Muscle adaptation to unloading

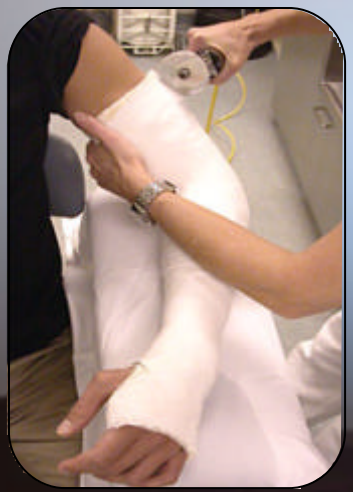
Edwin Mulder
PhD student
UMC St Radboud, Nijmegen

Spaceflight & adaptations

- Skeletal muscles
- Central nervous system
- Weight bearing bones
- Vestibular system
- Cardiovascular system

Spaceflight & models

- Increase number of subjects
- Controlled environment/activities
- Accessibility for researchers and equipment



Adaptations in the neuromuscular system

Berlin Bed Rest Study [BBR]

- 20 male subjects
- 8 weeks (56 days)
- Two groups:

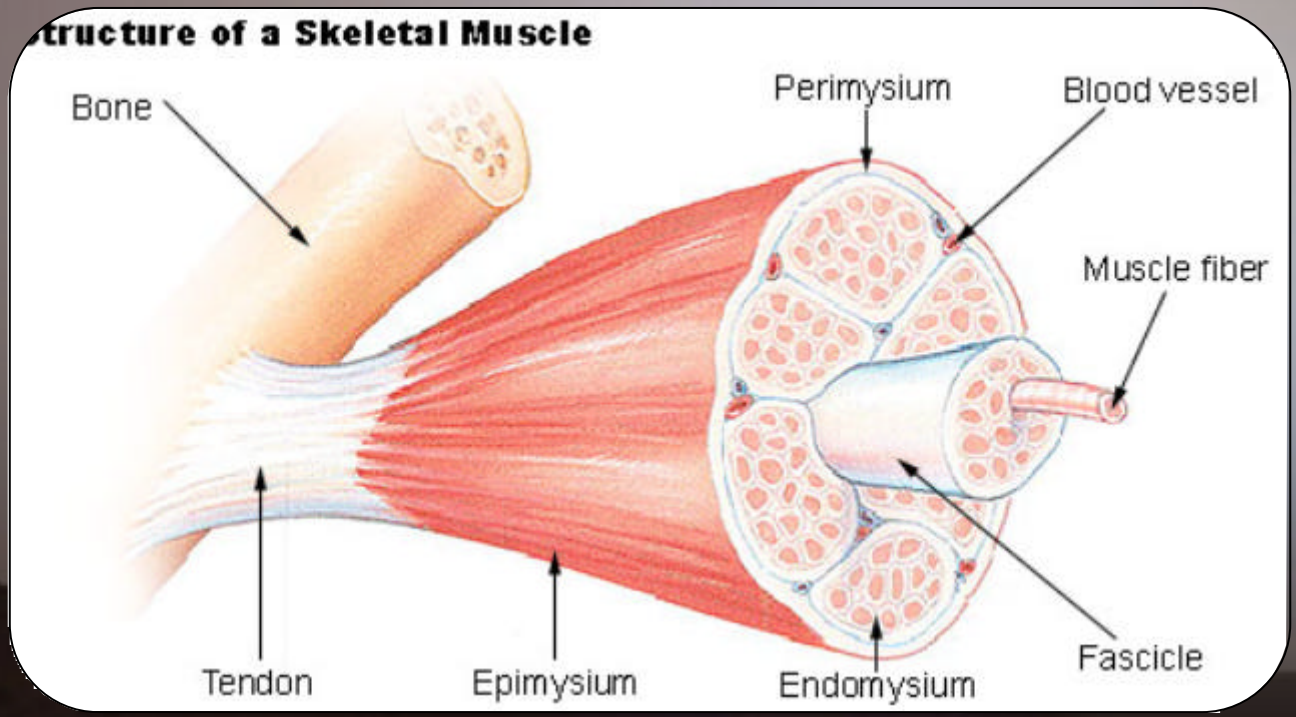
  Trainers
  Controls

Adaptations in the neuromuscular system

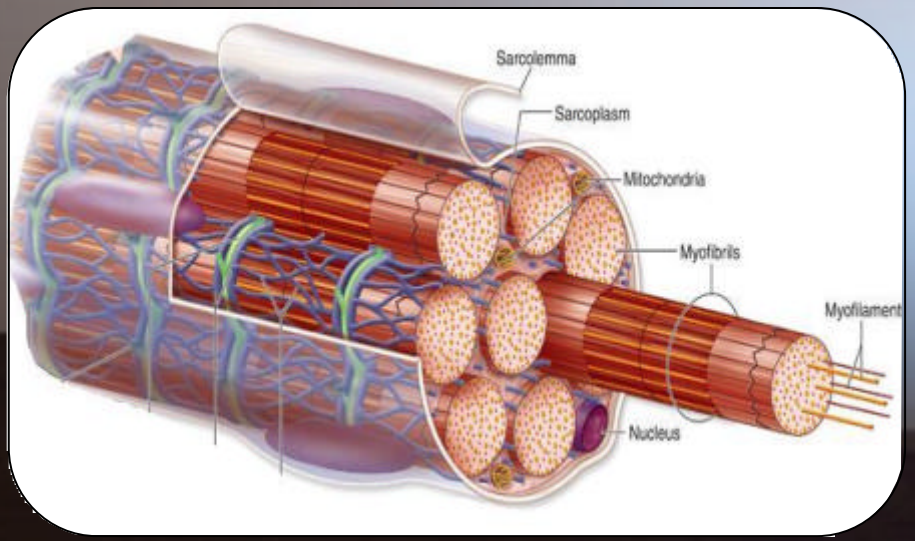
- Skeletal muscle size
- Skeletal muscle strength
- Role of the central nervous system
- Prevention of changes

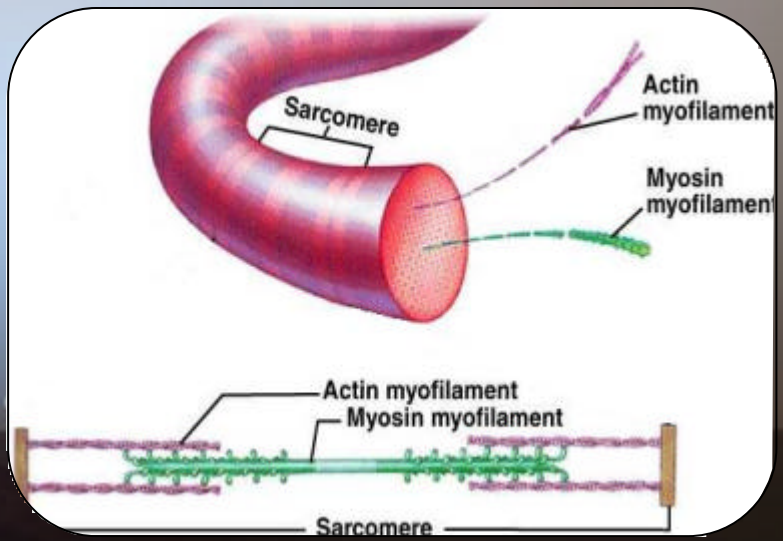
Skeletal muscle size [structure]

- Atrophy



Skeletal muscle size [structure]



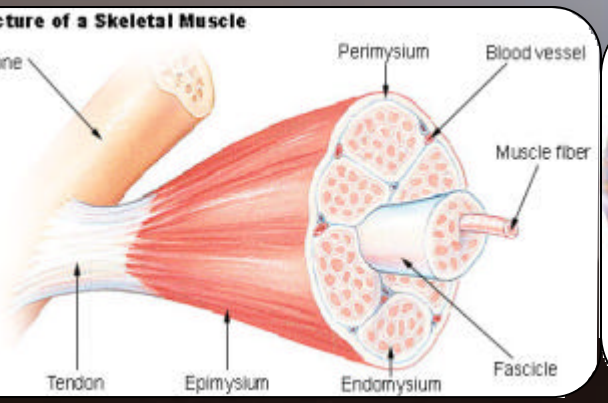


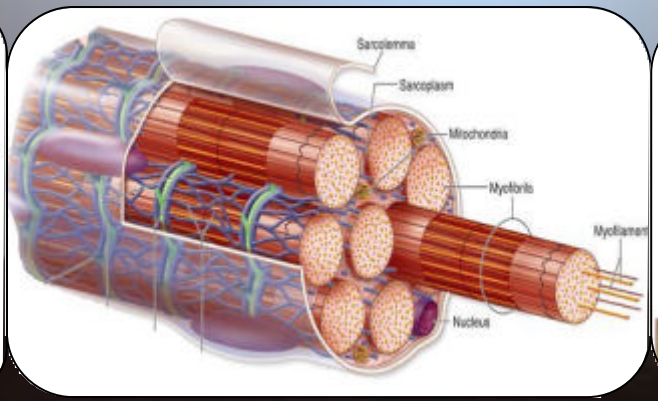
Skeletal muscle size [structure]

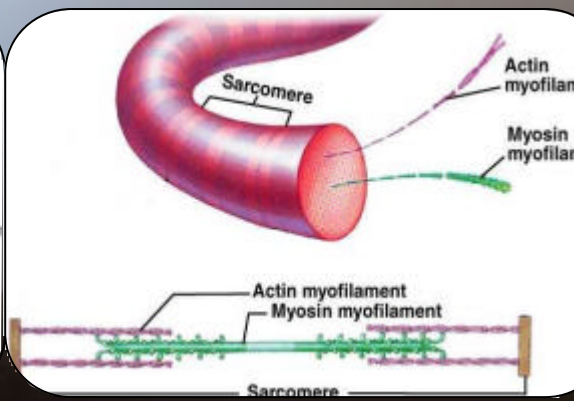
Atrophy = Skeletal muscle size ↓

Due to thinning of muscle fibres

Loss of myofilaments (proteins myosin & actin)

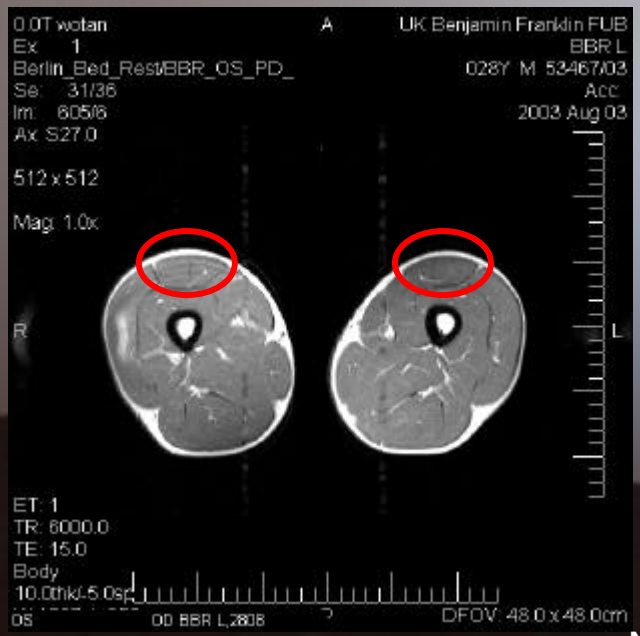


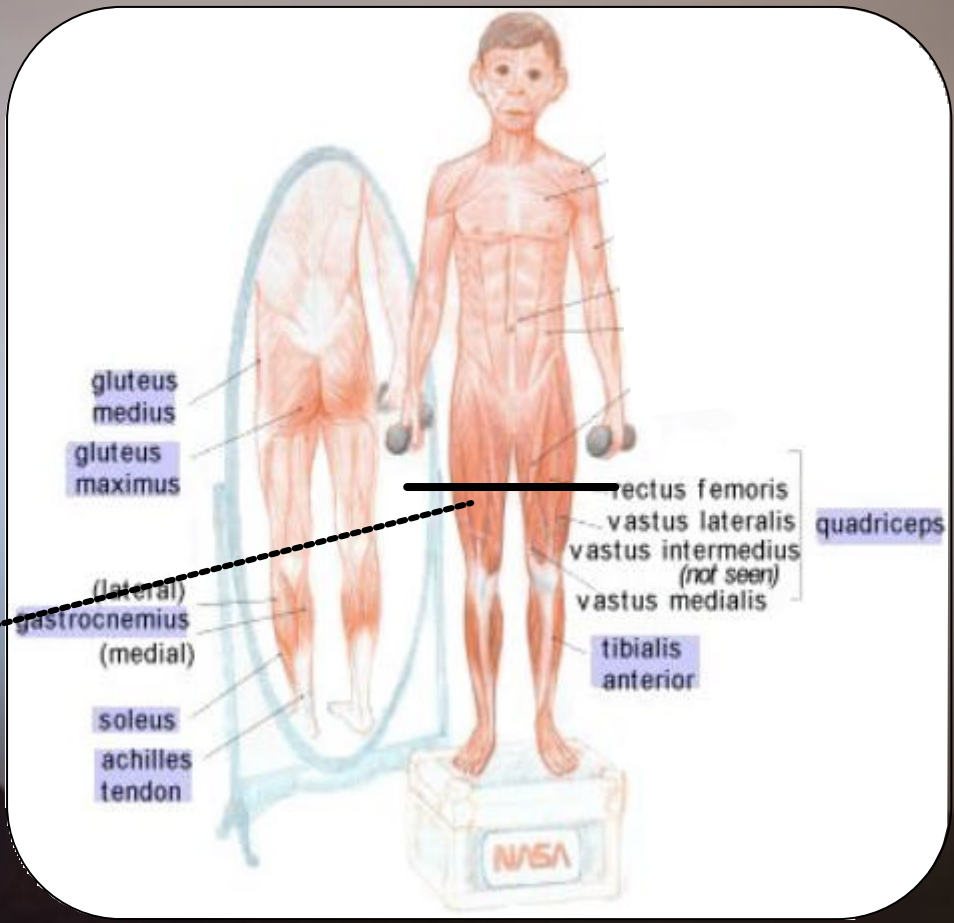




Skeletal muscle size [susceptibility]

- Anti-gravity muscles





Skeletal muscle size [time course]

- Exponential-type decay is expected (CSA ≠ 0)

Skeletal muscle size [time course]

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- Problem 1: almost never actually measured

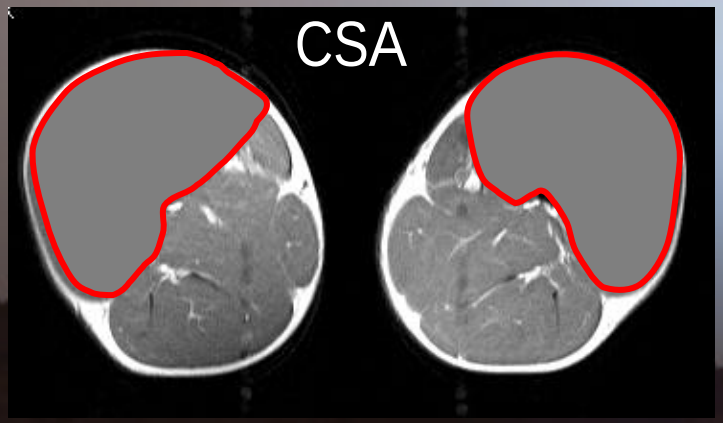
Skeletal muscle size [time course]

- Exponential-type decay is expected
- Problem 1: almost never actually measured
- Problem 2: lack of standardisation

Skeletal muscle size [time course]

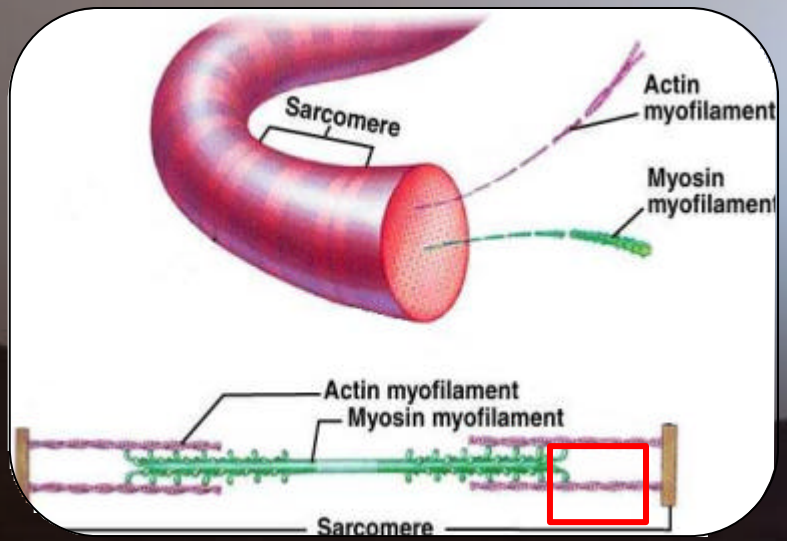
- Exponential-type decay is expected
- Problem 1: almost never actually measured
- Problem 2: lack of standardisation

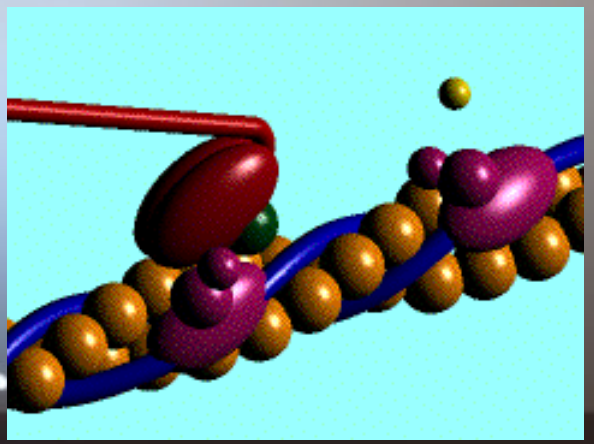
~ 1.5 – 2.0%/wk



Skeletal muscle function

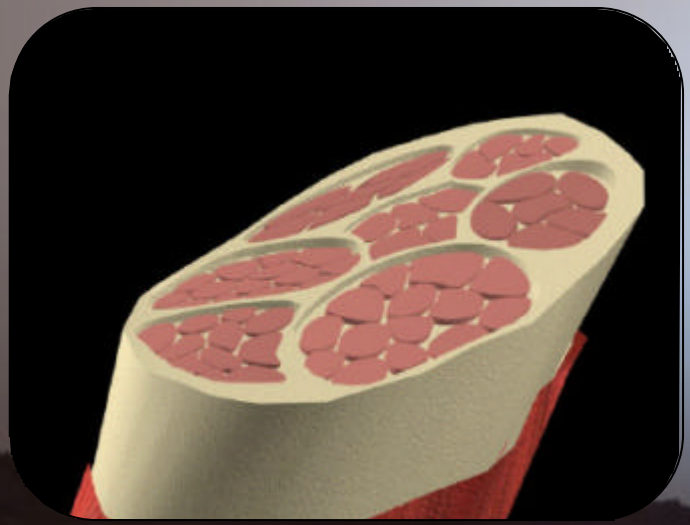
- Generation of force

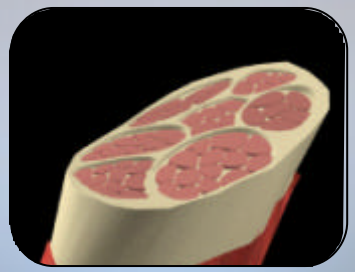




Skeletal muscle function

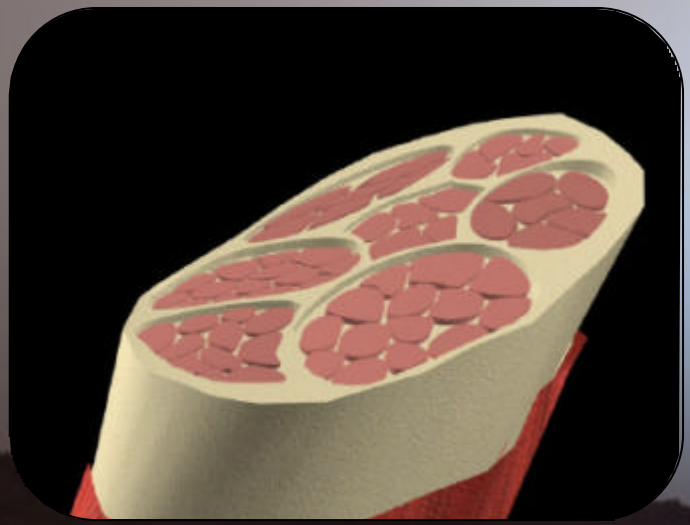
- Muscle strength proportional to size

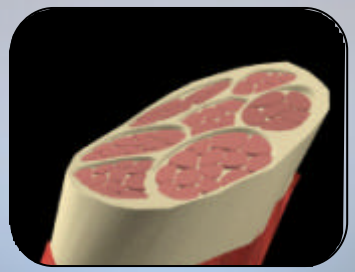




Skeletal muscle function

- Muscle strength proportional to size
- Muscle weakness proportional to atrophy ?



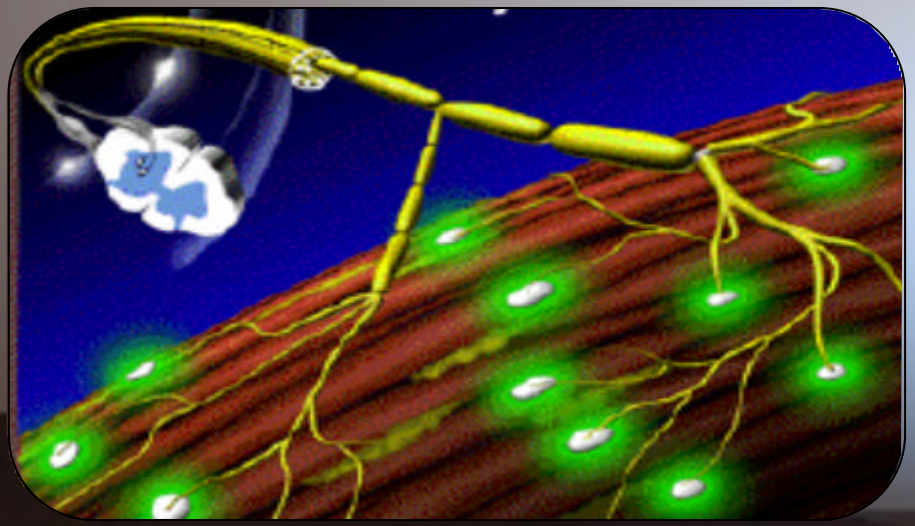


NO !

Weakness > atrophy

Skeletal muscle function

- Voluntary muscle weakness due to changes in neural control

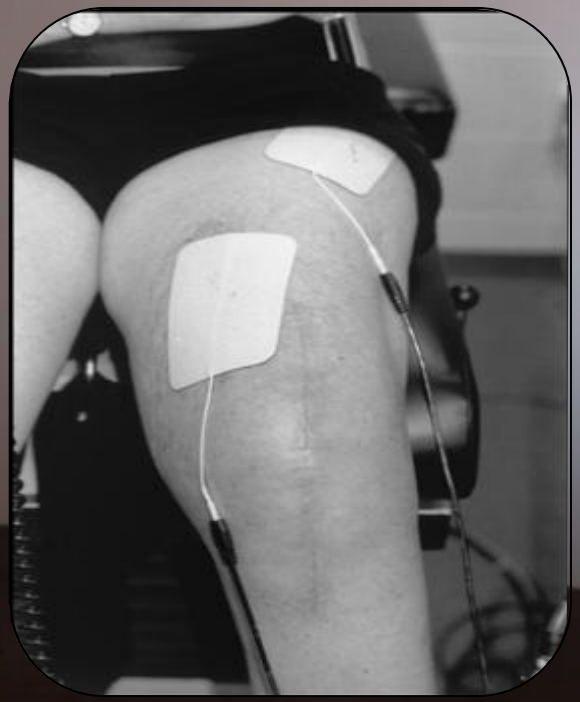


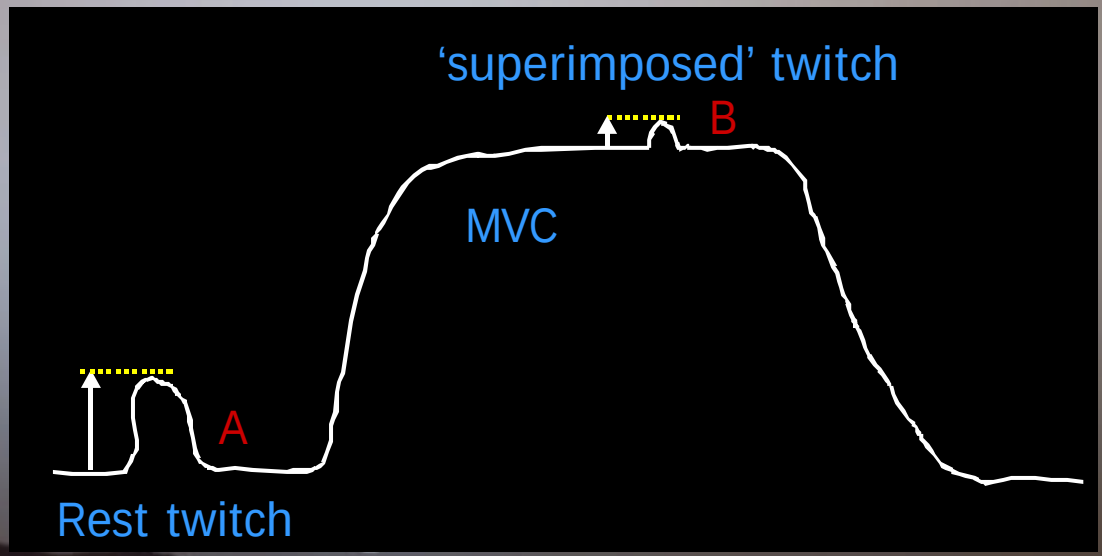
Electrical stimulation

EMG

Skeletal muscle function [BBR]

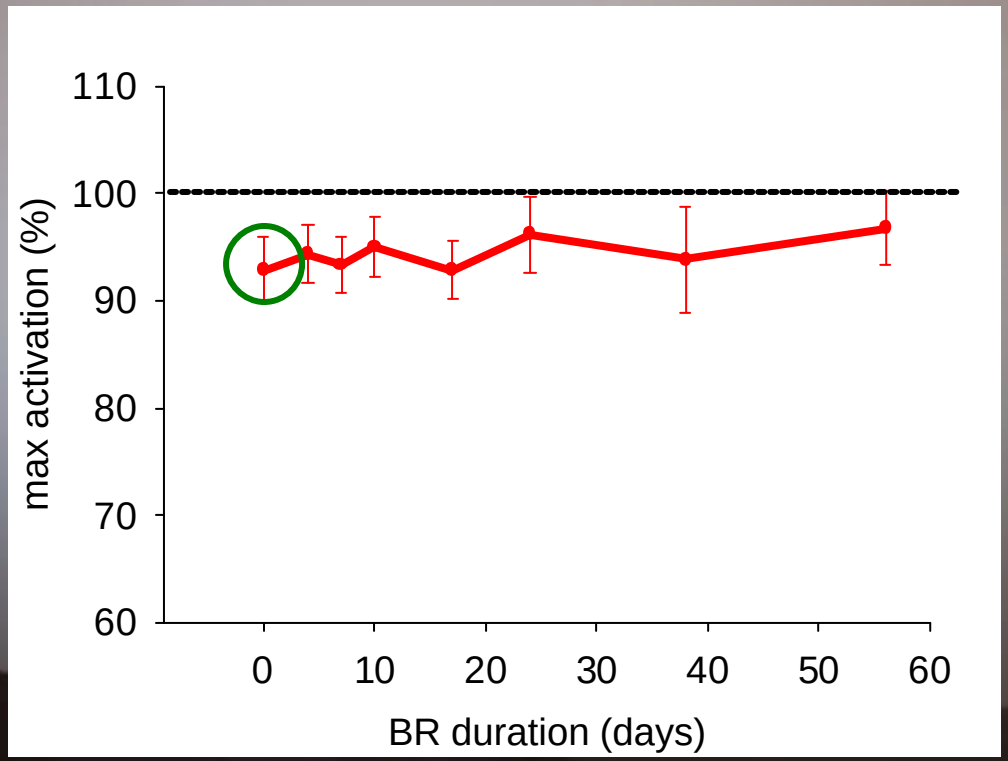
- Neural control measured by electrical stimulation





Skeletal muscle function [BBR]

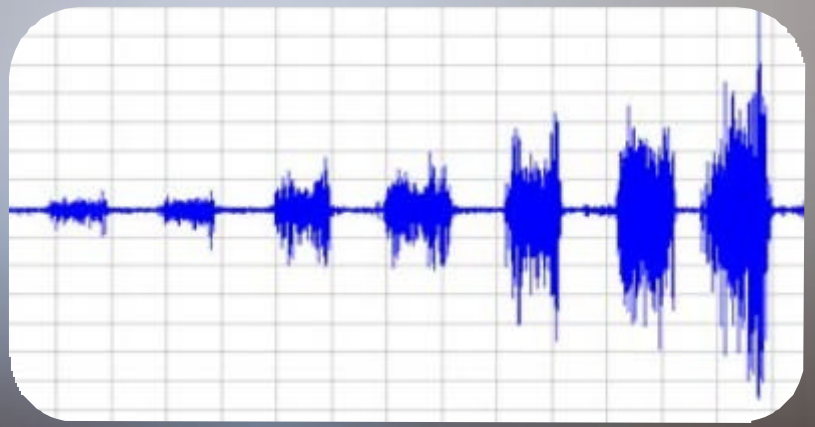
- Neural control measured by electrical stimulation



No change

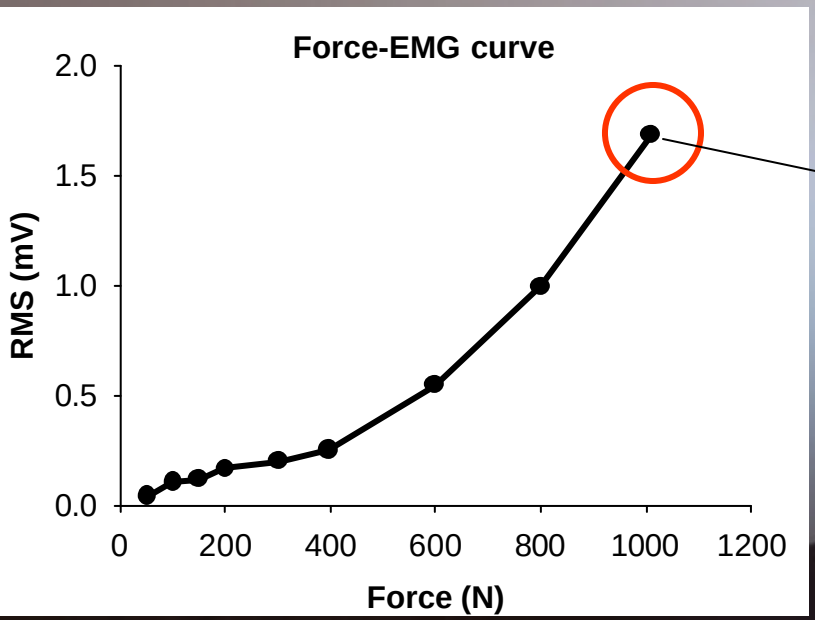
Skeletal muscle function [BBR]

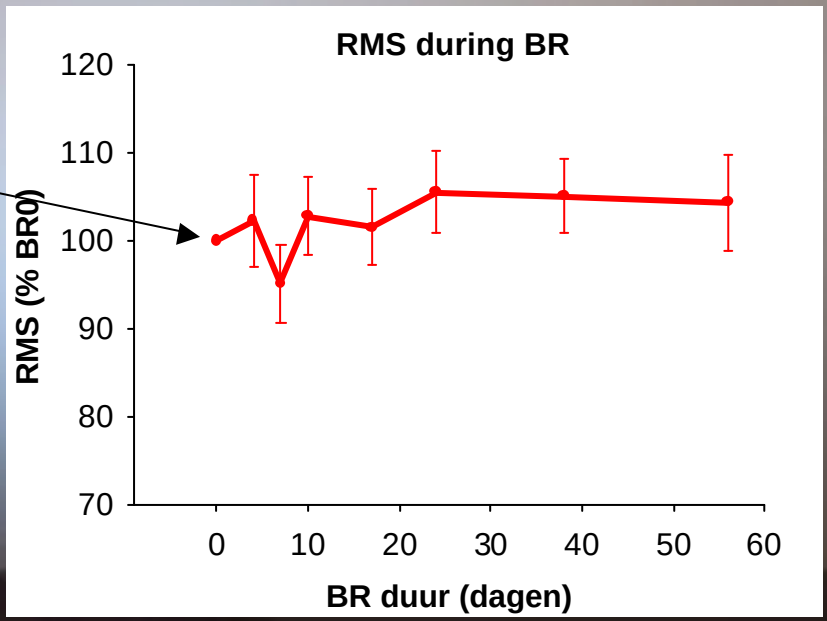
- Neural control measured by **E**lectro**M**yo**G**raphy (EMG)



Skeletal muscle function [BBR]

- Neural control measured by **E**lectro**M**yo**G**raphy (EMG)

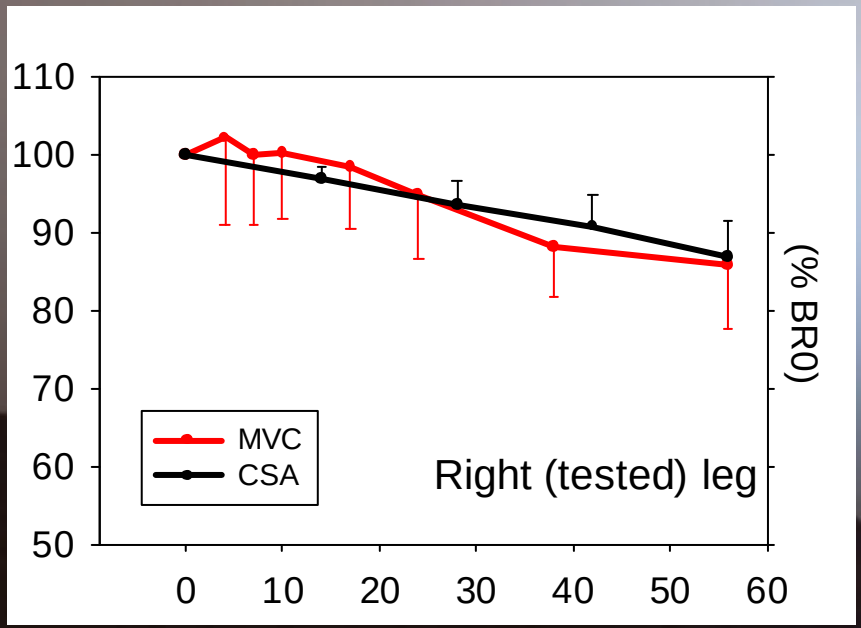


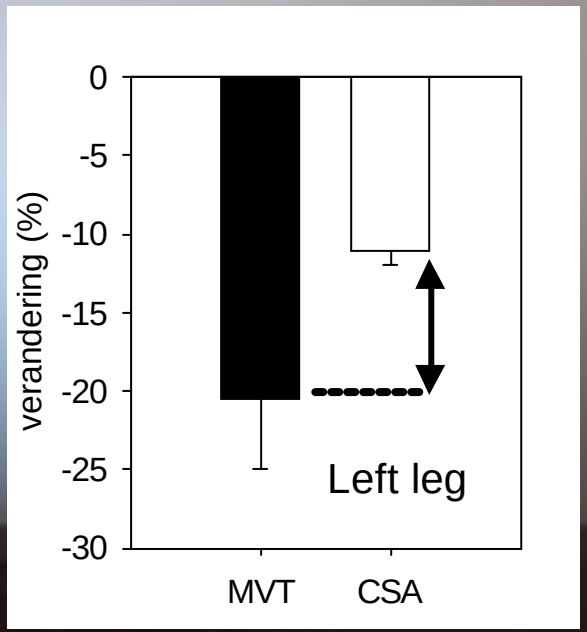


Skeletal muscle function [BBR]

- Berlin Bed Rest Study: effect of experimental tests

  preservation neural control





Neuromuscular preservation

- Berlin Bed Rest Study: effect of experimental tests

  preservation neural control

  task specific

  Did not counter atrophy

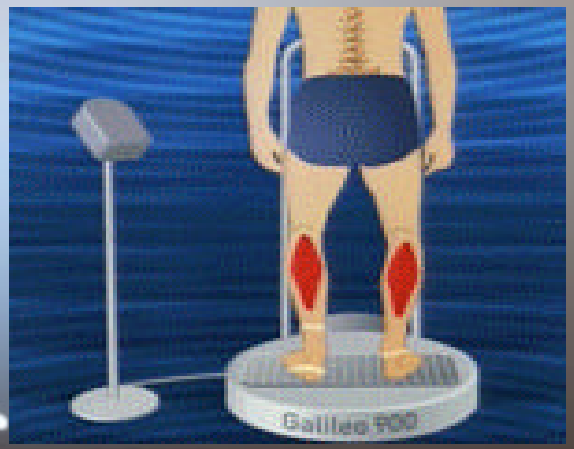
Neuromuscular preservation

- Counter effects of disuse by regular physical exercise
- Questions:

	BBR
What kind of exercise?	strength + vibration
How often?	2 times/day, 5 days/wk
How long?	< 10 min/day
What intensity?	maximal/ sub maximal

Neuromuscular preservation

- Resistance training + vibration



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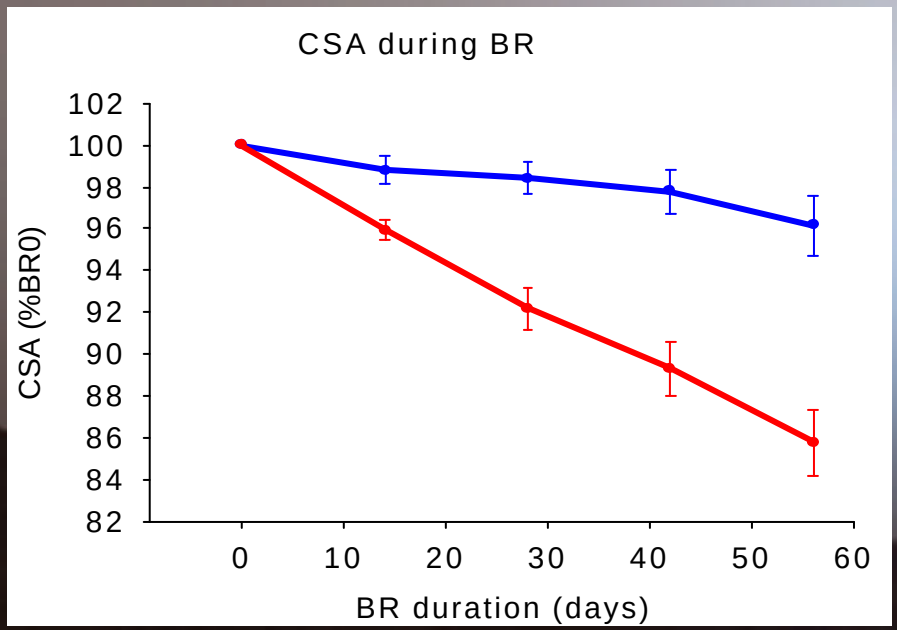
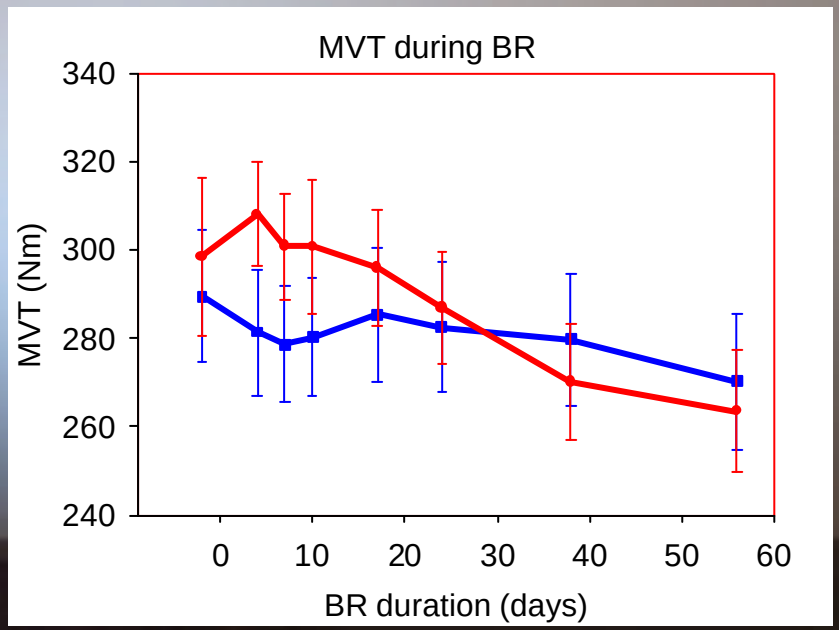
Neuromuscular preservation

- Resistance training + vibration

Controls

Trainers





Conclusions

- The effects of SF can be studied with Earth-based models
- Disuse leads to muscle weakness (periphery + neural)
- Physical activity (vibration training) is effective, not 100%
- Question: vibration, resistance exercise, or combination?


NASA's Mars Exploration Rover Spirit captured this view on May 19, 2005, as the Sun sank below the rim of Gusev crater on Mars....