Engineering Evaluation of the Energy-Storing Orthosis FES Gait System

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Objective
- Develop a hybrid system for walking by those with SCI using a new concept. The system uses FES + orthosis + energy storage.
- Design, construct and engineering bench test the system.

Why
- ESO system has one channel of stimulation
- All motion derived from stimulated quadriceps. No motors.

Concept
- Energy from stimulated quadriceps is stored and transmitted to the hip for hip movement.
- Pneumatics used for energy storage and transmission.

Right Step Sequence
1. Start position
2. Release R brakes to bring R to equilibrium
3. Stim R quad to extend Shank, lock R knee at full extension
4. Fall over L onto R
5. Open valve to extend R hip and bring trunk over R, L back.

References

Mechanical
- Brakes hold 60 Nm
- Brake solenoids: 660 mW
- System requires 21 J to operate, compared to predicted 15 J. Extra due to cylinder friction and higher elastic forces
- Compressed air storage: 9.7 J at 67 psig
- Structure bends somewhat under pneumatic cylinder load preventing full cylinder extension

Bench Test Results
- Dead volume results in pressure drop to 52 psig when valve opens. No energy lost but lower pressure less useful for driving hip joint.
- At end of high stroke, air pressure = 10.5 psi (ideal = 0 psi). Some assists knee retraction, some lost to atmosphere
- Weight = 16.8 kg, 10 kg over target

Pre-Clinical Evaluation
- One subject, T12, 9 years post injury
- Fit and standing support only
- Orthosis provided comfortable standing support with no pressure points
- More rigid AFO required to eliminate posture sag

Next Steps
- Case-study test on one subject with SCI
- Create next-generation design: lighter, smaller, easier to don & doff

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