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RESEARCH ARTICLE

THE OUTCOME ASSESSMENT REQUIRES BOTH PERFORMANCE-BASED AND PATIENT-REPORTED MEASURES AFTER REVISION TOTAL KNEE ARTHROPLASTY

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ABSTRACT

Purpose: To investigate the correlation between performance-based and patient-reported measures and their relation with knee muscle strength in the assessment of revision total knee arthroplasty (rTKA) patients.
Materials and Methods: This cross-sectional study recruited 92 patients with rTKA. The outcome assessment was performed using three performance tests (the Timed Up and Go (TUG), 30-second Chair Stand Test (30CST), and 50-Foot Walking Test (50FWT)) and one patient-reported questionnaire (the Hospital for Special Surgery (HSS)). The maximum isometric muscle strength of knee flexors and knee extensors was assessed with Handheld Dynamometry (HHD).
Results: The total HSS knee score showed low significant associations with performance-based tests (all, $p< 0.05$), but no associations with knee muscles strength. The knee extensor strength showed moderate to strong significant associations with all performance tests, while the knee flexor strength had a low to moderate significant correlation with these performance tests (all, $p<0.05$).
Conclusion: Our findings, which show a low correlation between performance-based tests and patient-reported questionnaire, suggest patient perception fails to accurately capture the functioning at the late follow-up of rTKA. Therefore, performance-based tests should be included in the outcome assessment to determine an appropriate rehabilitation program and exercise training after rTKA. Moreover, the higher associations between functional tests and knee muscle strength than the associations of the questionnaire with these performance measures advocate this assertion. These findings could be crucial in informing the design and implementation of interventions tailored to this population.

Keywords: Performance-based tests, patient-reported outcomes, functioning, muscle strength, revision total knee arthroplasty

INTRODUCTION

The annual total number of revision total knee arthroplasty (rTKA) is projected to increase by 90% by 2050 (1). Despite its growing frequency, rehabilitation and outcome measurement strategies for rTKA are lacking in the existing literature. Namely, this population has no standardized rehabilitation protocol, and the outcome assessment method is

based solely on patient-reported measures (2). Nonetheless, James Lind Alliance Priority Setting Partnership has identified rehabilitation and assessment strategies for rTKA as one of the top 10 priority research areas for patients and clinicians (3). The loss of motor function and muscle strength is considerable following rTKA, leading to decreased functional independence (4, 5). Hence, it is necessary to study the outcomes of specified interventions in this population, which need to be evaluated with appropriate outcome measures to interpret the benefits of the intervention.

Revision TKA surgery is technically more complex compared to primary TKA and requires more extensive exposure to the knee extensor mechanism, which is the primary determinant of overall functional independence. However, rTKA surgical techniques directly affect quadriceps strength, thus potentially leading to functional impairments (6, 7). Therefore, rTKA patients may not have as good outcomes as those with primary TKA after surgery (4). On the other hand, rTKA patients who are increasingly demanding postoperative functional results expect an early return to daily life and optimal functional level following surgery (2, 8). Hence, it is essential to qualitatively evaluate these patients regarding their postoperative outcomes and functioning to offer them timely access to an appropriate rehabilitation program.

Many available methods, such as patient-reported questionnaires and performance-based tests, measure function and symptoms at the perioperative stage of joint arthroplasty (9, 10). However, in the literature, it has been shown that the methods for assessing the functional status of rTKA patients rely solely on patient-reported questionnaires (4, 8, 11). Nonetheless, outcome assessment of joint arthroplasty should also include reproducible objective measures and permit identifying the functional performance at a point in time and assessing changes over time in the clinical setting (10, 12). Besides, the relationship between assessment tools should be determined to better understand the circumstances under which to administer a particular instrument. Nevertheless, the existing literature did not investigate the relationship between patient-reported questionnaires and performance-based tests in rTKA patients. In addition, no study to our knowledge has concurrently measured knee muscle strength level to determine its relation to patient-reported and performance-based measures. Therefore, specifically, the two main objectives were (1) to determine the correlation between the patient-reported measure and performance-based tests in rTKA patients and (2) which of these outcome measures is more relevant to knee muscle strength level.

MATERIALS AND METHODS

Study design and participants

A total of 92 patients with rTKA operated by the same surgeon were recruited for analysis in this study. Inclusion criteria were that patients had an rTKA for reasons including aseptic loosening, infection, ligamentous instability, and had undergone rTKA surgery at least one year prior to allocation, were 40 years of age or older, could walk at least 50 m independently with or without an assistive device, and could understand the instructions of the tests. Patients were excluded if they had previous disorders (i.e. orthopedic or neurologic conditions) causing gait disturbance, had undergone rTKA surgery within one year, and had a body mass index (BMI) of 40 kg/m2 or above.

This study design was a cross-sectional correlational analysis of patients who had undergone rTKA. According to a priori power analysis, a sample size of 88 was needed to achieve 90% statistical power with a probability of a 2-tailed type I error of 0.05 in the correlation analysis (13). To prevent power loss due to early withdrawal, and increase its generalizability to the population, the study was planned to be completed with 102 patients. A total of 115 patients who were operated by the same surgeon at least one year prior were called for an initial telephone screening and to determine their eligibility. 14 patients having exclusion criteria as given previously, and further 9 patients who were not interested in participating were excluded. As a result, 92 rTKA patients who met the eligibility criteria were scheduled for an outcome assessment. A flowchart of the study is shown in Figure 1.

Ethical considerations

This study was approved by the Non-interventional Research Ethics Committee of Dokuz Eylul University (Date: 03.04.2019, Approval number: 2019/08-39). In accordance with the Declaration of Helsinki, written informed consent was obtained from all participants prior to enrollment in the current study.

Outcomes assessment

Patients were assessed at the mean time of 6 (2.81) years postoperatively (range from surgery 1 to 12 years). The tests were ordered in the following sequence because patients' perception of fatigue resulting from performance tests may influence their questionnaire scores. The testing order was the completion of the patients' demographic and clinical data followed by a patient-reported questionnaire of the Hospital for Special Surgery (HSS). After completing the questionnaire, knee muscle strength and performance-based tests were assessed randomly to avoid potential confounding effects. Between performance assessments, all patients were allowed 10 minutes of rest in a comfortable chair to minimize fatigue-related effects. Prior to the actual test, a practice trial was conducted for each performance assessment so that patients could familiarize themselves with the tests. During walking-based functional performance tests, patients were asked to walk as quickly but safely as possible, using walking aids (e.g., walker and/or cane) if needed. All patients were evaluated by the same physiotherapist with seven years of clinical experience in orthopedic rehabilitation and in performing outcome assessment.

The HSS is a reliable and valid scale that assesses patients with knee osteoarthritis and knee arthroplasty (14). The HSS subscales specifically assess knee pain, function, range of motion, strength, flexion deformity and instability. The total HSS score is obtained by subtracting the scores for walking aids, loss of knee extension and valgus/varus deformity from the total score of all other subscales.

A reliable and valid method, the Timed Up and Go (TUG) test measures patients' functional mobility and balance ability (15). The TUG measures the time spent on testing, including rising from a standard chair, walking 3 meters, turning around, returning to the chair, and sitting down. The participant was instructed to walk as fast as possible but safely at a set distance.

A valid and reliable method, the 30-second Chair Stand Test (30CST) assesses the lower extremity strength and endurance associated with ambulation abilities (16). According to the 30CST protocol, a chair with a seat height of 17 inches (43.2 cm) was used. The patients' starting position was standardized for all assessments, including buttock placement, back support, back straight, and crossing their arms across their chests to avoid compensation. Then, participants were asked to stand up repeatedly as quickly as possible but safely within 30 seconds. Along the test duration, the number of full chair stands completed was recorded.

A reliable and valid measurement method, the 50-Foot Walking Test (50FWT) is widely used to measure patients' performance and locomotion (16). Participants are asked for walking in a straight line (25 ft), then turning around and walking (25 ft) back to the starting position (totally 15.24 meters/50 ft). The 50 ft walk was performed as quickly as possible but at a safe pace. The time spent during the test was recorded.

Handheld Dynamometer (HHD) was used to assess maximal isometric knee muscle strength. Before the measurement, the participants were seated at the examination table with approximately 90 degrees of hip flexion and 60 degrees of knee flexion and crossed their arms across their chest. Before the testing, the participants were instructed according to the standardized static muscle strength assessment protocol of knee flexors and knee extensors (17). The transducer was placed on the 1-2 centimetres proximal of the medial malleoli, anteriorly for strength assessment of knee extensors, and posteriorly for strength assessment of knee flexors. Participants performed one repetition of a practice trial to be familiarized with the test, then three consecutive maximum contractions for each knee muscle strength measurement. All muscle strength values were converted to Newton meters (Nm) for analysis.

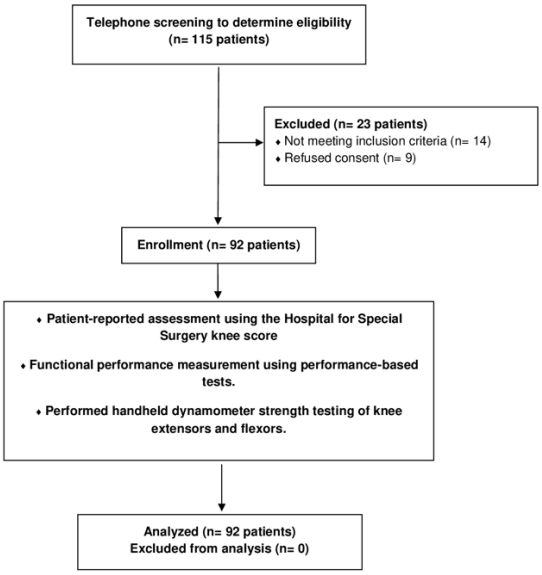

Figure 1. Flow diagram of study

Statistical analysis

The data was analyzed using the IBM® SPSS® (ver. 26.0; IBM Corp., Armonk, NY, USA) package program for Windows software. The normal distribution of the data was determined using the Shapiro-Wilk test. Descriptive statistics were described with numbers (percentages) and mean (standard deviation) values. The associations between the patient-reported questionnaire and performance-based measures and knee muscle strength were assessed using the Pearson's correlation coefficient. The correlation level was considered negligible if the coefficient was less than 0.10, low if it was between 0.10 to 0.39, moderate if it was between 0.40 to 0.69, and strong if it was greater than 0.70 (18). A value of $p<0.05$ was set as statistically significant.

RESULTS

No adverse events or complications were developed in participants during outcome assessments. Demographics and clinical characteristics of the patients are presented in in Table 1 and Table 2.

The total HSS knee score, showed low significant associations with TUG, 30CST, 50FWT. We found no significant associations between the total HSS knee score and knee muscles strength.

The HSS "Function" had low associations with 30CST, 50FWT, and knee extensors strength. There were low associations between the HSS "Muscle Strength" and TUG, 30CST, 50FWT, knee muscles strength. We found low associations between the HSS "Range of Motion" and 30CST, 50FWT, knee extensors strength. There was also a low correlation between the HSS "Deformity" and knee extensors strength. There were no significant associations between the other subscale of HSS knee score and the performance tests and knee muscles strength. The associations between patient-reported outcome and performance-based scores and knee muscles strength are presented in Table 3.

Both knee extensor and flexor strength were significantly correlated with performance-based tests but not patient-reported measure. In general, knee extensors strength was more strongly correlated with performance tests compared to knee flexors strength. The knee extensors strength showed a strong correlation with 30CST, and moderate associations with TUG and 50FWT. The knee flexors strength had moderate correlation with TUG, and low correlation with 30CST and 50FWT. The associations between knee muscles strength and performance-based scores are shown in Table 4.

The total HSS knee score showed low significant associations with TUG, 30CST, 50FWT. We found no significant associations between the total HSS knee score and knee muscles strength.

The HSS "Function" had low associations with 30CST, 50FWT, and knee extensors strength. There were low associations between the HSS "Muscle Strength" and TUG, 30CST, 50FWT, knee muscles strength. We found low associations between the HSS "Range of Motion" and 30CST, 50FWT, knee extensors strength. There was also a low correlation between the HSS "Deformity" and knee extensors strength. There were no significant associations between the other subscale of HSS knee score and the performance tests and knee muscles strength. The associations between patient-reported outcome and performance-based scores and knee muscles strength are presented in Table 3.

Table 1. Demographic characteristics of patients with revision-TKA

Variables	Mean (SD)
Age (years)	69.43 (8.98)
Height – cm	161.98 (7.35)
Weight– kg	81.58 (12.03)
BMI – kg/m^2	31.06 (3.87)
Time since surgery (years)	6.00 (2.81)
Sex (♀/♂), n, (%)	68/24 (73.90/26.10)
Side (right/left), n, (%)	61/58 (51.30/48.70)

Data are presented as number, percentage, and/or means and standard deviation (in parentheses); TKA: Total Knee Arthroplasty; BMI: body mass index; ♀: female; ♂: male

Table 2. Scores from the patient-reported questionnaire, performance-based measures, and muscle strength of patients with revision-TKA

Variables	Mean (SD)
HSS (total)	72.82 (13.38)
Pain	25.40 (5.90)
Function	11.97 (4.18)
ROM	15.19 (2.56)
Muscle strength	6.94 (2.58)
Deformation	4.30 (3.55)
Instability	9.45 (0.89)
TUG (sec.)	13.25 (6.02)
30CST (numbers)	10.63 (5.13)
50FWT (sec.)	29.63 (12.37)
Quad. (Nm)	106.40 (49.22)
Ham. (Nm)	116.60 (39.71)

Data are presented as means and standard deviation (in parentheses). TKA: Total Knee Arthroplasty; HSS: Hospital for Special Surgery; TUG: Timed Up and Go test; 30CST: 30-second Chair Stand Test; 50FWT: 50-Foot Walking Test; Quad.: quadriceps; Ham.: hamstring; Nm: Newton meter; sec.: second

Table 3. Correlations between patient-reported outcome and performance-based scores and muscle strength in patients with revision-TKA

Variables	TUG (r) 95% CI	30CST (r) 95% CI	50FWT (r) 95% CI	Quad. (r) 95% CI	Ham. (r) 95% CI
HSS (total)	-0.196*	0.191*	-0.316***	0.178	0.137
	-0.376/-0.016	0.011/0.371	-0.490/-0.142	-0.003/0.358	-0.046/0.318
Pain	-0.176	0.026	-0.118	0.048	-0.186
	-0.383/0.013	-0.169/0.222	-0.317/0.073	-0.155/0.259	-0.356/0.002
Function	-0.095	0.285**	-0.355***	0.308***	0.148
	-0.300/0.100	0.105/0.479	-0.549/-0.182	0.135/0.527	-0.042/0.339
ROM	-0.096	0.220*	-0.214*	0.239*	0.067
	-0.301/0.098	0.035/0.417	-0.413/-0.029	0.057/0.454	-0.125/0.260
Muscle strength	-0.222*	0.267**	-0.287**	0.314***	0.280**
	-0.429/-0.037	0.085/0.462	-0.484/-0.108	0.142/0.532	0.097/0.467
Deformation	0.023	0.183	-0.174	0.209*	0.139
	-0.177/0.225	-0.005/0.380	-0.373/0.014	0.024/0.426	-0.051/0.330
Instability	-0.054	-0.004	0.040	-0.036	0.096
	-0.257/0.144	-0.200/0.191	-0.155/0.237	-0.246/0.168	-0.095/0.286

TKA: Total Knee Arthroplasty; HSS: Hospital for Special Surgery; TUG: Timed Up and Go test; 30CST: 30-second Chair Stand Test; 50FWT: 50-Foot Walking Test; Quad.: quadriceps; Ham.: hamstring; r: Pearson's correlation coefficient; 95% CI: 95% Confidence interval with lower/upper bound
*0.01 < p ≤ 0.05, **0.001 < p ≤ 0.01, ***p ≤ 0.001

Table 4. Correlations between performance-based scores and muscle strength in patients with revision-TKA

Variables	TUG (r) 95% CI	30CST (r) 95% CI	50FWT (r) 95% CI
Quad.	-0.619***	0.853***	-0.578***
	-0.766/-0.476	0.760/0.953	-0.731/-0.429
Ham.	-0.540***	0.351***	-0.359***
	-0.642/-0.355	0.177/0.521	-0.518/-0.182

TKA: Total Knee Arthroplasty; TUG: Timed Up and Go test; 30CST: 30-second Chair Stand Test; 50FWT: 50-Foot Walking Test; Quad.: quadriceps; Ham.: hamstring; r: Pearson's correlation coefficient; 95% CI: 95% Confidence interval with lower/upper bound
*0.01 < p ≤ 0.05, **0.001 < p ≤ 0.01, ***p ≤ 0.001

Both knee extensor and flexor strength were significantly correlated with performance-based tests but not patient-reported measure. In general, knee extensors strength was more strongly correlated with performance tests compared to knee flexors strength. The knee extensors strength showed a strong correlation with 30CST, and moderate associations with TUG and 50FWT. The knee flexors strength had moderate correlation with TUG, and low correlation with 30CST and 50FWT. The associations between knee muscles strength and performance-based scores are shown in Table 4.

DISCUSSION

The primary findings of the current study were (1) patient-reported outcome showed low associations with performance-based tests of functional performance, (2) both knee extensor and knee flexor strength were significantly correlated with performance-based tests but not patient-reported measure. With respect to the performance-based tests, these findings are similar to previous studies in different populations with knee and hip arthroplasty that reported correlation coefficients with patient-reported questionnaires to be low (12, 19, 20). Showing generally moderate to strong correlation between muscle strength and performance tests, our findings are similar to other studies in primary TKA patients that reported moderate to strong correlation between lower extremity muscle strength and performance tests (7, 12, 21). On the other hand, to our knowledge, this is the first study that showed relationships between the performance-based tests and patient-reported questionnaires and their relevance to the knee muscle strength in patients with rTKA.

There could be some possible explanation for the current findings, which showed a low correlation

between the two types of assessment tools. Patient-reported questionnaires, having high internal consistency and ease of administration, assess the perception of ability to perform required daily living activities (9, 10). Nevertheless, these measures may not fully capture impairments in functional performance since they are influenced by many factors (i.e., patient's perception and experience, personality, cultural situations) (9). On the other hand, alternatively, performance-based tests, which measure the timing, counting, or distance, quantify a particular task mimicking daily living activities (22, 23). Thus, performance tests provide a continuous measure of difficulty instead of relying on the assessors' judgment to score and individuals' perception of performance (23). Therefore, using a combination of performance-based and patient-reported measures may be valuable to comprehensively measure functional recovery and patients' reports on their functional status after revision knee surgery, as these two methods assess tap into different aspects related to functioning. Our findings and also previous studies (10, 12), conducted on different populations support this assertion.

The quadriceps muscle strength is a significant determinant of gait, functional ability, and overall functional independence (7). However, rTKA directly affects knee muscle strength because more extensile exposure is required to the knee extensor mechanism during revision knee surgery (6). Therefore, identifying the lower extremity muscle strength and its correlation with functional performance is particularly important to determine the more efficient and accurate selection of therapeutic interventions in this population (24).

The current study showed associations between performance-based tests and knee muscles strength. A higher correlation was generally found for the knee extensors strength (quadriceps strength), but the knee flexors strength (hamstring strength) also affects the functional performance. Previous studies (25, 26) have shown a strong association between quadriceps strength and functional performance in TKA patients compared to other muscle groups, and this supports our findings. In addition, in agreement with previous studies (19, 21), conducted on TKA patients, the current study showed the highest correlation between knee extensors muscle strength (quadriceps muscle strength) and 30CST. This finding is clinically important because it implicates that this performance-based test is the potential predictor of knee extensors muscle strength. The 30CST, one of the performance-based tests, requires sit-to-stand but predominantly considerable balance level, muscle strength and endurance. These could be reasons for the results obtained in the current study. More, the current result suggests that this performance test can be used to determine the overall knee muscle strength when advanced equipment such as a handheld dynameter for assessment of knee muscle strength is not available. Our results showed no associations between the total score of HSS and knee muscles strength. This result is similar to the previous findings (19, 21), which reported no associations between patient-reported measures and muscles strength. On the other hand, some subscores of the HSS have low associations with knee muscle strength. However, inadequate associations suggest that both types of assessment tools examine independent dimensions and parameters of functional performance; therefore, neither should be used interchangeably in the outcome measure of rTKA patients. This result can be attributed to the fact that unlike the self-report of performance that is based on patients' perception of their ability, the performance assessment such as muscle strength testing with a dynamometer captures patients' actual ability to perform a specific task. Besides, previous evidence indicates that patients' perceptions and beliefs strongly influence pain perception rather than self-report of performance (27). Therefore, patients' perceptions and beliefs, namely psychological factors, may be misleading when scoring a questionnaire. Our results, showing that knee muscle strength has a low but significant correlation with the HSS "function", however, no correlation with the HSS "pain", confirm this assertion.

In clinical practice for assessing orthopedic patients, longer walk tests, such as the 2- and 6-minute walk test, have been used to assess functional mobility, and gait ability and endurance (22). However, performing such a long walk test might overburden patients with revision knee arthroplasty during the postoperative stage, especially if they use walking aids and have limited walking endurance or muscle weakness. Thus, a shorter walk test can be more appropriate and provide clinically practical assessment for patients with knee arthroplasty (22). In line with this assertion, the performance-based tests used in this study to assess functional performance were well received by patients, and all

of them could complete these tests safely during the postoperative period. More, the performance tests in this study, which involve sitting and standing, mainly assess quadriceps performance, a key factor in functioning for patients with knee arthroplasty. We, therefore, concluded that these performance tests can be easily used to assess the walking and functional ability of rTKA patients in the clinical setting.

Limitations

This study is a cross-sectional correlational analysis, and the same surgeon performed all surgeries at a single surgical center. These are the strengths of the current study. However, conducting the current study in a single-center surgery clinic is a limitation because it may influence the generalizability of our results. Another limitation was that as this study used a cross-sectional correlational analysis, it limited our ability to comment on causality and effect. More, patients with an extended follow-up period of 1 to 12 years after surgery were tested, which may have affected the functional status and therefore the current findings. Lastly, the parameters such as patients' expectation, preoperative functional level, and other muscles strength (e.g. the hip and ankle muscles) which possibly related to functional performance in rTKA patients were not evaluated. It may be relevant to investigate the impact of these parameters on function; therefore, further studies should be warranted.

CONCLUSION

The current findings demonstrate a low correlation between performance-based tests and patient-reported questionnaire. This implies that these assessment tools, although comparable, usually evaluate independent properties of functional performance; therefore, neither should be used interchangeably. Given that, a comprehensive assessment for rTKA patients should include a combination of these two assessment tools. In addition, the highest associations, especially between knee extensors strength and performance-based tests, suggest that these performance tests are clinically relevant surrogate measures of knee muscle strength. More, these findings could be crucial in informing the design and implementation of interventions tailored to this population.

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