Computational Modeling of Astronaut Kinematics and Injury Risks in a Standing Posture During Lunar Launch and Landing

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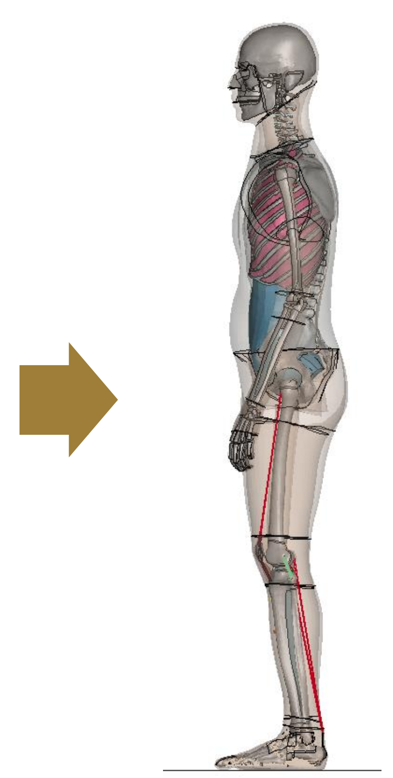
INTRODUCTION

- NASA is planning to send the first woman and next man to the Moon under the Artemis mission.
- Due to lower lunar gravity astronauts can pilot the future lunar vehicle in a standing posture, to minimize the space and material requirements.

Astronaut in a standing posture inside the Lunar module of the Apollo 11 mission



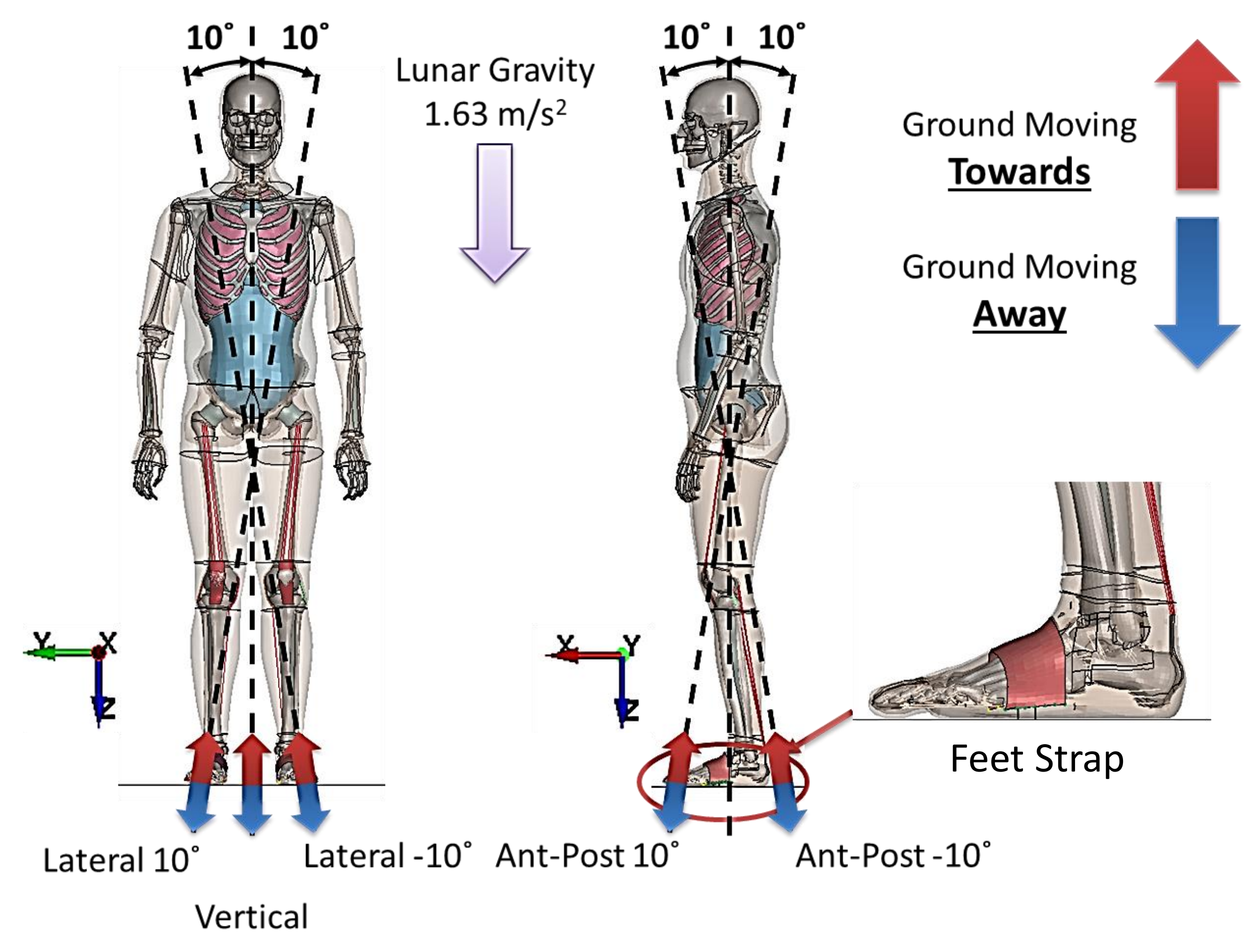
GHBMC M50-PS v1.5.2 Representing standing posture of astronaut

OBJECTIVE

Quantify and understand injury risks and body kinematics for astronauts in a standing posture during vehicle launch, abort, and landing scenarios encountered in lunar space missions using finite element human body modeling.

METHODS

- The standing posture of an astronaut was simulated using the Global Human Body Model Consortium (GHBMC) 50th percentile male model M50-PS.
- Model was restrained to the ground using feet straps and the lunar gravity was simulated by applying 1.63 m/s² acceleration in vertical direction.

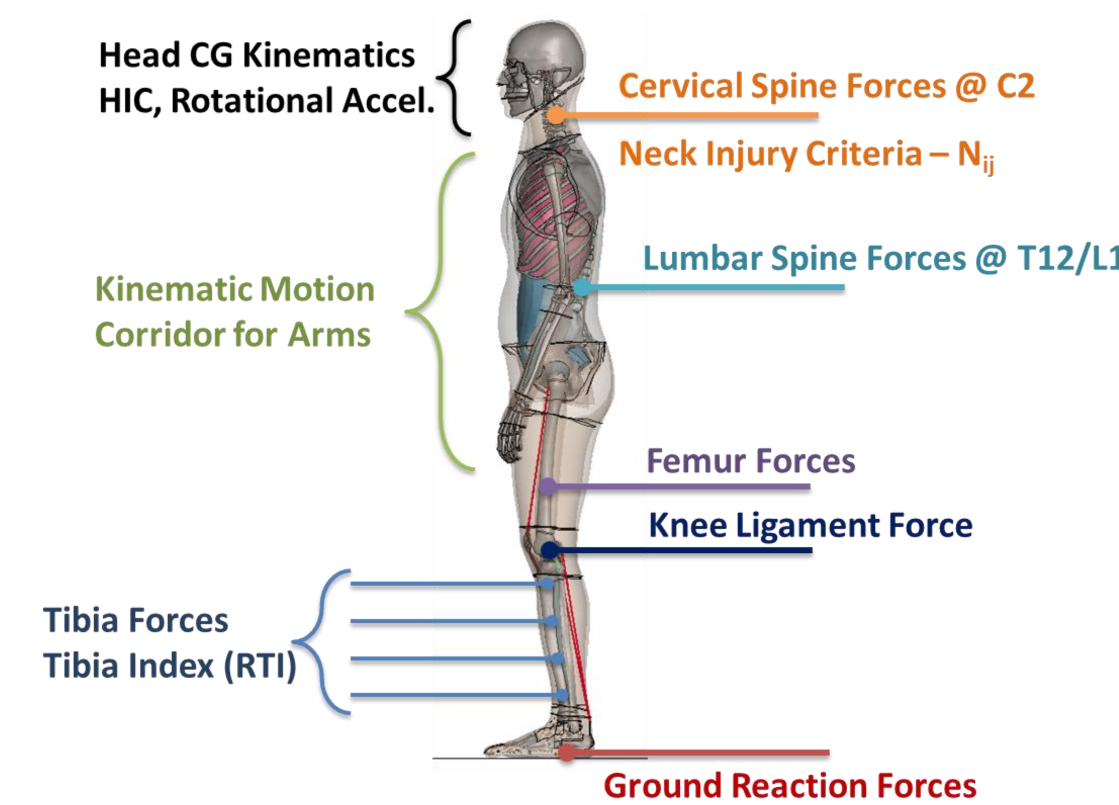


- Dynamic loading conditions were simulated by applying three different half-sinusoidal acceleration pulses with varied peak acceleration and rise time to the ground in five different directions – vertical, ±10º offset in lateral and anterior-posterior directions.

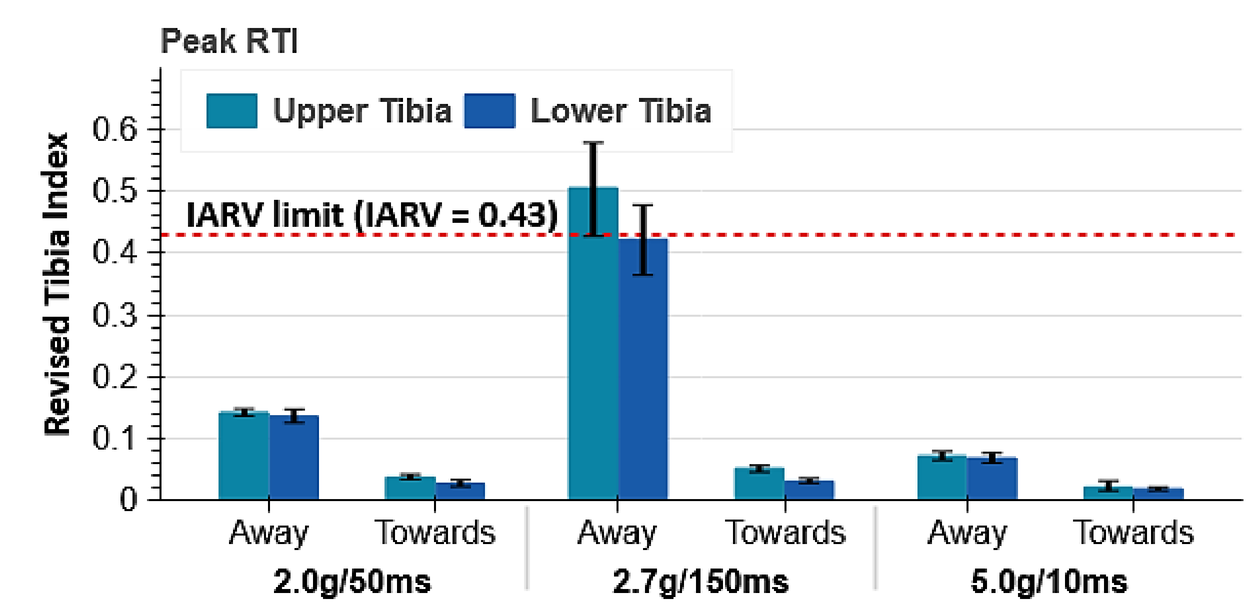
Loading Pulse	Peak Acceleration, g (m/s²)	Rise time, ms
1	5 (49.0)	10
2	2 (19.6)	50
3	2.7 (26.5)	150

RESULTS & DISCUSSION

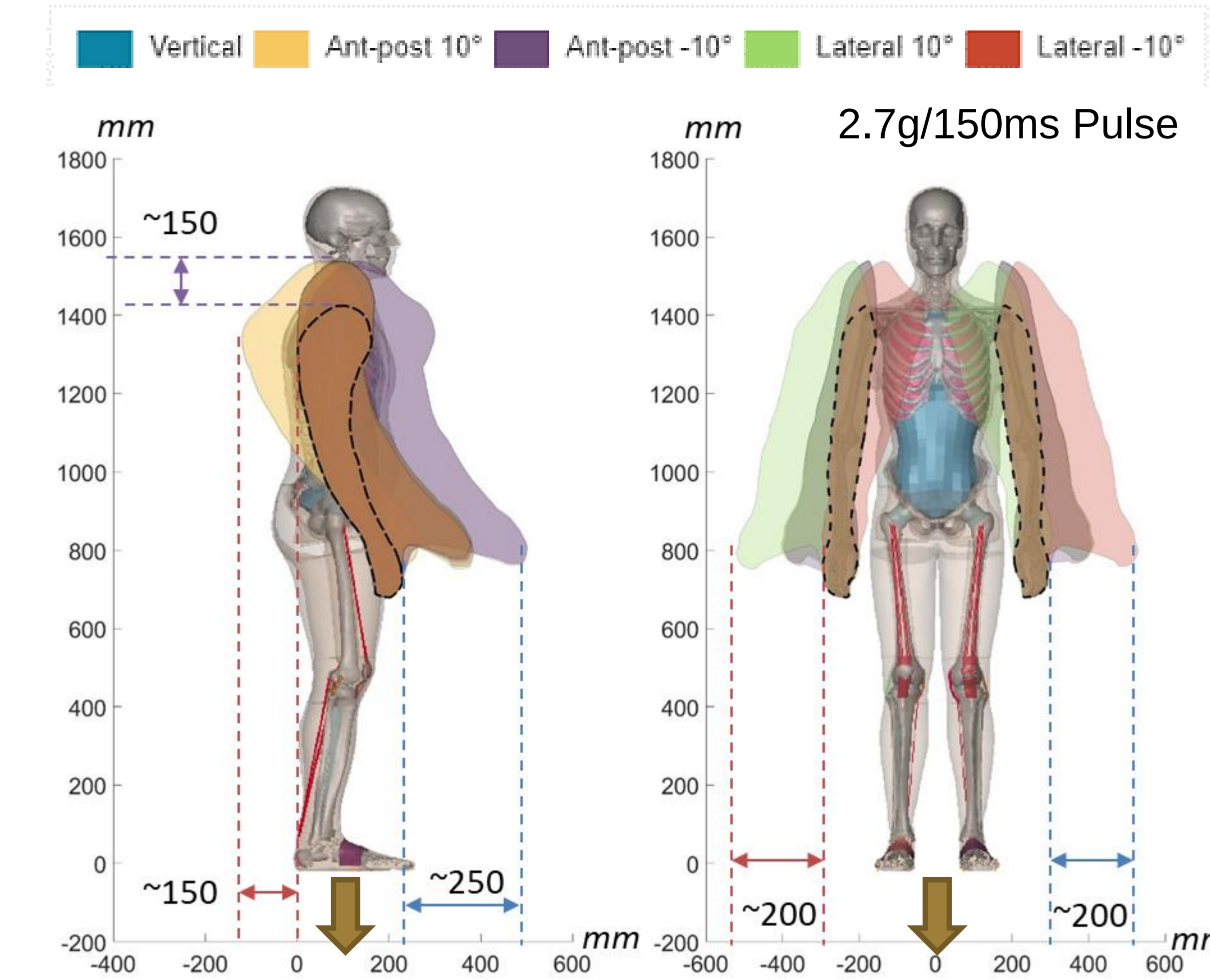
- Injury for different body regions were extracted and compared against the tolerance value by NASA.



- All the injury metrics except for tibia index (RTI) were within the NASA injury tolerance threshold.
- We observed that upper and lower tibia RTI values exceeded the tolerance limit for 2.7g/150 ms pulse in away polarity in most of the loading directions.



- We also extracted arm motion corridor and head CG displacement to assess kinematic response.



CONCLUSION

- Standing posture astronaut lunar mission simulations using the GHBMC human body model.
- Kinematic response of head and arms extracted, which can guide the design of spacesuits and space vehicles.
- Different injury metrics extracted and compared against the tolerance limits. All the injury metrics except for tibia RTI were within tolerance limit.

LIMITATION

In the current study, effects of active musculature were not taken into account. However, for a longer duration pulse, muscle activation can play an important role in injury and kinematic response of astronaut and is a topic of future investigation.

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