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Reflex connections from the lower limb to the erector spinae muscle in humans

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Introduction

Reflex pathways from cutaneous receptors connect all four limbs (Zehr et al., 2001). Activation of muscle spindles by displacement of the ankle joint generates reflexes in upper limb muscles (Kearney & Chan, 1981). However, similar displacements produce responses in the core muscles but at longer latencies (Diener, Horak, & Nashner, 1988).

Short latency reflex pathways between the lower limb and the core muscles have not been identified. The present experiments were designed to identify whether such reflexes are present, if they show task-dependency, and to investigate the afferent origin. Muscle spindles in the ankle extensors were activated and responses were recorded from the lower back muscles.

If reflex responses are present this circuitry could play a role in human postural control and the maintenance of stability.

Hypotheses

1) Spinal reflex pathways connect receptors in the ankle to the erector spinae (ES) muscle.

2) Reflex responses in the ES will be larger during standing as compared to sitting (i.e. task-dependency).

3) Responses in ES arise from the activation of muscle spindles in the triceps surae.

Methods

- 10 participants (6 ♂, 4♀; 21-42 yrs)
- Surface EMG recorded from:
  - right soleus (Sol)
  - bilateral lower ES, i*psilateral (iES) and contralateral (cES)*
- Trials:
  - standing, eyes open or closed
  - seated, eyes open or closed

ES contraction during standing was matched in the seated trials

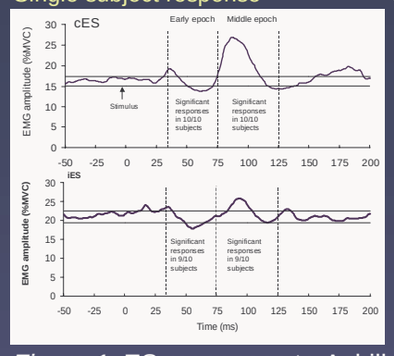
- Stimuli: Achilles' tendon taps (40/ trial)
- Control: Taps applied to lateral heel

- Single subject analysis: Responses were grouped into early (35-75ms) and late (75-125ms) epochs and considered significant if > ± 2 SD from the mean on-going EMG activity. The largest peak in each epoch was used for analysis. Response amplitude was determined by subtracting the mean on-going EMG activity from the response.

- Group analysis: Repeated measures analysis of variance followed by Fisher's LSD post-hoc test, as well as dependent-samples paired t-tests were used to determine statistical significance for the group across conditions ($p < 0.05$).

Results

Single subject response



Group response

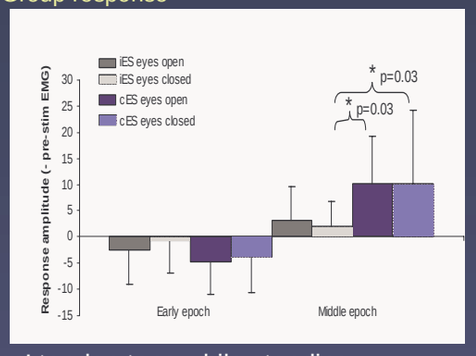
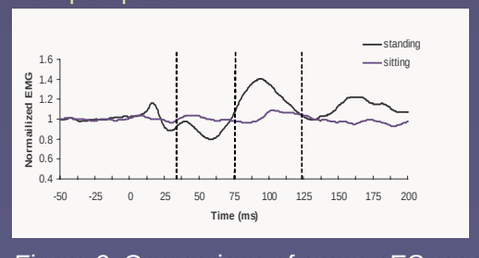


Figure 1. ES responses to Achilles' tendon taps while standing.

A main effect for cES vs. iES group responses was found for the middle epoch ($p = 0.044$).
No significant difference found between eyes open or eyes closed conditions across trials in either epoch.

Group response



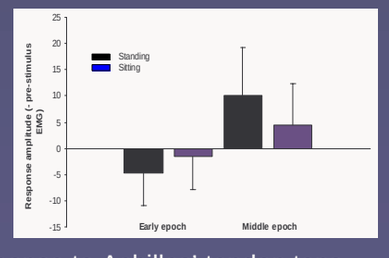


Figure 2. Comparison of group cES response to Achilles' tendon taps while standing and seated.

No significant difference was found across the group between standing and seated trials ($p = 0.097$).

Group responses

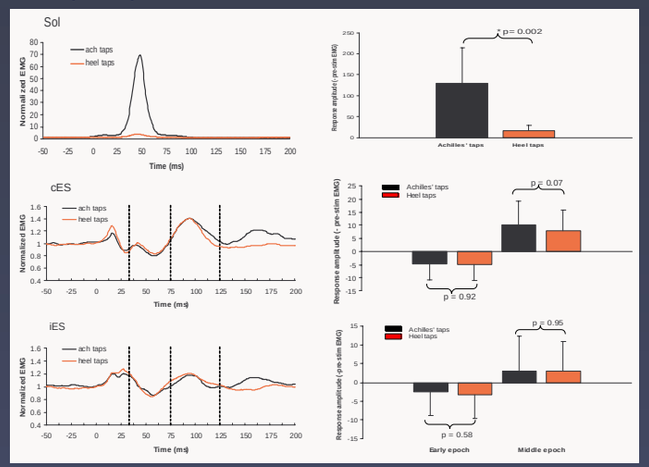


Figure 3. Group Sol and ES responses to Achilles' taps and heel taps, standing with eyes open.

Conclusions

The results of our study show that spinal reflex pathways are present between the lower limb and both the cES and iES, with larger responses in cES. Responses were not altered when subjects opened or closed their eyes. Furthermore, the responses were not significantly larger during standing as compared to sitting. Contrary to our third hypothesis, there was an ES response during heel tap trials, despite the lack of a stretch reflex in soleus. Therefore, our working hypothesis is that reflex responses in ES are driven predominantly by cutaneous afferents in the foot and ankle and not muscle spindles of the triceps surae.
The presence of the ES responses suggest a possible role in the control of human posture. Additionally, the responses in cES may contribute to EMG activity at heel strike during locomotion.

References

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