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Original Study

Walking-Induced Fatigue Leads to Increased Falls Risk in Older Adults

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A B S T R A C T

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Background: For older adults, falls are a serious health problem, with more than 30% of people older than 65 suffering a fall at least once a year. One element often overlooked in the assessment of falls is whether a person's balance, walking ability, and overall falls risk is affected by performing activities of daily living such as walking.

Objective: This study assessed the immediate impact of incline walking at a moderate pace on falls risk, leg strength, reaction time, gait, and balance in 75 healthy adults from 30 to 79 years of age. Subjects were subdivided into 5 equal groups based on their age (group 1, 30–39 years; group 2, 40–49 years; group 3, 50–59 years; group 4, 60–69 years; group 5, 70–79 years).

Methods: Each person's falls risk (using the Physiological Profile Assessment), simple reaction time, leg strength, walking ability, and standing balance were assessed before and after a period of incline walking on an automated treadmill. The walking task consisted of three 5-minute trials at a faster than preferred pace. Fatigue during walking was elicited by increasing the treadmill incline in increments of 2° (from level) every minute to a maximum of 8°.

Results: As predicted, significant age-related differences were observed before the walking activity. In general, increasing age was associated with declines in gait speed, lower limb strength, slower reaction times, and increases in overall falls risk. Following the treadmill task, older adults exhibited increased sway (path length 60–69 years; 10.2 ± 0.7 to 12.1 ± 0.7 cm; 70–79 years; 12.8 ± 1.1 to 15.1 ± 0.8 cm), slower reaction times (70–79 years; 256 ± 6 to 287 ± 8 ms), and declines in lower limb strength (60–69 years; 36 ± 2 to 31 ± 1 kg; 70–79 years; 32.3 ± 2 to 27 ± 1 kg). However, a significant increase in overall falls risk (pre; 0.51 ± 0.17 ; post; 1.01 ± 0.18) was only seen in the oldest group (70–79 years). For all other persons (30–69 years), changes resulting from the treadmill-walking task did not lead to a significant increase in falls risk.

Conclusions: As most falls occur when an individual is moving and/or fatigued, assessing functional properties related to balance, gait, strength, and falls risk in older adults both at rest and following activity may provide additional insight.

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For older adults, the likelihood of suffering a fall is a major risk that can have dramatic implications for overall health and well-being.¹ This increased risk is tied, in part, to the general age-related decline in physiological processes integral to the control of balance and gait, with decrements in neuromuscular function, strength, sensation, and cognitive processing all being key factors.^{2–4} The consequence of the declines in these physiological processes is that the older individual is less able to respond to everyday challenges when performing many

activities of daily living. A general feeling of being fatigued or tired has also been linked to an increased likelihood of suffering a fall,^{4–6} as the person who is fatigued may be less able to respond appropriately and/or in a timely fashion to challenges when performing daily activities of a dynamic nature (eg, walking outside, climbing stairs).

Fatigue has been broadly described as a transient decrease in the ability to perform physical activities⁷ and an overwhelming sustained sense of exhaustion and decreased capacity for physical and mental work. Most commonly, this decrement in movement performance over the time period of the activity can be linked to an inability to maintain a desired force level required for the given task,⁸ with the overall rate of decline dependent on the type of activity, intensity, and duration.⁹ With regard to those mechanisms that contribute to optimal balance, fatigue has a wide range of impacts, leading to increases in postural sway^{10–14}; declines in obstacle avoidance,¹⁵ stepping,¹⁶ or general walking ability^{17–19}; decreased muscle function and strength^{20–22}; and reduced proprioception and/or sensation.^{23–25} The consequences of fatigue are particularly pronounced for older adults, with these persons often citing increased levels of fatigue and tiredness as one reason for reducing their levels of physical activity.

There is no doubt that there is a strong association between fatigue and a number of factors that underscore falls risk in older adults. However, falls are a multidimensional problem, with more than 400 risk factors being linked with these events.²⁶ Our understanding of falls is further complicated by the fact that they can be considered a very individual event; that is, no 2 people fall for the same reason, under the same conditions, and suffer the same consequences. As a result, it is possible that, although fatigue may affect individual physiological components essential for optimal balance control, it is still unclear whether the summative effect on fatigue leads to an actual increase in overall risk. A secondary component often overlooked in the assessment of falls risk is *how* those selected metrics of balance and falls risk change as fatigue is induced during the performance of activities of daily living like walking. Although most falls occur during movement, most fall risk assessments are performed under resting conditions that fail to take this dynamic into account.

The aim of the current study was to assess the immediate impact of fatigue on overall falls risk, walking ability, balance, reaction time, and lower limb strength in 75 adults ranging from 30 to 79 years of age. It was predicted that the effects of fatigue (induced by performing a walking task) would manifest as an increased falls risk only in the older individuals.

Methods

Participants

Seventy-five healthy individuals of both sexes (age range 30–79 years) were recruited from the local community to participate in this study. Individuals were subdivided into 5 equal groups based on their age by decades: group 1, 30 to 39 years; group 2, 40 to 49 years; group 3, 50 to 59 years; group 4, 60 to 69 years; and

group 5, 70 to 79 years. All individuals were questioned regarding their current level of exercise/activity and the number of falls over the previous 12 months. All participants reported to be physically active. Exclusion criteria included any history of any neurological/cognitive disorders, neuromuscular injury, significant cardiovascular disease, unstable proliferative retinopathy, end-stage renal disease, uncontrolled hypertension, or lower limb arthritis that could influence movement performance.²⁷ A full physical evaluation, which included examination of central nervous system function, including coordination, neuropathy, and cerebella function, tests of balance and stability, and review of current medications was also performed.²⁸ General demographics for each age group and the number of previous falls (per age group) are shown in Table 1. Participants provided informed consent before inclusion and all procedures complied with university institutional review board guidelines.

Experimental Design

Participants attended the laboratory on one occasion to be evaluated on the tests underlying the falls risk assessment (physiological profile assessment [PPA]), reaction time, gait, and balance. This evaluation was followed by the walking-exercise fatigue protocol. Immediately afterward, all participants were reassessed on all measures.

Falls risk assessment

An indication of overall falls risk was determined using the long-form PPA. The PPA consists of 15 different physiological assessments, covering visual function, lower limb sensation, proprioception, lower-limb strength, reactions, general balance, and an assessment of postural coordinated stability. Values from 5 of the 15 measures (ie, hand reaction time, proprioception, knee extension strength, edge contrast sensitivity, sway on foam surface with eyes open) were used to generate an overall falls risk score (range +4 to –2) with lower values denoting a lower risk of falling.^{27,29}

Reaction time

All participants completed a simple reaction time (RT) task where upper limb (index finger) and lower limb (foot) responses were collected. After completing 5 practice trials, each person completed 20 trials with each segment (the initial 10 trials were used within the PPA design for derivation of falls risk). Participants responded to a visual cue by depressing a timing switch with either their foot or finger. For the foot RT, participants had their distal end of their foot positioned over a pedal switch placed on the floor.

Gait assessments

Walking performance was assessed using a 20-foot straight GAITrite pressure sensitive walking surface (CIR Systems Inc, Havertown, PA). Individuals were instructed to look straight ahead and walk at their preferred walking pace. Three walking trials were performed (sample frequency 120 Hz). The GAITrite data were assessed using the Protokinetics PKMAS software (ProtoKinetics LLC,

Table 1
Resting Subject Characteristics

	Age Group, y				
	30–39	40–49	50–59	60–69	70–79
n, male/female	8/7	7/8	7/8	7/8	7/8
Age, y	34.7 ± 0.4	45.1 ± 0.4	54.3 ± 0.4	64.2 ± 0.4	74.5 ± 0.3
Height, cm	170.0 ± 3.1	169.3 ± 3.1	171.5 ± 2.3	168.9 ± 2.9	162.6 ± 7.3
Weight, kg	92.2 ± 0.2	92.8 ± 0.2	97.5 ± 0.3	84.5 ± 0.2	86.4 ± 0.3
No. of persons who fell in the past year	1/15	2/15	2/15	6/15	4/15

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