

Enhancing Understanding and Correlation of Patient-Reported Outcomes and Biomechanical Measures in Total Knee Arthroplasty

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INTRODUCTION: At the end stage of knee osteoarthritis, total knee arthroplasty (TKA) offers substantial pain relief, restore mobility and function, yielding favorable long-term outcomes. While numerous studies have reported that TKA improved functional performance [1], many patients continues to experience pain and dissatisfaction, particularly in performing daily tasks and recreational activities. Recent research has highlighted the alignment between subjective functional assessments derived from patient reported outcome measures (PROMs) and objective biomechanical evaluations in TKA recipients [2]. Yet, the intricate nature of objective measurements often poses challenges for clinicians seeking a comprehensive grasp of these measures and making well-informed decisions. This study introduces the concept of a "Knee Biomechanics Index (KBI)" amalgamating seven key variables to create a unified quantitative measure that encapsulates various biomechanical aspects. Our primary aim is to scrutinize the interrelation between PROMs and biomechanical measurements. Prior investigations have hinted at PROMs potentially serving as indicators of biomechanical functionality [3]. Establishing a nexus between these measures holds promise for addressing the prevailing lack of standardization in assessing both patient-perceived function and post-surgery gait biomechanics [2]. Our hypothesis challenges the assumption of a direct correlation between patient-perceived function and biomechanical functionality. Through this exploration, we aspire to deepen our comprehension of the intricate interplay between patient experiences and objective biomechanical dynamics, contributing to the advancement of orthopedic care.

METHODS: 20 participants underwent unilateral posterior-stabilized TKA using the Persona implant (M/F: 11/9; age: 65±6 years, BMI: 31±5 kg/m²) and 20 participants underwent bi-cruciate stabilized TKA using the Journey II implant (M/F: 11/9; age: 65±6 years, BMI: 31±4 kg/m²) were recruited. All participants were assessed both prior to and six months after surgery. The study's ethical framework was approved by an institutional research board, and all participants provided written informed consent. The PROMs used included the Knee Society Score (KSS), Forgotten Joint Score, and the Short Form – 12 Survey. A 10-camera motion capture system (FX 40, VICON) was used to record motion data at 120 Hz. Two force plates (AMTI) were used to record ground reaction force at 1200 Hz. For accurate motion tracking, 52 reflective markers were affixed bilaterally to each participant. Participants performed five daily activities: level walking, ramp up walking, ramp down walking, upstairs walking, and downstairs walking. Participants were instructed to perform each activity five times at a self-selected pace. A custom-developed and validated MATLAB program was used to perform the analysis. To better understand the differences in biomechanics during five distinct daily activities, the KBI encompassed three-dimensional knee rotations, three-dimensional knee moments, and superior/inferior knee contact force. The KBI is determined based on their proximity to the control group, with a maximum achievable score of ten signifying optimal biomechanical performance. One-way ANOVA and Pearson correlation tests were run to compare the variables with alpha set to 0.05.

RESULTS: The overview of mean and standard deviations for both knee biomechanics variables and PROMs is presented in Table 1, highlighting the observed variations. Notably, the KBI, designed to reflect performance, demonstrated an advantageous trend: higher index values indicating superior performance. Specifically, participants exhibited their optimal performance during level walking (KBI: 7.925), as compared to downstairs walking (KBI: 5.750). In examining the relationships between the KBI and PROMs, no statistically significant differences were uncovered (Table 2), suggesting a lack of direct associations between these variables. Among the PROMs, the KSS had the strongest correlations when compared to the other two. Notably, across the spectrum of five daily activities, no single task emerged as having a consistently stronger correlation across all three PROMs. This underscores the intricate and multifaceted nature of the interplay between biomechanical performance and subjective patient experiences.

DISCUSSION: The null hypothesis was confirmed, as there were no significant distinctions found between patient-perceived function and biomechanical function. The stronger correlation observed with the KSS in comparison to other PROMs could be attributed to its comprehensive assessment of functional recovery. The more demanding activities, particularly stair climbing, posed greater challenges for participants in their post-surgery recovery. These activities could potentially serve as more accurate benchmarks for evaluating participants' overall recuperation. Future research endeavors should encompass an expanded participant pool, enabling a more robust exploration of age, gender, and BMI-matched comparisons. In conclusion, this study provides a foundational framework for the analysis of extensive datasets, encompassing both subjective PROMs and objective biomechanical and gait analysis variables. By shedding light on the interplay between these multifaceted factors, the study contributes to a more comprehensive understanding of post-surgery recovery dynamics.

SIGNIFICANCE/CLINICAL RELEVANCE: A patient's self-assessed pain level and ability to perform routine activities can serve as valuable indicators of their functional limitations. Objective functional tests play a crucial role in identifying and quantifying these deficits.

REFERENCES: [1] Benedetti MG et al. (2003) Clin Biomech; [2] Biggs, P. (2019) Gait Posture; [3] Levenger, P. (2018) Knee Surg Sports Traumatol Arthrosc.

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Table 1: Mean ± standard deviation for 6-month post-op knee biomechanics index for all five daily living tasks and the three patient reported outcome measures.

	Knee Biomechanics Index					Patient Reported Outcome Measures		
	Level Walking	Ramp Up	Ramp Down	Up Stairs	Downstairs	Knee Society Scores	Forgotten Joint Score	Short Form - 12 Survey
Mean ± Standard Deviation	7.925 ± 1.149	7.638 ± 1.278	7.481 ± 0.994	6.097 ± 2.361	5.750 ± 3.093	74.325 ± 17.302	48.532 ± 25.678	65.42 ± 5.78%

Table 2: Pearson correlation values for knee biomechanics index for all five daily living tasks compared with the three patient reported outcome measures.

	Knee Society Scores	Forgotten Joint Score	Short Form – 12 Survey
Level Walking	0.238	0.128	0.090
Ramp Up	0.304	0.221	0.058
Ramp Down	0.009	-0.067	-0.123
Up Stairs	0.196	-0.061	0.169
Downstairs	0.185	0.017	0.048

