Non-invasive identification of motor unit activity in typically developing children and children with cerebral palsy

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Summary

Understanding neuromuscular control in healthy and pathological pediatric populations requires, for ethical reasons, the development of non-invasive protocols. In this study we characterized the motor-unit activity in two lower limb muscles of typically developing children and children with cerebral palsy using non-invasive high-density surface electromyography. Preliminary results showed that motor-unit firing rates in gastrocnemius medialis were significantly lower in children with cerebral palsy than in typically developing children, showing that motor-unit activity can be measured non-invasively in both groups. Ongoing recruitment will enable further analysis.

Introduction

Studying neuromuscular control in children is crucial for understanding typical development and childhood disabilities like cerebral palsy (CP) and should be non-invasive, for ethical reasons [1]. CP often causes functional impairments in lower limb muscles [2], potentially due to altered motor unit (MU) activity [3]. While neuromuscular control has been characterized in detail in healthy adults using high-density surface electromyography (HDsEMG) [4], it is almost unexplored in typically developing (TD) children and those with CP. This study aims to non-invasively assess MU activity in the lower limb muscles of both TD children and children with CP.

Methods

20 TD children and 20 children with CP, aged 7-18 are currently being recruited. Three TD boys aged 8, 11, and 13 have been tested after obtaining informed consent from a parent. All procedures were approved by the UNSW Human Research Ethics Committee (Ref. number: iRECS6278). The participants were seated with their knee extended and foot (dominant side) strapped to a dynamometer foot plate. One maximum isometric voluntary contraction (MVC) was performed, followed by four submaximal trapezoidal contractions at 10%, 30%, 50% and 70% of MVC for both ankle dorsiflexion and plantarflexion. HDsEMG monopolar signals were recorded at 2048 Hz from the tibialis anterior (TA) and gastrocnemius medialis (GasMed) muscles using two 64-electrode grids (4 mm interelectrode distance, OT Bioelettronica, Italy) per muscle. Signals were decomposed into single MU spike trains using the Swarm Contrastive Decomposition (SCD) algorithm [5]. For a preliminary comparison against the neuromuscular control of boys with CP, we also decomposed the HDsEMG data from a publicly available dataset [6] (n = 6, aged 6-12), which tested GasMed with trapezoidal contractions at 15-20-70% of MVC. All identified MUs were characterized by the relationship between their mean instantaneous firing rate (FR) and force recruitment threshold (RT). Two-sample t-tests were used to statistically compare FR and RT between TA and GasMed in the TD group, and between TD and CP groups for GasMed.

Results and Discussion

In the TD group, 61 and 31 MUs were identified in the TA and GasMed, respectively, while in the CP subjects 33 MUs were identified in the GasMed (Figure 1).

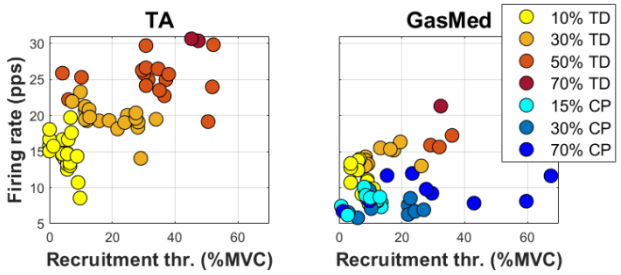

Figure 1: Identified MUs (FRs and RTs) across intensities.

In the TD group, FRs and RTs were 19.6 ± 5.1 pps and 18.2 ± 14.9%MVC (TA), and 12.7 ± 3.0 pps and 12.6 ± 9.1%MVC (GasMed). GasMed showed a significantly lower FR than TA among TD children. In the CP group, FRs and RTs were 8.1 ± 1.7 pps and 18 ± 16%MVC (GasMed). GasMed showed a lower FR in the CP group compared to the TD group. RT was never significantly different. These preliminary results suggest an overall narrower FR control range in GasMed and an apparent inability of children with CP to reach higher FRs, as was previously observed [2]. We are currently extending these findings with data from more participants.

Conclusions

Our findings show that MU activity can be measured non-invasively in children, enabling the study of neuromuscular control during typical childhood development and in children with CP.

References

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