TEXAS A&M UNIVERSITY
Department of Biomedical Engineering

12th Man BioFrontier – Astro-Ring

PROBLEM STATEMENT

Astronauts in microgravity experience rapid musculoskeletal and cardiorespiratory decline despite daily exercise [1][2]. Over six months, muscle strength decreases ~20% [3], calf volume 13% [4], soleus fiber force 35% [5], and leg muscle mass up to 40% [6]. Current countermeasures, ~2 hours daily on ARED, T2, and CEVIS, still result in impaired balance, slower task performance, and increased fracture risk post-mission [7] [8] [9]. Constraints in mass, volume, power, and vibration limit improvements, highlighting the need for compact, effective solutions to maintain crew health during long-duration missions.

BACKGROUND

Current ISS/Artemis countermeasures, such as ARED and the flywheel, are effective but bulky and resource-intensive for long-duration missions. Interviews with astronauts emphasized that **variability and enjoyment** are critical for adherence. While ARED offers versatility, the flywheel on Artemis is more limited. This guided our design: **addressing the lack of "fun" in confined, long-term environments**. Our solution is very lightweight, engaging, and targets underutilized muscle groups to supplement the flywheel's eccentric loading for maintaining and improving muscle power and hypertrophy [10], [11]. By enhancing core stability, flexibility, and enabling low-intensity rehabilitation, the device **complements primary countermeasures while increasing motivation through gamification, ultimately improving performance and productivity in space** alongside regular Flywheel use [12], [13].

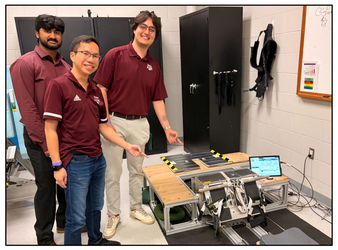

Figure 1. Flywheel

PROJECT SUMMARY

The **Astro-Ring** is a Pilates-inspired resistive device that combines exercise and interactive gameplay to counter microgravity-induced deconditioning. Integrated force sensors and a microcontroller track compression, force, and repetitions in real time, with onboard storage and USB transfer, all housed in a compact handle for portability.

Game-based commands ("squeeze," "twist," "stretch") target specific muscle groups across solo and multiplayer modes. By integrating fitness, tracking, and gamification, the Astro-Ring is a lightweight supplement that reduces muscle loss and monotony while enhancing crew engagement and cohesion.

TEAM MEMBERS

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DEVICE SHOWCASE

Test ended when the Instron machine hit its maximum displacement of 310.2mm, not when the device failed. **No structural collapse or damage to any part of the ring and or handle was recorded.** Force increased consistently from 0 to 185 kN across the compressive cycle, with no sudden drops indicative of buckling or failure even under extreme and rigorous conditions.

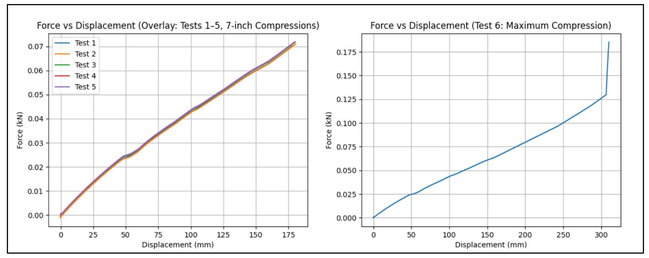

Figure 2. Instron Compression Test

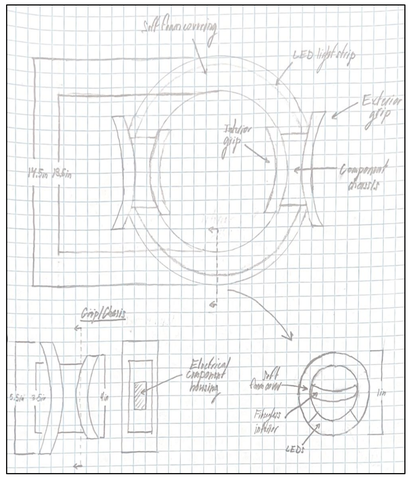

Figure 3. Astro-Ring POC

Figure 4. Astro-Ring SOLIDWORKS Model

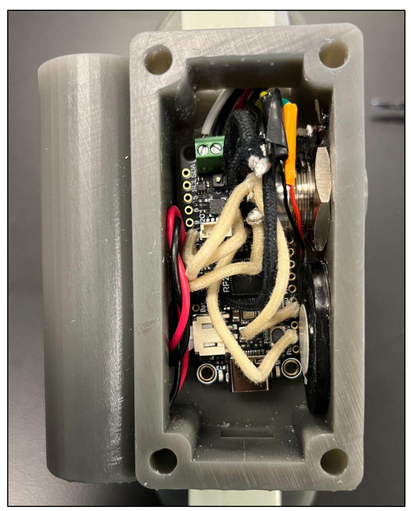

Figure 5. Astro-Ring Handle Electronics

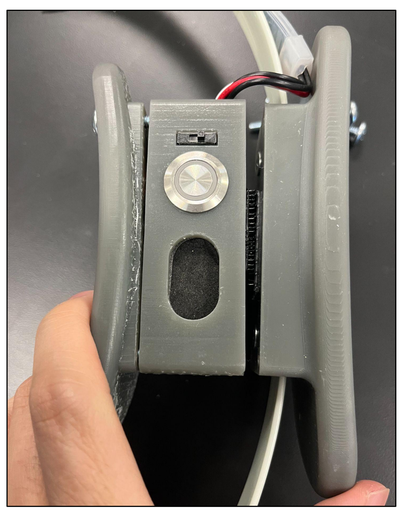

Figure 6. Astro-Ring Handle Controls

DEVICE FUNCTIONALITY

The Astro-Ring UI is based around the button located on the control handle (Fig. 6). **Menus and modes** are accessed by the pushbutton which can be then be used to **cycle through the various games** the Astro-Ring has to offer, indicated by the LED status of the button as well as the array of LEDs on the ring core (Fig. 4). The **LED array** will be the main indication of the progress throughout the game and will display a **visualization of the compression force** applied to the ring. A **speaker** embedded in the control handle supplements the LED array on **game progress** and **repetition counts**. Astro-Ring saves and remembers **settings and data for each player** with easily accessible and intuitive settings. The UI has been tested and verified by the **NASA Task Load Index** (Fig. 7) to be easy to use and learn, creating a stress-free and fun environment for focused exercise.

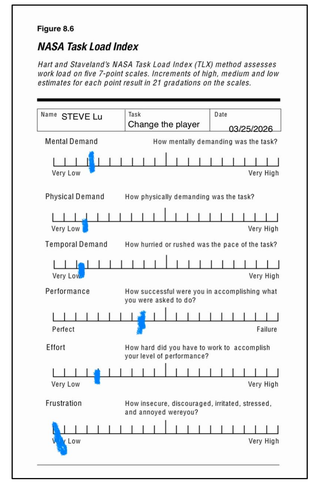

Figure 7. NASA TLX for UI and Human Factors Testing

FUTURE CONSIDERATIONS

Rethinking the core material is a consideration as fiberglass is a difficult material to contain when fragmented, turning into a **respiratory hazard** and **skin irritant**. While two to three times more expensive, a steel core is better suited for spacecraft environments. Steel also allows cores to be stacked on eachother to increase the total resistive force of the ring allowing for more versatility in exercise selection. In addition, the applicability of the controller to computer games makes for endless gamification options. The accelerometer and pushbutton can be used for other games, like Pac-Man, Galaga, and more, which only needs to be installed on a computer for limitless applications aboard Artemis craft.

CITATIONS

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