# BIOENGINEERING AND MEDICAL-SURGICAL SCIENCES

## Ammin/DET - Advanced methods for studying muscle neuromechanics through integrated electrophysiological and imaging techniques

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| **Context of the research activity** | This research focuses on the design and development of methods and technologies for the integration of advanced electrophysiological, ultrasound and photoacoustic imaging techniques to study neuromechanical interactions in skeletal muscles. The activity will aim to develop and validate novel technologies and methodologies to investigate the spatiotemporal relationship between electrical and mechanical muscle activity. |
| **Objectives** | Muscle force generation results from the interplay between neural excitation, motor unit contractile properties, and the three-dimensional organization of muscle fascicles. Over the past decade, technological advancements and innovative signal processing methods in the fields of electrophysiology and muscle imaging have contributed to enhance the understanding of the complex mechanisms underlying muscle control and force generation. In particular, High-Density surface Electromyography (HD-EMG) enabled non-invasive assessment of both central and peripheral properties of single motor units while high-frame-rate ultrasound allowed to enhance methods for fascicle tracking and for the quantification of local muscle tissue displacements associated with motor unit activation. In this context, integrating electrophysiological and muscle imaging techniques holds great potential for advancing the in vivo characterization of neuromechanical muscle function. This project aims to develop and validate novel technologies and methodologies to investigate the spatiotemporal relationship between electrical and mechanical muscle activity at both the global and single motor unit levels. A key focus of this project will be the integration of HD-EMG with 3D ultrasonography allowing for a volumetric assessment of muscle excitation and dynamics. By leveraging automated 3D ultrasound scanning and reconstruction methods, this approach will provide a multimodal characterization of neuromechanical function, capturing neural, structural and |

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| | functional adaptations that are not accessible with conventional techniques. Additionally, the project will explore the integration of HD-EMG with photoacoustic imaging, which provide valuable insights into muscle oxygen metabolism. By establishing and validating a multimodal technological framework for studying muscle neuromechanics and metabolism, this research will contribute to improving current methodologies for assessing muscle function in both health and disease. |

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| **Skills and competencies for the development of the activity** | The candidate should have a background in biomedical engineering . He/she should have documented experience with the concurrent acquisition and processing of ultrasound images and surface EMGs in static and dynamic contractions. Knowledge of programming languages such as MATLAB and Python is required. Knowledge of the acquisition instrumentation, and skills in the management of an experimental acquisition protocols including the integration of several devices is also necessary. |