BEEC Share and Learn Report: October 2024

Presenter: Nicole Ramo, PhD, Assistant Professor, Department of Biomedical Engineering, West Chester University

Topic: ASEE Education Showcase Deep Dive: Use of Bone Analogs for Tissue Mechanics

Resources:

- SawBones ($50 to $70 for health vs osteoporotic block, cut into 1 inch cubes)
  - Blocks Used: 1522-10, 15220-12
  - https://www.sawbones.com/?gad_source=1&gclid=CjwKCAjw68K4BhAuEiwAylp3krMQeTmW4eWtQN3g0dCPjXgIQRfG_Tuc1Zk3wzh9JYhIqOiLBDn05xoCagcQAvD_BwE
  - https://www.sawbones.com/catalog/biomechanical/blocks-and-sheets.html
- Patel 2008 "Compressive Properties of Commercially Available Polyurethane Foams as Mechanical Models for Osteoporotic Human Cancellous Bone" *BMC Muscul. Disorders*
  - https://link.springer.com/article/10.1186/1471-2474-9-137
- PASCO Materials Testing Machine ME-8236 ($3,200)
  - https://www.pasco.com/products/lab-apparatus/mechanics/materials-testing/materials-testing-machine
  - Software (can use Capstone version): https://www.pasco.com/products/guides/software-comparison
- 3D Printing of Temporal Bone for Surgical Simulation:
  - https://www.cmu.edu/bme/Academics/undergraduate-programs/Resources/design/2021-design-pojects/1p-3d-printing-of-the-temporal-bone-for-surgical-simulation.pdf
- Skin Testing Lab from CellScale and SynDaver:
  - https://syndaver.com/product/adult-skin/
  - https://www.cellscale.com/wp-content/uploads/2016/12/Lab-1-CellScale-Tensile.pdf
- DragonSkin to help create "prosthetics":
  - https://www.smooth-on.com/product-line/dragon-skin/
  - https://www.smooth-on.com/products/dragon-skin-20-nv/
  - Ninjatek Chinchilla for Wearables: https://www.matterhackers.com/store/l/ninjatek-chinchilla-sky-blue-tpe-filament-1kg/sk/MG6KS6KU?srsltid=AfmBOortTv7r07yVwcr19FMS5rL6eCHxTT_QNTL4B4EeuHxgigw4i5kO
- GI Tract Modeling with Cork: https://www.mdpi.com/1996-1944/2/3/776

Discussion and Lecture Notes:

Lecture Notes:

- Challenge Statement: Junior Level BME Lab on the relationship between structure, composition, function and mechanical properties to model disease (e.g.. osteoporosis)
    - Also show the mechanical parameter of strain-energy density and how to model non-linear materials of cells to model hyperelasticity etc.
- Novel Initiative: SawBones – offers cellular polyurethane foam blocks that model cancellous bone with cell size ranges
    - Compression tests of Sawbones to assess how good the model bone is good at representing osteoporotic and healthy bone
- Provided supplemental article Patel 2008 to show how important the model you are using is important for your specific experiment and goals – for example, lower density foam is not as good at energy absorption as a mechanical property as a model if you are looking for experiments on this
- Testing Standards: based on ASTM Standard for use of rigid foams in orthopedic device research – ASTM F1839-08
    - Gives dimensions, density calculation test method, and compression (load) rate based on standard
    - Had to double standard rate to save time and reference procedures based on established testing standards
- Performed Matlab trapz function to calculate area under curve for each sample to compare AUC for healthy vs osteoporosis bone and to show elongated plateau reason and higher strain energy density value to understand fracture resistance in healthy vs. osteoporotic bone
- Reflection: advantages over biological tissue samples – avoids challenges of handling of biological tissues and samples, can introduce safety aspects of machines one at a time before handling biological tissues safety handling concern
    - High school outreach – “don’t break your (grand)mother’s back” – can use as a K-12 outreach scenario without having to use biological tissue samples at the high school
    - PASCO Materials Testing Machine ME-8236 ($3,200)
- Can also provide more advanced age and target properties you’re looking for and ensure consistency of what you are looking for. If other biological tissues are tested, this one can be used to better focus on mechanical behavioral models that other properties and variability may obscure.
- Students can directly look at the blocks to appreciate difference in density to visualize density structure vs resulting mechanical properties
- Limitations: there is a cost involved, but can cut blocks into 1 inch blocks to make it ~$3 per block to test
    - Can also get donations or educational discounts
- 3D print samples with different in-fills? Could potentially try…
- Sawbones also offer biomechanical models of whole bones 😊

Discussion:

- Mechanical crank Instron – is it better/easier to use? PASCO system is travelable, hand-cranked but has high force capacity on it – haven’t tested it yet
- Do you look beyond hyperelastic modeling? They don’t do this until a full biomechanics class, this is a preview of non-linear systems lab
- This doesn’t expose them to applications related to materials (e.g. external fixation to messy material) but rather properties of materials – blocks can be used to do fixture pull out etc.
- 3D printing of bone – Conrad Zapanta worked on this to model temporal bone – used PETG
- How long did the experiment take? With sample size and 20% deformation per minute, it was 4 minutes per sample, can do 6 samples and have time to share data and talk during lab period

- Do you know if these blocks demonstrate viscoelasticity or hydration dependent effects that model bone effects?
    - Not sure
- Manual crank instron could show viscoelasticity by cranking it slower or faster to get different results
- Lab classes is computer programmed, hand crank is traveling one.
    - Even with different load rates, strain rate effects are so different you may not see it
- Have you tried any sheets or something to simulate chicken skin?
    - CellScale – artificial skin product
    - Doesn't always let students understand slipping and putting it into grips, but these can also make students lose focus of the lab.
    - SynDaver Artificial Skin Sheet
    - Won't require IRB 😊
- Modeling GI Tract? Try tripe or Cork Composites
    - https://www.mdpi.com/1996-1944/2/3/776
- Do you keep track of orientation when you cut them? We can expand on this since there may be anisotropic effects based on the manufacturing process

<u>Labs for Biomechanics:</u>

Skin Tension Testing

Bone 3-Point Testing

Compression Testing

Cartilage Spherical Indentation for Displacement

Testing Suture Strength, Patterns, Suture Materials