Designing high-fidelity medical skills trainers: Navigating the gaps

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Introduction

Medical skills trainers provide a method for clinicians to practice procedural skills prior to performing a procedure on a patient, however, there is a lack of trainers with high haptic fidelity. It is hypothesized that the lack of fidelity occurs because trainers are designed without matching synthetic and human tissue material properties. Due to the paucity of collated information regarding the biomechanical properties of human tissues, a scoping review was undertaken to synthesize the published literature.

Aims

1. Identify what biomechanical properties of human tissues have been measured and how they have been measured.
2. Identify the primary motivations for measuring the biomechanical properties of human tissues

Materials and methods

A scoping review was conducted in accordance with the JBI methodology[1] for scoping review and the Preferred Reporting Items for Systematic Review and Meta-Analysis extension for Scoping Reviews (PRISMA-SCR).[2]

Inclusion Criteria

- Human tissues
- Macroscopic samples
- Deformable body mechanics
- Quantitative studies

Exclusion Criteria

- Fluid mechanics
- Kinetics/kinematics
- Qualitative measurements

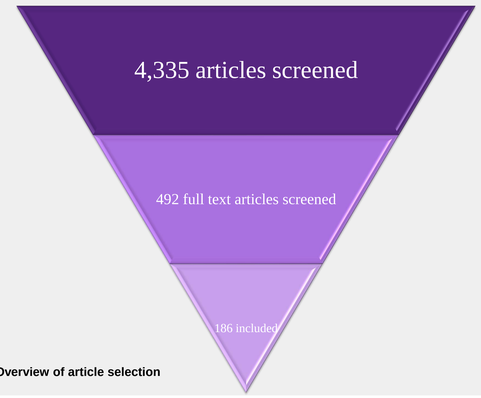


Figure 1: Overview of article selection

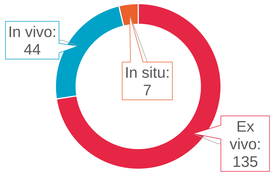
Study characteristics

186 Studies included

33 Different countries

1969 Year of oldest study

6 Studies published in 2022



Number of studies by sample type

Most commonly studied tissues from musculoskeletal system

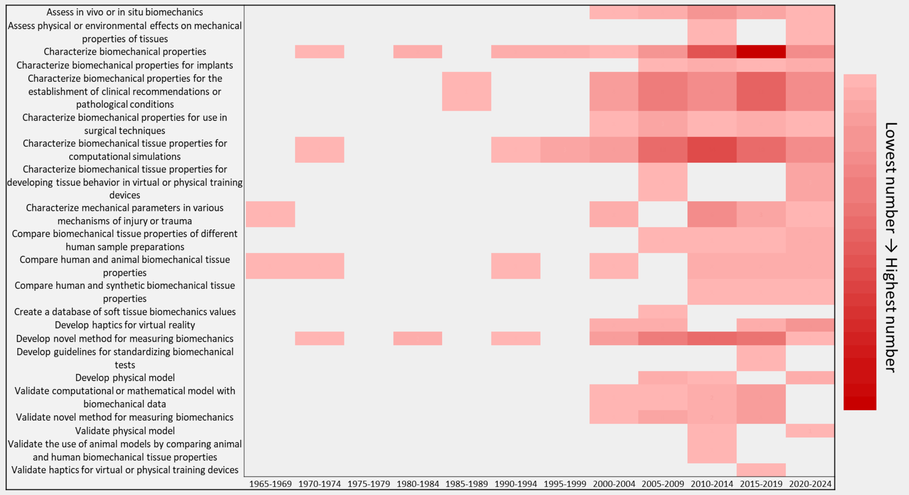


Figure 2: Heatmap of primary objectives behind biomechanical research

Summarized Results

Animal tissues do not replicate the biomechanical properties of human tissues to a high degree

Only 1 study found that synthetic materials accurately represented biomechanical properties of human tissues

There are not enough comparative studies assessing how preservation methods (e.g., freezing, embalming) alter the biomechanical properties of human tissues

There are no comparisons for how biomechanical properties of tissues change between in vivo and ex vivo methods

7 studies assessed biomechanics in the context of haptics
3 were qualitative studies
4 matched force-feedback

Recommendations

- Where high fidelity is required, synthetic and animal tissues do not replicate the biomechanical properties of human tissues
- Preservation methods of human tissues lack comparable data with fresh tissues
- It is difficult to compare biomechanical values because of the lack of standardization of reporting assumptions, methodology, and results
- Journals and/or experts in engineering fields should consider implementing reporting standards or guidance around methodology

Conclusions

- This is the first review that gives a broad overview of biomechanics in the published literature
- Research gaps: human tissue comparisons, methodology and terminology of biomechanical research, biomechanical properties in medical skills trainers

Literature cited

1. Peters MDJ, Godfrey C, McInerney P, Baldini Soares C, Khalil H, Parker D. Chapter 12: Scoping Reviews. In: Aromataris E, Munn Z, editors. JBI Manual for Evidence Synthesis [Internet]. Adelaide: JBI, 2021 [cited 2022 September 06]. Available from: https://synthesismanual.jbi.global.
2. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA extension for scoping reviews (PRISMA-ScR): Checklist and explanation. Ann Intern Med 2018;169(7):467-73.

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