Turkish Journal of Geriatrics
2014; 17 (3) 242-248

Hakan ALKAN[1]
Necmettin YILDIZ[1]
Ayşe SARSAN[1]
Nuray AKKAYA[1]
Gülin FINDIKOĞLU[1]
Özgür SEVİNÇ[2]
Oya TOPUZ[1]
Füsun ARDIÇ[1]

RESEARCH

THE RELATIONSHIP BETWEEN POSTUROGRAPHIC FALL RISK AND CLINICAL BALANCE TESTS AMONG COMMUNITY-DWELLING OLDER ADULTS

ABSTRACT

Introduction: The aim of this study was to determine whether there is an association between fall risk measured posturographically and clinical balance tests among people who are over 65 years of age, and to identify the discriminative ability of the posturographic fall risk index.

Materials and Methods: Two hundred and twenty participants who were over 65 years of age were included in the study. The balance and fall risk of participants were assessed with the Berg balance scale (BBS) and a posturography device; functional mobility with the Timed Up and Go (TUG) test; lower extremity neuromuscular function with the Chair Stand test (CST) and quality of life with the Short Form-36 (SF-36). Participants were grouped into two, as fallers and non-fallers, on the basis of the past year's fall history.

Results: A total of 78 participant (35.5%) had a history of falling, while 142 (64.5%) of the subjects did not. Age, TUG and posturographic fall risk index of fallers were significantly higher than for nonfallers, whilst some subgroups of the SF-36, BBS and mean CST scores were lower ($p<0.05$). There were negative correlations between posturographic fall risk and the BBS ($r=-0.84$) and CST ($r=-0.40$) yet a positive correlation with the TUG ($r=0.67$) ($p<0.05$). Using the agreement between the posturographic fall risk index and history of falls, the area under the ROC curve was 0.818. In this study, when the cut-off value 51≤ was used, sensitivity was found to be 76.9% and specificity was 73.9%, with a higher value for the Youden index: 0.508.

Conclusion: It was shown that fallers had poorer balance, functional mobility, lower extremity neuromuscular function and quality of life than nonfallers. The study also demonstrated that posturographically obtained fall risk was significantly correlated with clinical balance tests and had good discriminative ability to identify fallers.

Key Words: Aged; Postural Balance; Accidental Falls.

ARAŞTIRMA

TOPLUMDA YAŞAYAN YAŞLI BİREYLERDE POSTUROGRAFİK DÜŞME RİSKİ İLE KLİNİK DENGE TESTLERİ ARASINDAKİ İLİŞKİ

ÖZ

Giriş: Bu çalışmanın amacı, 65 yaş üstü bireylerde posturografik düşme riski ile klinik denge testleri arasında ilişki olup olmadığını değerlendirmek ve posturografik düşme indeksinin ayırt edici kapasitesini belirlemekti.

Gereç ve Yöntem: Çalışmaya, 65 yaş üstü 220 kişi alındı. Katılımcıların denge ve düşme riski; posturografik düşme riski ve Berg denge testi (BDT), fonksiyonel mobilitesi; Zamanlı Kalk-Yürü Testi (ZKYT), alt ekstremite nöromuskuler fonksiyonu; sandalyeye otur kalk testi (SOKT) ve yaşam kalitesi; Kısa Form-36 (KF-36) kullanılarak değerlendirildi. Hastalar son bir yıl içindeki düşme öyküsüne göre; düşenler ve düşmeyenler olmak üzere, iki gruba ayrıldı.

Bulgular: Çalışmaya alınan bireylerin 78'inde (%35,5) düşme öyküsü varken 142'inde (%64,5), düşme öyküsü yoktu. Düşme öyküsü olanların yaş, posturografik düşme riski, ve ZKYT skorları düşme öyküsü olmayanlara göre istatistiksel olarak anlamlı derecede yüksek iken, KF-36 yaşam kalitesinin bazı alt grup skorları, BDT skoru ve SOKT ortalama sayısı ise düşüktü ($p<0,05$). Posturografik düşme riski ile BDT ($r=-0.84$) ve SOKT ($r=-0.40$) arasında negatif korelasyon, ZKYT ($r=0.67$) ile pozitif korelasyon saptandı ($p<0,05$). Posturografik düşme riski ile düşme öyküsü arasındaki uyuma bakıldığında ROC eğrisi altında kalan alan 0,818 idi. Bu çalışmada, cut-off değeri 51 ve üzeri alındığında en yüksek Youden indeks skoru 0,508 ile sensitivite %76,9 ve spesifite %73,9 olarak saptandı.

Sonuç: Düşme öyküsü olanların denge, fonksiyonel mobilite, alt ekstremite nöromusküler fonksiyon ve yaşam kalitelerinin düşme öyküsü olmayanlara göre daha kötü olduğu gösterilmiştir. Çalışmada ayrıca posturografik düşme riskinin klinik denge testleri ile anlamlı olarak ilişkili olduğunu ve düşenleri belirlemede iyi ayırt edici kapasitesi sergilediği gösterilmiştir.

Anahtar Sözcükler: Yaşlı; Postural denge; Düşme.

İletişim *(Correspondance)*

Hakan ALKAN
Pamukkale Üniversitesi, Tıp Fakültesi Fiziksel Tıp ve Rehabilitasyon Anabilim Dalı DENİZLİ

Tlf: 0258 444 07 28
e-posta: alkangsc@yahoo.com

Geliş Tarihi: 18/03/2014
(Received)

Kabul Tarihi: 16/04/2014
(Accepted)

[1] Pamukkale Üniversitesi, Tıp Fakültesi Fiziksel Tıp ve Rehabilitasyon Anabilim Dalı DENİZLİ
[2] Pamukkale Üniversitesi, Tıp Fakültesi Halk Sağlığı Anabilim Dalı DENİZLİ

Introduction

Falling is a major public health problem for the elderly throughout the world (1). About one third of community-dwelling older adults fall once a year and half of these fall at least twice a year (2). Although there is increasing intervention focused on preventing falls in older people, it is still one of the most significant causes of morbidity and mortality. As a larger proportion of the elderly population in developing countries increasingly lives to an older age, falls will be more prevalent and will be an important cause of disability in the future. Therefore, to identify individuals who are at an elevated risk for falling and who should receive further assessment is mandatory for this population (3).

The usefulness of a screening tool in predicting falls may vary depending on the health status and functional level of the older adults being tested (4). Fall risk screening tools have been especially used to identify frail elderly individuals who are at risk for falling; however, these screening tools are less predictive of falls in community-dwelling older adults (4). Which functional tests of mobility and balance can better screen community-dwelling older adults at risk of falls is unclear. The ability to maintain postural stability is one of the most important factors in fall prediction. The quantitative method of assessing postural stability is posturography (5). Additionally, if posturographic fall risk index cut-off scores can be identified, the clinical usefulness of posturography as a fall screening tool may be improved.

The aim of this study was to determine whether there is an association between the posturographic fall risk index and clinical balance tests among community-dwelling older adults, and to explore whether the posturographic fall risk index can identify those older adults at high risk for falling.

Materials and Methods

Subjects

Community-dwelling older adults who were over 65 years of age and attended the Physical Medicine and Rehabilitation Clinic were enrolled in this study. Individuals were excluded from the study if they were unable to stand or walk independently, unable to cooperate, or living in a nursing home. The study protocol was approved by the university research ethics committee and informed consent was obtained from all individuals who agreed to participate the study. All participants received a comprehensive geriatric assessment at baseline. Subjects were asked about the number of falls in the past twelve months. In this study, a fall was defined as "an episode of unintentionally coming to rest on the ground or lower surface that was not the result of dizziness, fainting, sustaining a violent blow, loss of consciousness, or other overwhelming external factor"(2). Recurrent falling was defined as two or more falls within 12 months. All participants were divided into two categories according to history of falls as fallers or non-fallers.

Evaluation Parameters

The Berg Balance Scale (BBS), is a valid and reliable scale for the assessment of balance in older adults. The BBS consists of 14 tasks that are each scored on a scale of 0-4, for a total possible score of 56, indicating no identified balance difficulties. Scoring is on a 5-point ordinal scale with 0 indicating an inability to complete the task and 4 as independent in completing the task (6). The Turkish version of the BBS was demonstrated to be a reliable and valid scale for the balance assessment of Turkish older adults (7).

All subjects were also tested using a static posturography device the Tetrax Interactive Balance System (Sunlight Medical, Tel-Aviv, Israel). The Tetrax device uses a method based on the assessment of vertical pressure fluctuations on four independent force plates. Standard measurement consists of eight different positions that are held for 32 seconds. The software of the Tetrax system calculates stability, weight distribution, synchronizations, and sway intensity. A fall risk index derived from the balance parameters established by this device has been developed to produce a score that expresses this risk based on the patient's specific balance factors that affect falling. The fall risk index score rates the risk on a scale from 0-100, in which zero indicates no risk of falling and 100 represents the an extreme likelihood of falling (8).

The timed up and go test (TUG) was used to evaluate mobility. The TUG is a balance and gait index which requires subjects to rise from an armchair, walk 3 m at a normal and safe pace, turn around, walk back to the chair, and sit-down. The time required to complete this task is measured in seconds (9).

The chair stand test (CST) is a physical performance test used to assess lower extremity function. A standard chair with arms and a seat height of approximately 43 cm was used for all assessments. The subject was seated in the middle of the chair, back straight, arms crossed over chest, feet flat on floor. From the sitting position, the subject stood completely up, then completely back down, and this was repeated for 30 seconds. The total score was the number of completed chair stands in 30 seconds (10).

The Short Form-36 (SF-36) was used to evaluate quality of life as a general survey of health status in this study. The SF-36 includes eight subscale each score was converted to a range from 0-100, with a higher score indicating a better level of functioning (11). The reliability and validity of the Turkish version of the SF-36 were also demonstrated (12).

Statistics

All statistical analyses were performed using SPSS version 17.0 for Windows (Statistical Package for the Social Sciences Inc, Chicago, IL, USA). Descriptive statistics were used to describe demographic characteristics. For continuous variables, the significance of the differences were analyzed using Student's t-test while categorical variables were analyzed with chi-square tests. Pearson correlation coefficients were calculated to determine the relationship between the posturographic fall risk index and the clinical balance test. Posturographic fall risk sensitivity and specificity indices were computed and used for diagnostic classification of patients with respect to falling status. For each posturographic fall risk score, sensitivity and specificity were computed and graphed in a receiver operating characteristic (ROC) curve. The ROC curved was used to select optimal cut-off posturographic fall risk scores for screening community-dwelling elderly who had a higher fall risk. The Youden's index, positive predictive value, negative predictive value, and positive and negative likelihood ratios were also obtained. In all analyses, p values <0.05 were considered as statistically significant.

Results

A total of 244 individuals were eligible for this study, 24 of whom had to be excluded from the analysis. Of these 24 individuals, 11 could not independently stand, seven were unable to cooperate, five refused to participate and one was

Table 1— Demographic Characteristics of Older Individuals by History of Fall.

	Non-faller (n=142)	Faller (n=78)	p
Gender, n (%)			
Women	80 (56.3)	52 (66.7)	0.135
Men	62 (43.7)	26 (33.3)	
Age, (years) (mean ± SD)	70.26±3.89	71.85±4.56	0.007
BMI, (kg/m^2) (mean ± SD)	26.34±2.91	27.00±2.92	0.109
Marital Status, n (%)			
Married	114 (80.3)	40 (51.3)	<0.001
Widow(er)	28 (19.7)	38 (48.7)	
Living with Whom, n (%)			
Wife or husband	114 (80.3)	40 (51.3)	<0.001
Alone	19 (13.4)	28 (35.9)	
Son or daughter	9 (6.3)	10 (12.8)	
Tetrax (mean ± SD)	42.68±21.38	71.29±23.59	<0.001
BBS (mean ± SD)	47.08±7.05	37.15±10.06	<0.001
CST (mean±SD)	11.32±2.14	9.82±2.44	<0.001
TUG (mean±SD)	12.26±2.45	15.65±3.84	<0.001
Short Form-36			
SF-A	67.95±19.25	49.87±19.49	<0.001
SF-B	67.52±20.25	65.71±20.98	0.531
SF-C	52.20±18.76	49.72±18.54	0.345
SF-D	59.30±17.46	56.59±15.43	0.237
SF-E	80.03±26.66	79.90±28.10	0.973
SF-F	66.37±29.48	54.81±28.51	0.005
SF-G	63.65±12.93	61.78±12.00	0.295
SF-H	57.98±16.48	54.05±19.92	0.140

BBS: Berg-Balance-Scale, CST: Chair-Stand-Test, BMI: Body-Mass-Index, TUG: Timed-up-and-Go test.

living in a nursing home. Therefore, 220 participants who were over 65 years of age were included in this study. The mean age of participants was 70.8 years, and the majority of the participants were female (60%).

Seventy eight (35.5%) of the 220 subjects had a history of falls of whom 58 (26.4%) had one fall and 20 (9.1%) had a recurrent history of falling. Age, TUG and posturographic fall risk index of fallers were significantly higher than that of non-fallers, whilst two scores on two subtests of the SF-36 (physical function and role limitations due to physical problems), BBS and mean CST scores were lower ($p<0.05$). There were no significant differences regarding gender and BMI between fallers and non-fallers (Table-1) ($p>0.05$).

The correlation between the posturographic fall risk and the BBS was high and statistically significant ($r=-0.84$, $p<0.001$). There was a significant negative correlation between posturographic fall risk and the CST ($r=-0.40$, $p<0.001$), and a significant positive correlation with the TUG ($r=0.67$, $p<0.001$).

Using the agreement between the posturographic fall risk index and history of falls, the ROC curve for fall risk index scores was estimated. Area under the ROC curve was 0.818 when comparing fallers and non-fallers (Figure 1). Discriminant statistics for sensitivity, specificity, Youden index, positive predictive value, and negative predictive value for each posturographic fall risk score between 45 to 55, and then every 5 point score out of 100, are given in Table 2, illustrating the agreement between posturographic fall risk and history of falls. In this study, when the cut-off value of 51≤ was used, sensitivity was 76.9% and specificity was 73.9%, with a higher value for the Youden index: 0.508. Scores 51≤ represent a negative predictive value of 86%, and a positive predictive value of 61% (Table 2).

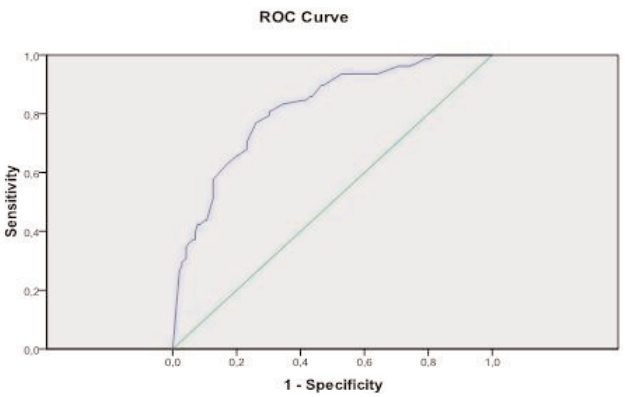

Figure 1— Receiver operating characteristic curve for posturographic fall risk by fall history. Area under-the-curve: 0.818

Discussion

In this study, we demonstrated significant differences between fallers and non-fallers according to posturographic fall risk and the clinical balance test. Posturographic fall risk was also found to be associated with the clinical balance test in community-dwelling older adults. Moreover, the posturographic fall risk index demonstrated good discriminative ability between fallers and non-fallers in the elderly.

Fall risk for community-dwelling older adults is an urgent, multifactorial, public health problem as incidence of falls and the aging population rises. More than one third of adults aged 65 or older sustain at least one fall each year (2,13). Similarly, the present study found that 35.5% our community dwelling participants had a history of falling, in accordance with previous reports.

It is important to determine whether the clinical assessment of balance can identify future fall risk. Many instruments have been developed to assess balance and predict falls in older adults; however, a standardized and valid screening instrument to identify elderly people at risk of falling is still not available (14). The BBS and the TUG were most rigorously studied and their reliability and validity for balance assessment had been established in community-dwelling older adults. Cross sectional and case controlled studies have shown that high scores on the TUG test are associated with an increased risk of falls (15,16). Furthermore, BBS has been shown to differentiate between faller and non-faller groups. With respect to the BBS, it has been reported that fallers had significantly lower scores than non-fallers (17,18). In accordance with these studies, we also demonstrated significantly lower BBS scores and higher TUG scores for fallers compared to non-fallers. In addition, a recent study has demonstrated that acceleration parameters were significantly correlated with BBS and TUG values (19). Similarly, we found a significant association between posturographic fall risk and clinical balance tests, including the BBS and TUG. Unlike our study, no significant correlation was found between scores on the posturographic fall risk index and BBS in another study (8). However, this study had small sample size and included older adults who had relatively good balance with a higher mean BBS value. This could be the reason that a significant correlation was not found in that study, which the authors also

Table 2— Discriminant Features of Posturography in Geriatric Patients according to History of Falling.

Cutoff Score	Sensitivity (%)	Specificity (%)	Youden Index	PPV	NPV	PLR	NLR
0	100	0.0	0.0	0.35	NA	1.00	NA
5	100	0.7	0.007	0.35	1.00	1.01	0.00
10	100	3.5	0.035	0.36	1.00	1.04	0.00
15	100	9.9	0.099	0.37	1.00	1.11	0.00
20	100	14.1	0.141	0.39	1.00	1.16	0.00
25	100	17.6	0.176	0.40	1.00	1.21	0.00
30	97.4	23.2	0.206	0.41	0.94	1.27	0.11
35	93.6	35.9	0.295	0.44	0.91	1.46	0.18
40	93.6	47.2	0.408	0.49	0.93	1.77	0.14
45	84.6	58.5	0.431	0.52	0.88	2.04	0.26
46	84.6	59.2	0.438	0.53	0.88	2.07	0.26
47	83.3	65.5	0.488	0.57	0.88	2.41	0.25
48	83.3	65.5	0.488	0.57	0.88	2.41	0.25
49	80.8	69.7	0.505	0.59	0.87	2.67	0.28
50	79.5	69.7	0.492	0.59	0.86	2.62	0.29
51	76.9	73.9	0.508	0.61	0.86	2.95	0.31
52	72.9	73.9	0.468	0.60	0.84	2.79	0.37
53	70.5	76.8	0.473	0.62	0.83	3.04	0.38
54	70.5	76.8	0.473	0.62	0.83	3.04	0.38
55	67.9	76.8	0.447	0.61	0.82	2.93	0.42
60	62.8	83.1	0.459	0.67	0.81	3.72	0.45
65	56.4	87.3	0.437	0.71	0.79	4.44	0.50
70	51.3	87.3	0.386	0.69	0.77	4.04	0.56
75	43.6	90.1	0.337	0.70	0.75	4.40	0.63
80	42.3	92.3	0.346	0.75	0.75	5.49	0.63
85	37.2	93.7	0.316	0.76	0.73	5.90	0.67
90	34.6	95.8	0.309	0.82	0.73	8.24	0.68
95	29.5	97.2	0.267	0.85	0.72	10.54	0.73
100	26.9	97.9	0.248	0.88	0.72	14.10	0.72

PPV: predictive-positive-value, NPV: predictive-negative-value, PLR: positive-likelihood-ratio, NLR: negative-likelihood-ratio, NA: not-applicable.

reported to be an unexpected result. On the other hand, in the same study it was concluded that a fall risk index measurement by posturography can identify individuals who have a high risk of falling, and that it seems to be a promising screening tool for the elderly (8).

No screening test is excellent, thus at present no screening test is known to be accurate enough to be regarded as a gold standard. Therefore, a good level of agreement between two tests, does not necessarily mean that prediction of falls will be accurate (4). Some studies have been conducted on risk factors for falls, and many factors related to future falls have been identified. The best predictors appear to be a history of falls and abnormalities of gait or balance (20). Among older adults, the strongest associations were reported for history of falls for all fallers (21). According to these findings, we used history of falls to categorize participants as fallers or non-fallers.

At present, recommending any single screening test for clinical practice is not possible. Poor balance is one of the major risk factors for falls among older adults (22). Furthermore, the force platform technique has been extensively used as a tool to assess balance (22). Force platform balance tests provide valid information about postural control that can be used to predict fall risk, even among older people without apparent balance problems or fall history (23). Only few studies have tested the sensitivity and specificity of posturog-

raphy techniques, let alone positive or negative predictive values (5). A systemic review, in which nine original prospective follow-up studies using the force platform as a tool to measure postural balance were included, aimed to determine whether posturography measurements can predict falls among elderly people (22). Associations between falls and certain sway parameters were found in only five of nine prospective studies. In this review it was concluded that certain aspects of force platform data may have predictive value for subsequent falls, especially various indicators of the lateral control of posture. However, the small number of studies available makes it difficult to draw definitive conclusions (22). In a recent study, it was suggested that the ability to control balance while standing with eyes open on a compliant surface, as a static posturographic finding, showed a high association with the fall history of older people (24). The role of the instrumented assessment of balance in clinical decisions has been recently reviewed and the contribution of center of pressure related measures in the detection of the risk of falling has been reported (25). Despite all these studies, the contribution of posturographic balance assessment to the prediction of falls remains unclear in the literature. On the other hand, our results demonstrated that posturography shows promising psychometric properties and good discriminant features for distinguishing fallers to non-fallers in community-dwelling elderly. In this preliminary study, the threshold established for posturographic fall risk index might identify individuals who should receive further comprehensive fall assessment and treatment to prevent falls.

A potential limitation of the present study is that data on fall frequency were collected retrospectively and were dependent on the subject's recall of the previous year. Moreover, the present study was performed only in a clinical setting, therefore the sample may not be representative of the general population of community-dwelling older adults because they were volunteers. Finally, further longitudinal prospective studies with larger sample sizes are needed to determine the predictive validity of posturographic measurements for detecting risk of falling in community-dwelling elderly in epidemiologic studies, because associations with fall history may not equate to predicting fall risk. After this preliminary study, we also planned prospective fall risk prediction of posturographic fall risk index for the cut-off value 51 established in this study.

In conclusion, it was shown that approximately one third of elderly participants fell at least once in the last year and that fallers had poorer balance, functional mobility, lower extremity neuromuscular function and quality of life compared to non-fallers. The study also exhibited that a posturographically obtained fall risk was positively correlated with clinical balance tests and afforded good discriminative ability in the identification of fallers.

Declaration of interest

We have no conflicts of interest.

REFERENCES

1. Gillespie LD, Gillespie WJ, Robertson MC, et al. Interventions for preventing falls in elderly people. Cochrane Database Syst Rev 2003;(4):CD000340. (PMID:14583918).
2. Tinetti ME, Speechley M, Ginter SF. Risk factors for falls among elderly persons living in the community. N Engl J Med 1988;319:1701–7. (PMID:3205267).
3. Muir SW, Berg K, Chesworth B, et al. Balance impairment as a risk factor for falls in community-dwelling older adults who are high functioning: A prospective study. Phys Ther 2010;90(3):338-47. (PMID:20056721).
4. Gates S, Smith LA, Fisher JD, Lamb SE. Systematic review of accuracy of screening instruments for predicting fall risk among independently living older adults. J Rehabil Res Dev 2008;45(8):1105-16. (PMID:19235113).
5. Visser JE, Carpenter MG, vander-Kooij H, Bloem BR. The clinical utility of posturography. Clin Neurophysiol 2008;119(11):2424-36. (PMID:18789756).
6. Berg KO, Maki BE, Williams JI, et al. Clinical and laboratory measures of postural balance in an elderly population. Arch Phys Med Rehabil 1992;73(11):1073-80. (PMID:1444775).
7. Sahin F, Yilmaz F, Ozmaden A, et al. Reliability and validity of the Turkish version of the Berg Balance Scale. J Geriatr Phys Ther 2008;31:32-7. (PMID:18489806).
8. Ozdemir O, Gökce Kutsal Y. Fall risk assessment of elderly by using posturography. Turkish Journal of Geriatrics 2009;12:177-80.
9. Wall JC, Bell C, Campbell S, Davis J. The timed get-up and go test revisited: Measurement of component tasks. J Rehabil Res Dev 2000;37:109-13. (PMID:10847578).
10. Jones CJ, Rikli RE, Beam WC. A 30-s chair-stand-test as a measure of lower body strength in community-residing older adults. Res Q Exerc Sport 1999;70(2):113-9. (PMID:10380242).
11. Ware JE, Sherbourne CD. The MOS 36-item Short-Form Health Survey (SF-36). I. conceptual framework and item selection. Med Care 1992;30:473-83. (PMID:1593914).
12. Kocyigit H, Aydemir O, Fisek G, et al. Validity and reliability of Turkish version of Short-form 36. Journal of Drug and Therapy 1999;12:102-6.
13. Hausdorff JM, Rios DA, Edelber HK. Gait variability and fall risk in community living older adults. A 1-year prospective

study. Arch Phys Med Rehabil 2001;82:1050–6. (PMID:11494184).
14. Scott V, Votova K, Scanlan A, Close J. Multifactorial and functional mobility assessment tools for fall risk among older adults in community, home-support, long-term and acute care settings. Age Ageing 2007;36:130-9. (PMID:17293604).
15. Shumway-Cook A, Brauer S, Woollacott M. Predicting the probability for falls in community-dwelling older adults using the timed up and go test. Phys Ther 2000;80:896–903. (PMID:10960937).
16. Chiu AY, Au-Yeung SS, Lo SK. A comparison of four functional tests in discriminating fallers from non-fallers in older people. Disabil Rehabil 2003;25:45–50. (PMID:12554391).
17. Lajoie Y, Gallagher SP. Predicting falls within the elderly community: comparison of postural sway, reaction time, the Berg Balance scale and the Activities-specific Balance Confidence (ABC) scale for comparing fallers and non-fallers. Arch Gerontol Geriatr 2004;38:11–26. (PMID:14599700).
18. Muir SW, Berg K, Chesworth B, Speechley M. Use of the Berg balance scale for predicting multiple falls in community-dwelling elderly people: A prospective study. Phys Ther 2008;88:449-59. (PMID:18218822).
19. O'Sullivan M, Blake C, Cunningham C, et al. Correlation of accelerometry with clinical balance tests in older fallers and non-fallers. Age Ageing 2009;38:308-13. (PMID:19252205).
20. Ganz D, Bao Y, Shekelle PG, Rubenstein LZ. Will my patient fall? JAMA 2007;297(1):77–86. (PMID:17200478).
21. Deandrea S, Lucenteforte E, Bravi F, et al. E. Risk factors for falls in community-dwelling older people: A systematic review and metaanalysis. Epidemiology 2010;21:658-68. (PMID:20585256).
22. Piirtola M, Era P. Force platform measurements as predictors of falls among older people:A review. Gerontology 2006;52:1–16. (PMID:16439819).
23. Pajala S, Era P, Koskenvuo M, et al. Force platform balance measures as predictors of indoor and outdoor falls in community-dwelling women aged 63-76 years. J Gerontol A Biol Sci Med Sci 2008;63(2):171-8. (PMID:18314453).
24. Merlo A, Zemp D, Zanda E, et al. Postural stability and history of falls in cognitively able older adults: The Canton Ticino study. Gait Posture 2012;36(4):662-6. (PMID:22832469).
25. Nardone A, Schieppati M. The role of instrumental assessment of balance in clinical decision making. Eur J Phys Rehabil Med 2010;46:221–37. (PMID:20485225).