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Posted Date: 30 June 2025

doi: 10.20944/preprints202506.2458.v1

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Quantitative Analysis of Functional Mobility in Elderly Patients Following Total Knee Arthroplasty via the Transquadriceps Approach

Andrei Trindade [1], Leonardo Rezende [2,*], Helder Araújo [3], Rodolfo Parreira [4] and Cláudia Santos Oliveira [5]

[1] Orthopedic Surgeon, Municipal Hospital of Aparecida de Goiânia (HMAP); Doctoral Candidate in Health Sciences, Faculty of Medical Sciences, Santa Casa de São Paulo (FCMSCSP), Brazil
[2] Medical Student, Evangelical University of Goiás (UniEVANGÉLICA), Anápolis, Brazil
[3] Orthopedic Surgeon; PhD in Health Sciences, Federal University of Goiás (UFG), Goiânia, Brazil
[4] Faculty Member and Researcher, Evangelical University of Goiás (UniEVANGÉLICA), Goiânia, Brazil
[5] Coordinator of Teaching and Research at Human Movement and Rehabilitation, Universidade Evangélica de Goiás, Anápolis 75083-515, Brazil
* Correspondence: leonardorezende4@gmail.com

Abstract

In a context of rising demand for total knee arthroplasty (TKA) in older adults and persistent uncertainty about long-term functional recovery quality, this study evaluated elderly patients' mobility after unilateral TKA via a transquadriceps approach using instrumented Timed Up and Go (TUG) tests. In this observational, retrospective, descriptive study, 54 patients treated between 2022 and 2024 at a tertiary hospital were invited, and 19 met inclusion criteria (age 50–80, Kellgren–Lawrence ≥4). Participants performed three TUG trials at two postoperative time points (mean 17.3 and 42.8 months), with a G-Walk inertial sensor capturing 15 kinematic variables. Descriptive statistics, Shapiro–Wilk tests, paired t-tests, Wilcoxon signed-rank tests, effect sizes (Cohen's d, r), and Spearman/Pearson correlations were applied. Total TUG duration remained stable (14.97 ± 3.48 vs. 15.47 ± 2.93 s; p = 0.58), while mid-turning peak velocity increased significantly (106.44 ± 30.96 vs. 132.77 ± 30.82°/s; p = 0.0039; r = 0.88). End-turning velocity and sit-to-stand parameters showed moderate to small effect-size gains without statistical significance. These findings indicate that, beyond the first postoperative year, patients refine movement fluidity and motor control—especially during turning—underscoring the value of segmented, sensor-based assessments and the need for extended rehabilitation protocols emphasizing rotational control and balance.

Keywords: aged; recovery of function; orthopedics

1. Introduction

Osteoarthritis (OA) is a degenerative joint disease that predominantly affects elderly individuals and is the leading indication for total knee arthroplasty (TKA) [1]. Its prevalence increases with age, with the majority of patients undergoing TKA between 60 and 80 years of age [2]. Treatment for advanced degenerative and inflammatory cases is achieved through TKA, an orthopedic surgical procedure that is both highly prevalent and successful for end-stage osteoarthritis, providing pain relief and improving quality of life, particularly in older adults. However, despite these benefits, long-term functional recovery often fails to reach the levels observed in healthy individuals of the same age. During the invasive procedure, TKA performed via a transquadriceps (medial parapatellar) approach involves a longitudinal incision through the quadriceps tendon to expose the joint [3]. The main advantage of the traditional transquadriceps approach (such as the quadriceps-

 doi:10.20944/preprints202506.2458.v1

splitting medial parapatellar technique) lies in its familiarity to surgeons and the excellent exposure it provides, facilitating visualization and manipulation during surgery.

Violation of the extensor mechanism inherent to the transquadriceps approach frequently results in postoperative muscle weakness, impacting functional mobility and manifesting as difficulty in ambulation and in rising from a chair [4]. Accurate assessment of these functional deficits goes beyond manual timing, requiring methods that capture movement quality. In this context, the Timed Up and Go (TUG) test, when instrumented with inertial sensors (G-Sensor), enables quantitative and segmented performance analysis, detailing parameters such as acceleration and angular smoothness during sit-to-stand transitions and turns [5,6]. This objective diagnostic approach is crucial for identifying subtle limitations and guiding more effective rehabilitation protocols for the elderly population following arthroplasty [7].

Total knee arthroplasty (TKA) represents one of the most successful and prevalent orthopedic procedures worldwide, being performed primarily in individuals over 60 years of age to treat advanced osteoarthritis [8]. Projections indicate an exponential increase in demand for this procedure, driven by population aging and the growing prevalence of degenerative joint diseases [9]. In Brazil, a similar upward trend is observed in the number of TKAs performed by the Unified Health System (SUS) within this age group [10].

Despite the well-established benefits of total knee arthroplasty (TKA), gaps remain in the comprehensive understanding of functional recovery in older adults, particularly with respect to movement quality and asymmetries between the operated and non-operated limbs [11]. Recent studies employing technologies such as inertial sensors indicate that, even after conventional rehabilitation, subtle deficits persist in gait biomechanics, postural control during dynamic tasks, and the capacity to execute rapid and safe changes of direction [12,13]. Therefore, in-depth characterization of these residual functional deficits and their correlation with different surgical and rehabilitation approaches remain areas requiring further investigation to optimize long-term outcomes [14].

In light of the persistent gap in our understanding of motor recovery quality, this study seeks to answer the following question: what is the functional performance of elderly patients following unilateral total knee arthroplasty via a transquadriceps approach when evaluated quantitatively by an inertial sensor during the Timed Up and Go (TUG) test? The relevance of this investigation lies in the use of an objective, detailed metric to characterize functional deficits that are not captured by traditional timed assessments. The results may provide the scientific and clinical communities with precise evidence of the functional impact of this surgical approach, thereby guiding the development of more specific and effective rehabilitation protocols to optimize mobility and independence in elderly patients.

2. Materials and Methods

This is an observational, retrospective, and descriptive study conducted with patients who underwent unilateral total knee arthroplasty (TKA) via the transquadriceps surgical approach, with the objective of identifying and describing those operated using this technique. As a descriptive study, no inferential statistical comparisons between groups or time periods were performed, nor was any hypothesis testing undertaken.

Initially, the target population comprised 54 patients who had undergone TKA at a tertiary hospital in Goiás, Brazil, between 2022 and 2024. This sample size was determined based on a prior calculation for an original longitudinal study, grounded in repeated-measures analysis of variance according to the statistical parameters described by Tsubosaka et al. [15]—a minimum difference between means of 0.2, a standard deviation of 0.3, 80% power, and an alpha of 5%.

Inclusion criteria required individuals to present with advanced knee osteoarthritis (grade ≥ 4 according to the Kellgren and Lawrence scale), be aged 50–80 years, and have undergone their first surgery for osteoarthritis via the transquadriceps approach. Exclusion criteria comprised neurodegenerative diseases, secondary osteoarthritis, primary unilateral total arthroplasty via a subvastus approach, prior knee surgeries, a history of knee fracture within the previous 12 months, hip arthroplasty, pre- or postoperative infections, comorbidities that could compromise recovery and rehabilitation, or a history of revision knee arthroplasty.

Assessments were conducted over a maximum of 30 minutes per day. Participants were evaluated using an inertial sensor (G-Walk) during the execution of the Timed Up and Go (TUG) test. This sensor captured and stored 15 variables related to functional mobility parameters. For each patient, the mean of three TUG repetitions was used. Evaluations occurred at two time points: an initial postoperative assessment (mean 12 months after surgery) and a second evaluation approximately two years following the surgical intervention. At the outset, participants completed an identification form and anthropometric data (body weight, height, and body mass index) were recorded.

The TUG test quantifies, in seconds, the time required for an individual to rise from a standard chair (without armrests), walk three meters, perform a turn, return to the starting point, and sit down again [16]. Participants were instructed to perform the test at a self-selected, safe speed to minimize fall risk. Two trials were performed, with the first serving as familiarization.

Data were collected via a portable inertial sensor (G-Walk) positioned at the L5 vertebral level. This wireless inertial system, designed for human motion analysis, is controlled by a data recording unit (capable of supporting up to 16 sensors) via ZigBee radio communication. Each sensor measures 62 × 36 × 16 mm, weighs 60 g, and comprises a triaxial accelerometer (±6 g), a triaxial gyroscope (±300°/s), and a triaxial magnetometer (±6 Gauss). The device is calibrated against gravitational acceleration immediately after manufacture. For this study, a single sensor configured at a 50 Hz sampling frequency was used. Captured data were transmitted via Bluetooth to a computer and processed with proprietary software (BTS G-STUDIO, version 2.6.12.0), which automatically provided the parameters of interest [17].

Statistical analyses were performed by one of the authors using procedures appropriate to the data's nature and the study's longitudinal design. First, the normality of quantitative variables was assessed with the Shapiro–Wilk test, which is recommended for small samples. This procedure determined whether parametric or nonparametric tests would be used for subsequent comparisons.

Descriptive statistics were presented as measures of central tendency (mean and median) and dispersion (standard deviation, minimum, and maximum values). To compare results between the two evaluation time points—denoted Collection 1 and Collection 2—the following tests were applied: a paired t-test for variables exhibiting a normal distribution to compare means, and the Wilcoxon signed-rank test for variables that violated normality assumptions to compare medians or the direction of paired differences.

In addition to statistical significance testing, effect sizes were calculated to quantify the magnitude of observed differences independently of p-values. Cohen's d was used for parametric tests, and the nonparametric effect-size coefficient r was computed as $r = z/\sqrt{n}$. Effect magnitudes were classified conventionally as small, moderate, or large.

Correlation analyses were also conducted to explore associations between biomechanical variables—such as time, acceleration, and velocity during different test phases. Pearson's correlation coefficient was applied to normally distributed data, and Spearman's rank correlation to nonparametric data. All analyses used a 5% significance level ($p < 0.05$).

Data were initially organized in Microsoft Excel® spreadsheets, and subsequent statistical analyses were carried out in IBM SPSS Statistics®, version 2019. Artificial intelligence (IA) was not used for literature searches or scientific writing. For grammatical corrections, the Grammarly tool was employed to address language and grammar deviations.

3. Results

The cohort of 54 patients originally determined for the longitudinal study was invited to participate in this research, of whom 36 attended the outpatient clinic for functional evaluation; 19 of these met the inclusion criteria, with their epidemiological characteristics detailed in Table 1. The

 doi:10.20944/preprints202506.2458.v1

descriptive analysis of functional and biomechanical variables revealed the sample's central parameters at two distinct time points: Collection 1 (18 months postoperatively) and Collection 2 (53 months postoperatively). Evaluated variables included execution time; accelerations during the sit-to-stand and stand-to-sit phases; and velocities and durations of the turning phases (mid turning and end turning).

Table 1. Characteristics of the Evaluated Patient Sample.

Sex	Value	19
	Female	10
	Male	9
Mean weight	79,0 Kg	
Mean height	1,61m	
Mean body mass index (BMI)	31,27	
Laterality		
	Right Limb	14
	Left Limb	5
Postoperative follow-up interval 1st assessment (mean)	17,31 months	
Postoperative follw-up interval 2 st assessment (mean_	42,80 months	

In the total task duration, a mean of 14.97 ± 3.48 seconds was observed in Collection 1 (median 14.72 s), with a slight increase to 15.47 ± 2.93 seconds in Collection 2 (median 14.76 s). These findings suggest stability in overall functional mobility performance over time, with no marked changes in total execution time.

For variables associated with the sit-to-stand transition, the mean time was 1.95 ± 0.46 seconds in Collection 1, decreasing slightly to 1.76 ± 0.40 seconds in Collection 2, indicating a possible improvement in the agility of this task. Anteroposterior, mediolateral, and vertical accelerations showed minimal variation between collections, maintaining similar profiles—for example, anteroposterior acceleration averaged 3.92 ± 1.81 m/s² in Collection 1 versus 3.78 ± 2.40 m/s² in Collection 2. In the stand-to-sit movement, the mean time was 2.08 ± 0.42 seconds in Collection 1, rising slightly to 2.30 ± 1.10 seconds in Collection 2, with increased dispersion that may reflect greater interindividual variability in the sitting strategy at the later evaluation.

The mid-turning phase demonstrated clinically relevant improvements in velocity. Peak mid-turning velocity increased from 106.44 ± 30.96°/s in Collection 1 to 132.77 ± 30.82°/s in Collection 2, while mean velocity rose from 65.22 ± 21.54°/s to 68.39 ± 22.07°/s, indicating significant functional gains in turning ability, as supported by the statistical results previously reported.

In the end-turning phase, velocities also increased. Peak end-turning velocity rose from 135.40 ± 25.07°/s in Collection 1 to 141.85 ± 22.22°/s in Collection 2, and mean velocity increased from 67.01 ± 13.81°/s to 76.77 ± 11.93°/s, reflecting enhanced fluidity and motor control at task completion.

Regarding the duration of turning phases (mid turning and end turning), values remained stable between collections, with small average reductions that appear not to be clinically meaningful but may reflect subtle adjustments in locomotor strategy.

In summary, the descriptive results indicate maintenance of global task performance over time, coupled with specific gains in turning velocities (mid turning and end turning) and modest improvements in transfer tasks (sit-to-stand). This suggests that, even beyond the first postoperative year, patients tend to refine aspects of movement fluidity and dynamic postural control.

3.1. Sample Normality

The normality of the data was assessed using the Shapiro–Wilk test, which is considered appropriate for small to moderate sample sizes [1]. Quantitative variables from both collections were evaluated, including execution time; accelerations during the sit-to-stand and stand-to-sit phases; and velocities in the mid-turning and end-turning phases. A significance level of 5% ($p < 0.05$) was adopted. According to the Shapiro–Wilk test, the total task duration in Collection 1 ($p = 0.4511$) and the vertical acceleration during sit-to-stand in Collection 1 ($p = 0.3222$) exhibited a normal distribution ($p > 0.05$).

However, the majority of variables did not follow a normal distribution, as was also the case for other acceleration and velocity measures in the mid-turning and end-turning phases. Visual inspection of histograms and Q–Q plots corroborated the statistical test results, revealing right-skewed patterns—particularly in acceleration variables, which were clustered at lower values with outliers at higher values [2]. Overall, these findings indicate a mixture of normally and non-normally distributed variables in the sample, justifying the use of nonparametric tests for most of the comparative analyses.

3.2. Statistical Test for Assessing Significance Between Variables

The comparison between Collection 1 (18 months postoperatively) and Collection 2 (53 months postoperatively) was conducted based on the assessment of data normality, which guided the selection of statistical tests. Table 2 presents the results of the Shapiro–Wilk normality test for each variable in both collections, as well as the results of the paired comparison tests.

Table 2. Comparison of statistical tests between Collection 1 (18 months post-op) and Collection 2 (53 months post-op).

Variable	Test	Shapiro-Wilk *p* Collection 1	Shapiro-Wilk *p* Collection 2	Test Statistic	*p* value
Total Task duration	Paired t-test	0,4511	0,1128	–0,5598	0,5825
Sit-to-Stand – Duration	Wilcoxon signed-rank test	0,0391	0,7071	52,5	0,1505
Sit-to-Stand – Anteroposterior acceleration	Wilcoxon signed-rank test	0,0409	0,0001	85,0	0,9826
Mid Turning – Peak Velocity	Wilcoxon signed-rank test	0,0022	0,2905	26,0	0,0039
End Turning – Peak velocity	Paired t-test	0,6651	–	–1,2425	0,2300

It was observed that only the variable related to peak velocity during mid-turning (intermediate turn) showed a statistically significant difference between collections ($p = 0.0039$). This finding indicates a significant improvement in patients' performance when executing turns, suggesting gains in agility, stability, and motor control—key factors for functionality in activities of daily living.

By contrast, total task duration ($p = 0.5825$), sit-to-stand duration ($p = 0.1505$), sit-to-stand anteroposterior acceleration ($p = 0.9826$), and peak velocity during end-turning ($p = 0.230$) did not exhibit statistically significant differences between evaluations. Nevertheless, mean values and trend plots indicate clinical improvement tendencies—particularly in postural transition tasks and final turns—even though these did not reach statistical significance.

These findings reinforce the hypothesis that, over time, patients exhibit more pronounced improvements in gait components related to movement fluidity, motor control during turns, and dynamic stability, whereas variables associated with total execution time or accelerations during transfers display more heterogeneous behavior and may depend on individual factors such as muscle strength, balance, and motor strategies.

3.3. Spearman's Correlation Analysis

Spearman's correlation was selected given the nonparametric nature of most variables, as evidenced by the Shapiro–Wilk tests; this monotonic correlation coefficient (ϱ) is less sensitive to nonnormality and outliers, allowing assessment of consistent relationships among temporal, acceleration, and velocity domains without assuming strict linearity. In the interrelation between global performance (total duration) and postural transfers, a moderate positive correlation was observed in Collection 2 (53 months) between total duration and sit-to-stand duration (ϱ = 0.54), indicating that individuals who were slower overall also took longer to complete the sit-to-stand phase at this later stage of recovery.

Conversely, in Collection 1 (18 months), anteroposterior acceleration during sit-to-stand showed a moderate negative correlation with total duration (ϱ = –0.58), suggesting that patients able to generate greater initial leg force completed the entire test more rapidly. The analysis of relationships between transfer acceleration and turning velocity revealed a moderate positive correlation in Collection 1 between anteroposterior acceleration in sit-to-stand and peak mid-turning velocity (ϱ = 0.35), implying that the ability to develop momentum when rising may enhance dynamic control and speed during intermediate direction changes.

Furthermore, in Collection 2, peak velocities in mid turning and end turning demonstrated a strong correlation (ϱ = 0.60), indicating that patients who improve agility in one turning phase tend to maintain high performance in the subsequent phase.

Finally, cross-collection correlations between variables were modest, reflecting that functional evolution after knee arthroplasty does not occur uniformly across all parameters. While gains in acceleration and turning velocity are evident, the maintenance of total execution time suggests that qualitative aspects of movement—such as fluidity and postural control during turns—may be more sensitive long-term recovery indicators than overall speed.

3.4. Effect Size Measures

Collection 1 (18 months postoperatively) and Collection 2 (53 months), using Cohen's d for paired t-tests and effect size r (Z/√n) for Wilcoxon tests. The thresholds adopted for interpretation were: ≤ 0.20 (very small effect), 0.20–0.50 (small effect), 0.50–0.80 (moderate effect), and > 0.80 (large effect). The results demonstrate that peak velocity during mid turning exhibited a large effect (r = 0.88), corroborating the statistical significance observed (p = 0.0039) and indicating a substantial improvement in agility and motor control during intermediate turns.

Table 3. Effect Size Measures.

Variable	Test	Corrected Effect Size	Interpretation
Total duration	Paired t-test	-0.128	Very small/ Negligible effect
Sit to Stand – Duration	Wilcoxon signed-rank test	0.392	Small to moderate effect
Sit to Stand – Anteroposterior acceleration	Wilcoxon signed-rank test	0.392	Small to moderate effect

 doi:10.20944/preprints202506.2458.v1

Mid Turning – Peak velocity	Wilcoxon signed-rank test	0.877	Large effect (High clinical relevance)
End Turning – Peak velocity	Paired t-test	0.469	Moderate effect

Peak velocity during end turning showed a moderate effect (d = 0.47), signaling a clinically relevant gain in this final turning phase despite not reaching statistical significance. Transfer variables—both sit-to-stand duration and anteroposterior acceleration—displayed small to moderate effects (r ≈ 0.39), suggesting discrete yet observable improvements in postural transition capacity. Finally, total test duration remained essentially unchanged (d = –0.13), reinforcing that overall execution time did not vary appreciably between collections.

Taken together, despite the sample size limitation, this effect size analysis indicates that the most significant functional gains occurred in tasks involving changes of direction and dynamic control—key elements for autonomy in activities of daily living. While stability in total execution time is a consistent finding in the literature—where qualitative improvements in fluidity and safety may precede or occur independently of changes in gross task time—the moderate to large effects identified in turning phases underscore the importance of incorporating rotation- and balance-specific exercises into medium- and long-term rehabilitation protocols.

4. Discussion

This study investigated the progression of functional mobility in patients undergoing unilateral total knee arthroplasty (TKA) via a transquadriceps approach, evaluated at two late postoperative time points (approximately 18 and 53 months). The primary finding was not a change in total task execution time—which remained remarkably stable—but rather a qualitative improvement in movement. Specifically, a statistically significant, large-magnitude effect was observed in peak velocity during the mid-turning phase, accompanied by a clinically relevant, moderate-magnitude improvement in end-turning velocity. These results suggest that, even after the functional recovery plateau typically reached within the first postoperative year, continuous refinements occur in more complex aspects of motor control, such as agility and dynamic stability.

Stability in total Timed Up and Go (TUG) test duration—mean values of approximately 15 seconds at both assessments—aligns with longitudinal studies showing that, although the greatest functional gains after TKA occur within the first 12 months, recovery can extend up to two years, after which performance tends to stabilize [18]. The mean time observed in our sample exceeds reference values for healthy adults of the same age group (typically under 12 seconds) [19], reinforcing that functional deficits persist even years after surgery. A recent systematic review confirmed that TKA patients continue to exhibit inferior performance on functional tests compared with healthy controls in the long term [20]. The absence of improvement in overall time may indicate that linear gait capacity and transfers—dependent on quadriceps strength—have reached their recovery peak, a factor to consider given the invasive nature of the transquadriceps approach on this muscle [21].

The most salient finding was the marked enhancement in turning velocities. Peak mid-turning velocity increased substantially, with a large effect size (r = 0.88), indicating a robust gain in directional change ability. Turning tasks are neuromotorically more demanding than straight-line gait, requiring greater postural control, coordination, and motor planning [22]. Late improvement in this parameter suggests ongoing motor learning and proprioceptive adaptation. As described by Maiora et al., the TUG is a valuable tool for assessing complex functional mobility [23]. Over time, patients may develop more efficient and safer movement strategies for turning—critical for everyday functionality and for reducing fall risk, a persistent problem in the TKA population [24]. The strong

doi:10.20944/preprints202506.2458.v1

positive correlation (ϱ = 0.60) between mid- and end-turning velocities at the second assessment supports the notion that patients have adopted a more consolidated and effective turning strategy.

Analysis of postural transfers, such as the sit-to-stand (STS), revealed small-to-moderate improvement trends, albeit without statistical significance. The moderate negative correlation (ϱ = –0.58) between sit-to-stand anteroposterior acceleration and total TUG duration at the first assessment suggests that the ability to generate initial momentum was a key factor in overall performance early on. Attenuation of this relationship at the second assessment may indicate a shift in functional strategy: whereas explosive strength was crucial initially, fluidity and dynamic control during turns became the primary determinants of long-term qualitative performance. This is consistent with studies showing persistent quadriceps strength deficits years after TKA, which can limit transfer tasks reliant on power [25].

These findings have significant clinical implications. First, assessment of functional recovery after TKA should not be limited to global time measures. Component analysis of the task—such as turning phases—using technologies like inertial sensors offers a more sensitive insight into movement quality. Furthermore, our results underscore the need for rehabilitation protocols extending beyond the first postoperative year. Such programs should incorporate exercises targeting dynamic postural control, coordination, and agility in directional changes, aiming to optimize performance in activities of daily living rather than solely linear gait capacity.

This study has several limitations. The small sample size (n = 19) restricts statistical power and generalizability. The observational design and absence of a control group (either healthy individuals or patients undergoing alternative approaches) preclude causal inferences. Additionally, focusing exclusively on patients treated via the transquadriceps approach at a single center may not reflect outcomes associated with other surgical techniques or patient populations.

Future research should aim to validate these findings in larger, multicenter cohorts. Comparative studies evaluating TUG kinematics across different surgical approaches (e.g., transquadriceps vs. subvastus vs. medial parapatellar) would be particularly valuable. Moreover, investigating correlations between kinematic parameters and other variables—such as quadriceps and hip muscle strength, patient confidence measures, and fall rates—could elucidate the mechanisms underlying this late functional improvement.

5. Conclusions

This study demonstrates that, in older adults undergoing unilateral total knee arthroplasty via a transquadriceps approach, global performance as measured by the Timed Up and Go (TUG) test remained stable between 18 and 53 months postoperatively, whereas qualitative movement parameters—specifically turning velocities (mid turning and end turning)—showed significant and clinically relevant gains [1]. The robust improvement in peak mid-turning velocity and the moderate effects observed in end turning and postural transfer components indicate a late and ongoing refinement in movement fluidity and motor control, which are critical for autonomy and fall-risk reduction [2].

These findings underscore the importance of segmented assessments and the use of inertial sensors to monitor subtle functional improvements not captured by traditional time-based metrics. It is recommended that physiotherapy protocols be extended beyond the first postoperative year and include exercises targeting rotational control and balance. Future multicenter studies with comparative groups are needed to validate and expand upon these results.

Supplementary Materials: The following supporting information can be downloaded at the website of this paper posted on Preprints.org, Figure S1: title; Table S1: title; Video S1: title.

Author Contributions: Conceptualization, Andrei Machado Viegas da Trindade; methodology, Andrei Machado Viegas da Trindade; software, Leonardo Pinheiro Rezende; validation, Leonardo Pinheiro Rezende; formal analysis, Rodolfo Borges Parreira; investigation, Leonardo Pinheiro Rezende; writing—original draft preparation, Leonardo Pinheiro Rezende; writing—review and editing, Leonardo Pinheiro Rezende; writing—

 doi:10.20944/preprints202506.2458.v1

review and editing, Andrei Machado Viegas da Trindade; writing—review and editing, Helder Rocha da Silva Araujo; writing—review and editing, Cláudia Santos Oliveira. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no specific grants from any funding agency in the public, commercial, or not-for-profit sectors.

Institutional Review Board Statement: The present study adheres to the national ethical guidelines and regulatory standards for research involving human subjects, as established by the Brazilian National Health Council (Ministry of Health) in October 1996 and updated under Resolution 466/2012. Ethical approval was obtained from the Plataforma Brasil Ethics Committee in Anápolis, Goiás (Protocol No. 6.775.127; CAAE 52052421.9.0000.5076). This prospective, observational, comparative study enrolled participants who provided written informed consent, acknowledging that their involvement was voluntary, free of charge, and experimental in nature. All participants received complete information about the study and could withdraw or revoke consent at any time without penalty. Their confidentiality and privacy were rigorously protected in accordance with ethical principles. The research was conducted at a tertiary hospital in partnership with a private university, both of which possess the necessary technical infrastructure and institutional support to ensure successful project execution. In particular, a fully equipped motion-analysis laboratory—featuring the portable, wireless G-Walk inertial sensor system (G-Sensor, BTS Bioengineering S.p.A., Italy)—was utilized for data collection.

Informed Consent Statement: All participants were given comprehensive information about the study's objectives, procedures, potential risks, and expected benefits. Participation was entirely voluntary, and each individual provided written informed consent, confirming their understanding of this information and their right to withdraw from the study at any time without penalty.

Data Availability Statement: We encourage all authors of articles published in MDPI journals to share their research data. In this section, please provide details regarding where data supporting reported results can be found, including links to publicly archived datasets analyzed or generated during the study. Where no new data were created, or where data is unavailable due to privacy or ethical restrictions, a statement is still required. Suggested Data Availability Statements are available in section "MDPI Research Data Policies" at https://www.mdpi.com/ethics.

Acknowledgments: We are grateful for the opportunity to write and publish this work, which was supported by the Scientific Initiation Scholarship Program of the Evangelical University of Goiás (UniEVANGÉLICA). We especially thank, on behalf of Cláudia Santos Oliveira, the National Council for Scientific and Technological Development (CNPq) for granting the Research Productivity Scholarship.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

OA: Osteoarthritis
TKA: Total Knee Arthroplasty
TUG: Timed Up and Go
G-Walk: Wearable inertial sensor system (BTS Bioengineering G-Walk)
BMI: Body Mass Index
L5: Fifth lumbar vertebra (sensor placement level)
SPSS: Statistical Package for the Social Sciences (IBM SPSS Statistics)
CAAE: Certificado de Apresentação para Apreciação Ética (Brazilian ethics approval certificate)
SUS: Sistema Único de Saúde (Brazilian Unified Health System)
IA: Inteligência Artificial (artificial intelligence)

 doi:10.20944/preprints202506.2458.v1

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