AN EXPLORATORY APPROACH TO MUSCULAR FATIGUE ASSESSMENT DURING EXOSKELETON-ASSISTED GAIT

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Introduction

Powered lower-limb exoskeletons are a new and emerging technology representing a promising solution for gait rehabilitation [1]. This technology has been studied and adopted mainly by spinal cord injury (SCI) and stroke patients [2]. During training with exoskeletons, evidence of muscular fatigue should be monitored because it can increase muscle spasticity, negatively impacting the recovery process [3]. Under fatigue conditions, the muscle's contractile capacity changes, and shows modifications in the electromyographic (EMG) signal. This study aims at assessing the presence of muscular fatigue, during exoskeleton-assisted gait training, via surface EMG (sEMG) spectrum-based analysis.

Methods

Data were collected at the Sport and Movement Lab of LUNEX University (Luxembourg). Thirty healthy subjects (mean age ± std. dev: 23.2 ± 2.7 years) performed an exoskeleton-based gait training session of 60 minutes. 4 sEMG sensors were placed on the tibialis anterior (TA), soleus (SOL), vastus lateralis (VL), and biceps femoris (BF) (dominant side). sEMG envelope (raw data rectified and 9 Hz low pass filtered) thresholding was used to detect the muscle onset/offset. The median frequency (MF) of the Power Spectrum was evaluated inside a 250ms window centred around the envelope peak via the Fast Fourier Transform (MF-FFT) and the Short Time Fourier Transform (MF-STFT) [4].

Results

Figure 1 shows the decrease of VL MF-FFT data of a single subject during the training period. This decrease is directly linked with the onset of muscular fatigue [4]. **Table 1** reports the average slopes (across all subjects) of the regression line that fits the MF-FFT values. TA, VL, and BF average slopes are negative with a smaller value for VL.

Discussion

Between the two used approaches for the assessment of muscular fatigue in exoskeleton-assisted gait training, the FFT algorithm applied to the MF was able to identify ongoing fatigue increase in three out of four muscles.

This preliminary investigation shows promising results on fatigue monitoring during exoskeleton-assisted gait training. In future works, the MF can feed machine-learning-based models to continuously supervise fatigue development in rehabilitation.

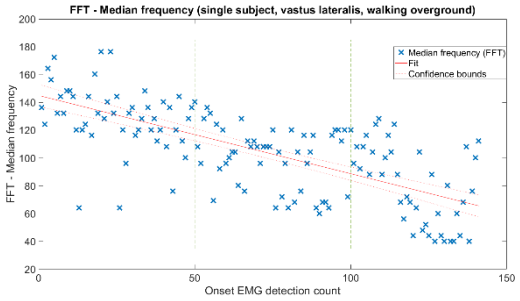

Figure 1: VL MF-FFT data of a single subject and regression line.

Muscle	Average slope
TA	-0.0177
SOL	0.0470
VL	-0.2424
BF	-0.0041

Table 1: Average slopes (across all subjects) of the MF-FFT data regression line.

References

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