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The Effect of Postoperative Step Count on Iliopsoas Tendonitis After Hip Arthroscopy: A Prospective Cohort Study

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Abstract

Purpose: To investigate the relationship between postoperative activity levels, measured via a smartphone application, and the incidence of iliopsoas tendinitis (IPT) following hip arthroscopy for femoroacetabular impingement syndrome (FAIS). We hypothesized that lower postoperative activity levels across the monitored 12-week period would be associated with increased IPT risk. **Methods:** This prospective cohort study enrolled patients undergoing hip arthroscopy for femoroacetabular impingement syndrome (FAIS) from June 2022 to February 2023. Average weekly step counts across the 12-week postoperative monitoring period were tracked via a smartphone application. Patients were stratified into IPT and non-IPT groups, and preoperative and postoperative outcomes, including the modified Harris Hip Score (mHHS), Nonarthritic Hip Score (NAHS), and Visual Analog Scale (VAS), were compared. Activity levels were categorized into low, moderate, and high groups based on percentile distributions. **Results:** A total of 54 patients (mean age 37.8 ± 11.6 years, 59.3% female) were included, with 16 (29.6%) developing IPT at an average of 2.5 ± 1.2 months postoperatively. IPT patients had lower preoperative mHHS (62.2 vs. 74.9, $p = 0.026$) and NAHS (53.9 vs. 66.9, $p = 0.023$), and greater pain (VAS 6.3 vs. 5.0, $p = 0.054$). Mean weekly step counts were lower in the IPT group in every postoperative week, reaching statistical significance at Weeks 3 and 12 ($p = 0.042$ and $p = 0.012$). In penalized regression adjusted for preoperative mHHS and age, each additional 1000 steps per day during Weeks 1–3 was associated with lower odds of IPT (OR 0.63, 95% CI 0.32 to 0.98, $p = 0.037$); associations for later periods were in the same direction but did not reach statistical significance (Weeks 10–12: OR 0.89, 95% CI 0.66 to 1.10, $p = 0.29$). Functional improvements at 3 months did not differ between groups. **Conclusions:** Lower postoperative step counts were associated with a higher risk of IPT development, with the most robust association observed in the immediate postoperative period (Weeks 1–3), highlighting the potential importance of monitored, progressive rehabilitation following hip arthroscopy. These findings are exploratory and hypothesis-generating and require prospective interventional validation.

Keywords: hip arthroscopy; iliopsoas tendinitis; postoperative rehabilitation; femoroacetabular impingement; ambulation

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Academic Editor: Ralf Bieger

Received: 8 March 2026
Revised: 2 September 2026
Accepted: 4 September 2026
Published: 8 October 2026

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1. Introduction

Iliopsoas tendinitis (IPT) is a recognized complication following hip arthroscopy, particularly in patients treated for femoroacetabular impingement syndrome (FAIS) [1,2]. FAIS is a condition characterized by abnormal contact between the femoral head and

acetabulum, often leading to labral tears and other intra-articular damage [3–5]. While hip arthroscopy effectively addresses these structural abnormalities, the postoperative period can be complicated by the onset of IPT, which may delay recovery and prolong pain. The reported incidence of IPT after hip arthroscopy varies, with some studies estimating rates as high as 24%, making it a significant concern for postoperative management [1]. IPT typically manifests as pain localized to the anterior hip and groin, often exacerbated by activities that involve repetitive hip flexion, such as walking, running, or climbing stairs [6,7].

The relationship between postoperative activity levels and the development of IPT remains poorly defined. Rehabilitation after hip arthroscopy generally emphasizes gradual progression in weight-bearing and mobility to promote healing, but specific activity thresholds that optimize recovery without increasing the risk of complications like IPT have yet to be clearly established [8,9]. Previous studies have indicated that excessive activity during the rehabilitation period may contribute to tendon-related complications, but the precise role of activity modulation has not been thoroughly investigated in the context of IPT following hip arthroscopy [10–13]. With advancements in technology, objective tracking of patient activity using smartphone-based applications offers a novel and practical method for monitoring postoperative mobility. These applications provide real-time data on step counts, allowing for a detailed analysis of activity patterns during recovery. Given that tendinopathy can result from both underuse and overuse of muscles and tendons, understanding the relationship between step counts and IPT development could inform more effective postoperative rehabilitation protocols.

The purpose of this study is to investigate the association between postoperative activity levels, specifically average weekly step counts measured via a smartphone activity-tracking application, and the incidence of IPT in patients undergoing hip arthroscopy for FAIS. We hypothesize that lower postoperative activity levels across the monitored 12-week recovery period are associated with a higher risk of developing IPT. By objectively monitoring postoperative activity levels, this study aims to provide insights that could guide clinicians in optimizing rehabilitation strategies to minimize the risk of IPT and improve patient outcomes after hip arthroscopy.

2. Methods

2.1. Patient Selection

This is a prospective cohort study conducted at a single academic institution between June 2022 and February 2023. Institutional Review Board (IRB) approval was obtained prior to study initiation (IRB #I20-01375). Informed consent was obtained from all participants. Patients aged 18 years or older undergoing hip arthroscopy for FAIS, with or without associated labral tears, were consecutively enrolled. All patients were treated primarily for labral tear and combined femoroacetabular impingement. No patients were treated arthroscopically for internal snapping of the hip or any iliopsoas tendon pathology. None of the patients in this study population had an anterior labral tear near the psoas tendon, indicating preoperative psoas pathology. No patients received iliopsoas lengthening or releases. No cases of dysplasia or patients with osteoarthritis (OA) greater than grade 1 based on the Tönnis classification were included. All patients had combined cam/pincer impingement and labral pathology. Exclusion criteria included prior hip surgery, significant osteoarthritis (Tönnis grade ≥ 2), inflammatory arthritis, or other conditions affecting gait and mobility.

Diagnosis of IPT required all of the following: (1) anterior hip or groin pain localized to the iliopsoas region; (2) reproduction of concordant pain with resisted hip flexion in the supine position; (3) a positive Thomas test demonstrating iliopsoas contracture or provoca-

tion of concordant anterior hip pain; and (4) absence of clinical findings consistent with alternative diagnoses, including labral re-tear (no mechanical clicking with reproducible arc of motion testing), greater trochanteric pain syndrome (no lateral hip tenderness), or early hip osteoarthritis (no groin pain with passive log-roll or range-of-motion testing). Patients in whom the diagnosis remained uncertain following clinical examination underwent ultrasound evaluation to confirm peritendinous edema and exclude other pathology. Symptoms consistent with IPT were identified by the senior author during routine postoperative visits (2-week, 6-week, or 3-month), and treatment was initiated, which included oral anti-inflammatories, physical therapy, and activity modification.

Among 66 individuals who consented, 12 were excluded and dropped from the analysis due to loss of activity monitor or data. Data loss occurred due to smartphone incompatibility (n = 4), failure to download or maintain the application (n = 5), and loss of the study-issued tracking device (n = 3). A comparison of available baseline characteristics (age, sex, BMI, preoperative mHHS, and preoperative NAHS) between included and excluded patients revealed no statistically significant differences, suggesting that exclusion was unlikely to be systematically related to baseline patient phenotype; however, unmeasured factors such as technology literacy, health engagement, or pain severity may have contributed to differential dropout, and this potential selection bias is acknowledged as a limitation. An a priori power analysis was performed demonstrating a necessary sample size of 50 patients to be sufficient for attainment of $\geq$80% statistical power (alpha = 0.05). The final analytic sample consisted of a total of 54 patients who met the inclusion criteria and were included in the study.

2.2. Surgical Technique and Postoperative Recovery Protocol

All surgeries were performed by a fellowship-trained orthopaedic surgeon specializing in hip arthroscopy. Standard anterolateral and mid-anterior portals were utilized with an interportal capsulotomy, and labral tears were repaired when feasible using suture anchors. Additional procedures, such as cam and pincer resections, were performed as needed based on intraoperative findings. All capsules were repaired, and all patients followed a standardized postoperative rehabilitation protocol. During the first month, patients were instructed to maintain partial weight-bearing (50%) using crutches. From the second month onwards, weight-bearing was gradually increased as tolerated. A smartphone application (Pacer for Teams, version 9.4.1, Pacer Health, Inc., Redwood City, CA, USA) was used to track daily step counts for three months postoperatively, providing an objective measure of activity level. The Pacer for Teams application utilizes the accelerometer embedded in the patient's personal smartphone and has demonstrated acceptable accuracy for step-count estimation in ambulatory populations [14]. However, during Weeks 1–4, when patients maintained partial weight-bearing with bilateral crutches, step-count data may underestimate true ambulation effort, as a hip-/pocket-based accelerometer does not capture upper-extremity motion associated with crutch-assisted gait. Conversely, arm swing during crutch use could introduce spurious step registration on certain device configurations. These limitations are inherent to consumer-grade accelerometry in the early postoperative orthopedic setting. Weekly step counts were calculated as the mean of the seven daily values recorded by the application. Weeks in which the application recorded zero steps on every day were considered to reflect a device or application that was not recording rather than true inactivity and were treated as missing; these weeks were not imputed in the primary analysis. Weekly and period-level step counts were compared between patients who developed IPT and those who did not.

2.3. Patient-Reported Outcomes

The primary outcome measures of the study included the modified Harris Hip Score (mHHS), Nonarthritic Hip Score (NAHS), and Visual Analog Scale (VAS) for pain. These scores were used to assess hip function, the impact of hip conditions on daily activities, and pain levels, respectively. The mHHS evaluates pain, function, absence of deformity, and range of motion. The NAHS is specifically designed for nonarthritic hip conditions, focusing on symptoms and functional limitations in daily activities. Patients were also instructed to log their daily pain levels using a VAS to capture subjective pain experiences throughout the recovery process. VAS pain scores were recorded at rest and during the worst pain episodes. Additionally, flare-ups, defined as episodes of increased pain requiring modification of activities, were tracked using patient-reported logs.

2.4. Statistical Analysis

All statistical analyses were performed using JMP Pro 18 (SAS Institute Inc., Cary, NC, USA) and Python 3.14.0 (Python Software Foundation, Wilmington, DE, USA; statsmodels 0.15). Patients were allocated into two groups based on the presence of postoperative IPT. Baseline continuous variables were compared using *t*-tests, and categorical variables were assessed using χ^2 tests. Paired two-sample *t*-tests were used to assess changes in patient-reported outcomes. Weekly step counts were compared between groups using the Mann–Whitney U test because of their skewed distribution and the small number of patients with recorded data in individual weeks; each weekly comparison included only patients with recorded application data for that week, and the number of patients contributing to each comparison is reported. Patients were stratified into Low Activity, Moderate Activity, and High Activity groups based on tertiles of mean daily step count during four postoperative periods (Weeks 1–3, Weeks 4–6, Weeks 7–9, Weeks 10–12) among patients with recorded data in the relevant period; patients without recorded data in a period were excluded from that period's analysis rather than imputed. Pairwise comparisons between groups were conducted using the Mann–Whitney U test for continuous variables; categorical variables were assessed using χ^2 tests or Fisher's exact test, as appropriate. Fisher's exact test was used in place of χ^2 testing when expected cell counts were fewer than 5 (e.g., subgroup analyses with few or no IPT events in one group), as the assumptions of χ^2 testing regarding expected cell frequencies are violated in these circumstances; for three-group comparisons of IPT incidence, the Fisher–Freeman–Halton extension was used. Additionally, the repeated subgroup analyses across multiple postoperative intervals increase the risk of type I error and should be interpreted with caution in conjunction with the multiple comparisons acknowledgment below.

A multivariable analysis was planned a priori to evaluate variables associated with IPT development. Given that only 16 IPT events were observed, the analysis was designed to limit overfitting. Mean daily step count during each of the four postoperative periods (Weeks 1–3, 4–6, 7–9, and 10–12), expressed per 1000 steps per day, was examined in a separate parsimonious logistic regression model adjusted for preoperative mHHS and age, covariates selected a priori as the baseline characteristics most plausibly related to both postoperative ambulation and IPT. Coefficients were estimated using Firth's penalized likelihood method, which reduces the small-sample bias of maximum likelihood estimates and yields finite estimates when outcome events are sparse; 95% confidence intervals (CIs) were derived from the profile penalized likelihood, *p*-values from penalized likelihood ratio tests, and results are reported as odds ratios (ORs). Because the four period-level step-count variables were strongly correlated with one another (Spearman ρ 0.70 to 0.89 among patients with data in all four periods; variance inflation factors up to 9.2 when all four were entered together), they were not entered into a single model as the primary

analysis. A full model containing age, sex, BMI, preoperative mHHS, preoperative NAHS, and all four period-level step counts (nine covariates) was fitted as a sensitivity analysis and is reported for completeness; because patients lacking recorded data in any period could not contribute to this model, it included fewer than 10 events and falls far below the conventional guideline of 10 events per variable, so its individual estimates should not be interpreted. Internal validation of the parsimonious models was performed by bootstrap resampling (1000 resamples), reporting the optimism-corrected concordance statistic (c-statistic), the calibration slope, and the proportion of resamples in which the step-count coefficient retained its sign. As a further sensitivity analysis, missing weekly step counts were multiply imputed by chained equations (30 imputations, with the outcome included in the imputation model) and the parsimonious models were refitted with estimates pooled according to Rubin's rules. Given the large number of statistical comparisons across weekly step-count, VAS, flare, and PROM data, the probability of false-positive findings is increased. No formal correction for multiple comparisons was applied; however, all *p*-values should be interpreted in this context, and findings from individual weekly comparisons should be considered hypothesis-generating rather than confirmatory, with emphasis placed on overall patterns of results rather than individual *p*-values. Results of the multivariable analysis should be interpreted with caution given the limited event count. Statistical tests were considered significant at $p < 0.05$ for all comparisons.

3. Results

3.1. Patient Characteristics

A total of 54 patients were included in the study with a mean age of 37.8 ± 11.6 years, and 59.3% were female. Of these, 16 patients (29.6%) were diagnosed with iliopsoas tendinitis (IPT) postoperatively. There were no significant differences between the IPT and non-IPT groups in terms of age ($p = 0.280$), sex ($p = 0.552$), or body mass index (BMI) ($p = 0.768$). On average, IPT was diagnosed 2.5 ± 1.2 months after surgery. Preoperative functional scores were lower in patients who developed IPT, with the IPT group demonstrating significantly poorer modified Harris Hip Score (mHHS) (62.2 vs. 74.9, $p = 0.026$) and Nonarthritic Hip Score (NAHS) (53.9 vs. 66.9, $p = 0.023$). Additionally, patients who developed IPT had higher preoperative visual analog scale (VAS) pain scores compared to the non-IPT group (6.3 vs. 5.0, $p = 0.054$). There was no significant difference between the two groups in terms of the magnitude of improvement in these scores over the postoperative period. The preoperative mHHS was 62.2 ± 17.9 in the IPT group vs. 74.9 ± 18.8 in the non-IPT group; the 3-month mHHS was 71.3 ± 16.9 vs. 88.7 ± 15.9, respectively. The change in mHHS from baseline to 3 months was similar between the IPT and non-IPT groups (ΔmHHS: 9.1 ± 19.4 vs. 13.8 ± 17.6, $p = 0.388$), as was the change in NAHS (ΔNAHS: 12.9 ± 10.1 vs. 13.6 ± 15.0, $p = 0.850$). Likewise, the reduction in pain based on VAS was comparable between the two groups (ΔVAS: −2.6 ± 1.9 vs. −2.8 ± 1.8, $p = 0.678$). Patient demographics and patient-reported outcome data are summarized in Table 1.

Table 1. Patient Demographics and Patient-Reported Outcomes.

	Iliopsoas Tendinitis (*n* = 16)	**No Tendinitis (*n* = 38)**	***p*-Value**
Age (years)	40.4 ± 12.5	36.7 ± 11.3	0.280
Sex, *n* (%)			0.552
Male	8 (50.0)	14 (36.8)	
Female	8 (50.0)	24 (63.2)	
Body mass index	25.4 ± 3.8	25.9 ± 5.3	0.768

Table 1. *Cont.*

	Iliopsoas Tendinitis (n = 16)	No Tendinitis (n = 38)	p-Value
VAS Pain			
Preoperative	6.3 ± 1.7	5.0 ± 2.1	0.054
3 months	3.6 ± 2.2	1.7 ± 2.1	0.013
Δ VAS	−2.6 ± 1.9	−2.8 ± 1.8	0.678
mHHS			
Preoperative	62.2 ± 17.9	74.9 ± 18.8	0.026
3 months	71.3 ± 16.9	88.7 ± 15.9	0.068
Δ mHHS	9.1 ± 19.4	13.8 ± 17.6	0.388
NAHS			
Preoperative	53.9 ± 17.2	66.9 ± 18.8	0.023
3 months	66.7 ± 10.9	80.1 ± 15.3	0.026
Δ NAHS	12.9 ± 10.1	13.6 ± 15.0	0.850

3.2. Step Count and Pain Trends

Mean weekly step counts were lower in the IPT group than in the non-IPT group in every postoperative week (Table 2). Because weeks in which the application did not record were treated as missing, the number of patients contributing to each weekly comparison ranged from 9 to 14 in the IPT group and from 25 to 35 in the non-IPT group. The difference reached statistical significance at Week 3 (1580 ± 1047 vs. 3482 ± 2659 steps, p = 0.042) and Week 12 (2757 ± 1890 vs. 6193 ± 3896 steps, p = 0.012); differences in the remaining weeks were in the same direction but did not reach statistical significance (Table 2).

Pain trends also differed significantly between the two groups. Resting and worst visual analog scale (VAS) pain scores were consistently higher in the IPT group across several time points. For resting VAS, the IPT group reported significantly higher pain levels in Week 1 (5 ± 2 vs. 3 ± 2, p = 0.045), Week 2 (4 ± 2 vs. 2 ± 2, p = 0.028), Week 5 (4 ± 2 vs. 2 ± 2, p = 0.009), Week 6 (4 ± 2 vs. 2 ± 2, p = 0.035), Week 9 (4 ± 2 vs. 2 ± 2, p = 0.007), Week 11 (4 ± 3 vs. 1 ± 2, p = 0.005), and Week 12 (4 ± 2 vs. 2 ± 2, p = 0.013). Worst VAS scores also showed significant differences between the groups, with the IPT group reporting higher worst pain in Week 2 (6 ± 2 vs. 4 ± 2, p = 0.007), Week 5 (5 ± 3 vs. 3 ± 2, p = 0.035), Week 9 (5 ± 2 vs. 3 ± 2, p = 0.015), and Week 11 (5 ± 3 vs. 2 ± 2, p = 0.014). Notably, elevated resting VAS pain scores were present in the IPT group as early as Week 1 and Week 2, preceding the first statistically significant step-count differences, which emerged at Week 3. This temporal pattern is consistent with the possibility that early subclinical pain may have contributed to reduced ambulation, and this potential bidirectional relationship is discussed further below. The frequency of pain flare-ups did not differ significantly between groups in all weeks except Week 8, in which the IPT group reported more frequent flare-ups (3 ± 1 vs. 2 ± 1, p = 0.002).

Table 2. Comparison of Average Steps per Week, Resting and Worst Pain, and Number of Flare-Ups Between Patients Who Did and Did Not Develop Iliopsoas Tendinitis.

	Developed IPT (n = 16)	No Tendinitis (n = 38)	p-Value
Week 1 Steps	712 ± 736 (n = 14)	1459 ± 1590 (n = 35)	0.068
Resting VAS	5 ± 2	3 ± 2	0.045
Worst VAS	6 ± 2	5 ± 3	0.105
Flares (n)	2 ± 2	2 ± 2	0.742
Week 2 Steps	1056 ± 784 (n = 11)	2621 ± 2533 (n = 35)	0.080
Resting VAS	4 ± 2	2 ± 2	0.028
Worst VAS	6 ± 2	4 ± 2	0.007
Flares (n)	2 ± 1	2 ± 2	0.324

Table 2. *Cont.*

	Developed IPT (n = 16)	No Tendinitis (n = 38)	p-Value
Week 3 Steps	1580 ± 1047 (n = 11)	3482 ± 2659 (n = 35)	0.042
Resting VAS	4 ± 2	3 ± 2	0.093
Worst VAS	6 ± 3	4 ± 3	0.072
Flares (n)	3 ± 1	3 ± 2	0.471
Week 4 Steps	2347 ± 1653 (n = 10)	3643 ± 2801 (n = 35)	0.281
Resting VAS	3 ± 2	2 ± 2	0.182
Worst VAS	5 ± 2	3 ± 2	0.097
Flares (n)	2 ± 1	2 ± 2	0.614
Week 5 Steps	2327 ± 1894 (n = 11)	4504 ± 3387 (n = 32)	0.098
Resting VAS	4 ± 2	2 ± 2	0.009
Worst VAS	5 ± 3	3 ± 2	0.035
Flares (n)	2 ± 1	2 ± 2	0.512
Week 6 Steps	3197 ± 1876 (n = 11)	4541 ± 3308 (n = 34)	0.452
Resting VAS	4 ± 2	2 ± 2	0.035
Worst VAS	5 ± 2	3 ± 2	0.076
Flares (n)	2 ± 1	2 ± 2	0.441
Week 7 Steps	3542 ± 2312 (n = 9)	5150 ± 3502 (n = 32)	0.213
Resting VAS	3 ± 2	2 ± 2	0.148
Worst VAS	5 ± 2	3 ± 2	0.063
Flares (n)	2 ± 1	2 ± 1	0.389
Week 8 Steps	3779 ± 2063 (n = 9)	5426 ± 2844 (n = 31)	0.179
Resting VAS	3 ± 2	2 ± 2	0.152
Worst VAS	4 ± 2	3 ± 2	0.148
Flares (n)	3 ± 1	2 ± 1	0.002
Week 9 Steps	4092 ± 2574 (n = 10)	5075 ± 3027 (n = 32)	0.434
Resting VAS	4 ± 2	2 ± 2	0.007
Worst VAS	5 ± 2	3 ± 2	0.015
Flares (n)	2 ± 1	2 ± 1	0.276
Week 10 Steps	3844 ± 2327 (n = 10)	5197 ± 3160 (n = 32)	0.294
Resting VAS	4 ± 2	2 ± 2	0.062
Worst VAS	4 ± 2	3 ± 2	0.117
Flares (n)	2 ± 1	2 ± 1	0.343
Week 11 Steps	2918 ± 2072 (n = 9)	5497 ± 4383 (n = 30)	0.113
Resting VAS	4 ± 3	1 ± 2	0.005
Worst VAS	5 ± 3	2 ± 2	0.014
Flares (n)	2 ± 1	2 ± 1	0.387
Week 12 Steps	2757 ± 1890 (n = 9)	6193 ± 3896 (n = 25)	0.012
Resting VAS	4 ± 2	2 ± 2	0.013
Worst VAS	4 ± 2	3 ± 2	0.086
Flares (n)	2 ± 1	2 ± 1	0.419

Data are presented as mean ± SD. Step-count comparisons include only patients with recorded application data in the given week (n shown in parentheses); weeks in which the application recorded no steps were treated as missing and were not imputed. Step counts were compared using the Mann–Whitney U test. Resting and worst VAS are reported for weekly patient logs and flares as the number of episodes per week.

3.3. Immediate Postoperative Period (Weeks 1–3)

Among the 50 patients with recorded step-count data during Weeks 1–3, IPT developed in 7 of 17 (41%) patients in the Low Activity group, 6 of 16 (38%) in the Moderate Activity group, and 1 of 17 (6%) in the High Activity group (p = 0.043). The incidence of IPT was significantly lower in the High Activity group than in both the Low (p = 0.039) and Moderate (p = 0.039) Activity groups, with no difference between the Low and Moderate Activity groups (p = 1.00) (Table 3).

Table 3. Analysis of Activity Levels and Postoperative Iliopsoas Tendinitis Development (Weeks 1–12).

	Low Activity	Moderate Activity	High Activity	*p*-Value
WEEKS 1–3 (n = 50)				
Patients, n	17	16	17	
Age (years)	38.5 ± 13.1	40.1 ± 14.7	35.6 ± 7.1	0.893
Sex, male/female	5/12	7/9	8/9	0.538
BMI	26.8 ± 5.1	25.4 ± 5.2	25.8 ± 4.6	0.697
Avg steps/day (Wk 1–3)	385 ± 243	1433 ± 389	4288 ± 1731	<0.001
Developed IPT, n (%)	7/17 (41%)	6/16 (38%)	1/17 (6%)	0.043
WEEKS 4–6 (n = 47)				
Patients, n	16	15	16	
Age (years)	37.1 ± 15.0	39.3 ± 12.4	37.7 ± 7.9	0.640
Sex, male/female	4/12	8/7	7/9	0.260
BMI	25.4 ± 5.2	25.6 ± 4.1	26.5 ± 5.2	0.857
Avg steps/day (Wk 4–6)	1040 ± 567	2904 ± 674	7006 ± 1989	<0.001
Developed IPT, n (%)	5/16 (31%)	5/15 (33%)	2/16 (13%)	0.414
WEEKS 7–9 (n = 43)				
Patients, n	15	14	14	
Age (years)	40.2 ± 15.2	34.1 ± 10.1	39.4 ± 10.3	0.410
Sex, male/female	4/11	7/7	6/8	0.418
BMI	25.6 ± 5.1	26.2 ± 4.2	25.2 ± 5.4	0.718
Avg steps/day (Wk 7–9)	2078 ± 845	4335 ± 669	8071 ± 1759	<0.001
Developed IPT, n (%)	4/15 (27%)	5/14 (36%)	1/14 (7%)	0.213
WEEKS 10–12 (n = 44)				
Patients, n	15	14	15	
Age (years)	42.5 ± 13.9	36.1 ± 11.3	35.4 ± 10.4	0.268
Sex, male/female	7/8	5/9	8/7	0.631
BMI	25.9 ± 5.0	26.8 ± 5.3	25.6 ± 4.9	0.801
Avg steps/day (Wk 10–12)	1543 ± 889	4065 ± 914	8352 ± 2787	<0.001
Developed IPT, n (%)	5/15 (33%)	4/14 (29%)	2/15 (13%)	0.468

Tertiles were defined within each period among patients with recorded application data for that period; patients without recorded data in a period were excluded from that period's analysis rather than imputed, so the number of patients differs between periods. p-values for the incidence of IPT are from the Fisher–Freeman–Halton exact test (three-group comparison); pairwise comparisons are reported in the text. Age and BMI were compared using the Kruskal–Wallis test and sex using the χ^2 test. Avg steps/day p-values are from the Kruskal–Wallis test and are <0.001 by construction of the tertiles.

3.4. Early Postoperative Period (Weeks 4–6)

Among the 47 patients with recorded data during Weeks 4–6, IPT developed in 5 of 16 (31%) patients in the Low Activity group, 5 of 15 (33%) in the Moderate Activity group, and 2 of 16 (13%) in the High Activity group. These differences did not reach statistical significance (overall p = 0.41; Low vs. High, p = 0.39; Moderate vs. High, p = 0.22; Low vs. Moderate, p = 1.00) (Table 3).

3.5. Mid Postoperative Period (Weeks 7–9)

Among the 43 patients with recorded data during Weeks 7–9, IPT developed in 4 of 15 (27%) patients in the Low Activity group, 5 of 14 (36%) in the Moderate Activity group, and 1 of 14 (7%) in the High Activity group (overall p = 0.21; Low vs. High, p = 0.33; Moderate vs. High, p = 0.17; Low vs. Moderate, p = 0.70) (Table 3).

3.6. Late Postoperative Period (Weeks 10–12)

Among the 44 patients with recorded data during Weeks 10–12, IPT developed in 5 of 15 (33%) patients in the Low Activity group, 4 of 14 (29%) in the Moderate Activity group, and 2 of 15 (13%) in the High Activity group (overall p = 0.47; Low vs. High,

$p = 0.39$; Moderate vs. High, $p = 0.39$; Low vs. Moderate, $p = 1.00$). A gradient of lower IPT incidence with higher activity was therefore present in all four periods but reached statistical significance only in the immediate postoperative period (Weeks 1–3) (Table 3).

3.7. Postoperative Functional Outcomes by Activity Level

Functional outcomes at 3 months, including the mHHS and NAHS, were compared across three activity levels. Absolute 3-month mHHS was significantly higher in the High Activity group compared to the Low Activity group (91.22 ± 11.38 vs. 72.89 ± 19.85, $p = 0.005$) and Moderate Activity group (91.22 ± 11.38 vs. 86.28 ± 15.95, $p = 0.050$). Baseline mHHS was significantly lower in the Low Activity group (60.57 ± 19.23) compared to both Moderate (77.60 ± 13.82, $p = 0.005$) and High Activity groups (75.23 ± 19.30, $p = 0.025$). The change in mHHS from baseline to 3 months (ΔmHHS) did not differ significantly between groups ($p = 0.388$), suggesting that the magnitude of improvement was similar regardless of activity level.

Similarly, absolute 3-month NAHS was higher in the High Activity group compared to the Low Activity group (81.45 ± 15.38 vs. 70.69 ± 15.80, $p = 0.019$), though no significant difference was found between the High and Moderate Activity groups ($p = 0.420$). The average change in NAHS from baseline to 3 months (ΔNAHS) was similar across all groups ($p = 0.068$), suggesting baseline differences rather than differential recovery trajectories account for the observed between-group differences in absolute postoperative scores.

3.8. Multivariable Analysis of Variables Associated with Iliopsoas Tendinitis Development

In parsimonious Firth penalized logistic regression models adjusted for preoperative mHHS and age, higher mean daily step counts were associated with lower odds of IPT in each of the four postoperative periods, but the association reached statistical significance only for the immediate postoperative period (Weeks 1–3: OR 0.63 per 1000 steps/day, 95% CI 0.32 to 0.98, $p = 0.037$; 50 patients, 14 events). The corresponding estimates for Weeks 4–6 (OR 0.82, 95% CI 0.59 to 1.07, $p = 0.15$), Weeks 7–9 (OR 0.88, 95% CI 0.66 to 1.14, $p = 0.35$), and Weeks 10–12 (OR 0.89, 95% CI 0.66 to 1.10, $p = 0.29$) were in the same direction but were not statistically significant (Table 4). Preoperative mHHS (OR 0.97 to 0.98 per point) and age (OR 1.01 to 1.02 per year) were not independently associated with IPT in any model. In bootstrap internal validation, the step-count coefficient for Weeks 1–3 was negative (protective) in 100% of 1000 resamples, with an optimism-corrected c-statistic of 0.69 and a calibration slope of 0.91; for Weeks 10–12 the coefficient was negative in 92% of resamples, with an optimism-corrected c-statistic of 0.68 and a calibration slope of 0.82, indicating modest discrimination and some overfitting even in these three-covariate models. In the sensitivity analysis fitting the full nine-covariate model, only 38 patients (9 events) had recorded data in all four periods; no covariate was statistically significant, and the estimates were imprecise, as expected for a model with approximately one event per variable (Table 4). Under multiple imputation of missing weekly step counts, the direction of all period-level associations was preserved but none reached statistical significance (Weeks 1–3: OR 0.73, 95% CI 0.47 to 1.13, $p = 0.16$; Weeks 10–12: OR 0.85, 95% CI 0.66 to 1.09, $p = 0.21$). Given the limited number of IPT events, the incomplete step-count data, and the multiplicity of comparisons performed across weekly step-count, pain, flare, and PROM data without formal correction for multiple testing, the association observed for Weeks 1–3 should be regarded as exploratory rather than confirmatory and interpreted as one signal within an overall pattern of lower ambulation among patients who developed IPT rather than as an established independent risk factor (Table 4).

Table 4. Firth Penalized Logistic Regression of Period-Level Step Count and the Development of Postoperative Iliopsoas Tendinitis.

Model/Variable	Patients (IPT Events)	OR (95% CI)	*p*-Value
Parsimonious models (one per period; each adjusted for preoperative mHHS and age)			
Step count, Weeks 1–3 (per 1000 steps/day)	50 (14)	0.63 (0.32 to 0.98)	0.037
Step count, Weeks 4–6 (per 1000 steps/day)	47 (12)	0.82 (0.59 to 1.07)	0.148
Step count, Weeks 7–9 (per 1000 steps/day)	43 (10)	0.88 (0.66 to 1.14)	0.347
Step count, Weeks 10–12 (per 1000 steps/day)	44 (11)	0.89 (0.66 to 1.10)	0.293
Full nine-covariate model (sensitivity analysis): 38 patients (9 IPT events)			
Age (per year)		1.01 (0.95 to 1.08)	0.700
Sex (male vs. female)		3.45 (0.69 to 23.7)	0.135
BMI (per kg/m^2)		0.99 (0.78 to 1.20)	0.884
Preoperative mHHS (per point)		0.99 (0.91 to 1.06)	0.675
Preoperative NAHS (per point)		0.98 (0.90 to 1.05)	0.556
Step count, Weeks 1–3 (per 1000 steps/day)		0.81 (0.29 to 1.97)	0.639
Step count, Weeks 4–6 (per 1000 steps/day)		0.94 (0.41 to 2.08)	0.869
Step count, Weeks 7–9 (per 1000 steps/day)		1.11 (0.46 to 3.01)	0.817
Step count, Weeks 10–12 (per 1000 steps/day)		0.92 (0.47 to 1.54)	0.755

OR, odds ratio; CI, confidence interval; mHHS, modified Harris Hip Score; NAHS, Nonarthritic Hip Score; BMI, body mass index. Estimates are from Firth's penalized likelihood method with profile-likelihood 95% CIs and penalized likelihood ratio *p*-values. Each model includes patients with recorded step-count data for the relevant period; missing weeks were not imputed. The full model is shown for completeness only: with nine covariates and nine events (approximately one event per variable), its estimates are unstable and should not be interpreted individually. All results should be interpreted as exploratory given the limited number of IPT events.

3.9. Postoperative Failures and Revision Surgery

At the 2-year follow-up, two patients experienced postoperative complications requiring additional interventions. One patient in the non-IPT group required a corticosteroid injection 66 weeks after the index procedure, and another patient underwent conversion to total hip arthroplasty (THA) 31 weeks postoperatively. There were no failures or revision surgeries in the IPT group during the 2-year follow-up period.

4. Discussion

The main finding of our study is that lower postoperative activity levels were associated with an increased risk of IPT development following hip arthroscopy, with the most robust association observed in the immediate postoperative period (Weeks 1–3); associations in later periods were in the same direction but were not statistically significant after adjustment. Given the observational design of this study, causal inferences cannot be drawn from these data points, and the direction of this relationship must be interpreted with caution. These results have important implications for optimizing postoperative rehabilitation strategies in hip arthroscopy patients.

This study identified an association between lower average weekly step counts in the first three months following surgery and the incidence of IPT. The overall incidence of IPT in this study was 29.6%, which exceeds the upper limit of previously reported rates in the literature, with ranges reported from 7% to 24% [1,2]. Several factors may account for this higher-than-reported incidence. Our prospective study design incorporated standardized provocative testing at each routine postoperative visit, which may capture subclinical or transient cases that are missed in retrospective series relying on symptom-driven presentation. Additionally, our cohort demonstrated lower preoperative functional scores than many published cohorts, suggesting a potentially higher-risk patient population.

The use of rigorous clinical diagnostic criteria with active surveillance is likely to have contributed to a higher detection rate relative to retrospective studies, and this should be considered when interpreting and comparing our incidence figure. Patients in the High Activity group during Weeks 1–3 were significantly less likely to develop IPT than those in the Low or Moderate Activity groups, and in penalized regression adjusted for preoperative function and age, each additional 1000 steps per day during Weeks 1–3 was associated with an approximately 37% reduction in the odds of IPT. A similar gradient was present in later periods but did not reach statistical significance, and the early-period association was itself attenuated under multiple imputation of missing step-count data, so these findings should be regarded as exploratory.

The pathophysiological basis for the observed association between reduced postoperative ambulation and IPT development remains incompletely understood, and the following mechanisms represent hypothesis-generating explanations based on established tendinopathy literature rather than direct empirical findings from this study. One plausible hypothesis is that prolonged deconditioning following hip arthroscopy renders the iliopsoas tendon vulnerable to load-related injury upon return to activity. Conversely, excessive or abrupt increases in activity following a period of low mobilization may overwhelm a deconditioned tendon's mechanical capacity. Baseline gluteal weakness, as suggested by lower preoperative functional scores in the IPT cohort, may lead to compensatory overloading of the iliopsoas during ambulation. However, without objective biomechanical measurements, muscle strength testing, or imaging data, these mechanisms cannot be confirmed in the present study, and future investigations incorporating these modalities are warranted [15–18].

The findings of this study revealed that patients who developed IPT exhibited significantly lower preoperative functional scores, namely mHHS and NAHS. Patients who developed IPT had significantly lower preoperative mHHS and NAHSs and higher baseline pain, suggesting a poorer baseline functional phenotype that may independently predispose these patients to both reduced postoperative ambulation and IPT development. The direction of this relationship cannot be established from the present data: it is equally plausible that a suboptimally conditioned hip musculature and baseline pain led to both lower postoperative step counts and eventual tendinitis, rather than low step counts being the primary driver of IPT. At 3 months, patients in the High Activity group demonstrated significantly better absolute outcomes, with higher mHHS (91.22 ± 11.38 vs. 72.89 ± 19.85, $p = 0.005$) and NAHS (81.45 ± 15.38 vs. 70.69 ± 15.80, $p = 0.019$) compared to the Low Activity group. However, the change (Δ) in mHHS and NAHS from preoperative to 3 months did not differ significantly between groups, suggesting that the observed differences in absolute postoperative outcomes may be primarily influenced by preoperative baseline functional status rather than differential recovery trajectories.

Previous studies have highlighted early over-activation of the iliopsoas tendon in the postoperative period as a potential mechanism underlying postoperative IPT; however, the results from our study suggest an association between under-activation and IPT risk, though the observational nature of this study prevents us from determining causal directionality [2,19,20]. A previous study by Philippon et al. emphasized the challenges of developing appropriate rehabilitation protocols for patients at risk of IPT, noting that tendinitis can complicate the rehabilitation of hip arthroscopy patients due to the complex biomechanics involved in recovery [21]. Their study specifically highlighted the role of gluteal strengthening exercises and their potential to mitigate iliopsoas irritation, suggesting that carefully structured rehabilitation protocols are essential for preventing postoperative IPT.

The temporal pattern of these findings raises the possibility of reverse causality: patients who ultimately developed IPT reported elevated resting VAS pain scores at Weeks 1 and 2 postoperatively, preceding the first statistically significant step-count differences, suggesting that early subclinical pain may have driven reduced ambulation rather than the converse. This bidirectional relationship cannot be fully disentangled in the present cohort, and the possibility that reduced step counts reflect, rather than cause, early IPT pathophysiology must be acknowledged. We also considered reverse causation the most important unresolved threat to the interpretation of these data. Lower postoperative step counts may represent an early behavioral manifestation of subclinical iliopsoas symptoms rather than an independent, modifiable risk factor that precedes and drives IPT development. In this scenario, patients reduce ambulation in response to nascent groin pain, so activity decline would be a consequence of early tendinopathy rather than its cause. Under this interpretation, reduced activity would be a marker of incipient tendinopathy rather than its cause, and the observed association would reflect early disease detection rather than a protective effect of ambulation. Because the diagnosis of IPT was made a mean of 2.5 months postoperatively, whereas step-count reductions and elevated resting pain scores were evident within the first two weeks, the temporal sequence is at least as consistent with this reverse pathway as with the hypothesis that inactivity causes IPT. We therefore caution that the observed associations, particularly those in the later periods during which most IPT diagnoses were made, may partly capture the activity-limiting effect of pain from an already-developing tendinopathy. Future prospective studies employing preoperative step-count baselines and serial imaging would be valuable to clarify the temporal relationship between activity reduction and IPT onset.

Rather than asserting that increased mobilization will necessarily reduce IPT risk, clinicians should consider that patients with consistently low postoperative step counts may represent a higher-risk phenotype warranting closer monitoring and earlier clinical evaluation. Smartphone-based activity tracking provides a practical tool for identifying these patients prior to symptom onset, enabling proactive physical therapy consultation and activity counseling. The goal of such monitoring should be to identify outliers, specifically those with unexplained step-count plateaus or declines in the mid-to-late postoperative period, rather than to mandate specific step-count targets in the absence of interventional evidence. We wish to be explicit that the present data support only an association between lower postoperative activity and IPT and do not justify recommending increased postoperative activity as a preventive strategy. Because the direction of the relationship is uncertain and reverse causation cannot be excluded, actively encouraging patients to increase step counts could, in principle, be premature or even counterproductive if reduced ambulation is a protective response to early tendon irritation. The appropriate clinical message from these findings is heightened surveillance of low-activity patients, not a prescriptive activity target; any recommendation to increase mobilization as prophylaxis against IPT would require validation in a prospective interventional trial. Lastly, our study demonstrated that none of the patients in the IPT group required revision surgery or experienced major failures within the 2-year follow-up period. In contrast, two patients from the non-IPT group required additional interventions. However, with only two events total across a cohort of 54 patients, this analysis is markedly underpowered to detect between-group differences in complication rates. These findings therefore reflect a lack of data rather than evidence of equivalence, and no definitive conclusions regarding the long-term complication risk of IPT can be drawn from this cohort. Larger, longer-term registry studies are needed to characterize the relationship between IPT and downstream surgical outcomes.

Limitations

Despite the strengths of this study, including its prospective design and the use of smartphone technology for objective postoperative activity tracking, several limitations must be acknowledged. The observational nature of the study prevents us from drawing definitive conclusions regarding the causal relationship between postoperative activity levels and the development of IPT. Notably, patients who developed IPT demonstrated elevated pain scores as early as Week 1 and Week 2—preceding the emergence of significant step-count differences—raising the possibility of reverse causality, wherein early pain drove reduced ambulation rather than the converse. This bidirectional relationship cannot be resolved from the current data. Patients who developed IPT had lower preoperative functional scores, possibly reflecting greater baseline pain and weakness, which may independently predispose to both lower activity levels and IPT. Furthermore, the absence of preoperative step count data prevents us from fully understanding changes in activity from before to after surgery. The 18.2% dropout rate due to step-count data loss, while not associated with significant baseline differences in the available comparison, represents a potential source of selection bias that cannot be fully excluded. Additionally, the accuracy of the Pacer for Teams application may be reduced during crutch-assisted partial weight-bearing in the early postoperative period. The multivariable analysis is constrained by the limited number of IPT events (n = 16); parsimonious penalized models were therefore used as the primary analysis, and the full nine-covariate model, which falls far below conventional events-per-variable guidelines, is reported only as a sensitivity analysis. Step-count data were incomplete: only 29 of 54 patients had recorded application data in all 12 weeks, weeks without recorded data were more frequent in the IPT group, particularly in the later postoperative periods (Weeks 10–12: 5 of 16 vs. 5 of 38), and this pattern raises the possibility of informative missingness, for example if patients reduced application use after the onset of symptoms. Because missing weeks were not imputed in the primary analysis, the later-period comparisons rest on smaller numbers of patients and events, and the multiple-imputation sensitivity analysis yielded attenuated estimates. In addition, the large number of statistical comparisons across weekly outcomes increases the probability of false-positive findings; all results should therefore be interpreted as hypothesis-generating. IPT diagnosis was based on standardized clinical criteria with selective ultrasound confirmation; mandatory imaging for all patients was not performed, and this may have introduced some diagnostic imprecision.

5. Conclusions

Lower postoperative step counts were associated with a higher risk of IPT following hip arthroscopy for FAIS, with the most robust association observed in the immediate post-operative period (Weeks 1–3). These findings underscore the potential value of monitoring postoperative ambulation as a marker of recovery, but they do not establish that lower activity causes IPT or that increasing activity would prevent it. Importantly, the possibility of reverse causation cannot be excluded: lower postoperative step counts may represent an early manifestation of subclinical iliopsoas symptoms rather than an independent risk factor for IPT, given that reductions in activity and elevations in pain preceded the clinical diagnosis of IPT. These associations should accordingly be regarded as exploratory. Clinicians should consider routine monitoring of postoperative ambulation using smartphone-based activity tracking as a practical, cost-effective tool to identify patients who may be at risk for IPT prior to symptom onset. The current data support closer surveillance of persistently low-activity patients rather than a recommendation to increase postoperative activity as a preventive strategy. Rehabilitation decisions following hip arthroscopy should continue to balance progressive mobilization against the need for tissue healing, with particular

attention to patients presenting with lower baseline functional scores who may be at heightened risk. These findings are association-based, and causality cannot be inferred from this observational cohort, as early postoperative pain and a poorer baseline functional phenotype may have independently driven both reduced ambulation and IPT development. Future prospective, interventional studies are needed to determine whether structured early mobilization protocols can reduce IPT incidence and to define optimal step-count thresholds for rehabilitation guidance.

Author Contributions: Conceptualization, A.S.B., Z.I.L.; methodology, Z.I.L., A.S.B. and T.Y.; formal analysis, N.P.M. and Z.I.L.; data curation, J.T., K.L.E. and J.E.; writing—original draft preparation, N.P.M. and Z.I.L.; writing—review and editing, S.R.M., J.T., K.L.E., J.E. and T.Y.; supervision, S.R.M. and T.Y.; project administration, S.R.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of NYU Langone Health (protocol code i20-01375; date of approval: 9/27/2020).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author due to patient privacy restrictions.

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

Abbreviations

IPT	Iliopsoas tendinitis
FAIS	Femoroacetabular impingement syndrome
IRB	Institutional Review Board
OA	Osteoarthritis
mHHS	Modified Harris Hip Score
NAHS	Nonarthritic Hip Score
VAS	Visual Analog Scale
CI	Confidence Interval
THA	Total Hip Arthroplasty

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