SENIAM-guided electromyography electrode placement is suboptimal for triceps surae muscles

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Summary

The SENIAM guidelines are one of the most widely used references for surface electromyography (sEMG) electrode placement. While these guidelines are imensly useful to practitioners working with, but not specifically trained in the use of, sEMG, they do not take into account the large inter-individual variability in muscle morphology for the triceps surae muscles. In this study we determined muscle anatomical boundaries and assessed the closeness of SENIAM-guided as well as palpation-by-expert electrode placement to muscle boundaries. Our results show that SENIAM guidelines are suboptimal for the LG and SOL muscle, likely affecting the quality of data collection and interpretation.

Introduction

Accurate electrode placement is critical in sEMG recordings to ensure a maximal signal-to-noise ratio and minimal crosstalk [1]. A widely used guideline for electrode placement is the SENIAM recommendation [2]. However, these guidelines do not account for variation in individual muscle morphology, meaning the suggested sEMG electrode placement may not be optimal for all individuals. This study assessed sEMG electrode placement on the triceps surae muscles, which show substantial antomical variation between individuals, by comparing SENIAM-guided placement to expert placement.

Methods

Twenty-four participants (13 females, 11 males; age: 35.6 ± 11.1 years) were recruited for this study. Electrode placement for the medial gastrocnemius (MG), lateral gastrocnemius (LG), and soleus (SOL) was determined by two researchers according to two methods: one researcher followed the SENIAM guidelines, while a second experienced researcher used palpation at rest and during contraction. Both researchers were blinded from each other's electrode placement. A single small sticker (⌀ = 5 mm) was used to represent electrode placement and placed on the skin (Fig. 1). Ultrasound imaging was used to locate the MG and LG medial and lateral muscle boundaries at a 90 degrees ankle angle with the knee extended and to track the muscle-tendon junction displacement (representing the distal muscle boundary) during isometric contractions. Contractions were performed for two joint angles, 20 degrees plantar flexion and at 60% of maximal tolerable dorsiflexion (27.3 ± 4.4 deg), and at 40% and 80% of maximal voluntary contraction (MVC), which was determined for each joint angle using a dynamometer. Shortest electrode-muscle boundary distances were calculated to the medial, lateral, and distal muscle boundaries, with values below zero indicating the electrode exceeded the muscle boundary, reflecting suboptimal placement.

Results and Discussion

Our results suggest that SENIAM-guided electrodes on the LG tend to be placed more laterally (electrode-boundary distance: 0.73 ± 0.92cm) and distally (5.28 ± 2.59cm) compared to expert placement (4.05 ± 0.86; 10.70 ± 1.46cm respectively). In four participants, SENIAM electrode placements were positioned outside the muscle boundary. In soleus, SENIAM-guided placements were positioned remarkably close to the tibial border (0.65 ± 0.34cm), compared to expert placement (6.25 ± 0.98cm). For MG, no notable differences were found between methods.

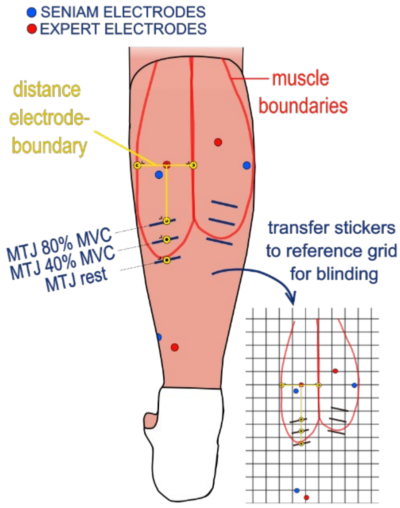

Figure 1 Electrode placement and analysis overview.

Conclusions

We conclude that SENIAM electrode placements for the LG and soleus muscles are suboptimal at a group level and very problematic, i.e. not even (fully) on the target muscle, in some individuals. This significantly increases the risk of crosstalk (LG) or low detection area (SOL), affecting the interpretation of the EMG signal. We aim to provide new guidelines taking into account these findings and the individual variability in triceps surae muscle morphology.

Acknowledgments

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References

[1] De Luca and Merletti 1988

[2] https://www.seniam.org