Subject-specific intrinsic and extrinsic thumb muscle activity during functional tasks of daily life

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Introduction

The trapeziometacarpal (TMC) joint is subjected to severe compressive forces during manual tasks which are for a large part due to muscle contraction. Furthermore, muscles surrounding the TMC joint are important stabilizers of this highly mobile, and intrinsically unstable, joint. On the other hand, joint instability and high compressive forces have been linked to the onset of osteoarthritis (OA), suggesting that the muscles surrounding the TMC joint play an important role in the development of TMC OA. The aim of this study is to explore if specific muscle activation patterns can be found during a lateral key pinch, power grasp and jar twist task to eventually relate those to joint loading.

Method & Materials

Isometric forces and fine-wire electromyographic (fEMG) activity produced by 4 intrinsic thumb muscles (m. abductor pollicis brevis, m. adductor pollicis, m. flexor pollicis brevis, m. opponens pollicis) and 4 extrinsic thumb muscles (m. extensor pollicis brevis, m. extensor pollicis longus, m. abductor pollicis longus, m. flexor pollicis longus) were measured in 11 healthy female volunteers. Muscle activity was captured using an 8 channel Delsys wireless system. Pairs of disposable hooked wire electrodes were inserted by a certified hand surgeon using an ultrasound guided technique.

Isometric force data were collected using a load cell embedded in a custom-made polycarbonate jig. The participants performed isometric contractions for 5 seconds during a key pinch, a power grasp and a jar twist task. They were instructed to perform two maximal isometric contractions and one contraction at 80% of their maximal force per task. The tasks were executed with and without EMG recording to verify if electrode placement influenced force production.

The raw EMG signals were filtered (10 Hz, high pass 2nd order Butterworth) and the full wave was rectified using EMGworks 4.0 analysis software. Normalization was achieved by using the highest EMG amplitude per muscle and per subject.

A Wilcoxon signed-rank test was used to statistically test the difference between the normalized intrinsic and extrinsic muscle activity. A paired t-test was applied to compare the generated force pre- versus post-electrode insertion.

Results

A high interindividual variability in muscle activity was seen in all three tasks. In both the maximum effort as well as the 80% effort, no significant differences in activation between intrinsic and extrinsic muscles were found in the pinch or grasp task ($p>=0.05$). However, the maximal effort jar twist task resulted in a significantly higher activation of the intrinsic compared to the extrinsic muscles ($p=0.003$).

Insertion of the fEMG electrodes appeared to significantly decrease the external force production in all tasks during both maximum and 80% effort contractions (table 1).

Conclusion

The thumb muscles display a high interindividual variability in muscle activity during functional tasks of daily life, such as pinch, grasp and jar twist. The results of this study suggest that to produce a substantial amount of force, a well-integrated, but subject-specific, co-contraction between the intrinsic and extrinsic thumb muscles is necessary. Despite the variability, these findings can be used as input for an EMG-driven musculoskeletal model. Further research will focus on how differences in muscle activation patterns influence joint loading and if this could contribute to the onset of trapeziometacarpal joint osteoarthritis.

Table 1. Exerted force during maximum and 80% effort for each task, before and after insertion of the fEMG electrodes (values are mean ± SD). [1] Significant difference in produced force before and after electrode insertion at $P<0.05$

Effort	Task	Force Before (N)	Force After (N)	p-value
Maximum	Grasp	119.04±26.38	97.13±23.67	$p<0.001$[1]
	Pinch	100.96±27.45	75.85±17.34	$p<0.001$[1]
	Jar twist	148.97±45.14	112.24±43.65	$p<0.05$[1]
80%	Grasp	82.95±20.24	73.04+18.29	$p<0.05$[1]
	Pinch	72.30±18.87	58.58±14.53	$p<0.05$[1]
	Jar twist	100.69±27.98	82.24±31.50	$p<0.05$[1]