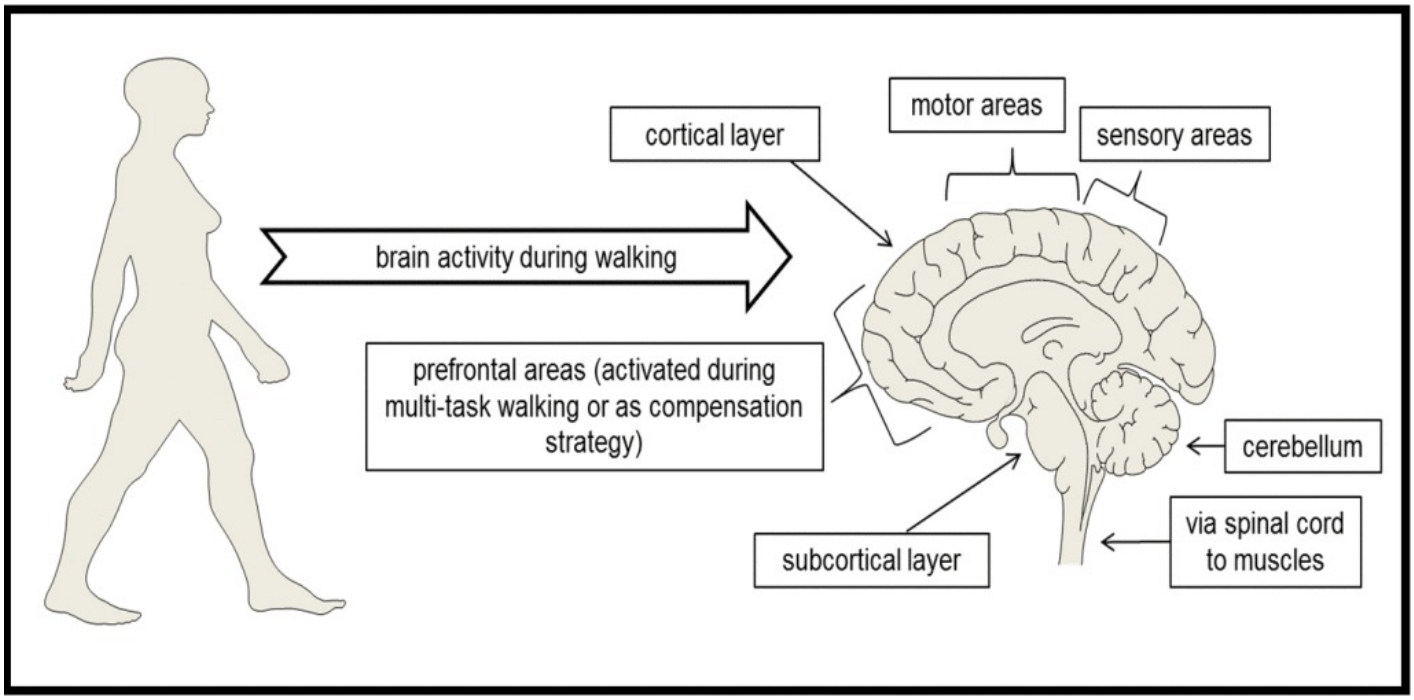
The walking brain

Walking is the most common locomotion strategy to move from one to another place. Normally, we do not think about our steps and we would consider walking as a natural and automatic behaviour. However, more challenging environmental demands (multi-task situations like walking and simultaneously texting on a mobile phone) lead to unstable gait. An unstable gait may indicate that our brains have not enough capacity to handle multiple tasks at the same time. Furthermore, gait is more unstable in people with neurological impairments affecting the central nervous system (e.g. Parkinson´s disease). All these aspects let us assume that our brains place crucial roles in the execution of human walking.

The aim of our work was to summarize the current body of knowledge regarding the brain's activity during walking. Therefore, we conducted a literature search to identify all relevant studies. After searching and exclusion of irrelevant articles we included 48 articles in our review.

Our results indicate that stable walking depends on specific networks in brain. These networks consist of cortical (outer layer of the brain) and subcortical (below the cortex) structures which interact with each other and send neuronal commands via the spinal cord to the muscles (please see Figure 1). There is a higher activity in cognitive (information processing), sensory (feedback processing) and motor areas (planning and commanding movements. Unfortunately, no clear conclusion can be drawn as to what degree the walking is an automatized behaviour because it depends on influencing factors. To our knowledge the activation of brain areas were, for instance, influenced by neurological pathologies or the solving of an additional task during walking (e.g. talking while walking).



In situations where we talk to other people while walking, an activation of additional frontal brain regions occurs. This increased activity especially in prefrontal areas seems important in order to solve both tasks properly (please see Figure 1).

However, younger people mostly rely on fewer or lesser activation of brain areas for the execution of walking when compared to older people. Especially physical inactive older people show a higher activation of sensory and motor areas in backwards walking or walking over obstacles. Therefore, we assume that this phenomenon reflects either a compensation strategy of insufficient sensory feedback (e.g. from vision) or/and a greater dependence on sensory areas in older people. Moreover, this phenomenon could be also caused by the loss of brain mass in age.

People with neurological disease have specific structural and functional changes in disease dependent areas of the brain. It seems that these patients either compensate their neuronal deficits by a stronger activation or the recruitment of additional brain areas during walking (please see Figure 1). Although these additionally activated areas are not part of the normally used gait network, these neuronal processes are crucial to ensure walking. Notably, the compensational strategies seem often not sufficient enough because walking became more unstable which is associated with higher risk of falling.

All in all, we summarize that the activity of cortical and subcortical brain areas during walking depend, for example, on age and pathologies. The compensation processes reflect the plasticity of our brains which are always aiming to ensure a minimum of motor control under every circumstance. However, our results not only indicate that brain involvement is required to walk in a stable fashion, but also that walking (in whatsoever way) is required to remain and enhance our cognitive functions. This means, in turn, that the lack of movement in our sedentary societies negatively affects brain plasticity. Therefore, it is strongly recommended to adopt and maintain a physically activity life style.

Publication

Brain activity during walking: A systematic review.
Hamacher D, Herold F, Wiegel P, Hamacher D, Schega L
Neurosci Biobehav Rev. 2015 Oct;