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EFFECT OF FATIGUE ON BALANCE AND DUAL TASK PERFORMANCE IN ELDERLY

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ABSTRACT

Objective: Effect of fatigue on balance and dual task performance in elderly
Background: Fatigue has been defined as time related phenomenon of decline in the maximal force generating capacity in medical literature usually defined Fatigue in the sense of experienced fatigue as an overwhelming sense of tiredness, lack of energy and feeling of exhaustion. Fatigue as a concept determined by two dimensions psychological and physiological.
Study design: Experimental study.
Methods: A total of 31 subjects with 24 male and 7 female participated in the study based on inclusion exclusion criteria. Subjects were recruited from general community dwelling people.
Results: There is significant difference in pre and post fatigue B.B.S score. $p<.005$ there is significant reduction in post fatigue value also in case of calculation error $p<.005$ that is significant increment in post fatigue calculation error. In case of gait sped $p<.005$ means there is significant increment in post fatigue gait speed.
Conclusion: In the present study we investigated that fatigue impaired the balance in elderly. Also have effect on cognition. We found that gait speed is increased in elderly during dual task performance and make them more susceptible to fall. So, fatigue is one of the causes of risk falls in elderly. Also fatigue places higher demand of attention during performance of task.

Keywords: Fatigue, BBS score, dual task, balance, gait, elderly.

INTRODUCTION

Fatigue has been defined as time related phenomenon of decline in the maximal force generating capacity in medical literature usually defined Fatigue in the sense of experienced fatigue as an overwhelming sense of tiredness, lack of energy and feeling of exhaustion. Fatigue as a concept determined by two dimension psychological and physiological (i.e. bodily phenomenon contributing to the perception of fatigue) thus psychological factor well being, concentration problem attention social function, in physiology fatigue is usually defined as the loss of voluntary force producing capacity during exercise the loss of force producing capacity can both (and simultaneously) have a peripheral and central origin The loss of force producing capacity can have a peripheral and central origin this decline in force or force generating capacity may originate from various levels of neuronal axis from motor cortex and spinal cord, to NMJ, muscle membrane and metabolism. Peripheral fatigue-fatigue at the peripheral level ie in the muscle tissue. Declining force during contraction is attributing to changing intracellular ion level .accumulation of lactate and extracellular k+together with lowering of the Ph ,affect membrane excitability. Central fatigue_the decrease of voluntary activation of muscle by the nervous system. A muscle receiving suboptimal input from the CNS will not be able to develop its maximal force capacity. In case of submaximal central activation, Central activation failure is said to be present .an increase in of CAF during exercise is called central fatigue[1].

Part of central fatigue is “supraspinal fatigue” because motor cortical output becomes less than

optimal eventually this is task failure. when exercise can no longer be continued this point is often termed exhaustion. At spinal level relevant factor include the intrinsic behavior of the motorneuron. Recurrent inhibition reflex input reaching α and γ motor neuron and spinal circuity. The contribution of these various factor will varying during the course of fatiguing exercise[2]. Overall physical activity may affect the way is experienced. Mammalian skeletal motor units have differing properties including their different susceptibility to fatigue. Two feedback pathways are of concern here: one via the related muscle unit and muscle spindle afferents (proprioceptive path), and one via recurrent motor axon collaterals and Renshaw cells (recurrent inhibitory path). Contribute to shape the firing patterns of motor units so as to minimize their loss of force during fatiguing contraction[3]. The discharge rate of most motor units declined despite an increase in the excitatory drive to the motoneuron pool during the fatigue task[4].

Postural control involves controlling the body position in space for the dual purpose of stability and orientation. Postural stability or balance is the ability to maintain the body inequilibrium. A body is in equilibrium either when it is at rest (static equilibrium) or when it is in steady state motion (dynamic equilibrium).orientation is defined as the ability to maintain appropriate relationship between the body and environment for the task. Postural control requires complex interaction of the musculoskeletal and neural system. Musculoskeletal system includes R.O.M. , spinal flexibility muscle properties and biomechanical relationship. Neural component essential to postural control encompasses: a)motor process including neuromuscular response synergy b)sensory process including (visual, vestibular, somatosensory system) and higher level integrative process essential for mapping sensation to action and ensuring anticipatory and adaptive aspect of postural control. higher level neural process can be reformed as cognitive influences on postural control. There are many aspect of cognition such as attention, motivation. During ageing changes in these systems contribute to increased likelihood of fall. In elderly strength or amount of force production of muscle decline with age.

Decreased R.O.M and loss of spinal flexibility in many older adults can lead to stooped posture Several studies found that many older adults generally uses strategy involving hip movement rather than ankle; older uses different response synergy than young adults. With ageing decline in fine touch pressure and vibration sensation, there is typically loss of visual field, decline in visual acuity visual contrast sensitivity. In process of ageing there is also loss of 40 percent of the vestibular hairs and nerve cells by 70 year of age these changes in the system lead to risk of fall in elderly. Statics in the injury and accident in the older adults indicate that fall is the seventh leading cause of death in people over 75 year of age. In addition fall rates in persons 65 year of age and older are at least 33percent per year in community dwelling older adults with women being more prone to fall than male[5]. During sustained maximal contraction the discharge of motor neuron declines, commonly to below the level required to produced maximal force from the muscle whose contraction speed is usually slowed, thus some central fatigue develops. Motor cortex is one site at which suboptimal output generate during human muscle fatigue[6].

Martine simoneu et al found that fatigue induced by fast walking had an initial negative impact on the control of balance in young healthy adults. However greater proportion of cognitive resources be allocated to the active control of balance task[7]. Maintenance of posture is reliant on input from the visual, vestibular and somatosensory system. Sensory motor system receives input from articular cutaneous, musculotendinous receptor including muscle spindle, GTO that sends afferent signal regarding change in length and tension. Muscle fatigue may impair the proprioceptive and kinesthetics properties of joint by increasing threshold of muscle spindle discharge disrupting afferent feedback and subsequently conscious joint awareness. Therefore altered somato sensory input due to fatigue could result deficit in neuromuscular control as represented through deficit in postural control[8].

Sharpe M Hetal found proprioceptive signal from receptor in and around muscle changes during muscle fatigue[9].The acuity of position sense at the ankle is reduced subsequent to a fatigue protocol[10]. Fatigue placed higher demand on the postural control system by increasing the frequency of action needed to regulate the upright stance[11].Muscle spindle discharge does decline during such sustain contraction, and suggest that fusimotor mediated spindle support to alpha motor neuron decline as muscle fatigue[12].

Gait changes following physical fatigue in older person suggest fatigue may be risk factor for fall in elderly[13].According to above such studies it is clear that fatigue affect the balance. With aging, attentional demand for postural control increases as sensory information decreases; in addition the inability to allocate sufficient attention to postural control under multiple condition may be a contributing factor to imbalance and fall in older adults[14].Age related changes in sensory and motor function appear to increase the requirement of cognition regulation of sensorimotor process.[15] For the elderly person, postural control regulating a reweighting of sensory inputs could lead to increased risk for loss of balance and fall if insufficient attentional resources are allocated with postural task.[16] So it is evident that aging needs more attentional demand for postural control and any loss of allocation of more attention leads to risk of fall in elderly. It is clear that fatigue affects the postural control in healthy adults due to decrease in sensory information. And also with aging attentional demand for postural control increases. During many activities of daily living people need to perform more than one activity at a time.

Dual task performance is index of attentional demand. Here attention can be defined as information processing capacity of an individual. An assumption regarding this information processing capacity is that it is limited for any individual and that performing any task requires a given portion of capacity. Thus, if two task are performed together and they require more than the total capacity, the performance on either or both deteriorates[17]. Dual task performance is highly advantageous during walking because it allows for communication between people. Transportation of object from one location to another and monitoring of environment so that threat to balance can be avoided. Dual task performance is also known as “concurrent performance “and involve the execution of a primary task, which is a major force of attention, and secondary task performed at the same time[18]. Priest Aw etal found that gait speed decreased and stride variability increased were greater in the older subject than younger subject during dual task walking. This indicate that cognitively demanding task (counting backward) during walking have a destabilizing effect on gait that may place the older person at greater risk of fall. Thus older person needs more attention demand than younger in dual task paradigm[19].

Methods

Participants

A total of 31 subjects with 24 male and 7 female participated in the study based on inclusion exclusion criteria. Subjects were recruited from general community dwelling people.

Inclusion Criteria

1. Age : 60-80 yrs
2. Both genders.
3. Ability to walk 10 meter independently.
4. Able to do simple calculation

Exclusion Criteria

1. History of cardiopulmonary disease.
2. History of neurological impairment.
3. M.M.S.E below 23.
4. Musculoskeletal surgery of lower limb during last 2 year
5. Terminally ill.
6. History of postural hypotension.
7. Fracture of lower limb during last two year
8. History of osteoarthritis of knee.

Instrumentation

1. Berg Balance Scale
2. Chair with armrest and without armrest.
3. Foot step.
4. Stop watch.
5. Measuring tape.

Procedure

Before starting the process consent form was taken from the each subject. After that they were instructed about the whole procedure. The experiment was divided in three stages.

1) Pre fatigue stage 2) Fatigue protocol 3) Post fatigue stage

Pre fatigue stage: - in this stage balance of subject was examined by Berg balance scale (B.B.S) during whole procedure they were properly instructed regarding each component of B.B.S. And also demonstration of item was done as per required for the explanation. Examiner was remained close with the subject to avoid fall during the test

Dual task performance: In dual task there were two components counting backward in 3 digit gap was taken as the cognitive component and simultaneously 10 meter walking at self-selected speed by the subject was taken as the motor component. Digit selected for counting backward in 3 digit gap was present in between 20 and 100 and randomly selected by the subject. Subjects were instructed to count loudly so, that counting was audible to the examiner. While performance subjects were instructed to concentrate on both the gait and calculation simultaneously. They were closely followed by the examiner during the performance for the prevention of fall and making notice gait speed and error done in calculation. During the performance no any feedback was given to the subject regarding the performance.

Fatigue protocol: Sit-up exercise was taken as a protocol for the production of fatigue .They were instructed to sit on without armrest chair, cross their arm and repeatedly rise to an erect position and sit down against at fast speed in whole procedure they were verbally encouraged by the examiner to continue until they get exhausted to do any more repetition.

Post fatigue state: Immediately after fatigue protocol dual task performance and balance by the BBS was checked to prevent any recovery from the fatigue.

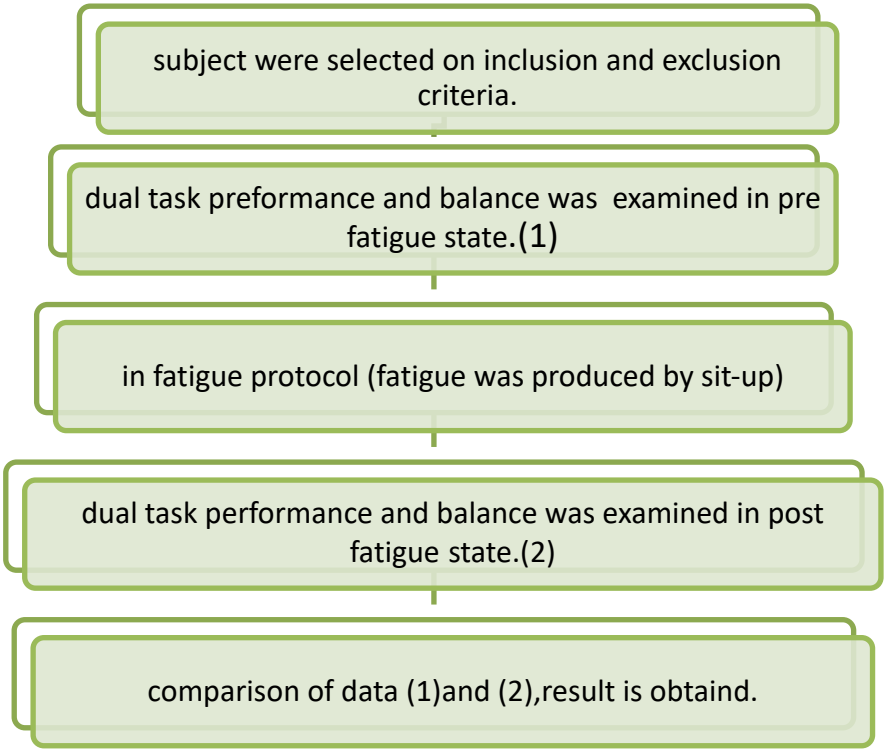

Figure 3: Flow chart of the procedure

Study Protocol

A total of 31 subjects with 24 male and 7 female participated in the study based on inclusion exclusion criteria. Subjects were recruited from general community dwelling people.

Results

The data was analyzed for 31 subjects (24 male and 7 female) with mean age 65.22±4.08. Results were analyzed for variables such as B.B.S, Gait speed and Calculation error in pre and post fatigue conditions. Result obtained in a group between different variable.

n	AGE(mean± SD)	SEX	MMSE(mean± SD)
31	65.22±4.08	24male,7female	28.28±1.54

Table No 5.1: Descriptive data (mean and SD) for pre fatigue and post fatigue BBS for 31 subject.

variable	Mean	SD
Pre fatigue B.B.S	51.38	2.12
Post fatigue B.B.S	47.48	2.66

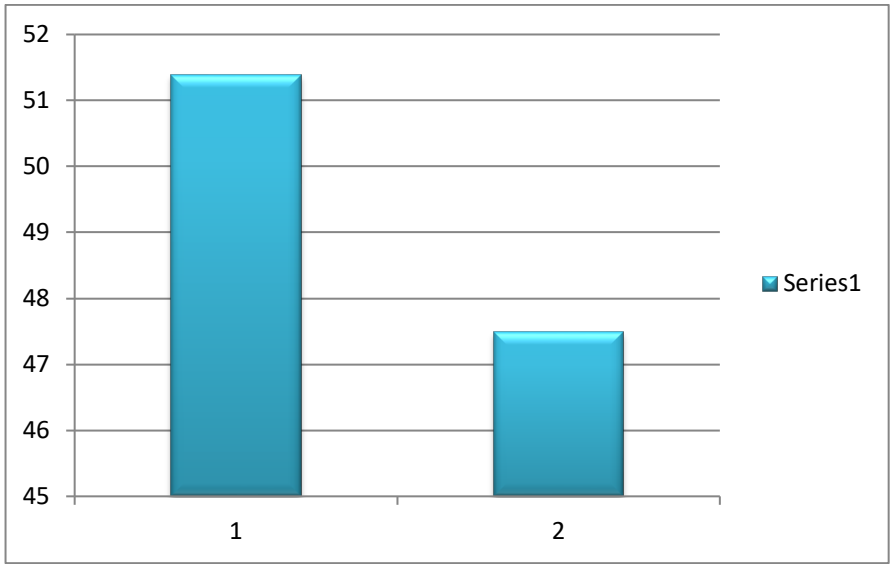

Figure 5.1: Showing comparison between pre and post fatigue B.B.S

Series 1: Pre fatigue B.B.S
Series 2: Post fatigue B.B.S
By the comparison between pre and post fatigue B.B.S, it can be analyzed that there is significant reduction in B.B.S after the fatigue protocol.

Table No 5.2: For descriptive data (mean and SD) for pre and post fatigue calculation error.

variable	Mean	SD
Pre fatigue error	1.93	1.03
Post fatigue error	2.70	1.10

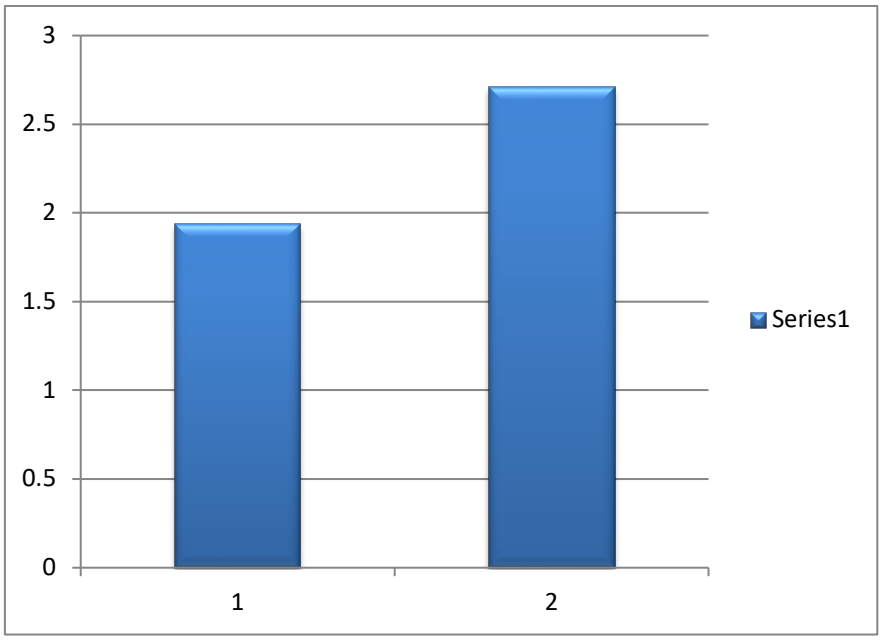

Figure 5.2: Showing comparison between pre fatigue calculation error and post fatigue calculation error.

Series1: Pre fatigue calculation error.
Series2: post fatigue calculation error.
By the comparison between pre fatigue and post fatigue calculation error it can be analyzed that there is significant increase in post fatigue (2.7) from pre fatigue (1.93) value.

Table No: 5.3 for descriptive data (mean and SD) pre fatigue gait speed and post fatigue gait speed in (m/s).

Variable	Mean(m/s)	SD
Pre fatigue gait speed	.387	.143
Post fatigue gait speed	.423	.127

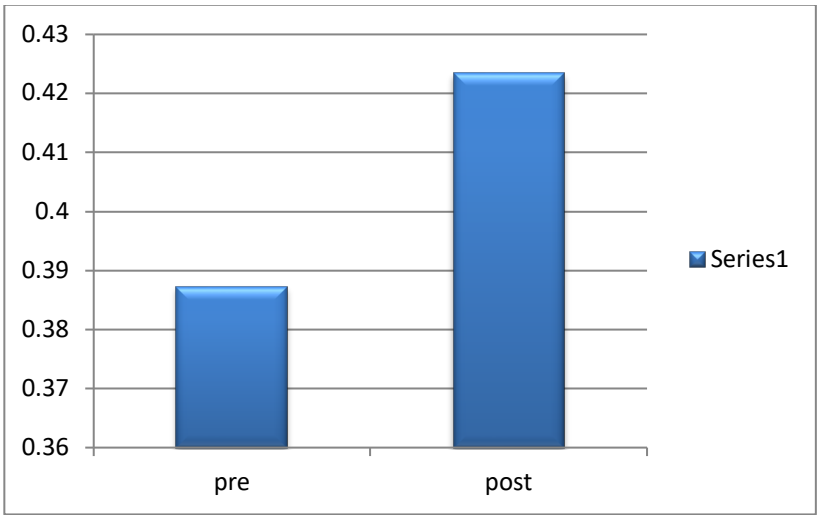

Figure No 5.3: Showing comparison between pre fatigue gait speed and post fatigue gait speed in m/s.

Series1: Pre fatigue gait speed.
Series2: Post fatigue gait speed.
By the comparison between pre fatigue gait speed and post fatigue gait speed it can be analyzed that there is significant increase in gait speed from pre fatigue value (.387)m/s to post fatigue value (.423) m/s.

Table no 5.4:

Pre and post fatigue variable	n	correlation	t-value	Sig(2 tailed)
B.B.S	31	.807	13.771	.001
Calculation error	31	.688	-5.10	.001
Gait speed	31	.910	-3.384	.002

There is significant difference in pre and post fatigue B.B.S score. p<.005 there is significant reduction in post fatigue value also in case of calculation error p<.005 that is significant increment in post fatigue calculation error. In case of gait sped p<.005 means there is significant increment in post fatigue gait speed.

Discussion

The purpose of the present study was to find the effect of fatigue on balance and dual task performance in normal elderly. We hypothesized that fatigue may alter the balance. we also expected that fatigue may have effect on cognition.

It is found that there was significant reduction in B.B.S score in post fatigue condition compared with no fatigue condition. That is balance was decreased in normal elderly after fatigue. This decline in balance agrees with the simonue etal who found that fatigue induced by fast walking have initial negative impact on the balance control but later participant compensate the negative impact of fatigue on balance control by the allocation of greater number of cognitive resources[7]. With fatigue muscle spindle tends to decrease their firing rate and the discharge of motorneuron (from cortex one possible site) declines below the level required to produce the maximum force[6]. Furthermore, fatigue induces greater variability in afferent signal[2].

Neurophysiological changes produced during fatigue may be certain other causes. It produces change in proprioceptive signal from receptor in and around muscle during muscle fatigue[9]. Muscle fatigue may impair the proprioceptive and kinesthetic properties of joint by increasing the threshold of muscle spindle discharge, disrupting afferent feedback, and subsequently altering joint awareness. Therefore altered somatosensory input due to fatigue could result in deficit in neuromuscular control as represented through deficit in postural control (Philip A.Griblle etal) ,(Fornand Riberio etal)[8,37].

Also finding of Philip corbill suggest that localized muscular fatigue of the ankle planter flexor seems to affect more the motor output of postural control system than the sensory system. That is fatigue tend to decrease the rate of force development generated by fatigued skeletal muscle. And also, sensory system affected mainly at the peripheral level through change in the spindle threshold of the fatigued muscle but other receptor could compensate for this increased threshold[11].

Compared with no fatigue conditions, fatigue places higher demand on the postural control system. The factors that could potentially cause a decrease in balance performance after fatigue focus on both central and local means of fatigue. Central or whole-body fatigue refers to decrease in the central nervous system output to the muscles and likely has a component that includes factors responsible for the sense of effort in addition to the alterations in motor pathways. Localized muscle fatigue is induced by a decrease in the metabolic substrates available for muscle contraction, such as adenosine triphosphate, creatine phosphate, and glycogen, as well as an increase in metabolites, including lactic acid, in the muscle, resulting in an inability to maintain a desired muscular force output, this accumulation of metabolites and/or inflammatory substances within the muscle

during activity to fatigue (i.e. lactic acid or bradykinin), have been shown to elicit increased muscle spindle static and/or dynamic sensitivity via reflex-mediated pathways from chemo sensitive group III and IV afferents onto Ɣ-motoneurones what would affect one`s ability to maintain equilibrium due to an incomplete afferent information[38].

In the second part of study we examined the effect of fatigue on cognitive task through dual task performance. It was found that after fatigue they required more cognitive resources for the dual task performance. After the fatigue protocol they showed more errors in the subtraction and also gait speed was increased. Older adults may walk faster in order to overcome the feeling of fatigue-induced physical discomfort as quickly as possible Further, a practice and/or learning effect may have occurred from pre to post testing Physiologic rationale may comprise motor unit remodeling in old age resulting in larger proportions of type I fibers and thus higher fatigue-resistance and/or increased muscle spindle sensitivity following fatigue leading to improved forward propulsion of the body[34]. In another study Nicolas Vuillermer found that after fatigue protocol attentional demand for postural control is increased because reaction time (secondary task) is increased after fatigue and that was based on the assumption that the performance of secondary task is inversely proportional to the attentional demand of the primary task[39].

Further this result can be supported with the assumption regarding attention (information processing capacity) that, it is limited for any individual and that performing any task requires a given portion of capacity. Thus, if two tasks are performed together and they require more than the total capacity, the performance on either or both deteriorates. Jaap Swaenberg etal showed that combined articulation and attention demanding secondary task stressed the attentional system of elderly most that is counting backward loudly need more attention than silently counting[22].

Alteration in the performance of gait speed and error done in calculation both can be favored by the study of Monicque M Lorist etal they found that there is mutual interaction during motor fatigue between motor task and cognitive task. The interaction resulted in a decline in the performance of the motor task as well as the cognitive task. Not only the CRT , but also the performance of the submaximal maintained contraction was negatively affected during the dual task condition. This decline indicated that the dual task condition imposed a 100% workload on the subject's limited attention resources. No residual resources or effort seemed available to compensate for the increasing task demands in the dual task situation compared to single task performance. The increase in incorrect response with time -on –task indicated that subjects used a more risky strategy at the end of the fatiguing dual task condition[20]. That is in the present study might be one of the cause was they used guesses for the calculation that resulted in more error.

Limitations

1) A small sample was recruited in the study.
2) Although fatigue is a subjective feeling but not measured on any scale.
3) Dual task performance was examined for very short distance only 10 meter

Conclusion

In the present study we investigated that fatigue impaired the balance in elderly. Also have effect on cognition. We found that gait speed is increased in elderly during dual task performance and make them more susceptible to fall. So, fatigue is one of the causes of risk falls in elderly. Also fatigue places higher demand of attention during performance of task.

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