Reasoning of dissertation topic and competency of potential supervisor for admission onto joint LSU and TU doctoral studies in 2019

Area of research (title and code)	**Biomedicine**
Field of research (title and code)	**Physiology**
Topic of research	**Exercise physiology**
Institution	**Örebro University, Sweden // Institute of Sport Science and Innovations, LSU**

Potential supervisor

Pedagogical and scientific degree	**Name, surname**	**Academic position**
PhD	Chaillou Thomas	Senior lecturer in Exercise Physiology, Örebro University, Sweden

Short reasoning of proposed dissertation topic

Title

Effect of post-exercise cooling and heating on muscle recovery and training adaptations in endurance sports.

Summary

Background

Post-exercise recovery methods using cooling and/or heating, have become more popular in the last few years in athletes in order to optimize recovery and reduce fatigue following training and competition (5, 13). Cryotherapy, such as cold-water immersion (CWI) is believed to reduce the perception of fatigue, muscle soreness and edema, as well as to limit the inflammatory response and exercise-induced muscle damage following strenuous exercise (4, 10). Some benefits of applying heat to muscle after exercise have also been reported, including decreased muscle soreness, and attenuated loss of muscle strength and power following resistance exercise (7, 12, 15). Concerning the training adaptations, some studies indicate that chronic use of CWI could impair long-term benefits of resistance exercise on muscle strength and hypertrophy (8, 14), while it does not seem to affect the improvement of endurance performance(9, 16). Furthermore, the impact of post-exercise heating on training adaptations remains unclear. To date, only a limited number of studies investigated post-exercise recovery methods using cooling or heating in endurance athletes, and these athletes usually performed intense and short-to-moderate duration exercises.

In skeletal muscle, glucose is stored as glycogen, which is crucial to maintain a high level of performance during prolonged and high intensity exercises (3). Post-exercise recovery and the ability to daily repeat prolonged endurance exercises at high intensity are also influenced by the capacity to recover muscle glycogen stores. Recently, prolonged depression of contractile force observed at low stimulation frequencies, called prolonged low-frequency force depression (PLFFD) (1), was proposed to depend on glycogen stores, at least in mouse muscle fibers (6). This study demonstrated that recovery of submaximal force and fatigue resistance following fatiguing stimulations were impaired in single mouse fibers exposed to low temperature during the recovery period, while the opposite result was found at higher temperature. In addition, the repletion of glycogen after fatiguing contractions was improved at high compared with low temperatures in mouse muscle. Although it remains to be investigated, this suggests that the post-exercise recovery method including heating or cooling may affect muscle glycogen repletion in humans, leading to changes in fatigue resistance and recovery of submaximal force.

Long-distance running and endurance cycling are characterized by prolonged and intense exercises during training sessions and competitions, resulting in high depletion of muscle

glycogen stores (2, 11). Although these activities share similarities in terms of metabolic demands, they present marked differences in terms of biomechanical patterns and regimens of muscle contraction of the lower limb (i.e. concentric contractions at moderate frequencies and low impact during cycling vs. plyometric contractions at high frequencies and high impact during running). Consequently, the post-exercise method to optimize recovery and training adaptations may differ between cycling and running.

The overall aim of this PhD project is to investigate whether cooling and heating can facilitate muscle recovery after an exhaustive exercise and improve training adaptations in endurance sports.

Research design

Part I: acute study

Aim 1. ***Effect of cooling and heating on glycogen repletion, force recovery and subsequent endurance performance after an exhaustive exercise in long-distance runners and endurance cyclists.***

Aim 2. ***Effect of cooling and heating on muscle soreness, inflammation and cell stress response after an exhaustive exercise in long-distance runners and endurance cyclists***

This study will comprise a randomized cross-over design in which 24 recreationally active subjects (12 runners and 12 cyclists) will complete 3 exhausting endurance sessions separated by at least one week. Each session will consist in long duration interval exercises performed at 85% VO_{2max} (total duration of 60 min) followed by six 30s-all out exercises. These exercises will be performed on a treadmill by the runners and on an ergocycle by the cyclists. Each session will be followed by either cold water immersion (CWI), warm water immersion (WWI) or passive recovery (PR). CWI (13ºC) and WWI (44ºC) will consist of 2 bouts of 20 min during which the subjects will seat in a bath with both legs immersed in water up to the waist. During PR, the subjects will seat in a comfortable position during 40 min. The participants will consume carbohydrate during 6 hours after the end of the exercise session to stimulate glycogen resynthesis.

For Aim 1, maximal voluntary isometric contraction torque and isometric torque induced by electrical stimulations will be determined in the knee extensor muscles before, and after 45min, 90min 180min and 360min following the end of the exercise session. Muscle biopsies from the vastus lateralis muscle will be collected before and after exercise (directly, 6h and 24h after exercise) to quantify muscle glycogen concentration and evaluate the activities of glycogen synthase and glycogen phosphorylase. 24h after the exhausting exercise session, the subjects will perform 90min moderate-intensity exercise followed by 10 min-all out exercise to evaluate subsequent endurance performance.

For Aim 2, muscle soreness will be determined before, and after 45min, 90min 180min, 360min and 24h following the end of the exercise session from a 1-100mm scale when standing or squatting at 90ºC. Blood samples will be collected before and after exercise (directly, 6h and 24h after exercise) to determine the concentration of markers of muscle damage and inflammation [creatine kinase (CK), interleukin-6 (IL-6) and Tumor Necrosis Factor α (TNF-α)]. The mRNA levels of *TNFA, IL6*, *IL1B, MCP1* and *HSF1*, as well as the protein level of HSP70 will be determined in muscle samples.

Part II: training intervention and acute response

Aim 3. ***Effect of cooling and heating on physiological and muscle adaptations after a training intervention in long-distance runners and endurance cyclists***

This part of the study will include the cross-over design presented in part I and a training intervention. For the training intervention, a three-arm randomized controlled design will be used and the cyclists and runners will be divided into 3 groups: each group will perform an identical 8-week training program (3 sessions per week consisting of aerobic exercises), with each exercise session followed by either CWI, WWI, or PR (as described in part I).
VO_{2max}, power and speed at VO_{2max}, ventilatory thresholds and time to exhaustion at 85% VO_{2max} will be determined before and after the training program. Muscle biopsies will be collected before and after the training program to evaluate some markers of oxidative capacity and mitochondrial content (citrate synthase activity, cytochrome c oxidase activity, protein content of electron transport chain and myoglobin content) and assess changes in muscle capillarization (from the staining of muscle capillaries).
Muscle samples collected after an acute session (part I) will be used to evaluate some molecular factors and signaling pathways involved in mitochondrial biogenesis, including PGC-1α, TFAM, NRF1, NRF2, AMPK, and P38 MAPK.

Budget

The equipment required for the exercise testing, training intervention and biological analyses is available at the institution.

With the budget available, we will purchase the following consumables/materials

- Material for muscle biopsies: 3500 E
- Kits for measuring glycogen concentration 1500 E
- Consumables for qPCR (reverse transcription kit, primers…) 2000 E

In addition, we will apply for external funding, which will be required to perform all the analyses presented in this project.

Reference list

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Currently I am supervisor of ____0__ doctoral students.

Supervisor

(signature)

Chaillou Thomas

(Name, surname)

Date 11/03/19