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Original Article

Physiotherapy Section

Test-retest Reliability of Balance Error Scoring System in Individuals with Osteoarthritis Knee: A Cross-sectional Study

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ABSTRACT

Introduction: Osteoarthritis (OA) of the knee is a degenerative joint disease that leads to changes not only in the articular cavity but also in the ligaments, tendons and muscles. These structures play an important role in human balance, which is important for daily activities. Due to the degeneration of ligaments, tendons and muscles, OA of the knee results in balance impairment.

Aim: To evaluate the test-retest reliability of the Balance Error Scoring System (BESS) in patients with OA of the knee.

Materials and Methods: This cross-sectional study was conducted at Department of Physiotherapy, MMIPR, MMDU, Ambala, Haryana, India, from March 2023 to April 2024. A total of 20 participants were recruited for the study and balance was evaluated using BESS on a firm surface, first in double limb stance, then in single limb stance and finally in tandem stance, both with eyes open and closed. A single rater conducted the same process twice on a foam surface. Descriptive statistics were used to represent the demographic characteristics of the participants. Reliability was examined using both Intraclass Correlation Coefficients (ICCs) and Cronbach's alpha was executed to check internal consistency.

Results: The mean age of the participants in the present study was 49.4±10.6 years and the Body Mass Index (BMI) was 26.2±4.2. Both males 9 (45%) and females 11 (55%) were recruited for the present study. When comparing the demographic characteristics between males and females using an independent t-test, it revealed that no significant difference exists between them. The reliability analysis demonstrated excellent reliability for all parameters of BESS (ICC: 0.9). Cronbach's alpha for all parameters was also 0.9. The limits of agreement plotted with the Bland-Altman plot indicated an excellent level of agreement, as the maximum scores fell within the 95% Confidence Interval (CI).

Conclusion: Based on the findings of the present study, the authors can conclude that BESS is a reliable tool for balance assessment in patients with OA of the knee.

Keywords: Joint diseases, Joint inflammation, Knee ligament, Ligament degeneration

INTRODUCTION

The OA knee is characterised by progressive degeneration [1] of the capsule, tendon, ligament, cartilage and meniscus, which causes pain, swelling and stiffness [2]. OA is the most common form of degenerative disease that leads to musculoskeletal disorders of the knee, with a reported occurrence rate of 28.7% [3]. OA knee is one of the common disabling conditions that affect more than one-third of the population under 65 years of age and the incidence rate is higher in women than in men [2,3].

Obesity and old age are positively correlated as predisposing factors for developing OA knee, as shown in various studies [3-5]. OA is a disease of cartilage and obesity leads to cartilage breakdown and erosion, accompanied by bony changes such as osteophytosis, subchondral sclerosis and bony cysts [4]. Obesity increases joint load, causing the force exerted on the cartilage to make it more vulnerable. Additionally, obesity increases subchondral bony stiffness, which makes the subchondral bone less deformable under load, resulting in greater pressure on the cartilage and promoting damage and tears [5].

People suffering from OA knee experience mild to moderate loss of balance [6,7]. Normal balance control requires the integration of sensory information regarding proprioception, position sense and the ability to make appropriate motor responses [8,9]. It is controlled by sensory inputs, control processing and neuromuscular responses [10].

Joint proprioceptors are mainly present in joint cartilage, ligaments and tendons and they are more prone to damage in patients with OA knee due to the degeneration of articular surfaces and cartilage destruction. Thus, joint proprioception and position sense become compromised, resulting in decreased balance control, increased postural instability and ultimately a higher occurrence of falls [4,11,12]. Pain associated with OA knee is also considered a contributing factor to the loss of balance, which alters postural stability during functional activities [10,13].

To assess balance in patients with OA knee, a valid and reliable tool is necessary. Various clinical methods available for checking balance include the Timed Up and Go Test, Berg Balance Scale, 10-Metre Walking Test and Functional Reach Test, among others [14-16]. However, these methods may not effectively assess balance in patients with OA knee because they were specifically developed for neurologically impaired patients and do not assess all the various aspects of static balance control, such as standing on double limbs, single limbs, or in tandem. They also do not assess balance on hard surfaces as well as foam surfaces with eyes open and closed [16]. All these components of balance assessment are crucial for OA knee patients, as proprioceptors play a significant role in balance control [4,11,12].

Posturography quantitatively measures balance by estimating postural sway. The ability to control balance is primarily measured quantitatively using a force plate system that assesses various weight distributions of the feet. However, this method is costly and may not be available in various settings [16]. Therefore, we need a simple assessment tool that can reliably check the balance of patients with OA knee so that clinicians can effectively assess the efficacy of various therapeutic interventions.

The Balance Error Scoring System (BESS) is a simple tool that has already been used by researchers to reliably assess balance in athletes [17]. This system includes assessing the balance of individuals in double-leg stance, single-leg stance and tandem

stance on hard and foam surfaces, with eyes open and closed, respectively. The main advantages of BESS are that it is very simple, easy to use, requires less skill and is also less time-consuming. As the reliability of this tool in OA knee patients is still untested, the main purpose of the present study was to evaluate the test-retest reliability of BESS in patients with OA knee.

MATERIALS AND METHODS

The present cross-sectional study was conducted from March 2023 to April 2024 at Department of Physiotherapy, MMIPR, MMDU, Ambala, Haryana, India. The study was carried out in accordance with the ethical principles laid down by the World Medical Association in the Declaration of Helsinki, 2013. The study commenced after receiving ethical approval from the Student Project Committee of MMIPR (Approval No: SPC-2013-09). Written consent was obtained from every participant involved in the study. All participants were recruited from the outpatient department of MMIPR.

Inclusion criteria: Subjects with bilateral OA knee, aged 45 to 65 years, with pain levels between 4/10 and 7/10 on the Numeric Pain Rating Scale (NPRS) and a radiological diagnosis of grade 3 or 4 OA knee (according to Kellgren and Lawrence grading) were included [18]. Participants needed to be able to understand and follow simple commands.

Exclusion criteria: Subjects with a history of lower extremity surgery, neurological and/or orthopaedic impairments that may affect gait and balance, or any systemic illnesses other than OA, such as peripheral vascular disease, diabetes, heart disease, or rheumatoid arthritis, were excluded.

Sample size calculation: For the present study, the sample size was calculated using G*Power statistical software. The alpha value was set at 0.05, with 80% power to detect a minimum reliability coefficient of 0.75. The sample size was calculated to be 11; however, considering potential dropouts, a total of 20 participants were recruited.

Study Procedure

All the participants recruited in the present study were first assessed for their demographic characteristics, like age, height, weight and BMI. The BESS scale [19] was used for the test-retest reliability study and the principal investigator conducted all assessments over two consecutive days. The time gap between the assessment sessions was kept at 48 hours. The BESS consists of three different standing positions: double limb, single limb and tandem stance. Participants were instructed to stand in these three stances with both hands placed on their iliac crests. These three positions were repeated with eyes open and closed, first on a firm surface and then on a foam surface. Prior to the assessment, all participants were familiarised with the procedure. Each participant was allowed to take a 15-minute rest between stances to overcome fatigue.

The actual scoring of the original BESS scale includes the number of balance disturbances in 20 seconds; however, since the participants recruited in the present study had OA knee with pain, only the time until the first balance disturbance was recorded to minimise the chances of falls. Initially, the responses for the single limb stance and tandem stance were recorded according to the dominant leg, but responses for the opposite leg were also noted. This did not affect the actual scoring; the authors just wanted to assess the balance ability of both legs. Rather than recording multiple displacements, they only recorded the time for the first displacement.

STATISTICAL ANALYSIS

The data were analysed using the Statistical Package for the Social Sciences, version 20.0 (SPSS 20). The normality of the data was established by the Shapiro-Wilk test. Since the BESS data do not follow a normal distribution, descriptive statistics were reported as the median and Interquartile Range (IQR). The demographic characteristics of the recruited samples followed a normal distribution; therefore, they were represented as mean±Standard Deviation (SD) and an independent t-test was used to establish statistical significance. Intrarater reliability was established using the Intraclass Correlation Coefficient (ICC) with a 95% Confidence Interval (CI). To find the association between the two repeated sessions, the Spearman's rank correlation test (ρ) was used.

To check the internal consistency of the data, Cronbach's alpha was also estimated.

RESULTS

A total of 20 participants (9 males and 11 females) with OA took part in the present reliability study. None of them complained of any discomfort during the test. An independent t-test revealed that both males and females did not show any significant differences in their demographics, such as age, height, weight and BMI. Thus, it can be concluded that the males and females were matched in terms of age, height, weight and BMI, confirming that all the participants recruited had similar demographic characteristics [Table/Fig-1].

Demographic characteristic	Total (Mean±SD)	Male (Mean±SD)	Female (Mean±SD)	p-value
Age (years)	49.4±10.6	52±10.63	47±10.83	0.43
Height (cm)	157.2±9.8	164±6.21	151±8.4	0.10
Weight (kg)	65±12.91	69.17±14.14	61±11.58	0.30
BMI (kg/m^2)	26.2±4.2	25±4.06	26±4.60	0.59

[Table/Fig-1]: Demographic characteristics of male and female participants.

The ICC values of the repeated measures of two sessions by the same investigator for the BESS are displayed in [Table/Fig-2-4]. The average ICC value was 0.9 across all parameters. The Cronbach's alpha value was also 0.9 for all parameters, indicating that the internal consistency of the measured values was excellent.

BESS	Cronbach's alpha (α)	1st session Median (IQR)	2nd session Median (IQR)	ICC (95% CI)	ICC	Spearman's rho
DHO (s)	0.99	33 (17, 77)	37 (17, 66)	0.91-0.99	0.97	0.98
DHC (s)	0.99	29 (10.5, 70.5)	32 (10.50, 61)	0.91-0.95	0.97	0.97
DSO (s)	0.99	28 (10, 57.5)	30 (11.5, 58)	0.98-1	0.99	0.97
DSC (s)	0.99	20 (6, 52)	25 (6.5, 51)	0.94-0.99	0.98	0.98
SHO (s)	0.96	9 (6.50, 17.8)	12 (7.3, 19.3)	0.97-0.99	0.99	0.93
SHC (s)	0.95	5.5 (2.5, 10.5)	6.5 (3.5, 11.5)	0.74-0.97	0.91	0.92
SSO (s)	0.98	6 (3.3, 10)	6.5 (4, 10)	0.90-0.99	0.97	0.91
SSC (s)	0.99	3 (1.3, 7.8)	4 (1.8, 8)	0.93-0.99	0.98	0.95
THO (s)	0.99	9 (5, 23.5)	12.5 (6, 25.5)	0.91-0.99	0.97	0.85
THC (s)	0.98	7.5 (3.25, 19)	11 (5, 19.25)	0.85-0.99	0.95	0.86
TSO (s)	0.98	7.5 (3.8, 19.3)	9.5 (5, 21.8)	0.87-0.99	0.96	0.84
TSC (s)	0.96	6 (1.5, 13.5)	7.5 (4, 18.5)	0.74-0.97	0.91	0.92

[Table/Fig-2]: Reliability of Balance Error Scoring System (BESS) in patient with Osteoarthritis (OA)- Double limb support (in seconds).
DHO: Double limb support hard surface eyes open; DHC: Double limb support hard surface eyes closed; DSO: Double limb support soft surface eyes open; DSC: Double limb support soft surface eyes closed; SHO: Single limb support hard surface eyes open; SHC: Single limb support hard surface eyes closed; SSO: Single limb support soft surface eyes open; SSC: Single limb support soft surface eyes closed; THO: Tandem support hard surface eyes open; THC: Tandem support hard surface eyes closed; TSO: Tandem support soft surface eyes open; TSC: Tandem support soft surface eyes closed

BESS	Cronbach's alpha (α)	1st session	2nd session	ICC (95% CI)	ICC
RSHO (s)	0.99	8 (7, 20)	10 (8, 21.5)	0.96-0.99	0.99
LSHO (s)	0.99	10 (6, 17)	11 (6.5, 19)	0.97-0.99	0.99
RSHC (s)	0.96	5 (3, 11.5)	7 (3.5, 12)	0.78-0.98	0.93
LSHC (s)	0.94	5 (2, 9.5)	5 (3, 12)	069-0.98	0.90

RSSO (s)	0.98	7 (3.5,11)	7 (4, 11)	0.89-0.99	0.96
LSSO (s)	0.98	6 (2,10)	6 (3, 10)	0.89-0.99	0.97
RSSC (s)	0.97	3 (1, 9)	4 (2.5, 9.5)	0.82-0.98	0.94
LSSC (s)	0.99	2 (1, 8.5)	3 (1.5, 7.5)	0.90-0.99	0.97

[Table/Fig-3]: Reliability of Balance Error Scoring System (BESS) in patients with Osteoarthritis (OA)- Single limb support (in seconds) (Right and left limbs).
RSHO: Right single limb support hard surface eyes open; LSHO: Left single limb support hard surface eyes open; RSHC: Right single limb support hard surface eyes closed; LSHC: Left single limb support hard surface eyes closed; RSSO: Right single limb support soft surface eyes open; LSSO: Left single limb support soft surface eyes open; RSSC: Right single limb support soft surface eyes closed; LSSC: Left single limb support soft surface eyes closed

BESS	Cronbach's alpha (α)	1st session	2nd session	ICC (95% CI)	ICC
RTHO (s)	0.98	10 (5.5, 24)	12 (6.5, 26)	0.89-0.99	0.97
LTHO (s)	0.98	10 (6, 23)	11 (7, 25)	0.90-0.99	0.97
RTHC (s)	0.98	9 (3.5, 19.5)	10 (5, 19)	0.88-0.99	0.96
LTHC (s)	0.96	6 (3, 18.5)	11 (4.5, 19.5)	0.76-0.98	0.92
RTSO (s)	0.99	7 (4, 20)	10 (6, 21.5)	0.91-0.99	0.97
LTSO (s)	0.97	8 (3.5, 18.5)	9 (4, 22)	0.82-0.98	0.94
RTSC (s)	0.97	7 (1.5, 14.5)	8 (4.5, 18.5)	0.82-0.98	0.94
LTSC (s)	0.94	5 (1, 12.50)	7 (3, 18.50)	0.64-0.96	0.88

[Table/Fig-4]: Reliability of Balance Error Scoring System (BESS) in patients with Osteoarthritis (OA)- Tandem support (in seconds) (right and left feet).
RTHO: Right tandem support hard surface eyes open; LTHO: Left tandem support hard surface eyes open; RTHC: Right tandem support hard surface eyes closed; LTHC: Left tandem support hard surface eyes closed; RTSO: Right tandem support soft surface eyes open; LTSO: Left tandem support soft surface eyes open; RTSC: Right tandem support soft surface eyes closed; LTSC: Left tandem support soft surface eyes closed

DISCUSSION

The present study was done to check the test-retest reliability of BESS to assess balance in patients with OA knee. Results of the present study demonstrated that the test-retest reliability of BESS is satisfactory for assessing balance in this population.

A total of 20 participants were recruited for the present study and all shared similar demographic characteristics, indicating that the results were not influenced by age, gender, or BMI. ICC showed an excellent correlation between the two trials of BESS in patients with knee OA (ICC=0.97-0.99). The internal consistency of the trials was also reported to be high (0.99-0.96), demonstrating that the data were not only similar between the trials but also similar across participants.

Additionally, the authors employed Spearman's rank correlation to confirm the reliability of BESS and the results indicated an excellent correlation (r=0.98-0.84). According to the criteria set by Portney LG and Watkins MP for judging reliability values, there was a good degree of positive correlation between the two repeated sessions of BESS, with Spearman's r ranging from 0.84 to 0.98 [20]. The additional analysis of single limb stance and tandem stance between the right and left legs also showed excellent correlation (ICC=0.97-0.93 and ICC=0.97-0.88).

To the best of authors knowledge, the present study is the first to assess the test-retest reliability of BESS in patients with OA knee. This finding aligns with previous studies regarding the reliability of BESS in athletes. Hunt TN et al., conducted an inter-rater reliability study with 18 young athletes, achieving a good ICC score ranging from 0.78 to 0.96, which is very similar to the present study [21]. Broglio SP et al., also demonstrated good test-retest reliability of BESS with 48 normal young adults [22]. According to a systematic review by Bell DR et al., BESS exhibits moderate to good reliability with good concurrent validity [17].

Clinically, BESS is a useful tool for balance assessment in patients with OA knee compared to other scales, as it consists of simpler tasks to perform, whereas other scales include more complicated items or tasks. This complexity may exacerbate the condition and cause fatigue for the patients. Since patients with OA knee are neurologically stable, a quick tool like BESS for assessing balance is useful. Although posturography is a simple tool for balance assessment, it is costly and not readily available in every setting [21].

Most patients with OA knee experience balance impairment, which can lead to difficulties in daily living and social life. This scale will assist physiotherapists in effectively using BESS to assess balance in patients with OA knee and determine the appropriate treatment for them. BESS is a simple and reliable measure of balance assessment that can be easily applied without the need for special equipment or extensive training.

The threats to internal validity were minimised, as one rater took two readings at short intervals for the test-retest reliability of BESS in patients with OA knee. Similarly, threats to external validity were addressed because of the similar baseline characteristics of the patients, all of whom were selected according to fixed inclusion criteria.

Limitation(s)

The study has several limitations, such as a heterogeneous population that includes both males and females and the assessment focused on only a single component of reliability. Therefore, future studies should be conducted to evaluate both intrarater and inter-rater reliability. Additionally, research could be performed based on age, sex, BMI and specific to OA knee severity.

CONCLUSION(S)

Checking balance is an important aspect of the overall OA knee assessment. So we need a very simple and quick assessment tool that can reliably evaluate balance in OA knee patients. In the present study, the authors observed that BESS obtained satisfactory level of reliability. Thus, BESS can be used as a quick and reliable tool for balance assessment in OA knee patients.

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