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Mental simulation of balance tasks: Neural control and age-related changes

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Recently, the combination of MI during AO (AO+MI) has been proposed as a new form of non-physical training. However, the neural mechanisms involved during AO+MI remain largely unknown, as well as the age-related differences during neural processing of mental stimulation. Therefore, this thesis aims to provide a better understanding of the neural processing of mental simulation, and the impact of aging on these mechanisms.

In the first study, changes in corticospinal (CSE) and spinal excitability were investigated using TMS, when young adults performed different types of mental simulation of a dynamic and static postural task. The CSE was modulated by the task complexity and the form of mental simulation. The AO+MI condition presented the greatest CSE, followed by the MI and the AO conditions and CSE was always larger in the dynamic balance task compared to the static task.

The second study aimed to assess changes in the intracortical inhibition (ICI) during execution and mental simulation of a stable and unstable standing task. The ICI showed a task-specific modulation during both execution and mental simulation. Therefore, mental simulation of postural tasks induces changes in the ICI and, presents similar neural processing with real balance task execution.

The third study examined age-related differences when mentally simulating postural tasks, by comparing corticospinal and spinal excitability in young and old. There was an increase of the CSE in the older adults compared to the young adults. In addition, no changes in the H-reflex were observed indicating that age-related changes during mental simulation mainly occur at the cortical level and seem to encompass 'cortical overactivation'.

Similarly, study number four revealed, by fMRI techniques, greater brain activity in the old compared to the young adults when mentally simulating postural tasks. Increased cerebral activity was observed in PFC, premotor cortex, SMA, M1, and putamen. In both age groups, brain activity in the SMA and PFC was larger when the dynamic task was compared to the static task. Moreover, elderly showed to be more dependent on visual input (i.e. AO+MI and AO) than young adults in order to activate subcortical brain areas.

In conclusion revealed that AO+MI had the greatest impact on brain activity, CSE and ICI, and that these neural mechanisms presented a task-related modulation. In addition, AO+MI displayed the most similar modulation of the ICI with the pattern of the real task execution. Regarding the elderly, they exhibited greater CSE and brain activity, but no change was observed in the spinal excitability. This implies that aging induces changes in the neural processing of mental simulation, which mainly occur at the cortical level. Therefore, future non-physical balance training interventions should mainly focus on challenging balance tasks, and promote the combination of MI with AO as a form of mental simulation.

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