



Research article: Gibson, O.R., Taylor, L., Watt, P.W. and Maxwell, N.S., 2017. Cross-adaptation: heat and cold adaptation to improve physiological and cellular responses to hypoxia. *Sports medicine*, 47(9), pp.1751-1768.

Summary: Cross adaptation is described as the phenomenon where alternative environmental interventions, **heat acclimation (HA)** or **cold acclimation (CA)**, can be considered an alternative to altitude interventions. Providing physiological stress and inducing adaptations at observable altitudes.

HA: reduces the physiological strain of subsequent hypoxia, via improvements to the cardiovascular system.

CA: reduces the physiological strain of subsequent hypoxia by reducing sympathetic responses attenuating the autonomic responses.

Cellular level: heat adaptations reduce the necessity to transcript further heat shock protein responses for cyto-protection. The cellular adaptations to cold stress in subsequent hypoxia in humans remain largely unknown.

Heat acclimation(HA) 	Cold acclimation(CA) 
Plasma volume ↑	Catecholamines ↓
SpO ₂ ↑	Heart rate ↓
Heart rate ↓	Breathing rate ↓
O ₂ pulse ↑	Minute ventilation ↓
Core temperature ↓	O ₂ uptake ↓
Skin temperature ↓	CO ₂ production ↓
Glycolysis ↓	Glycolysis ↓
Lipolysis ↑	Lipolysis ↑

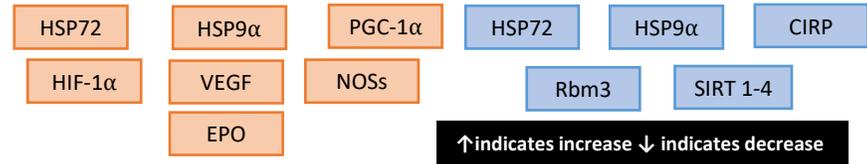


Fig. 1 Identified mechanisms for cross-acclimation between heat and hypoxia (left), cold and hypoxia (right), and identified molecular targets relevant to cross-tolerance in hypoxia (bottom).

Identified molecular targets relevant to cross tolerance: *CIRP* cold-inducible RNA-binding protein, *CO₂* carbon dioxide, *EPO* erythropoietin, *HIF* hypoxia-inducible factor, *HSP* heat shock protein, *NOSs* nitric oxide synthases, *O₂* oxygen, *PGC* peroxisome proliferator activated receptor gamma coactivator, *Rbm3* putative RNA-binding protein 3, *SIRT* sirtuin, *SpO₂* peripheral oxygen saturation, *VEGF* vascular endothelial growth factor.

Take Home Message:

Benefits of using cold to hypoxia-cross adaptation and heat to hypoxia-cross acclimation:

= **HA:** By exercise-heat stress, sauna exposure &/or hot water immersion:

- **PV expansion**
- **Reduced body temperature**
- **Improved blood distribution**
- **Enhanced exercise performance**



= **CA:** By exercise-cold stress, cold water immersion &/or ice bathing:

- **Reduced body temperature**
- **Enhanced central nervous system-mediated fatigue**
- **Reduced cardiovascular strain with enhanced parasympathetic activation**
- **Improved sleep quality**
- **Reduction in thermal strain**
- **Increase in gene transcripts allied to mitochondrial biogenesis and HS response**

