**The role of the 'brain-muscle' interaction in the regulation of fatigue and the perception of effort / exertion during physical exercise in the young and the master athlete: significance on exercise performance and tolerance**

The University Côte d'Azur (Nice, France) is offering a **3-year fully funded PhD position in the field of physiology** (see project summary below). During the PhD, the student will conduct her/his work in the **Laboratory of "Motricité Humaine, Expertise, Sport, Santé**" in Nice under the supervision of Dr. Grégory Blain and Florian Monjo. At completion of the project, the student will receive a **PhD in "Sciences of the Human Movement" from the University Côte d'Azur**.

The **University Côte d'Azur** is a recently created cluster of higher education establishments on the French Riviera. Université Côte d'Azur aims to develop a new University model based on interactions between disciplines, coordination between research, teaching, and innovation, and strong partnerships with the private sector and local authorities. Université Côte d'Azur won the prestigious "IDEX" award from the French government, placing it among the **top 10 world-class, comprehensive universities** in France.

**Outstanding applicants** should have a background in one or several of the following research fields: neurophysiology, exercise physiology. Data analysis and treatment skills (e.g. Matlab), although not mandatory, will be valued. Essential requirements for this PhD position are: excellent grades, the ability to learn, understand and apply new (neuro-)physiological concepts and experimental methodologies from different disciplines, a strong motivation as well as the willingness to work in a team.

**Fluency in French is not mandatory. An intermediate level in English (or higher) is expected**.

**The starting date is September 2021**. **Applications are accepted until May 30th, 2021**. Short-listed candidates will be asked to prepare an interview for the hiring committee, composed of members from the doctoral school in Sciences of the Human Movement. Interviews will take place in early July 2021 (dates to be announced soon). Net salary is approximately 1500€ (not including possible extra income from teaching assistance) and includes a health insurance package. Professional expenses (e.g. experiments, hardware, software, publications) will be covered by the LAMHESS.

Applicants should contact Dr. Grégory Blain (gregory.blain@univ-cotedazur.fr) and Florian Monjo (florian.monjo@univ-cotedazur.fr) to prepare their application as soon as possible (**deadline May 30th, 2021**). A cover letter with a statement of research interests, CV, publications (if any), relevant certificates (degrees and grades), and the name and contact of at least two references who are capable to evaluate the research skills of the applicant should be attached to the email in one merged PDF. This document can be either in French or in English.

**The role in the 'brain-muscle' interaction in the regulation of fatigue and the perception of effort / exertion during physical exercise in the young and the master athlete: significance on exercise performance and tolerance**

Determining the links between the mechanisms controlling the development of fatigue, the sense of effort and exertion, as well as how aging modulates these links, is of critical importance to better understand exercise tolerance and performance in young and elderly adults.

Fatigue development during exercise progressively limits the power producing capabilities of the neuromuscular system. In order to prevent excessive fatigue, the working muscle inhibit the CNS motor output during fatiguing exercise. Findings from our group suggest a pivotal role of group III–IV muscle afferents in monitoring and limiting exercise-induced fatigue or, more accurately, the accumulation of associated intramuscular metabolites. The purpose of this 'brain–muscle' interaction might be to prevent a severe deviation from muscle homeostasis and, ultimately, a potentially harmful impairment of the muscle contractile function.

The projection of groups III-IV muscle afferents to the central nervous system (CNS) also plays a central role in the conscious perception of exertion. Given that these afferents have reflex inhibitory actions upon the cortical structures involved in motor command generation, they might also modulate the sense of effort, which can be defined as the conscious awareness of the central motor commands sent to muscles. While perceived effort and perceived exertion are distinct conscious perceptions, they might be unconsciously interrelated through the actions of III and IV afferents on corticomotor structures. Specifically, as exertion increases, muscle activation is restricted due to this inhibitory feedback mechanism, leading to an increased effort to maintain a particular contraction/exercise intensity. Exercise might stop when the flow of afferent signals and the amount of fatigue becomes too hard to support, preventing subjects from producing and perceive a maximal effort.

It remains however unclear to what extent the effects of this 'brain-muscle' interaction on neuromuscular functions as well as on exercise performance and effort perception are modulated by:

1) Aging: recent findings support that older inactive adults experience both reduced mechanical power and increased muscle fatigability during fatiguing exercises, in response to a greater accumulation of metabolic by-products associated with fatigue in the working muscle. While insightful, these results might not be sufficient to elucidate the mechanisms accounting for the decreases in muscle functioning with age because inactivity is an important confounding factor in elderly population.

2) Exercise intensity / duration, by the amount of work that can be performed above the critical power (W'): findings from our group showed that, within the severe intensity domain, the increase in exercise intensity during cycling time-trials of different durations increased peripheral fatigue and modulated the time course of neuromuscular fatigue recovery.

Answering these questions would provide important insights and raise critical questions about the integrated psychophysiological responses and the role of the 'brain-muscle' interactions to physical exercise of various intensities and durations in young and elderly adults. Understanding the effects of aging on the mechanisms of this 'brain-muscle' interactions is also key to the development of preventive and possible treatment options based on physical exercise in the elderly.

Therefore, this project will attempt to:

1) determine the interrelation between muscle activation, neuromuscular fatigue, and W' during exercise within the severe intensity domain in young and master athletes.

2) determine how this interrelation modulate the sense of effort, perceived exertion and exercise performance.

The mechanistic bases of exercise-induced fatigue, effort / exertion perception and exercise performance / tolerance will be investigated within the framework provided by the power output - time to exhaustion relationship.

At completion of project, it is expected that the candidate will master:

- Theoretical concepts related to the neuromuscular fatigue, the critical power, the effort / exertion perception and the effects of aging on these concepts.
- Experimental techniques including motor nerve stimulation, electromyography, cardiorespiratory and gas measurements and analysis, ergometry, exploration of effort and exertion perception.

**Key words:** neuromuscular fatigue, muscle activation, effort, exertion, perception, critical power, exercise performance, aging, master athletes.

### Relevant literature (not exhaustive):

Abbiss CR, Peiffer JJ, Meeusen R, Skorski S (2015). Role of Ratings of Perceived Exertion during Self-Paced Exercise: What are We Actually Measuring? Sport Med 45:1235–1243.

Amann M, Blain GM, Proctor LT, Sebranek JJ, Pegelow DF & Dempsey JA (2011). Implications of group III and IV muscle afferents for high-intensity endurance exercise performance in humans. J Physiol (Lond) 589, 5299–5309.

Blain GM & Hureau TJ (2017). Limitation of fatigue and performance during exercise: the brain–muscle interaction. Exp Physiol 102, 3–4.

Blain GM, Mangum TS, Sidhu SK, Weavil JC, Hureau TJ, Jessop JE, Bledsoe AD, Richardson RS & Amann M (2016). Group III/IV muscle afferents limit the intramuscular metabolic perturbation during whole body exercise in humans. J Physiol (Lond) 594, 5303–5315.

Ducrocq GP, Hureau TJ, Bøgseth T, Meste O, **Blain GM**. Recovery from Fatigue following Cycling Time-Trials in Elite Endurance Athletes. Med Sci Sports Exerc. 2020 Nov 3. doi: 10.1249/MSS.0000000000002557.

Halperin I, Emanuel A (2020) Rating of Perceived Effort: Methodological Concerns and Future Directions. Sports MedN50(4):679-687;

Poole DC, Burnley M, Vanhatalo A, Rossiter HB & Jones AM (2016). Critical Power: An Important Fatigue Threshold in Exercise Physiology. Med Sci Sports Exerc 48, 2320–2334.

Thomas K, Elmeua M, Howatson G & Goodall S (2016). Intensity-Dependent Contribution of Neuromuscular Fatigue after Constant-Load Cycling. Med Sci Sports Exerc 48, 1751–1760.

Sundberg CW, Kuplic A, Hassanlouei H & Hunter SK (2018). Mechanisms for the age-related increase in fatigability of the knee extensors in old and very old adults. J Appl Physiol 125: 146–15

### More information:

Laboratory of “Motricité Humaine, Expertise, Sport, Santé”: https://lamhess.univ-cotedazur.fr/
Université Côte d’Azur : http://univ-cotedazur.fr/en
Doctoral School Sciences of the Human Movement: https://ecole-doctorale-463.univ-amu.fr/fr