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Senescence – a determinant or contributory cause of increasing the risk of falling? (Note I)
Senescenţa - factor determinant sau cauză favorizantă pentru creşterea riscului de cădere? (Nota I)

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Abstract

Aproximately one third of elderly persons over the age of 65 who live in the community fall each year; 3-5% of falls result in a fracture and 5 to 10% of them result in other serious injuries requiring medical care. Intrinsic risk factors for fall include: advanced age, female sex, impaired balance, gait abnormalities, reduced muscular strength, cognitive deficiencies, impaired visual acuity and use of sedative-hypnotic medications.

For a standardized locomotor assessment, the following are used: self-selected gait velocity, the chair rise test, tandem standing and tandem walking, the timed up and go test, clinical gait analysis with special focus on regularity. Gait analysis is an indicator of mobility, balance and fall risk in balance-impaired older adults. The relationship between two tests of stepping ability was determined: the maximal step length (MSL) and the rapid step test (RST); MSL score was associated with the risk of being a frequent faller. The following factors are crucial for recurrent falls among the elderly: abnormal posture balance, 2 or more falls recorded the previous year, a drop in the score of hand grip strength, the presence of a depressive state.

Keywords: senescence, fall risk, gait abnormalities.

Rezumat

La 1/3 dintre vârstnicii de peste 65 ani ce trăiesc în comunitate sunt raportate căderi, din care 3-5% se soldează cu fracturi, 5-10% determină leziuni serioase ce solicită echipa medicală. Factorii de risc intrinseci pentru căderi au inclus: vârsta avansată, genul feminin, tulburările de echilibru (balans), tulburările de mers, scăderea forţei musculare, deficitul cognitiv, scăderea acuităţii vizuale şi folosirea de medicamente sedative sau hipnotice.

Pentru evaluarea locomotorie standard se utilizează: viteza de mers autoselectată; testul ridicării de pe scaun; dublul sprijin în ortostatism şi mers; testul „ridică-te şi mergi"; analiza clinică a mersului, ţintită pe simetria mersului. Testarea mersului este un indicator al mobilităţii, balansului şi riscului de cădere în disfuncţia echilibrului la vârstnici. S-a determinat relaţia între 2 teste de abilitate a mersului: MSL (lungimea maximă a pasului) şi RST (testul mersului rapid); scorul MSL se asociază cu riscul de căderi frecvente.

Factorii determinanţi pentru căderile recurente la vârstnici sunt: balansul postural anormal, 2 sau mai multe căderi în anul precedent, scăderea scorului pentru forţa de prindere a mâinii, prezenţa unei stări depresive.

Cuvinte cheie: senescenţa, risc de cădere, tulburări de mers.

Introduction

Aging is a process that turns a vigorous adult into a frail individual, with limited resources in most bodily tracts and systems; at the same time, there is an exponential increase of susceptibility to most diseases. The influence of aging on the general state of health and on the quality of life goes beyond the effects of any known illness, age itself being the main risk factor for contracting most of the existing serious diseases. During the aging process, physiological functions undergo many deteriorative changes. Senescence analyzes these deteriorative changes incurred over time, during the post-maturity stage, that lead to an increased vulnerability and a lower survival capacity (Prada, 2001).

Senescence and the risk of falling

Some studies show that about one third of the elderly people above the age of 65 living in the community fall every year and 3-5% of these falls lead to fractures, while 5-10% lead to serious injuries that require the intervention of a medical team. Even without serious bodily injuries, the falls can have important psychological consequences that will accelerate the functioning capacity decay (Dargent-Molina & Breart, 1995).

In reality, the frequency of falling is actually higher than the one officially reported because old people sometimes hide these events, out of pride or fear. Some random epidemiological investigations conducted among elderly people over the age of 65 show that between 30 and 50%

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of the community and institutionalized elderly population fall at least once a year. 20% of these incidents require the intervention of a medical team and 10% lead to fractures. Other surveys show that 20% of the falls recorded among the elderly population cause serious trauma (62% fractures, 25% sprains, 8% deep soft tissue wounds). An epidemiological survey conducted on institutionalized old persons shows that these subjects fall three times more frequently than the elderly people living at home. These investigations also reveal a high recurrence rate, about 50% of the elderly population falling repeatedly. The psychological consequences of falling are also mentioned, as they compromise the independence of the elderly person in question (Avorn, 1998).

These surveys report various levels of falling frequency and prevalence among different elderly groups:

- 33% of the healthy elderly population living in the community fall each year.

- 67% per year is the falling frequency among home-assisted elderly people, although they have limited activities and they are protected against inherent risk factors.

There are no surveys conducted on the falling frequency among hospitalized elderly people. However, it is known that this rate is higher than the one recorded among elderly living in the community, a fact that might be explained by the increased frailty of hospitalized patients.

Falling is the main cause of death among the population over the age of 65 and the 7th cause of death among the elderly, in general. In the USA, 75% of the deaths caused by falling are recorded among the over 65s, although the over 65s account for merely 2% of the entire population of the country. The rate of deaths caused by falling increases exponentially after the age of 75, in both genders. Before the age of 75, these deaths are more frequently encountered among women. After 75 years, the frequency is the same in both genders, while the highest rate of deaths caused by falling is recorded after the age of 85. (Cartier, 2001).

The frequency of falling increases with age: 35% of those aged between 65-79, 45% of those aged between 80-89 and 55% of those aged 90 and over fall at least once each year.

The information recorded by European Institutions (The European Home and Leisure Accident Surveillance System – EHLASS) leads to similar conclusions on this matter. The age-fall relation is not linear (Campbell, 1997); this relationship can only be seen in cases of recurrent falls, without being visible in the case of singular falls. These singular falls tend to affect women more frequently than they affect the men of the same generation. However, when it comes to recurrent falls, the frequency is approximately the same among both genders (Gostynski, 1999).

Some epidemiological surveys have identified the main risk factors increasing the number of falls. They comprise: old age, female gender, balance disorders, walking disorders, decrease in muscle strength, mental impairment, loss of visual sharpness and the use of sedatives and hypnotic medications.

Some recent epidemiological surveys compare the falls leading to serious bodily injuries to those with no such consequences, suggesting that an appropriate bone structure, an appropriate speed and good protective reflexes have a great impact on the risk of trauma after a fall (Dargent-Molina & Breart, 1995).

Non-syncopal falls, occurring during normal daily activities conducted by the elderly people, can have serious consequences, such as: hip fractures, shoulder fractures, hand fractures or pelvis fractures. The fear of falling and the self-imposed limitation of physical activities can lead to psychological disorders. A pathological link is born between age-related walking disorders and balance disorders leading to falls and bearing consequences, through the occurrence of fractures, on the neuro-myo-arthro-kinetic system (NMAK). The significant increase in the risk of falling, due to walking and balance disorders, can be considered as a distinct chronic pathological illness (defined as "age-related walking disorder").

The risk of fracture requires the assessment of falling risk, the assessment of the falling mechanism and that of bone resistance. Elderly people with walking and balance impairment usually fall on the diagonal, while the impact of each fall on the general balance generates enough force to fracture the non-osteoporotic thigh bone of the subject. Osteoporosis can decrease bone resistance even more, thus becoming the main risk factor for fractures and going beyond the normal age-driven changes.

Some prospective surveys have independently tracked the risk factors for non-syncopal falls among the elderly: the muscle strength of the legs; lateral postural stability; the clinical assessment of gait; visual impairment; four or more various psychotropic medications; cognitive impairment; falling history. The neuromuscular status can be appropriately assessed after a fall by 3 diagnostic procedures: 1) the chair-rise test assesses muscle strength, being relevant both for the falling risk and for the mobility and the functional independence impairment; 2) the measurement of lateral postural stability can be added to this procedure; 3) the clinical assessment of gait should be focused on the regular aspect of walking, as a clinical process. For an individual, the level of falling risk depends, to a great extent, on the number of independent risk factors that have accumulated (prevention and therapy should be focused on each of these individual risk factors) (Runge, 2002).

The neuromuscular parameters of locomotion and the risk of falling among elderly people

The neuromuscular parameters defining locomotion are necessary for discovering and treating frailty, fracture risks and osteoporosis. A standard locomotion assessment conducted scientifically is an essential part of medical examination, both in clinical practice and in research. This should comprise parameters predicting both a future fracture and an imminent destabilisation. The following tests have been put forward for a standard locomotion assessment. 1) The self-selected speed of walking, seen as the best way to assess the general locomotor status and as a good indicator of age-triggered adverse reactions. 2) The chair-rise test measures the vertical movement strength and the hip muscle strength as the most important neuromuscular factor for falling and for fractures caused by falling. Tandem standing and walking measure the posture balance capacity. 3) The timed "up and go" test is a global screening procedure. 4) The clinical gait analysis, focusing on the symmetry of gait. Mechanical means are used, at research level, to record the ground

reaction forces during walking, the linear movement speed on the pressure point, the strength used during the free physiological movements. In the mechanical means used for this purpose, the eccentric and the concentric stages of movement can differ and energy accumulation within the elastic tissues can be analyzed; the kinetics of human movement can be explained mechanically, through a two feet jump: the ground reaction forces resulting from a jump under the height of 0.46 m prove that this performance is representative for coordination (Runge & Hunter, 2006).

Gait analysis is a mobility and balance indicator, as well as an indicator for the falling risk among the balance-impaired elderly population. A connection has been established between two tests of stepping ability: MSL (maximal step length) and RST (the rapid step test) and the standard balance, mobility, walking and impairment tests among the group of elderly people with a high falling risk.

A number of 167 old people with medium level balance impairment (and an average age of 78 years) were examined. The following were measured: MSL (maximal step length) and the return to the initial position as well as the walking pace (RST - the minimum time needed for the steps to be taken and for a turn towards a different direction as fast as possible), tandem walk (TW), timed unipedal stance (US), timed up and go (TUG), performance oriented mobility assessment (POMA), the 6 minutes walking test (SMW), measuring the step length (the peak knee and ankle torque and power at slow and fast speeds); self-reported measurements compared to those of frequent fallers (who suffer more than two falls per year); the Established Population for Epidemiologic Studies of the Elderly (EPESE) physical function and confidence to avoid falls - Activity specific Balance Confidence (ABC Scale). MSL is an indicator predicting the number of self-reported falls and the measurement performance; it is correlated with EPESE (physical function impairment), with ABC, TUG, with the POMA score, the SMW test. The peak of the maximum knee and ankle torque and the force should be correlated with TS, TW, US. The MSL score is associated with the risk of frequent falling (6 MSL directions were highly correlated - up to 0.96 - with the risk of falling) (Cho et al., 2004).

A study was performed on the indicators of occasional or recurrent falls among the elderly: it included 622 people aged over 65 years, 107 of which (17.2%) reported occasional falls (at least once). Other 36 (5.5%) reported 2 or more falls (recurring) during the last 6 months. The predictors for all falls were: age, female gender, lack of family, poor health state, memory impairment, depression, sleeping disorders, incontinence, vertigo, 3 or more diseases found, physical impairment and low mobility (Gassmann et al., 2009).

The disturbance time and the walking speed influence the falling direction and the impact location: the falling direction and the impact of the fall on the pelvis were studied in four different cases – fainting, slipping, walking downhill and marching, for three different speeds (fast, normal, slow). The falling direction and the falling impact on the pelvis were measured. In the case of falling and slipping at slow speed, the impact on the hip was detected. Marching or walking downhill at slow speed led to forward falls, with an exaggerated frontal impact; usual slips and fainting at high speed led to forward falls, with a frontal impact. Usual slips at slow speed led to diagonal or back falls, with an impact on the hip's joint area. Fainting and slipping at slow speed resulted in hip impacts, increasing the risk of hip fracture; 56% of the impact velocity followed a standard deviation seen as an average velocity needed for hip fractures to occur in elderly people (Smeesters et al., 2001).

The falls were simulated using the ATB (articulated total body) and creating a model for passive falls; the predictions regarding the fall direction, the velocity impact, the functional impact in various perturbing circumstances (fainting, slipping, walking downhill, marching) were compared for various walking speeds - fast, normal, slow. ATB is a three-dimensional model with 17 segments and 16 joints. For each perturbing combination and walking speed, the ATB model for passive falls under the influence of gravity was applied up to the floor impact. The model thus predicts the falling and the impact angle (Smeesters et al. 2007).

This model is a step forward in the field of simulated falls; it can be used for a better understanding of the etiology and the mechanism of a fall, in relation to hip fractures.

A percent of 90% of the hip fractures recorded among the elderly are caused by falls. The hip fracture risk is higher in the case of a diagonal fall and, most of all, in the case of direct hip impact. Direct hip impact can be avoided during a diagonal fall, by rotating forwards, arms fully stretched. Another option is rotating backwards and landing on the buttocks. During a diagonal fall, the risk of hip impact and hip fracture can be decreased either through a forward or through a backward rotation, depending on the individual factors. For the backward rotation with landing on the buttocks, some studies revealed a higher velocity impact on the pelvis and a huge kinetic impact energy on the entire body (Robinovitch et al., 2003).

Factors increasing the risk of elderly people falling while at home. A risk model for falling

The method of assessing walking outside a lab identifies the risk factors for the elderly to fall while at home. The parameters used were: length of the step, walking speed, walking initiation, ability to turn the head while walking, static balance. The following were discovered in the case of the elderly group: slow walking speed (≤ 0.5 m/s), small steps, difficulties in turning the head while walking and balance disorder - significantly associated with unstable walking ($p \leq 0.01$). These parameters were significantly associated with the frequency of self-reported falls among single women. Slow speed walking was associated with symptoms of depression (detected through screening tests - the Geriatric Depression Scale) and with a poor health condition. 58% of those living alone were found to be exposed to one or more risk factors (Fried et al, 1990).

The predictive value of risk factors for recurrent falls was analyzed, a risk model being thus created, in order to facilitate the assessment of elderly mobility and that of elderly risk for recurrent falls.

The following aspects have been taken into consideration in 311 studies: previous falls, age, gender. Those aged over 70 were asked to answer a series of questions regarding several important aspects, including: physical and mental assessment, balance, walking, muscle strength. Previous falls and injuries caused by them were

assessed. 33% of the participants reported a total of 197 falls. 1 fall for 17%, 2 or more falls for 16%. 45% of those who reported falls also reported after-fall injuries: 2% hip fractures, 4% other fractures, 39% minor injuries. According to the fall risk model predicting the risk of recurrent falls based on logistic regressive analysis, the following elements are deemed decisive for the occurrence of recurrent falls: abnormal posture balance, 2 or more falls recorded in the previous year, a drop in the score of hand grip strength, the presence of a depressive state. There are three risk categories: low risk (0-1 predictor), moderate risk (2 predictors) and high risk (more than 3 predictors). In conclusion, the impairment of posture balance, a falling history, the decrease of hand grip strength (assessed with a dynamometer) and the presence of depression facilitate the prediction of recurrent falls (Stalenhoef et al, 2002).

Recurrent falls were analyzed in 30 elderly people (average age: 84.4 years) in relation to the double task situation (the simultaneous association of posture and cognition). The occurrence of falls for the following year was calculated (by collecting monthly data); the participants were split in 3 groups, based on the frequency of falling (0, 1, ≥2). The recurrent falls were defined as 2 or 3 falls during the last 12 months; 9.4% of the subjects reported recurrent falls. The frequency and the recurrence of these falls were associated with: age, number of medications taken and the walking speed (for usual walking and backwards walking). Only the walking speed and the double task situation were associated with the incidence of falling. A slow walking speed and backwards walking were associated with recurrent falls, suggesting that changing the walking performance during a double task situation might be a convenient way to identify the frailty of falling-prone elderly people (Beauchet et al, 2008).

Walking changes during a double task situation were associated with an increased falling risk among the elderly and a higher frailty of the same. The relation between the inherent falling risk factors and the walking changes associated with a double task situation increases elderly frailty. The walking time and the number of steps taken during usual and backwards walking were measured in 83 year-old men and 84 year-old women. The relation between walking changes, associated with a double task situation (walking time and number of steps), and age over 85, poly-medication, psychotropic substances, visual impairment, abnormal mobility, cognitive impairment was explored through a multiple regressive linear analysis. From a strictly walking point of view, both the walking time and the number of steps increased significantly during backwards walking. Poly-medication and abnormal mobility were associated with a significant increase in the walking time and in the number of steps taken; the walking changes associated with a double task situation were correlated with poly-medication and mobility impairment, indicating a higher transition frailty among the elderly (Beauchet et al., 2005).

Conclusions

1. Gait analysis as a mobility, balance and falling risk indicator among balance impaired elderly people requires two tests of stepping ability: MSL (maximal step length) and RTS (the rapid step test). The MSL score is associated with the risk of frequent falling.

2. 90% of the hip fractures recorded among the elderly population are caused by diagonal falls. Their hip impact can be prevented by forward rotation during the fall, arms stretched, or by backward rotation and landing on the buttocks.

3. The following factors are crucial for recurrent falls among the elderly: abnormal posture balance, 2 or more falls recorded the previous year, a drop in the score of hand grip strength, the presence of a depressive state.

Conflicts of interest

Nothing to declare.

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