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Improved Walking Steadiness Following total Hip Arthroplasty Compared to Total Knee Arthroplasty

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ABSTRACT

Background: Total knee (TKA) and hip arthroplasty (THA) effectively treat end-stage osteoarthritis by restoring mobility and reducing pain; however, it is unclear how balance and steadiness compare between TKA and THA patients. This study utilized wearable technology to objectively compare functional recovery between TKA and THA patients.
Methods: Two Hundred Nine patients underwent TKA (n = 152) or THA (n = 57) and were followed for 1 year. Participants wore Apple Watches with HealthKit to track daily step count, steadiness, standing duration, gait speed, and estimated 6-minute walk test distance. Data were analyzed at baseline, 6 weeks, 6 months, and 12 months postsurgery. Propensity score matching (1:1 ratio) yielded a final cohort of 110 patients (55 TKA, 55 THA). A multivariate regression analysis was conducted to evaluate the effect of THA vs TKA on steadiness, adjusting for contralateral Kellgren−Lawrence classification, age, sex, and body mass index.
Results: Both groups improved mobility and endurance, with similar increases in step count, standing duration, and 6-minute walk test distance over 12 months. THA patients showed significantly greater steadiness at 6 (0.63 vs 0.49, *P* = .031) and 12 months (0.84 vs 0.66, *P* = .044). Multivariate analysis confirmed that TKA was associated with lower steadiness scores.
Conclusions: This study, the first to utilize Apple HealthKit data to compare TKA and THA recovery, found that THA patients exhibit better steadiness and balance recovery at 6 and 12 months. These findings suggest that balance-focused rehabilitation may benefit TKA patients. Wearable technology provides valuable, objective insights, enabling personalized guidance and enhancing patient outcomes.
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Introduction

Osteoarthritis (OA) is one of the most prevalent sources of chronic pain and functional impairment worldwide, particularly affecting the hip and knee joints [1-3]. The demand for total knee (TKA) and hip arthroplasty (THA) is projected to increase such that millions of individuals will undergo these procedures annually [4], making comparisons of their functional recovery crucial for

clinicians and patients. Evaluating the recovery rate is especially relevant for individuals considering undergoing both procedures sequentially [5,6].

Each surgery poses distinct postoperative challenges. For example, TKA recovery often involves intensive rehabilitation for knee stability and strength, whereas THA may follow different patterns of pain relief and mobility restoration [7,8]. Understanding these differences in recovery trajectories aids in setting expectations, improving patient satisfaction, and optimizing care plans. Although both procedures generally yield positive outcomes, functional limitations and fall risk may differ [9-11].

Traditional recovery assessments after TKA and THA have relied on patient-reported outcomes and periodic clinical evaluations

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[12-14]. These approaches provide valuable subjective insights but may not fully capture the objective, day-to-day progress that patients experience [15]. Advancements in wearable technology, such as Apple HealthKit, have introduced new possibilities for continuous monitoring of physical activity and functional metrics. These devices offer objective measurements that allow for a detailed, data-driven analysis of functional recovery [16-19]. Despite the potential of wearable devices to transform postoperative monitoring, few studies have used them to compare recovery outcomes between TKA and THA patients.

This study is the first to prospectively use Apple HealthKit to evaluate and compare the recovery trajectories of patients undergoing TKA and THA over a 1-year postoperative period. By tracking objective metrics such as daily steps, standing duration, 6-minute walk test (6MWT) performance, and steadiness, this study aims to comprehensively analyze functional recovery differences between the 2 procedures. These findings will help guide clinicians in counseling patients on recovery expectations and tailoring postoperative support to reduce fall risk and enhance quality of life.

Material and methods

Study design

This prospective cohort study enrolled patients undergoing TKA or THA for end-stage OA at a single institution. All participants provided informed consent before enrollment, and the study was approved by the institution's ethics review board (IRB: Pro00115921).

Eligibility criteria included adults (≥18 years old) with advanced OA of the knee or hip, scheduled for a primary TKA or THA, possessing an iPhone compatible with an Apple Watch, and able to ambulate independently or with minimal assistance preoperatively. Exclusion criteria included a history of inflammatory arthropathies, substance abuse, or conditions likely to interfere with postoperative recovery or adherence to monitoring protocols, including severe cognitive impairment, active neurological conditions (eg, Parkinson's disease, history of stroke), and unstable cardiac or pulmonary disease.

To enable accurate comparisons between the TKA and THA groups, patients were matched based on propensity scores, accounting for both age and sex. Propensity score matching was conducted at a 1:1 ratio (TKA to THA) using the nearest-neighbor approach with a caliper width of 0.1.

Participant characteristics

Over a 2-year recruitment period, 209 patients (152 undergoing TKA and 57 undergoing THA) were enrolled in the study. There were 2 THA patients that fell outside this caliper range and were excluded.

A total of 110 patients were included in this study, with 55 patients in each of the TKA and THA groups. The groups were balanced in terms of age, sex, and preoperative functional metrics, with no statistically significant differences in baseline characteristics (P > .05 for all, Table 1). The mean participant age was 64.04 years (standard deviation = 8.87), and the mean body mass index (BMI) was slightly higher in the TKA group (33.07 vs 30.43, P = .01). The two groups had similar EuroQol 5-Dimension (EQ5D) scores at the various postoperative time points (Table 2). Other preoperative metrics showed no significant differences between groups, including preoperative step count, steadiness, standing time, gait speed, and 6MWT performance.

Table 1
Study cohort characteristics.

Variable	Overall (n = 110)	THA (n = 55)	TKA (n = 55)	P value
Age, yr (sd)	64.04 (8.87)	64.10 (8.92)	63.98 (8.90)	.943
BMI, kg/m2 (SD)	31.75 (5.45)	30.43 (4.89)	33.07 (5.70)	.01
Male (%)	44 (40.0)	24 (43.6)	20 (36.4)	.559
Diabetes (%)	1 (0.9)	1 (1.8)	0 (0.0)	1
KL (Contralateral) (%)				.234
0	11 (13.3)	9 (20.0)	2 (5.3)	
1	18 (21.7)	10 (22.2)	8 (21.1)	
2	25 (30.1)	14 (31.1)	11 (28.9)	
3	13 (15.7)	6 (13.3)	7 (18.4)	
4	16 (19.3)	6 (13.3)	10 (26.3)	

SD, standard deviation.

Daily activity metrics

Each participant was provided an Apple Watch with Apple HealthKit software and instructed to wear it daily from the preoperative period to 1 year postoperatively. Apple HealthKit metrics collected included:

- Daily Steps: Average daily step count, recorded as a measure of physical activity and mobility.
- Steadiness: HealthKit's steadiness score was used as a balance metric, scored on a scale from 0 to 1, with higher scores indicating better stability and balance.
- Standing Duration: Total hours spent standing daily, reflecting weight-bearing capacity and functional endurance.
- 6MWT: An estimated performance of the 6MWT calculated by HealthKit based on motion data, providing a surrogate for cardiovascular and functional endurance.
- Gait Speed: Average walking speed calculated by HealthKit, serving as an indicator of mobility and overall recovery progress.

These metrics were averaged weekly and analyzed at multiple postoperative time points: 6 weeks, 6 months, and 12 months, with preoperative baseline measurements recorded before surgery.

Additionally, falls over the 12 months were tracked using Apple HealthKit's fall detection feature, which monitors fall events using the Apple Watch's accelerometer and gyroscope.

Data collection

Patient demographic information, including age, sex, diabetes status and BMI, was collected prospectively at baseline. To assess subjective functional outcomes, patient-reported outcome measures were also gathered at key time points: preoperatively, and at 1 month, 6 months, and 12 months postoperatively. These measures included the EQ5D, a validated tool assessing overall health-related quality of life. The Knee Injury and Osteoarthritis Outcome Score for Joint Replacement (KOOS, JR) was collected for TKA patients, and the Hip Disability and Osteoarthritis Outcome Score for Joint Replacement (HOOS, JR) was collected for THA patients. As each measure is joint-specific and was not collected for the other group, direct comparisons between TKA and THA using KOOS, JR and HOOS, JR were not feasible. Therefore, these joint-specific scores were excluded from the comparative analysis. The EQ5D, a joint-agnostic measure of overall health-related quality of life, was used instead to enable consistent comparison across both groups.

Table 2
Patient-reported outcome measures.

Variable	Overall (n = 110)	THA (n = 55)	TKA (n = 55)	P value
KOOS, JR Preoperative (SD)	53.69 (11.74)	N/A	53.69 (11.74)	N/A
KOOS, JR 1 Mo (SD)	64.18 (11.57)	N/A	64.18 (11.57)	N/A
KOOS, JR 3 Mo (SD)	69.90 (11.08)	N/A	69.90 (11.08)	N/A
KOOS, JR 6 Mo (SD)	74.82 (10.74)	N/A	74.82 (10.74)	N/A
KOOS, JR 1 Y (SD)	82.40 (13.11)	N/A	82.40 (13.11)	N/A
EQ5D Preoperative (SD)	73.80 (17.88)	71.55 (19.03)	76.15 (16.46)	.209
EQ5D 1 Mo (SD)	77.81 (13.99)	78.09 (12.02)	77.55 (15.74)	.856
EQ5D 3 Mo (SD)	83.40 (12.52)	83.59 (12.45)	83.23 (12.71)	.896
EQ5D 6 Mo (SD)	85.06 (11.98)	86.29 (12.72)	83.83 (11.20)	.355
EQ5D 1 Y (SD)	84.82 (11.58)	84.07 (12.67)	85.55 (10.49)	.555

SD, standard deviation; N/A, not applicable.

Contralateral knee assessment

In addition to functional recovery metrics, the severity of OA in the contralateral knee was evaluated using the Kellgren−Lawrence (KL) grading system, a standardized measure for assessing radiographic OA. KL grades, which range from 0 (no OA) to 4 (severe OA), were recorded preoperatively for each patient's nonoperated knee [20]. The KL classification was assigned by an orthopaedic surgeon fellowship-trained in adult reconstructive hip and knee surgery, using preoperative weight-bearing radiographs. This measurement was meant to control for the impact of contralateral knee OA on functional outcomes and balance, particularly steadiness, during the analysis of postoperative recovery trajectories. Intraobserver reliability was not assessed due to prior literature validating the intraobserver reliability of the KL classification [21].

Contralateral hip OA was not assessed, as many THA patients did not have bilateral disease, and the study aimed to maintain consistency by focusing on the contralateral knee for all participants. Moreover, prior research has shown that hip OA patients typically reduce joint loading during gait and stair ambulation without compensatory overloading of the contralateral limb [22]. In contrast, knee OA patients exhibit more pronounced contralateral and ipsilateral compensatory loading patterns [22].

Data analyses

Statistical analyses were performed using R software, version 4.2 (R studio team, Boston, MA). Descriptive statistics were used to summarize patient demographics and baseline characteristics, with means and standard deviations for continuous variables and percentages for categorical variables. Independent *t*-tests were applied to compare baseline and postoperative metrics between TKA and THA groups. Repeated-measures ANOVA was conducted to assess changes in metrics over time within each group, with a focus on the interaction between time and treatment type (TKA vs THA).

A multivariate regression analysis was conducted to assess the impact of TKA vs THA on steadiness, adjusting for potential confounders such as contralateral KL classification, age, BMI, and sex, at 6 and 12 months postoperatively. A *P* value of <0.05 was considered statistically significant.

Additional multivariate regression analyses were performed for other functional outcomes (step count, gait speed, standing duration, and 6MWT), adjusting for baseline (preoperative) values, age, sex, BMI, and contralateral KL grade. Results are reported in Appendix Table 1. Pearson correlation analyses were conducted between EQ5D scores at 12 months and wearable-derived functional metrics.

Results

Steadiness

Steadiness scores, a surrogate for balance and stability, were similar between groups preoperatively (TKA: 0.61 ± 0.20 vs THA: 0.57 ± 0.27, *P* = .679) (Table 3). At 6 weeks postoperatively, both groups showed slight decreases in steadiness (TKA: 0.42 ± 0.17 vs THA: 0.47 ± 0.23, *P* = .459), with no significant differences between groups. However, at 6 months, the THA group demonstrated a significantly higher steadiness score compared to the TKA group (THA: 0.63 ± 0.19 vs TKA: 0.49 ± 0.19, *P* = .031). This trend continued at 12 months, with THA patients achieving higher steadiness scores (THA: 0.84 ± 0.11 vs TKA: 0.66 ± 0.17, *P* = .044).

During the 12-month study period, there was a higher rate of falls within the TKA group compared to the THA group (30.9% vs 16.4%; *P* = .116). However, this difference was not statistically significant.

Step count

Preoperative daily step counts were similar between groups (TKA: 3754.70 ± 2131.28 vs THA: 3570.64 ± 1959.95, *P* = .649). At 6 weeks, both groups showed a reduction in step count from baseline without a significant difference between them (TKA: 2973.23 ± 1463.14 vs THA: 3383.55 ± 1942.70, *P* = .229). At 6 months, THA patients had a higher average step count (4843.61 ± 2443.73) compared to TKA patients (4079.84 ± 1873.20) which was not significantly different (*P* = .078). At 12 months, THA patients continued to have a higher step count (5039.41 ± 2414.72 vs TKA: 4260.92 ± 1938.47), though the difference was again not statistically significant (*P* = .075).

Standing duration

Preoperative standing duration was equivalent between groups (TKA: 0.97 ± 0.11 hours vs THA: 0.97 ± 0.14 hours, *P* = .85). At 6 weeks, both groups increased standing duration, with no significant difference (TKA: 12.00 ± 3.52 hours vs THA: 11.41 ± 3.86 hours, *P* = .432). By 6 months and 12 months, standing duration remained elevated in both groups, with TKA patients showing slightly higher durations, though the differences were nonsignificant (6 months, *P* = .094; 12 months, *P* = .224).

Gait speed

Gait speed remained stable preoperatively and throughout the postoperative period between groups. At 6 weeks, TKA patients had an average gait speed of 0.86 ± 0.14 m/s, while THA patients

Table 3
Daily activity metrics across various time points.

Variable	Overall (n = 110)	THA (n = 55)	TKA (n = 55)	P value
Preoperative Steadiness (SD)	0.59 (0.23)	0.57 (0.27)	0.61 (0.20)	.679
Steadiness at 6 wks (SD)	0.44 (0.20)	0.47 (0.23)	0.42 (0.17)	.459
Steadiness at 6 Mo (SD)	0.55 (0.20)	0.63 (0.19)	0.49 (0.19)	**.031**
Steadiness at 12 Mo (SD)	0.75 (0.17)	0.84 (0.11)	0.66 (0.17)	**.044**
Postoperative Falls, yes (%)	22 (20.8)	7 (13.2)	15 (28.3)	.094
Preoperative Step Count (SD)	3661.77 (2038.60)	3570.64 (1959.95)	3754.70 (2131.28)	.649
Step Count at 6 wks (SD)	3180.38 (1725.96)	3383.55 (1942.70)	2973.23 (1463.14)	.229
Step Count at 6 Mo (SD)	4465.43 (2203.00)	4843.61 (2443.73)	4079.84 (1873.20)	.078
Step Count at 12 Mo (SD)	4653.94 (2215.94)	5039.41 (2414.72)	4260.92 (1938.47)	.075
Preoperative Standing H (SD)	0.97 (0.12)	0.97 (0.14)	0.97 (0.11)	.85
Standing Hours at 6 Wks (SD)	11.70 (3.69)	11.41 (3.86)	12.00 (3.52)	.432
Standing Hours at 6 Mo (SD)	11.23 (3.81)	10.53 (4.23)	11.94 (3.24)	.094
Standing Hours at 12 Mo (SD)	11.14 (3.36)	10.59 (3.36)	11.77 (3.32)	.224
Preoperative Gait Speed (SD)	0.97 (0.12)	0.97 (0.14)	0.97 (0.11)	.85
Gait speed at 6 wks (SD)	0.87 (0.14)	0.88 (0.13)	0.86 (0.14)	.42
Gait speed at 6 Mo (SD)	0.96 (0.13)	0.97 (0.13)	0.95 (0.13)	.451
Gait speed at 12 M (SD)	0.98 (0.12)	0.99 (0.13)	0.96 (0.10)	.263
Preoperative 6MWT (SD)	401.27 (78.62)	392.55 (90.61)	408.63 (67.51)	.439
6MWT at 6 wks (SD)	372.54 (85.51)	370.23 (97.20)	374.85 (73.59)	.836
6MWT at 6 Mo (SD)	426.10 (67.65)	426.70 (71.96)	425.37 (63.99)	.95
6MWT at 12 Mo (SD)	441.00 (59.89)	440.60 (65.07)	441.75 (52.94)	.966

SD, standard deviation.
Bold values indicate statistical significance at $P < .05$.

averaged 0.88 ± 0.13 m/s, with no significant difference ($P = .42$). By 6 and 12 months, gait speeds were similar between groups, with P-values of 0.451 and 0.263, respectively.

6MWT

The 6MWT performance was similar preoperatively (TKA: 408.63 ± 67.51 m vs THA: 392.55 ± 90.61 m, $P = .439$). At 6 weeks, both groups had reduced 6MWT distances, with TKA patients at 374.85 ± 73.59 m and THA at 370.23 ± 97.20 m, without a significant difference ($P = .836$). By 6 months, both groups improved to near-baseline distances (THA: 426.70 ± 71.96 m vs TKA: 425.37 ± 63.99 m, $P = .95$). At 12 months, THA and TKA patients demonstrated similar 6MWT distances, with no significant differences observed ($P = .966$).

Multivariate regression analysis

TKA was associated with significantly lower steadiness scores than THA (Estimate = −0.178, 95% confidence interval: −0.348 - −0.008, $P = .042$), indicating that the true difference in steadiness scores likely ranges from 0.008 to 0.348 points lower in patients following TKA compared with THA, even after adjustment for these factors (Table 4). Higher BMI and more advanced contralateral KL grade were also associated with reduced steadiness scores at 12 months (Fig. 1).

Table 4
Multivariate regression for average steadiness at the 12-month postoperative time point.

Variable	Estimate	95% confidence interval		P value
		Lower	Upper	
KL (contralateral)	−0.072	−0.141	−0.004	**.042**
TKA (over THA)	−0.178	−0.348	−0.008	**.042**
BMI	−0.012	−0.024	−0.001	**.04**
Age	−0.005	−0.013	0.003	.169
Male Sex	0.134	−0.035	0.303	.103

Bold values indicate statistical significance at $P < .05$.

Pearson correlations

Correlation analyses were conducted between EQ5D scores at 12 months and wearable-derived functional metrics. Of these, only gait speed demonstrated a statistically significant correlation with EQ5D ($r = 0.522$, $P = .0003$), suggesting a moderate positive relationship between objective walking performance and self-reported quality of life. Other metrics, including steadiness ($r = −0.031$, $P = .928$), step count ($r = 0.037$, $P = .780$), standing duration ($r = −0.149$, $P = .322$), and estimated 6MWT distance ($r = 0.082$, $P = .738$), did not show statistically significant associations.

Discussion

This study is the first to leverage Apple HealthKit's objective data to compare postoperative functional recovery between TKA and THA. While both groups demonstrated significant recovery in physical function over the year following surgery, distinct differences in balance and steadiness emerged, with THA patients exhibiting superior steadiness at 6 and 12 months. The improved steadiness observed in THA patients remained significant in multivariate regression analysis, even after controlling for factors such as contralateral KL classification, age, sex, and BMI. Additionally, although not statistically significant, TKA patients exhibited a higher rate of tracked falls compared to THA patients. These findings highlight the potential benefits of THA over TKA in terms of balance-related recovery, which has important implications for counseling patients who may undergo both procedures or those who have recurrent falls.

The primary finding of this study was that THA patients showed significantly better steadiness scores than TKA patients at 6 months and 12 months postoperatively. This difference suggests that THA may provide more favorable outcomes in balance and stability recovery, potentially due to differences in the biomechanics and rehabilitation of the hip vs the knee [22,23]. Total hip arthroplasty may allow for faster re-establishment of gait mechanics, possibly due to fewer mechanical constraints than TKA [7]. Our results are consistent with studies indicating that THA patients often experience improved outcomes compared to TKA patients. In a meta-analysis of 32 studies, Ethgen et al found that
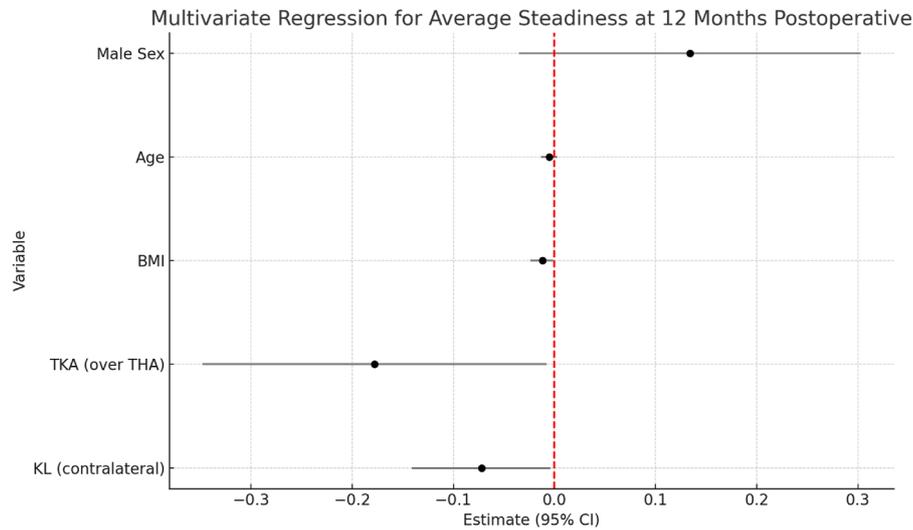
Figure 1. Multivariate regression analysis of factors associated with average steadiness at 12 months postoperatively. Each point represents the regression estimate for an independent variable, with horizontal bars indicating the 95% confidence intervals. The red dashed line represents the null value (estimate = 0). Negative estimates indicate factors associated with reduced steadiness. KL classification (contralateral limb). All models adjusted for baseline value, age, sex, BMI, and KL grade.

while both THA and TKA significantly improved health-related outcomes at 6 to 12 months postsurgery, THA was more effective in restoring functional ability to levels closer to those of the general population compared to TKA [24]. These results also align with prior findings suggesting that hip replacements tend to allow for a more natural gait pattern than knee replacements, which often require more extensive adaptation in mobility and strength. Araujo Fernandes et al studied 28 patients undergoing 37 TKAs and found that although balance improved following surgery, these improvements did not restore to the level of healthy individuals [25].

These differences in physical activity following arthroplasty may directly relate to patient satisfaction. In their study, Bourne et al investigated patient outcomes following THA and TKA, focusing on satisfaction, willingness to undergo surgery again, and achievement of expectations [26]. Their findings demonstrated that, 1 year postoperatively, patients undergoing THA reported higher satisfaction and willingness to repeat surgery compared to TKA patients. Total hip arthroplasty patients also had higher scores on the Western Ontario and McMaster Universities Arthritis Index, suggesting superior improvements in pain, stiffness, and function. Bourne et al concluded that, although both surgeries provide substantial benefits, THA tends to result in more favorable short-term patient satisfaction and functional outcomes than TKA.

The significantly lower steadiness scores in TKA patients may have clinical relevance for fall risk, particularly in patients who have undergone both procedures [27]. Lower steadiness scores indicate a potential imbalance that may persist even in the later stages of recovery. For patients who have undergone THA and are planning a TKA, these findings suggest the importance of fall-prevention strategies and potentially extended balance-focused rehabilitation after TKA [27]. Counseling patients on this difference in functional outcomes may also help set realistic expectations, particularly for those at higher risk of falls due to pre-existing conditions or advanced age [28]. Additionally, clinicians and surgeons may benefit from offering rehabilitation methods targeted at balance for patients undergoing TKA [28].

Both TKA and THA groups showed significant improvements in daily step count, standing duration, and 6MWT distance over the 12 months following surgery. However, no significant differences between groups were observed in these metrics. This outcome

suggests that, while both procedures support similar levels of physical activity and endurance, THA may offer an edge in balance and steadiness recovery. Step count and standing duration are key metrics that reflect activity levels, and their similarity across TKA and THA groups aligns with previous studies showing that both procedures effectively restore mobility and weight-bearing capacity [24-27].

Gait speed, another important functional indicator, improved steadily in both groups over the study period, returning to near preoperative levels by 12 months. This trend is consistent with prior literature, which often reports that gait normalization following TKA or THA occurs gradually over 1 year [17,29]. The absence of differences in gait speed between the TKA and THA groups suggests that both procedures can achieve similar improvements in movement efficiency, although the distinct advantage of THA in steadiness may still contribute to a more stable gait.

The results support the integration of wearable technology in routine postoperative monitoring, as it provides valuable real-time data that can guide individualized patient care. Objective metrics from devices like Apple HealthKit offer a complementary perspective to traditional patient-reported outcomes and clinical assessments, enabling a more holistic view of recovery [27]. Clinicians could use these insights to tailor rehabilitation protocols, adjusting focus based on each patient's recovery trajectory and specific needs. For example, the observed differences in steadiness recovery between TKA and THA patients suggest that balance-specific rehabilitation may be particularly beneficial for TKA patients, especially during the later stages of recovery [28]. These patients could benefit from targeted interventions to enhance postural stability to potentially reduce the risk of falls [27].

Several prior studies have highlighted the utility of wearable technology for monitoring patient activity and recovery following lower extremity arthroplasty. For example, Bolander et al. used skin-mounted inertial sensors placed above and below the knee joint line to monitor recovery in 566 patients undergoing TKA [30]. They reported progressive improvements in step count and functional mobility over time, demonstrating the feasibility and clinical value of real-time, objective monitoring during postoperative recovery. Similarly, Visser et al. employed body-fixed accelerometers to assess physical activity in 35 patients following THA and 42 patients following TKA [6]. Their findings revealed significant

improvements in physical activity levels postoperatively in both groups, although they did not directly compare outcomes between THA and TKA.

Comparative studies using wearables are more limited but provide important insights. Kugelman et al. used wearable devices to compare daily activity recovery in patients undergoing TKA vs unicompartmental knee arthroplasty [31]. They found short-term improvements in gait steadiness and speed in the unicompartmental knee arthroplasty group, though these differences did not persist in the long term. While the previous study focused on comparing 2 types of knee arthroplasty, the present study extends this line of inquiry by directly comparing recovery trajectories between THA and TKA using commercially available wearable devices. This comparative approach adds to the growing literature by revealing potential differences in recovery patterns between hip and knee arthroplasty patients, which may inform expectations for postoperative function and guide rehabilitation strategies.

Our analysis of the relationship between wearable-derived functional metrics and patient-reported quality of life showed a moderate correlation between gait speed and EQ5D scores at 12 months. This supports the validity of gait speed as a clinically meaningful, objective outcome following arthroplasty. In contrast, steadiness, step count, standing time, and 6MWT performance were not significantly correlated with EQ5D, highlighting a potential disconnect between patient perceptions and certain objective functional measures. These findings suggest that while some digital health metrics align well with subjective health status, others may capture distinct aspects of recovery not fully reflected in general health questionnaires [15].

This study has several limitations. First, the sample size of 110 patients, while sufficient to identify significant differences in steadiness, may limit the generalizability of the findings to broader populations with varying comorbidities or demographic characteristics. Larger-scale studies could help confirm these results and provide further insights into how individual characteristics influence recovery patterns. Second, while Apple HealthKit provides valuable objective metrics, adherence to wearing the device daily may have varied among participants, potentially affecting the accuracy of the recorded data. Future studies could explore alternative wearable devices to confirm the reliability and validity of these measurements across different settings and populations. Although patients were aware they were being monitored, the risk of observation bias was minimized by the long duration of the study and absence of feedback regarding their performance. Nonetheless, this remains a potential limitation. Formal intraobserver reliability testing was not conducted; however, KL grading was performed by a fellowship-trained adult reconstruction surgeon following standardized criteria. Future studies may consider including reliability analysis to further support reproducibility. Another limitation of this study is that KOOS, JR and HOOS, JR scores were not collected for all patients; KOOS, JR was collected only for TKA patients and HOOS, JR only for THA patients. As a result, these joint-specific outcomes could not be directly compared between groups and were excluded from the analysis. Finally, this study focused on a 1-year follow-up period, which may not capture the full trajectory of functional recovery, particularly for patients who experience prolonged or delayed recovery. Longitudinal studies with extended follow-ups could provide a more comprehensive understanding of how balance, mobility, and overall function evolve beyond 1-year postsurgery.

Conclusions

This study highlights key differences in functional recovery following TKA and THA, with THA patients demonstrating superior balance and steadiness at 6 and 12 months postoperatively. These findings underscore the value of wearable technology for tracking postoperative recovery and support the need for targeted balance-focused rehabilitation for TKA patients. As wearable devices become more integrated into clinical practice, they offer a promising avenue for enhancing patient monitoring, supporting personalized care, and ultimately improving functional outcomes for patients undergoing joint replacement surgery.

CRediT authorship contribution statement

Kevin A. Wu: Writing – original draft, Conceptualization, Writing – review & editing, Formal analysis, Project administration, Investigation. **David N. Kugelman:** Writing – original draft, Formal analysis, Writing – review & editing, Investigation, Supervision, Data curation, Methodology, Conceptualization. **Samuel Rosas:** Writing – review & editing, Supervision, Validation, Writing – original draft, Methodology, Visualization, Investigation. **Sharrieff Shah:** Writing – original draft, Writing – review & editing, Investigation, Resources, Methodology. **Sean P. Ryan:** Writing – review & editing, Methodology, Supervision, Visualization, Investigation, Validation, Conceptualization. **Samuel S. Wellman:** Supervision, Validation, Conceptualization, Writing – review & editing, Resources, Visualization, Methodology. **Michael P. Bolognesi:** Supervision, Conceptualization, Visualization, Investigation, Resources, Writing – review & editing, Methodology. **Thorsten M. Seyler:** Writing – review & editing, Software, Data curation, Supervision, Investigation, Visualization, Resources, Conceptualization, Validation, Methodology.

Conflicts of interest

Sean P. Ryan receives royalties from Smith & Nephew and Zimmer Biomet.

Samuel S. Wellman is a paid consultant for Total Joint Orthopaedics; receives research support from Smith & Nephew, Zimmer Biomet, DePuy, A Johnson & Johnson Company, Medacta, and Stryker; has stock options in Joint Development; is on the editorial board of Journal of Arthroplasty; and is a Board member of the Hip Society.

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Appendix Table 1
Multivariate Regression Models for Functional Outcomes at 12 Months

Outcome measure	Estimate (TKA vs THA)	95% confidence interval		P value
		Lower	Upper	
Step Count	780.93	−777.11	2338.96	.32
Gait Speed	0.07	−0.01	0.15	.09
Standing Hours	2.77	−1.2	4.73	.08
6MWT	87.29	−64.69	239.28	.2