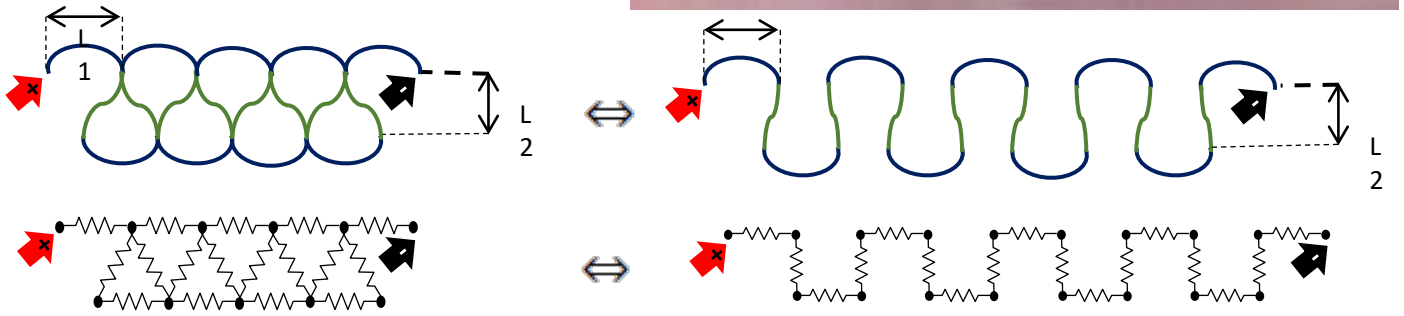






Active UMN WTL Research

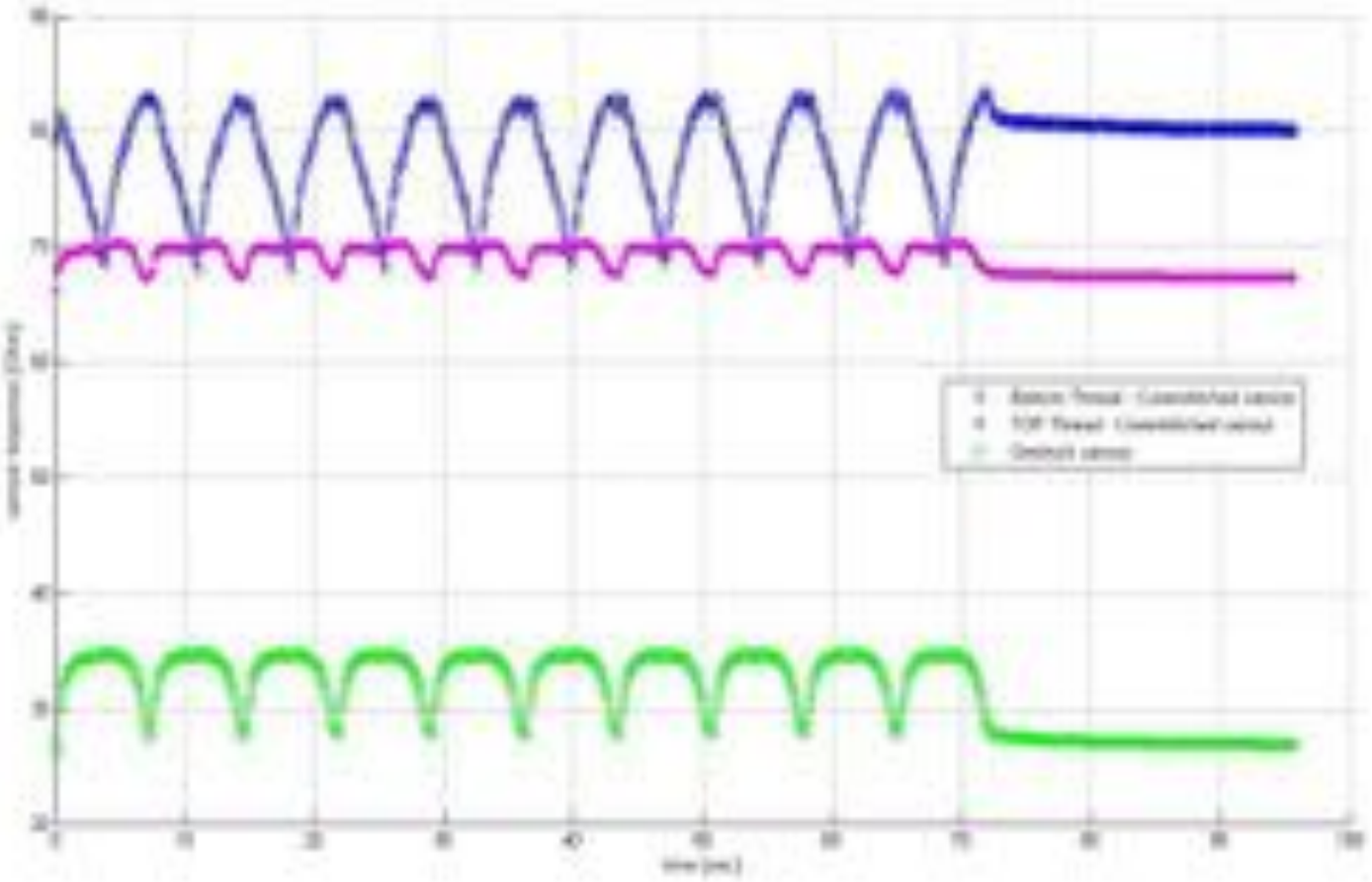




Circuit 1. **Anti-ladder** topology of resistors (loops are in contact)

Circuit 2. **Series** of resistors (loops are separated)

Gioberto and Dunne, SMC 2012



Compton et al., ISWC 2013

Figure 1: Prototype 1 Photos

Figure 3: Prototype 2 Photos

Figure 2: Sensor Placement Prototype 1

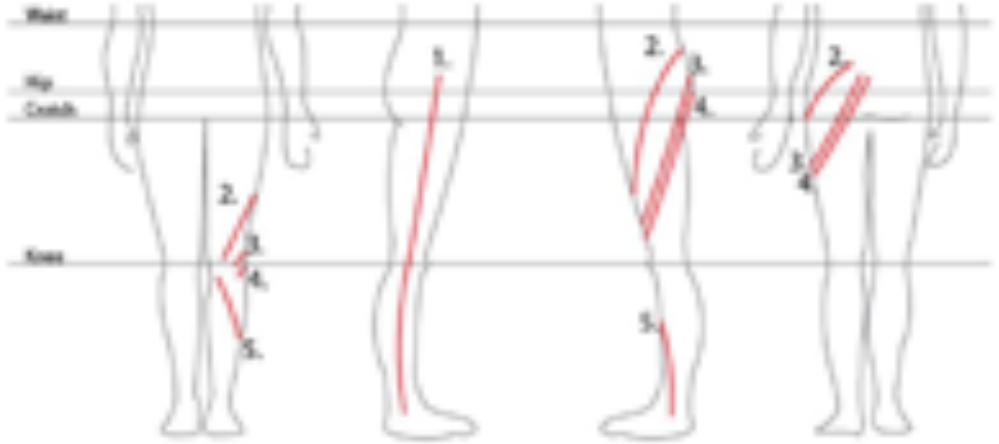
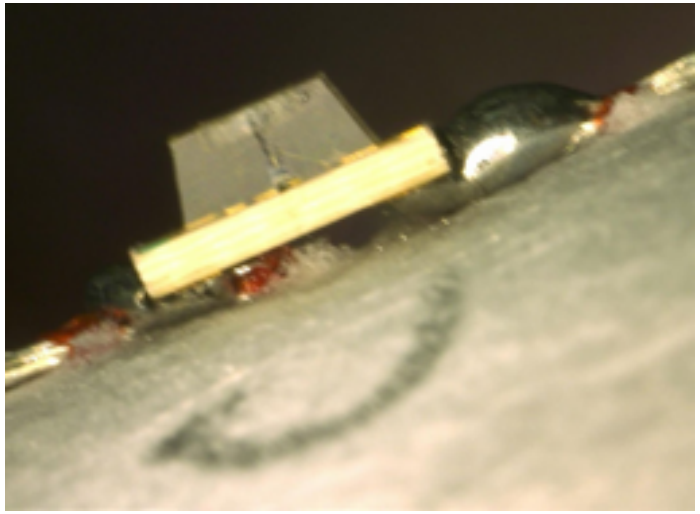
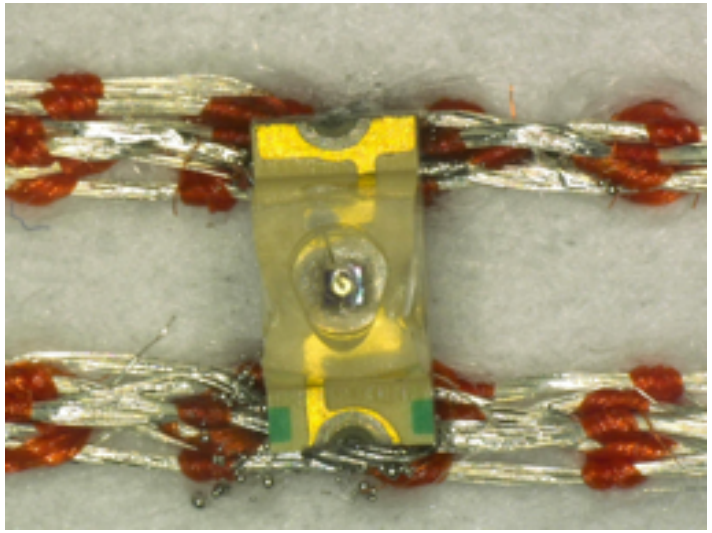
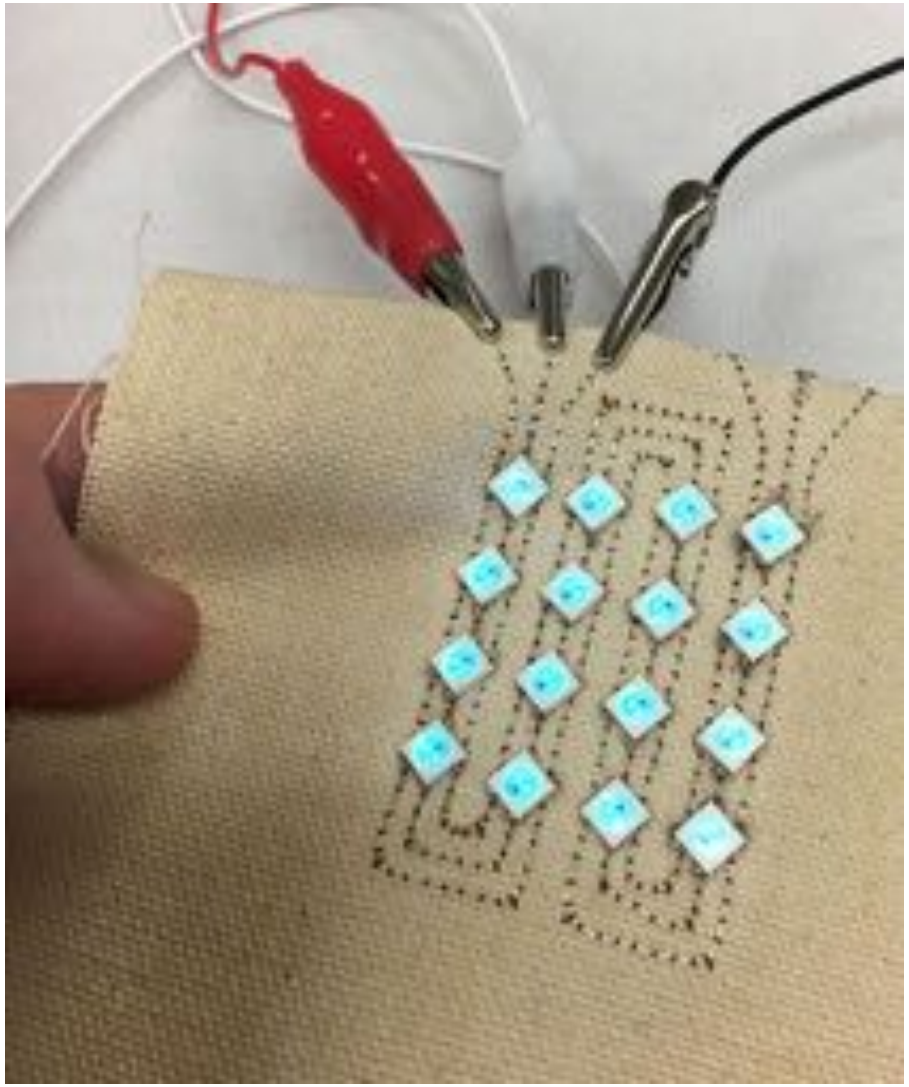
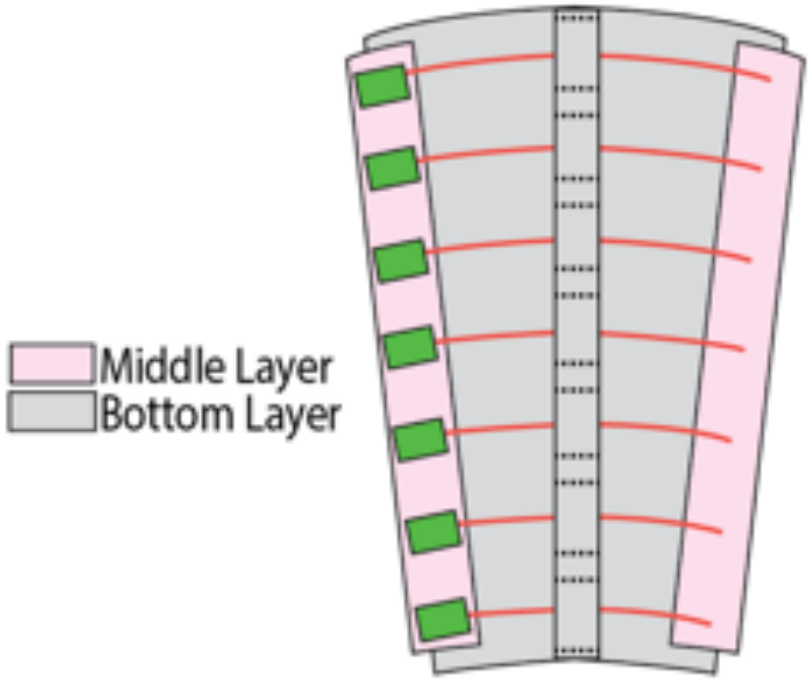


Figure 4: Sensor Placement Prototype 2

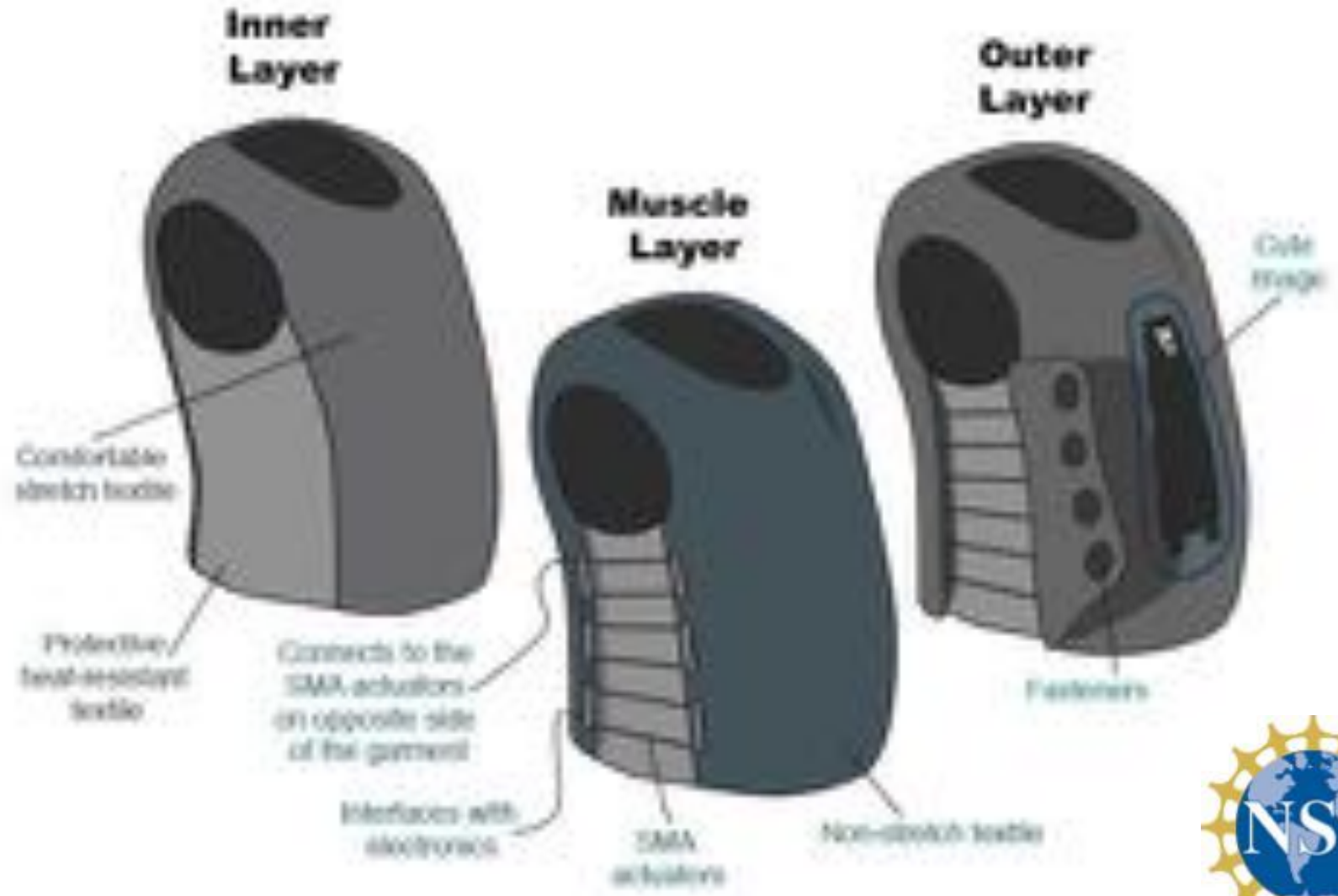




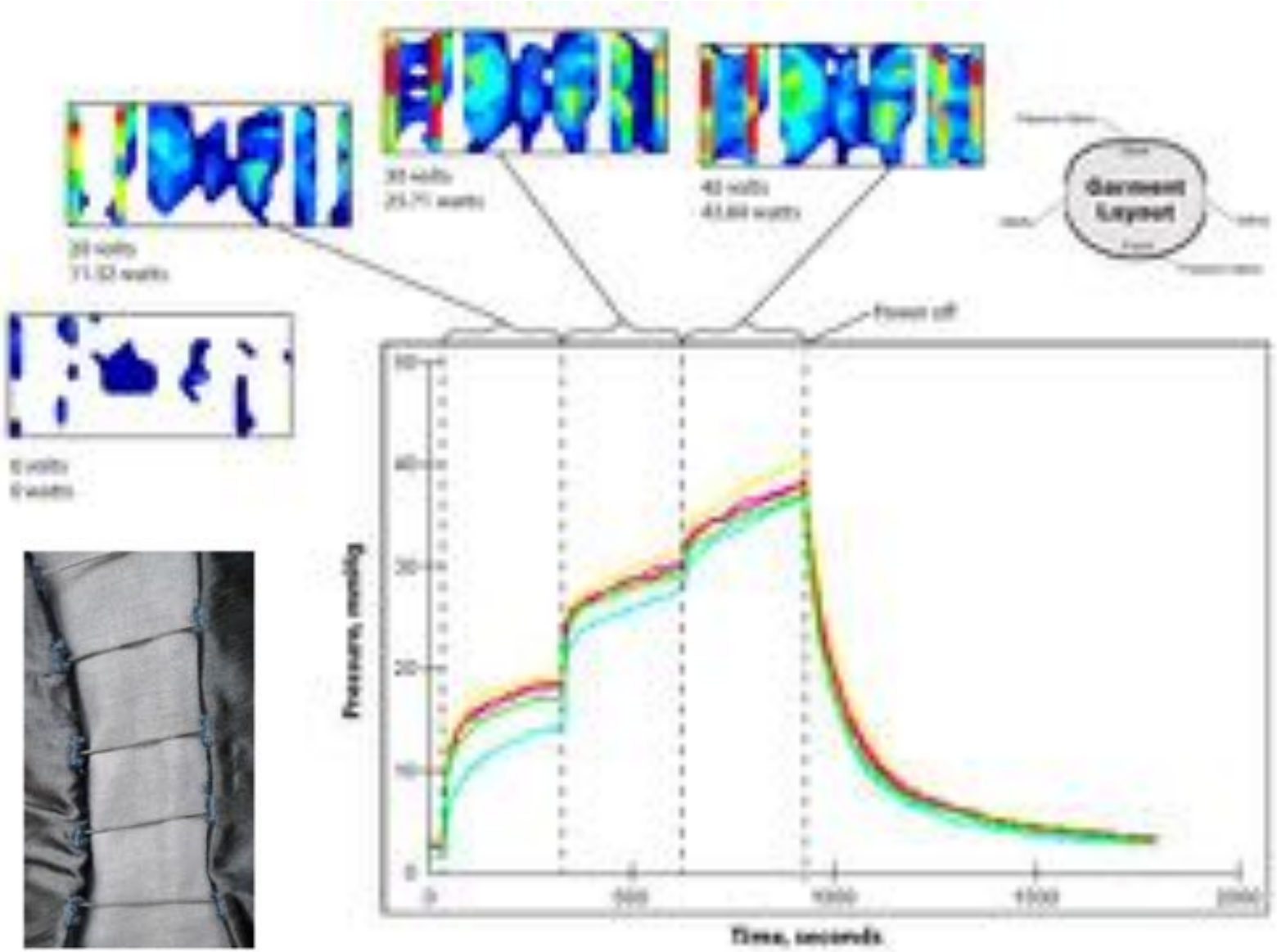


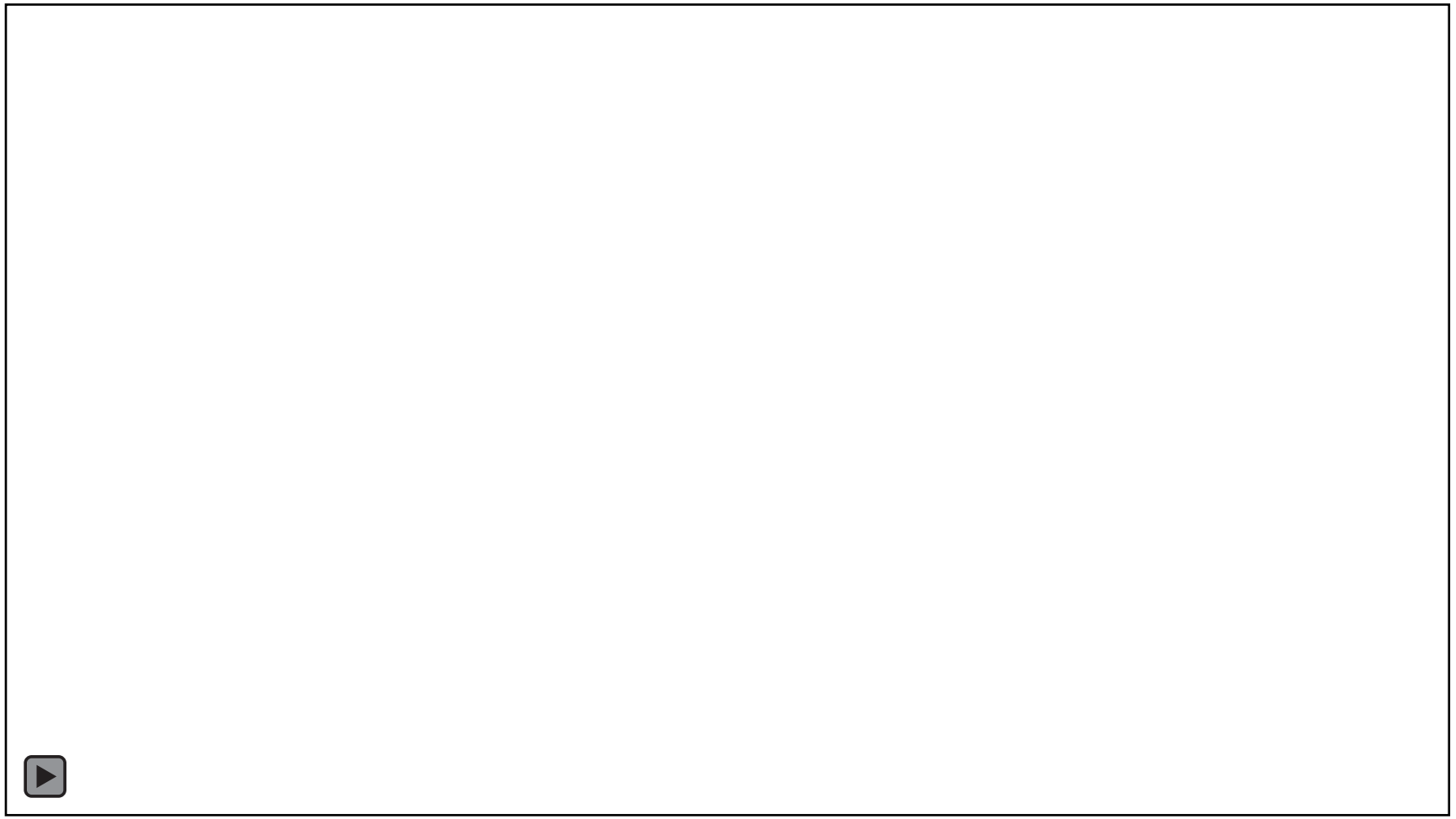


R. Pettys-Baker et al. (DMD 2018)



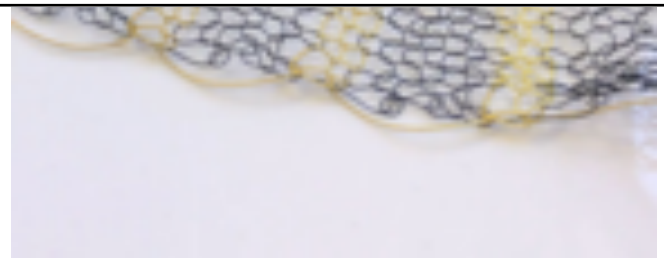
Duvall et al. 2016, Foo et al. 2018


Garment Layer
Power off
Pressure, mmHg
Time, seconds



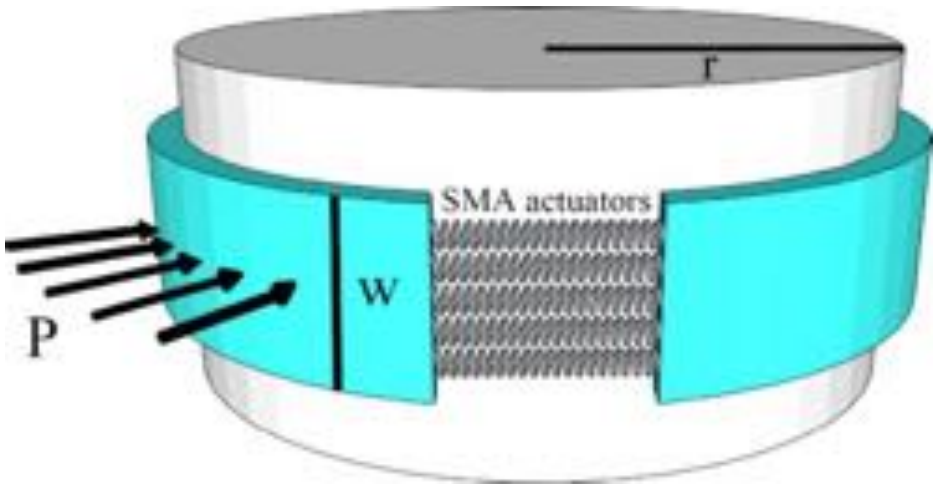
E. Foo et al., 2019

Foo et al., 2019



Other Potential Applications

The DARPA Warrior Web concept aims to develop a skin-suit with embedded technology to reduce Soldier injuries while maintaining Soldier performance.




Normal spine
Scoliosis
Spine


Normal spine
Kyphotic spine


SPANX
HOSIERY

Thank you!

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