

## ACS 2026 Surgeons and Engineers: A Dialogue on Surgical Simulation

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### Research In-Progress

#### Developing Soft Impact Exercise Foot Stepper Prototype to Reduce Frailty Preoperatively of Patients Undergoing Major Abdominal Surgery

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**Introduction:** Patients often present for surgery with an already impaired functional status by illness and a possibly undermined psychological sphere. These individuals are then expected to endure the physiological stress of surgery. Exercise prehabilitation has been identified as an intervention that promises to address the vulnerability to psychological and physical stressors that frail individual's encounter. This study describes the development of a soft impact exercise foot stepper prototype designed to reduce frailty in older patients set to undergo a major abdominal surgery.

**Methods:** Health Sciences North engaged Cambrian R&D, a specialized research hub, at a local post secondary institution to help design the novel foot stepper exercise. This apparatus is tailored for pre- and post-operative patients requiring targeted lower abdominal muscle rehabilitation. The main steps for development included: systematic engineering design process, rigorous prototyping and testing cycles.

**Preliminary Results:** Iterative prototyping and testing eliminated multiple resistance and motion concepts that demonstrated instability under load or abrupt, uncomfortable resistance changes. The most promising configuration was a compact friction belt based design with a reduced footprint, simplified two-pulley drive, and controlled linear motion. This approach provided smooth, adjustable resistance, strong mechanical stability, and reduced weight without sacrificing durability. Its advantages in manufacturability, patient safety, and ergonomic adaptability positions it as the leading candidate for final optimization and clinical evaluation.

**Next Steps:** The iterative prototyping process has yielded significant insight into the mechanical behavior, durability, and usability of various stepper concepts. Endurance testing and ergonomic evaluations will finalize the optimal configuration, targeting comfort, safety, and clinical effectiveness. Preliminary testing of the prototype is planned to proceed with the already approved protocol at the tertiary surgical center.

