Impact of exercise and/or passive heating on hemodynamics and cardiovascular health

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BACKGROUND

America is becoming an inherently unhealthy nation. Some would argue that with our current obesity rates and cardiovascular disease rates we already are at that point.

Unfortunately, at least 48% of Americans have some form of cardiovascular disease (CVD).

Exercise is among the most powerful ways to reduce risk of CVD.

Why is exercise healthy?

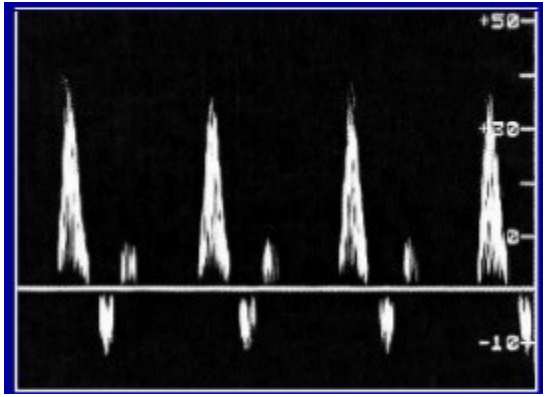
Exercise strengthens the heart and improves blood vessel health due to changes in blood flow patterns.

Blood flow during exercise increases shear stress on the arterial walls, due to increased blood flow demand from exercising muscle.

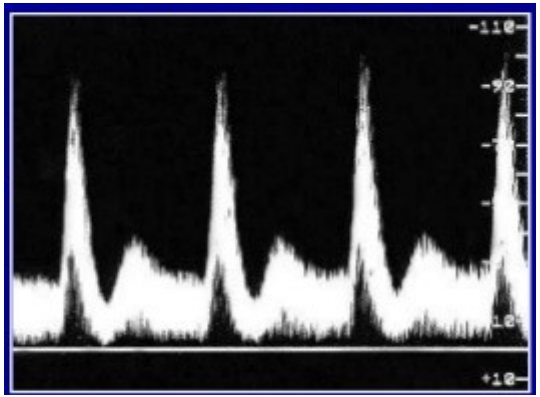
Shear stress is the mechanical force of blood flow on the walls of arteries.

-Anterograde shear (forward flow)

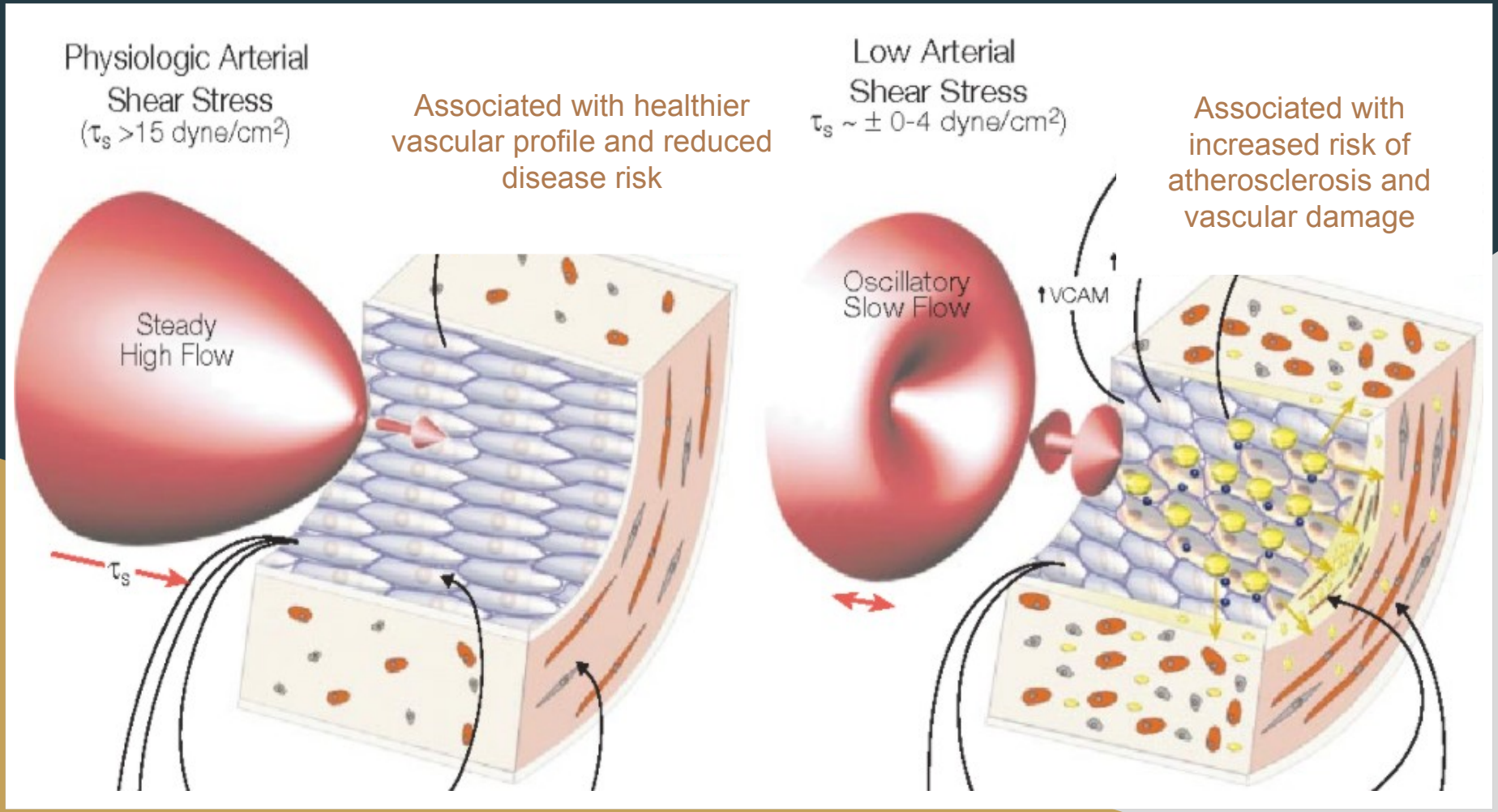
-Retrograde shear (backward flow)



Blood velocity at rest



Blood velocity during exericse


Physiologic Arterial Shear Stress
(τ_s >15 dyne/cm^2)
Associated with healthier vascular profile and reduced disease risk
Low Arterial Shear Stress
τ_s ~ ± 0-4 dyne/cm^2)
Associated with increased risk of atherosclerosis and vascular damage
Steady High Flow
τ_s
Oscillatory Slow Flow
↑VCAM

How do we increase shear stress?

Shear stress is an important indicator of vascular health.

Increasing antegrade shear rates while decreasing retrograde shear rates would be ideal for someone with CVD.

Two studies have examined ways to increase antegrade rates through exercise and passive heat therapy.

The idea is that both interventions increase blood flow to active muscle (exercise) or skin for thermoregulation (exercise and heat stress).

Warm

Exercise and heat increase shear stress

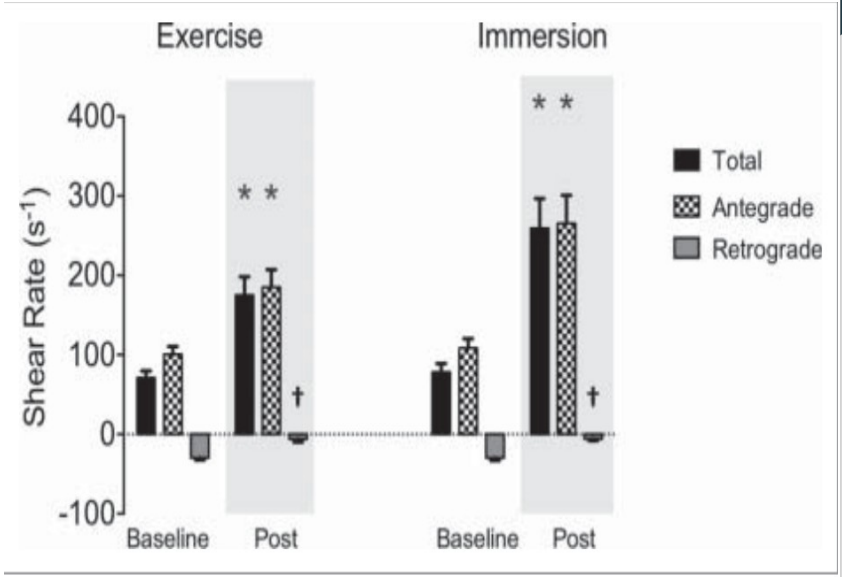
One study completed by Thomas et al. examined exercise vs warm water immersion.

Purpose: to understand the response in limbs with administered heat and exercise. Lower limbs were examined more closely because atheroschertic disease is more prevelant in lower limbs than upper limbs.

Protocol: Young healthy individuals exercised for 30 minutes at 65-75% HRmax. The heating portion was immersion of the lower limbs while seated at 42□.

Water immersion: increased antegrade shear rates by 250% while reducing retrograde shear rates.

Exercise: 150% increase in antegrade rates while reducing retorgrade.



Thomas et al.

CVD in Individuals with Spinal Cord Injury

CVD is very complex and is known for having various risk factors. Those who suffer from Spinal cord injuries are far more susceptible to CVD.

CVD is the cause of death in approximately 40% of individuals with SCI, in part due to a limited ability to perform full-body exercise.

The hope is with the consideration of alternative and complementary therapies like passive heat exposure, we can help those who suffer the most from these diseases.

Heat to increase blood flow in people with SCI

Another study performed by Coombs et al. examined heat therapy in individuals who suffer from chronic SCI.

Purpose: to examine if heat therapy had a similar effect on vascular function that exercise has.

Protocol: 60 minutes of lower limb heating at 40□ with a heated electric blanket covering the upper body.

Population: 15 injured individuals compared with 15 uninjured individuals. Individuals were matched based on age and risk factors.

Results of heat therapy in SCI

Category	SCI Group		CON Group	
	Baseline	End heating	Baseline	End heating
Hemodynamics				
Heart rate, beats/min	55 (10)	58 (9)*	59 (11)	66 (9)*
Systolic blood pressure, mmHg	120 (18)	118 (24)	126 (21)	121 (26)
Diastolic blood pressure, mmHg	68 (16)	66 (17)	73 (15)	65 (18)*
Mean arterial pressure, mmHg	81 (10)	84 (15)	87 (12)	85 (10)
Brachial flow, ml/min	83 (59)	83 (44)	81 (58)	108 (51)
Femoral flow, ml/min	88 (58)	171 (81)*	98 (54)	199 (84)*
Thermodynamics				
Core temperature, °C	36.37 (0.62)	37.05 (0.63)*	37.10 (0.26) †	37.45 (0.24)* †
Skin temperature (shoulder), °C	32.12 (1.35)	32.67 (1.47)	32.84 (1.34)	32.85 (1.40)
Skin temperature (calf), °C	31.78 (1.19)	38.81 (0.91)*	32.48 (0.92)	38.73 (0.88)*

Coombs et al.

Notable results

Thermodynamics: increase in core body temp and leg skin temp. No increase in arm skin temp.

Hemodynamics: heart rate increased. Femoral blood flow increased 100%. Systolic bp and MAP saw no change while diastolic saw slight decrease.

Importance

With CVD being one of the leading causes of death in individuals with SCI it is important to search for solutions to help.

Both studies show promising results. Exercise itself has been proven numerous times to have a multitude of benefits. Since individuals with SCI can not perform full body exercises alternative therapies should and need to be examined like heat therapy.

It has encouraged us to take a deeper dive into the potential interventions to help those who suffer from spinal cord injuries. These studies have opened a gateway for us to examine the combination of heat therapy and exercise with hopes of expecting the same if not better results.

The future

In the upcoming weeks we will be running our own study on individuals who have suffered spinal cord injuries.

We hope to be the first study that combines exercise and heat therapy in individuals suffering from SCI.

With our findings the goal is to help provide alternative interventions in the future for those with such injuries so they can lead a life full of health and happiness.

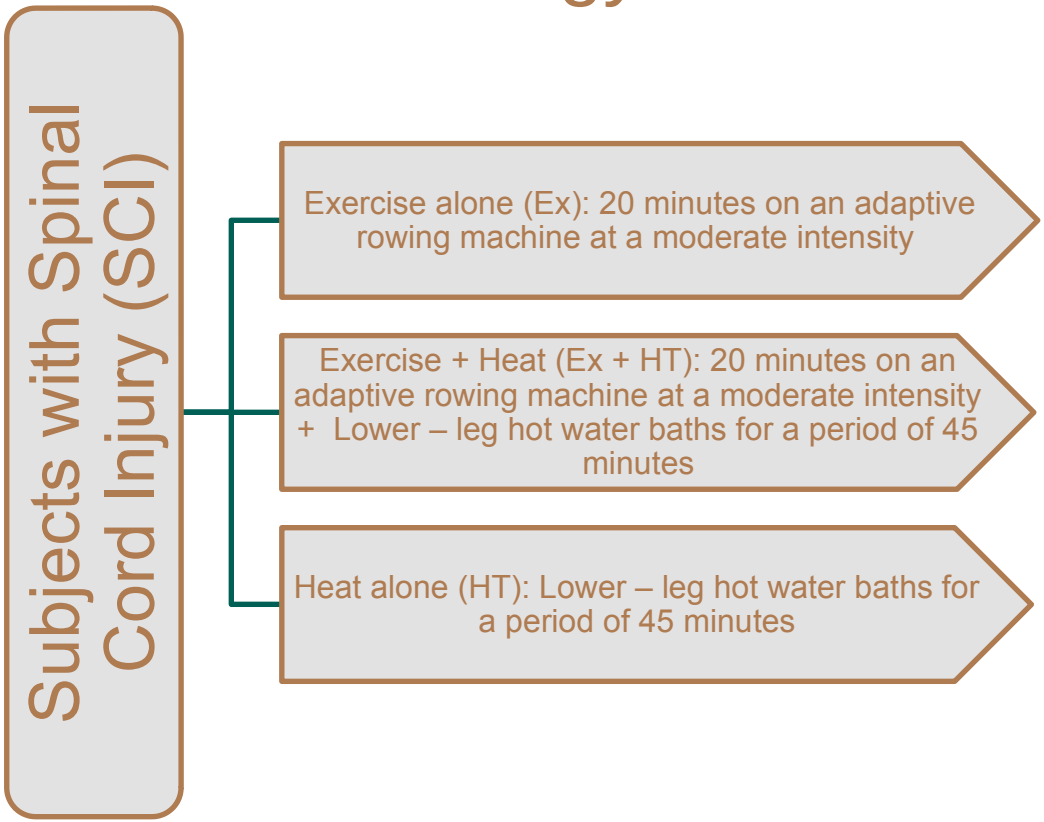
Research proposal

Our proposed research will be performed at Spaulding Rehabilitation Center in Cambridge MA.

At spaulding we will work with their Exercise for Persons with Disabilities lab, with people who have complete spinal cord injuries.

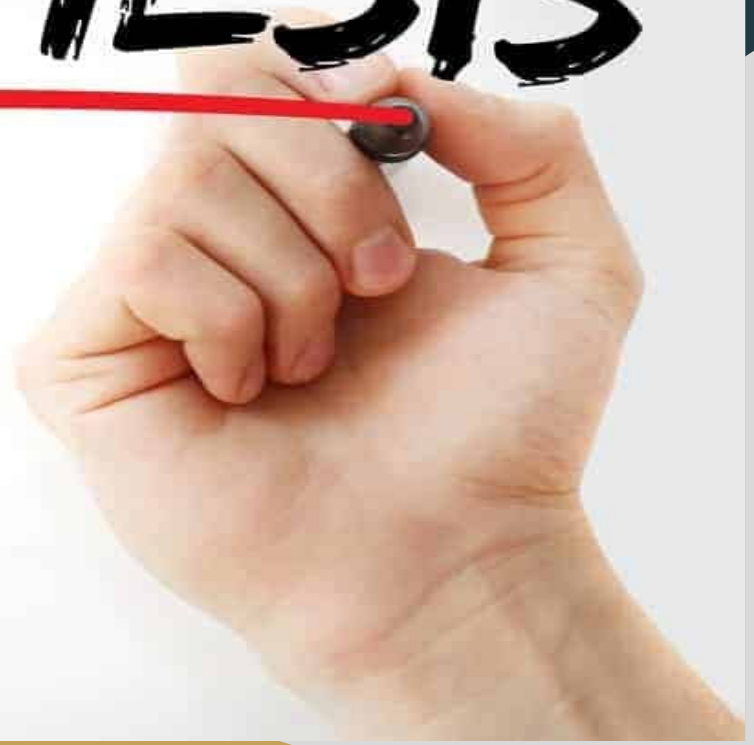
We are hoping to work with 12-16 individuals with spinal cord injuries to examine the impact of exercise and lower leg heat exposure on leg blood flow and blood pressure, as well as heart rate variability (HRV).

Brief methodology



During the post-exercise and/or heating portion of the trial blood pressure, heart rate, and body temperature will be continuously monitored. In a related study, Overnight HRV will be measured using the Biostrap.

HYPOTHESIS



We hypothesize that our study will show that both heat and exercise increase leg blood flow, and improve blood pressure in individuals with SCI, and the biggest impact will be seen with combined therapy (exercise + heat).

If our hypothesis holds true this will add to the other literature, indicating that both heat and exercise can improve cardiovascular health through increased blood flow and shear stress, and can be used to reduce the risk of CVD in those with SCI.

Questions

Citations

1. Cragg JJ, Noonan VK, Krassioukov A, Borisoff J. Cardiovascular disease and spinal cord injury: results from a national population health survey. *Neurology*. 2013;81(8):723-728. doi:10.1212/WNL.0b013e3182a1aa68

2. Coombs GB, Barak OF, Phillips AA, et al. Acute heat stress reduces biomarkers of endothelial activation but not macro- or microvascular dysfunction in cervical spinal cord injury. *Am J Physiol Heart Circ Physiol*. 2019;316(3):H722-H733. doi:10.1152/ajpheart.00693.2018

3. Kate N. Thomas, André M. van Rij, Samuel J.E. Lucas, Andrew R. Gray & James D. Cotter (2016) Substantive hemodynamic and thermal strain upon completing lowerlimb hot-water immersion; comparisons with treadmill running, Temperature, 3:2, 286-297, DOI: 10.1080/23328940.2016.1156215