

# EXTRACTION OF MUSCLE SYNERGIES IN SPORT: APPLICATION TO THE EVALUATION OF CHRONIC ANKLE INSTABILITY (CAI)

SEPTEMBER 11<sup>TH</sup> 2023

## HANDS-ON SESSION - GUIDELINES

### Requirements:

SKILLS	DESCRIPTION
<b>Programming</b>	Basic knowledge of MATLAB® (entering commands and creating variables, analyzing and visualizing vectors/matrices, calling functions, etc.).
<b>Data Management and Processing</b>	<ul style="list-style-type: none"><li>• Familiarity with MATLAB® Live Editor for data loading, pre-processing, and filtering</li><li>• Ability to understand the main steps for extracting muscle synergies from sEMG data.</li></ul>
<b>Data Visualization</b>	<ul style="list-style-type: none"><li>• Familiarity with 2D-plots for representing processed data.</li></ul>
<b>Data Interpretation</b>	<ul style="list-style-type: none"><li>• Ability to interpret muscle synergy results</li><li>• Ability to interpret the signs of ankle instability.</li></ul>
<b>Communication</b>	Ability to communicate results in a clear and precise manner with the aim of highlighting the results produced.

# HANDS-ON SESSION - TASKS

## Preamble:

It is important to evaluate **Chronic Ankle Instability** (CAI) after an injury to **prevent re-injury** and estimate the **optimal Return-To-Sport time**. Indeed, not only mechanical damage of the ankle joint can be present, but also **modifications** of the overall body schema and **motor control**. The **muscle synergy theory** can provide an in-depth understanding of the **motor control strategies** adopted by the central nervous system during specific motor tasks or athletic gestures.

The assignment consists of the **analysis of surface EMG data** acquired from 13 muscles during **Single-Limb Stance** (SLS), to **extract muscle synergies** and **interpret them**. The team will be provided with MATLAB® routines to extract muscle synergies and surface EMG data from two subjects (one of which is affected by CAI). After having evaluated the complexity of the neuromuscular control (i.e., the number of muscle synergies needed to model the original EMG data) and the composition of the muscle synergies (i.e., the temporal (C) and spatial components (W) of the muscle synergies), the team should **compare the two subjects** and **establish which one shows the best ankle stability** (to be reported on the athlete's passport).

The total score is **10 points**.

## Tasks:

TASKS	DESCRIPTION	TIME	SCORE
<b>Download data and read docs</b>	<u>Download MATLAB® routines and surface EMG data</u> available on <a href="#">GitHub</a> . <u>Read the provided documentation</u> to know about data format and recordings.	~15'	0
<b>Retrieve the number of muscle synergies</b>	<p>Using the MATLAB® routines available, extract muscle synergies and <u>calculate the final number of muscle synergies</u> (<math>N</math>) of each subject.</p> <p>Notice that:</p> <ul style="list-style-type: none"> <li>- the muscle synergy extraction step may take a few minutes depending on your PC's hardware.</li> <li>- due to the random initialization of the factorization algorithm, different runs can provide slightly different results.</li> </ul> <p><b>Expected outcomes:</b>            Provide <math>N_1</math> (<math>N</math> of Subj01)            Provide <math>N_2</math> (<math>N</math> of Subj02)            [The referent person of the team should fill-in the <a href="#">Google Form</a>]</p>	~20'	2
<b>Represent muscle synergy composition</b>	<p><u>Plot and save the muscle synergy “weights” (<math>W</math>) and “activation coefficients” (<math>C</math>)</u> of each subject.</p> <p><b>Expected outcomes:</b>            Muscle synergy plot of Subj01            Muscle synergy plot of Subj02            [The referent person of the team should fill-in the <a href="#">Google Form</a>]</p>	~5'	2
<b>Interpret the results obtained</b>	<p>Compare the two subjects considering <u>the number of muscle synergies and the weights vector</u> of each represented synergy (<math>W_1, W_2</math>, etc.) and notice:</p> <ul style="list-style-type: none"> <li>• is there a subject showing a lower number of muscle synergies?</li> <li>• which are the muscles mainly activated in each synergy?</li> <li>• how many muscles are co-activated in each synergy?</li> <li>• to which extent are they activated (percentage)?</li> </ul>	~50'	6

TASKS	DESCRIPTION	TIME	SCORE
	<p>(Notice that the routines provided DO NOT implement synergy re-ordering between subjects)</p> <p><b>Expected outcomes:</b>            After the comparison of the 2 subjects, identify:</p> <ul style="list-style-type: none"> <li>the subject with a less selective motor control (e.g., smaller number of muscle synergies and more muscle co-contractions per synergy) as the one showing CAI</li> <li>the subject with the better ankle stability (and report his number of muscle synergies on the athlete's passport)</li> </ul> <p>Justify your choices.</p> <p>[The referent person of the team should fill-in the <a href="#">Google Form</a>]</p>		
<b>TOTAL</b>		<b>~1h 30'</b>	<b>10</b>