The role of geriatric assessment tests and anthropometric measurements in identifying the risk of falls in elderly nursing home residents

Bulent Yardimci, MD, Sinan N. Aran, MD, Ismail Ozkaya, PhD, Sevki M. Aksoy, MD, Tarik Demir, MD, Gulsen Tezcan, MD, Aysegul Y. Kaptanoglu, MD.

ABSTRACT

الأهداف: لتحديد العلاقة بين خطر السقوط، وتقييم الشيخوخة، والقياسات البشرية، بما في ذلك دراسة مصغرة للحالة النفسية، ومقياس الاكتئاب المسنين، واختبار المقبض، واختبار مسكة المفتاح.

الطريقة: اشتملت هذه الدراسة الاستباقية على 89 مقيم في المستشفى خلال الفترة من مايو 2014م حتى سبتمبر 2015م في وحدة رعاية المسنين، مستشفى اسطنبول باليكلي رم، اسطنبول، تركيا. بمتابعة المرضى لمدة سنة واحدة وتسجلت السقوط. تم استخراج السجلات الطبية للمرضى وتحليلها.

النتائج: أدرجت مجموعة 89 مريض، تضم 37 رجل و 52 امرأة بمتوسط عمر 75.8 ± 8.2 سنة في الدراسة. وكانت معدلات الوقوع السنوية للسكان 1.0 ± 1.5. وقد تم تحديد أهم العوامل المهمة للتنبؤ وهي كتلة العضلات، ومؤشر الهيكل العظمي والعضلات، والتحليل الطيفي للجسم ، وقوة عضلات الذراع المهيمنة، والتحليل الطيفي للذراع المهيمنه، والكتلة الخالية من الدهون.

الخاتمة: أن الاختبار المصغر للحالة النفسية ومقياس الشيخوخة والاكتئاب ومقياس ووتون برودي مع اختبار المقبض، ومشي 6 أمتار سيراً على الأقدام واختبار التحليل الطيفي للكشف عن خطر السقوط والمتكررة للمقيمين المعرضين للسقوط في مركز كبار السن.

Objectives: To determine the relation among the risk of falls, geriatric assessment, and anthropometric measurements, including the mini mental state examination, geriatric depression scale, handgrip test, and key pinch test.

Methods: This prospective study included 89 residents hospitalized between May 2014 and September 2015 in the geriatric care unit of the Istanbul Balikli Rum Hospital, Istanbul, Turkey. Patients were followed-up for one year, and their falls were recorded. Medical records of the included patients were retrieved and analyzed.

Results: A total of 89 patients, comprising 37 men and 52 women with an average age of 75.8 ± 8.2 years were included in the study. The residents' annual falling averages were 1.0 ± 1.5. The most significant factors were identified to be predicted muscle mass, skeletal muscle index, whole body bioimpedance, dominant arm muscle strength, dominant arm bioimpedance, and free fat mass.

Conclusions: The mini mental test, geriatric depression scale and lawton-brody scale combined with the handgrip, 6-meters walking, and bioimpedance tests are favorable for detecting the risk of falls and recurrent falls in vulnerable elderly nursing home residents.

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From the Department of Internal Medicine (Yardimci), Division of General Internal Medicine, Faculty of Medicine, Istanbul Bilim University, Istanbul, the Department of Internal Medicine (Aran), Istanbul Florence Nightingale Hospital, the Department of General Surgery (Aksoy), Bahcesehir University Medical Faculty, the Department of Nursing Home (Demir, Tezcan), Balikli Rum Hospital, Istanbul, the Department of Nutrition and Dietetics (Ozkaya), Kirklareli University Health School, Kırklareli, and the Department of the Health Management Section (Kaptanoglu), Faculty of Health Sciences, Trakya University, Edirne, Turkey.

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Address correspondence and reprint request to: Asst. Prof. Bulent Yardimci, Department of Internal Medicine, Division of General Internal Medicine, Faculty of Medicine, Istanbul Bilim University, Istanbul, Turkey. E-mail: bulentyardimci@yahoo.com

Since 1960, the ratio of the elderly >60 years has increased by 57% and 80 years by 26.6%, in Turkey.[1] This increase resulted in an additional number of nursing homes. In combination with other healthcare problems, falls are a major problem in these homes because half of the injured residents remain disabled or bedridden afterward. Accordingly, falls may lead to higher rates of hospitalization resulting from hip fractures, brain injuries, and upper extremity injuries.[2] In addition, 2.2% of falls may lead to death.[3,4] According to the World Health Organization,[5] 28-35% of people >65 years fall at least once a year. The ratio increases with age and reaches 32-42% by 70 years and 50% by 80 years. The risk of falls is 3-fold higher in nursing home residents than in the elderly living in the community.[6] Approximately 30-50% of nursing home residents fall at least once a year, whereas 40% fall more than once.[2,7-9] Aging leads to muscle loss and strength.[10,11] The handgrip test is an anthropometric test, which may indicate frailty and physical disability in the elderly. It is a valid and reliable tool to assess muscle strength.[12-15] Another valid method of measuring muscle strength is the key pinch test, which assesses the strength of the more distal muscles. Sarcopenia is the main reason for the decrease in muscle strength in the elderly. It is defined as the loss of skeletal muscle mass and muscle strength occurring with advancing age. Bioimpedance evaluates the volume of fat and lean body mass, and it is an inexpensive and easy-to-use test.[16] This study evaluates whether there was any relation among the risk of falls, geriatric assessment, and anthropometric measurements (namely, mini mental test, geriatric depression scale, handgrip, and key pinch tests). In addition, it assesses if there is any correlation between these tests and bioimpedance measurements.

Methods. This prospective study included 89 residents hospitalized between May 2014 and September 2015 in the Geriatric Care Unit, Istanbul Balikli Rum Hospital, Istanbul, Turkey. Patients confined to bed, who walk with assistance, those with neurologic disorders (namely, severe ataxia and epilepsy), those lacking one of the lower extremities, those using a supporting device for walking and those who did not wish to participate in the study were excluded. Written consent was obtained from all patients, or their guardian for participation in the study.

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The patients were examined by one physician in charge of the geriatric care unit, and all tests were performed by this physician. The patients whose height and weight were measured underwent the mini-mental state examination test (mini mental test, the reliability of which has been acknowledged in Turkish),[17] geriatric depression scale and lawton-brody scale inquiries. The total points were calculated for each test according to the responses. Subsequently, the patients underwent the handgrip, key pinch and bioimpedance tests. During the study, the Jamar Hydraulic Hand Dynamometer (Sammons Preston Rolyan, UK) was used for the handgrip test, Jamar Baseline Hydraulic Pinch Gauges (Sammons Preston Rolyan, UK) for the key pinch test, and Tanita BC 418 Bioimpedance (Tanita Corporation, Tokyo, Japan) device for the bioimpedance tests. All instruments were approved by the International Conformité Européenne and calibrated by the Istanbul Florence Nightingale Biomedical Department.

Handgrip test. The patient in a sitting position gripped the device as much as possible with a 90° elbow-arm angle, without any other support. The handgrip distance of the device was adjusted by the physician according to the hand size of the patient. This test was performed 3 times for the right and left arms at 5 minutes intervals. For both arms, the average of these 3 measurements was calculated in kilograms.[18]

Key pinch test. This test was performed within the framework of the same position and protocol as the handgrip test. However, the patients were requested to grip as hard as they could while holding the device between their thumb and index finger. This test was performed 3 times for the right and left hands in intervals of 5 minutes. For both hands, the average of these 3 measurements was calculated per kilogram.[18]

Bioimpedance test. The patients were asked to step onto the device barefooted and step on the footmarks, hold the handgrips with both hands and stand firm without assistance. Following the automatic measurement by the device, they were told to step off. In the case of any loose contact (namely, skin thickening of the hands and feet), the test was repeated after these regions were moistened using conductive gel. The documents printed out by the device were recorded on the chart that was prepared by the same physician for the purpose of this study.

Six-meter up and go test. The patients were seated on standard chairs with a sitting height of 46 cm. They were dressed in footwear and clothing. Starting with the command 'get up', they walked the marked distance of 3 meters, returned and sat back on the chair. The time passing from the 'get up' command until the return to a seated position was recorded by the physician in seconds. The patients were followed-up for one year, and their falls were recorded. The analysis was performed by assigning the residents into 3 subgroups: Group 1 included residents who did not fall during the follow-up period; Group 2 included residents who fell once; and Group 3 included residents who fell at least twice during the follow-up period. Group 3 was defined as repetitive falls group.

Statistical analyses were performed using the Statistical Package for Social Sciences (SPSS Inc., Chicago, IL, USA) version 15.0 software. For the descriptive statistics, numerical variables are expressed as an average, standard deviation, minimum, maximum and median. The categorical variables were represented as the number and percentage. For the comparisons of more than 2 independent groups in which the numeric variables fulfil the normal distribution conditions, a one-way analysis of variance was performed, and when it was not, the Kruskal-Wallis test was performed. The subgroup analysis was performed by parametric and Tukey tests. The non-parametric test was performed by a Mann-Whitney U test and interpreted using the Bonferroni correction. Since the parametric test condition was not fulfilled, the relation between the numeric variables was examined using the Spearman Correlation Analysis. In independent groups, the rate comparisons were compared via a Chi-square analysis. The risk factors were analyzed using the Linear and Logistic Regression Analysis. The cut-off values were determined using the receiver operating characteristic (ROC) curve analysis. The statistical alpha significance level was considered to be $p<0.05$.

Results. There were 91 residents at the beginning of the study. One resident refused to participate and another was bedridden. Hence, both were not included in the study. A total of 89 nursing home residents, comprising 37 men and 52 women, with an average age of 75.8±8.2 years were included in this study. The nursing home resident-evaluated parameters are summarized in **Table 1**.

The mean age in Groups 1, 2, and 3 were summarized in **Table 2**. The annual fall rate of female nursing home residents was 1.3±1.7, whereas it was only 0.7±1.1 for men. The fall rate of the female nursing home residents was significantly higher than that of the male nursing home residents (p=0.040). The nursing home residents' annual number of falls was statistically positively correlated with age (p=0.007), whole body bioimpedance (p<0.001), dominant leg (p<0.001) and dominant arm bioimpedance (p<0.001). Falls were negatively correlated with body mass index (BMI) (p=0.026), mini mental test (p=0.007), geriatric depression scale (p=0.037), lawton-brody scale (p<0.001), free fat mass (FFM) (p<0.001), predicted muscle mass (p<0.001) and skeletal muscle index (p<0.001).

In the model formed from the variables, which were found to be correlated with the number of falls in a year in the single variable analysis, the backward

Table 1 - Demographic characteristics and anthropometric measurements of 89 nursing home residents.

Demographic characteristics	Mean ± SD
Mean age	75.8±8.2 (64-97)
Gender n (%)	
Men	37 (41.6)
Women	52 (58.4)
Falls in a year n (%)	1.0±1.5
None	42 (47.2)
1 time	25 (28.1)
2 times or more	22 (24.7)
Body mass index	28.2±6.2 (14.7-56.4)
Mini mental test	16.0±8.8 (0-33)
Geriatric depression scale	13.8±5.8 (0-26)
Lawton-brody scale	2.4±2.7 (0-8)
Six-metre up & go test	22.7±14.4 (8-63)
Dominant handgrip	13.2±9.4 (0.5-48)
Dominant key-pinch	4.3±2.1 (0.5-12.5)
Dominant arm circumference	29.6±5.7 (17-51)
Dominant biceps skinfold	19.9±11.0 (4-42)
Dominant triceps skinfold	22.0±9.3 (6-43)
Fat %	33.2±8.8 (10.4-55)
Fat mass	24.7±11.0 (3.4-69.8)
Free fat mass	47.6±10.0 (29.7-73.6)
Bioimpedance whole body	594.7±103.2 (398-891)
Bioimpedance dominant leg	249.1±55.9 (139-404)
Bioimpedance dominant arm	319.6±53.5 (227-472)
Predicted muscle mass	25.7±5.1 (16.8-37.5)
Skeleton muscle mass index n (%)	10.0±1.3 (7.5-13.3)
Normal	25 (28.1)
Sarcopenia moderate	49 (55.1)
Sarcopenia severe	15 (16.9)

Values are given as Mean ± SD (min-max)

method, predicted muscle mass ($p<0.001$, odds ratio [OR] 95% confidence intervals [CI]: 0.717-0.908) and geriatric depression scale ($p=0.002$, OR 95% CI: 0.554-0812) were identified as the most significant factors in determining the number of falls in a year. A significant difference was identified for age, BMI, mini mental test, geriatric depression scale, lawton-brody scale, right key pinch, right biceps skinfold, right triceps skinfold, FFM, whole body bioimpedance, dominant leg muscle strength, dominant arm muscle strength, predicted muscle mass, and skeletal muscle index averages for each group on the basis of the annual number of falls (**Table 2**).

Only the lawton-brody scale average of the nursing home residents with no falls in a year was significantly higher than that of those who had fallen once ($p=0.014$). We did not determine any other statistically significant differences for any of the other parameters. Statistically significant differences in all variables were found comparing the nursing home residents with no falls and the nursing home residents who fell twice, or more in a year. The only exceptions were found for the dominant key pinch ($p=0.067$) and dominant triceps skinfold average ($p=0.358$). The age and whole body bioimpedance tests of the patients who fell twice, or more were significantly higher, and all other parameters were significantly lower. The significance level of the nursing home residents who fell once and those who fell twice or more was statistically significant with the exception of age, BMI, mini mental test, geriatric depression scale, lawton-brody scale, dominant biceps skinfold and dominant leg muscle strength averages (**Table 3**).

Regarding gender ($p=0.123$) and low muscle strength ($p=0.799$) between groups, no statistically significant differences were found in the number of falls in a year. There was a significant difference in the number of falls in a year in the nursing home residents with sarcopenia ($p<0.001$). Specifically, there was a high rate of the nursing home residents with severe sarcopenia who fell twice or more (**Table 4**). In the model, which was formed to analyze the factors that determine the likelihood of

Table 2 - Demographic characteristics and anthropometric measurements in the fall groups of the residents.

Demographic characteristics	Falls in a year (Mean ± SD)			
	None (Group 1)	One time (Group 2)	≥2 (Group 3)	*P*-value
Age	73.8 ± 8.4	76.5 ± 8.4	78.9 ± 6.6	0.025
Body mass index	29.2 ± 6.0	29.1 ± 6.7	25.4 ± 5.0	0.041
Mini mental test	18.2 ± 8.1	16.2 ± 7.9	11.4 ± 9.6	0.020
Geriatric depression scale	14.7 ± 4.7	15.2 ± 5.9	10.5 ± 6.7	0.036
Lawton-brody scale	3.2 ± 2.7	1.8 ± 2.4	1.4 ± 2.6	0.002
Six-metre up & go test	24.5 ± 16.0	18.3 ± 10.0	24.2 ± 14.8	0.339
Dominant handgrip	14.5 ± 10.4	14.2 ± 8.9	9.5 ± 6.9	0.129
Dominant key-pinch	4.6 ± 2.4	4.7 ± 1.7	3.5 ± 1.6	0.024
Dominant arm circumference	29.1 ± 5.1	30.9 ± 5.9	29.0 ± 6.5	0.410
Dominant biceps skinfold	21.0 ± 10.7	20.7 ± 10.9	17.1 ± 11.8	0.041
Dominant triceps skinfold	21.8 ± 8.9	25.3 ± 9.1	18.5 ± 9.3	0.047
Fat %	32.4 ± 7.7	34.2 ± 9.8	33.8 ± 9.8	0.575
Fat mass	25.3 ± 10.3	26.4 ± 12.8	21.6 ± 10.1	0.266
Free fat mass	51.7 ± 10.1	47.7 ± 8.9	39.7 ± 5.7	<0.001
Bioimpedance whole body	554.5 ± 76.0	583.8 ± 95.8	683.8 ± 105.9	<0.001
Bioimpedance dominant leg	233.4 ± 36.2	246.5 ± 50.4	284.1 ± 62.5	0.001
Bioimpedance dominant arm	302.2 ± 43.0	315.9 ± 52.0	357.0 ± 56.4	<0.001
Predicted muscle mass	27.7 ± 4.9	26.0 ± 4.7	21.7 ± 3.2	<0.001
Skeleton muscle mass index	10.5 ± 1.1	10.1 ± 1.1	8.9 ± 1.0	<0.001

falling (Model 1: age, gender, mini mental test, geriatric depression scale, BMI, lawton-brody scale, 6 meters up and go test, dominant handgrip, dominant key pinch, dominant arm circumference, dominant biceps skinfold, dominant triceps skinfold, FFM, whole body bioimpedance, predicted muscle mass, and skeleton muscle mass index), the most significant factors were identified as the geriatric depression scale, dominant arm circumference, dominant triceps skinfold, FFM, and skeleton muscle mass index (**Table 5**).

Discussion. This study has shown that advanced age, female gender, deteriorated mini mental test, increased depression, decreased body mass index, decreased lawton-brody scale and decreased gait speed are associated with an increased risk of falling in the elderly. In addition, handgrip and key pinch tests of the dominant arm, whole body bioimpedance and estimated muscle mass measurements are reliable tools for predicting the risk of falls.

Our results have revealed that advanced age is an indicator of possible repetitive falls in the elderly. The

Table 3 - Demographic characteristics and anthropometric measurements, post hoc analysis, alpha significance levels of the patients that are admitted to the nursing home in their fall groups.

Demographic characteristics	Fall in a year (P-value)		
	None versus one time	None versus ≥2 times	One time versus ≥2 times
Age	0.149	0.008	0.263
Body mass index	0.953	0.014	0.052
Mini mental test	0.343	0.006	0.070
Geriatric depression scale	1.000	0.013	0.043
Lawton–brody scale	0.014	0.001	0.280
Dominant key pinch	0.370	0.067	0.004
Dominant biceps skinfold	0.917	0.095	0.158
Dominant triceps skinfold	0.277	0.358	0.032
Free fat mass	0.145	<0.001	0.002
Whole body bioimpedance	0.233	<0.001	0.002
Dominant leg muscle strength*	0.527	<0.001	0.023
Dominant arm muscle strength*	0.513	<0.001	0.014
Predicted muscle mass	0.213	<0.001	0.002
Skeleton muscle mass index*	0.445	<0.001	<0.001

*Parametric test $p<0.001$, other comparisons, Bonferroni correction $p<0.017$

Table 4 - Gender and sarcopenia rates in the fall groups of residents.

Gender and sarcopenia	Fall in a year (%)			
	None	1 time	≥2 times	P-value
Gender				0.123
Male	22 (59.5)	9 (24.3)	6 (16.2)	
Female	20 (38.5)	16 (30.8)	16 (30.8)	
Sarcopenia				<0.001
Normal	15 (60.0)	9 (36.0)	1 (4.0)	
Medium	24 (49.0)	14 (28.6)	11 (22.4)	
Severe	3 (20.0)	2 (13.3)	10 (66.7)	

Table 5 - Multivariate regression analysis for predicting falls (backward model; Model 1).

Multivariate regression	*P*-value	Odds ratio	95% confidence interval (min-max)
Geriatric depression scale	0.063	0.894	0.794 - 1.006
Dominant arm circumference	0.028	1.225	1.022 - 1.467
Dominant triceps skinfold	0.043	0.895	0.804 - 0.997
Free fat mass	0.043	0.867	0.756 - 0.995
Skeleton muscle mass index	0.023	0.373	0.159 - 0.872

mean age of Group 3 was significantly higher than that of Groups 1 and 2. This result was expected because the current literature has repeatedly shown that advanced age represents a risk factor for falls.[19-24] Tinetti et al[19,20] showed that 50% of people >80 years will fall at least once in a year. Moreover, a meta-analysis found that physiological senescence as well as chronological aging are contributing factors of falls in the elderly.[25] However, there is conflicting data regarding gender as a risk factor. Although some authors showed that there is no significant difference in the rates of falls between the 2 genders, others reported the opposite findings.[26-28] Many authors suggested that females are more prone to falls than males.[27] Aoyama et al[28] attributed the increased risk of falls in women to the lack of postural sway control and inadequate anteroposterior stability. Similarly, our results have shown that female nursing home residents are more likely to fall than their male counterparts. In particular, 32 (68%) female and only 15 (32%) male residents fell during the follow-up period. Moreover, severe organ injuries due to falls are more frequent in women, particularly in those who have accompanying chronic systemic diseases. Women are more likely to suffer from fractures, whereas men are more likely to suffer from brain injuries, which may lead to more severe clinical conditions in men. Although, we have seen many falls during our study, we did not report any fall-related deaths.

Aging is a natural process of life. However, it is associated with several declining attributes, including the loss of bone and muscle mass, strength and vision. Although these particular features are well defined, objective assessment tools are required for measuring these losses to delineate the group at the most risk of falls in the elderly. Under this perspective, the handgrip and key pinch tests might be valuable objective tools. The handgrip test is an easy procedure to assess upper extremity muscle strength and has many advantages. It is performed with a portable device, and the test can be repeated without causing any discomfort to the resident. The key pinch test functions similar to the handgrip test; however, it evaluates the most distal muscles of the upper extremities. Several studies have shown that both tests are effective in assessing the muscle strength and life expectancy of the elderly.[29,30] In our study, we found that the mean handgrip value in Groups 2 and 3 was significantly lower than that in Group 1. This finding shows that the muscle strength and mass were more protected in residents who did not fall during the follow-up period. In addition to the handgrip test, we report that the mean key pinch results were significantly lower in residents who fell at least once during the follow-up period. Reis et al[31] reported similar results in 65 subjects who were at least 67 years. They observed that handgrip measurements dropped as the frequency of falls increased. Furthermore, in a report that included 1882 participants, the authors showed that the frequency of sarcopenia and falls are higher in subgroups which have lower values in the handgrip tests.[32]

Our results reveal that the decreased BMI was associated with a possible risk of falls. In contrast, bioimpedance tests reveal that fat-free mass was significantly lower in residents who fell recurrently. This finding might be expected because individuals who have a higher BMI may not have a proper ratio of skeletal mass. Although some people may have a higher index, this might be the result of a higher fat ratio of the body. The tests concerning the ratio of muscle to fat were performed using bioimpedance. Whole body bioimpedance is an important tool to assess the body composition of fat and muscle, and a higher bioimpedance is associated with an increased ratio of fat.[33,34] As expected, the mean bioimpedance value of Group 3 was significantly higher than that of Groups 1 and 2. The residents who had a lower muscle mass and a higher proportion of body fat were more prone to falls during the follow-up period. This finding is supported by previous reports, which found that a decrease in fat mass by 5% leads to a decreased risk of falls by 30%.[35] There are many factors contributing to falls in the elderly. Loss of physical strength and skeletal muscle mass are well-known contributors. However, the deterioration of cognitive function and dementia may also lead to an increased number of falls in this fragile population. Impaired cognition and deficit are associated with an increased risk of falls. Nursing home residents with dementia have been reported to fall twice as frequently as those with normal levels of cognition. In our study, we assessed the cognitive functionality of nursing home residents using the mini-mental test and geriatric depression scale. The mini mental test is an easy examination, which can be performed in a short period and effectively assesses the mental status of the patient. In our study, the mean test results were significantly impaired in Group 3 and were lower in Group 2. The geriatric depression scale is also a valuable tool and has high sensitivity and specificity rates. This test is particularly useful because most cases of depression are missed in the elderly and can be identified with this simple test. Our results have demonstrated that residents who presented with recurrent falls were more prone to depression. This finding is in line with similar studies presented in the literature.[36,37] Moreover, dementia and cognitive dysfunctions are regarded as non-modifiable risk factors for falls in the elderly.[38-41] Two important factors limited our investigation, at least in part: 1) this was a single-center study; and 2) the analysis was performed on a small number of patients.

In conclusion, our study has shown that the mini mental test, geriatric depression scale, lawton–brody scale combined with the handgrip, 6-meters walking test, and bioimpedance tests are favorable for detecting the risk of falls and recurrent falls in vulnerable elderly nursing home residents. These tests may aid in delineating the groups at the highest risk of falls and in need of dedicated rehabilitation as well as medical therapy to avoid falls and subsequent injury.

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