Spring 5-2022

Identifying the Neural Correlates of Postural Control: A Novel fMRI Paradigm

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INTRODUCTION

Postural control is essential for maintaining balance and facilitating goal-directed action during voluntary limb movement. Altered postural control is a characteristic of aging and of multiple neurological/musculoskeletal conditions[1,2]. It has not previously been possible to determine the patterns of altered brain activation underlying impaired postural control in patient populations. **The purpose of this study was to demonstrate the feasibility of a novel fMRI-compatible postural control paradigm and identify the brain activation associated with postural control in the trunk/hip musculature during a voluntary lower-limb task.**

METHODS

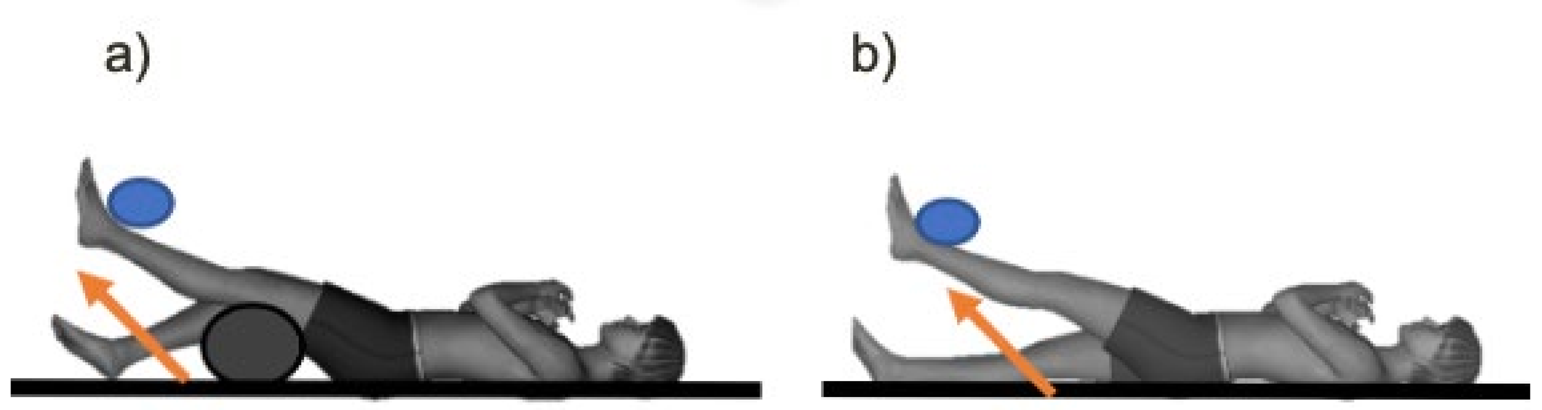


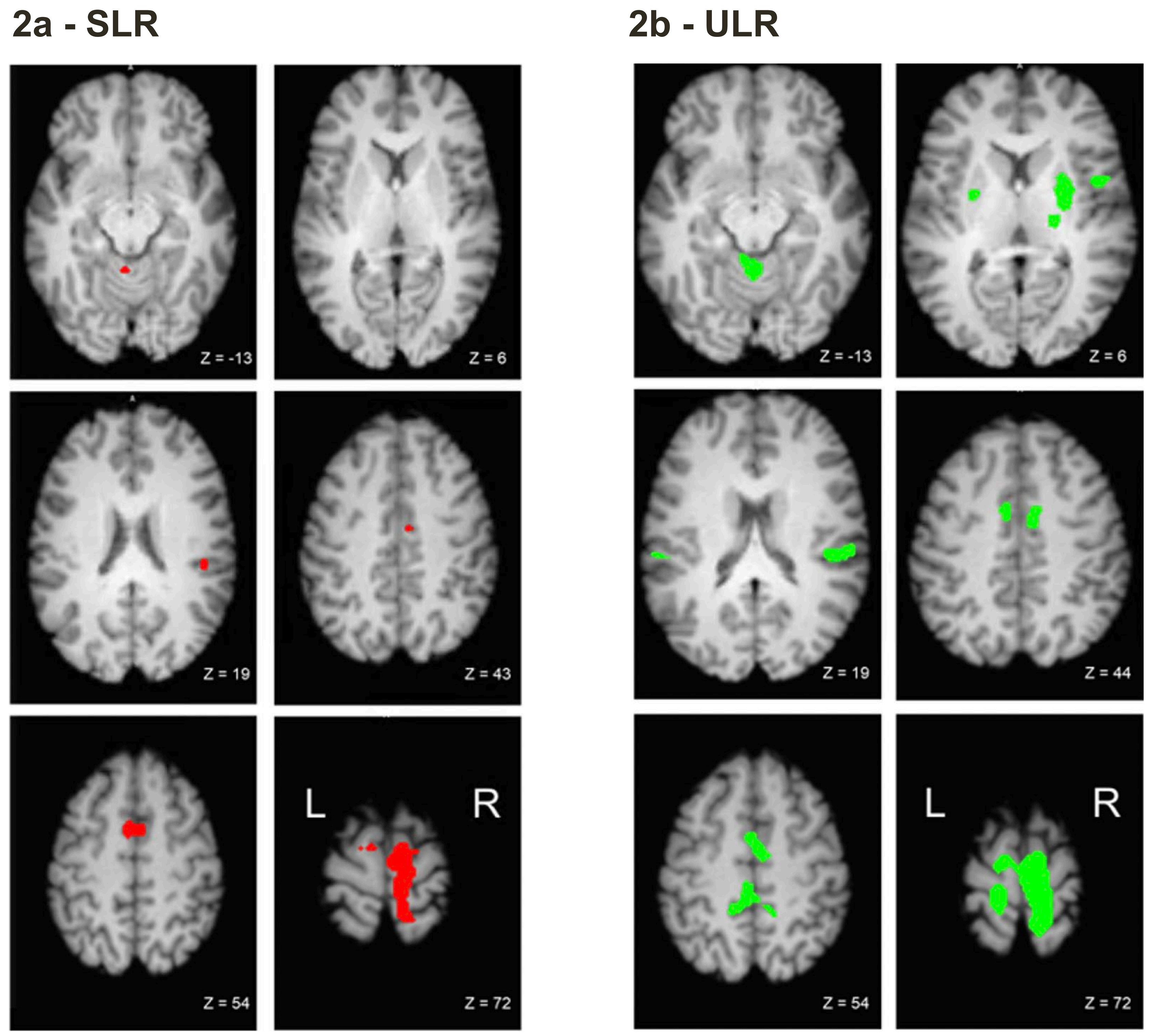
Figure 1. Schematic showing a). Supported leg raise b). Unsupported leg raise

- BOLD fMRI imaging was performed on 20 healthy young adults (23 ± 4 years, 13 female, 7 male, Siemens Prisma 3T MRI).
- Performed two lower-limb tasks in the scanner to touch a horizontal target with their non-dominant, left limb in response to visual cues.
  - The supported leg raise task (SLR), the leg is raised from the knee with the thigh supported (Figure 1a)
  - The unsupported leg raise task (ULR), the leg is raised from the hip[1] (Figure 1b)
- Data were processed using SPM12[3] and head motion was quantified using the Artifact Detection Tool[4].
- For each task, significant activation compared with rest was calculated for the whole brain (FWE corrected, $p < 0.05$).
- Percent signal change was calculated for sensorimotor regions of interest.

RESULTS

- Head motion was negligible for both tasks;
  - Average frame-wise displacement, SLR = 0.27 (0.10)mm; ULR = 0.18 (0.10)mm
- Significant brain activation during the SLR task occurred predominantly in the right primary and secondary sensorimotor cortical regions (Figure 2a).
- In contrast, significant brain activation during the ULR task occurred bilaterally in the primary and secondary sensorimotor cortical regions, as well as cerebellum and putamen (Figure 2b).

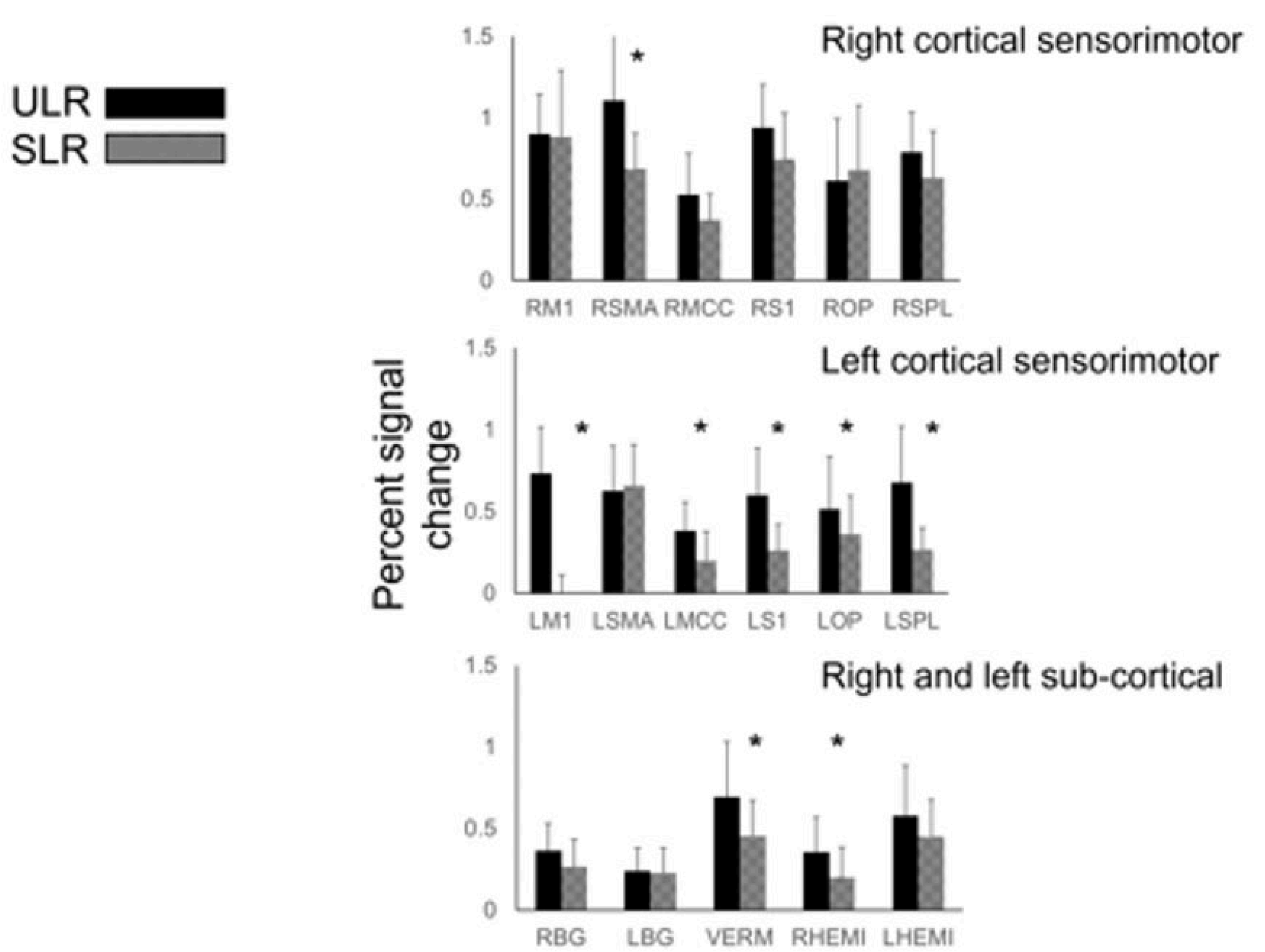
Figure 2. Significant brain activation during a) Supported leg raise b) Unsupported leg raise



- Percent signal change was significantly greater during the unsupported leg raise for the following areas: right and left supplementary motor, left primary motor, left middle cingulate, left primary sensory, left superior parietal lobule, left parietal operculum, cerebellar vermis, and right cerebellar hemisphere (Figure 3).

RESULTS

Figure 3. Percent signal change in regions of interest



CONCLUSION

This novel paradigm enables simultaneous and noninvasive identification of human cortical and subcortical brain activation associated with postural trunk and hip muscle recruitment during a voluntary lower-limb task. Regions activated during the unsupported leg raise, but not during the supported leg raise, were consistent with the planning, execution, and sensory experience of a task involving multisegmental and bilateral postural control. This paradigm provides a foundation for future studies that will isolate neural mechanisms of impaired postural control in patients with neurological and musculoskeletal dysfunction.

ACKNOWLEDGEMENTS

This study was funded by a grant from NICHD (K01 HD092612)
IRB approval # 1617H094

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