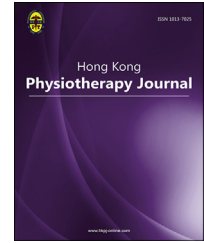




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RESEARCH REPORT

# Evaluation of psychometric properties of Tinetti performance-oriented mobility assessment scale in subjects with knee osteoarthritis



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## KEYWORDS

validity;  
reliability;  
impairment;  
outcome;  
gait;  
balance

**Abstract Objective:** The objective of this study was to determine the psychometric properties of the Tinetti Performance-Oriented Mobility Assessment (POMA) scale to measure balance and gait impairments in individuals with knee osteoarthritis (OA).

**Methods:** A convenient sample of 25 individuals with bilateral OA knee were recruited. The convergent validity was determined by correlation analysis between scores of Berg Balance Scale (BBS) with balance subscale (POMA-B) and the Timed Up and Go Test (TUGT) with gait subscale (POMA-G). The intrarater reliability [intraclass correlation coefficient (ICC 3,1)], the Bland–Altman plots limits of agreement (LOA), the standard error of measurement (SEM), minimum detectable change (MDC) and ceiling/floor effects were determined.

**Results:** Score of BBS was significantly correlated with POMA-B scores,  $r_s = 0.63$ ,  $p = 0.001$ , whereas TUGT showed a negative correlation with POMA-G,  $r_s = -0.481$ ,  $p = 0.020$ , showing moderate convergent validity. ICC results of the total POMA scale (POMA-T), POMA-B, and POMA-G were 0.96, 0.93, and 0.96, respectively, indicating high test retest reliability. SEM, for POMA-T, POMA-B, and POMA-G was 0.35, 0.27, and 0.35, respectively; MDC values were 0.97 for POMA-T, 0.75 for POMA-B, and 0.63 for POMA-G.

**Conclusion:** The findings indicate that the POMA is a valid and reliable tool to assess balance and gait impairments in people with OA knee.

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## Introduction

Balance and gait impairments are quite frequent in people with osteoarthritis of the knee (OA knee) [1–3]. The Berg Balance Scale (BBS) and the Timed Up and Go Test (TUGT) are valid and reliable tools for assessing balance and mobility, respectively, in many populations, including those with OA knee. The BBS assesses static and dynamic balance whereas TUGT helps in assessing the mobility component of balance control [4–7]. Hatfield et al [8] suggest more investigations in order to understand balance impairment in OA knee, with the help of easy to administer clinical balance assessment scales.

It may be time saving for the therapist if a tool is available to assess both balance and mobility together. The Performance-Oriented Mobility Assessment (POMA) scale was developed by Tinetti et al [9] and first published in 1986. It is a widely used simple tool for assessing balance and mobility in older people [9]. The advantage of the POMA scale is its inclusion of both balance and gait components [10]. Its reliability and validity has been established in neurological disorders [11].

There is no psychometric data available on the POMA scale in musculoskeletal conditions. Therefore, the aim of this study was to assess the validity and reliability of the POMA scale in individuals with OA knee to assess the balance and gait impairment. The study was done to determine a valuable outcome measure that assess both gait and balance abnormalities at the same time. It may also help to determine the impairments produced by gait and balance abnormality and develop individualized plans aimed at identified functional limitations.

## Methods

### Patients

A convenient sample of 25 patients was recruited from the Department of Physiotherapy, Jamia Millia Islamia and ESI Hospital, Okhla, New Delhi. The individuals included were both male and female aged between 45 years and 70 years, with bilateral/unilateral OA knee based on radiographic findings using Kellgren and Lawrence classification ( $\geq$  KL rating of 2) [12], knee pain of  $\geq$  4 months, Numeric Pain Rating Scale (NPRS) score  $>$  3, and able to walk with or without an assistive device. Individuals with a history of lower extremity joint replacement surgery, any inflammatory arthritic condition, uncontrolled blood pressure, or a fall within the previous year were excluded. All patients gave their informed consent to participate in the study. The purpose and possible risks of the study were explained to all participants. Participant characteristics collected included age, height, weight, the amount of knee pain felt on average during the previous week on a NPRS from 0 to 10 (0 = no pain, 10 = worst possible pain). To check the health status of the participants a self-report questionnaire, Western Ontario, and McMaster Universities Osteoarthritis Index (WOMAC) [13] had been used to assess the pain, stiffness, and physical function in patients with OA knee. The study was approved by the Ethics Committee of Jamia Millia Islamia and ESI Hospital, New Delhi, India.

### Sample size

With an alpha level of 0.05 and statistical power of 80%, for the testing of a null hypothesis intraclass correlation coefficient (ICC) value = 0.3, and an alternative hypothesis value of ICC = 0.7, the required sample size was 22 for two observations per patient. For convergent validity evaluation, a sample size of 19 achieves 80% power to detect a difference of  $-0.60$  between the null hypothesis correlation of 0.00 and the alternative hypothesis correlation of 0.60 with a significance level of 0.05 [14,15]. A total of 25 patients were recruited in the study.

### Procedure

The patients were assessed on three different days, each session lasting from 45 minutes to 1 hour. On Day 1 the TUGT and BBS were administered with a gap of 10 minutes between each test. The 1<sup>st</sup> assessment on the POMA scale was carried out on Day 2 and the 2<sup>nd</sup> assessment on the POMA scale was done on Day 7. The WOMAC and NPRS assessment were also performed on Day 1 and Day 7. The protocol of the study is shown in Figure 1. The assessments were carried out by a physiotherapist with  $>$  5 years of experience in managing individuals with musculoskeletal and mobility problems. The therapist was blinded from the objectives of the study. During the testing procedure an assistant was present to prevent participants from falling. The scores obtained in the TUGT, BBS, and POMA were used to determine convergent validity, reliability (intrarater), limits of agreement, standard error of measurement (SEM), minimum detectable change (MDC), and ceiling/floor effect.

### Instruments

#### Tinetti POMA

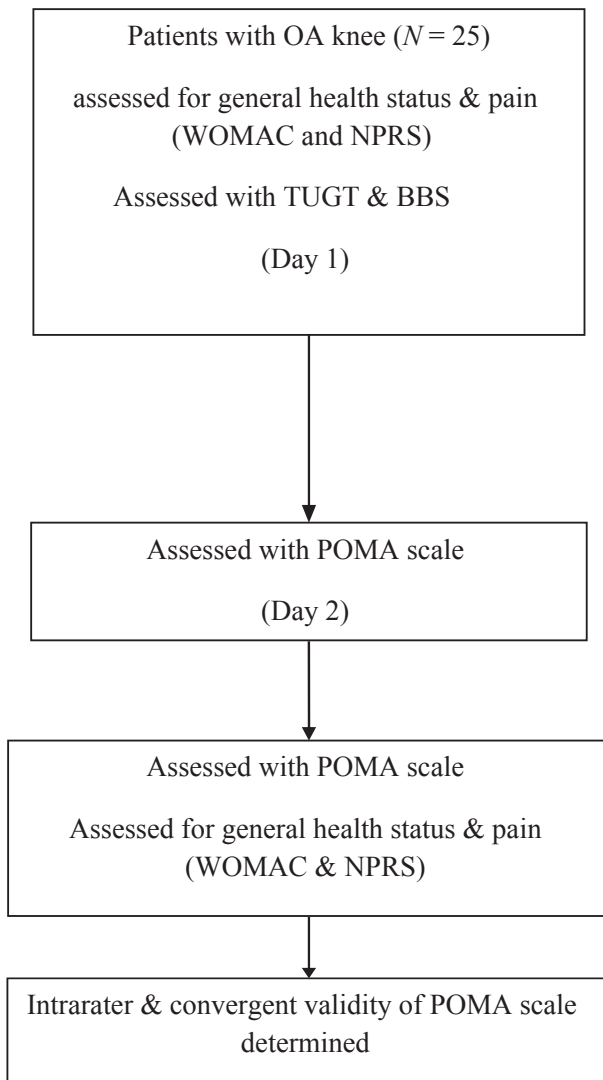
The Tinetti POMA, also called the Tinetti mobility test, is a reliable and valid clinical test used to measure balance and gait abilities in elderly individuals and some patient population. The total POMA scale (POMA-T) comprises of a balance subscale (POMA-B) and a gait subscale (POMA-G). The maximum possible total score for POMA-T is 28, for POMA-B is 16, and for POMA-G is 12. It is an easy and simple tool when applied in clinical settings, the observer can complete the evaluation in  $<$  15 minutes [16]. A few adjusted versions of the POMA have been published, yet in this study, just the first 28-point form is considered as it is the most regularly utilized version.

#### TUGT

The TUGT scale primarily assesses the mobility component. The patient sits in a chair of standard height, gets up and walks a distance of 3 m, turns around and sits back in the chair on the command of the examiner. The total time taken (in seconds) for the activity is the TUGT score [17].

#### BBS

BBS is used to assess balance impairments and consists of 14 activities scored on a 5 point ordinal scale, with a maximum



**Figure 1.** Protocol of the study design. BBS = Berg Balance Scale; NPRS = Numeric Pain Rating Scale; OA = osteoarthritis; POMA = Performance-Oriented Mobility Assessment scale; TUGT = Timed Up and Go Test; WOMAC = Western Ontario and McMaster Universities Osteoarthritis Index.

score of 56 and a minimum score of 0. Components of the test are supposed to be representative of daily activities that require balance. They include simple mobility tasks (e.g., transfers, standing unsupported, moving from sitting to standing) and more difficult tasks (e.g., tandem standing, turning 360°, simple leg stance) [18].

### Data analysis

The data was analysed using SPSS version 21.0 (SPSS Inc., Chicago, IL, USA). The data was determined and checked for normal distribution. Normal distributions of data were assessed using histograms, Shapiro–Wilks (S–W) test, and the skewness analysis. Assumptions of normality were not met for the POMA-T, POMA-B, POMA-G, and TUGT. Therefore, all calculations of intrarater reliability and of concurrent validity were based on nonparametric test.

### Convergent validity

To assess convergent validity of the POMA, Spearman rank correlation coefficient between the POMA-B and BBS, POMA-G and TUGT were calculated. Correlations  $<0.5$  were considered weak to fair, correlations of  $0.5–0.75$  were considered moderate and correlations  $>0.75$  were considered strong [19].

### Intrarater reliability

Before intrarater reliability analysis, a *t* test was applied where data was normally distributed, or the Wilcoxon signed rank test for nonnormally distributed data was performed to check for any systematic error. It is assumed that there is a systematic error in the data if a significant difference is observed in the *t* test or Wilcoxon signed rank test. The level of statistical significance was set at 0.05.

### ICC

ICC 3,1 (2-way mixed effect and consistency) of measurements 1 and 2 were computed to determine the intrarater reliability. Intrarater reliability was considered to be acceptable for ICC  $>0.75$  and considered to be very good for ICC  $>0.9$  [18]. ICC (3,1) was adopted because the rater was not randomly selected. Spearman correlation coefficients of measurements 1 and 2 were computed. Spearman's correlation was used because the data were not normally distributed. A correlation of 0.61 or more is considered good [20].

### Limits of agreement

Limits of agreement (LOA) between measurements 1 and 2 were calculated according to the procedure described by Bland and Altman [21]. LOAs were expressed together with the mean differences between measurements 1 and 2, and it was decided whether they were narrow enough for the test to be of practical use [22].

### SEM

The SEM was chosen to test absolute reliability and was calculated as follows:

$$SEM = SD \times \sqrt{1-ICC}, \quad (1)$$

where SD is the standard deviation. A high SEM indicates a high level of error and implies nonreproducibility of the measurements.

### MDC

The MDC at 95% confidence was calculated to provide clinical interpretation, as follows:

$$MDC = SEM \times 1.96 \times \sqrt{2} = 2.77 \times SEM \quad (2)$$

Scores of WOMAC and NPRS at the time of retest measurement of POMA were compared with the score of WOMAC and NPRS on Day 1. A significant change in the scores of WOMAC and NPRS shows the improvement and deterioration, respectively, in the participant disease characteristics.

## Results

The demographic characteristics of all the participants such as age, gender, duration, body mass index, BBS, TUGT,

POMA-T, POMA-B, POMA-G, and KL grading is shown in [Table 1](#). The NPRS and functional status of the participant is shown in [Table 2](#), with comparison between both measurements. The Shapiro–Wilks test showed that the TUGT ( $p = 0.001$ ), BBS ( $p = 0.04$ ), and POMA-T1 ( $p = 0.007$ ) were not normally distributed.

### Convergent validity

Score of BBS were significantly correlated with POMA-B scores [ $r_s(25) = 0.63, p = 0.001$ ], whereas TUGT showed a negative correlation with POMA-G [ $r_s(25) = -0.481, p = 0.02$ ], indicating moderate convergent validity ([Table 3](#)).

### Reliability of measures

The intrarater reliability (ICC 3,1), MDC, and SEM results for the POMA-B, POMA-G, and POMA-T are presented in [Table 4](#). The results indicated that there was no significant difference between the first and second measurements.

### Intrarater reliability

ICC results of POMA-T, POMA-B, and POMA-G were 0.98, 0.96, and 0.98, respectively, indicating high intrarater

**Table 1** Participants' demographic characteristics and baseline values of BBS, POMA-T, POMA-G, POMA-B, and KL grading.

Characteristics	Mean (SD)	
Age (y)	50.5 (6.3)	
Duration (y)	3.7 (2.4)	
Sex (male:female)	9:16	
BMI (kg/m <sup>2</sup> )	27.2 (4.8)	
BBS	52.4 (2.12)	
TUGT (s)	12.3 (2.53)	
POMA-T	24.28 (2.47)	
POMA-G	10.2 (1.55)	
POMA-B	14 (1.35)	
KL grading	Right 2.2 (0.43)	Left 2.1 (0.43)

B = balance subscale; BBS = Berg Balance Scale; BMI = body mass index; G = gait subscale; KL = Kellgren and Lawrence; POMA = Performance-Oriented Mobility Assessment scale; SD = standard deviation; T = total scale; TUGT = Timed Up and Go Test.

**Table 2** Pain and disability characteristics of the participants.

Characteristics	Day 1	Day 7	Wilcoxon $p$
	Mean (SD)	Mean (SD)	
NPRS (right)	5.4 (1.5)	5.5 (1.4)	0.56
NPRS (left)	4.5 (1.6)	4.6 (1.5)	0.73
WOMAC	42.3 (14.1)	43.4 (13.9)	0.18

NPRS = Numeric Pain Rating Scale; SD = standard deviation; WOMAC = Western Ontario and McMaster Universities Osteoarthritis Index.

**Table 3** Convergent validity of the POMA-T, POMA-B, and POMA-G.

	Spearman rank correlation coefficient ( $r_s$ )	$p$
POMA-B with BBS	0.637	0.001*
POMA-G with TUGT	-0.481	0.020**

\* Significant at 0.01.

\*\* Significant at 0.05.

B = balance subscale; BBS = Berg Balance Scale; G = gait subscale; POMA = Performance-Oriented Mobility Assessment scale; T = total scale; TUGT = Timed Up and Go Test.

reliability of the scale [15]. The Spearman correlation coefficient for POMA-T ( $r_s = 0.97, p = 0.001$ ), POMA-B ( $r_s = 0.92, p = 0.001$ ), and POMA-G ( $r_s = 0.97, p = 0.001$ ) was statistically significant, showing a good correlation in scores obtained by the same rater on two consecutive visits with an interval of 5 days ([Table 4](#)).

### MDC

MDC values were 0.97 for POMA-T, 0.75 for POMA-B, and 0.63 for POMA-G ([Table 4](#)).

### SEM

SEM of POMA-T, POMA-B, and POMA-G was 0.35, 0.27, and 0.23, respectively ([Table 4](#)).

### LOA plots

The Bland–Altman plots illustrated that in the POMA-B subscale there was one data point outside the +1.96 SD; and two data points were outside +1.96 SD and one data point outside -1.96 SD for POMA-G subscale ([Figures 2 and 3](#)). Whereas all the data points for POMA-T were within the 95% LOA ([Figure 4](#)). The mean difference between the measurements was also calculated to determine the agreement between the 1<sup>st</sup> and 2<sup>nd</sup> assessment. The mean difference was -0.20, 0.08, and -0.12 for POMA-B, POMA-G, and POMA-T, respectively.

### Ceiling/floor effect

The lowest possible score (0 points) on the POMA-T, POMA-B, and POMA-G scales was not observed. A significant ceiling effect was present on the POMA-T (28%) and its subscale of POMA-G (24%). A significant ceiling effect is present when > 20% of individuals reach the maximal score of the scale [23]. The ceiling effect was likewise observed for BBS (20%; [Table 5](#)).

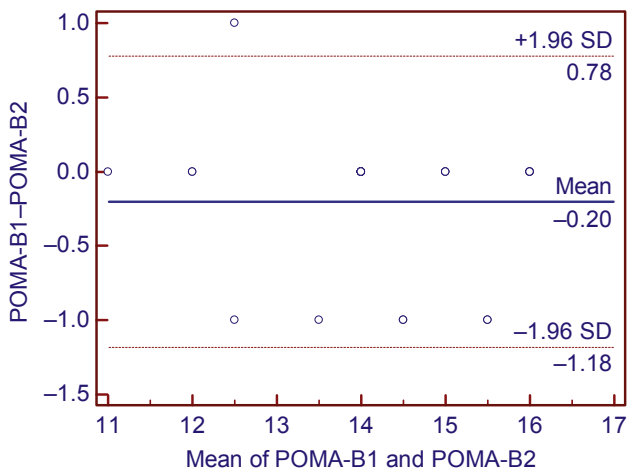
### Discussion

The purpose of this study was to assess the validity and reliability of the POMA-T, POMA-B, and POMA-G scales in individuals with OA knee. The POMA displayed moderate

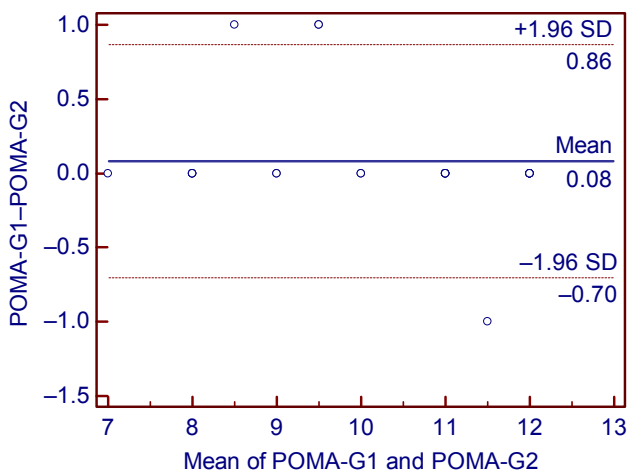
**Table 4** Summary of the statistical analysis for measurements 1 and 2 of the POMA for test–retest reliability.

Parameter	Reliability analysis							
	Day 1	Day 7	Wilcoxon	$r_s$	ICC (3,1) for ICC	95% CI	SEM	MDC <sub>95%</sub> CI
	X (SD)	X (SD)	$p$					
POMA-T	24.28 (2.4)	24.52 (2.5)	0.083	0.97	0.98	0.96–0.98	0.35	0.97
POMA-B	14 (1.35)	14.4 (1.35)	0.052	0.92	0.96	0.92–0.98	0.27	0.75
POMA-G	10.2 (1.55)	10.1 (1.66)	0.31	0.92	0.98	0.96–0.99	0.23	0.63

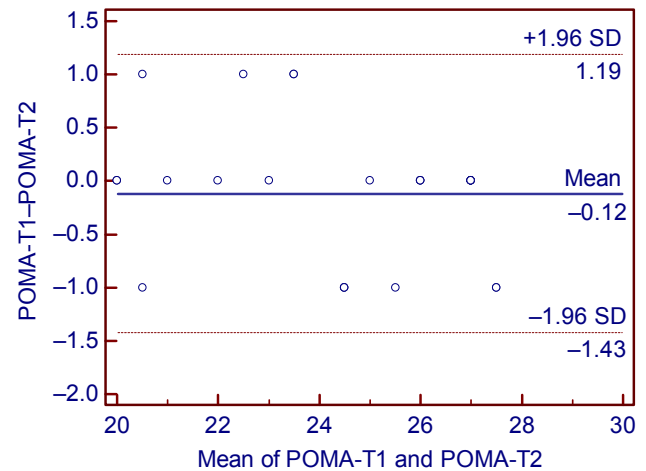
B = balance subscale; CI = confidence interval; G = gait subscale; ICC = intraclass correlation coefficient; MDC = minimal detectable change; POMA = Performance-Oriented Mobility Assessment; SD = standard deviation; SEM = standard error of measurement;  $r_s$  = Spearman correlation coefficient; T = total scale; X = mean.



**Figure 2.** Bland–Altman plot of agreement between test and retest of POMA-B scores. The figure reveals that only 1 data point lies outside  $\pm 1.96$  SD. POMA-B = Performance-Oriented Mobility Assessment scale–balance subscale; SD = standard deviation.



**Figure 3.** Bland–Altman plot of agreement between test and retest of POMA-G scores. The figure reveals that 2 data points were outside  $\pm 1.96$  SD and 1 data point was outside  $-1.96$  SD. POMA-G = Performance-Oriented Mobility Assessment scale–gait subscale; SD = standard deviation.



**Figure 4.** Bland–Altman plot of agreement between test and retest of POMA-T scores. The figure reveals that all data points are within  $\pm 1.96$  SD. POMA-T = Performance-Oriented Mobility Assessment scale–total scale; SD = standard deviation.

convergent validity with administered tests of balance and mobility (BBS and TUGT) in individuals with OA knee. Intrarater reliability of the POMA-T, POMA-B, and POMA-G were also high. The 95% MDC value was 0.97 for the test retest scores of POMA-T and SEM was 0.35.

The findings in this study demonstrated a moderate positive correlation between the scores of BBS and POMA-B, demonstrating that the two scales are specifically related,

**Table 5** Number and percentage of patients reaching the highest possible score (ceiling effect).

Scale	Score	$N$	%
BBS	55/56	5	20
POMA-T1	27/28	7	28
POMA-B1	16/16	4	16
POMA-G1	12/12	6	24

BBS = Berg Balance Scale; POMA-B1 = balance subscale of Performance-Oriented Mobility Assessment scale of measurement 1; POMA-G1 = gait subscale of Performance-Oriented Mobility Assessment scale of measurement 1; POMA-T = Performance-Oriented Mobility Assessment scale of measurement 1.



both having features that predict balance impairments. The positive relationship between these scales is because the tasks evaluated are almost same in both (sitting balance, sit-to-stand move, remaining with eyes open and shut, and turning 360°). In agreement with our findings, Silva et al [24] performed a study which assessed balance, coordination, and agility of 61 older adults, aged from 60 years to 75 years, and discovered a significant positive connection between BBS and POMA. This moderate relationship between the POMA-B and BBS has been shown in other studies that have assessed the validity of the POMA in diverse populations. Ko et al [25] reported a moderate to high relationship between POMA, POMA-B, POMA-G and the activities specific balance confidence scores in Korean older adults evaluated with activities specific balance confidence scale (ABC), POMA, activities of daily living (ADL), and instrumental activities of daily living (IADL). Another investigation by Lin et al [26] in community-dwelling older adults demonstrated a moderate association between POMA-B and older adults' resources and services ADL scale. The TUGT is a valid tool for assessing mobility impairments in individuals with knee OA; in the present study POMA-G scores were significantly negatively correlated with TUGT scores. There is a similar report, in which the BBS demonstrated moderate negative correlation with the TUGT and usual gait speed [27].

Intrater reliability of an instrument is a key property permitting researchers and clinicians to administer a test more than once to individuals to assess change over time. Intrater reliability, which analyses the relationship between multiple repeated measurements, can be determined by computing the ICC [28]. The POMA-T displayed very high reliability. There was no significant difference in the health status and pain perception in the present study as measured by the WOMAC scale and NPRS (Table 2). The results show that there was no systematic error and the participants were not different in health status and pain perception during the two assessment sessions. Balance and mobility subscale of total POMA-T, POMA-B, and POMA-G also displayed very high intrareliability. Our findings of intrater reliability analysis are similar to previous reports of test-retest reliability by Van Iersel et al [29] and Daly et al [30]. Spearman correlation coefficients also indicate intrater relative reliability; the Spearman correlation coefficients value in the present study is 0.97 for POMA-T and POMA-B, and 0.92 for POMA-G. These values of Spearman correlation coefficients were higher when compared with the previous study of Faber et al [31] LOA provides a 95% range of error for two measurements [21,32]. The mean difference calculated as part of the LOA analysis was very small and there was only a total of three data points outside the LOA plot. This shows an agreement with the two measurements and no systematic errors.

Absolute reliability, which depicts the participant variability attributable to repeated measures, is evaluated by calculating the SEM [22]. The SEM can be used to obtain the MDC. It is defined as the minimal amount of change that is required to distinguish a true performance change from a change due to variability in performance or measurement error and change as real and beyond the bounds of measurement error. The SEM for the POMA-T, POMA-B, and POMA-G were low, as per the investigation of Nair et al [33].

Small estimations of SEM for the balance and gait subscale scores show that estimations made by POMA-B and POMA-G were steady and reproducible over time subsequently suggesting the accuracy in estimation, demonstrating high absolute reliability and further affirming low individual variety. Both relative and absolute reliability of measures are essential when interpreting the findings, therefore the high reliability of the POMA scale makes it an attractive device for assessing changes in balance and gait impairment over time. Currently we know the test is highly reliable, with participants scoring an average of 24.28 on the first test and 24.52 on the second test. Could we be certain that this change is a real change or is the change just because of estimation error? To be 95% sure that our participants improved as a result of intervention, 0.97 (MDC<sub>95</sub>) difference should be present in the retest score of POMA-T from the test score. MDC provides an assessment of a relative improvement or deterioration in the value of a parameter and it would be beneficial to the clinician to determine whether performance has truly changed over time with intervention [34]. MDC value for POMA-T calculated by Faber et al [31] was 4.2, with individual assessments of 4.0 for rater 1 and rater 2, which is higher than our findings. For group assessment MDC values were 0.8, with values of 0.7 for rater 1 and rater 2, which is similar to MDC values of the present study.

Ceiling effects limit the usefulness of an evaluation tool, as assessments among better functioning individuals may not be possible [35]. Pardasaney et al [36] reported that people with severely limited function demonstrate no ceiling impact on the BBS, recommending that the measure may be more appropriate for utilization in community-dwelling older adults with lower levels of functioning. When a measure is used to monitor change, high baseline scores and ceiling effects present a serious concern for type II errors in clinical trials. There are indications that some current measures of balance and mobility assessment tools may have ceiling effects, where scores group around the maximum possible score [37]. This is also true for this study as BBS showed a ceiling effect (20%). The balance characteristics POMA-B and BBS are similar to those in a study of community-dwelling older adults, supporting generalizability of our outcomes [38]. Behrman et al [39] also observed a ceiling effect in the gait component of Tinetti POMA.

The weak correlation found between the POMA-G and the TUGT may be due to the fact that 68% of participants performed the TUGT with a time  $\leq 12$  seconds and scored between 10 points and 12 points in the POMA-G, as an indication of the normal gait and low risk of falls; 32% of the participants performed the TUGT with time between 13 seconds and 18 seconds and had a score between 8 and 9 in POMA-G, indicating a low to moderate risk of falls and gait impairments. So more than half of the participants scored high on both scales. Moderate correlation between POMA-B with BBS may be because of ceiling effects [14]. The scores were clustered around the highest possible scores in either scale. The lack of variability in individual scores in both scales might have led to the weakening of a correlation between the BBS, TUGT, and POMA scales used in this study.

There were some limitations of the present study. Most of the participants were mobile and highly functional.

There were no individuals with KL Grade 4 (severe) OA, and it is possible that those with more severe grades of knee OA may have lower levels of function, thus the relationship of balance and mobility test scores may have been altered. This study has limitations related to the homogeneity of the study population, which contributed to the low variability between the scores obtained during the execution of the proposed functional scales, which may have contributed to the fact that the correlation values between the tests varied from moderate to weak. Another limitation of this study is the difference in the rating scale, BBS is a 5-point rating scale while the POMA has a 2- or 3-point rating scale. The differences between the rating scales are not exactly the same because we were working with quantities and correlations require precise measurements.

Further research could include using the POMA scale to investigate the correlation of the gait and balance subscales with other commonly used physical performance tests, such as the stair climb test and the 6 minute walk test. An investigation that prospectively evaluates other measurement properties of the Tinetti POMA scale, such as responsiveness and predictive value, could also be performed.

## Conclusion

The POMA scale and its subscales have excellent intrarater reliability and moderate convergent validity, as shown in a sample of patients with mild OA knee rated by an experienced physiotherapist. These findings indicate that the POMA can be used as a valid and reliable tool to assess balance and gait impairments in people with OA knee.

## Authorship contribution

Conception and design of study: H. Parveen, M.M. Noohu.

Data acquisition: H. Parveen.

Data analysis and/or interpretation: M.M. Noohu.

Drafting the manuscript: M.M. Noohu, H. Parveen.

Revising the manuscript critically for important intellectual content: M.M. Noohu, H. Parveen.

Approval of the version of the manuscript to be published: M.M. Noohu, H. Parveen.

## Conflicts of interest

We hereby declare that there are no conflicts of interest related to this study in terms of monetary benefits or in any other form.

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