Turkish Journal of Geriatrics
2015;18(2):151-155

Emir İbrahim IŞIK[1]
Filiz ALTUĞ[2]
Uğur CAVLAK[2]

RESEARCH

RELIABILITY AND VALIDITY OF FOUR STEP SQUARE TEST IN OLDER ADULTS

ABSTRACT

Introduction: The aim of this Cross-sectional descriptive study was to determine the reliability and validity of Four Step Square Test for use to evaluate balance ability in older adults.

Materials and Method: Participants were 44 men and 36 women (n=80; Mean age of the participants were 72.69±5.09 years. Participants performed the Four Step Square Test, the Time Up & Go test, the Functional Reach test, the One Leg Standing test and completed the Berg Balance Scale.

Results: The Four Step Square Test has good Cronbach's Alpha (0.96) with the other balance measures. The Four Step Square Test has good correlations with the Time Up & Go test ($p<0.001$) and in the same way there were a good correlations between the Four Step Square Test and Berg Balance Scale ($p<0.001$).

Conclusion: Four Step Square Test is a reliable and valid tool for measuring the dynamic balance ability in older adults.

Key Words: Postural Balance; Aged; Reproducibility of Results.

ARAŞTIRMA

YAŞLILARDA DÖRT ADIM KARE TESTİNİN GEÇERLİLİK VE GÜVENİLİRLİK ÇALIŞMASI

ÖZ

Giriş: Bu çalışma dengeyi değerlendirmek için kullanılan Dört Adım Kare Testi (Four Step Square Test)'nin yaşlılarda geçerlilik ve güvenilirlik çalışmasını yapmak amacıyla planlanmıştır.

Gereç ve Yöntem: Araştırmaya 65-85 yaş aralığında 80 yaşlı birey alınmıştır. Olguların 44'ü erkek, 36'sı kadındır. Katılımcıların ortalamaları 72,69±5,09 yıldır. Bu araştırmada olguların denge yetenekleri Berg Denge Skalası, Süreli Kalk Yürü Testi, Fonksiyonel Uzanma Testi, Tek Ayak Üzerinde Durma Testi ve Dört Adım Kare Testi ile değerlendirilmiştir.

Bulgular: Dört Adım Kare Testinin geçerliliği için; daha önce geçerlilik ve güvenilirliği saptanmış testler ile Dört Adım Kare Testi skorları karşılaştırılmıştır. Cronbach Alpha ölçümü sonucu ise 0,96 bulunmuştur. Dört Adım Kare Testi ile Süreli Kalk Yürü Testi arasında güçlü bir ilişki ($p<0,001$) ve aynı şekilde Dört Adım Kare Testi ile Berg Denge Skalası arasında da güçlü bir ilişki ($p<0,001$) bulunmuştur.

Sonuç: Dört Adım Kare Testi yaşlılar için geçerli ve güvenilir bir testtir.

Anahtar Sözcükler: Postural Denge; Yaşlı; Geçerlilik ve Güvenilirlik.

Correspondance

Filiz ALTUĞ
Pamukkale University, School of Physical Therapy and Rehabilitation, DENİZLİ

Phone: 0258 296 42 54
e-mail: fkural@pau.edu.tr

Received: 24/11/2014

Accepted: 02/03/2015

[1] Private Rehabilitation Center, GAZİANTEP
[2] Pamukkale University, School of Physical Therapy and Rehabilitation, DENİZLİ

INTRODUCTION

The ageing process has chronological, biological, social and psychological dimensions. The physiological and physical changes that occur among the elderly limit or prevent some activities in individuals (1). The prevalence of some acute and chronic diseases is related to the ageing process. Ageing is related to a high incidence of functional and physical deficiency regardless of whether it is related to a particular disease (2). Falls resulting in injuries increased by 46%–60%, depending upon the amount that physical activity level decreases of 19%–26% on elderly (3). The most important causes of falling among older adults are a decrease in mobility and in ability to maintain balance. Most falls that result in injuries occur during movement. The balance is the ability of keeping the centre of body gravity within the support level and ability of maintaining this situation (1,2,4).

Clinical, laboratory and functional approaches are used to evaluate balance in the elderly (1,4,5). Clinical balance measurements include static balance tests, such as timed heel-toe stance and single leg stance (4,5,6). Laboratory balance tests assess dynamic postural reflexes using various tools and force platforms. In addition, balance evaluations in the laboratory environment frequently combine static and dynamic balance tests (4,5).

This study was planned with the aim of improving the objective evaluation method of the Four Step Square Test (FSST) used by the medical team that evaluates balance of older patients in the clinical setting. This study includes evaluating both its validity and reliability. The result of this study may help clinicians to use balance assessment to improve the quality of health of the elderly.

MATERIALS AND METHOD

Our study was conducted between May and August of 2013 on the elderly residents, aged 65–85 in nursing homes. Before starting the study, informed consent was obtained from the volunteer participants. Using inclusion and exclusion criteria described below, a total of 80 cases were found suitable for participating in the study.

Inclusion Criteria of the Study

- Healthy individuals aged 65–85
- Absence of a neurological or orthopaedic problem that may prevent the tests
- Absence of a vision or hearing impairment that may prevent the tests
- No history of surgery of a lower extremity or the lumbar spinal region
- Able to independently perform activities of daily living

Exclusion Criteria of the Study

- Individuals with a result of 7 or less on the Hodkinson's Abbreviated Mental Test
- Presence of a cognitive, vision or hearing impairment,
- Individuals with a lower extremity impairment that could affect balance.

This study was certified by the Pamukkale University Medical Ethics Committee (B.30.2.PAU.0.20.05.09/90).

Outcome Measurement

Demographic features, dominant extremity, educational background, additional diseases, use of adaptive mobility equipment and vision and hearing disorders of all participants were recorded.

Static and dynamic balance tests were used to evaluate balance level of the participants. The Single Leg Stance Test (SLST) and Functional Reach Test (FRT) were used as static balance tests. The Four Step Square Test (FSST), Timed Up and Go Test (TUGT) and Berg Balance Scale (BBS) were used as dynamic balance tests.

Before obtaining measurements, we informed the participants regarding the tests and the positions they would be asked to perform in them. The physical therapist (PT), who recorded each test in the study, demonstrated the correct way to perform each position. Then, before each test, the participants were allowed to make one timed trial to accustom them to the measurement method and decrease the potential negative effect of unfamiliarity with the test on their scores. Because multiple tests were recorded per session, 5-min rest breaks were provided to the participants to reduce the potential effect of fatigue on the results.

Static Balance Tests

The Single Leg Stance Test (SLST); one leg is raised without touching the standing leg. At the beginning, the eyes remain open. The patient is instructed to close his/her eyes, and he/she should sustain his/her balance for 30 second. If the raised leg touches the supporting leg, if the raised leg touches the ground, if the patient hops on the standing leg, or if he/she touches something for balance, the presence of a balance disorder is suspected.

Inability to balance on one leg for 30 s during SLST is an indicator of decreased balance function. However, the clinical expectation for the ability to balance on one leg decreases based on the patient's age. Healthy individuals who are 60–69-year-old should be able to stand on one leg with eyes open for at least 5 s (7).

Functional Reach Test (FRT); developed by Duncan et al., FRT is a reliable and validated test used in clinical measurement of balance. While standing barefoot in a relaxed position, the patient is instructed to raise his/her right arm to 90° and then to reach forward with the right arm to the farthest position that he/she can without taking a step and losing his/her balance. During FRT, the physical therapist observes whether the patient keeps both feet on the ground and does not step forward. If either of these behaviors occurs, the patient repeats the test. Functional Reach Test is repeated three times, and the best measurement is recorded (8). Decreased reach ability indicates that the patient's has an increased future fall risk; a value of 15 cm or lower indicates a markedly increased fall risk, whereas a value of 15–25 cm indicates a mild fall risk (9,10).

Dynamic Balance Tests

The Four Step Square Test (FSST); test clinically assesses the ability to change directions while stepping. At the beginning of the test, the patient stands on the upper left square (Square 1) and faces in the direction of Square 2. First, the stepping sequence is clockwise: Square 1, followed by Squares 2, 4 and 3. Then, the stepping sequence is counterclockwise: Square 3, followed by Squares 4, 2, and 1. The patient is instructed to step through the sequence as quickly a possible without touching the canes and contacting both feet with the ground in each square (10). The physical therapist demonstrates the test and the patient is allowed to practice the pattern to learn the sequence. The test is repeated if the patient cannot complete the sequence successfully or if he/she either loses his/her balance or touches the cane. Two scores are obtained, and the better of these two scores is recorded. The timed effort begins when the first foot touches the ground in Square 2 and then ends when the patient's second foot contacts the ground in Square 1 (10,11,12).

Timed Up and Go Test (TUGT); the test evaluates functional mobility, balance and performance in adults aged 65 years and older. Wearing his/her regular shoes and customary walking aids, the patient begins the test seated in a standard armchair with his/her back against the chair, arms rested on the chair's arms and both feet flat on the floor. The patient is instructed to rise and walk to a line on the floor 3 m away, turn around at the line, walk back to the chair and sit down in the chair. The test ends when the patient's buttocks touch the seat. The test is repeated twice; the fastest time is recorded.

A time of <10 s is classified as mobile, <20 s as generally independent and >30 s as limited mobility (10,13,14).

Berg Balance Scale (BBS); test is a 14-item scale designed to measure balance of the elderly in a clinical setting. It can be used to detect the fall risk. Each item is scored between 0 and 4 points in accordance with the ability of the patient to meet specific time and distance requirements of the test. The lowest level of function indicates '0' indicates the lowest level of function and '4' indicates the highest level of function. The patient's score the score indicates the ability in terms of completing the duty independently. The total score ranges from 0 to 56. For this study, scores ranging from 41 to 56 indicate that the patient's balance is good; scores ranging from 21 to 40 indicate that the patient's balance is acceptable (may need some assistance), and scores from 0 to 20 indicate that the patient's balance is poor (cannot ambulate) (12,13).

Statistical Evaluation

All data were computed and calculated using Statistical Package for the Social Sciences (SPSS) for Windows statistical program (20.0 versions) $p<0.05$ was accepted statistically significant. Descriptive results were given as min-max., mean± standard deviation (mean±sd) and percentage (%). The Reliability Analyze was used to look Cronbach alpha value a selected sample (n=20) with one week interval (test-retest). Pearson correlation analysis was used to show the relation between FSST and other four balance tests (15).

RESULTS

A total of 80 were participants included in the study with average age of 72.69±5.09 participated to the study; 55% (n=44) were male and 45% (n=36) were female. Average height, body weight and body mass index (BMI) were 165.35±6.29 cm, 71.05±8.72 kg and 25.90±2.02 kg/m^2, respectively. The right lower extremity of 78.8% (n=63) was dominant, whereas the left lower extremity of 21.2% (n=17) was dominant.

Test-Retest Reliability

Test-Retest analysis was done to look Cronbach alpha (internal consistency) it was found to be 0.96 ($p<0.001$).

Table 1— Static and Dynamic Balance Test Results.

Balance Tests	Min. – Max.	mean±sd
Static Tests		
Single Leg Stance Test (sec)	2.90 -37.60	16.37±10.54
Functional Reach Test (cm)	3.30 – 26.20	9.38±4.02
Dynamic Tests		
Four Step Square Test (sec)	6.20 – 26.50	15.24±5.06
Timed Up and Go Test (sec)	6.60 - 35	15.18±5.61
Berg Balance Scale score (max=56)	38 - 56	50.08±4.19

Table 2— Relation of Four Step Square Test with Balance Tests.

Balance Tests	Four Step Square Test	
	r	p
Static Tests		
Single Leg Stance Test	-0.348	< 0.01*
Functional Reach Test	-0.232	< 0.05*
Dynamic Tests		
Timed Up and Go Test	0.595	< 0.001*
Berg Balance Score	-0.641	< 0.001*

*Pearson Correlation Analysis.

When static balance test results were examined, the average values of SLST and FRT were 16.37±10.54 s and 9.38±4.02 cm, respectively. According to FRT results, the majority of participants showed a high fall risk. When dynamic balance test results examined, the average values of FSST, TUGT and BBS were 15.24±5.06 s, 15.18±5.61 s and 50.08±4.19, respectively. Berg Balance Scale results showed no significant balance impairment in our study group. Static and dynamic test results are shown in Table 1.

Simultaneous Validity

When the relationship between FSST and the other balance tests was examined, a negative statistically significant (r=-0.348; p <0.01) relationship with SLST among static balance tests was observed. Similarly, a negative statistically significant (r=-0.232; p=p<0.05) relationship was observed between FSST and FRT.

When the relationship between FSST and other dynamic balance tests was examined, a positive statistically significant (r=0.595; p<0.001) relationship was observed with TUGT among static balance tests. A negative (r=-0.641; p<0.001) relationship was observed between FSST and BBS. The relationship of FSST with static and dynamic balance tests is shown in Table 2.

Discussion

In our study, according to the test-retest reliability results of FSST, it was determined that FSST was homogenous and has strong internal reliability. When simultaneous validity results were examined, it was determined that FSST is a valid test method for assessing balance among the elderly.

Dite et al. (3) studied 81 geriatric patients (average age, 70 years) to rate validity and reliability of FSST in Australia. Their participants were divided into three groups. The first group consisted of patients who had fallen two or more times in the previous 6 months, the second group consisted of patients who had fallen less than once in the previous 6 months and the third group consisted of patients who had never fallen in the previous 6 months. They used TUGT, FRT and FLST tests as well as FSST to assess balance and observed a negative relationship (r=-0.83) between FSST and TUGT scores as well as a negative relationship (r=-0.47) with FRT and a positive relationship (r=0.88) with TUGT (p<0.001). The optimum score of the FSST to differentiate between the individuals with decreased balance and an increased risk of falling from healthy individuals was at 15 s. The results of our study showed scores similar to those of Dite et al.; this indicates that FSST can be used effectively to rate balance and fall risk in both of these communities.

Whitney et al. observed average FSST scores among their 32 participants (average age, 67.3 years) of 13.6 s. They divided participants into three groups based on the number of falls each participant reported per day. The group of participants who had no falls received FSST scores from 9 to 11 s; the individuals who fell once a day received scores from12 to 18 s, and the participants who reported falling two or more times per day received scores from 14 to 21 s. The average FSST score in our study was 15.24 s. Comparing our scores with those of Whitney et al., we observed that our FSST scores were reliable to identify our participants as individuals with a significant risk of falling (16).

Blennerhassett, et al. used FSST method to asses pre-treatment and post-treatment balance on 37 ambulatory hemiparetic individuals (14 right hemiparetic, 16 left hemiparetic and seven bilateral hemiparetic), with an average age of 53 years. Average FSST score of the pre-treatment individuals was 20.8±15.0 s; Average FSST score of the post-treatment individuals was 17.9±11.6 s. According to these results, FSST is

a sensitive and reliable test not only for healthy elderly individuals but also for evaluating balance changes receiving hemiparetic rehabilitation services (17).

Ceceli et al. measured SLST scores of their elderly participants to be 12.4±10.73 s. In our study, the average SLST score was 16.37±10.54 s, which negatively correlated (r=-0.348) with FSST (p<0.01) (18,19). In contrast, Ceceli et al. stopped recording when their participants successfully reached the time of 30 s. Therefore, two groups of SLST scores differed.

Finally, several tests have clinical uses to evaluate balance in the elderly. We observed there are very few easily understandable clinical methods that are simple and fast to administer. We believe that FSST, whose validity and reliability we evaluated in this study, is important for because it is easy to administer, requires only a short time to administer, is easy to understand and produces valid and objective results. We believe that studies on the application of FSST to patient populations with different types of impairments as well as with other age groups can help to determine valid cut-off scores that may indicate risks of falling.

Conflict of Interest

All authors of this study declare no conflict of interest.

References

1. Narin S. Geriatric Rehabilitation. In: Algun CZ. Physiotherapy and Rehabilitation. Nobel Med Press, İstanbul, Turkey 2013, pp 213-35. (in Turkish).
2. Lewis CB, Cobbs EL, Laftin MT. Effective geriatric rehabilitation is not non-individualized group health education. J Rehabil Med 2011;43(6):558. (PMID:21461554).
3. Dite W, Temple VA. A clinical test of stepping and change of direction to identify multiple falling older adults. Arch Phys Med Rehabil 2002;83(11):1566-71. (PMID:12422327).
4. Hagedorn DK, Holm E. Effects of traditional physical training and visual computer feedback training in frail elderly patients. A randomized intervention study. Eur J Phys Rehabil Med 2010;46(2):159-68. (PMID: 20485221).
5. Ullmann G, Williams HG, Hussey J, Durstine JL, McClenaghan BA. Effects of Feldenkrais exercises on balance, mobility, balance confidence and gait performance in community-dwelling adults age 65 and older. J Altern Complement Med 2010;16(1):97-105. (PMID: 20070145).
6. Lihavainen K, Sipilä S, Rantanen T, Kauppinen M, Sulkava R, Hartikainen S. Effects of comprehensive geriatric assessment and targeted intervention on mobility in persons aged 75 years and over: a randomized controlled trial. Clin Rehabil 2012;26(4):314-26. (PMID:22007041).
7. Stevenson TJ, Garland SJ. Standing balance during internally produced perturbations in subjects with hemiplegia: validation of the balance scale. Arch Phys Med Rehabil 1996;77(7):656-62. (PMID:8669991).
8. O'Sullivan BS, Schmitz TJ. Parkinson's Disease. In: O'Sullivan SB, Schmitz TJ, Fulk GD. Physical Rehabilitation. 5th edition, F.A Davis Company, Philadelphia, USA 2007, pp 853-95.
9. Schulz BW, Hughes SH, Gordon MT, Bulat T. Training implications of maximal forces on a computer-controlled and motor-driven leg press by age group, sex, footplate direction, and speed. Experimental Gerontology 2012;47(4):295-303. (PMID:22289381).
10. Duncan PR, Earhart GM. Four Square Step Test performance in people with Parkinson Disease. J Neurol Phys Ther 2013;37(1):2-8. (PMID:23364168).
11. Shubert TE, McCulloch K, Hartman M, Guiliani CA. The effect of an exercise-based balance intervention on physical and cognitive performance for older adults: a pilot Study. J Geriatr Phys Ther 2010;33(4):157-64. (PMID:21717919).
12. Gunendi Z, Demirsoy N, Ozyemisci-Taskiran O. The effect of 4-week aerobic exercise program on postural balance in postmenopausal women with osteoporosis. Rheumatol Int 2008;28(12):1217-22. (PMID:18648815).
13. Harrison JK, McArthur KS, Quinn TJ. Assessment scales in stroke: climetric and clinical considerations. Clin Interv Aging 2013;8:201-11. (PMID:23440256).
14. Müjdeci B, Aksoy S, Atas A. Evaluation of the balance in fallers and non-fallers elderly. Braz J Otorhinolaryngol 2012;78(5):104-9. (PMID:23108828).
15. Cook DA. Medical desicion making: what do we trust? J Gen Intern Med 2010 ;25(4):282-3. (PMID:20217269).
16. Whitney SL, Marchetti GF, Morris LO, Sparto PJ. The reliability and validity of the four square step test for people with balance deficits secondary to a vestibular disorders. Arch Phys Med Rehabil 2007;88(1):99-104. (PMID:17207683).
17. Blennerhassett JM, Jayalath VM. The Four Square Step Test is a feasible and valid clinical test of dynamic standing balance for use in ambulant people poststroke. Arch Phys Med Rehabil 2008;89(11):2156-61. (PMID:18996245).
18. Ceceli E, Kocaoğlu S, Okumuş M, Gökoğlu F, Yorgancıoğlu R. The relation between balance, age and functional status in geriatric patients. Turkish Journal of Geriatrics 2007;10(4):169-72. (in Turkish).
19. Baczkowicz D, Szczegielniak J, Proszkowiec M. Relations between postural stability, gait and falls in elderly persons-preliminary report. Ortop Traumatol Rehabil 2008;10(5):478-85. (PMID:19043353).