CANADIAN SPORT INSTITUTE'S SPORT RESOURCE PUBLICATION
PERFORMANCE POINT

THE EFFECTS OF HEAT ON HIGH PERFORMANCE ATHLETES

QUANTIFYING THE EFFECT OF HEAT ADAPTATION ON PLASMA VOLUME

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Athletes routinely train and compete in the heat and humidity, which adds more stress to the body during exercise. The body regulates its core temperature (thermoregulation) in order to stay within a tight base range of 37.0 ° C +/- 0.5°C. If exercise intensity increases and results in a higher core temperature, the body responds by initiating several heat dissipating mechanisms such as:

1. Sweating - the evaporation of sweat cools the skin
2. Dilating peripheral (skin) blood vessels - heated blood is pushed from the core to the skin for cooling

Both of these mechanisms are effective for cooling, but they rely on the maintenance of blood volume; more specifically the watery portion of the blood called plasma. Maintaining blood plasma volume becomes very difficult in higher temperatures because there is a second heat load – heat generated from exercise with the addition of heat from the environment. Therefore, as sweat rate increases there is a loss of body fluids, which compromises blood plasma volume. With a reduced blood plasma volume, the need to cool the body competes with the need to fuel the exercising muscles. If too much fluid is lost due to high sweat rates, the need to thermoregulate wins and the body will eventually shut down.

Canada's triathlete Kyle Jones at the London 2012 Olympic Games. Photo © Jason Ransom, COC.

THERMOREGULATION WILL ALWAYS WIN OVER EXERCISE

Heat adaptation is a natural process allowing the body to handle heat stress more effectively. One of the biggest adaptations is an increase in blood plasma volume. Increased blood plasma volume equals an increase in circulating volume of blood which results in:

- less competition between cooling and fuelling exercising muscles
- more fluids available for sweating = better cooling capabilities
- better performance

Recent studies done by Lorenzo et al. (2010) and Garrett et al. (2011) demonstrated improved endurance performance by 1.5-2% in hot conditions following heat adaptation. In terms of elite athletes, small changes can lead to substantial performance improvements within this 2% range. We know heat adaptation increases blood volume, however we don't know what magnitude of change we can expect to see with the heat adaptation protocol used at Canadian Sport Institute. Thus, we undertook a pilot project to assess our Canadian Sport Institute heat adaptation protocol by measuring blood plasma volume pre and post-adaptation.

PROTOCOL

Subjects included 21 elite female athletes. The heat adaptation protocol consisted of seven exposures (four days on, one off, three on) to 90 minute cycling exercises within a closed indoor environment at a temperature of 33.6°C ± 1.9°C and 59.6% ± 18.3% relative humidity. Sweat rates and hydration status were monitored daily (Table 1). Of the 21 subjects, nine participated in the study to assess plasma volume pre and post-adaptation.

Jasmin Glaesser, Canadian Olympic track cyclist.
Photo © Canadian Sport Institute.

TABLE 1

Sweat rate and hydration status for a seven day heat exposure were monitored daily (Table 1). Of the 21 subjects, nine participated in the study to assess plasma volume pre and post-adaptation.

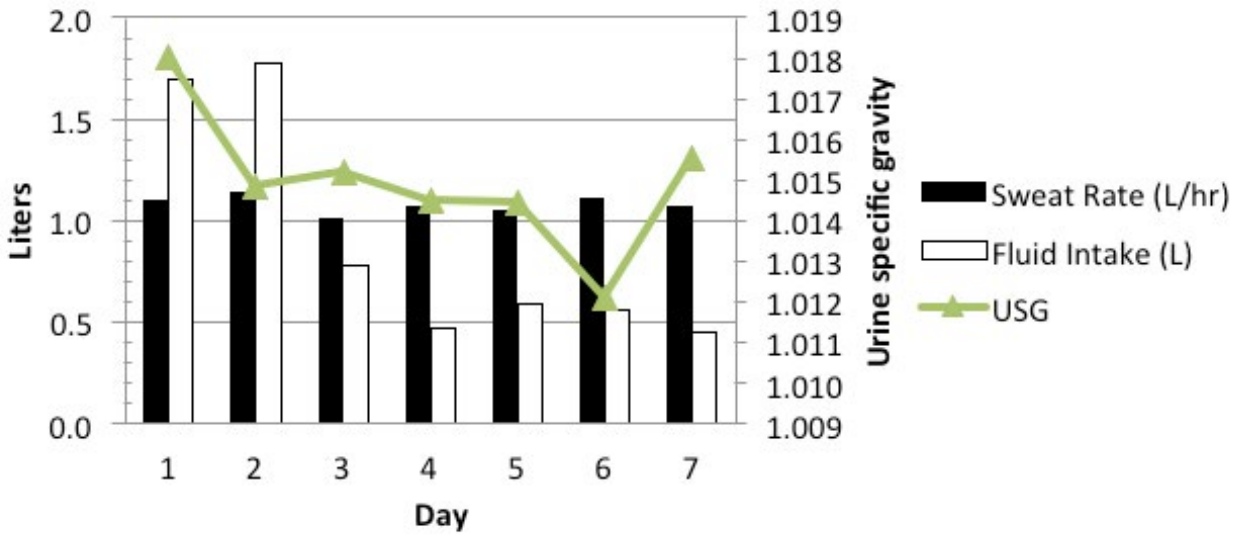
	7 Day Heat Exposure		
	Team Average	Range High	Low
Sweat Rate L·hr-1	1.08	1.98	0.16
USG	1.015	1.035	1.004

< 1.015	Full Hydrated
1.015-1.020	Mild Dehydration
1.021-1.030	Moderate dehydration
>1.030	Severe Dehydration

*Urine specific gravity is a measure of the body's hydration level

FIGURE 1

A comparison of average sweat rate, average fluid intake, and urine specific gravity (USG) over the seven day heat adaptation protocol

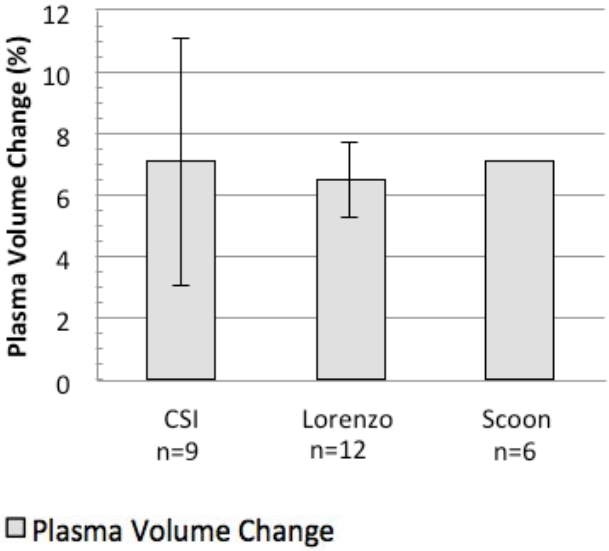


RESULTS

The heat adaptation protocol increased resting plasma volume by approximately 7.1%, which is in agreement with changes reported in other studies (Lorenzo et al. 2010 and Scoon et al. 2006) (Figure 2). These results confirm the efficacy of the Canadian Sport Institute heat adaption protocol in eliciting plasma volume expansion. Further directions in this area would be to determine if these changes enhance performance in the heat, as has been reported by previous research (Lorenzo et al. (2010) and Garrett et al. (2011).

The Canadian Sport Institute conducts heat adaptation tests in the Mobile Environmental Trainer on national team race walkers. Photo © Canadian Sport Institute.

FIGURE 2
A comparison of plasma volume change, in percent, between three studies (Lorenzo 2010; Scoon 2006)



REFERENCES

1. Garrett AT, Creasy R, Rehrer NJ, Patterson MJ, Cotter JD. Effectiveness of short-term heat acclimation for highly trained athletes. Eur J Appl Physiol. 2011.

2. Garrett AT, Rehrer NJ, Patterson MJ. Induction and Decay of Short-Term Heat Acclimation in Moderately and Highly Trained Athletes. Sports Med. 2011; 41(9): 757-771.

3. Lorenzo S, Halliwill JR, Sawka MN, Minson CT. Heat acclimation improves exercise performance. J Appl Physiol. 2010; 109: 1140-1147.

4. Scoon GSM, Hopkins WG, Mayhew S, Cotter JD. Effect of post-exercise sauna bathing on the endurance performance of competitive male runners. J Sci Med Sport. 2007; 10: 259-262.