Ascend 0 G: Micro-Gravity Vertical Cardio Climber

Texas A&M University: Team Aggienauts

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Advisor: Dr. Jeff Reynolds | Mentor: Colonel Fossum

Initial Problem Statement

Deep space missions expose astronauts to altered physiologic conditions that can significantly impact cardiovascular health. In reduced gravity, fluids shift differently in the body, which can lead to cardiac deconditioning and muscular atrophy. This can result in reduced aerobic capacity, posing a risk to astronaut health before, during and after missions. There is a need for an integrated medical device that supports cardiovascular function in astronauts during prolonged spaceflight [1].

From a biomedical engineering perspective, this device must be safe, lightweight, and energy-efficient, and capable of operating within the constraints of spacecraft environments. Its effect should be measurable using standard cardiovascular parameters, and the design should be adaptable to individual astronaut physiology. Addressing this challenge allows for sustained astronaut health, mission success, and the feasibility of future long-term human exploration of the Moon, Mars, and beyond.

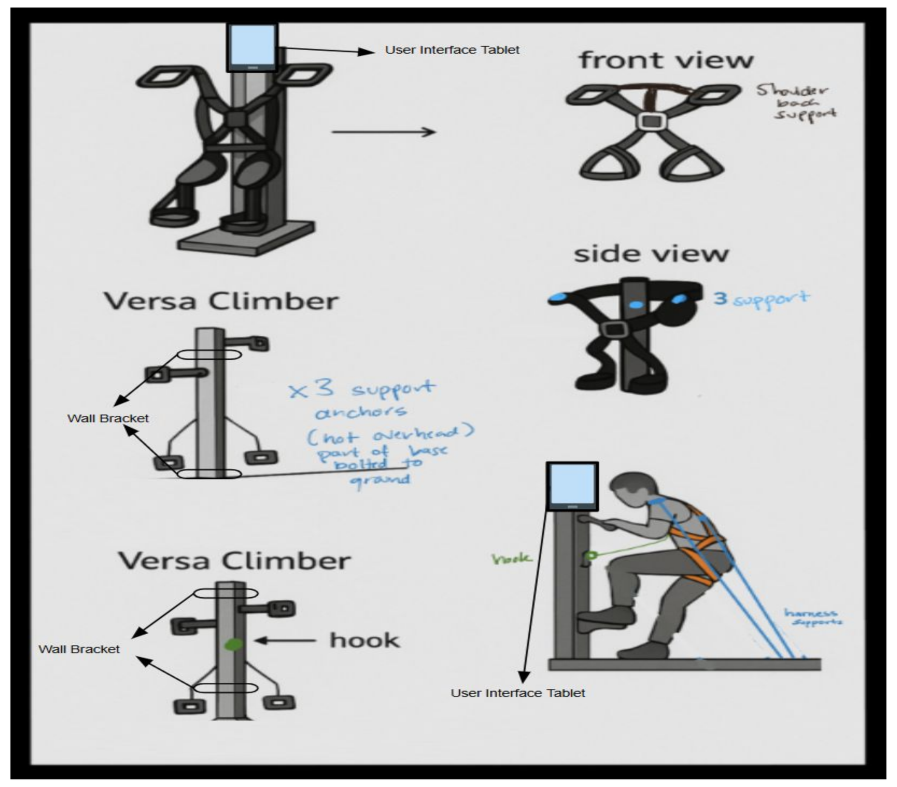


Figure 1: Concept Ideation 1

Concept Ideation

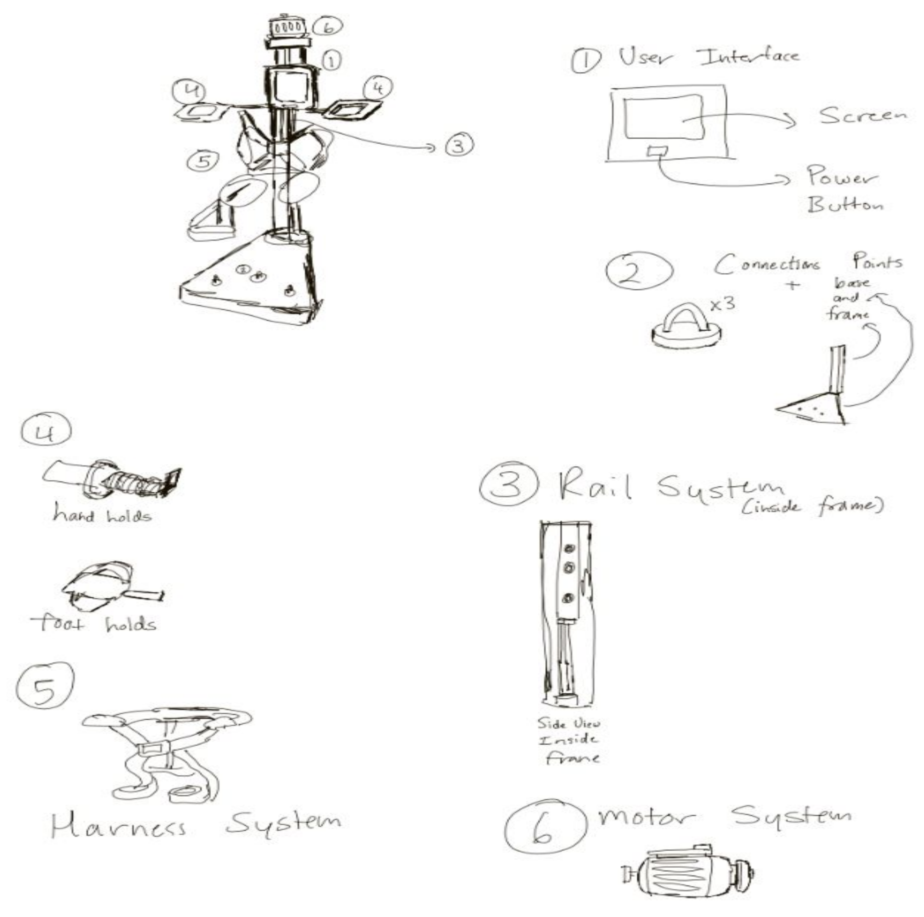


Figure 2: Concept Ideation 2

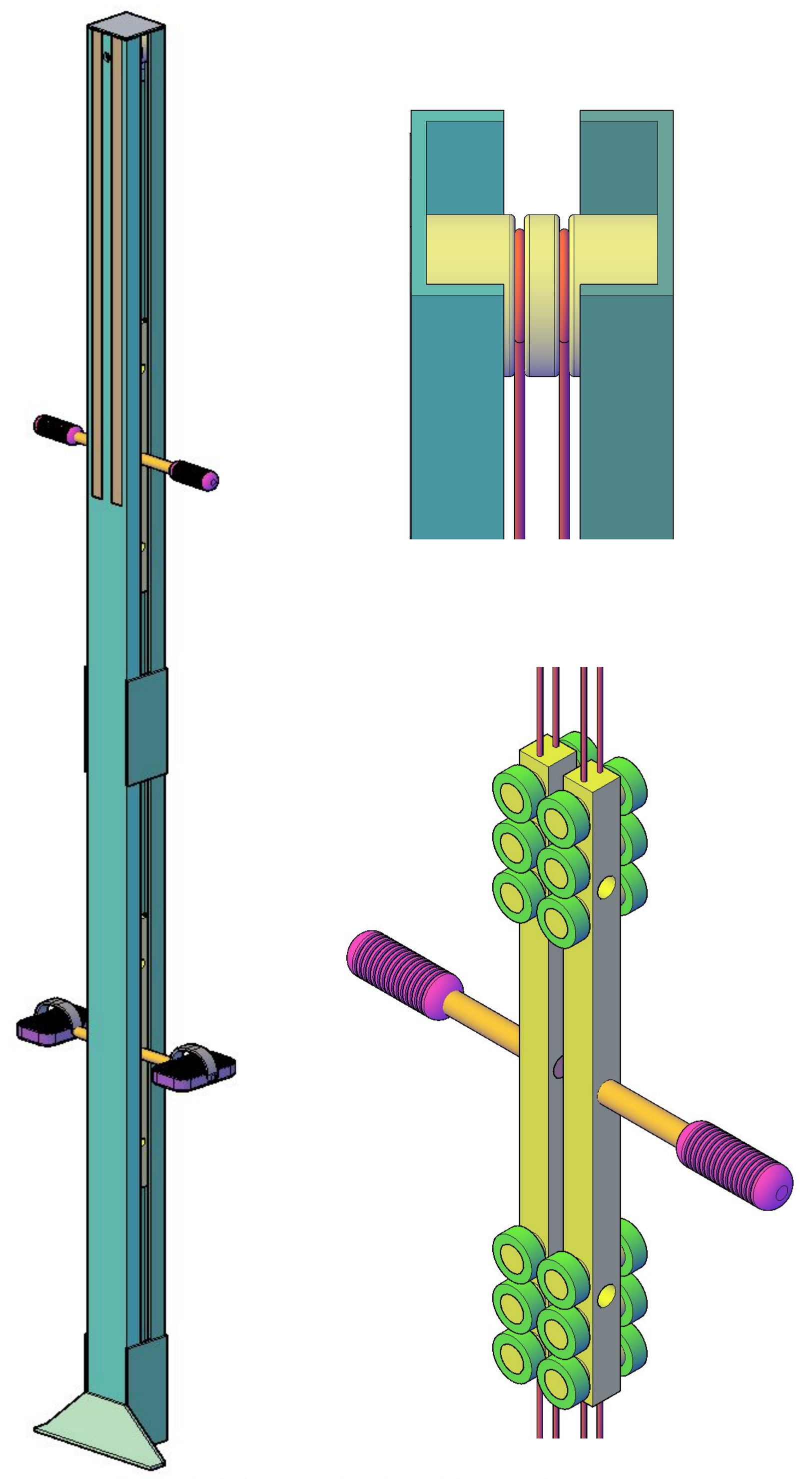


Figure 3: Solidworks Display of Climber Components

Current Tests and POC

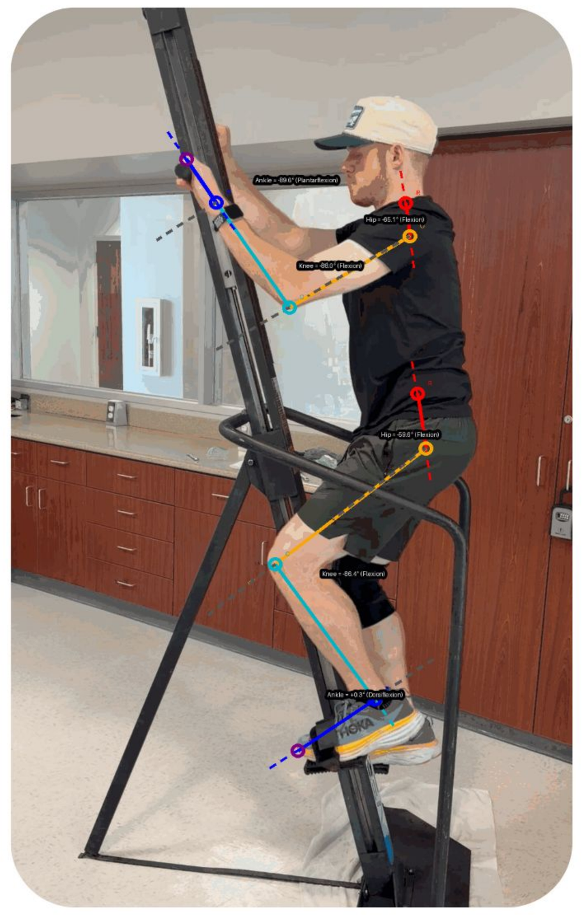
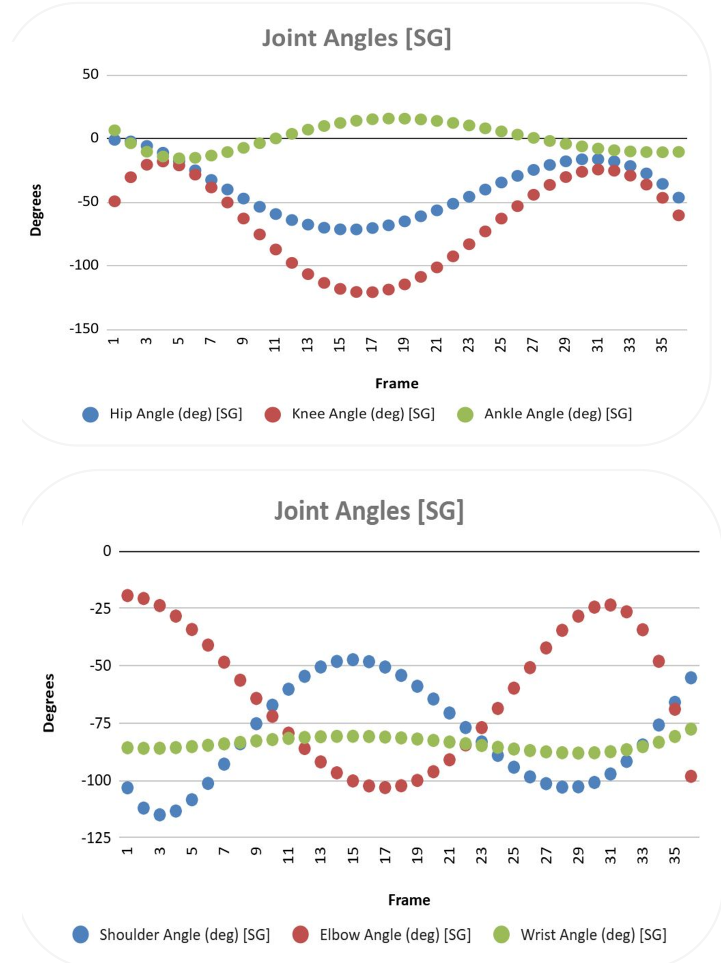


Figure 4: Animated Joint Motion



Figures 5-6: Graphed Joint Motion

We evaluated the zero-gravity vertical cardio system through load testing, motion tracking, and harness validation. Force measurements (10–150 lbf) confirmed performance within NASA standards, while motion-capture data showed full-body joint engagement comparable to running [2]. Harness tests verified stable, comfortable load distribution suitable [3] for partial-gravity use.

Table 1: Range of Motion Standards and Measurements

Joint	Standard	Measured
Hip	80°	91°
Knee	130°	106°
Ankle	50°	51°
Shoulder	55°	69°
Elbow	30°	92°

POC and Future Work

Table 2: Force Measurements Needed to Generate Peg Motion

Peg Side and Direction	Right Peg Pulled Down	Left Peg Pulled Down	Right Peg Pushed Up	Left Peg Pushed Up
Average Force (N)	130.15	143.45	115.25	119.55
Average Force (lbf)	29.28	32.25	25.94	26.89

We analyzed the device's vibrational response by running a frequency study in SolidWorks based on the measured peg-pull and peg-push loads. Modes 1–4 correspond to the primary bending motions produced during these tests, while the fifth mode reflects a higher-frequency local vibration outside normal operating conditions.

Table 3: Vibrational Frequencies output by the device when a force of 150 N is applied

Mode No.	Frequency (Hz)	Y direction	Z direction
1	6.2669	0.0029	0.0238
2	6.2734	0.0238	0.0029
3	6.2771	0.0134	0.0131
4	6.2849	0.0131	0.0135
5	38.4750	0.0057	0.0025
SUM		0.0590	0.0558

Future

Future work includes ideation between between different resistance systems such as motor, flywheel, and vacuum cylinders. As well as, additional concept ideation impacting user interface experience.

References

[1] Space Station Research Integration Office, "Counteracting Bone and Muscle Loss in Microgravity - NASA," NASA, Dec. 01, 2023. https://www.nasa.gov/missions/station/iss-research/counteracting-bone-and-muscle-loss-in-microgravity/

[2] JC. Maynard, "Miniature Exercise Device-2 — Compact Motorized Resistive and Aerobic Rowing Exercise Device," NASA Technical Memorandum, NASA/TM-2018-06490, National Aeronautics and Space Administration, Washington, DC, USA, 2018. Available: https://ntrs.nasa.gov/api/citations/20180006490/downloads/20180006490.pdf

[3] W. Gov, "Harness Station Development Test Objective (Harness SDTO) harness station development test objective." Accessed: Sep. 19, 2025. [Online]. Available: https://www.nasa.gov/wp-content/uploads/2025/08/M-2275-HarnessFinal.pdf?emrc=c6721b

TEXAS A&M UNIVERSITY
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Current Tests and POC:

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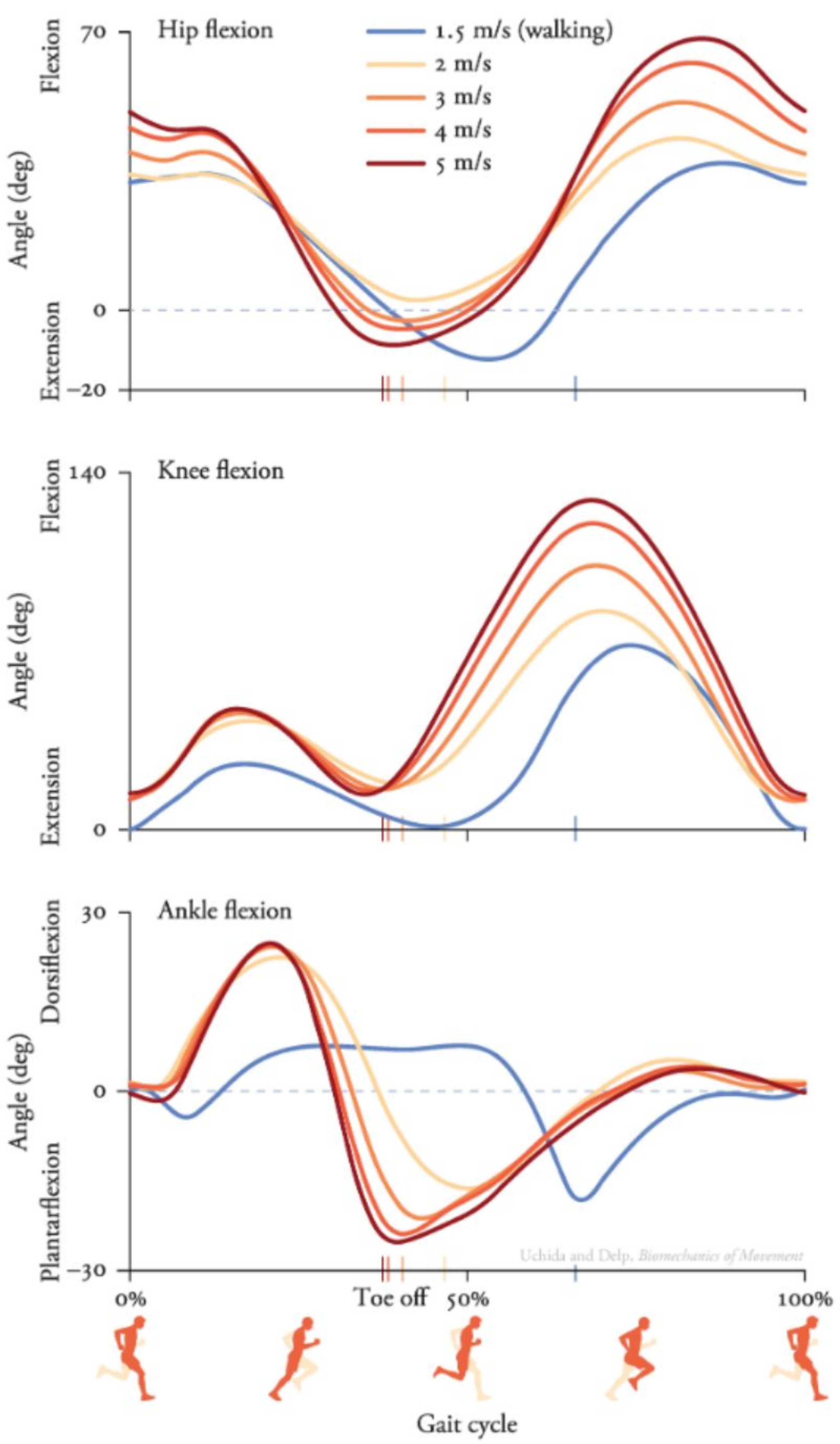
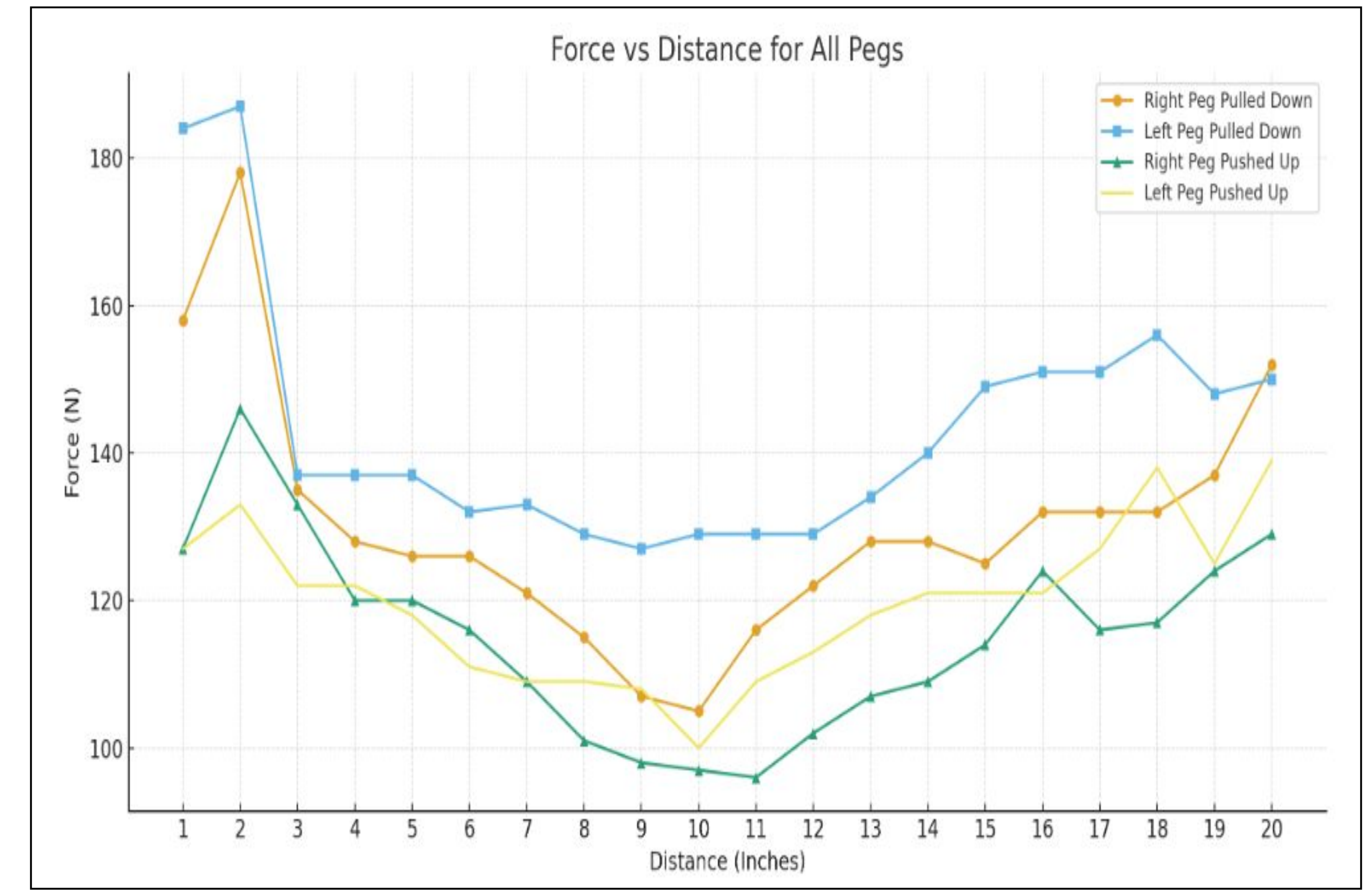
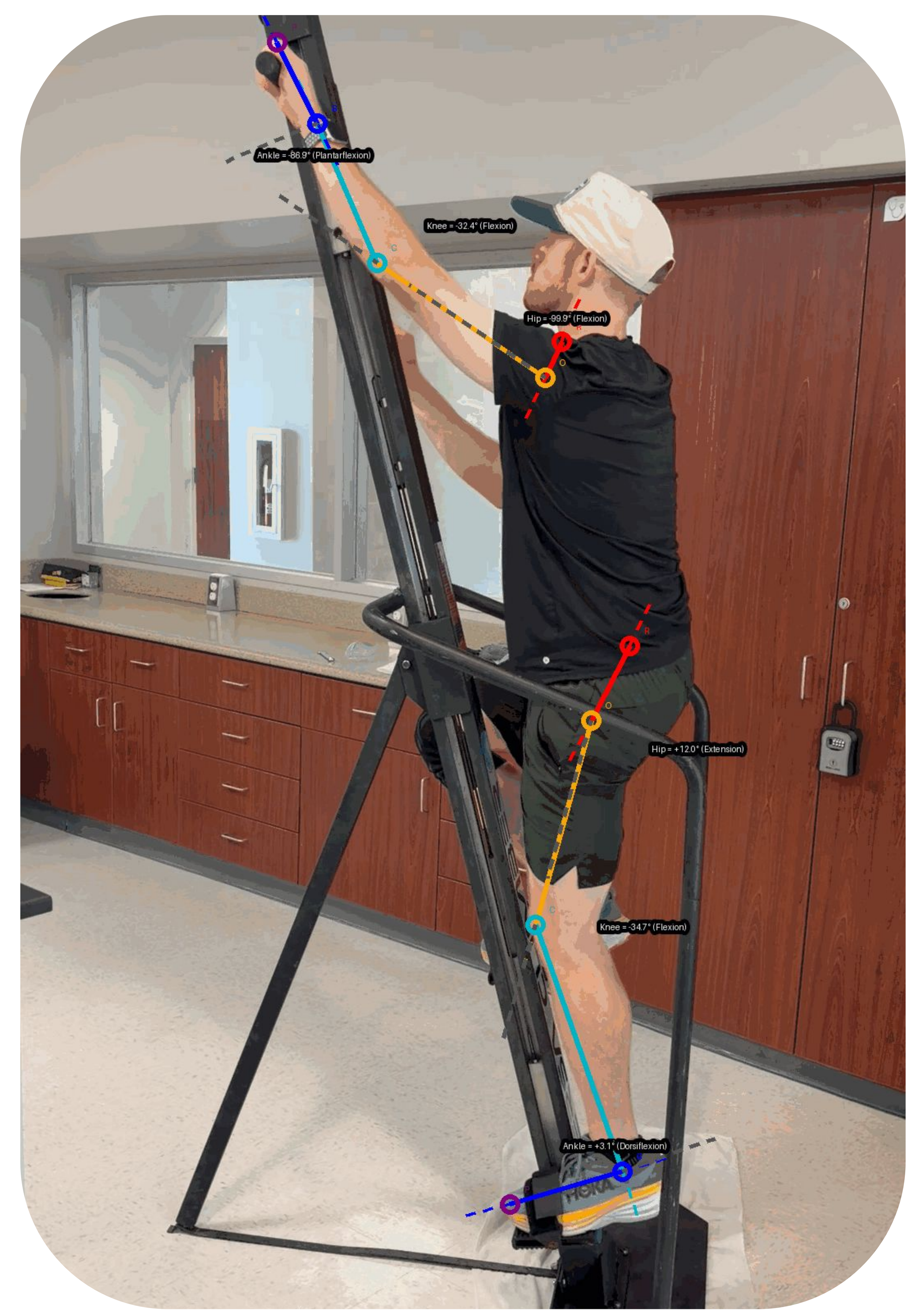
Subsystem Table:







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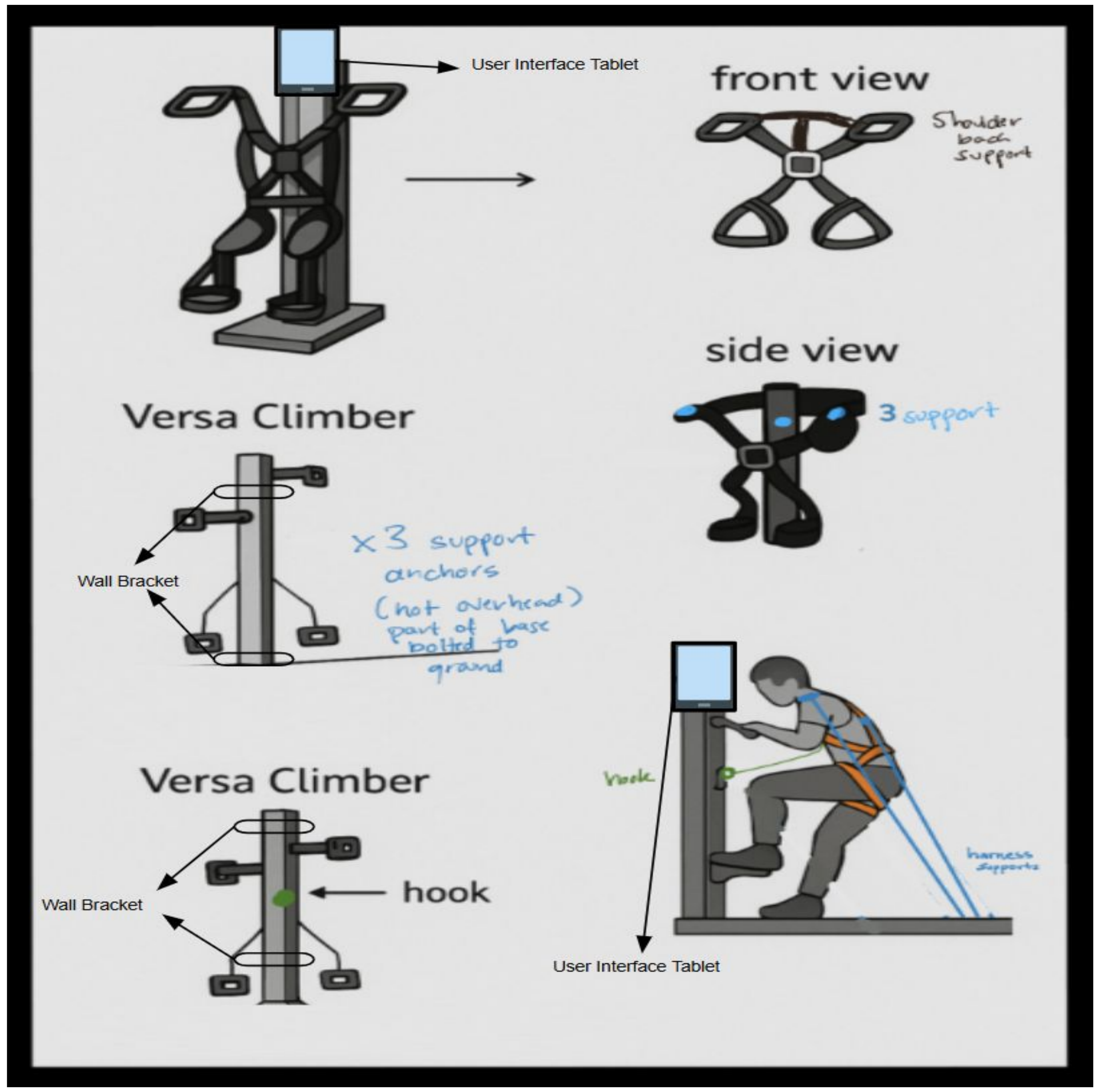

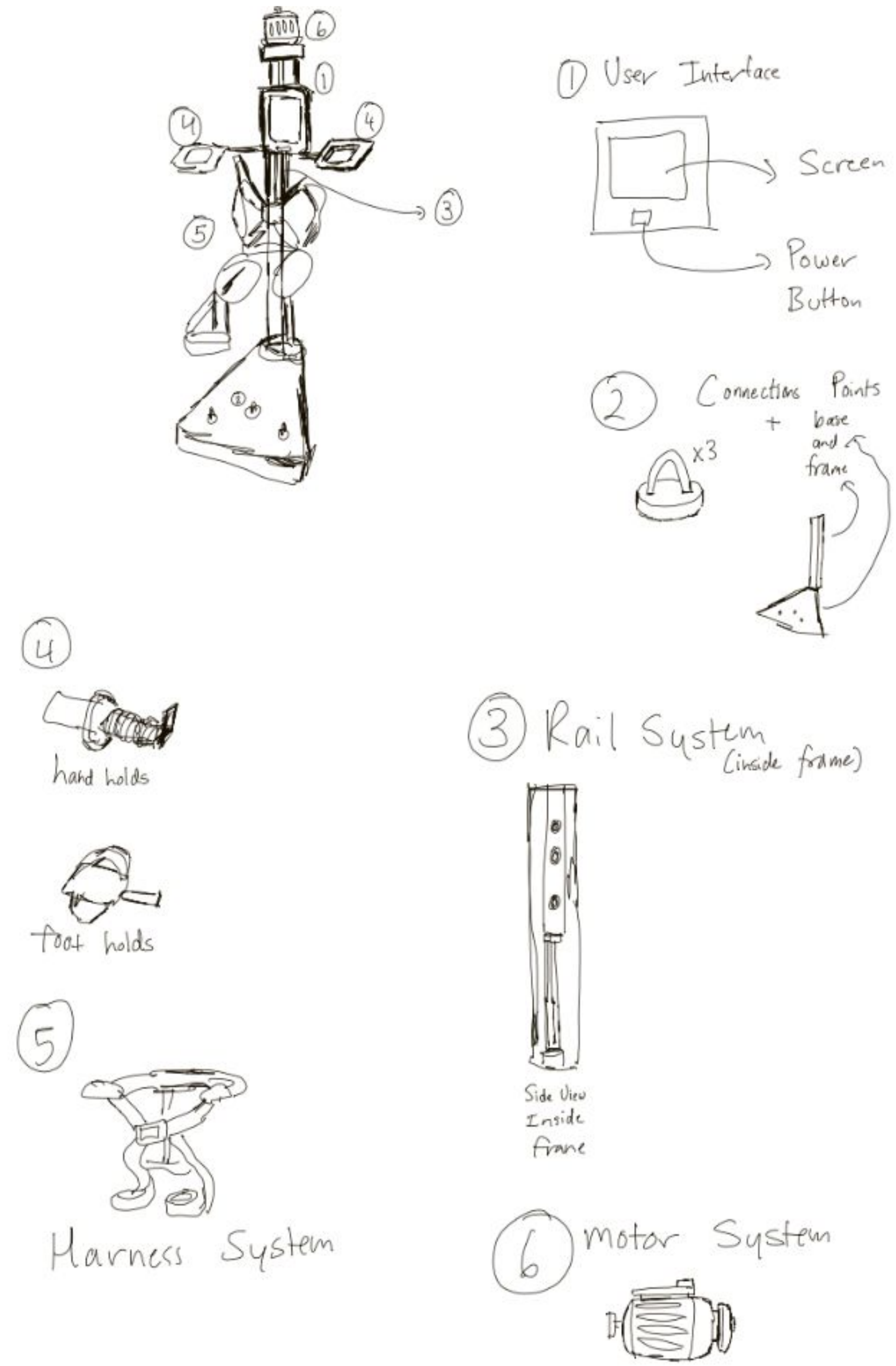

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