Reliability of a Test Battery Designed for Quickly and Safely Assessing Diverse Indices of Neuromuscular Function

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Introduction

- Spaceflight affects nearly every physiological system

- Spaceflight-induced alterations in physiological function translate to decrements in functional performance

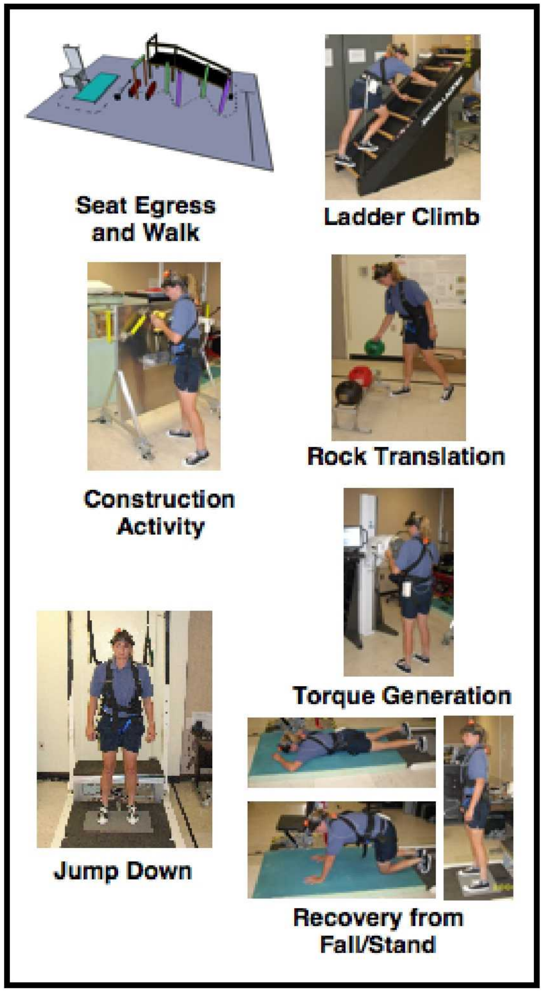
Introduction

- Challenge:
  - How do we develop countermeasures to offset the plethora of physiological decrements?

- Solution:
  - Identify the physiological factors most critical for functional outcomes
  - Develop countermeasures targeted toward the most critical factors

Introduction

Functional Performance



Map

Physiological Measures

Muscle

- Strength
- Power
- Endurance
- Control
- Neuromuscular Drive

Sensorimotor

- Posture
- Gait
- Dynamic Visual Acuity
- Fine Motor

Cardiovascular

- Plasma Volume

What "Neuromuscular Performance Variables" Do We Assess?

- Reduced strength is a hallmark consequence of spaceflight
  - Strength is strongly associated with functional performance (Visser et al. 2000)
  - "Neural factors" (e.g., central activation) clearly contribute to unloading-induced strength loss (Clark et al. 2006)
- Power is perhaps the strongest predictor of functional performance (Puthoff et al. 2008)
- Force steadiness might relate to functional performance (Seynnes et al. 2005; Manini et al. 2005)

Purpose

- To develop a test battery for quickly and safely assessing diverse indices of neuromuscular performance
  - Quickly:
    - Battery of tests must be completed in ~30 min
  - Safely:
    - Increased susceptibility to muscle damage after spaceflight
    - Impaired postural stability post-spaceflight
  - Diverse indices:
    - Strength
    - Central activation
    - Power
    - Endurance
    - Force steadiness

Methods

- Subjects
  - 10 healthy volunteers (5 women, 5 men)
  - Age: 31 ± 5 y
  - Height: 173 ± 11 cm
  - Weight: 73 ± 14 kg

- Procedures
  - Completed a battery of neuromuscular performance tests on 3 occasions separated by at least 48 h

Knee Extension Tests

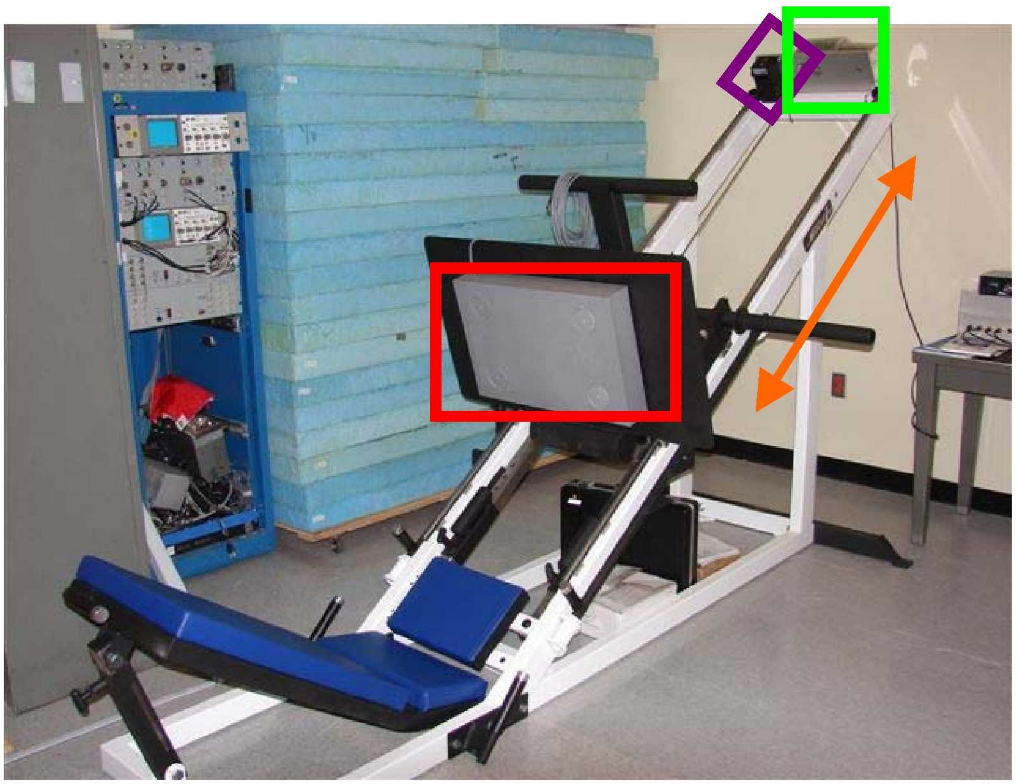
Test #1: Interpolated Twitch Test

–Central Activation

Test #2: Force Steadiness Test

–With and without Visual Feedback

Leg Press Tests



Test #3: Maximal Isometric Force Test

-Maximal Strength

-Rate of Force Development

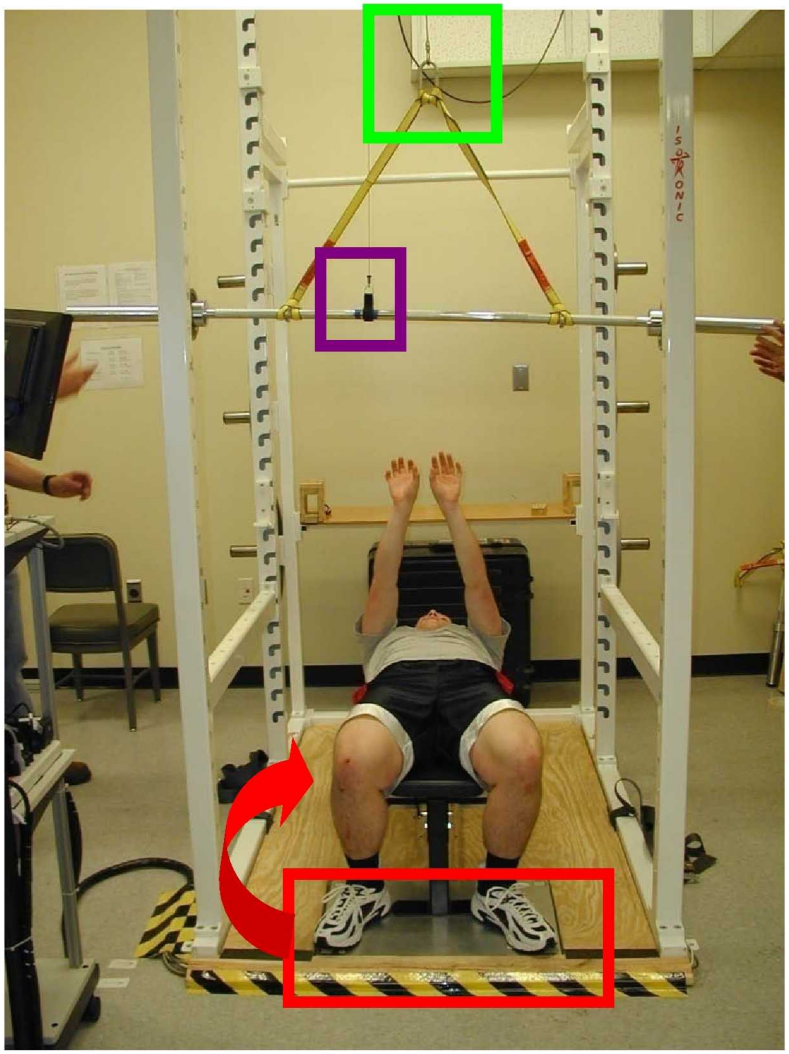
Test #4: Power Endurance Test

-Maximal Power

-Fatigue Index

-Total Work

Bench Press Tests



Test #5: Maximal Isometric Force Test
-Maximal Strength
-Rate of Force Development

Test #6: Force Steadiness Test
-With and without Visual Feedback

Test #7: Power Endurance Test
-Maximal Power
-Fatigue Index
-Total Work

Statistical Analyses

- Reliability of each test was assessed via
  - Standard error of the measurement (SEM)
    - SEM reported as percent of the mean
  - Intraclass correlation coefficient (ICC)
- Time required to set up and conduct each test is reported as mean ± SD

Results: Knee Extension Tests

Test	Dependent Variable	SEM	ICC
Interpolated Twitch	Central Activation Capacity (%)	3%	0.87
Force Steadiness	Force Steadiness with Visual Feedback (CV)	35%	0.20
	Force Steadiness without Visual Feedback (CV)	35%	0.28

Results: Leg Press Tests

Test	Dependent Variable	SEM	ICC
Maximal Isometric Force	Maximal Isometric Force (N)	4%	0.99
	Rate of Force Development (N/ms)	9%	0.94
Power Endurance	Maximal Power (W)	3%	0.99
	Fatigue Index (%)	18%	0.36
	Total Work (J)	4%	0.99

Results: Bench Press Tests

Test	Dependent Variable	SEM	ICC
Maximal Isometric Force	Maximal Isometric Force (N)	3%	0.99
	Rate of Force Development (N/ms)	14%	0.93
Force Steadiness	Force Steadiness with Visual Feedback (CV)	20%	0.60
	Force Steadiness without Visual Feedback (CV)	33%	0.26
Power Endurance	Maximal Power (W)	9%	0.97
	Fatigue Index (%)	16%	0.62
	Total Work (J)	4%	0.99

Results: Time Requirements

Testing Device	Test	Session 1	Session 2	Session 3
Knee Extension	ITT Current Optimization	11 4	9 3	9 2
	Interpolated Twitch	7 2	6 2	7 3
	Force Steadiness	4 2	5 2	5 2
Leg Press	Maximal Isometric Force	8 4	6 1	7 2
	Power Endurance	3 1	2 1	2 0
Bench Press	Maximal Isometric Force	5 2	4 1	4 1
	Force Steadiness	6 3	5 2	5 1
	Power Endurance	2 1	2 1	3 1
	Total	**46 6**	**39 5**	**40 6**

Conclusions

- Purpose: To develop a test battery for quickly and safely assessing diverse indices of neuromuscular performance
  - Quickly:
    - Battery of tests can be completed in ~30-40 min
  - Safely:
    - No eccentric muscle actions or impact forces
    - Tests present little challenge to postural stability
  - Diverse indices:
    - Strength: Excellent reliability (ICC = 0.99)
    - Central activation: Very good reliability (ICC = 0.87)
    - Power: Excellent reliability (ICC = 0.99)
    - Endurance: Total work has excellent reliability (ICC = 0.99)
    - Force steadiness: Poor reliability (ICC = 0.20 – 0.60)

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