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Examination of the Scales and Tests Evaluating the Risk of Falling in Stroke Patients

İnme Hastalarında Düşme Riskini Değerlendiren Ölçek ve Testlerin İncelenmesi

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ABSTRACT Objective: The aim of this study was to examine the Berg Balance Scale, Timed Up and Go Test, Functional Reach Test in individuals with stroke and to compare the distinctive sensitivity and specificity of these scales and tests for falling and non-falling individuals. **Material and Methods:** The 83 stroke individuals participated in the study. The balance level and risk of falling were evaluated with Berg Balance Scale, Timed Up and Go Test and Functional Reach Test. To evaluate the differentiation of Berg Balance Scale, Timed up and Go Test and Functional Reach Test between falling and non-falling individuals with stroke, receiver operating characteristic analysis was used and the area under the curve was calculated. **Results:** According to the history of falling, we compared values of the Berg Balance Scale, Timed up and Go Test, and Functional Reach Test. It was seen that the individuals with the history of falling had lower Berg Balance Scale and Functional Reach Test values and higher the Timed Up and Go Test score ($p<0.05$). The clinical cut-off points for the Berg Balance Scale, Timed up and Go Test, Functional Reach Test was calculated as 45.5 points (area under the curve=0.731), 15.22 sec (area under the curve=0.707), 22.25 cm (area under the curve=0.714), respectively. **Conclusion:** As a result of this study, it was found that all tests identified individuals who fell and did not fall; however, the Berg Balance Scale was more sensitive in determining the risk of falling. Our results are important in terms of showing reference values for clinicians working in neurological rehabilitation.

Anahtar Kelimeler: Stroke; postural balance; falling; cut-off point

ÖZET Amaç: Çalışmamızın amacı, inmeli bireylerde Berg Denge Ölçeği, Zamanlı Kalk ve Yürü Testi, Fonksiyonel Uzanma Testi'ni incelemek ve bu ölçek ve testlerin, düşen ve düşmeyen bireyler için ayırt edici duyarlılığını ve özgüllüğünü karşılaştırmaktır. **Gereç ve Yöntemler:** Çalışmaya, 83 inmeli hasta katıldı. Denge seviyesi ve düşme riski Berg Denge Ölçeği, Zamanlı Kalk ve Yürü Testi ve Fonksiyonel Uzanma Testi ile değerlendirildi. Berg Denge Ölçeği, Zamanlı Kalk ve Yürü Testi, Fonksiyonel Uzanma Testinin, inmeli hastalarda düşen ve düşmeyen hastaları ayırt ediciliğini değerlendirmek amacıyla alıcı işletim karakteristiği eğrisi analizi yapıldı ve eğri altında kalan alan hesaplandı. **Bulgular:** Berg Denge Ölçeği, Zamanlı Kalk ve Yürü Testi, Fonksiyonel Uzanma Testi değerlerini düşme öyküsüne göre karşılaştırdığımızda, düşme öyküsü olan bireylerin daha düşük Berg Denge Ölçeği ve Fonksiyonel Uzanma Testi değerlerine sahip oldukları ve Zamanlı Kalk ve Yürü Testi sürelerinin daha yüksek olduğu görüldü ($p<0,05$). Berg Denge Ölçeği, Zamanlı Kalk ve Yürü Testi, Fonksiyonel Uzanma Testi için klinik kesme noktası sırasıyla 45,5 puan (eğri altında kalan alan=0,731), 15,22 sn (eğri altında kalan alan=0,707), 22,25 cm (eğri altında kalan alan=0,714) olarak belirlendi. **Sonuç:** Bu çalışmanın sonucunda tüm testlerin düşen ve düşmeyen bireyleri belirlediği, ancak Berg Denge Ölçeğinin düşme riskini belirlemede daha hassas olduğu bulundu. Sonuçlarımız, nörolojik rehabilitasyon alanında çalışan klinisyenlere referans değerleri göstermesi açısından önemlidir.

Keywords: İnme; postüral denge; düşme; kesme puanı

Stroke causes disability, and one of the most common complications of stroke is falling. It was reported in previous studies that 50-70% of individuals with stroke fall particularly after discharge, and the falling has negative effects on the results of the rehabilitation and functional recovery.[1,2] Therefore, preventing falls is one of the important targets of stroke rehabilitation. Decreased motor function, im-

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paired balance, visual-spatial problems, decreased senses, gait disorders, fear of falls, and cognitive function are among the risk factors for falling.[3-5]

Hyndman et al. reported that balance function is an important factor for predicting falls in stroke patients.[6] Accordingly, it is important to evaluate the reactive and proactive balance function in individuals with stroke in the clinic in predicting the risk of falling.[7] Various proactive balance and functional mobility tests and scales were used in the literature to determine the fall risk in individuals with stroke; however, the results are conflicting. Berg Balance Scale (BBS), Functional Reach Test (FRT), and Timed Up and Go (TUG) Test are among the most commonly used tools to evaluate proactive balance and functional mobility in individuals with stroke.[8-10] Although there is no gold standard among these methods; the important thing is that the scales and tests that will be used are practical, valid and reliable, sensitive and specific.[8] The psychometric properties of BBS were investigated in many disease groups, and is frequently used in neurological diseases.[6,8,11] The TUG Test is a simple test that was developed by Podsiadlo and Richardson used to evaluate functional mobility. The high intra-rater and inter-rater reliability of this test in stroke patients was proven.[11,12] In addition, a number of different studies reported that the TUG Test is sensitive and specific in predicting falls.[13] Although the FRT, which is used to determine the risk of falling and evaluate dynamic balance, was designed to evaluate functional mobility in the elderly population; less studies were conducted about the use of FRT in individuals with stroke than other scales. Smith et al. concluded that FRT was a fast and easy-to-use balance test and was associated with BBS in acute and subacute strokes. In another study, it was found that FRT allocates individuals who fall and who do not fall in chronic stroke individuals.[9,14] There are differences in the literature regarding the cut-off point of the BBS and TUG Test as in the FRT cut-off point. Also, the number of studies in the literature is less regarding which scale better determines the risk of falling in individuals with stroke.

Therefore, the aim of this study was to examine the BBS, TUG, FRT in individuals with stroke and to compare the distinctive sensitivity and specificity of these scales and tests for falling and non-falling individuals.

MATERIAL AND METHODS

This study was a cross-sectional study and was carried out between April 2020 and August 2020. The individuals, who were diagnosed with ischemic or hemorrhagic stroke by a specialist physician, who were able to walk 10 m independently with or without support, over the age of 18, were included in the present study. The socio-demographic and clinical data of individuals (i.e. age, body mass index, dominant hand, affected side, stroke type, and history of falling) were recorded. The individuals who fell twice or more in the last year were recorded as fallers. The study was approved by Non-Interventional Ethics Committee of Kırıkkale University (Decision no: 2020.03.03; Date: 2020.03.04). Informed consent forms were obtained from all participating individuals. The study was carried out in accordance with the Helsinki Declaration principles. The power of the study was determined by post-hoc power analysis. G*Power program (version 3.0.10 Universität Düsseldorf, Düsseldorf, Germany) was also used. In the post-hoc power analysis, when the statistical significance of alpha was found to be 5% and the confidence interval was taken as 95%, the power (1-β) of the study was found to be 96%. Primer outcome was determined as BBS.

Individuals with Mini Mental Test score were <24, those with other neurological or musculoskeletal problems that would affect functionality and balance other than stroke, and those with contraindications for advanced cardiovascular disease and mobilization were not included in the study. The balance level and risk of falling were evaluated with BBS, TUG, and FRT.

BERG BALANCE SCALE

BBS is a scale that is designed to evaluate the balance quantitatively and determine the risk of falling. BBS consists of 14 items. Each item is scored between 0-4 depending on the ability of the patient to meet the specific time and distance requirements of the test. According to the scores received from this test, the cases are divided into groups as "high risk of falling (0-20 points)", "moderate risk of falling (21-

40 points)", "low risk of falling (41-56 points)", and it is accepted that the highest score of 56 shows the best balance. The validity and reliability of BBS were examined in stroke patients.[15] The standard error of measurement and the smallest real differences of BBS were calculated as 2.4 and 6.7, respectively.[16]

TIMED UP AND GO TEST

TUG was used to evaluate the balance and risk of falling of patients. A standard chair was used for the test. Firstly, the patient was asked to sit on the chair by leaning on it. Then, the patient was asked to stand up and walk regularly at a distance of 3 meters, and to return at the end of 3 meters, and sit in the chair again. The walking time of the patient during the test was recorded in seconds. The test was repeated 3 times, and the mean value was recorded.[9] The absolute and relative minimal detectable change at the 95% confidence interval for TUG were shown 8 seconds and 28%.[17]

FUNCTIONAL REACH TEST

FRT was used to functionally measure the both balance and the amount of dynamic reach of the individual. A measuring tape was glued to the wall when the patient was standing on the edge of a wall on the patient's shoulder level. Firstly, the patient was asked to make fist with his/her hand, and extend arm straight forward, and the distance reached at the third metacarpophalangeal joint level was recorded. Then the patient was asked to extend as far as s/he could before s/he stood up from the ground. The maximum value without losing balance, reaching and going back to old position was measured. The measurements were repeated 3 times, and the average of these three values was recorded. Validity and reliability study of FRT was performed in individuals with stroke.[9]

STATISTICAL ANALYSIS

Statistical analysis was performed using IBM SPSS Statistics V23.0 (IBM Corp, Armonk, NY, USA). The fitness of the variables to the normal distribution was tested with the Kolmogorov-Smirnov test. All numerical variables were expressed as arithmetic mean±standard deviation. The relationship between BBS, TUG and FRT was evaluated by Spearman correlation test. The Spearman correlation coefficient values were interpreted in the following way; very high 0.90-1.00, high: 0.70-0.90, moderate 0.50-0.70, low 0.30-0.50, and negligible 0.00-0.30. The receiver operating characteristic (ROC) curve is a graphical representation of the relationship between sensitivity and specificity. With the help of curves, the best threshold value for a test can be determined and the most suitable model can be decided. Therefore, ROC curve was used to determine the cut-off scores for significant predictors of risk of falling according to history of falling. The Youden index (sensitivity + [1 - specificity]) was calculated and the largest Youden index was chosen to determine the cut-off score. Also the area under the curve (AUC) is calculated. An AUC value of 0.50 did not show sensitivity, and a value of 1.00 represented excellent sensitivity and specificity.[18] The statistical level of significance was determined as $p<0.05$.

RESULTS

This study included a total of 83 individuals with stroke (age 62.03±10.28 years, post stroke 16.64±27.62 month) in the study. The sociodemographic and clinical data of the individuals are shown in Table 1.

When the correlations between the BBS, TUG, FRT values were examined, a high relationship was found between the BBS and TUG (rho=0.706, p=0.001), and a moderate relationship between FRT and TUG (rho=0.500, p=0.001) and BBS (rho=0.671, p=0.001).

The clinical cut-off point for the BBS, TUG, FRT was determined as 45.5 points (AUC=0.731; 72% sensitivity and 62% specificity), 15.22 sec (AUC=0.707; 72% sensitivity and 49% specificity), 22.25 cm (AUC=0.714; 72% sensitivity and 62% specificity), respectively (Table 2). It was also found that the BBS, TUG and FRT were statistically significant at moderate level accuracy (Figure 1, Figure 2, Figure 3).

DISCUSSION

As a result of our study, it was shown that BBS, TUG, and FRT allocates individuals who had risk of falling and who did not fall in individuals with stroke, and are good markers for determining the falls. The BBS

TABLE 1: The demographic and clinical variables of the participants (n=83).

Variable	Values
Gender	
Female, n (%)	22 (26.5)
Male, n (%)	61 (73.5)
Age (years), mean±SD	62.03±10.28
BMI (kg/m^2), median (minimum-maximum)	26.39 (15.56-48.83)
Stroke duration (month), median (minimum-maximum)	4 (1-84)
Stroke etiology, n (%)	
Hemorrhagic	21 (25.3)
Ischemic	62 (74.7)
Stage, n (%)	
Subacute	44 (853)
Chronic	39 (47)
Dominant hand, n (%)	
Right	68 (81.9)
Left	15 (18.1)
Affected side of the body, n (%)	
Right	41 (49.4)
Left	42 (50.06)
History of falling, n (%)	
Nonfallers	47 (56.6)
Fallers	36 (43.6)
BBS score, median (minimum-maximum)	45 (7-56)
TUG (second), median (minimum-maximum)	18 (5.39-90)
FRT (cm), mean±SD	21.42±9.13

SD: Standard Deviation; BMI: Body Mass İndex; BBS: Berg Balance Scale; TUG: Timed Up and Go Test; FRT: Functional Reach Test.

TABLE 2: The area under the curve, sensitivity, and specificity of Berg balance scale, timed up and go test, and functional reach test.

Variable	AUC	Sensitivity (%)	Specificity (%)	p value
BBS (score)	0.731	72.0	62.0	0.001*
TUG(sec)	0.707	72.0	49.0	0.001*
FRT (cm)	0.714	72.0	62.0	0.001*

p<0.05; AUC: Area Under the Curve; BBS: Berg Balance Scale; TUG: Timed Up and Go Test; FRT: Functional Reach Test.

is the most commonly used test among the balance scales in the literature. The predictive values of BBS were investigated in different populations in many studies, and different cut-off and AUC values were reported for each population. In a study on chronic obstructive pulmonary disease patients, the BBS cut-off value was reported as 52.5 with 73% sensitivity and 77% specificity; and the AUC value was reported to be 0.84 (95% CI=0.72-0.96).[19] In another study with older individuals, the BBS scale had 95.5% sensitivity and 95.5% specificity, and it was observed that the AUC value was 0.96.[20] In studies on individuals with stroke, different values were reported. According to the history of the falling in the study conducted by Maeda et al., it was found that the BBS cut-off value was 31 with an accuracy of 81.1%.[21] In another study, it was reported that there was a correlation between the number of falls in stroke patients and the BBS score, the BBS score was useful in predicting falling, and that the falls increased when BBS fell below 44 points.[22] In the study conducted by Tsang et al., the cut-off value of the BBS in chronic stroke individuals was 50.5% with 52% specificity and 80.2% accuracy, and the AUC value was 0.72 (95% CI=0.61-0.83).[23] In the study comparing two clinical scales that evaluated the balance, Madhavan et al. reported that BBS had a cut-off value of 47.5 with 81% sensitivity and 56% specificity, and the AUC value was 0.67.[24] In an other study, Sahin et al. examined different balance scales in the Turkish population, and showed with ROC analysis that the cut off value of BSS was 46.5 with 75% sensitivity and 76.9% specificity, and the AUC value had moderate accuracy (AUC=0.81).[25] As a result of our study, BBS cut-off and AUC values were found to be 45.5 points and 0.731, respectively.

TUG is a test of functional mobility and fall in the elderly, and is used widely in the clinic.[12] It is also

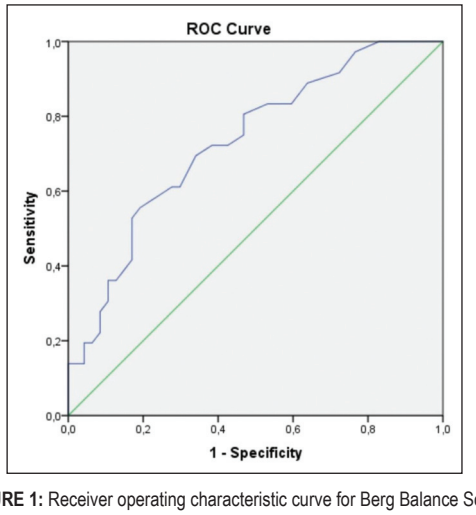

FIGURE 1: Receiver operating characteristic curve for Berg Balance Scale.

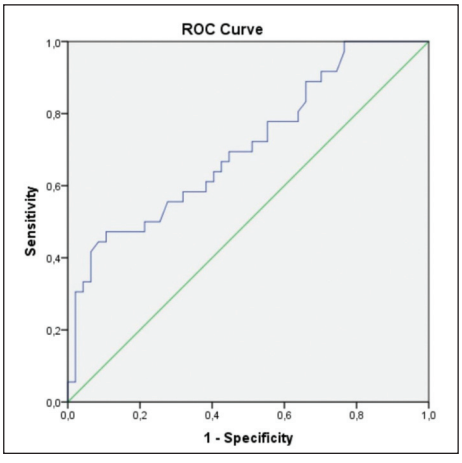

FIGURE 2: Receiver operating characteristic curve for Timed Up and Go Test.

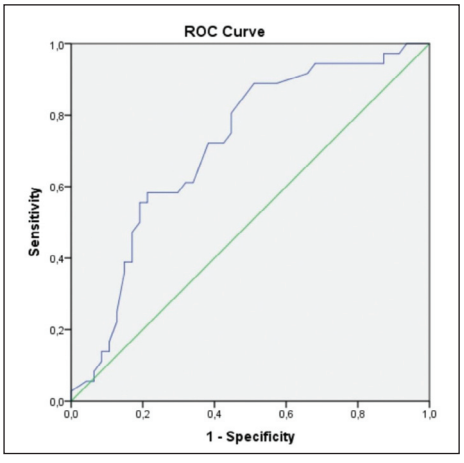

FIGURE 3: Receiver operating characteristic curve for Functional Reach Test.

frequently used to assess the dynamic balance of patients in neurological rehabilitation. The psychometric properties of TUG were investigated in many studies, and different cut-off values were reported.[17,26,27] In their study, Alghadir et al. reported that TUG and BBS had excellent intra-rater reliability.[26] TUG cut-off value was reported to be between 12.6-15.3 in studies conducted in older individuals.[28-31] A study on multiple sclerosis patients reported that TUG cut-off value validated individuals falling by 51%, and individuals who did not fall by 37%, with a cut-off value of 19.34 sec (70% sensitivity at and 43% specificity), and that BBS cut-off value was 44%.[32] The cut-off value for TUG in stroke patients is not clearly known. Different values were reported in previous studies.[10,13] Pinto et al. reported the accuracy as 25 sec 66% with optimum cut-off point of 36%, sensitivity of 90%, specificity as -25 sec. An et al. conducted a study with individuals with chronic stroke, and reported the cut-off value of TUG as 14.87 sec, and the AUC value as 0.871 (95% CI=0.797-0.945) based on the level of Independent Community Ambulation.[10,13] In another study of chronic stroke individuals according to the history of falling, it was also found that TUG had a cut-off of 60.9% sensitivity and 67.01% specificity as 19 sec, and AUC=0.66 (95% CI=0.53-0.80).[23] As a result of our study, the cut-off value of TUG was calculated as 0.707 with 15.22 sec AUC. FRT was designed to detect balance disorder in older individuals and the changes in balance performance over time. In recent years, it has also been used to determine the risk of balance and fall in neurological diseases. However, compared to BBS and TUG, the psychometric analysis studies are less common in the literature. Alenazi et al. showed that there was a relation between FRT and the number of falls in chronic stroke individuals, and the number of falls increased as the FRT value decreased, and argued that this was indicative of weak balance.[9] The FRT cut-off value was reported to be 18.15 in this study. In another study, the FRT cut-off was with 52% sensitivity and 74% specificity at 24.1 cm according to the history of falling in chronic stroke individuals, and AUC=0.67 (95% CI=0.55-0.79).[23] As a result of the present study, the cut-off and AUC values of FRT were 22.25 cm and 0.707, respectively.

In the present study, the sensitivity and specificity of the scale and tests used frequently in the clinic were examined separately according to the history of falling. In terms of AUC value, it was found that BBS, FRT and TUG had a moderate specificity, but BBS had the highest value. When the sensitivity and specificity of these methods were compared, the test with the highest specificity was BBS. The test with the highest sensitivity was FRT. When the properties of the tests were considered, all of them evaluate the dynamic balance, but BBS additionally evaluates static balance. The fact that BBS is functional balance scale including functional reach and TUG explains the high AUC value, including many functions.

CONCLUSION

As a result of the present study, it was found that all tests identified the individuals who had fallen and who had not; however, BBS had a higher AUC value in determining the risk of falling than other tests. Our results are important in terms of showing reference values for clinicians working in neurological rehabilitation.

LIMITATIONS

The low number of sample is one of the limitation of the present study. A healthy control group was not added to our study. In future studies, psychometric properties of these scales and tests can be compared with a control group. Subacute and chronic individuals who could walk independently were included in our study. Studies are needed to verify the ability of these balance tests in determining the risk of falling, comparing larger number of sample and results in different phase. In addition, generalization can be made by comparing the results with objective measurement methods evaluating the balance and postural control like Biodex or posturography.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Saniye Aydoğan Arslan, Cevher Demirci;* ***Design:*** *Saniye Aydoğan Arslan, Cevher Demirci;* ***Control/Supervision:*** *Kübra Uğurlu, Zekiye İpek Katırcı, Saniye Aydoğan Arslan.* ***Data Collection and/or Processing:*** *Kübra Uğurlu, Zekiye İpek Katırcı Kırmacı;* ***Analysis and/or Interpretation:*** *Saniye Aydoğan Arslan;* ***Literature Review:*** *Kübra Uğurlu, Cevher Demirci;* ***Writing the Article:*** *Saniye Aydoğan Arslan;* ***Critical Review:*** *Esra Dilek Keskin, Cevher Demirci, Zekiye İpek Katırcı Kırmacı;* ***References and Fundings:*** *Esra Dilek Keskin;* ***Materials:*** *Esra Dilek Keskin.*

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