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# On exploring age difference using HD-sEMG signals during STS exercise

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## 1. Introduction

Aging affects all biological systems, significantly impacting muscle structure and function, a process known as sarcopenia. This condition leads to a loss of muscle mass, strength, and function, adversely affecting individuals' physical capabilities and quality of life, and presenting challenges to global healthcare systems (Guo et al. 2022). Concurrently, advancements in biomedical engineering, such as the development of High-Density Surface Electromyography (HD-sEMG), have enhanced the diagnosis and monitoring of muscle function. HD-sEMG, a technology that records muscle electrical activity through a dense grid of electrodes, offers enhanced insights over traditional surface EMG by providing higher spatial resolution, enabling more detailed and accurate analysis of local muscle activity variations, including those affected by aging (Imrani et al. 2023).

This study investigates the impact of aging on HD-sEMG signals to enhance understanding and management of muscle aging. It aims to demonstrate the potential of HD-sEMG technology in identifying and mitigating the effects of muscle aging during a Sit To Stand (STS) exercise.

## 2. Methodology

### 2.1. Signal Preprocessing

In the study, a fourth-order Butterworth band-pass filter with a frequency range of 20 to 500 Hz was used to remove low-frequency noises and high-frequency interferences from the sEMG data, concentrating on frequencies related to muscle activity while excluding noise from sources like power lines. Additionally, a Notch filter at 50 Hz was employed to specifically address powerline interference. Following filtering, the sEMG data underwent an automated segmentation process, and was then sampled at 1000 Hz for digitization. The segmentation used the Bottom-up

approach, partitioning the signal into segments that resulted in 2000 points per signal, thus preparing the data for further analysis including feature extraction and classification.

### 2.2. Feature Extraction

In our study on the aging process and its impact on muscle function using HD-sEMG, feature extraction is essential. This process converts complex signal data into meaningful metrics, allowing for a detailed analysis of age-related differences in muscle performance. Key features, as detailed in SE Moctar et al. (a) 2023, were selected for their ability to reflect the intensity, activity, consistency, and variability of muscle contractions, providing a comprehensive view of muscle function changes with age.

### 2.3. Statistical Analysis

In this section, we delve into the intricate realm of statistical analysis to decipher potential differentiations in the HD-sEMG features across diverse age class's subjects. The first analysis involved an Analysis of Variance (ANOVA) test to assess the overall significance of differences in features values across the various age classes. Subsequently, Tukey's Honest Significant Difference (HSD) test, a post hoc test was conducted for identifying specific age class pairs exhibiting statistically significant differences in the HD-sEMG feature. This statistical investigation aids in pinpointing the nuances in muscle activity patterns that distinguish one age group from another. For each subject, we take the average of the values of the channels over the electrode grid for each feature.

## 3. Results and Discussion

We gathered HD-sEMG data from the rectus femoris muscle of 64 subjects engaged in the STS exercise, as part of the CHRONOS dataset (ClinicalTrials.gov Identifier: NCT03560648). The STS test is widely used in clinical practice to evaluate muscle fatigue and functional mobility, making it an ideal choice for our study. Participants, selected based on their international physical activity questionnaire (IPAQ score of 2 or 3), included 34 females and 30 males. The dataset was categorized into five age groups, spanning from 25 to 74 years (for more details, see Imrani et al. 2023).

The ANOVA results for RMS, MAV, MAV1, AAC, and DASDV features indicate significant differences in the means across different age groups. The F-Statistic and associated p-values suggest significant differences among age classes for each feature.

The Tukey HSD test results further detail specific group differences. Particularly, the variations in Average Amplitude Change (AAC) between younger and older age classes were more pronounced compared to other features, as shown in Table 1. Figure 1 visually

represents the AAC differences among age classes, underscoring significant shifts in amplitude parameters with aging.

Initial comparisons show minor differences among the first three age groups, suggesting stable chair-rising strategies. However, marked increases in mean differences between younger groups (class 1 and 2) and older ones (class 4 and 5) reveal adaptive strategies in response to age-related physical declines. This trend highlights an evolving chair-rising technique, becoming more pronounced with age to accommodate decreasing muscle strength or efficiency. This justifies why AAC was the most informative feature for age classification (see SE Moctar et al. (b) 2023).

In addition, we explored a range of time and frequency domain features; however, none demonstrated statistical significance in distinguishing between age classes. These results affirm the critical influence of aging on muscle performance and highlight the ability of sEMG to be used to monitor these changes. The HD-sEMG approach provides new insights into evaluating age-related changes in muscle function, particularly for the rectus femoris, which is crucial in the STS movement. By focusing on HD-sEMG's ability to reveal nuanced age-related changes in muscle performance, this study underscores the value of advanced electromyography techniques in clinical evaluations of aging and physical function.

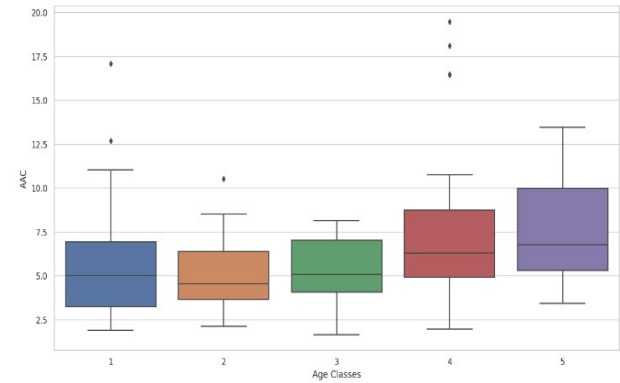
**Table 1** : Tukey HSD test result -Multiple Comparisons for AAC

G1	G2	meandiff	p-adj	95% Confidence Interval		reject
				Lower	upper	
1	2	-0.544	0.9273	-2.397	1.308	False
1	3	-0.179	0.999	-2.102	1.7434	False
1	4	1.9273	0.0497	-0.158	3.6127	True
1	5	2.0044	0.031	0.1191	3.8898	True
2	3	0.3655	0.9826	-1.487	2.2182	False
2	4	2.2721	0.0062	0.4582	4.0861	True
2	5	2.5492	0.0014	0.7353	4.3632	True
3	4	1.9066	0.046	0.0213	3.792	True
3	5	2.1837	0.0142	0.2984	4.0691	True
4	5	0.2771	0.9938	-1.570	2.1243	False

## 4. Conclusion

The study investigated the impact of aging on muscle function using the HD-sEMG technique to analyze electrical signals from individuals performing the STS exercise across different ages. Statistical analyses, including ANOVA and Tukey HSD tests, revealed significant age-related differences in muscle electrical activity, particularly with the AAC feature emerging as a differentiator between age groups. The results enhance our understanding of the physiological changes due to aging and underscore the potential of the HD-sEMG

technique in developing strategies to counteract age-related muscle decline.



**Figure 1.** Comparison of Age-Related Differences in AAC among Different Age Classes

## Conflict of Interest Statement

The authors declare no conflict of interest.

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