Cardiovascular responses to heat acclimatisation in athletes with spinal cord injury

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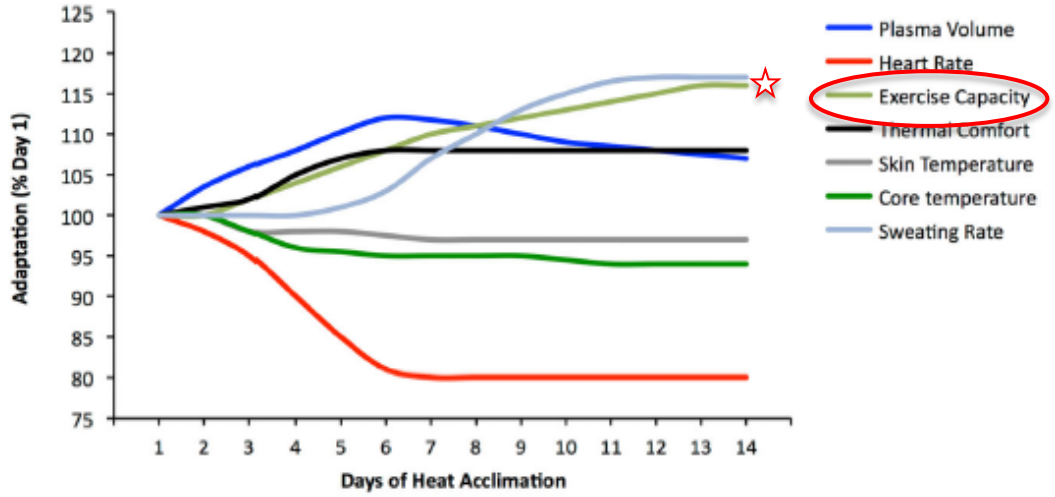


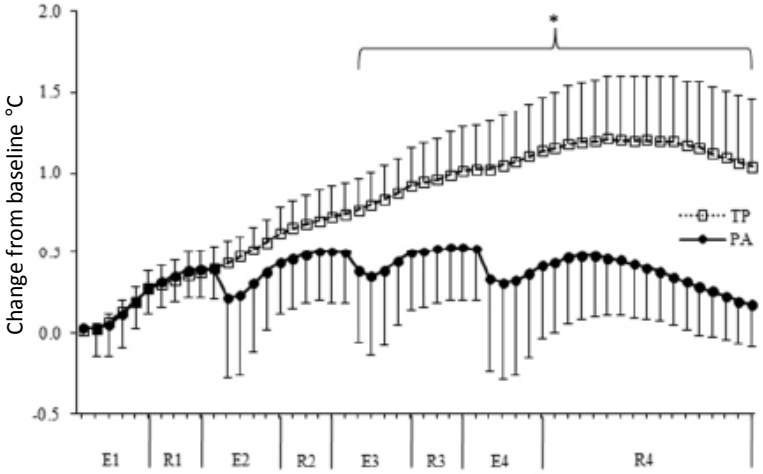
Periard (2015). *Scand J Med Sci Sport*

Adaptations and mechanisms of heat acclimation

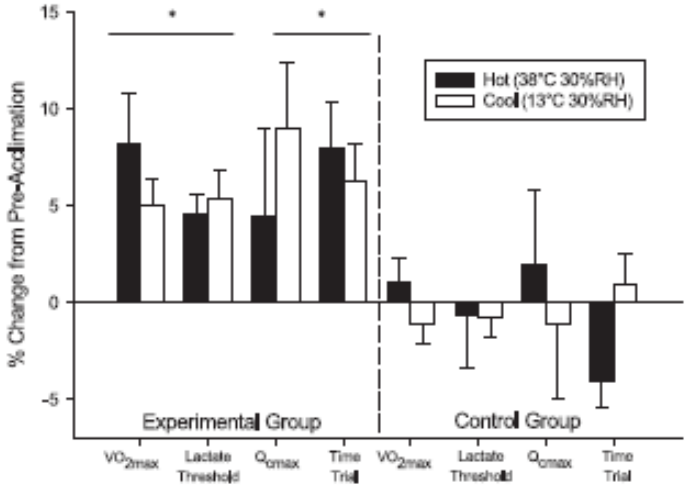
Table 1. Physiological adaptations and functional consequences associated with the heat acclimation phenotype that lead to improved thermal comfort and submaximal aerobic performance, and increased maximal aerobic capacity

Adaptation	Consequence	Adaptation	Consequence
Core temperature	Reduced	Cardiovascular stability	Improved
Rest (temperate) – decreased		Heart rate – lowered	
Exercise – decreased		Stroke volume – increased	
Sweating	Improved	Cardiac output – better sustained	
Onset threshold – decreased		Blood pressure – better defended	
Rate – increased		Myocardial compliance – increased	
Sensitivity – increased		Myocardial efficiency – increased	
Skin temperature	Reduced	Cardioprotection – improved	
Skin blood flow	Improved	Skeletal muscle metabolism	Improved
Onset threshold – decreased		Muscle glycogen – spared	
Sensitivity – increased		Lactate threshold – increased	
Rate (tropical) – increased		Muscle and plasma lactate – lowered	
Fluid balance	Improved	Muscle force production – increased	
Thirst – improved		Whole-body metabolic rate	Lowered
Electrolyte losses – reduced		Acquired thermal tolerance	Increased
Total body water – increased		Heat shock proteins expression – increased	
Plasma volume – Increased		Cytoprotection – improved	

Adapted with permission from Sawka et al. (2000, 2011).

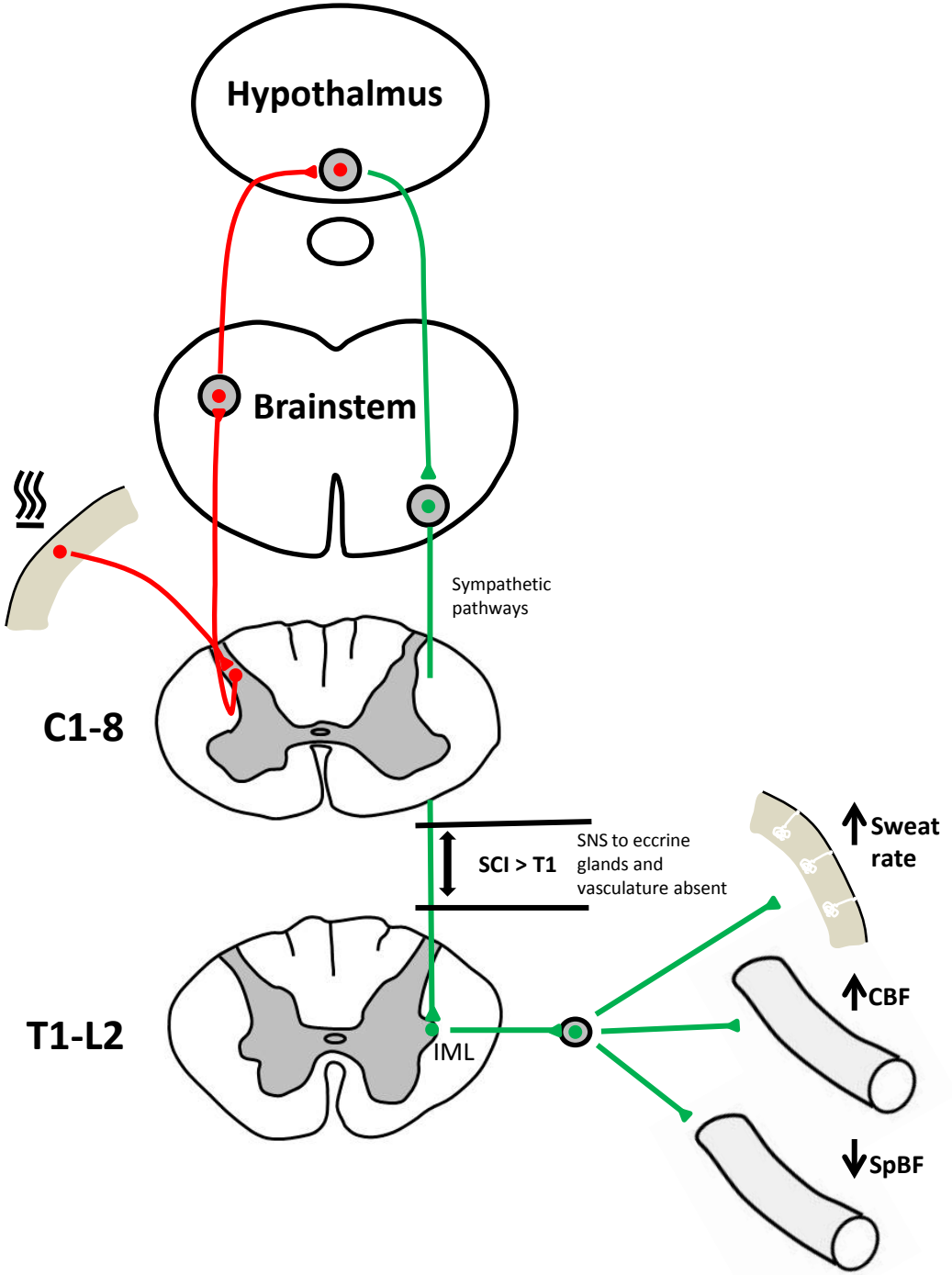


Griggs, *et al* (2015). *Int J Sports Physiol Perform*

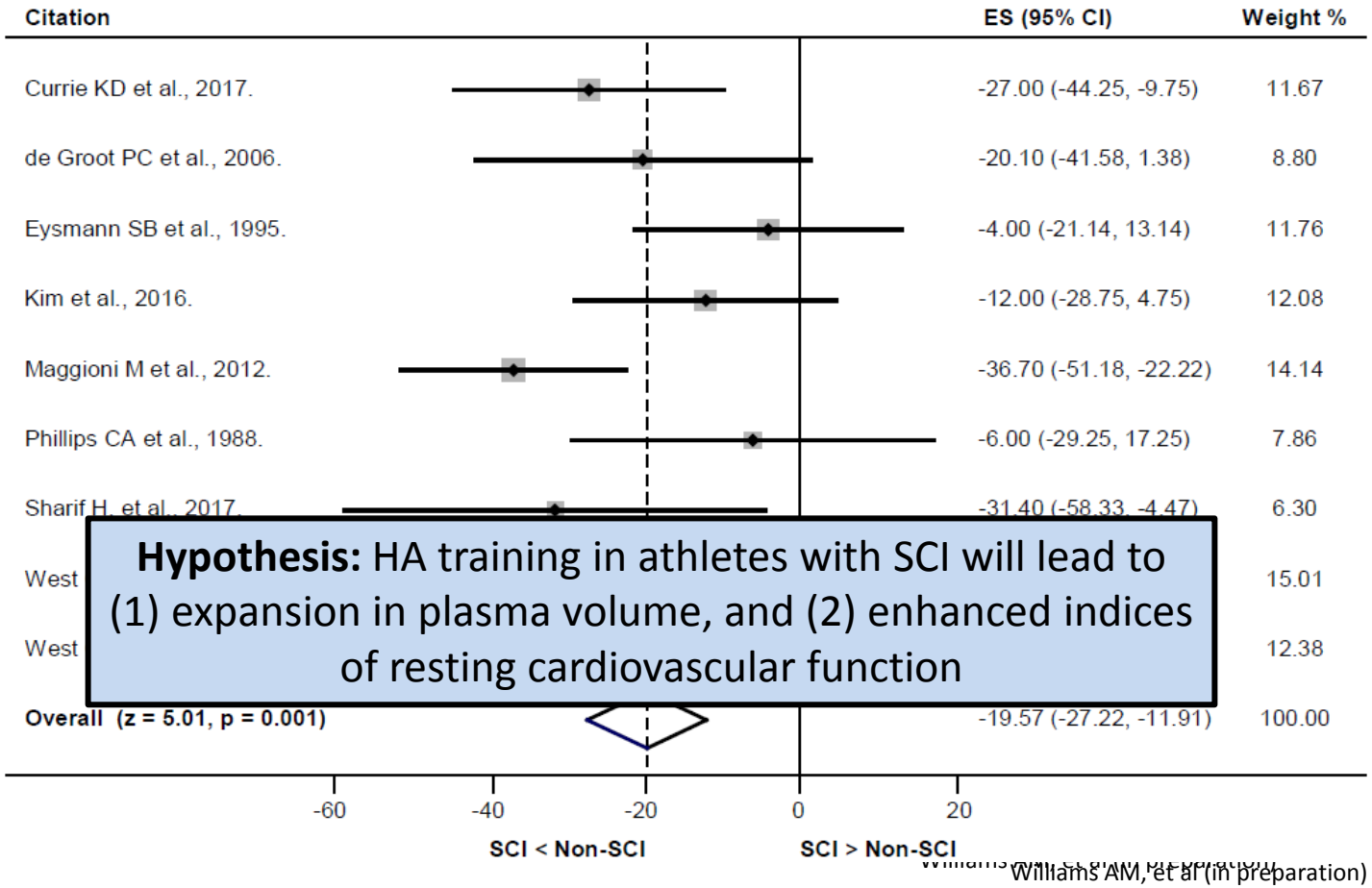


Lorenzo, et al (2010). *J Appl Physiol*

"Our observed increase in maximal oxygen uptake could be mediated by **plasma volume expansion**, improved myocardial efficiency, and increased ventricular compliance..."



Stroke Volume (mL)



Hypothesis: HA training in athletes with SCI will lead to (1) expansion in plasma volume, and (2) enhanced indices of resting cardiovascular function

Williams AM, et al (in preparation)

Left Ventricular Mechanics in Untrained and Trained Males with Tetraplegia

Katharine D. Currie,[1] Christopher R. West,[1,2] Eric J. Stöhr,[3] and Andrei V. Krassioukov[1,4,5]

Variable	*TT (n=8)*	*AB (n=9)*	*Main-effect p value*
Global LV systolic function			
SV (mL)	63±9‡	82±11	**<0.001**
Heart rate (bpm)	57±16	57±8	0.177
$\dot{Q}$ (L/min)	3.6±1.3*	4.6±0.7	0.136
EF (%)	60±7	63±4	**0.017**

Discussion

return.[5] Mechanical effects, including SCI-induced reductions in circulating blood volume[22] and loss of skeletal and respiratory muscle pumps,[23,24] as well as sympathetic effects, including reductions in vascular tone and an absence of vasoconstriction below the level of injury,[25,26] are responsible for reduction in venous return.

Currie KD, et al (2016) *J Neurotrauma*

Methods

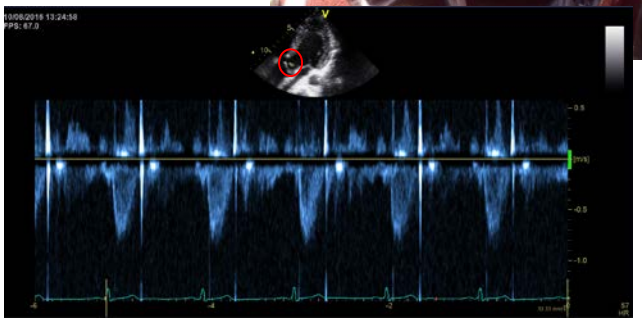
Participants:

Participant	Sex	Age	Height (m)	Mass (kg)	TSI (months)	LOI	AIS	IWRF Class
1	M	35	1.88	64	216	C7	A	3.0
2	M	33	1.68	63	204	C6	A	2.0
3	M	39	1.83	65	288	T3	C	2.5
4	F	27	1.80	67	134	C6	B	1.0
5	M	32	1.90	68	177	C5	B	0.5
6	M	32	1.85	58	192	C5	A	1.0
7	M	40	1.85	95	192	C6	C	3.0
8	M	28	1.88	62	97	C6	A	2.0
9	M	31	1.75	66	158	C6	B	1.0
10	M	48	1.75	66	252	C5	B	2.0
11	M	37	1.78	58	228	C7	B	1.5
Mean±SD		**34.7±6.0**	**1.81±0.07**	**66.3±10.1**	**194±54**			

Abbreviations: TSI, Time Since Injury; LOI, Level of Injury; AIS, American Spinal Injury Association Impairment Scale (A = motor/sensory complete injury; B – motor complete/sensory incomplete; C=motor/sensory incomplete); IWRF, International Wheelchair Rugby Federation (classification range: 0.5-3.5).

Training Intervention:

5 day isothermic HA protocol, following team session athletes completed 60 min circuit/interval training or cooling as necessary to maintain **Tc at 38.5°C**. HA followed normal team training session.



Pre/Post Outcome Measures:

Blood Profiles: Hb, Hct %, ΔPV % (n=11)

Cardiac Ultrasound: HR, SV, VTI, Strain, Strain rate (n=5)

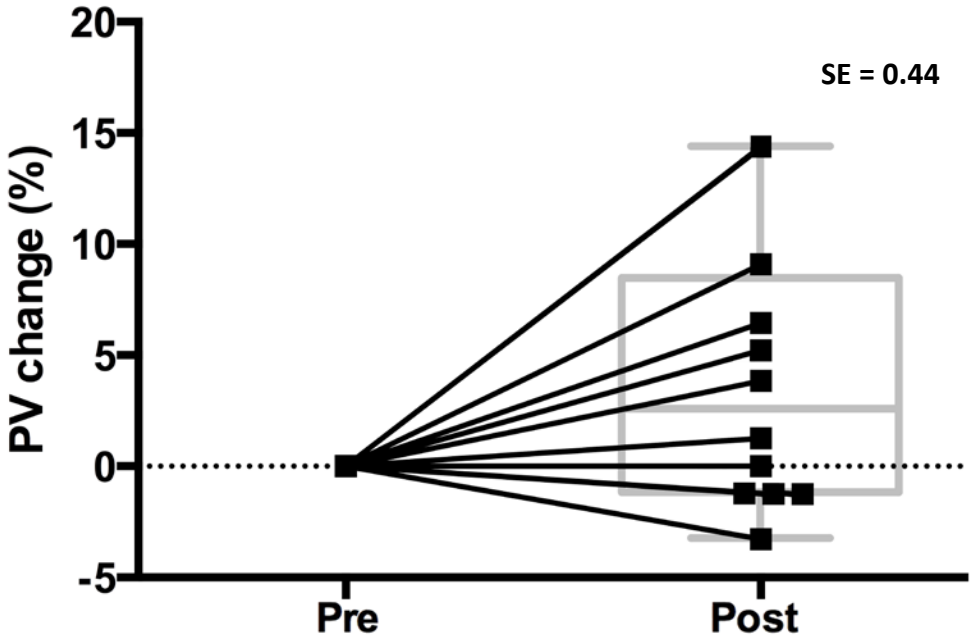
During Training Outcome Measures:

Tc, **HR**, **Tcom** (1-5 scale), **Tsen** (0-9 scale), **RPE** (6-20 scale)

Results

Day	Air Temperature (°C)	Relative Humidity (%)	HRavg (bpm)	HRmax (bpm)	Tcavg (°C)	Tcmax (°C)	Tcom	Tsen	RPE
1	31	31	125±7	139±10	38.3±0.5	39.1±0.8	3.0±0.5	7.1±0.5	14.2±1.8
2	33	26	125±14	131±16	38.4±0.4	38.5±0.5	2.7±1.1	6.7±0.9	15.3±1.5
3	43	13	119±15	129±15	38.4±0.2	38.8±0.4	3.2±0.6	7.2±0.5	14.3±2.7
4	38	14	123±11	135±14	38.4±0.3	38.7±0.4	3.0±0.8	7.0±1.0	15.4±2.2
5	36	22	116±11	134±14	38.2±0.4	38.5±0.4	2.8±0.8*	6.7±0.9†	14.6±2.6
Mean±SD	**36±5**	**21±8**	**121±12**	**134±14.0**	**38.3±0.4**	**38.7±0.5**	**2.9±0.8**	**6.9±0.8**	**14.7±2.2**

Abbreviations: HR, heart rate; Tc, core temperature; Tcom, thermal comfort; Tsen, thermal sensation; RPE, ratings of perceived exertion. *SE=0.35 compared to day 1; † SE=0.51 compared to day 1.



Results

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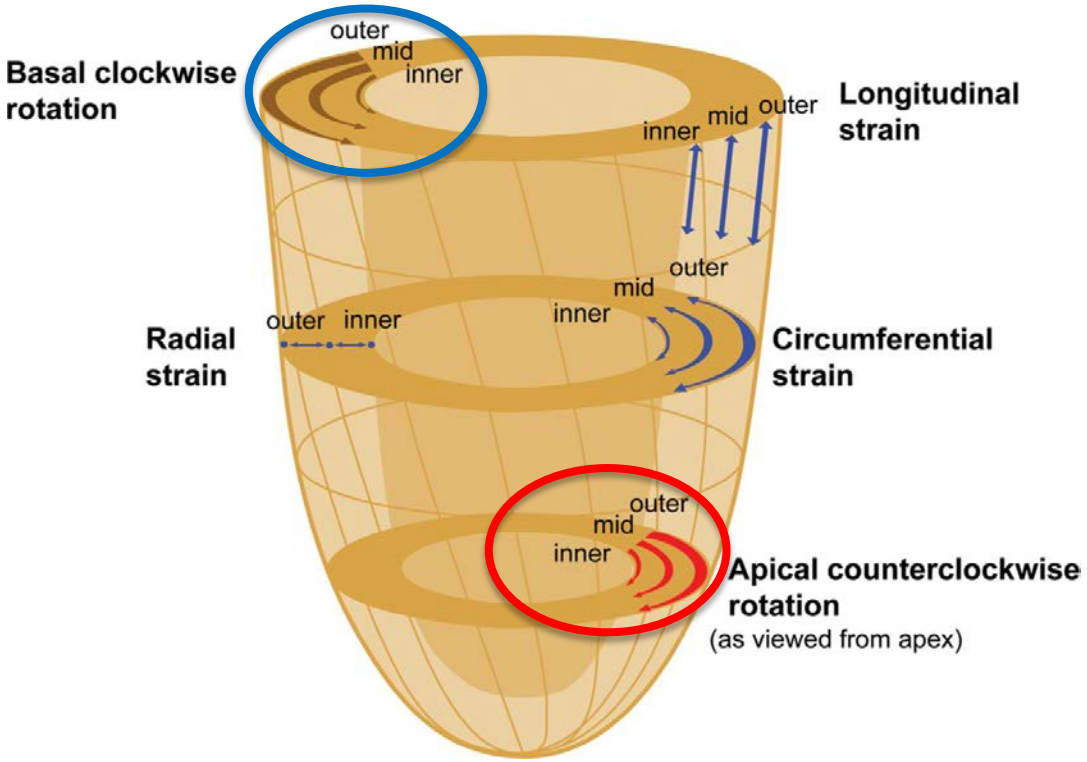
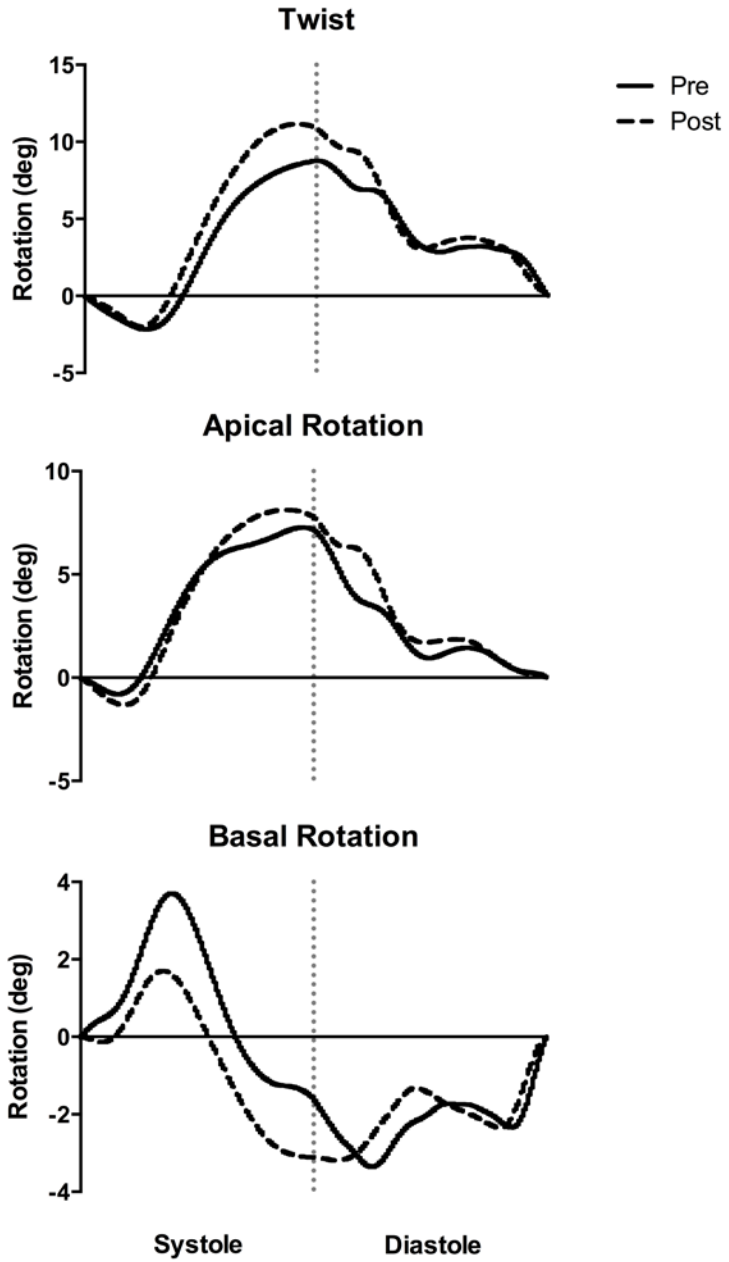

Basal clockwise rotation
outer
mid
inner
Longitudinal strain
inner
mid
outer
Radial strain
outer
inner
Circumferential strain
outer
mid
inner
Apical counterclockwise rotation
(as viewed from apex)
outer
mid
inner

Results



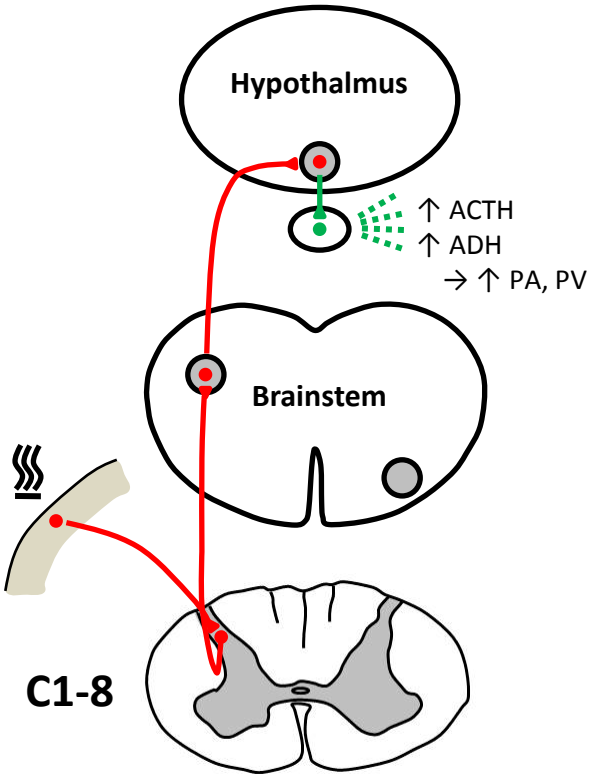
- Twist increased from 10.3±4.9 to 12.4±2.9. SE = 0.52.
- Post values similar to that found by Stohr EJ, *et al* (2011)in 9 healthy active males (13.9 ± 3.9 deg.)

Conclusion

- First study to examine the feasibility of HA training in **athletes with spinal cord injury**

- A five-day isothermic HA intervention has the potential to **improve indices of resting cardiac function** which may be due to **increases in plasma volume**

- Potential non-sympathetically mediated mechanisms for an **↑ in plasma volume due to ↑ plasma aldosterone mediated sodium retention following an ↑ in hormone secretion by pituitary (e.g. ACTH) and hypothalmus (e.g. ADH)** and/or the oncotic effect of an ↑ in intravascular proteins



Future Studies:

- Pre/post performance variable (e.g. repeat 20-metre sprints)
- Monitor training workload (e.g. circuits/lap completed per session)
- Determine optimal timeframe for HA in SCI.

- To understand **mechanisms of HA in SCI** by measuring circulating hormones in response to exercise & heat exposure (e.g. PA, Renin, ACTH, ADH)

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