

# The Benefits of Long Duration Ultrasound

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## ABSTRACT

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## Opinion

Emerging clinical evidence demonstrates that ultrasound dose timing (i.e. daily treatment) and duration significantly impact benefits and treatment results. Therapeutic wearable ultrasound for multi-hour therapy has been shown to be an effective treatment for many musculoskeletal injuries by increasing circulation, oxygen and nutrient deliver, removal of cellular waste products, and collagen matrix repair. Wearable Long Duration Ultrasound (LDUS) devices have been developed that allow for daily ultrasound therapy for up to four hours per day. One LDUS device is the SAM® SPORT (which stands for “sustained acoustic medicine”). It is capable of delivering daily ultrasound therapy, at home or in the office, for up to 4 hours. This device is self-administered, wearable and allows the patients to utilize daily extended ultrasound therapy outside of a medical facility. Clinical research has demonstrated that LDUS can be effective in several therapeutic areas including tendinopathy, fracture healing, skeletal muscle recovery and reduction in chronic pain and osteoarthritis.

## Technology Behind LDUS

LDUS is made possible by advances in microelectronics that enable miniaturization of ultrasound applicators and power controllers. There are four major components to the ultrasound system: the generator, the crystal, the soundhead, and the applicator. LDUS devices contain all four standard ultrasound components repackaged into smaller units (about the size of your cell phone, or portable TENS unit) with simple application procedures, allowing for patients to use the device during both normal daily activity and during physical therapy.

## Power Controller

The power controller is comprised of rechargeable batteries (typically Lithium-ion), timing and control circuitry and is easily

attached to a belt or armband for portable use. Controls are typically located on the controller housing unit, allowing the user to power on/off and set the treatment duration to their prescribed dosage time and in some cases, keep track of device use and treatment history.

## Applicator

The applicator contains the crystal, soundhead, and electronics that operate the transducer. SAM SPORT’s transducer is composed of a crystal in a silver-plated Piezocrystal of Lead-Zirconate-Titanate (PZT-4) that is air backed and uses a 5° divergent lens to channel ultrasound into tissue. Ultrasonic waves are emitted from the piezocrystal transducer at a frequency of 3 MHz through a 5.0 cm<sup>2</sup> soundhead. These unique features allow SAM SPORT to have an ERA rating of 6.0 cm<sup>2</sup>, surpassing the surface area of the applicator’s soundhead. Two applicators (ERA of 12.0 cm<sup>2</sup>) can be used simultaneously, each delivering 0.132 W/cm<sup>2</sup> for the entire 4-hour treatment session, delivering 18,720 J of energy deposition into the treatment area.

## Fixation System

LDUS typically uses an ultrasound coupling system to safely secure the applicator to the treatment area. SAM SPORT’s coupling bandage contains the manufacturer recommended ultrasound gel agent for maximum potentiation of acoustic energy into tissue. Appropriate application of the coupling bandage is extremely important to accurately and efficiently transmit ultrasonic waves to the tissue of interest.

## Clinical Use

LDUS has been used to promote healing of several biologic tissues including tendon, muscle, ligaments, bone, and tendon-bone

junctions. Additionally, research utilizing LDUS devices to treat chronic pain and arthritis has shown promise.

### **Tendon Injuries**

Clinical studies utilizing LDUS demonstrate improvement in several types of tendonopathies. Patients with Achilles tendinopathy show a reduction in pain scores throughout the six-week treatment period and an increase in strength after four weeks of treatment. Studies have shown an increase in tendon strength and a decrease in patient pain scores with 20-minute daily ultrasound therapy sessions. However, several additional studies found no difference between traditional ultrasound treated and control group pain scores. Thus, the success found in tendon recovery requires daily ultrasound therapy and may require longer treatment durations.

### **Skeletal Muscle Treatment**

LDUS therapy has been shown to be effective in treating skeletal muscle related injuries. In pre-clinical studies ultrasound therapy following gastrocnemius injury was found to increase satellite cell proliferation, increase in myogenin and actin proteins, increase regeneration of myofibers. These results are consistent with previous traditional ultrasound data indicating ultrasounds increased nutrient transfer and tissue recovery. Additionally, athletes treated with LDUS for one-hour post-exercise experienced a 20% reduction in blood lactate accumulation, increased average power, and increased average torque compared to the control group.

Thermal effects are primarily responsible for the vasodilation effect and increased blood flow. However, both thermal and non-thermal effects of LDUS contribute to improved nutrient transfer.

In a study exploring the benefits of LDUS in relieving symptoms of myofascial pain, LDUS was applied to relieve trapezius muscle spasm induced pain. Patients with acute pain caused by trapezius muscle spasms experienced overall decreased pain scores over the course of 10 treatment sessions and within a single four-hour treatment time frame. Some patients reported pain relief after one hour of therapy, which could indicate an analgesic effect during the treatment session. The results of clinical studies indicate that LDUS can be an effective tool for enhanced muscle therapy by increasing temperature, blood flow, and nutrient transfer in the treatment area.

### **Bone-Tendon Junction Repair**

LDUS shows promise in healing progression of bone-tendon junction injuries, including surgical repair sites where injured ligaments were replaced with tendons. Pre-clinical studies show an enhancement in several measured areas such as increased failure

load, increased ultimate strength, increased new bone formation and cell proliferation following ultrasound therapy. Additionally, injury healing advanced at a faster rate, possibly due to increased vascular endothelial growth factor YEGF providing advanced restoration of oxygen and nutrient supply as well as supporting chondrogenesis. Over the course of a six week study, patients with medial or lateral epicondylitis experienced a decrease in pain and an advanced increase in grip strength in as early as two weeks with daily LDUS therapy for four hours per day. Thus, using LDUS for at least 20 minutes per day reduces patient discomfort, and yields accelerated healing rates for bone-tendon junction injuries and surgical repairs.

### **Ligament Injuries**

LDUS has been used in several pre-clinical ligament treatment studies. Daily 20-minute LDUS therapy shows accelerated healing in medial collateral ligament injury indicated by higher ultimate load tolerance, increased stiffness, increased energy absorption and increased fibril diameter than control samples.

### **Fracture Healing**

LDUS has been employed to aid in the treatment of fractures, including cases of non-union bone. Results indicate that LDUS is an effective method of improving bone repair and decreasing recovery time. LDUS (via SAM Sport and Exogen) has been used in several clinical studies to improve fracture healing with promising results varying from 33% to 88% successful non-union fracture treatment rate. Daily LDUS treatments for bone injuries are typically 20-minutes. Due to the improved performance of LDUS devices, this could be extended to up to 4-hours daily, resulting in dramatically increased treatment volume and energy deposition into the treatment area.

### **Chronic Joint Pain and Arthritis**

LDUS has displayed potential symptom relief in patients with knee osteoarthritis. Patients showed an overall decrease in pain scores and increased mobility as a result of both thermal and non-thermal effects of LDUS. This corresponds with studies showing several biological benefits of ultrasound on pre-clinical osteoarthritis models including an increase in type II collagen and a decrease in overall damage of the joint over time. Treatment options for chronic joint pain and mild to severe degeneration include joint injections, pharmaceutical intervention for pain, and surgery. LDUS has shown to be a viable option for delaying the onset of arthritis and mitigation of symptoms without invasive procedures or opioid treatments.

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