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Review Article

Impact of cognitive fatigue on gait and sway among older adults: A literature review

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ABSTRACT

Cognitive fatigue is an alteration in central nervous system (CNS) processing due to prolonged performance of mentally demanding tasks. Decreased gait speed and increased stride length variability have been noted in cognitively fatigued older adults (≥65 years). Further, cognitive fatigue may weaken the visual, vestibular, and proprioceptive systems of the CNS, contributing to increased postural sway. Detriments in gait and sway caused by cognitive fatigue could increase fall risk. The objective of this literature review was to evaluate the impact of cognitive fatigue on changes in gait and postural sway and its role in fall risk.

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By the year 2030, over 20% of the population will be over the age of 65 (Center for Disease Control and Prevention, 2015). Older adults (i.e. individuals aged 65 years and older) are more prone to falls. In 2013, direct fall-related costs were estimated to exceed $34 billion, and falls incidence rates and associated financial costs continue to rise (Center for Disease Control and Prevention, 2015). Falls among older adults have been known to cause institutionalization, premature mortality, and increased use of healthcare services (Rubenstein, 2006). Approximately two-thirds of unintentional injury deaths within the older adult

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population are attributed to falls, and over 45% of those aged 75 years and older experience a fall each year (Cebolla et al., 2015). The prevalence of falls among the older adult population may be related to diminished neuromuscular functioning, which accompanies natural aging. Examples include reductions in balance, muscle strength, peripheral sensation, vision, and cognition, which have all been associated with increased fall risk among older adults (Martin et al., 2013).

Common cognitive disorders among the older adult population including stroke, Parkinson's disease, and dementia (including mild cognitive impairment) have been reported to increase fall risk (Fischer et al., 2014). More recently, declines in the cognitive abilities of healthy older adults have been associated with increased fall risk (Herman et al., 2010). The most common reason for mildly impaired cognitive function among older adults is cognitive fatigue, a failure to sustain attention for optimal performance (Holtzer et al., 2011). Consequently, cognitive fatigue may cause changes in gait and postural sway among older adults because both tasks require higher order neurological processes (Herman et al., 2010). To the authors knowledge there is no current literature that examines the role of cognitive fatigue in falls and fall risks. Therefore, the objective of this literature review was to examine the current literature to assess the role that cognitive fatigue may have on gait and postural sway. A better understanding of cognitive fatigue's role in gait and postural sway may raise awareness among researchers and healthcare professionals about this important risk factor and guide future efforts to integrate this knowledge into fall prevention protocols and future studies to examine the role of cognitive fatigue in fall risk factors.

1. Methodology

A literature search was conducted from July 1, 2015 to July 5, 2015 using Medline, Science Direct, Pubmed, CINAHL, and Cochrane library databases for articles published between June 2005 and June 2015. The following combination of mesh terms were used "fall risks" or "falls" and "cognitive fatigue" or "central fatigue".

We were unable to find literature that directly linked central or cognitive fatigue to falls, therefore we changed our search strategy to reflect a literature review to indirectly link central or cognitive fatigue to falls and fall risks. To conduct the literature review we used the following mesh terms "fall risk older adult" or "fall risk elderly"; "central fatigue elderly" or "mental fatigue elderly" or "cognitive fatigue elderly"; "fatigue and gait elderly" or "fatigue and gait older adults"; "fatigue and sway elderly" "fatigue and sway older adults".

2. Cognitive fatigue

Fatigue is a temporary loss of strength and energy resulting from hard physical or mental work (Gardiner et al., 2009). The word "fatigue" can refer to peripheral fatigue or central fatigue (Holtzer et al., 2011). Cognitive fatigue, a component of central fatigue (Holtzer et al., 2011), is a psychobiological state caused by prolonged periods of demanding cognitive activities (Marcora et al., 2009). It is characterized by feelings of tiredness and lack of energy (Marcora et al., 2009), and results in failure to maintain attention necessary for optimal performance (Holtzer et al., 2011; Shortz et al., 2015). Acute cognitive fatigue is a common part of everyday activities, such as driving through traffic (Marcora et al., 2009), but can also arise from sustained performance of multiple tasks requiring mental effort, such as fatigue after a work day in the office (van der Linden et al., 2003). Fatigue is usually accompanied by weariness and reduced alertness, which could contribute to decreased productivity and accidents (Liu et al., 2010).

Prolonged performance of a mentally-demanding task causes changes in the activation of the prefrontal cortex (Tanaka et al., 2014), an area of the brain involved with executive function. Tanaka et al. (2014) found that performing a mental fatigue-inducing task causes increased beta-frequency band power, which may be related to decreased brain alertness and arousal levels (Tanaka et al., 2014).

Individuals experiencing cognitive fatigue have reported difficulty when performing tasks that require attention and concentration (Boksem et al., 2006). Decreased efficiency of attentional allocation causes a decline in efficiency when performing a task during or following a mentally-fatigued state (Boksem et al., 2006). Another reason for decreased performance when cognitively fatigued may be impaired action monitoring (i.e. the ability to use environmental information to adjust ongoing behavior) (Boskem et al., 2005). Cognitive fatigue among older adults may lead to changes in gait and postural control, both of which require cognitive processes (Herman et al., 2010).

3. Gait

Normal gait requires stability to provide antigravity support of body weight, mobility to allow smooth motion, and motor control while body weight is transferred from one limb to another (Gamble and Rose, 1994). Gait has been previously used as a reliable clinical tool to predict functional mobility (Podsiadlo and Richardson, 1991) and falls (Shumway-Cook et al., 2000) among older adults. Additionally, gait tests have been commonly used as the motor task component for dual-task assessments (Montero-Odasso et al., 2012). Several versions of gait tasks are available, including 3-m walking (i.e. Time Up-and-Go), walking at a preferred or fast speed (i.e. 2-Minute Walk Test), with or without turns, and with or without obstacles, with the assumption that walking at a fast speed, with turns, and with obstacles, is more challenging (Hall et al., n.d.).

Arm swing and gait symmetry are other characteristics that are correlated with local dynamic stability (Punt et al., 2015). Increased gait variability and decreased symmetry has been consistently observed among older adults (LaRoche et al., 2014) due to the normal aging process (Barak et al., 2006). For individuals older than 70 years of age, changes in gait include average gait speed decreases 12–16% per decade; stride length decreases at a given walking speed; stride frequency increases; and double-support duration increases (Barak et al., 2006). These changes in gait may be due to reduction of energy costs, compensation for muscle weakness, balance impairments, and coping with increased walking variability (Barak et al., 2006).

Another possible explanation for gait declines among older adults may be reduced cognitive functioning (Amboni et al., 2013). Gait and cognition impairments are common among older adults, and they often coincide (van Iersal et al., 2008). Gait is considered an activity requiring attention, memory, and planning (Theill et al., 2011), as well as motivation and judgment (Amboni et al., 2013). Cognition as a contributor to gait abnormalities has been experimentally supported by the dual-task (DT) paradigm (i.e. changes in gait from a single task to a dual task condition) (Amboni et al., 2013).

4. Postural stability and sway

The ability to maintain good balance is critical for most activities of daily living (Hanson et al., 2010). Balance, or postural control, describes an ability to keep the body in an upright position, and when necessary, make adjustments to this position (Hanson et al., 2010). Visual, vestibular, and proprioceptive organs interact to maintain balance by detecting environmental cues and translating these cues to signals that are processed by the central nervous system (Hanson et al., 2010).

Sensorimotor tasks, such as postural control, were previously considered automatic (Smolders et al., 2010); however, postural stability is a complex skill, dependent on coordination of the motor and sensory systems through higher order neurological processes, particularly executive functioning (Muir-Hunter et al., 2014). Executive functioning is required for planning movements, divided attention, and responding to changes within the environment (Muir et al., 2012). Attentional demands needed to minimize sway increase with aging, pathology, and task difficulty (Bisson et al., 2011).