



## ABSTRACT

Stress proteins are molecular chaperones that protect cells from the damaging effects that can be caused by exercise and environmental changes. Cold-inducible RNA binding protein (CIRP) and RNA binding motif protein 3 (RBM3) protect cells from mild hypothermia and hypoxia. They allow cells to rapidly respond to environmental stresses by regulating gene expression. Heat shock proteins 27, 70, and 90 protect skeletal tissue from exercise and heat stress. They accelerate cellular repair and prevent misfolding of proteins. These proteins, especially CIRP and RBM3, have been studied in cell cultures and animal models, but limited data exist in humans. **Purpose:** To determine the response of human skeletal muscle stress proteins to exercise, temperature, and hypoxia. **Methods:** We will analyze human skeletal muscle samples obtained during previous investigations. These studies included resting and endurance exercise in three different environmental temperatures, resistance exercise with localized temperature application, and endurance exercise with recovery in hypoxic environments. While heat shock proteins have been widely studied, very little data exists on the cold shock proteins. The data that does exist is from animal, cell culture, or surgery and do not reflect normal human physiological responses. Examining muscle biopsy samples from human participants encountering common physiological stress will add to the current understanding of stress proteins.

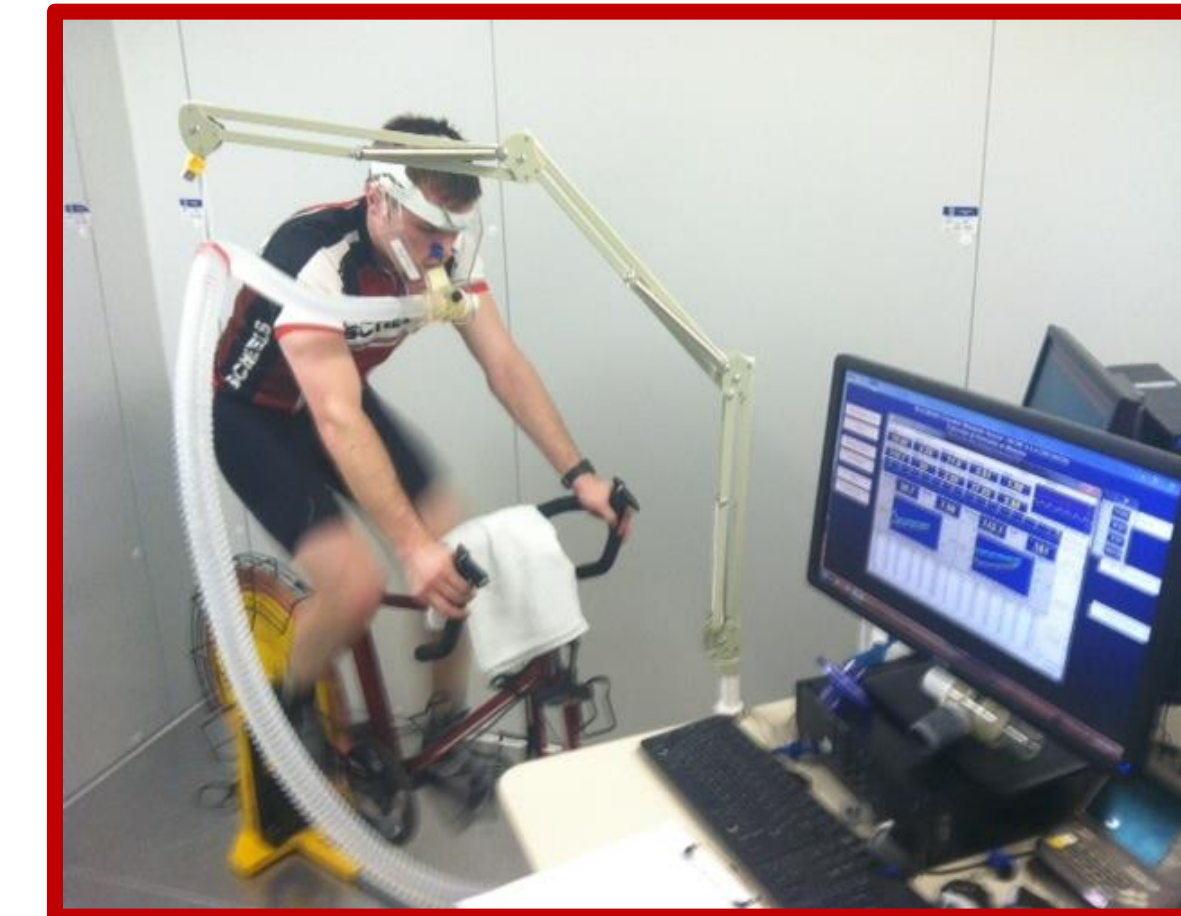
## INTRODUCTION

- Skeletal muscle stress proteins protect muscle tissue from destructive effects of exercise and environmental stress.
- Research on recently discovered cold shock proteins lack information on effect in the human model.
- CIRP and RBM3 from animal cell cultures increase gene expression in shifts from warm temperatures (37 °C) to moderate cold shock (31 °C – 33 °C).
- HSP27 and HSP70 increases in human muscle biopsy samples taken from the *vastus lateralis* and *biceps brachii* pre- and post-exercise consisting of extensive eccentric muscular contractions. They both increase in expression during heat shock (44 °C – 45 °C) whereas HSP70 expression decreases during cold shock treatments (25 °C – 27 °C).
- HSP90 increases in human blood samples during heat shock (45 °C) combined with exercise, but not during exercise without a change in environmental temperature.
- Studying the effects of exercise and temperature on heat and cold shock proteins in humans will add to the existing research.

## AIMS & METHODS



Resting with Environmental Temperature



Endurance Exercise with Environmental Temperature

- **Aim 1** – To examine the effect of environmental temperature on skeletal muscle stress protein mRNA response independent of exercise.
- Eleven recreationally trained males completed 3 separate randomized trials at rest for 3-h in a cold (7 °C), room temperature (22 °C), and hot (33 °C) environment controlled by an environmental chamber.
- Muscle biopsies were taken from the *vastus lateralis* pre- and 3-h post-temperature exposure.
- **Aim 2** – To study the effects of environmental temperature and endurance exercise on skeletal muscle stress protein mRNA response.
- Twelve recreationally trained males cycled on 3 separate occasions for 1-h at 60%  $W_{max}$  in a cold (7 °C), room temperature (22 °C), and hot (33 °C) environment controlled by an environmental chamber.
- Muscle biopsies were taken from the *vastus lateralis* pre-, post-, and 3-h post-exercise.
- **Aim 3** – To investigate the effect of localized temperature application combined with resistance exercise on skeletal muscle stress protein mRNA response.
- Twelve recreationally resistance trained males had one leg cooled and one leg heated using the ThermaZone continuous thermal therapy system which was worn during exercise and throughout recovery.
- Participants completed 4 sets of 8-12 repetitions of leg extension and 4 sets of 8-12 repetitions of leg press at 75% of 1RM with each leg (unilateral).

## AIMS & METHODS

- These exercises isolated the *vastus lateralis* muscle which was also targeted by the placement of the thermal pads. Muscle biopsies were taken from the *vastus lateralis* pre- and 4-h post-exercise.
- **Aim 4** – To study the effect of recovery in normobaric and hypobaric hypoxia after endurance exercise on skeletal muscle stress protein mRNA response.
- Nine male and six female recreationally trained subjects completed 3 separate randomized trials consisting of cycling for 1-h at 70%  $W_{max}$  followed by a 4-h recovery.
- Recovery conditions consisted of atmospheric, hypobaric hypoxia, and normobaric hypoxia. Muscle biopsies were taken from the *vastus lateralis* pre-exercise and post-recovery.
- All stress protein gene expression will be measured using qRT-PCR normalized using  $2^{-\Delta\Delta CT}$  method. They will be analyzed with a two-way repeated measures ANOVA (time x trial) with a probability of type I error of less than 5% considered significant ( $p < 0.05$ ).



Resistance Exercise with Local Temperature



Hypobaric Hypoxia chamber

## IMPLICATIONS

- This will be the first study to describe cold shock protein mRNA response in humans after exercise, temperature exposure, and hypoxic exposure.
- Results may provide useful information on the effect of temperature and exercise during therapies for clinical populations with diabetes, chronic fatigue syndrome, or muscular dystrophies.