# Novel Analog For Muscle Deconditioning

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## ABSTRACT

Existing models (such as bed rest) of muscle deconditioning are cumbersome and expensive. We propose a new model utilizing a weighted suit to manipulate strength, power, or endurance function relative to body weight (BW). Methods: 20 subjects performed 7 occupational astronaut tasks while wearing a suit weighted with 0-120% of BW. Models of the full relationship between muscle function/BW and task completion time were developed using fractional polynomial regression and verified by the addition of pre- and postflight astronaut performance data for the same tasks. Spline regression was used to identify muscle function thresholds below which task performance was impaired. Results: Thresholds of performance decline were identified for each task. Seated egress & walk (most difficult task) showed thresholds of leg press (LP) isometric peak force/BW of 18 N/kg, LP power/BW of 18 W/kg, LP work/BW of 79 J/kg, isokinetic knee extension (KE)/BW of 6 Nm/kg, and KE torque/BW of 1.9 Nm/kg. Conclusions: Laboratory manipulation of relative strength has promise as an appropriate analog for spaceflight-induced loss of muscle function, for predicting occupational task performance and establishing operationally relevant strength thresholds.

## RESULTS

### Seated egress and walk task

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<td>4.9</td>
<td>13.1</td>
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<tr>
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<td>10.8</td>
<td>4.0</td>
<td>5.7</td>
<td>13.3</td>
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<tr>
<td>Translation</td>
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<td>13.3</td>
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<tr>
<td>Construction board</td>
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<td>4.0</td>
<td>5.7</td>
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### Discussion

- Laboratory manipulation of relative strength has promise as an appropriate analog for spaceflight-induced loss of muscle function, for predicting occupational task performance and establishing operationally relevant strength thresholds.
- Addition of astronaut data appears to confirm the models established using the weighted suit.
- Future work should focus on optimization of both predictors and tasks.

## INTRODUCTION AND PURPOSE

- Lower body muscle strength and power is related to performance of ambulatory tasks of daily living in older adults (1-4).
- Minimal strength / power requirements to perform ambulatory activities of daily living are related to body mass (4).
- Greater body mass requires more strength / power
- Develop and validate a methodology for evaluation leg strength / power requirements of occupational astronaut tasks.

## METHODS

- Subjects were tested for leg press (LP) maximal isometric force (MIF), power and work (21 reps at 40% MIF) as well as knee extension MIF and isokinetic peak torque at 60 deg/sec.
- Subjects performed a series of occupational tasks including seated egress & walk, ladder climb, rock translation, hatch opening, recover y from fall, and construction board.
- Tasks were performed wearing a weighted garment loaded with 0, 20, 40, 60, 80, 100 or 120% of body weight distributed over the body according to limb weight segments to minimize changes in the center of gravity.

## STATISTICAL MODELING

### Spline Regression

- Extension of OLS regression that estimates the relationship between outcome and predictor as a piecewise linear function composed of two or more linear segments.
- Used to model a single-knot/two-slope linear association between all strength/body weight predictors and the time to completion for each task.
- Modeled a two-slope association, where the interaction of the two segments (knot) represents the threshold where the association between strength/body and performance changes. Separate models were estimated varying the knot location by percentile increments throughout the range of X including a no-spline (linear) model. The model of best-fit was chosen based on the highest multiple R2 coefficient of determination.

### Fractional Polynomial Regression

- Generalization of polynomial regression that allows fractional powers and/or powers of the natural log of X in the estimation of a curvilinear relationship.
- Used to estimate the full curvilinear association between individual strength/body weight predictors and time to completion.
- Consistent with our threshold-hypothesis we restricted our models to include, at most, three terms including the Y-intercept.

## REFERENCES