SHOULDER MUSCLE ACTIVITY DIFFERS BETWEEN FORWARD AND REVERSE WHEELCHAIR PROPULSION – AN EXPERIMENTAL STUDY OF THE IMPACT OF A NOVEL WHEELCHAIR DRIVING DEVICE

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Introduction

Wheelchair propulsion increase independent mobility in disabled. Conventional wheelchairs propelled by manual application of forward/downward directed force results in high incidence of shoulder and neck pain. The underlying mechanisms remain relatively unexplored, but muscle fatigue and biomechanics during high repetitive load is considered to play a major role (1).

A novel device was developed to allow forward wheelchair propel-ling by pushing as well as pulling the hand rim.

This study explored the shoulder muscle activity by surface electromyography measurements during push and pull tasks in a wheelchair in a laboratory setting.

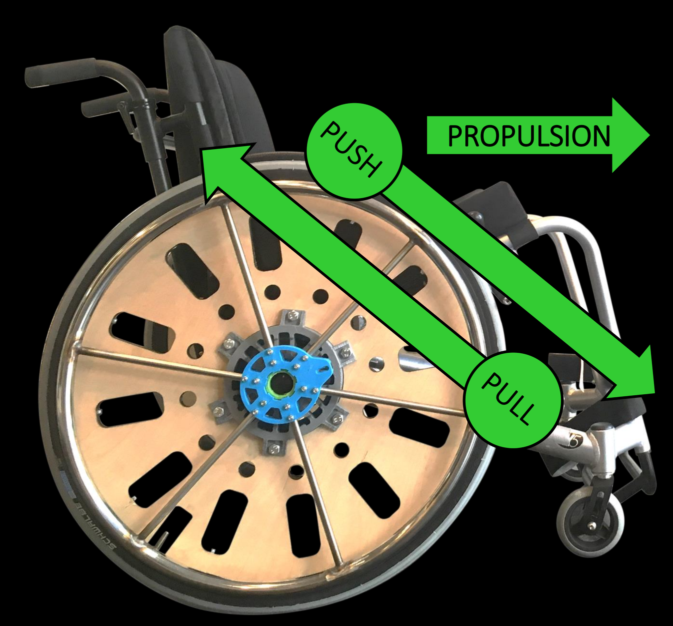


Fig. 1. Push versus pull propulsion tasks

Aim and hypothesis

The aim was to compare surface EMG activity of selected shoulder muscles during forward propulsion of a wheelchair wheel by pushing compared with pulling techniques.
We hypothesized significant differences in muscle activity in selected shoulder muscles between the two techniques.

Methods – procedure

20 healthy young participants (age 23.8±2.5 years, 18 women) completed two series of 20 seated forward and backward propulsions in a wheelchair rig designed for the experiment after completing maximal voluntary contraction tests (MVC).

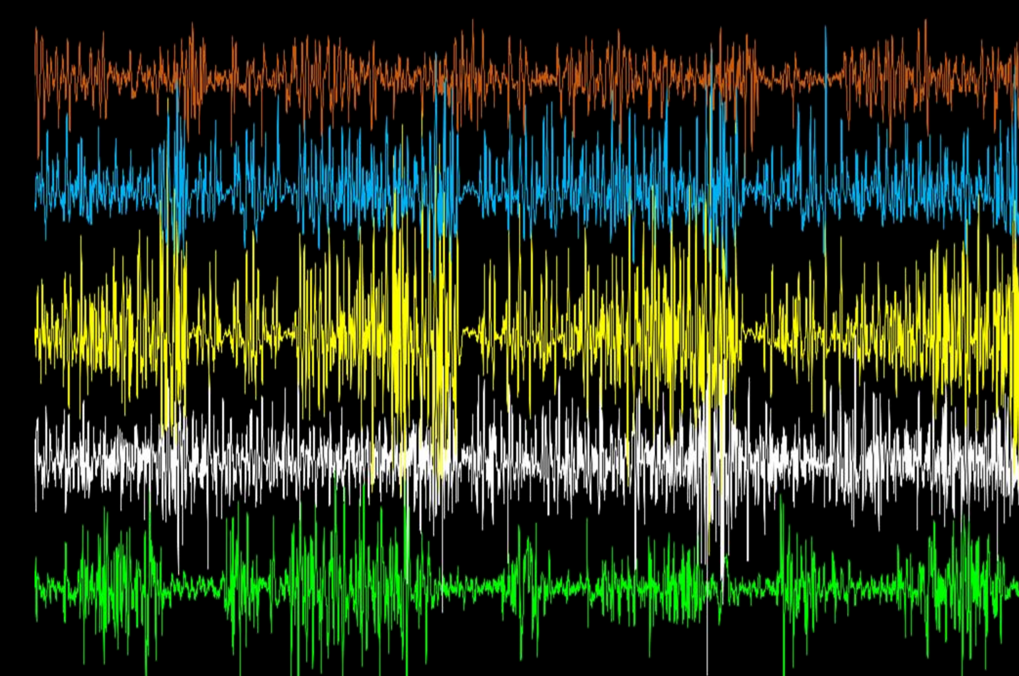
The participants were randomized to start forward or reverse wheeling with a 3 minutes break between the series. EMG activity was recorded from 9 dominant side muscles (Biceps and Triceps Brachii, Deltoideus (anterior, medial and posterior), Trapezius (pars descendens and transversus), Latissimus Dorsi and Pectoralis Major) with a Noraxon™ wireless EMG system and synchronized video recordings of sagittal and frontal plane movements.

Methods - analysis

Video recordings of last to first rim contact defined propulsion phases. Raw propulsion phase EMG data was filtered, full-wave rectified and smoothed before MVC normalization and calculation of mean and peak Root-mean-Square (RMS) EMG. No statistical differences were observed between the groups that were pooled into one group before comparison of mean and peak RMS-EMG between the two tasks by repeated measures ANOVA (RM-ANOVA) tests and post-hoc t-tests.

Fig. 2. Raw EMG data (5 second window from one representative participant) of selected muscles during pull tasks. Data illustrated the synchronized EMG amplitude as different but clearly phasic muscle activity during the tasks

------ = m. Biceps Brachii
------ = m. Deltoideus anterior
------ = m. Deltoideus medius
------ = m. Trapezius, upper part
------ = m. Latissimus Dorsi



Results

The analyses of differences between pull and pull tasks during wheelchair propulsion phases showed statistical differences between the two tasks in 9 selected shoulder and upper extremity muscles in mean (P<0.001, Fig. 3.) and peak (P<0.001) RMS-EMG normalized to MVC for the individual muscle.

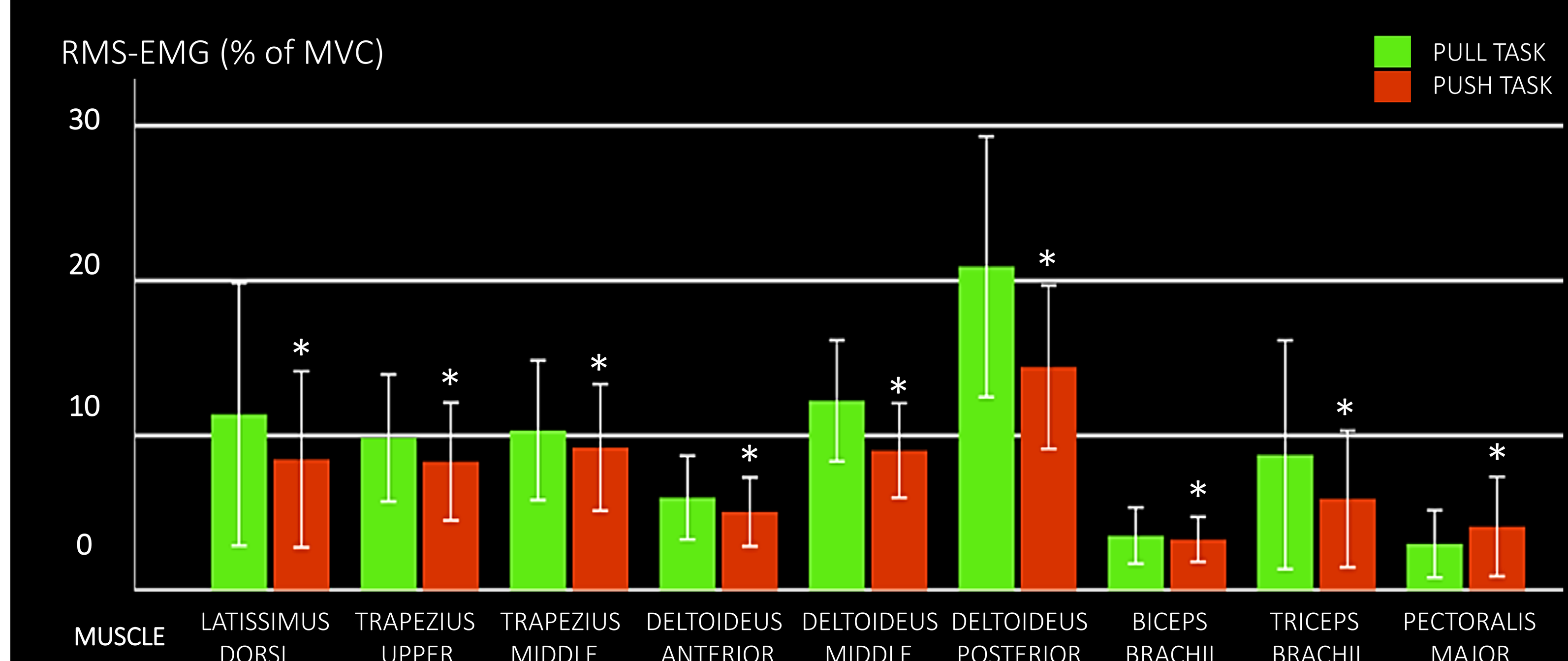


Fig. 3. Mean±SEM (N= 20) muscle activity (RMS-EMG normalized to,MVC). Pulling compared to pushing wheelchair propulsion tasks resulted in significantly higher (*, P<0.05) mean RMS-EMG in all muscles but m. Pectoralis Major that demonstrated significantly lower mean RMS-EMG (*, P<0.03).

Results – supplementary

Visual inspection of normalized RMS-EMG data across the participants revealed reverse muscle activity during the propulsion phase during pulling compared with pushing tasks (Fig.4.)

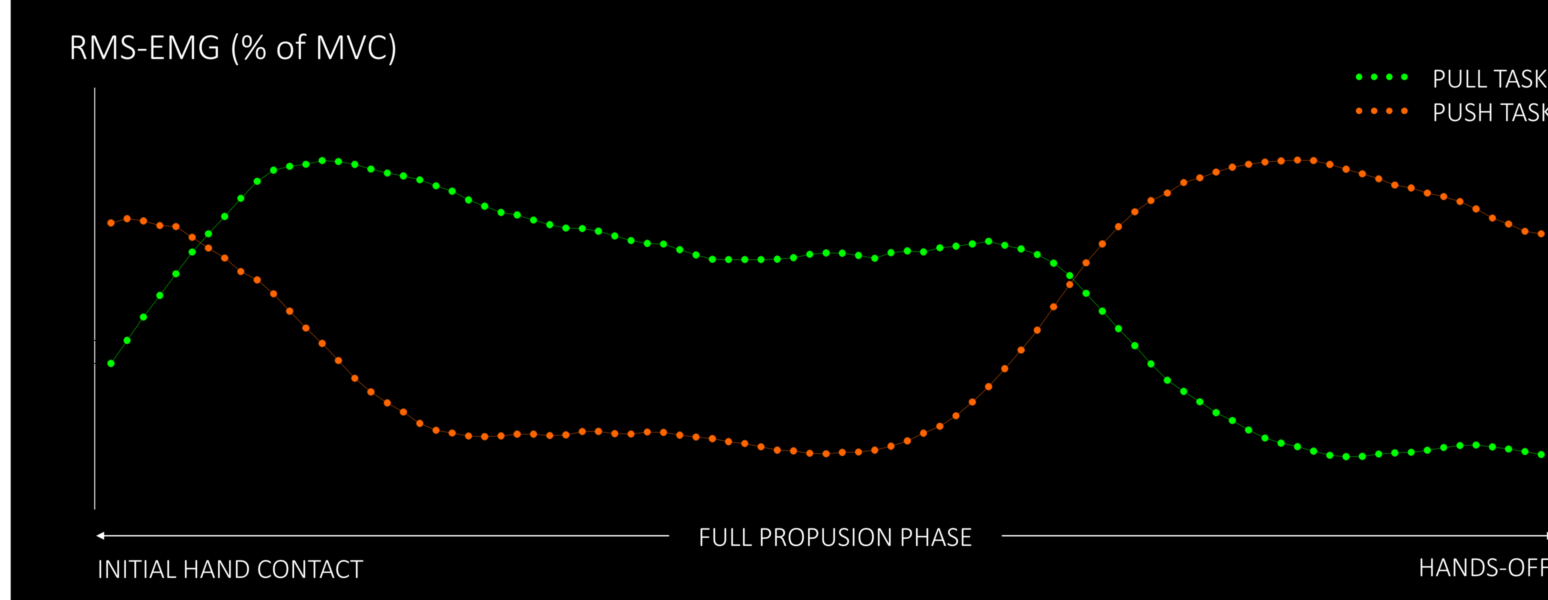


Fig. 4. Mean (N= 20) muscle activity (RMS-EMG normalized to,MVC) in a representative muscle (m. Biceps Brachii) during a single propulsion phase during pulling and pushing tasks.
Pulling seems to result in higher muscle activity during the initial and pushing during the final part of the phase. Pulling furthermore resulted in relatively high muscle activity during a longer proportion of the propulsion phase. Similar patterns was observed I all muscles indicating different strategies during the tasks and pushing seems more effective than pulling .

Conclusion

The use of an innovative device effectively allowed the participants to drive a wheelchair forwards by pushing and pulling. The two tasks resulted in significant differences in shoulder and upper extremity muscle activity. This may decrease the risk of overuse injuries in wheelchair users but more research is needed to explore this.

Discussion

Propulsion of a wheelchair by pulling the rim backwards may be a possible motor strategy to distribute mechanical load in contractile structures in or related to the muscles. The pulling strategy, however, seems to be less effective than pushing.

More experimental and clinical research is needed to explore the underlying mechanisms in pain syndromes in wheelchair users. Other mechanical factors like seated posture and non-contractile structure tissue load may play a role, but the ability to use different propulsion strategies may decrease the risk of musculoskeletal pain caused by repetitive strain injuries. The short- as well as the long-term impact should be examined in future prospective studies.

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Disclosure Stine Bjerringgaard is co-owner and inventor of the pull-and-push wheelchair device.

Reference
1. Jain, NB. et al 2010. Association of Shoulder Pain With the Use of Mobility Devices. PM&R 2(10):896–900