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ORIGINAL ARTICLE

Assessment of factors that increase risk of falling in older women by four different clinical methods

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Abstract

Background Women aged 65 years and over are at increased risk of falling. Falls in this age group increase the risk of morbidity and mortality.

Aims The aim of the present study was to find the most common factors that increase the risk of falling in older women, by using four different assessment methods.

Methods 682 women, who attended a geriatric outpatient clinic and underwent comprehensive geriatric assessment, were included in the study. History of falling last year, the Timed Up and Go (TUG) test, Performance-Oriented Mobility Assessment (POMA), and 4-m walking speed test were carried out on all patients.

Results The mean age (SD) of patients were 74.4 (8.5) years. 31.5% of women had a history of falling in the last year. 11%, 36.5%, and 33.3% of patients had a falling risk according to POMA, TUG and 4-m walking speed test, respectively. We identified the following risk factors that increase the risk of falling, according to these four methods: urinary incontinence, dizziness and imbalance, using a walking stick, frailty, dynapenia, higher Charlson Comorbidity Index and Geriatric Depression Scale score, and lower basic and instrumental activities of daily living scores ($p < 0.05$). We found a significant correlation between all the assessment methods ($p < 0.001$).

Conclusion There is a strong relationship between fall risk and dizziness, using a walking stick, dynapenia, high number of comorbidities, low functionality, and some geriatric syndromes such as depression, frailty, and urinary incontinence in older women. Therefore, older women should routinely be screened for these risk factors.

Keywords Falls · Risk factors · Older · Women

Introduction

Falling is one of the most common geriatric syndromes and public health problem for older adults and their caregivers [1, 2]. According to the World Health Organization (WHO) data, falls are the second leading cause of accidental or unintentional injury deaths worldwide. Each year, approximately 28–35% of people aged 65 years and over fall and the frequency of falls increases with age and frailty level [3, 4].

Falling is important for older adults because it leads to functional impairment, disability, decreased quality of life, premature nursing home admission, increased length of stay in hospitals, and mortality [5, 6]. In addition, the high incidence and long-term effects of falls cause high costs and have an adverse effect on health-care systems. For this reason, it is necessary to identify causes of falls and risk factors, and take precautions for modifiable factors.

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Previous falls; strength, gait and balance impairments, and use of specific medications are among the strongest risk factors for falling [2]. Other identified risk factors are advanced age, female sex, visual impairment, polypharmacy, cognitive decline, depression, chronic diseases, and environmental factors such as poor fitting footwear, slippery floor or loose rugs, lack of railings or bars, unstable furniture, and poor lighting [6, 7]. Falls and the risk factors also differ between genders. While non-fatal fall injury rates were higher among women, fatal fall rates are known to be higher among men [8]. Although the reasons for the different fall rates between genders are not fully clarified, it is shown that differences in physical activity levels, bone mass, gait patterns, anthropometric structures, and some other sex-specific risk factors can affect this situation [8–10]. A number of studies have reported that there are different fall risk factors, different consequences, and different fall characteristics between women and men [8–10]. Furthermore, the results of these studies are not similar since the studies evaluated the patients with different methods. Therefore, the present study aims to identify risk factors that increase risk of falling in only older women using four different, but all common fall risk assessment methods. These methods include history of falling last year, Performance-Oriented Mobility Assessment (POMA), Timed Up and Go (TUG) test, and 4-m walking speed test.

Materials and methods

A total of 682 women who were admitted to Dokuz Eylul University, Department of Geriatrics between March 2014 and April 2018 underwent a comprehensive geriatric assessment, and those who had no exclusion criteria were included in this retrospective study. The investigation conformed to the Declaration of Helsinki and was approved by the local ethics committee.

Exclusion criteria

The exclusion criteria are as follows:

- Patients who have a history of severe illness that may impair general health status, such as acute cerebrovascular event, gastrointestinal bleeding, sepsis, acute renal failure, acute coronary syndrome, acute liver failure, and acute respiratory failure.
- Patients under 65 years of age.
- Patients with a pacemaker (because of contraindication to electrical bioimpedance).
- Patients who did not agree to undergo the CGA.
- Immobile patients who cannot be evaluated with TUG, POMA, and 4 m walking test.

Patients' characteristics

Patients were evaluated for their age, level of education and year, self-reported comorbidities (hypertension, diabetes mellitus, cerebrovascular disease, depression, osteoarthritis), Charlson Comorbidity Index, using a walking stick, and the number of the drugs used by the patients were recorded. Using five or more drugs was considered polypharmacy and using ten or more drugs was considered hyperpolypharmacy [11]. It was recorded whether the patients had self-reported dizziness and imbalance, pain, urinary incontinence, and whether they had fallen in the last year. Dementia was diagnosed according to the Diagnostic and Statistical Manual of Mental Disorders—Fifth Edition (DSM-5) major cognitive impairment diagnostic criteria [12]. Orthostatic hypotension was diagnosed according to the active standing test [13]. Serum glucose, thyroid-stimulating hormone, vitamin D, vitamin B12, folic acid levels, and glomerular filtration rates were performed to evaluate the metabolic status of the patients.

Comprehensive geriatric assessment

The following assessments were used for detailed geriatric evaluation, the Mini-Mental State Examination (MMSE) [14] and the Clinical Dementia Rating scale (CDR) [15], were used for neurocognitive assessment, The Yesavage Geriatric Depression Scale (YGDS) [16, 17] for emotional state assessment, The Lawton–Brody Instrumental Daily Living Activity Scale (IADL) [18] and Barthel index (BI) [19] for daily living activities, Mini Nutritional Assessment (MNA) [20] for nutritional evaluation, and FRAIL frailty index [21] for frailty evaluation. We considered walking speed < 0.8 m/s as slow walking for all cases, and hand grip power < 20 kg as low. We diagnosed "sarcopenia" in patients with decreased muscle strength and/or walking speed together with decreased muscle mass, and "dynapenia" in patients with decreased muscle strength, without any decrease in muscle mass [22].

Evaluation for risk of falling

A fall is defined as an event which results in a person coming to rest unintentionally on the ground or other lower level, not due to any intentional movement, a major intrinsic event or extrinsic force. To perform the TUG test as described in the original derivation study, the patient is timed while they rise from an arm chair (approximate seat height 46 cm), walk at a comfortable and safe pace to a line on the floor 3 m away, turn and walk back to the chair, and sit down again. The subject walks through the test once before being timed to

become familiar with the test [23]. Records of ≥ 13.5 s are defined as a risk of falling [24]. We also used the Tinetti POMA Scale to assess the gait with seven components (initiation of gait, step length, step symmetry, step continuity, path, trunk and walking stance; maximum 12 points) and balance abilities of participants with nine components (sitting balance, arises, attempts to arise, immediate standing balance, standing balance, nudged, eyes closed, turning 360°, and sitting down; maximum 16 points). Each subscale was measured as abnormal = 0 or normal = 1; in some cases, adaptive = 1 and normal = 2. The maximum sum score of both gait and balance components are 28 points. POMA total scores < 19 are defined as a high risk of falling [25, 26]. We instructed the patient to walk at their normal pace. Then we asked the patient to walk down a hallway through a 1-m zone for acceleration, a central 4-m "testing" zone, and a 1-m zone for deceleration (the patient should not start slowing down before the 4-m mark). We started the timer with the first footfall after the 0-m line and stopped with the first footfall after the 4-m line. We considered a walking speed below 0.8 m/s as a risk factor for falls [27].

Statistical analyses

Analysis of the data was carried out using the Statistical Package for the Social Sciences 22. Descriptive statistics are shown as mean ± standard deviation for continuous variables, and percentage (%) for nominal variables. The variables related to the risk of falling were adjusted for age, education level, and the living environment of the patients. The variables were modeled using multiple logistic regression analysis. Relations between the parameters indicating a risk of falling (history of falling, POMA, TUG, low walking speed) were calculated using the Chi square test. Results for $p < 0.05$ were considered statistically significant. The required number of samples was calculated to be at least 292 patients with an acceptable error of 5% and 95% confidence level.

Results

In the present study, we included a total of 682 women aged 65 years and over. The mean age (SD) of the patients are 74.4 (8.5). The characteristics and comorbidities of the participants are shown in Table 1. 215 (31.5%) women had a

Table 1 Characteristics of the participants ($n = 682$)

Characteristics	Values	Characteristics	Values
Age–mean (SD)	74.4 (8.5)		
Level of education			
Equal or less than 5 years	19.6 (%)	More than 5 years	80.4 (%)
Living status			
Alone	23.1 (%)	Roommate/caregiver	76.9 (%)
Comorbidities			
Hypertension	71.3 (%)	Diabetes	26.0 (%)
Cerebrovascular disease	4.4 (%)	Osteoarthritis	47.6 (%)
Dementia	13.8 (%)	Charlson Comorbidity Index (SD)	0.86 (0.97)
Cataract	50.2 (%)	Hearing impairment	29.6 (%)
Laboratory findings			
Vitamin D (SD)	24.5 (13.3)	Folate (SD)	9.76 (4.86)
Vitamin B12 (SD)	452 (310.5)		
Geriatric syndromes and comprehensive geriatric assessment			
Fall history	31.5 (%)	POMA	25.2 (4.2)
TUG (s)	13.6 (9.1)	4 m walking speed (m/s)	1.1 (2.8)
Polypharmacy	48.4 (%)	Hyperpolypharmacy	7.9 (%)
Orthostatic hypotension	28.1 (%)	Dizziness/disbalance	47.5 (%)
Urinary incontinence	55.4 (%)	Frailty	20.4 (%)
GDS score ≥ 5	28.0 (%)	Dynapenia	70.7 (%)
Malnutrition	1.9 (%)	Sarcopenia	39.4 (%)
MMSE (SD)	23.94 (6.33)	BMI (SD)	29.45 (5.4)
BADL (SD)	90.21 (0.9)	CDR	0.48 (0.73)
IADL (SD)	18.46 (5.7)		

BADL basic activities of daily living, *BMI* body mass index, *CDR* Clinical Dementia Rating scale, *GDS* Geriatric Depression Score, *IADL* instrumental activities of daily living, *POMA* Performance-Oriented Mobility Assessment

history of falling. 75 (10.9%) women had falling risk according to POMA, 249 (36.5%) women according to TUG, and 227 (33.2%) women according to lower walking speed.

The risk factors that increase the risk of fall and their odds ratios according to the history of falling, POMA, TUG, and low walking speed are shown in Table 2. CCI, urinary incontinence, dizziness and imbalance, using a walking stick, frailty, dynapenia, high GDS, and low BADL and IADL scores increase the risk of falling in women according to all of the four risk clinical assessments ($p < 0.05$).

13.8% of patients were demented (CDR 1: 52.3%, CDR 2: 34.7% and CDR 3: 13.0%). Orthostatic hypotension and sarcopenia did not increase the risk of falls according to any risk assessment method ($p > 0.05$). There was no significant difference in laboratory tests of patients with and without fall risk ($p > 0.05$). Hypertension, cerebrovascular disease, and dementia increased the risk of falling according to only TUG ($p < 0.05$).

Although the number of patients who were at risk of falling according to POMA was lower than the other three instruments, we found a significant correlation between all the clinical methods ($p < 0.001$) (Table 3).

Discussion

Falling is one of the most common geriatric syndromes [1]. In our study, the rate of falls in women over 65 years was 31.5% supporting findings from previous literature [3, 28]. Many studies have investigated risk factors for falls in older adults. Multiple risk factors have been identified with conflicting findings [5]. This may be owing to differences in the methods used to determine the risk of falling. Therefore, we performed four different assessment methods that are most commonly used for the evaluation of older adults at risk of falling and the common risk factors that increase the risk of falling were identified including self-reported dizziness and imbalance, using a walking stick, high GDS and CCI scores, low BADL and IADL scores, urinary incontinence, dynapenia, and frailty. These factors were associated with the risk of falling in older women by all four clinical methods. Additionally, although some risk factors and odds ratios were different for detecting fall risk, there was a significant correlation between the methods.

While evaluating older adults, assessment of basic and instrumental daily living activities gives important information about both the physical and cognitive states of patients. In our study, it was also found that low scores of daily living activities were strongly correlated with the risk of falling and every ten points in the BADL score increased the risk of falls from 8.79 to 9.61. There was also a similarly strong relationship for IADLs, which is consistent with previous studies [29–31]. When a growing aging population and the proportion of people with functional disability and loss of independence is considered, it is likely that falls and falls-related complications will exponentially increase in the future. Another important risk factor identified in the present study was having high GDS scores. An association between depression and increased risk of falling has also been shown [32, 33], but the underlying mechanisms have not been clearly identified. Depressive symptoms can lead older people to fall through physiological and cognitive impairments, especially lack of attention [32].

On the other hand, in the first look, dementia seems to like not being a risk factor for falling based on history of falling and POMA in the present study. Actually, this is not surprising, due to the fact that most of demented patients in our study group were in CDR 1. It is well known that slow gait and cognitive impairments are important risk factors for falls, and walking speed can be affected in the early stage of cognitive impairment as in motoric cognitive risk syndrome [34, 35]. Therefore, dementia cannot be demonstrated as a risk factor for fall by history of falling and POMA in contrast to TUG and walking speed.

With advancing age, as a result of changes in body composition and musculoskeletal system, dynapenia and sarcopenia are also common [22]. In our study, it was shown that one of the most common risk factors that increase falling was dynapenia. However, there was no significant relationship between sarcopenia and fall risk according to any clinical method. Although some studies suggest that both sarcopenia and dynapenia increase the risk of falling [36, 37], others, similar to ours, show that sarcopenia was not associated with falls, but dynapenia was [38]. This may be because muscle strength is more important than muscle mass in achieving balance [39]. In assessing the risk of falling, simply measuring muscle strength is more effective than muscle mass measurement methods. Frailty that is closely related to sarcopenia and dynapenia is another risk factor for falls [40]. The relationship between frailty and falling has been shown in many studies [28]. This may be due to the fact that muscle weakness and gait alterations are part of frailty, besides this multiple comorbidities and polypharmacy may increase the risk of falling in frail older adults [41].

It has been shown in many studies that vision and hearing loss increase the risk of falling [42] and have negative effect on gait and balance functions in older adults [43, 44]. However, in the present study, the risk of falling according to the history of fall was only related to cataract and hearing loss reported by the patients in accordance with the literature, and POMA, TUG, and walking speed scores were found to be different from the literature [43, 44]. This is because sensory loss including visual and hearing disorders could not be elaborated in our study. Self-reported dizziness and imbalance are other common risk factors according to all clinical methods. In addition, using a walking stick increases the risk

Table 2 Odds ratios for falling risk factors

Female	Risk of falling according to fall history			Risk of falling according to POMA score			Risk of falling according to Timed Up and Go test			Risk of falling according to Lower walking speed		
	Coefficient	Odds ratio	*p* value	Coefficient	Odds ratio	*p* value	Coefficient	Odds ratio	*p* value	Coefficient	Odds ratio	*p* value
Dementia	0.345	1.412	0.166	0.390	1.477	0.230	0.875	2.399	**0.002**	0.781	2.184	**0.005**
Diabetes	0.189	1.208	0.319	0.611	1.842	**0.030**	0.706	2.027	**0.001**	0.509	1.663	**0.017**
CCI	0.212	1.236	**0.015**	0.272	1.313	**0.025**	0.421	1.523	**< 0.001**	0.348	1.416	**0.001**
Osteoarthritis	0.249	1.283	0.145	0.744	2.105	**0.008**	0.541	1.718	**0.005**	0.688	1.990	**0.001**
Polypharmacy	0.609	1.839	**0.001**	0.534	1.706	0.059	0.889	2.433	**< 0.001**	0.733	2.082	**< 0.001**
Hyperpolypharmacy	1.098	2.999	**< 0.001**	0.514	1.671	0.197	0.933	2.542	**0.006**	0.582	1.790	0.083
Walking stick	0.649	1.913	**0.007**	1.865	6.454	**< 0.001**	2.217	9.183	**< 0.001**	1.766	5.849	**< 0.001**
Use of glasses	−0.154	0.857	0.447	−0.419	0.658	0.154	0.004	1.004	0.985	−0.179	0.836	0.443
Urinary incontinence	0.476	1.609	**0.006**	1.079	2.943	**0.001**	0.638	1.892	**0.001**	0.928	2.530	**< 0.001**
Dizziness	0.930	2.535	**< 0.001**	1.123	3.073	**< 0.001**	0.682	1.979	**< 0.001**	0.805	2.237	**< 0.001**
Pain	0.278	1.320	0.118	0.476	1.610	0.105	0.553	1.739	**0.006**	0.839	2.315	**< 0.001**
Cataract	0.492	1.635	**0.006**	−0.069	0.934	0.808	0.081	1.084	0.682	−0.075	0.928	0.714
Hearing impairment	0.663	1.941	**< 0.001**	0.201	1.223	0.478	0.046	1.047	0.828	0.341	1.407	0.111
Vitamin D	0.003	1.003	0.633	−0.022	0.979	0.069	−0.012	0.988	0.106	−0.007	0.993	0.366
Vitamin B12	< 0.001	1.000	0.734	< 0.001	1.000	0.884	< 0.001	1.000	0.205	< 0.001	1.000	0.279
Folate	−0.009	0.991	0.603	0.004	1.004	0.882	−0.007	0.993	0.739	0.006	1.006	0.759
MMSE	−0.008	0.992	0.660	−0.076	0.926	**0.002**	−0.067	0.935	**0.001**	−0.057	0.945	**0.005**
GDS ≥ 5	0.926	2.524	**< 0.001**	0.698	2.010	**0.049**	1.097	2.994	**< 0.001**	1.040	2.828	**< 0.001**
BADL	−0.039	0.961	**< 0.001**	−0.117	0.890	**< 0.001**	−0.118	0.888	**< 0.001**	−0.128	0.879	**< 0.001**
IADL	−0.039	0.962	**0.028**	−0.168	0.845	**< 0.001**	−0.157	0.854	**< 0.001**	−0.160	0.852	**< 0.001**
BMI	0.017	1.017	0.287	0.020	1.020	0.414	0.085	1.067	**< 0.001**	0.053	1.055	**0.004**
Malnutrition	0.939	2.557	0.119	1.129	3.092	0.083	1.520	4.570	0.097	2.925	18.633	**0.017**
Dynapenia	0.427	1.533	**0.035**	1.321	3.746	**0.006**	0.641	1.898	**0.006**	1.082	2.952	**< 0.001**
Frailty	1.101	3.008	**< 0.001**	3.323	27.738	**0.001**	1.419	4.135	**< 0.001**	1.564	4.777	**< 0.001**

Bold values show that the *p* values are statistically significant

BADL basic activities of daily living, *BMI* body mass index, *CCI* Charlson Comorbidity Index, *GDS* Geriatric Depression Score, *IADL* instrumental activities of daily living, *MMSE* Mini-Mental State Examination, *POMA* Performance-Oriented Mobility Assessment

*All data are adjusted for age, education level, and living environment

Table 3 Chi square test of association between the variables

	Risk of falling according to fall history	Risk of falling according to POMA	Risk of falling according to Timed Up and Go test
Risk of falling according to POMA	14.303 ($p < 0.001$)		
Risk of falling according to Timed Up and Go test	25.506 ($p < 0.001$)	134.485 ($p < 0.001$)	
Risk of falling according to low walking speed	21.381 ($p < 0.001$)	130.826 ($p < 0.001$)	268.696 ($p < 0.001$)

of falling. It is clear that these patients use walking sticks more for reasons such as balance problems and fear of falling. All of these suggest that patients with self-reported dizziness and using a walking stick should be examined more in detail about the risk of falling during clinical evaluation [45]. Many women accept urinary incontinence as a normal part of aging [46]. However, it has a significant psychosocial, economic burden and can lead to low quality of life [47]. Besides, it has been shown that urinary incontinence is a risk factor for falling [48, 49]. In our study, urinary incontinence was associated with an increased risk of falls in all groups. The reasons are limited. However, it is thought that there may be reasons such as rushing to go to the toilet, or urinary incontinence may be more frequent in individuals with mobility limitation [49].

Interestingly, the present study found that each unit increase in CCI increased the risk of falls in all four groups. There is a limited number of studies in the literature that investigate the association between CCI and the risk of falls; however, our findings do support the limited literature in this area [50, 51]. These findings suggest that comorbidity indexes may be more useful to assess the risk of falls rather than evaluating comorbidities separately. Within comorbidities, diabetes and osteoarthritis were most frequently associated with falls according to different assessment methods. Osteoarthritis increased the risk of falls according to three different clinical methods. There are some controversial studies in the literature, but in many studies increased risk of falling in osteoarthritis has been shown [52, 53]. The older patients with knee and hip osteoarthritis adopt different compensatory biomechanical strategies during walking. Changes in walking patterns can cause postural instability and difficulties with transfer of center of gravity and increase the risk of falls [52]. Additionally, another comorbidity, diabetes, increases the risk of falls too. In the literature, the association of diabetes with the risk of falls has been established, which is thought to be related to many diabetic complications such as peripheral neuropathy, diabetic retinopathy and visual disturbances, and hypoglycemia [54, 55]. Advancing age and increased comorbidity are often accompanied by polypharmacy. In studies, drug groups and comorbidities, leading to the use of drugs, have been shown to be as important as the number of drugs for falls [56, 57]. In our study, polypharmacy also increased the risk of falling according to three assessment methods.

One of the strengths of this study is the large sample of older women allowing for the identification of sex-specific risk factors. Four different fall risk assessment methods were used. Thus, falling history, balance, walking, and walking speed were evaluated and the possible differences between these clinical methods were identified. On the other hand, this study has a number of limitations. First, this study had a retrospective design. Second, fear of falling could not have been assessed. Third, cutoff points of some instruments used in this study varies in the literature, but we used the common cut points based on the literature.

Conclusion

In older adults, falling is a problem with important negative outcomes, affecting independence and quality of life. In our study, we identified nine risk factors that increased the risk of falling according to four different clinical methods. This demonstrates the importance of comprehensive geriatric assessment in older patients to evaluate fall risk factors. To prevent falls, it is important that the risk factors are clearly identified and modified.

Author contributions OD performed data collection and manuscript writing; SKO and AEA contributed to data collection; IY conducted data analysis; LS performed manuscript writing; PS designed the study and performed manuscript writing; and ATI designed the study and supported manuscript writing and conceptualism.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interests.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent All participants provided informed consent prior to their participation.

References

1. Lakhan P, Jones M, Wilson A et al (2015) A prospective cohort study of geriatric syndromes among older medical patients admitted to acute care hospitals. J Am Geriatr Soc 59:2001–2008
2. Tinetti ME, Kumar C (2010) The patient who falls: "it's always a trade-off". JAMA 303:258–266
3. World Health Organization (2007) WHO global report on falls prevention in older age. WHO, Geneva
4. World Health Organization. 16 Jan 2018. http://www.who.int/news-room/fact-sheets/detail/falls
5. King B, Pecanac K, Krupp A et al (2018) Impact of fall prevention on nurses and care of fall risk patients. Gerontologist 58:331–340
6. Mazur K, Wilczyński K, Szewieczek J (2016) Geriatric falls in the context of a hospital fall prevention program: delirium, low body mass index, and other risk factors. Clin Interv Aging 11:1253–1261
7. Ambrose AF, Paul G, Hausdorff JM (2013) Risk factors for falls among older adults: a review of the literature. Maturitas 75:51–61
8. Stevens JA, Ballesteros MF, Mack KA et al (2012) Gender differences in seeking care for falls in the aged Medicare population. Am J Prev Med 43:59–62
9. Duckham RL, Procter-Gray E, Hannan MT et al (2013) Sex differences in circumstances and consequences of outdoor and indoor falls in older adults in the MOBILIZE Boston cohort study. BMC Geriatr 13:133
10. Stevens JA, Sogolow ED (2005) Gender differences for non-fatal unintentional fall related injuries among older adults. Inj Prev 11:115–119
11. Unutmaz GD, Soysal P, Tuven B et al (2018) Costs of medication in older patients: before and after comprehensive geriatric assessment. Clin Interv Aging 13:607–613
12. American Psychiatric Association (2013) Diagnostic and statistical manual of mental disorders, 5th edn. American Psychiatric Publishing, Arlington. https://doi.org/10.1176/appi.books.9780890425596
13. Aydin AE, Soysal P, Isik AT (2017) Which is preferable for orthostatic hypotension diagnosis in older adults : active standing test or head-up tilt table test? Clin Interv Aging 12:207–212
14. Folstein MF, Folstein SE, McHugh PR (1975) Mini-mental state. A practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res 12:189–198
15. Morris JC (1993) The clinical dementia rating (CDR): current version and scoring rules. Neurology 43:2412–2414
16. Dokuzlar O, Soysal P, Usarel C et al (2018) The evaluation and design of a short depression screening tool in Turkish older adults. Int Psychogeriatr 30:1541–1548
17. Durmaz B, Soysal P, Ellidokuz H et al (2018) Validity and reliability of geriatric depression scale—15 (short form) in Turkish older adults. North Clin Istanb 5:216–220
18. Lawton MP, Brody EM (1969) Assessment of older people: self-maintaining and instrumental activities of daily living. Gerontologist 9:179–186
19. Mahoney FI, Barthel DW (1965) Functional evaluation: the Barthel index. Md State Med J 14:61–65
20. Guigoz Y (2006) The Mini Nutritional Assessment (MNA) review of the literature—what does it tell us? J Nutr Health Aging 10:466–485
21. van Kan GA, Rolland YM, Morley JE (2008) Frailty: toward a clinical definition. J Am Med Dir Assoc 9:71–72
22. Bulut EA, Soysal P, Aydin AE et al (2017) Vitamin B12 deficiency might be related to sarcopenia in older adults. Exp Gerontol 95:136–140
23. Podsiadlo D, Richardson S (1991) The timed "Up & Go": a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc 39:142–148
24. Shumway-Cook A, Brauer S, Woollacott M (2000) Predicting the probability for falls in community-dwelling older adults using the Timed Up & Go Test. Phys Ther 80:896–903
25. Tinetti ME (1986) Performance-oriented assessment of mobility problems in elderly patients. J Am Geriatr Soc 34:119–126
26. Al-Momani M, Al-Momani F, Alghadir AH et al (2016) Factors related to gait and balance deficits in older adults. Clin Interv Aging 11:1043–1049
27. BCGuidelines.ca (2017) Frailty in older adults—early identification and management. https://www2.gov.bc.ca/assets/gov/health/practitioner-pro/bcguidelines/frailty-gaitspeed.pdf. Accessed 18 Oct 2018
28. Gale CR, Cooper C, Aihie Sayer A (2016) Prevalence and risk factors for falls in older men and women: the English longitudinal study of ageing. Age Ageing 45:789–794
29. Brown J, Kurichi JE, Xie D et al (2014) Instrumental activities of daily living staging as a possible clinical tool for falls risk assessment in physical medicine and rehabilitation. PM R 6:316–323
30. Sekaran NK, Choi H, Hayward RA et al (2013) Fall-associated difficulty with activities of daily living in functionally independent individuals aged 65 to 69 in the United States: a cohort study. J Am Geriatr Soc 61:96–100
31. Stenhagen M, Ekström H, Nordell E et al (2014) Both deterioration and improvement in activities of daily living are related to falls: a 6-year follow-up of the general elderly population study Good Aging in Skåne. Clin Interv Aging 9:18391846
32. Kojima R, Ukawa S, Ando M et al (2016) Association between falls and depressive symptoms or visual impairment among Japanese young–old adults. Geriatr Gerontol Int 16:384–391
33. Stewart Williams J, Kowal P, Hestekin H et al (2015) Prevalence, risk factors and disability associated with fall-related injury in older adults in low- and middle-income countries: results from the WHO Study on global AGEing and adult health (SAGE). BMC Med 13:147
34. Holtzer R, Verghese J, Xue X et al (2006) Cognitive processes related to gait velocity: results from the Einstein aging study. Neuropsychology 20:215–223
35. Callisaya ML, Ayers E, Barzilai N et al (2016) Motoric cognitive risk syndrome and falls risk: a multi-center study. J Alzheimers Dis 53:1043–1052
36. Landi F, Liperoti R, Russo A et al (2012) Sarcopenia as a risk factor for falls in elderly individuals: results from the ilSIRENTE study. Clin Nutr 31:652–658
37. Tanimoto Y, Watanabe M, Sun W et al (2014) Sarcopenia and falls in community-dwelling elderly subjects in Japan: defining sarcopenia according to criteria of the European working group on sarcopenia in older people. Arch Gerontol Geriatr 59:295–299
38. Benjumea A-M, Curcio C-L, Duque G et al (2018) Dynapenia and sarcopenia as a risk factor for disability in a falls and fractures clinic in older persons. Open Access Maced J Med Sci 6:344–349
39. Bijlsma AY, Pasma JH, Lambers D et al (2013) Muscle strength rather than muscle mass is associated with standing balance in elderly outpatients. J Am Med Dir Assoc 14:493–498
40. Soysal P, Ates Bulut E, Yavuz I et al (2018) Decreased basal metabolic rate can be an objective marker for sarcopenia and frailty in older males. J Am Med Dir Assoc S1525–8610:30362-1
41. Samper-Ternent R, Karmarkar A, Graham J et al (2012) Frailty as a predictor of falls in older Mexican Americans. J Aging Health 24:641–653
42. Deandrea S, Lucenteforte E, Bravi F et al (2010) Risk factors for falls in community-dwelling older people: a systematic review and meta-analysis. Epidemiology 21:658–668

43. Reed-Jones RJ, Solis GR, Lawson KA et al (2013) Vision and falls: a multidisciplinary review of the contributions of visual impairment to falls among older adults. Maturitas 75:22–28
44. Jiam NTL, Li C, Agrawal Y (2016) Hearing loss and falls: a systematic review and meta-analysis. Laryngoscope 126:2587–2596
45. Bloch F, Thibaud M, Tournoux-Facon C et al (2013) Estimation of the risk factors for falls in the elderly: can meta-analysis provide a valid answer? Geriatr Gerontol Int 13:250–263
46. Siddiqui NY, Levin PJ, Phadtare A et al (2014) Perceptions about female urinary incontinence: a systematic review. Int Urogynecol J 25:863–871
47. Padmanabhan P, Dmochowsi R (2014) Urinary incontinence in women: a comprehensive review of the pathophysiology, diagnosis and treatment. Minerva Ginecol 66:469–478
48. Soliman Y, Meyer R, Baum N (2016) Falls in the elderly secondary to urinary symptoms. Rev Urol 18:28–32
49. Bresee C, Dubina ED, Khan AA et al (2014) Prevalence and correlates of urinary incontinence among older community-dwelling women. Female Pelvic Med Reconstr Surg 20:328–333
50. Bates DW, Pruess K, Souney P et al (1995) Serious falls in hospitalized patients: correlates and resource utilization. Am J Med 99:137–143
51. Vu T, Finch CF, Day L (2011) Patterns of comorbidity in community-dwelling older people hospitalised for fall-related injury: a cluster analysis. BMC Geriatr 11:45
52. Ng CT, Tan MP (2013) Osteoarthritis and falls in the older person. Age Ageing 42:561–566
53. Khalaj N, Osman NAA, Mokhtar AH et al (2014) Balance and risk of fall in individuals with bilateral mild and moderate knee osteoarthritis. PLoS ONE 9:e92270
54. Chau RMW, Ng TKW, Kwan RLC et al (2013) Risk of fall for people with diabetes. Disabil Rehabil 35:1975–1980
55. Kachroo S, Kawabata H, Colilla S et al (2015) Association between hypoglycemia and fall-related events in Type 2 diabetes mellitus: analysis of a U.S. commercial database. J Manag Care Spec Pharm 21:243–253
56. Zia A, Kamaruzzaman SB, Tan MP (2015) Polypharmacy and falls in older people: balancing evidence-based medicine against falls risk. Postgrad Med 127:330–337
57. Richardson K, Bennett K, Kenny RA (2015) Polypharmacy including falls risk-increasing medications and subsequent falls in community-dwelling middle-aged and older adults. Age Ageing 44:90–96