

# FUNCTIONAL TASK TESTS IN PARTIAL GRAVITY DURING PARABOLIC FLIGHT

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## BACKGROUND

Understanding how critical mission tasks are performed in partial gravity such as on the moon or Mars is necessary to define effective and comprehensive countermeasure strategies for preserving crew performance during exploration missions. We studied the performance of tasks such as standing, balancing, walking, and jumping during the partial gravity phases of parabolic flight. We hypothesized that the acute effects of partial gravity on vestibular, proprioceptive, and sensorimotor functions would negatively impact performance.

## METHODS

Twelve subjects (6F, 6M;  $40.2 \pm 8.5$  years) were tested over three flights of 30 parabolas each, including 10 parabolas at 0.25g, 10 parabolas at 0.5g, and 10 parabolas at 0.75g. Subjects also performed tests in 1g between parabolas. During the seat egress and walk task, subjects rose from a seated position and walked as quickly as possible straight ahead towards a cone (4 m distance), stepped over a 30 cm high obstacle, walked around the cone making a 180° left turn, returned to the chair, and sat down in the chair. Other tasks included a tandem stance on rails, jump down from a 30cm platform, recovery from fall (prone to stand), and limits of stability tasks. Data were collected using inertial measurement units (Opal V2, APDM, Portland, OR) worn on the head and trunk, heart rate monitors (Polar, Finland), and a force plate (Bertec, Columbus, OH). During the jump down and limits of stability tasks, falls were recorded if subjects took extra steps, lifted their heels/toes, or used their arms to recover balance.

## RESULTS

Gravity level had a significant effect on performance, with the greatest changes from 1g tending to be at the 0.25g level (Table 1). Lower gravity levels were associated with increased times to complete the seat egress and walk task and the recovery from fall task, increased head-trunk coordination, decreased tandem stance rail balance times, decreased change in heart rate during the recovery from fall task, and increased cone of stability distance in the anterior-posterior direction. In addition, there were significantly more falls recorded at the lower gravity levels: 31 falls at 0.25g, 14 falls at 0.5g, 6 falls at 0.75g, and 6 falls at 1g.

Table 1. Functional task performance at different gravity levels (<sup>^</sup>Published in *Clement et al., 2024*)

Measure	Significant ( $p < 0.05$ ) g-level effects
Seat egress and walk (SEaW) – time to complete( <sup>^</sup> )	0.25g > 0.5g, 0.75g, and 1g
SEaW – cone turn rate( <sup>^</sup> )	0.25g < 0.5g, 0.75g, and 1g
SEaW – seat turn rate( <sup>^</sup> )	0.25g < 0.5g and 0.75g; 0.5g and 0.75g > 1g
SEaW – coherence head-trunk pitch	0.25g > 0.75g and 1g
SEaW – roll head-trunk velocity deviation	0.25g < 1g
Tandem stance duration – EO and EC( <sup>^</sup> )	0.25g < 0.75g and 1g
Recovery from Fall – time to stand/settle( <sup>^</sup> )	0.25g > 0.75g and 1g
Recovery from Fall – changes in heart rate( <sup>^</sup> )	0.25g < 0.75g and 1g
Limits of Stability – anterior posterior( <sup>^</sup> )	0.25g > 1g (but with more falls)

## DISCUSSION

These data suggest that there is a dose-response relationship between gravity level and functional task performance. The largest changes in performance were expected at the lowest gravity level (0.25g) because subjects would no longer be able to use the gravitational reference for the perception of upright. Understanding the extent of performance deficits informs the risks and design of countermeasures for exploration spaceflight missions.

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