Tissue Temperature Increase Using Immersion Therapeutic Ultrasound At 3MHz, 10 Minutes, 1.5 cm Depth, With Varying Intensities Of 1.0W/cm² and 1.5W/cm²

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Abstract

- **Background:** The purpose of this study was to examine the thermal effects of both 1.0 watts per centimeter squared (W/cm²) and 1.5 W/cm² at a frequency of 3 megahertz (MHz) with continuous US while the triceps surae was immersed in 37°C water.

- **Methods:** Twenty college-students, 10 males and 10 females (M=23.45±1.986 years), participated in 2-sessions separated by a minimum 48hr. A thermocouple was inserted into the gastrocnemius, measuring intramuscular temperature during an immersion US treatment.

- **Results:** There was not a significant mean difference in intramuscular temperature increases between intensities at 0 minutes (M=0.1230, SE=0.5617), 5 minutes (M=0.3570, SE=0.5617), and 10 minutes (M=0.8889, SE=0.5691 ) The level of significance was set at p≤0.05.

- **Conclusion:** This study indicated no significant difference in tissue temperature increases between intensities 1.0W/cm² and 1.5W/cm² throughout a 10-minute treatment. In addition, the research showed no evidence of vigorous heating after 5 minutes of treatment.

- **Keywords:** water, thermocouples, immersion therapeutic ultrasound, intramuscular temperature.

Methods

**Experimental Design:** The study was a repeated measures design. Each subject received both interventions. The independent variable was intensity (1.0 W/cm² and 1.5 W/cm²), and the dependent variable was gastrocnemius intramuscular temperature.

**Procedures:**
- Subjects were positioned prone on a treatment table with their left gastrocnemius exposed.
- The treatment and insertion area were determined using a carpenters square with a level affixed on top.
- Diagnostic Ultrasound was used over the treatment and insertion area to measure adipose thickness and scan for any abnormalities.
- A 20 gauge 1.16 needle catheter was inserted into the gastrocnemius, then the needle was retracted (Figure 1).
- A thermocouple was inserted through the catheter to a depth of 1.5 cm, then the catheter was removed.
- The thermocouple was secured to the leg and the template (Figure 2) was attached using Powerflex.
- Subjects were positioned in a seated position with the left leg submerged in the prepared water bucket (Figure 3).
- The US treatment began with the following parameters: frequency, 3MHz; Time, 10 minutes; intensity 1.0 W/cm²; duty cycle, continuous US.
- During the second session the intensity was increased to 1.5 W/cm².
- The second session was within 10 days of the first session and at least 48-hours after the first.
- Subjects were returned to the prone position and the thermocouple was removed.
- The subject's leg was cleaned with an alcohol pad then covered the insertion site with a Band-Aid.

**Statistical Design:** A 2 x 3 Univariate Mixed Model Repeated Measures ANOVA was run to determine the differences in intramuscular tissue temperature at 0 minutes, 5 minutes, and 10 minutes, between the 2 intensities. The level of significance was set at p≤0.05.

Results

There was a significant effect on time F(2,113) = 72.31, p<0.001. There was no significant interaction between time and intensity F(2,113) = 0.588.

Research Questions

1. What is the overall tissue temperature increase with the parameters of 3 MHz, continuous US, 1.5 cm depth, treatment time of 10 minutes, 37°C water, at the intensity of 1.5 W/cm², using the Dynaton Solaris Therapeutic Ultrasound Machine?

2. What is the overall tissue temperature increase with the parameters of 3 MHz, continuous US, 1.5 cm depth, treatment time of 10 minutes, 37°C water, at the intensity of 1.5 W/cm², using the Dynaton Solaris Therapeutic Ultrasound Machine?

3. Is there a statistical difference in the overall tissue temperature increase with the parameters of 3 MHz, continuous US, 1.5 cm depth, a treatment time of 10 minutes, with 37°C water, with the intensities of 1.0W/cm² and 1.5 W/cm², using the Dynaton Solaris Therapeutic Ultrasound Machine?

Acknowledgements

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Conclusions and Clinical Significance

The primary conclusion drawn from the results of this study indicate that there was no significant difference in intramuscular temperature increases between 1.0 W/cm² and 1.5 W/cm² intensities with the following parameters: continuous US, 10 minutes, 3 MHz, 37°C water, and 1.5 cm depth immersion ultrasound treatment with the Dynatron Solaris® 700 Series Ultrasonic machine (Table 1). Increasing the intensity by 50%, as originally theorized, did not have any statistical or clinical significance. Clinically, the results of the research show that if 1.0 W/cm² or 1.5 W/cm² are used during an immersion US treatment the intramuscular temperature will increase at the same rate producing the same thermal effects. In addition, a longer treatment time than 5 minutes should be selected when vigorous heating effects are the treatment goal. A 4°C temperature increase was not reached by 5 minutes with either intensity (Table 2).

![Figure 1: 20 gauge 1.16 needle catheter insertion](Image 2)

![Figure 2: Template 1 cm thick](Image 3)

![Figure 3: Patient positioning and data collection](Image 4)

![Figure 4: Template 1 cm thick](Image 5)

![Figure 5: Patient positioning and data collection](Image 6)

![Table 1](Image 7)

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<th>Intensity (W/cm²)</th>
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Future Research

- Future research should be conducted to examine intramuscular temperature increase with a 75% or 100% intensity increase during an immersion US treatment.
- Other US machines have been suggested to significantly raise tissue temperature more efficiently than the Dynatron Solaris® 700 Series Ultrasound machine. These parameters should be examined further on various US machines to determine if a 50% intensity increase would produce significant intramuscular temperature increases.
- Future studies may also wish to study the effect of such a treatment on damaged or injured tissue for which therapeutic ultrasound is most commonly used.

References


Table 1: Estimated mean intramuscular temperature increase from 0, 5, and 10 minutes for both 1.0W/cm² and 1.5W/cm² intensities.

Table 2: Estimated mean overall intramuscular temperature increase between 0, 5, and 10 minutes.