Movement adaptations to acute noxious stimuli and subjective pain experience in walking

Kirsty A. McDonald[1,2], Raffy Beylerian[1,2], Blake Dickson[2,3], Ingvars Birznieks[2,3], Jeanette Thom[1,4], Felix Aplin[2,3]
[1]School of Health Sciences, University of New South Wales, Sydney, Australia
[2]Neuroscience Research Australia, Sydney, Australia
[3]School of Biomedical Sciences, University of New South Wales, Sydney, Australia
[4]School of Health Sciences, The University of Sydney, Sydney, Australia
Email: kirsty.mcdonald@unsw.edu.au

Summary

This study examines how electrical stimulus magnitude and subjective pain rating affect limb loading in walking. Participants showed significant reductions in peak vertical ground reaction force (vGRF) of their stimulated (painful) limb when stimulus magnitude or pain rating exceeded certain thresholds. Unstimulated limb loading was not affected.

Introduction

Humans often adapt their movement in the presence of noxious stimuli and pain [1]. Yet it remains unclear how the magnitudes of each factor contribute to the observed biomechanical changes. Given that movement adaptations can have negative long-term consequences on musculoskeletal health [2], the aim of the current study was to explore how subjective pain rating and noxious stimulus magnitude affect movement adaptations when a task-relevant electrical stimulus is unilaterally applied to the lower limb during walking.

Methods

This protocol was approved by the University of New South Wales Human Research Ethics Committee. Healthy adult participants (N=10) provided informed consent but were not initially made aware of the study aim to avoid influencing their gait strategy. Two foam electrodes were applied to their left lateral heel. They walked on an instrumented treadmill (M-Gait, Motekforce Link, The Netherlands) at 0.8 m/s while ground reaction forces (GRFs) were collected (1000 Hz). Participants first completed a baseline trial where they walked with no stimulation. A noxious electrical stimulus (DS5 Isolated Bipolar Constant Current Stimulator, Digitimer, UK) was then delivered to participants via the electrodes as they walked. The stimulus could be modulated by modulating the magnitude of the left limb vGRF. It increased linearly from 0 mA when participants completely offloaded their left limb, to the maximal prescribed current for that trial when participants loaded their left limb with a peak vGRF equal to, or greater than 100% of the mean peak vGRF obtained from the baseline walking trial. At first, the stimuli were Graded, ramping from no stimulus to a stimulus that represented an 8/10 subjective pain rating for that participant (0: no pain, 10: worst possible pain). These stimulus magnitudes were then delivered in a Randomized order. Each stimulus was delivered for 60 s, with prescribed current and subjective pain rating recorded, and average bilateral peak vGRF (normalized by bodyweight) processed in bins at 0-5, 5-10, 10-20, 20-30, 30-40, 40-50 and 50-60 s. Linear mixed effects models, ANOVAs and post-hoc tests were used for statistical analysis (RStudio version 2024.09.1).

Results and Discussion

A significant reduction in stimulated (left) limb vGRF relative to the Baseline trial was present for prescribed current values of 3.5 mA and above in the Graded condition ($p<0.05$), except for 6 mA ($p=0.480$). No differences in vGRF relative to Baseline were observed for prescribed current values in the Randomised condition ($p>0.05$). A significant reduction in unstimulated limb vGRF relative to the Baseline trial was present for subjective pain scores of 6/10 and above in the Graded condition ($p<0.001$) and 8/10 in the Randomised condition ($p=0.011$). No differences for the unstimulated (right) limb were observed for prescribed current and subjective pain rating ($p>0.05$).

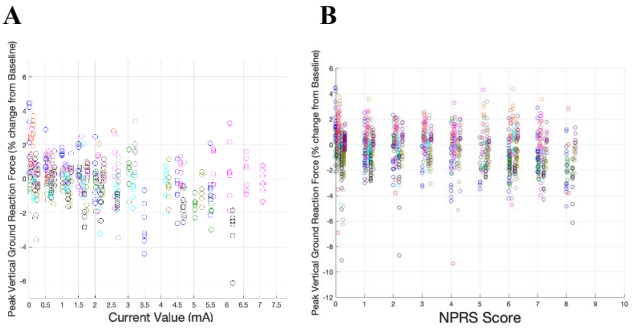

Figure 1: The effect of A) noxious stimulus magnitude (current value) and B) subjective pain rating determined via a numerical pain rating scale (NPRS) on stimulated limb loading (vGRF) in walking. Data from both Graded and Randomised conditions are plotted. Participants are represented by different colours and individual data points relate to a single bin.

Conclusions

Minimal but statistically significant reductions in peak ground reaction force of the stimulated (left) limb were observed for both prescribed current and numerical pain rating (1-2% of bodyweight). Future work should clarify to participants that they can adapt their movement, otherwise they may feel obligated to walk as normally as possible.

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References

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