Tension-Controlled Active Compression Garment for Treatment of Orthostatic Intolerance

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Introduction

This project investigates the use of Shape Memory Alloy (SMA) actuators to produce dynamic compression garments to treat orthostatic intolerance. The system is comprised of two calf and two thigh sleeves that generate compression when integrated SMA coils contract with applied current (Figure 1). The garments include a set of tension management switches designed to generate consistent compression for a wide-range of body types without the need for precise fit or active power management.

Figure 1. Garment on the Body

Garment Design

Each garment is comprised of three layers: a base insulating sleeve, a middle actuation layer that holds the tension switch and SMA actuators, and an insulating cover that protects the user and the environment from the actuation system (Figure 2). The middle actuation layer is mechanically separate (i.e., unattached) to the base layer, but is held in place by a series of loops (just as a belt is held in place on a pair of pants). This allows the layers to stay in alignment without inhibiting the actuation system.

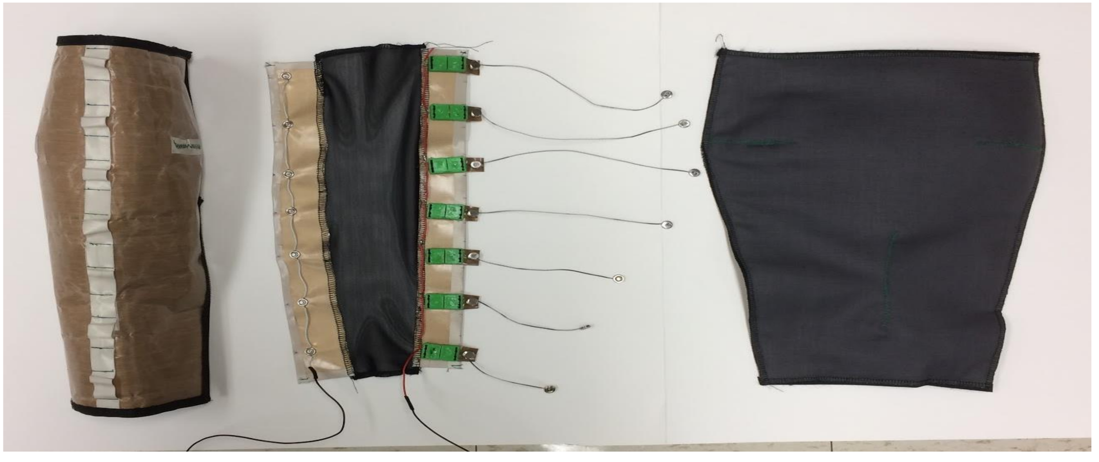
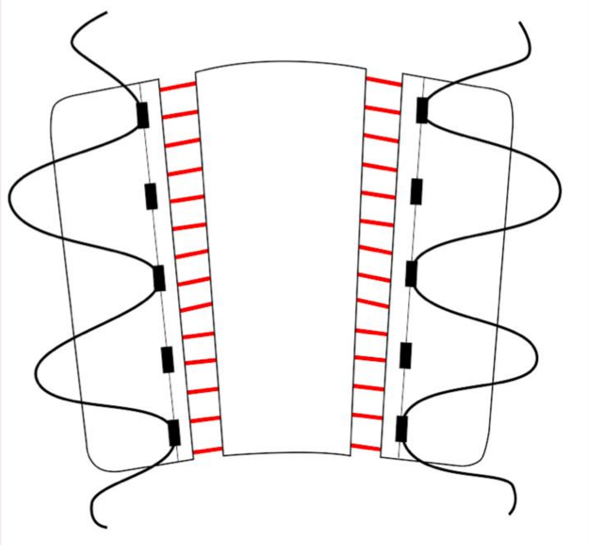
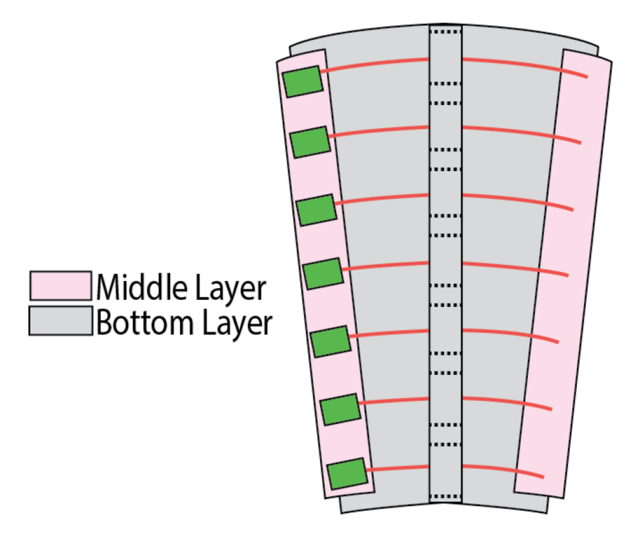


Figure 2. Garment Layers: Base Sleeve (left), Middle Layer (center), Cover (right)

	Garment Comparison	
	Previous Design (Duvall et al. (2017))	Current Prototype
Schematic		
SMA Coil Design	Two SMA actuator regions (each region consists of a singular SMA coil held in a serpentine pattern)	Independent rows of SMA coil. Each coil, connected with snaps, wraps around the anterior leg
SMA Fixture	Fiberglass Tape	Snaps; Fiberglass Tape
Control System	None (manual control)	Passive tension switches limit each actuator (circuit breaks above critical tensions, regardless of applied power)

Tension Switch Control System

The tension switch system maintains a desired range of tension by stopping the current flow to an actuator at a critical tension level. Once a critical tension is achieved, the two copper plates shown in Figure 3 separate, passively cutting the power. Figure 4 demonstrates this principle (tension vs. conductivity).

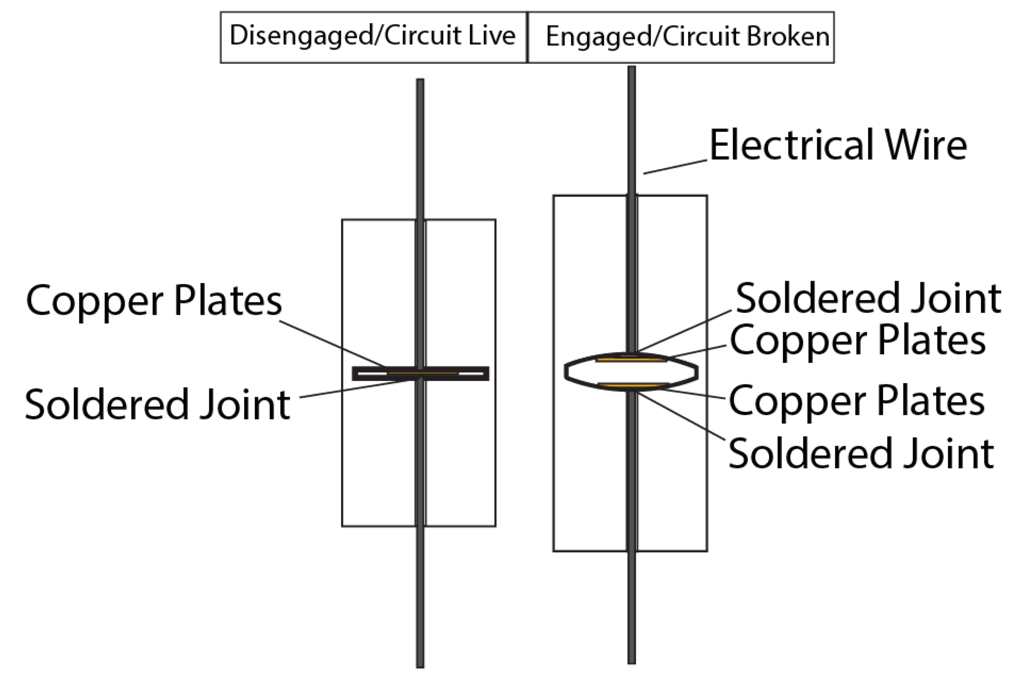


Figure 3. Copper switch diagram

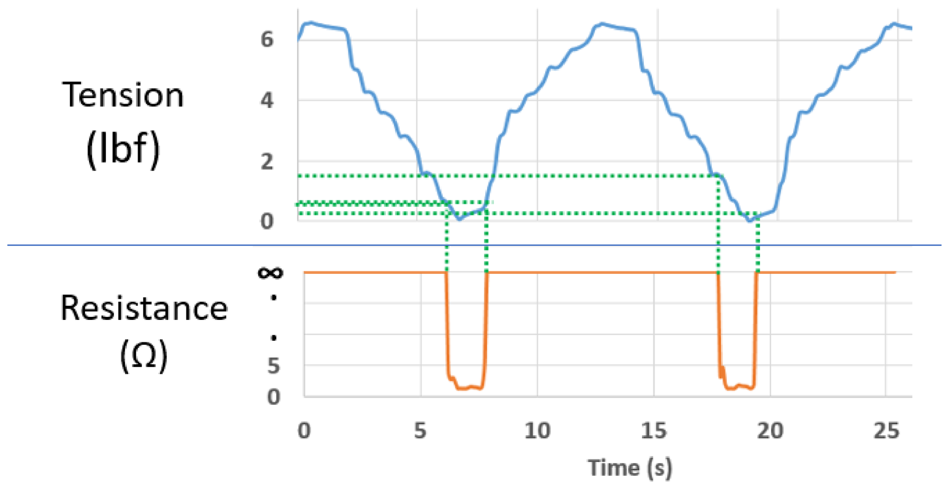


Figure 4. Tension switch behavior

Conclusion and Implications

This garment system is currently in the hands of our Mayo Clinic partners for human subject testing. Figure 5 shows preliminary data for this testing, which demonstrates success in stabilizing blood pressure during garment activation. Human subject testing is ongoing.

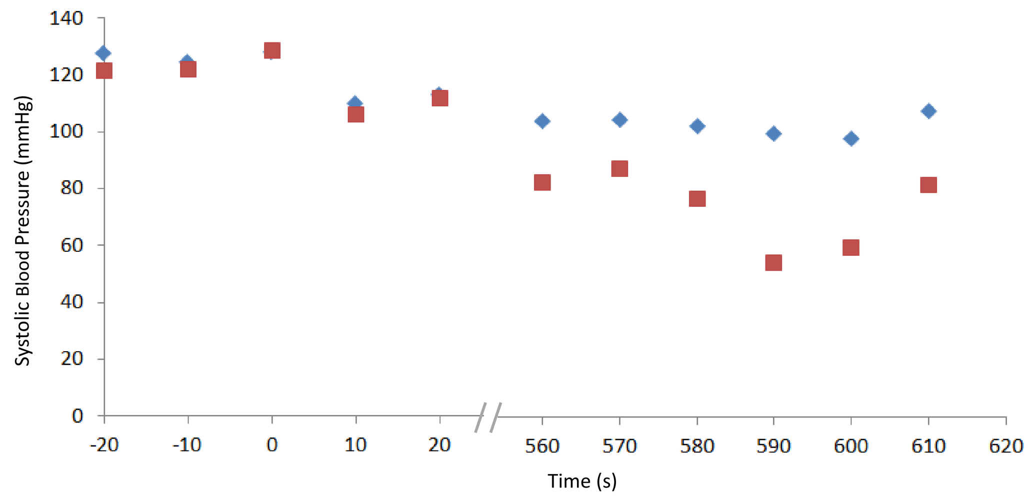


Figure 5. Comparison of blood pressures in tilt-table testing: No garment (red), Garment (blue)

References

Duvall, J., Granberry, R., Dunne, L. E., Holschuh, B., Johnson, C., Kelly, K., ...&Joyner, M. (2017, April). The design and development of active compression garments for orthostatic intolerance. In *2017 Design of Medical Devices Conference*(pp. V001T01A013-V001T01A013). American Society of Mechanical Engineers.

Acknowledgements

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