The Effects of Ultrasound Delivery Method and Energy Transfer on Skeletal Muscle Regeneration

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GRANT INFORMATION SUMMARY

PRACTICAL SIGNIFICANCE

When comparing ultrasound treatments providing identical total energy delivery a continuous duty cycle has a greater influence on skeletal muscle regeneration following blunt trauma than does a pulsed duty cycle.

STUDY BACKGROUND

Non-thermal ultrasound is commonly used in an attempt to improve tissue repair and regeneration, although the efficacy of this practice is not firmly established. Ultrasound is normally described in terms of duty cycle and spatial averaged intensity (SAI;W/cm2). The combination of these two, spatial averaged temporal averaged intensity (SATA), provides an indication of total energy delivered per unit of time. There is an untested suggestion that non-thermal ultrasound treatments with an equivalent SATA, but that use different combination of duty cycle and SAI might produce different results. It has been speculated that for a given SATA, a low SA with continuous duty cycle treatment might produce better effects than the more common practice of a moderate SAI with pulsed duty cycle treatment.

OBJECTIVE

To examine the influence of non-thermal ultrasound on markers of skeletal muscle regeneration and to compare 4 different combinations of duty cycle and SAI representing two common SATA intensities.

DESIGN AND SETTING

A 2x2x2 factorial design comparing treatment (ultrasound or control), duty cycle (20% or 100%) and SATA (0.1 W/cm2 or 0.3 W/cm2) was used. A bilateral contusion injury to the gastrocnemius muscle via a drop mass technique was performed. Animals were randomly assigned to one of 4 different US treatment groups: 1) 0.5W/cm2 at 20% duty cycle (SATA, 0.1 W/cm2); 2) 1.5W/cm2 at 20% duty cycle (SATA, 0.3 W/cm2); 3) 0.1W/cm2 100% duty cycle (SATA, 0.1 W/cm2); and 4) 0.3W/cm2 100% duty cycle (SATA, 0.3 W/cm2). US administration commenced 24-hrs post contusion injury, and was delivered 5 minutes daily on 4 consecutive days (Figure 1.)

SUBJECTS

Forty male 8-month old Wistar rats were used in this study in which the protocol was ILACUC approved.

MEASUREMENTS

Various indices of skeletal muscle regeneration were measured: muscle mass (g), fiber cross-sectional area (micrometers2), and centrally localized nuclei (n).

RESULTS

A multivariate treatment x SATA interaction was found for all skeletal muscle regeneration variables (P = .017). US increased muscle mass more than no treatment (3.34g vs. 3.18g; P <.0001) and increases in muscle mass was found with the continuous US treatment compared to the pulsed duty cycle treatment at the same SATA (3.46g vs. 3.20g; P = .019). An increase in the number of centrally located nuclei was found compared to the non-treated leg (6.2% vs. 5.2%; P = .079) as well. The interaction of treatment and SATA on fiber cross sectional area (P = .021) and centrally located nuclei (P = .016) is highly significant; suggesting that if treated, SATA makes a difference on both CSA and centrally located nuclei

CONCLUSIONS

The specific non-thermal ultrasound treatments we studied have beneficial effects on skeletal muscle regeneration following blunt trauma. These treatments increased muscle mass, fiber cross sectional area and centrally located nuclei. Continuous duty cycle US at low SATA intensities increases the mass of regenerating muscle compared to a pulsed duty cycle treatments with the same SATA intensity.

Publication and Presentation List:

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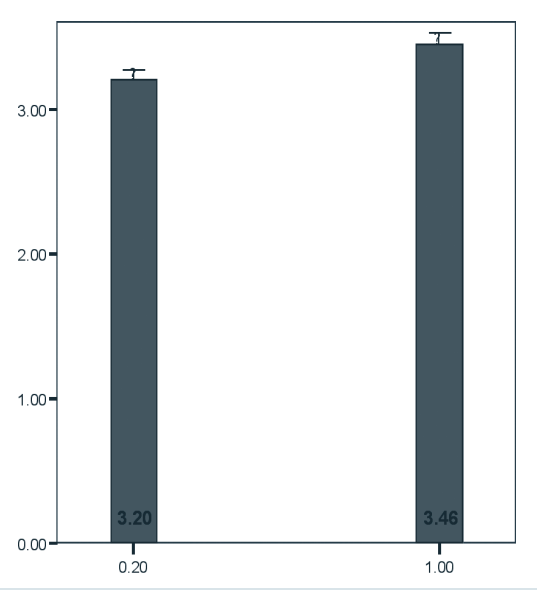

Figure 1. Muscle mass treated with ultrasound at both a pulsed and continuous duty cycle.

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Nicole McBrier is currently finishing her doctoral work at The Ohio State University. She will defend her dissertation work in July, and graduate with a PhD in Exercise Physiology with a concentration in muscle physiology and a minor in statistics and research design. She will join the faculty at Penn State University commencing in the Fall.