

# Executive Functions of Sedentary Elderly May Benefit from Walking: A Systematic Review and Meta-Analysis

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**Objective:** *The goal of the present meta-analysis was to address studies that examined the relationship between walking as one of the most prevalent types of leisure-time activity and executive function being a higher-order cognitive function essential for independent functioning. Methods:* *The following data sources were used: English-language publications in PubMed, EMBASE, PsycINFO, Cinahl, and Cochrane; the last search took place in January 2012. From these data sources, only randomized controlled trials including older people with ( $N = 3$ ) and without ( $N = 5$ ) cognitive impairment were selected. Results:* *Walking has been shown to improve set-shifting and inhibition in sedentary older persons without cognitive impairment ( $d = 0.36$ ; 95% confidence interval:  $0.16-0.55$ ;  $z = 3.56$ ;  $p < 0.0001$ ). In older persons with cognitive impairment, walking did not show improvements in executive functioning ( $d = 0.14$ ; 95% confidence interval:  $-0.36-0.64$ ;  $z = 0.35$ ;  $p = 0.56$ ). Conclusion:* *This finding is clinically relevant because participation in a walking program may prevent or postpone a (further) decline in executive function in those who are sedentary. (Am J Geriatr Psychiatry 2013; ■:■-■)*

**Key Words:** Walking, executive functions, sedentary elderly, meta-analysis, set-shifting, inhibition

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## INTRODUCTION

During the last decade, the increase in the number of studies that have examined the relationship between physical activity and cognition in normal and pathologic (i.e., age-associated neurodegenerative

diseases) aging is impressive.<sup>1-3</sup> For example, results from a prospective, observational, cohort study showed a positive relationship between the level of cognitive functioning and qualitative aspects of physical activity such as mobility (i.e., the lower the level of mobility, the lower the level of cognitive

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*Walking and Executive Functions in Sedentary Elderly*

functioning).<sup>4</sup> In a cross-sectional study, a similar relationship was observed between the level of cognitive functioning and quantitative aspects of physical activity (e.g., intensity of total daily activity) in older persons.<sup>5</sup> The results of the former study do not imply that only high intensity physical activity is associated with cognitive functioning but that moderate levels of physical activity might be beneficial as well. Results from a prospective study suggest that both vigorous and nonvigorous physical activity (e.g., fast and slow walking, respectively) predicted cognitive functioning in old age.<sup>6</sup> Findings are, however, inconsistent. In a large observational study, self-reported weekly physical activity, such as walking, gardening, and dancing, appeared not to be related to the risk of Alzheimer disease (AD).<sup>7</sup> In addition, in patients with AD, no association has been found between physical activity, measures by self-report, and cognition.<sup>8</sup> On the other hand, physical activity measured by actigraphy did reduce the risk of AD.<sup>9</sup>

The question arises whether the above-mentioned inconsistencies in results also exist in studies examining a possible *causal* relationship between physical activity and cognition. Several meta-analyses report positive exercise effects on cognition in older persons with and without dementia.<sup>10,11</sup> In contrast, a more recent meta-analysis concluded there was insufficient evidence that aerobic exercise improves cognition in patients with neurologic diseases like traumatic brain injury and multiple sclerosis and in older persons with cognitive impairment and dementia.<sup>1,2</sup> However, the most recent meta-analysis indicated that separate randomized controlled studies do show beneficial effects of exercise on different cognitive functions in, for example, patients with traumatic brain injury (e.g., attention) and multiple sclerosis (e.g., reaction time).<sup>1</sup>

The inconsistency in results from meta-analyses may be due to the variety in exercise programs, consisting of aerobic physical activity, combined with training of strength, flexibility, and balance, and the variety of cognitive outcome measures used in different studies. Cognitive functions that responded positively to exercise programs vary from global cognitive functioning, spatial processing, varieties of memory, varieties of attentional processes, and different components of executive control. One way to address the inconsistency in results is to relate only one type of physical activity with only one type of cognitive function.

Therefore, the goal of the present systematic review is to address studies incorporating older persons with and without cognitive impairment that limited the variety in exercise programs to walking and the variety in cognitive outcomes to executive functions.

The rationale underlying this goal is twofold. First, walking is one of the most prevalent types of aerobic leisure-time activity,<sup>12</sup> which increases the feasibility for its application on a daily basis across an extended period of time. Walking has been paraphrased as “near-perfect exercise.” It can be implemented in work and household activities<sup>13</sup> and can take place at any time of the day and at any age.<sup>14</sup> Importantly, regular physical activity decreases the risk for AD<sup>8</sup> or delays its onset,<sup>15</sup> whereas *physical inactivity* increases the risk for AD considerably.<sup>16</sup>

Second, executive functions are considered higher-order cognitive functions because, compared with other cognitive functions, they mature the latest (i.e., in adulthood) and control lower-order cognitive functions<sup>17</sup> (e.g., associative learning<sup>18</sup>). Executive functions consist of various subfunctions such as purposive action, problem solving, attention, planning, set-shifting and multitasking, cognitive flexibility, inhibition, and impulse control.<sup>19</sup> Disturbances in executive functions are reflected in a decline in independent functioning, because one is less able to plan, necessary for a purposive action, and less capable of problem solving, a prerequisite for making decisions.<sup>20</sup> Executive functions show an age-related decline,<sup>21</sup> a decline that accelerates in a preclinical stage of, for example, AD.<sup>22</sup> Furthermore, executive dysfunction appeared to be characteristic for those older persons who converted to AD patients during a period of 4 years.<sup>23</sup> We argue therefore that maintaining (or even improving) the level of executive functions, and thus independent functioning, as long as possible by regular physical activity may postpone the onset of dementia.

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## METHODS

### Literature Search Strategy

PubMed, EMBASE, PsycINFO, Cinahl, and Cochrane were searched by using the search (MeSH) terms “walking,” “gait,” “gait speed,” “locomotion,” “executive functions,” “planning,” “set-shifting,” “problem-solving,” “cognitive flexibility,” “purposive

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