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Myotonometric Measurements of Muscle during Changes in Gravitational Forces

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TITLE

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GOAL

Assess operational characteristics and reliability of the Myotonometer, a portable medical device that quantifies muscle tone and strength, while gravitational forces are changing.

OBJECTIVES

1) Perform correlational analysis comparing myotonometric measurements of resting and contracting muscle at 0 and 1g. 2) Determine intra-rater reliabilities of myotonometric measurements at 0g. 3) Obtain inter-rater reliabilities of myotonometric measurements at 0g. 4) Descriptive and anecdotal information relating to the feasibility and constraints of obtaining myotonometric measurements of muscle health in a 0g environment.

It is hypothesized the myotonometric measurements of the soleus muscle will be the same regardless of whether measurements are acquired in 0 or 1g. It is also hypothesized that intra- and inter-rater reliabilities will be very high, matching similar published results acquired in 1g.

METHODS AND MATERIALS

Instrument = Myotonometer

The Myotonometer is a patented[1], FDA-approved electronic instrument that measures muscle stiffness (tone/compliance) by quantifying resistance, measured as millimeters of tissue displacement per unit of a perpendicularly applied force of a hand-held probe. An examiner presses a probe onto the skin overlying the desired muscle to a pre-prescribed force level. Computational software instantaneously computes and displays force-displacement characteristics of the muscle. Measurements obtained from a relaxed muscle reflect resting muscle stiffness. Measurements taken during maximal voluntary contractions (MVCs) provide a measure of voluntary muscle activation capabilities of the muscle (strength). This is possible because muscle stiffness increases proportionally with increasing levels of muscle contraction and joint torque.[2,3,4,5]

Measurements are highly reliable at 1g.[6,7,5]

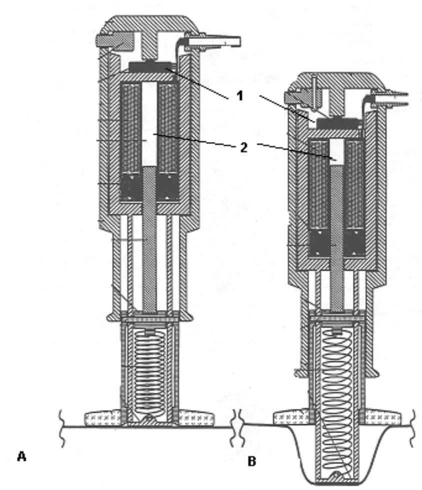

Figure 1. Myotonometer probe diagram. A) Illustrates probe positioned on skin overlying muscle to be tested. B) Illustrates pressure being applied by the examiner. Outer Plexiglas collar remains relatively motionless on the skin while the inner probe compresses underlying tissue. 1= force transducer; 2= electromagnetic coil assembly that measures tissue displacement. Probe is connected to laptop computer for data storage and analysis.

The Myotonometer probe measures 13.5 x 3.7 centimeters and weighs 15 ounces. It is powered by a computer USB port.

Figure 2. Photograph of Myotonometer being used to measure soleus muscle compliance during a 0g parabolic trial aboard the C-9 aircraft.

Subjects and Procedures

Four investigators also served as subjects. Measurements were obtained during 28 parabolas. It was possible, using one instrument, to obtain measurements of resting tone and tone change during soleus MVCs of two subjects during each parabola. Each investigator measured the soleus muscle of the other 3 flyers. Each investigator obtained 3 recordings of a subject's resting and contracted soleus tone during 3 separate 0g parabolas. An equal number of measurements were obtained on the ground at 1g. Each subject's data at 0g were compared to data obtained at 1g to determine whether the measurements differed and to determine the degree of correlation. Data were also analyzed for the degree of intra- and inter-rater reliabilities.

RESULTS

Intra- and Inter-rater Myotonometric Measurement Reliabilities

Myotonometer intra- and inter-rater reliabilities were $r > 0.90$ during 1g measurements. The Myotonometer worked well in 0g, but reliability statistical analysis became a moot point secondary to examiners having difficulty stabilizing adequately in 0g. All examiners had difficulties centering the Myotonometer probe over the muscle in the same location during each parabola. The inability of the examiners to accurately place the hand-held probe over the same spot on the muscle during each trial negatively affected reliabilities, not Myotonometer performance.

Correlation Between Myotonometric Measurements at 0 and 1g

As above, correlational analysis was not possible secondary to unreliable examiner positioning of probe over muscle during 0g trials.

Differences in Myotonometric Measurements During 0 and 1g

There was an apparent trend toward increased muscle stiffness (decrease in compliance) in 0g when compared to 1g measurements (Figure 3).

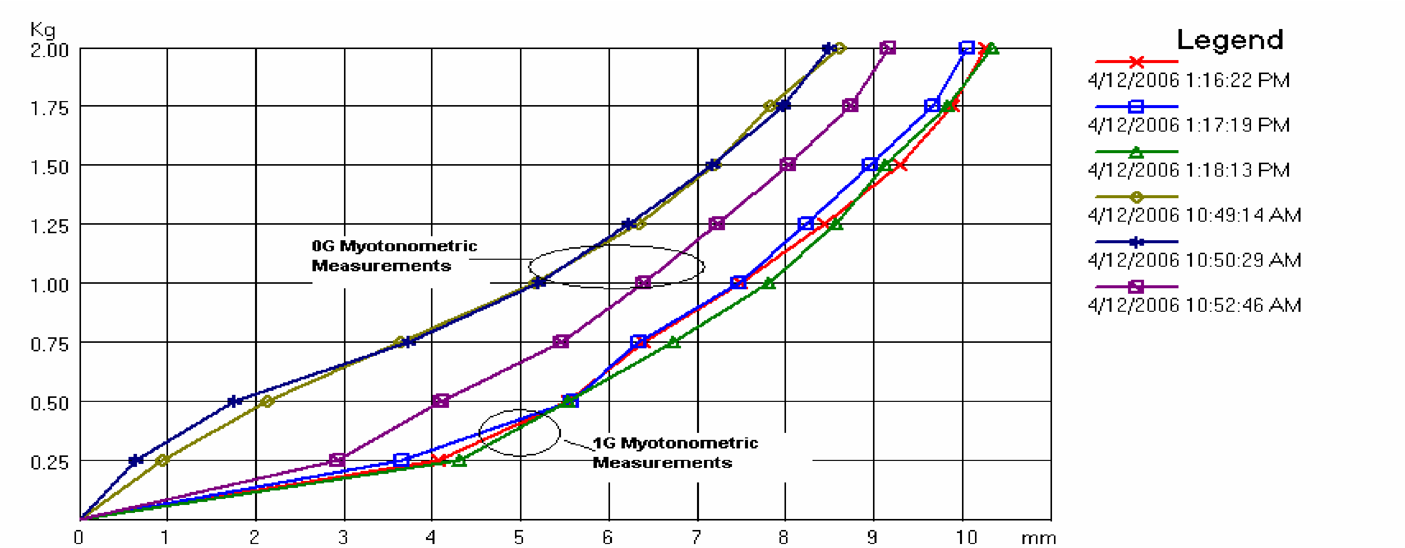

Figure 3. Myotonometric measurements of soleus muscle at rest during 0 and 1g

This figure shows 3 measurements obtained during 1g and 3 measurements obtained at 0g. It illustrates the high reliability of measurements at 1g and more variance at 0g. It also illustrates the trend toward an increase in muscle stiffness during 0g (less muscle displacement per unit of applied force).

DISCUSSION

The Myotonometer has been shown to produce valid measurements of resting muscle tone [8,9]and strength[4,10]. Myotonometric measurements of muscle stiffness (tone/compliance) are highly correlated with surface electromyographic (sEMG)[11]and joint torque measurements[4,5]. The myotonometer has distinct advantages over sEMG and torque measurements that include its portability, ease of use and ability to measure two characteristics of muscle health (tone and strength) in a single testing session that requires less than 1 minute to obtain and display results. Additionally, it is possible to obtain measurements of a single muscle (not just total joint torque).

The Myotonometer worked well in the 0g environment. There were no technical difficulties or malfunctions during parabolic flight. Unfortunately, correlational and reliability statistics were not appropriate secondary to examiner error. The error related to the inability of examiners to obtain measurements from the same location on the soleus muscle during each measurement trial. In order for precise measurements to be obtained myotonometric measurements must be obtained from the same location on the muscle during each trial. This was not possible during the present experiments because our strapping and stabilization procedures were not adequate and examiners struggled to maintain their positions during 0g.

Of interest was a general trend for all subjects to have increased muscle stiffness during 0g, as evidenced by less muscle displacement per unit of applied force (Figure 1). Additional experiments, correcting for potential confounding influences of examiner stabilization problems, would be needed to validate this preliminary finding. Previous results obtained induced 0g during parabolic flight by other investigators, indicate that alpha motor neuron excitability, measured by H-reflex change, increases during 0g[12,13]. These results are consistent with, and possibly help to explain, presently reported results.

CONCLUSION

The Myotonometer, a portable hand-held computerized device that requires no external power supply, performed well during parabolic flight. Conceivably, the device could be used to monitor astronaut muscle health during prolonged exposures to microgravity and to assess efficacy of muscle health interventions. Astronauts could self-test and assess changes in specific muscles over time. Flight surgeons would be able to use myotonometry data to monitor the efficacy of specific countermeasures to muscle atrophy and to selectively tailor participation of individual crew members in these countermeasures based on these measurements as an indicator of skeletal muscle health.

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PHOTOGRAPHS

JSC2006E14452 to JSC2006E14470

VIDEO

- None

Videos available from Imagery and Publications Office (GS4), NASA/JSC.

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