MOON GAIT PILOT EXPERIMENT

M. M. Mukadam[1*]; I. L. Schlacht[2]; J. Rittweger[3,4]; M. Masali[5]; A. Del Mastro[6]; B. Foing[7]

[1*]Karlsruhe Institute of Technology, Germany,
[2]International Association for the Advancement of Space Safety (IAASS), The Netherlands. (iaass.space-safety.org & www.extreme-design.eu),
[3]Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Germany
[4]Department of Pediatrics and Adolescent Medicine, University of Cologne, Germany
[5]Universitá di Torino, Italy
[6]Mars Planet, Italy
[7]ESA/ESTEC, ILEWG & VU Amsterdam, The Netherlands

In the context of Moon and Mars missions, the difference in gravity strongly affects human posture and gait, the Ohr-Augen-Ebene (OAE), movement, and physical interaction. In light of current plans for Moon and Mars missions, human interaction needs to be integrated starting from the earliest phases of mission design. Many studies have been done in simulated conditions, starting from the Lunar Gravity Simulation performed at NASA in 1966 by the famous Prof. Moon (Prof. Dr. Walter Kuehnegger), or the Gantry experiment in 1964, also at NASA. Today we still lack detailed biomechanical data in order to completely understand the interactive behavior on the Moon and Mars terrain and gravity. Indeed, altered gravity conditions also affect locomotor-related tasks, such as the negotiation of stationary and moving obstructions during walking or gait initiation/termination [1].

To investigate human behavior in hypogravity, a new pilot experiment called Moon Gait has been performed at the German Aerospace Center (DLR) under the guidance of Prof. Jörn Rittweger (Head of `Space Physiology' division at the DLR), Dr. Irene Lia Schlacht and different international field specialists.

This paper presents the first pilot experiment result and formulated hypothesis after measuring the differences in gait's posture under the influence of hypogravity, starting from the video realized by DLR on a normal horizontal treadmill and a vertical treadmill. The vertical treadmill is an instrument where the participant is able to walk vertically. In this position, gravity no longer has any influence and hypogravity can be simulated using a special type of software that calculates the tightness of the string where the subject is belted.

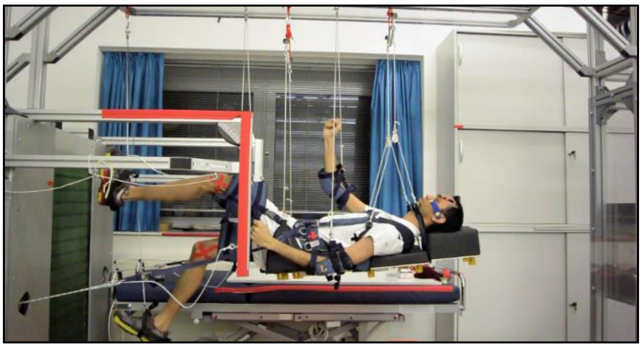

Figure 4: Student Mukadam self experimenting Vertical Treadmill at DLR in Köln, © Mukadam 2017

In the frame of the first author's thesis "Moon Gait: Investigating a methodology for analysis of hypogravity gait posture for architecture design in space." [2] in cooperation with Karlsruhe Institute of Technology and DLR, a detailed optimization of the Moon Gait experiment design, setup and statistical analysis procedure has been identified and tested. The statistical analysis has been done with 5 tests on 36 videos with a sample size of 6 participants of different age, gender and mass. The video analysis has been performed using a software called Tracker, through this software the gait vertical oscillation has been measured (the variation in the height given by the oscillation of the top of the head) and the variation of OAE angle again during the gait. The steps applied are:

1. Record a participant's video with defined markers on the vertical treadmill at slow and fast speeds (4km/h & 11.5km/h) and different weight loads (0.3*g*, 0.6*g* & 1*g*).
    1. Extract position data with the Tracker software to compare:
        a. Different speeds and same weight load.
        b. Different weight loads and same speed.
    2. Statistical significant difference analysis using Kruskal-Wallis H test with an alpha level of 0.05.

The results of Kruskal-Wallis H Test showed that there was statistically significant difference of participants, in vertical oscillation running at 4km/h & 11.5km/h at the same weight load of 1*g* (simulated Earth gravity) on the vertical treadmill, while there was no statistical significant difference in vertical oscillation running at 4km/h and 11.5km/h at the same weight load of 0.6*g* and 0.3*g* (simulated Martian gravity).

Variable	Mean	Std. Deviation	Chi-square	Asymp. Sig.	Statistical Sig.
Amplitude at Earth Gravity	9.255	5.677	7.410	.006	Yes
Amplitude at Martian Gravity	8.791	6.372	2.564	0.109	No
Amplitude at 0.6*g* Simulated Gravity	19.38	8.495	1.844	.175	No

Table 1: Result of statistical significant difference analysis with alpha level 0.05

This significant result of the Moon Gait pilot experiment brought about an enticing hypothesis that, on Earth vertical oscillation variates relative to speed of running, as well known to field experts [3], while on Mars or any other hypogravity region like the Moon this behavior is completely different, the vertical oscillation during the gait has no major change at both slow and fast speed. This hypothesis should be investigated with the following setup:

1. Number of subjects 30.
2. Data analysis made step by step, (left step separate from the right one).
3. Application of "Linear Mixed Effects Model" statistical test.
4. Bed rest performed by participant before vertical run on treadmill.

The observations of the effects of hypogravity will help to reveal the intrinsic properties of locomotor pattern generators facilitating greater understanding of Earth, Mars and Moon gait. Further development of this study including effects of vestibular system on gait balance in relation with difference in gravity is planned to be performed both on parabolic flight and also on the Motigravity tool developed by Mars Planet [4]. This tool uses virtual reality and a biomechanical system to simulate the interaction in low gravity environment including walking behavior.

References

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Short Summary

The pilot experiment in simulated hypogravity on the DLR's vertical treadmill brought about the hypothesis that comparing slow and fast gait (4-11.5 km/h), the vertical oscillation on Earth confirms a significant change, while on Mars or Moon it is completely different, it has a similar oscillation at both the speeds.