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RE: the article entitled "Effect of footwear on intramuscular EMG activity of plantar flexor muscles in walking" by Péter, A., Arndt, A., Hegyi, A., Finni, T., Andersson, E., Alkjaer, T., Tarassova, O., Ronquist, G., Cronin, N

Dear Editor,

We have read with interest the article entitled "Effect of footwear on intramuscular EMG activity of plantar flexor muscles in walking" by Péter, A., Arndt, A., Hegyi, A., Finni, T., Andersson, E., Alkjaer, T., Tarassova, O., Ronquist, G., Cronin, N in the Journal of Electromyography and Kinesiology (2020, 55, 9) in which the authors concluded that greater activity of the plantar flexors during propulsion was required for the majority of participants when walking in shoes compared to barefoot and flip-flops. We congratulate the authors on the comprehensive approach of analysing the muscle activity from multiple plantar flexors including flexor hallucis longus, which receives comparatively little attention in the literature and for using statistical parametric mapping to analyse the electromyography (EMG) across the entire waveform rather than exclusively at discrete time points.

Péter et al observed no systematic effect of footwear on EMG amplitudes recorded from flexor hallucis longus, soleus and medial and lateral gastrocnemius. They noted, however, that they observed higher peak EMG amplitudes in the majority of their participants when they walked in shoes compared to barefoot or flip-flops. While the precise randomization protocol was not clearly described, EMG data appear to have been recorded first while the participants walked in shoes, then in a randomized order of the barefoot and flip-flops conditions. Indeed, there may have been a missed but important confounding effect of test order impacting their findings.

In a recent publication, we reported that fine-wire EMG amplitude was systematically reduced after 25 minutes of walking, independent of any experimental effects and without an accompanying change in surface EMG amplitude (Reeves et al. , 2020).

Based on this observation, we recently sought to explore the impact of recording time on the amplitude of fine-wire EMG signals recorded from the biceps brachii muscle, while also evaluating the potential confounding factor of task type (isometric, dynamic) (Reeves and McLean, 2021). Participants performed 30- second contractions of the biceps brachii every five minutes for two hours. Fine-wire EMG amplitude reduced significantly over time in both the isometric and dynamic tasks, without an accompanying change in the surface EMG amplitude. This decline was more pronounced in the dynamic task.

Based on the findings of these two recent publications, the effect of footwear observed by Péter et al may have been the result of test order and not of footwear.

In the article by Péter et al., surface EMG was recorded from all plantar flexors, but only the fine-wire EMG results were presented. Given that we have shown surface EMG to be more consistent than fine-wire EMG over time (Reeves and McLean, 2021, Reeves, Starbuck, 2020), it would be interesting to know whether the higher amplitude in the shoe condition was also evident in the surface recordings. Péter et al justified their decision to report on intramuscular EMG alone by referencing a previous paper (Peter et al. , 2019), in which they concluded that the surface and intramuscular EMG recordings of the medial and lateral gastrocnemius were similar when walking at different speeds. Yet the focus of that paper was not to establish the validity of the fine-wire EMG amplitudes relative to the surface EMG signals. And indeed, on inspection of the individual plots in this earlier study (particularly figure 8 B-F and 8 I, figure 9 A, I and J and figure 10 A, D, E, G, H and J) a difference in the normalised amplitudes between the fine-wire and surface EMG signals can be seen at each speed.

The cause of a decrease in intramuscular EMG amplitude over time remains unknown. However, based on physiological responses to foreign bodies, a decline in signal amplitude could be a result of focal oedema, which could reduce signal amplitude by distancing the electrode from the active tissue (Geddes and Roeder, 2003) and/or electrode fouling in which the adhesion of biomolecules to an implanted sensor can result in changes in the characteristics of the recorded signals (Hanssen et al. , 2016, Harreither et al. , 2016). Further, dynamic tasks such as walking may damage to the electrode tip (Helton et al. , 2011). It is also conceivable that the electrode tips may not maintain a fixed relationship to the active fibres as the muscle changes its length and pennation angle during contraction, as suggested by a recent expert consensus (Besomi et al. , 2019).

The evidence for a potential time-dependent decline in fine-wire EMG amplitude during dynamic tasks like walking should not be ignored. It may have serious implications for the valid interpretation of findings. While we need to investigate the cause of fine-wire EMG signal decline over time in order to mitigate it, there is a clear need to fully randomize task order in studies in which fine-wire EMG amplitude is used as an outcome measure. We commend the authors for reporting their findings at the individual level, which is particularly important given both the highly individual nature of EMG recordings and the increasingly evident individual responses to footwear in the literature (Nigg et al. , 2003, Weir et al. , 2019).

Sincerely,

Dr Jo Reeves and Dr Linda McLean

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