THE INFLUENCE OF DELTOID MUSCLE LENGTH ON MOTOR UNIT BEHAVIOUR DURING SINGLE AND MULTIPLE DEGREES-OF-FREEDOM TASKS

J Greig Inglis, Silvia Rio, Caterina Cosentino, Hélio V. Cabral, Roberto Zanotti, Elmira Pourreza, Francesco Negro
Department of Clinical and Experimental Sciences, Università degli Studi di Brescia, Brescia, Italy

Email: james.inglis@unibs.it

Summary

Challenges recording motor unit behaviour in the deltoid have led to limited research in this muscle group. Therefore, we investigated five subjects (2 females, 3 males) at three low force levels (10, 20, and 30% MVC) during tasks involving both single and two degrees-of-freedom (DoF) at two muscle lengths to illuminate the effect changes in force output, synergistic and independent movements, and muscle length have on motor unit behaviour. We observed that when performing synergistic tasks in two DoFs, the MUDR was greater than that of a single DoF task regardless of force output or muscle length. Additionally, we observed higher CoV-ISI (coefficient of variation of the inter-spike-interval, CoV-ISI) in the shortened condition compared to the lengthened, regardless of the force level or task.

Introduction

The complex movement of the shoulder requires the deltoid to be activated in single and multiple degrees of freedom across various muscle lengths. Additionally, it has been shown previously [1, 2] that changes in muscle length can influence motor unit behaviour. Therefore, we sought to unravel the complexities of the shoulder by evaluating motor unit behaviour between two deltoid muscle lengths during isometric contractions in one and two degrees-of-freedom.

Methods

Five subjects performed voluntary isometric contractions of the deltoid at 10, 20, and 30% of a maximal voluntary contraction (MVC). During the contractions, the shoulder was positioned at either 25° (muscle lengthened) or 70° (muscle shortened). Each participant performed two contractions at each force output. The contractions were performed during either a single (lateral abduction in the sagittal plane (Y) or flexion in the frontal plane (Z)) or two DoF (combination of lateral abduction and flexion (YZ)) tasks. Force was recorded from a six DoF load cell. During each bout, the participants followed a tracking box to provide visual feedback on the forces produced during the trapezoidal contractions. Deltoid high-density surface electromyography was recorded using two 64 grid electrodes placed horizontally in succession (superior to inferior) from the border of the proximal tendon towards the insertion. Each trail was completely decomposed, and motor unit statistics (MUDR and CoV-ISI) were calculated for each task.

Results and Discussion

Results for MUDR indicate that both in the shortened and lengthened conditions MUDR was greater during the two DoF task compared to either of the single DoF tasks across all force levels (**Figure 1**, 10% MVC: Shortened: YZ=17.8 [14.8-20.8]; Y=16.1 [13.1-19.1]; Z=15.5 [12.5-18.5]; Lengthened: YZ=16.9 [13.9-19.8]; Y=15.9 [12.9-18.9; Z=14.5 [11.5-17.5]; 20% MVC: Shortened: YZ=18.5 [16.3-20.7]; Y=17.1 [14.9-19.3]; Z=15.8 [13.6-18.0]; Lengthened: YZ=18.3 [16.2-20.5]; Y=16.5 [14.3-18.7; Z=14.7 [12.5-16.9]; 30% MVC: Shortened: YZ=18.5 [16.3-20.7]; Y=17.1 [14.9-19.3]; Z=15.8 [13.6-18.0]; Lengthened: YZ=18.3 [16.2-20.5]; Y=16.5 [14.3-18.7; Z=14.7 [12.5-16.9], pps, $p < 0.01$). Additionally, differences for the CoV-ISI were observed at each force output between the shortened and lengthened conditions, where the shortened had greater variability ($p < 0.01$).

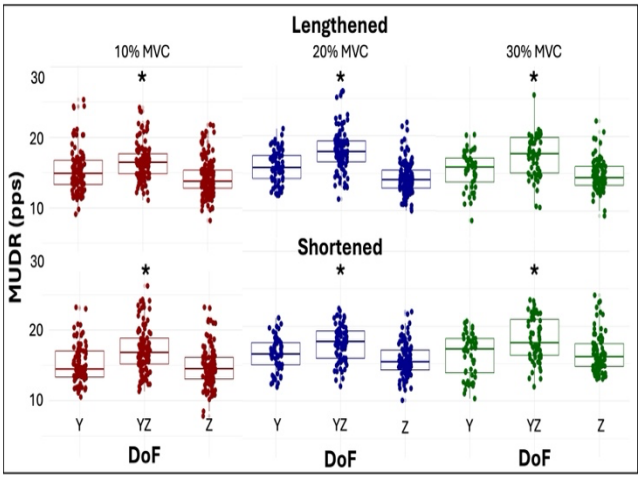

Figure 1: MUDR across force levels, DoF, and muscle lengths. * Indicates a difference between one and two DoF ($p < 0.05$).

When the task requires synergistic activation of a greater area of the deltoid, two DoF, there is an increase in neural drive, leading to a greater MUDR compared to one DoF. This was reflected in the CoV-ISI where muscle length and task changes may lead to greater synaptic noise in the common inputs to motoneurons. Based on previous reports on the tibialis anterior, lengthening the muscle leads to changes in coherence and less physiological tremors [1], which may also be true in the deltoid.

Conclusions

Therefore, changing muscle length and task may have significant implications on how the task is performed, with significant changes in both the MUDR and variability in the ISI. These changes may have significant implications in clinical populations, such as stroke, when prescribing tasks for rehabilitation. For instance, the inclusion of challenging tasks with more than one DoF in the rehabilitation protocol may inspire shorter recovery times.

Acknowledgments

This study was funded by the European Research Council Consolidator Grant 'INcEPTION' contract no. 101045605. J Greig Inglis is funded by the Marie Skłodowska-Curie Actions Grant 'MUDecomp' agreement no. 101151712. Silvia Rio's PhD is partially funded by OT-Bioelettronica.

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