Mitigate Deconditioning Syndrome using Resistive Exercise as a Countermeasure

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Abstract

We propose to design an optimized lower extremity force acquisition system (LEFAS) that integrates with a lower body negative pressure (LBNP) box and subject-specific protocols for improved fitness results by taking a computationally simulated optimization approach. Current countermeasures to date on the International Space Station lack sufficient mechanical and physiological loads to maintain preflight musculoskeletal (MSK) mass, strength, and aerobic capacity. Our approach combines LEFAS, LBNP and personalized controls to combat microgravity deconditioning syndrome including induced muscle atrophy, bone decalcification and poor cardiovascular health minimizing the gap between pre-flight and post-flight syndrome, allowing astronauts to respond to emergencies, and remain healthy during and after extended space travel. The LEFAS/LBNP countermeasure combines two forms of resistance achieving required loads and allowing for exploration at greater distances from Earth and extended stays in space. In parallel, we will educate students, teachers, and community about solving the challenges of human space travel using advanced modeling techniques and ground-based experiments.

Figure 1 (above) shows the components of an exercise device within the LNBP

Introduction

Gravity has had a profound effect on the development of life on Earth over millions of years and has shaped the anatomy and physiology of human beings. Exposure to microgravity affects such development causing the body to undergo a reduction in:

- Heart size and blood volume
- Impaired balance control,
- Decreased bone and muscle mass,
- Reduction of the immune function
- Changes in nervous system sensitivity.

Methods

It is our objective to leverage lessons learned from prior research, and to overcome data restrictions by designing an optimized LEFAS that integrates with a LBNP box through a computationally simulated optimization approach. Such approach combines a multidimensional response surface and MSK modeling within a simulated microgravity environment using the simulation program OpenSim.

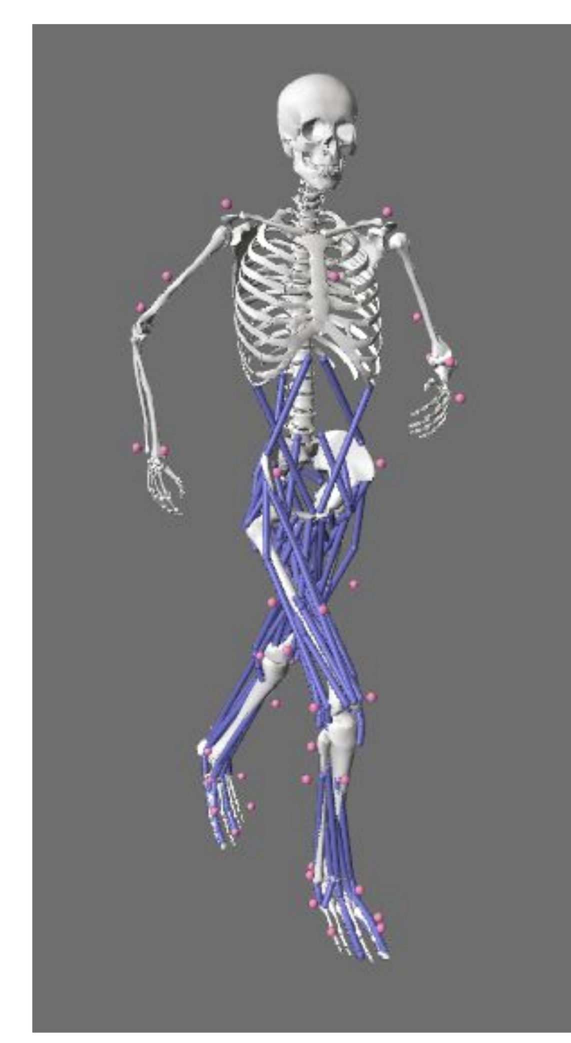

Figure 2 (above) is a model generated from OpenSims showing the affected muscles in the lower body during a walk.

Results

Results will be gathered by the simulation program OpenSim portraying forces using dynamics and a static optimization approach. These results will be ran through MatLab codes in order to fully recreate and account for all forces and their locational impacts on the human body.

Discussion

Validating results, we will run an inverse dynamics problem using motion capture data paired a MSK modeling environment dependent on biomechanical properties ranging from short- to long-term microgravity. Further optimization techniques using the response surface, will develop a routine protocol to minimize the time spent exercising while maximizing functional benefits the astronauts can follow when using the system

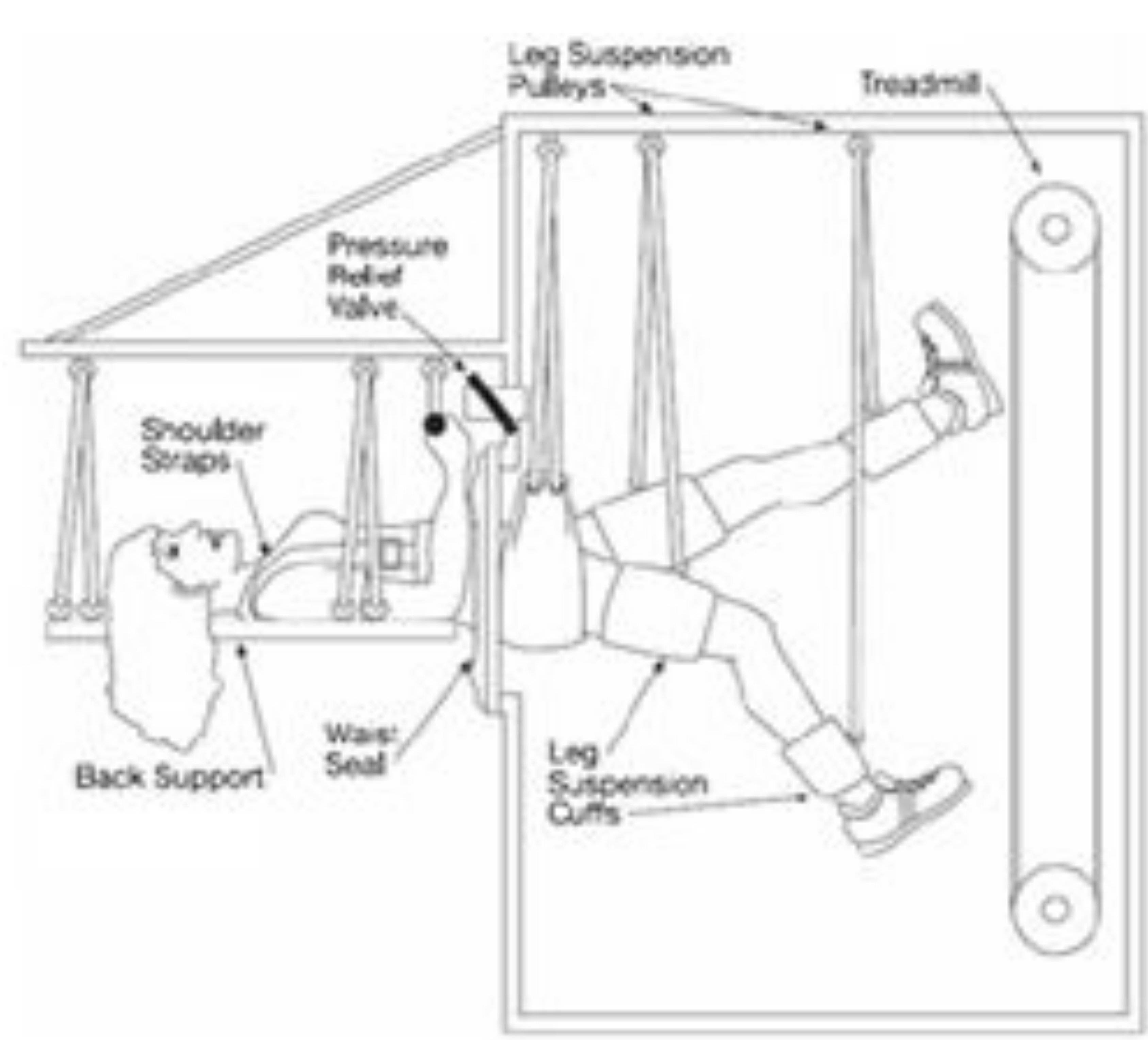

Figure 3 portrays the suspended treadmill inside of an LNBP

References

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