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Effects of Local Blood Flow on Muscle Stiffness

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Background

- Muscle injuries affect millions of people each year through undue tension on muscles.
- Injuries can take from a few weeks to even months to heal, with patients having to deal with inflammation, swelling, and pain throughout the healing process.
- Scar tissue forms when muscle is injured, which regenerates throughout the healing process, but never fully recovers to its state prior to injury (1).
- Scar tissue makes the muscle more prone to subsequent injury, making it important to avoid muscle injury so as to not lose overall strength and range of motion.
- Currently, there is limited evidence as to what physiological conditions make an individual more susceptible to injury.

Methods

The gastrocnemius muscle, or the back of the calf, is studied to identify if there is a correlation between blood flow velocity and muscle stiffness.

DOPPLER ULTRASOUND (2)

- Estimate blood flow through blood vessels by bouncing high-frequency sound waves, or ultrasound, off circulating red blood cells
- Blood flow through femoral and popliteal arteries is identified and measured

ULTRASOUND ELASTOGRAPHY (3)

- Shear waves introduced by an external mechanical shaker
- Shear waves imaged using high frame rate ultrasound
- Directional filtering is applied to obtain a unidirectional shear wave

Results

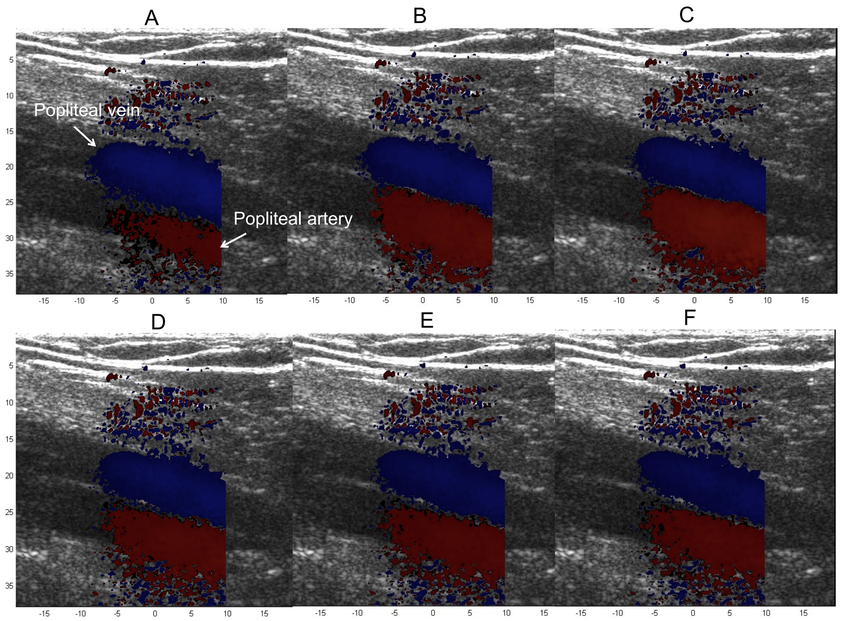

Figure 1: Six consecutive frames of color Doppler ultrasound data (A-F) depicting blood flow through the popliteal artery and popliteal vein during a single heartbeat. Blue color signifies blood flow moving up towards the transducer, or a vein, whereas red color signifies blood flow moving down away from the transducer, or an artery.

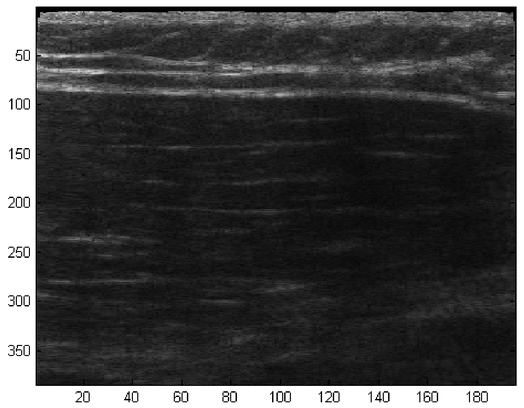

Figure 2: Ultrasound B-mode image obtained through ultrasound elastography data collection depicting leg muscle

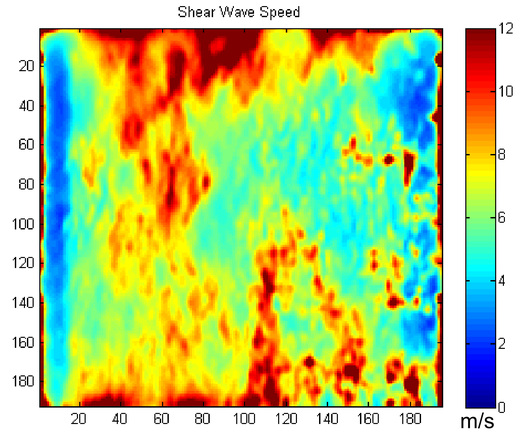

Figure 3: Shear wave speed through leg muscle obtained through ultrasound elastography data collection

Conclusions

- Doppler ultrasound utilizing color imaging is able to effectively identify the femoral vein and popliteal artery
- Ultrasound Elastography can be used to measure the shear wave speed through leg muscle and map the corresponding elastic properties of the tissue
- Both methods are quick, non-invasive and provide useful data on the muscle and its blood supply

Future Work

- The specific velocity of blood flow through the popliteal artery is to be measured to determine what blood supply the gastrocnemius muscle is getting
- It will be investigated as to if there is a notable correlation between blood flow and muscle stiffness
- A correlation between blood flow and muscle stiffness could allow the identification of a predisposition to muscle injury

References

(1) Derrer DT. Muscle strain overview. 2014. Web.
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(3) Engel et al. *IEEE Trans. Ultrason., Ferroelect., Freq. Control, 2015.*

Acknowledgements

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