SOFT EMBALMED CADAVERS FOR SURGICAL & EDUCATIONAL TRAINING

By Lauren McLaughlin-Kelly

PI: Dr. Inglis

Jacobs School of Medicine and Biomedical Sciences
University at Buffalo

WARNING

This presentation contains graphic images and content

Viewers discretion is advised

No photos/videos allowed of presentation as it contains cadaver images

What Are Cadavers & Their Uses

- Cadavers are deceased humans filled with chemicals to preserve them
- Cadaver Uses:
  - Medical Education
  - Medical Training
  - Medical Research
  - Determining Cause of Death
  - Forensics
  - Tissue Donations
  - And more

Why Are Cadaver's Important?

- Many medical discoveries have come from the use of human cadavers
- They allow us to advance medicine by:
  - Learning how the human body works & why
  - Learning how diseases affect the body
  - Medical research
  - Medical devices
  - Medical education
  - Allows surgeons to practice new techniques
  - Better prepare medical students for residency

Issues with the Current Standard of Cadavers

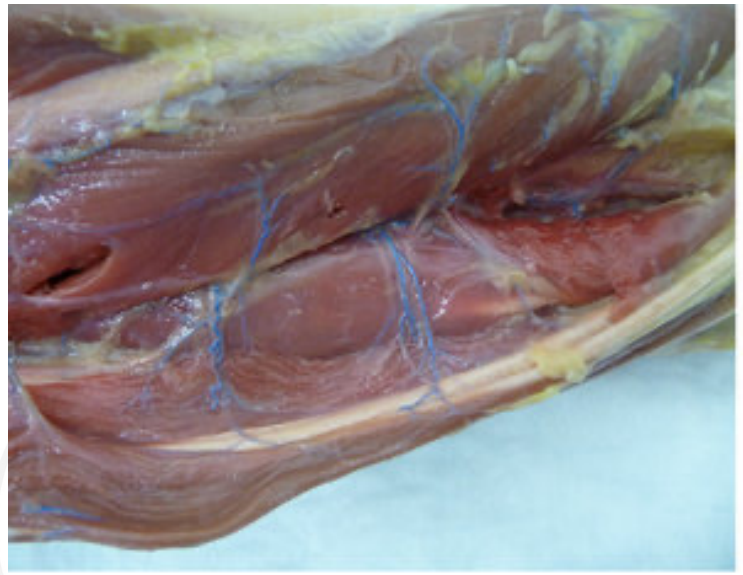
- Main issues with the current standard of cadavers:
  - Don’t maintain lifelike characteristics
  - Health hazard
  - Lack of research
  - Embalming chemical compositions vary at many institutions
  - All 3 goals of embalmment aren’t often met
- UB is changing the gross anatomy curriculum
  - We need to know which type of cadaver is more beneficial to the new curriculum

Hard Embalmed Cadavers

- Current standard for medical schools
- Known as Formalin or Formaldehyde-based cadavers
- Greatly utilized due to the preservation lasting for a long time
- Cons:
  - Very stiff
  - Toxic
    - Formalin causes adverse side effects
  - Loss of lifelike characteristics:
    - Lacks variation in internal coloring
    - Very limited range of motion (ROM)
    - Organs are hardened
- Are there other options?

Fresh Frozen Cadavers

- Donors are not embalmed
  - Stored in a freezer until utilized
- Pros:
  - Maintains lifelike characteristics
- Cons:
  - Only used for more advanced studies
  - Risk of splash
  - Increased disease transmission
  - Limited work time
  - Requires additional freezer storage



Other Options?

- Hard cadavers last for a long time
- Fresh frozen cadavers maintain the lifelike characteristics
- Limitations:
  - Cost
  - Access to devices for data collection
  - Number of cadavers
  - Lack of previous research
- Ideal cadaver:
  - Available for prolonged use
  - Maintains lifelike characteristics

Soft Embalmed Cadavers

- Known as Phenol-based embalmment
- Pros:
  - Less stiff
  - Maintains lifelike characteristics better
    - Better range of motion in joints & soft tissues
    - Coloring
    - More accurate feel of soft tissues
  - Potentially less expensive at some schools
- Con:
  - More prone to microbial colonization
    - Which leads to decomposition

Embalming Process

- Soft & hard embalming processes are the exact same
- Only difference is embalmment chemical composition

Hard:

- Ethanol
- Phenol
- Thymol
- Sodium Acetate
- **Formaldehyde***

Soft:

- Distilled water
- Phenol
- Alcohol
- **Ethylene Glycol***

Phenoxyethanol-Based Embalming for Anatomy Teaching

- University of Otago established a protocol involving phenoxyethanol
  - Another type of soft embalmment

Haptic Characteristics	Formaldehyde (Hard)	Phenoxyethanol (Soft)
Overall appearance	Stiffened	Pliable, soft
Skin, subcutaneous fat	Strongly indurated	Pliable
Bones	Brittle	*in-vivo*-like
Joint mobility	Strongly decreased	Moderately decreased
Muscles	Strongly indurated	Pliable, elastic
Vessels	Stiffened	Elastic, blood clots
Nerves	Rigid	Soft, elastic

Cadavers Improving the Medical Field

- More flexible cadavers increase the quality of education & training by:
  - More accurately mimicking a live patient
  - Increasing how far cadaver research can go
  - Better preparing medical professionals
- Shortcoming:
  - We don't know how much joint mobility there is in soft embalmed cadavers
- We need to assess the range of motion differences between soft & hard embalmed cadavers

Current Study

- Question 1:
  - Are there meaningful differences in the range of motion (ROM) in soft vs. hard embalmed cadavers?
    - Experiment 1
- Question 2:
  - Does the increase in ROM make soft embalmed cadavers a better alternative for medical education and training?
    - Experiments 2 & 3
- Experiment 1: Comparing range of motion (ROM)
- Experiment 2: Pre-med/Medical students perform visual and tactile assessments + survey
- Experiment 3: Surgeons perform visual and tactile assessments + survey

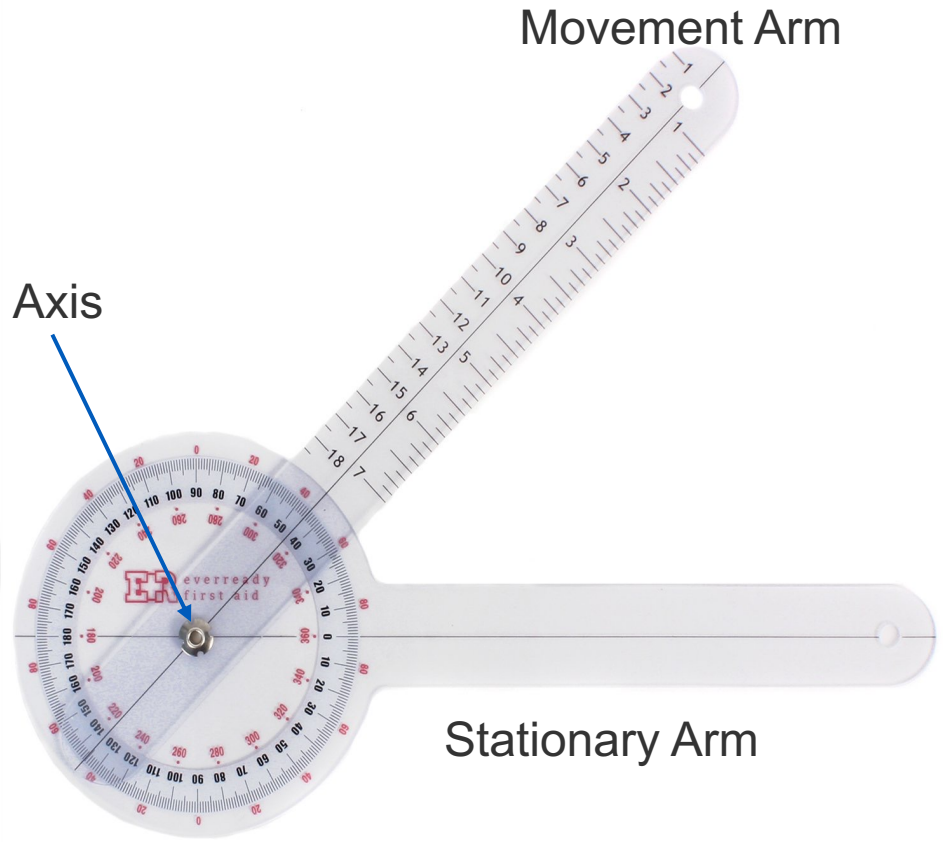
QUESTION 1: ARE THERE MEANINGFUL DIFFERENCES IN THE ROM OF SOFT VS. HARD EMBALMED CADAVERS?

Methods – Experiment 1

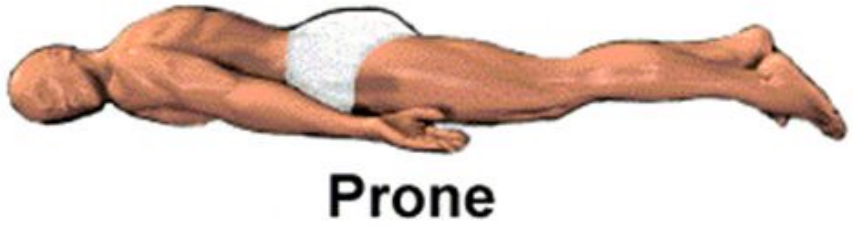
- Experiment 1: comparing the range of motion (ROM) of soft & hard embalmed cadavers to expected ROM's
- Materials:
  - Goniometer
  - 2 donors
    - Donor 1: Soft embalmed female
    - Donor 2: Hard embalmed male
- Comparing ROM of cadavers to live humans allows us to see which type of cadaver best maintains ROM after preservation
- Cadavers placed in supine position to measure flexion & abduction
- Cadavers placed in a prone position to measure extension

Goniometer

- Tool used to measure ROM in joints of the body
- Axis:
  - Placed anteriorly or laterally to the center of the joint
- Stationary Arm:
  - Arm of the goniometer that holds it in place against the body
- Movement Arm:
  - Arm is placed against the portion of the body being passively moved



Experiment 1 – Set Up

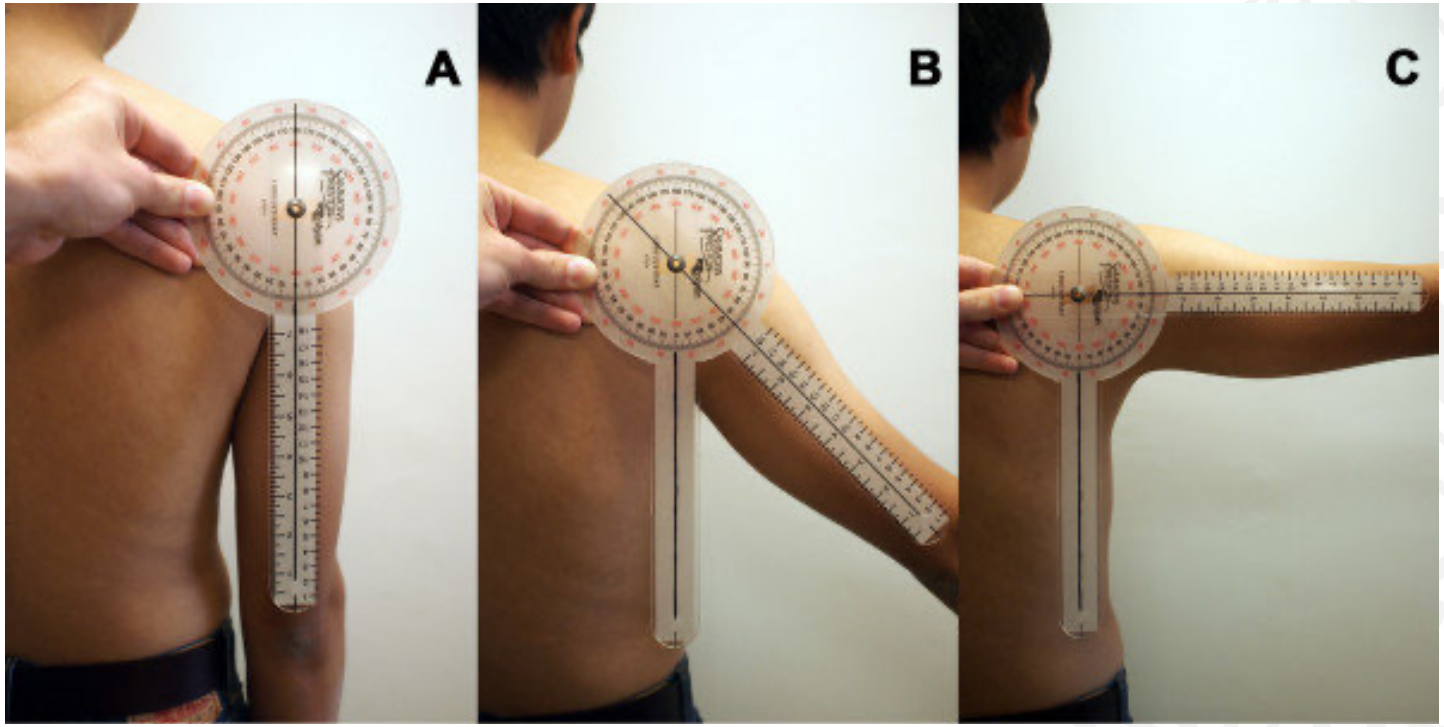


1. Obtain 12 inch + 360 degrees goniometer
2. Determine locations to properly measure ROM
3. Stretched each joint 3 times
4. Placed both cadavers in a supine position to measure flexion & abduction
5. Placed both cadavers in a prone position to measure extension
6. Compared data to the expected ROM of a live human to see how it compares

Experiment 1 – Goniometer Placement

	Axis Location	Stationary Arm	Moving Arm
Shoulder Flexion/Extension	Center of shoulder joint (laterally)	Parallel to serratus anterior	Parallel to humerus
Shoulder Abduction	Center of shoulder joint (anteriorly)	Parallel to trapezius	Parallel to humerus
Hip Flexion/Extension	Center of hip joint (laterally)	Parallel to abdomen	Parallel to femur
Hip Abduction	Center of hip joint (anteriorly)	Parallel to glutes	Parallel to femur
Elbow Flexion/Extension	Lateral epicondyle of elbow	Parallel to humerus	Parallel to radius
Knee Flexion/Extension	Lateral epicondyle of knee	Parallel to femur	Parallel to fibula

Experiment 1 – Goniometer Placement for Shoulder Abduction

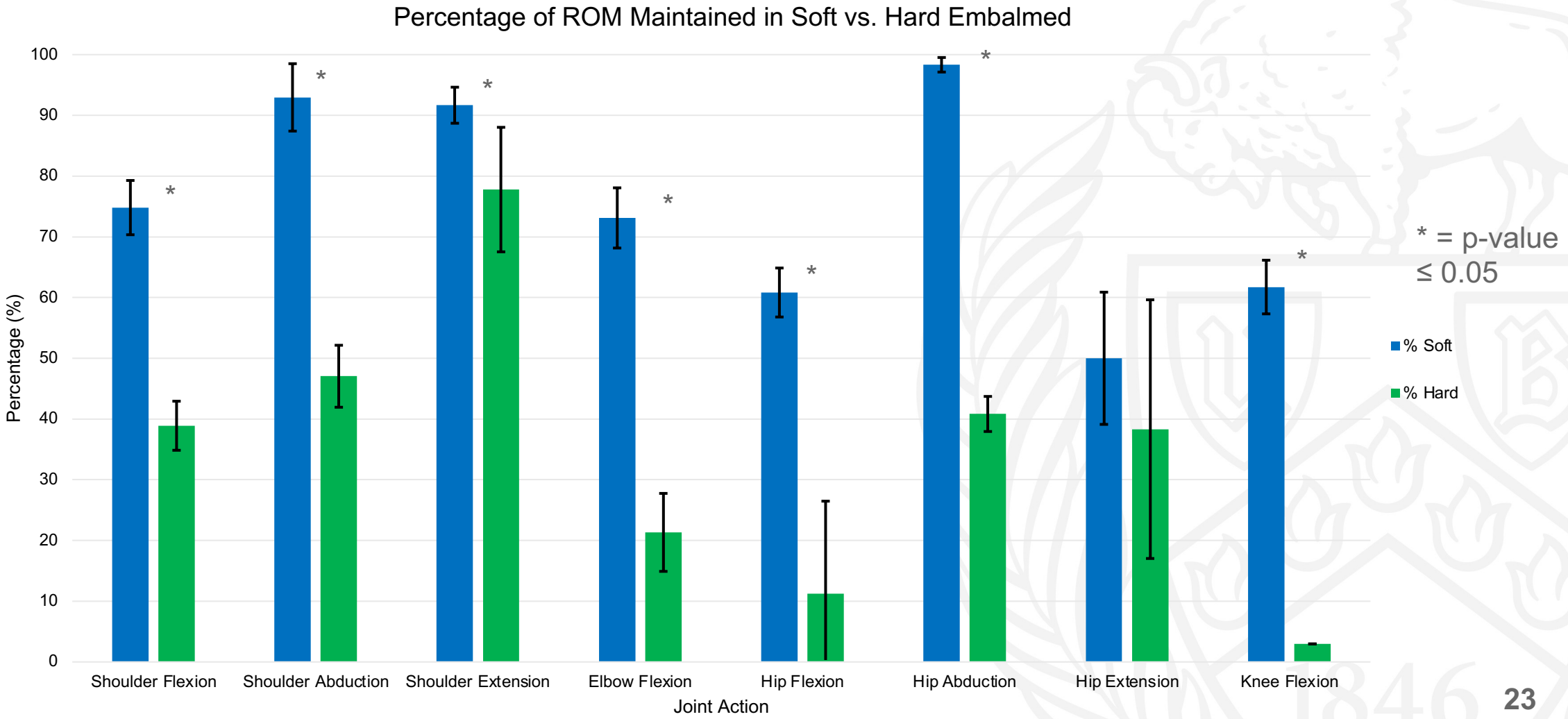


Results – Experiment 1

Joint Action	Soft Embalmed	Hard Embalmed	P-value
Shoulder Flexion	129, 132, 143	94, 100, 100	0.00146
Shoulder Abduction	79, 82, 90	39, 43, 44	0.00032
Shoulder Extension	53, 55, 57	36, 45, 47	0.02605
Elbow Flexion	102, 113, 114	48, 51, 53	0.00014

Joint Action	Soft Embalmed	Hard Embalmed	P-value
Hip Flexion	70, 72, 77	11, 13, 16	1.94E-05
Hip Abduction	39, 39, 40	13, 14, 14	1.85E-05
Hip Extension	13, 15, 17	16, 19, 22	**0.12705**
Knee Flexion	79, 83, 88	<5, <5, <5	6.91E-06

Results – Experiment 1



Question 1 Summary

- **Question 1: Are there meaningful differences in the range of motion (ROM) in soft vs. hard embalmed cadavers?**
- Performed ROM of four different joints on both soft & hard embalmed cadavers
- Out of 8 ROM taken, 5 soft embalmed ROM were about twice as large as the hard embalmed cadavers
- According to the p-value, Hip Extension didn't have a significant difference
  - Potentially due to hip being dissected
- 87.5% of the data had a statistically significant difference in ROM
- Experiment 1 supports that there's a meaningful difference in ROM in soft vs. hard embalmed cadavers

QUESTION 2: DOES THE INCREASE IN ROM MAKE SOFT EMBALMED CADAVERS A BETTER ALTERNATIVE FOR MEDICAL EDUCATION AND TRAINING?

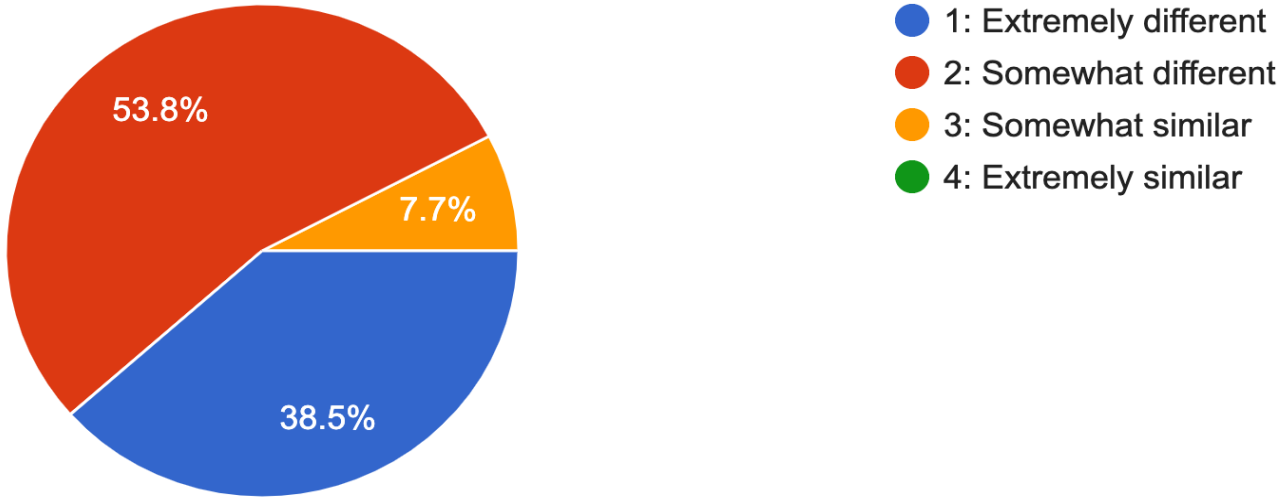
Methods – Experiment 2

- Experiment 2: Pre-meds/medical students complete a visual & tactile assessment
- Soft embalmed donor was placed in a supine position for assessments
- Students evaluated:
  - Range of motion of the joints
  - Range of motion of the soft tissues
  - Color
  - Feel of soft tissues
  - How the soft embalmed compared to a hard embalmed cadaver
  - How the soft embalmed compared to a live human
- Students were then asked to complete a survey
  - Data collection is still ongoing

Supine

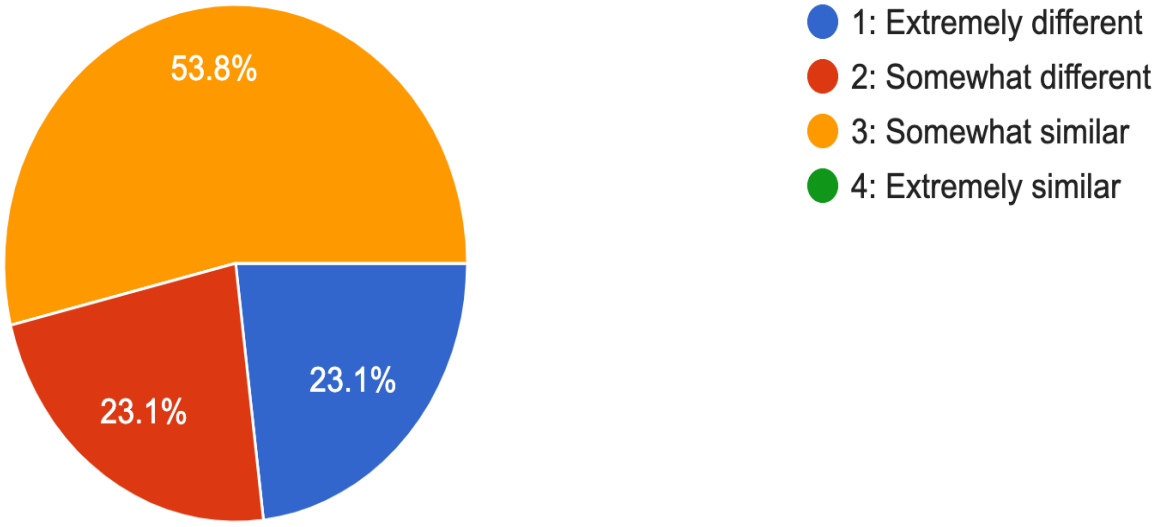
Results – Experiment 2

- Students were asked, “In what ways did the soft embalmed and hard embalmed cadavers vary in the assessment”
  - 100% students said ROM of joints
  - 76.9% students said ROM of soft tissues
  - 84.6% students said color of soft tissues
  - 76.9% students said feel of soft tissues
- Figure 1: On a scale of 1-4, how would you compare a soft embalmed to a hard embalmed cadaver?

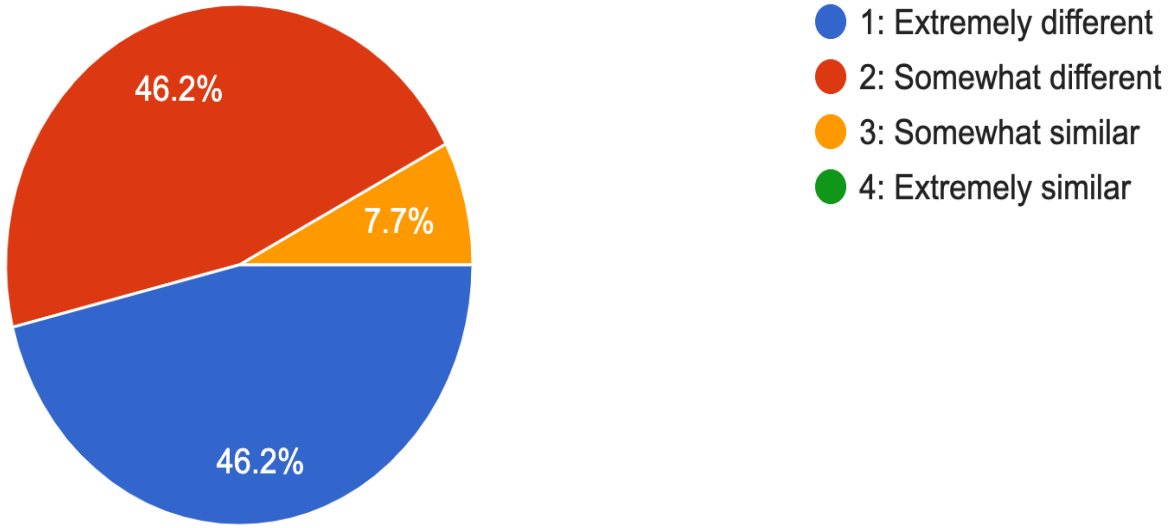


Results – Experiment 2

- Figure 2: On a scale of 1-4, how would you compare a soft embalmed cadaver to a live human?



- Figure 3: On a scale of 1-4, how would you compare a hard embalmed cadaver to a live human?



Results – Experiment 2

- Type of cadaver preferred for medical training
  - Soft Cadaver: 100%
- Suggested uses for soft embalmed cadavers:
  - Surgical Specialties
  - PT/OT
  - Nursing
  - Respiratory Therapy
- Additional comments:
  - “The soft embalmed is a lot easier to dissect”
  - “Soft embalmed is easier to move around and study”
  - “Soft embalmed is great. I have experience with both hard and soft cadavers. Soft is by far a better experience for dissection and education. Much more realistic tactile feel and tissue response in a soft embalmed cadaver. Vasculature and nerves look distinctly different, whereas they are more likely to be confused in a hard embalmed cadaver”

Methods – Experiment 3

Supine

- Experiment 3: Surgeons complete visual & tactile assessments
- Soft embalmed donor will be placed in a supine position for assessments
- Visual & tactile assessments:
  - Range of motion of the joints & soft tissues
  - Color comparison test
  - Feel of soft tissues
  - Fixing a specific injury (i.e., MCL tear)
- Surgeons will then be asked to complete a survey
- March 16th will be the first day of Experiment 3
  - Will be meeting with about 25 surgeons in the surgical skills lab
  - Other days will be organized as the semester goes on

Question 2 Summary

- **Question 2: Does the increase in ROM make soft embalmed cadavers a better alternative for medical education and training?**
- 92.3% of students thought the soft & hard embalmed cadavers were different
- 53.8% of students thought that soft embalmed cadavers & live patients were similar
- 92.4% of students thought that hard embalmed cadavers & live patients were different
- Experiment 2 supports that increase in ROM makes soft embalmed cadavers a better alternative for medical education and training
  - We anticipate Experiment 3 will have very similar results

Assessing Soft-Embalmed Cadavers as a Biological Hazard

- Masters' student at the University at Kingston assessed soft embalmed cadavers as a biological hazard (2019)
- Found evidence that they do become more colonized than hard embalmed
  - This causes decay to occur sooner
- Biosafety risk isn't necessarily increased just because there are more microbial colonies
  - This is evidenced by the quantity of microbial life in the microbiome
- This is something we would want to further investigate

Future Plans

- UB's medical school is changing the gross anatomy curriculum
  - Cadavers will be utilized for a year instead of one semester
  - Hard embalmed cadavers can begin to dry out within a year
    - A dried-out cadaver is much harder to dissect
  - Can soft embalmed cadavers stay preserved for a year?
- Since the data currently supports the hypothesis that soft embalmed cadavers are more suitable for medical education, its important we know:
  - How long it takes the soft embalmed cadaver to become contaminated with a significant amount of microbial colonies
  - How long it takes the soft embalmed to begin to decay
  - How to increase the duration of preservation of the soft embalmed cadaver

Future Plans

- **How long until the cadavers begin to decay:**
  - Perform Youngs Modulus tests over time
    - One paper showed the Youngs Modulus minimally changed for soft embalmed cadavers over a 6-month period
  - Test for changes in histological appearance
- **How long it takes for the cadaver to be contaminated with a significant number of microbial colonies:**
  - Perform cultures over time to see how long it takes for microbial colonization to occur
- **Increasing length of preservation:**
  - Modifying the wetting solution
  - Modify embalming solution

Thank you

- Dr. Inglis
- Dr. Hoekstra
- Cianna Currie
- Dr. Marzo
- PAS427/527 & medical students
- Residents in the surgical skills lab
- Cadaver donors
- All of you