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Novel Smartphone App Demonstrates Correlations Between Gait Metrics and Patient Reported Outcomes

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Disclosures

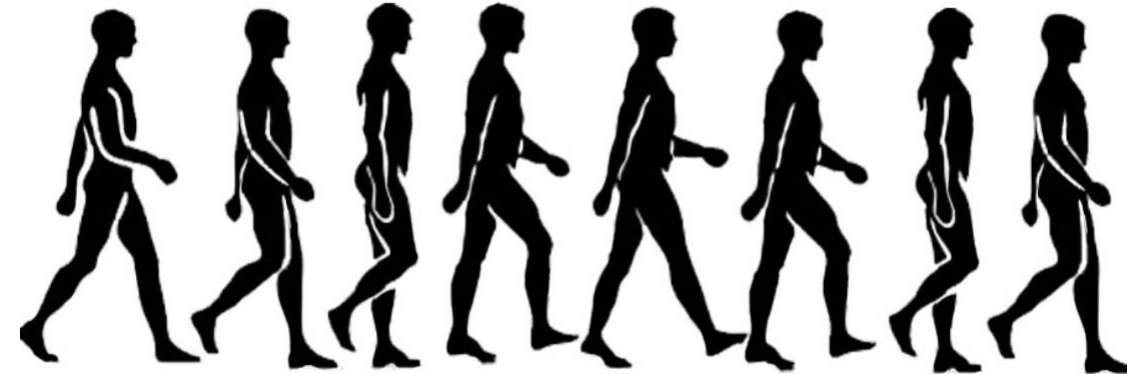


- Sachin Allahabadi, MD: Nothing to Disclose
 - Thomas W. Fenn, BS: Nothing to Disclose
 - Jordan H. Larson, BS: Nothing to Disclose
 - David Zhu, MD: Nothing to Disclose
 - Shane J. Nho, MD, MS: Allosource, AJO, AOSSM, Arthrex, AANA, Athletico, DJ Orthopaedics, Linvatec, Miomed, Ossur, Smith & Nephew, Springer, Stryker
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Background



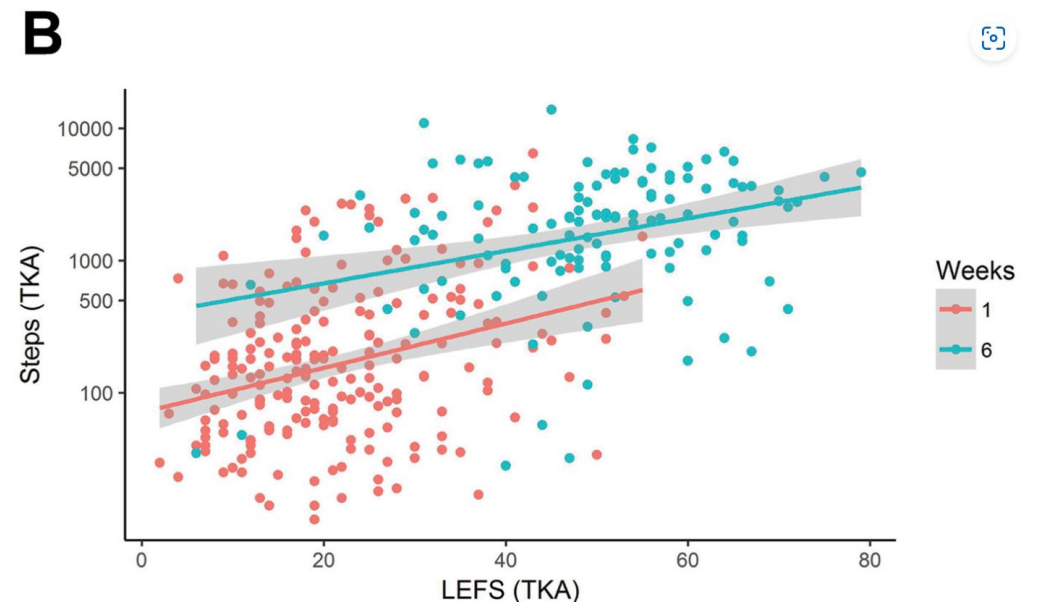
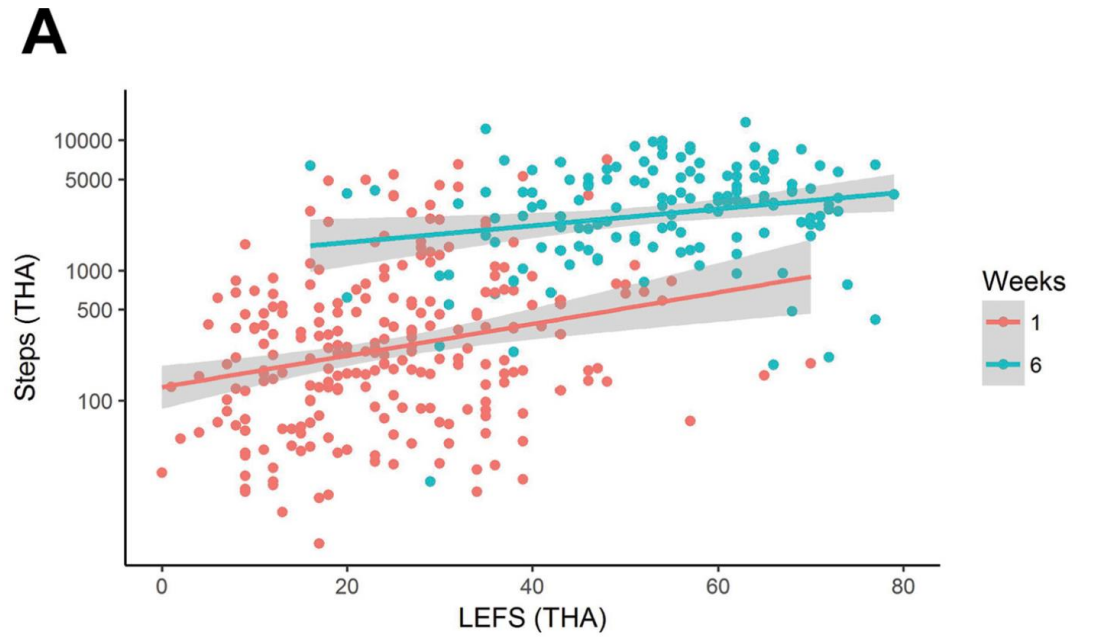
- **Hip arthroscopy** is the mainstay surgical intervention for **femoroacetabular impingement syndrome (FAIS)**
- Functional changes can result in adaptations to gait such as **walking speed, cadence, step & stride length**, and **distance** covered
- Traditionally, patient reported outcomes (PROs) are utilized to track postoperative recovery
- However, gait parameters may better represent **patient activity** and **function** postoperatively



Stepping Toward Objective Outcomes: A Prospective Analysis of Step Count After Total Joint Arthroplasty

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- **589** patients undergoing total knee/total hip arthroplasty using mobile step-tracking application
- **Step-count** demonstrated a **weakly positive** correlation with **lower extremity function scale (LEFS) scores**
 - Week 1: correlation of 0.27 (THA) and 0.29 (TKA)
 - Week 6: correlation of 0.18 (THA) and 0.29 (TKA)



Purpose



To use a smartphone app to collect gait metrics in patients undergoing hip arthroscopy for femoroacetabular impingement syndrome (FAIS) and determine:

(1) When gait metrics return to preoperative levels

(2) If gait metrics correlate with postoperative hip-specific patient reported outcomes

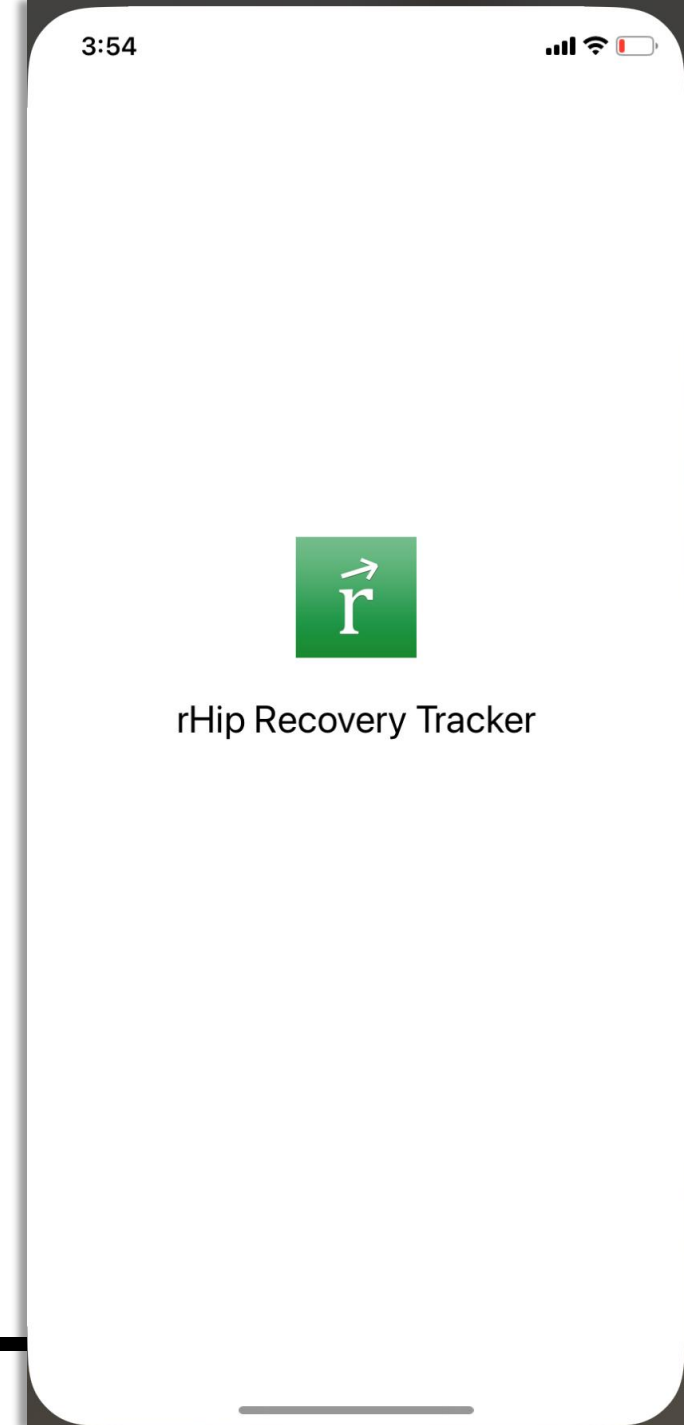
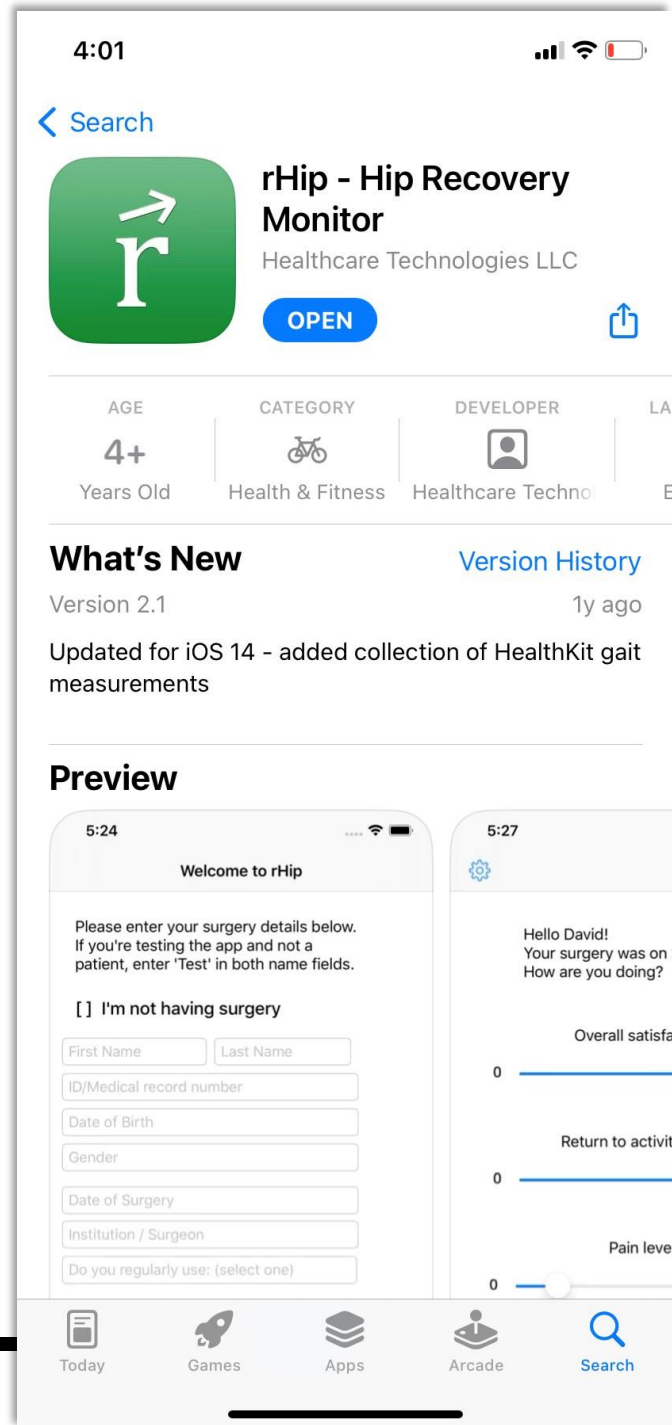
Methods: Patient Selection



- Prospective collection of patients with FAIS who underwent primary hip arthroscopy from August 2021 – July 2022; patient recruitment at 6-month postoperative visit
 - Inclusion criteria
 - Clinical and radiographic evidence of FAIS
 - Failed preoperative conservative treatment (physical therapy, oral NSAIDs, intra-articular injection)
 - Access to iOS operating system (Apple iPhone)
 - Exclusion criteria
 - Bilateral/revision surgery
 - Concomitant hip procedures (ie., gluteus medius/minimus repair)
 - History of developmental disorders (dysplasia, SCFE, Legg-Calve-Perthes)
 - Hip dysplasia defined by LCEA < 25 degrees
 - Worker's compensation case
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Methods: App Development

- Novel smartphone app, **rHip**, developed for iOS Apple iPhone operating system
 - Automatic communication with built-in Apple Health sensors
 - Download of the app allowed retroactive 365 days of data (ie 6-months preoperative to 6-months postoperative)
- App was free to download via Apple app store
- Corresponding secure database was arranged to communicate and store data



Methods: Outcome Measures



- *PROs* collected preoperatively, 3-months, and 6-months postoperatively:
 - Hip Outcome Score Activities of Daily Living (**HOS-ADL**) and Sports (**HOS-SS**) subscales
 - 12-item International Hip Outcome Tool (**iHOT-12**)
 - Patient Reported Outcomes Measurement Information System (**PROMIS**) for Pain and Physical Function (**PF**) subscales

 - *Gait Metrics:*
 - Step count (average daily steps)
 - Step length (meters)
 - Walking speed (meters/second)

 - *Data Analysis*
 - Gait metrics collected 6-months preoperative to 6-months postoperatively
 - Gait metrics sorted on weekly basis, ie postop day 1-7 averaged to obtain postop week 1 value
 - Each postop week was compared (t-tests) to preoperative baseline value (average preop weeks 1 & 2) and evaluated for when metric met preoperative value
 - Pearson correlations evaluated for PROs to each gait metric
-

Results: Patient Demographics



Table 1. Patient Demographics

Count	50
Sex (females)	40 (80%)
Age (years)	31.9 ± 14.5
BMI (kg/m²)	24.7 ± 2.5

Results: Step Count Trendline

- Compared to baseline, Step Count significantly **reduced** postop weeks 1-5
- Significant **improvement** on baseline **step count** weeks 13, 16-26
- Most significant change between **weeks 1 to 2** (**77.5% increase**)

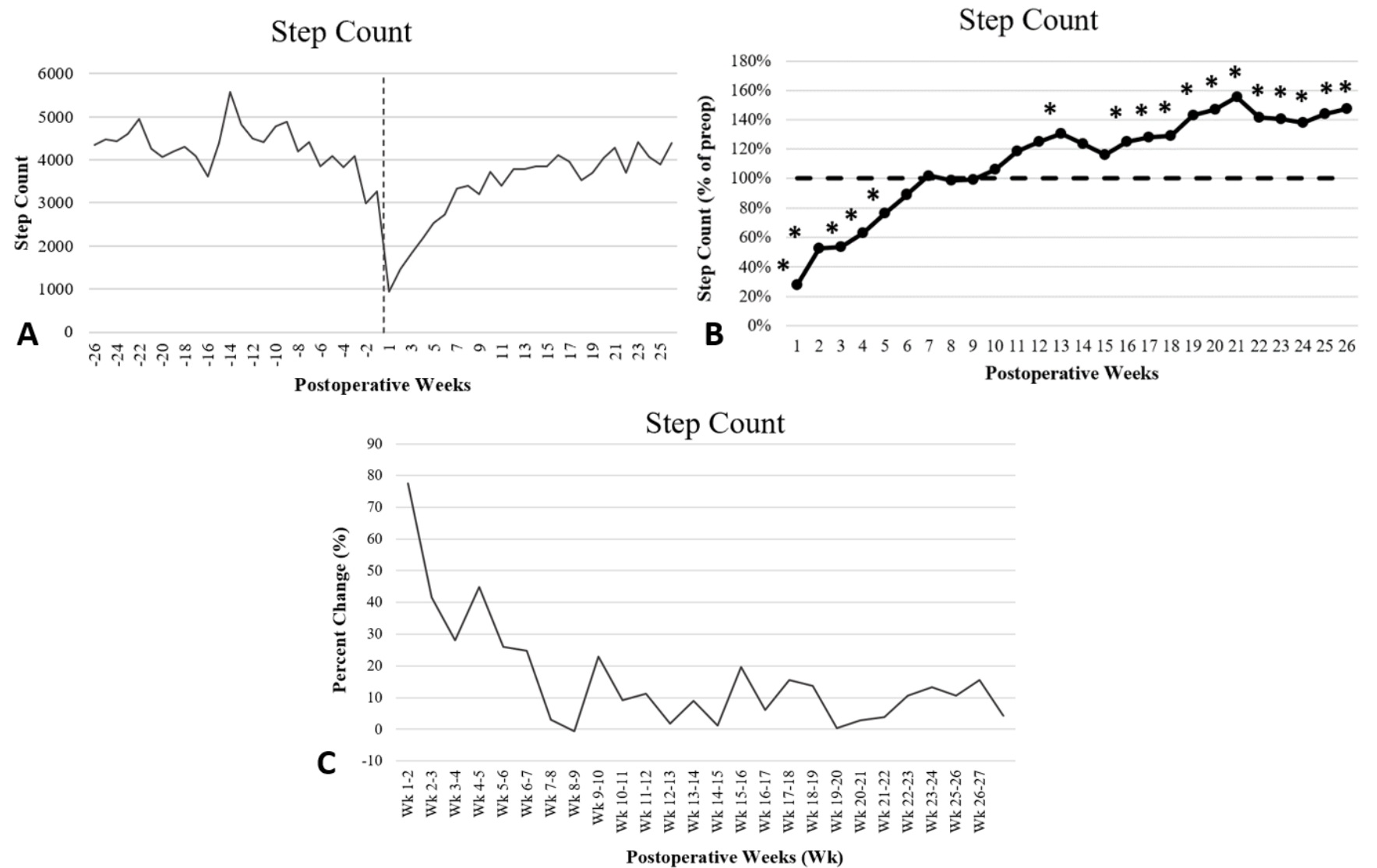


Figure 1, (A) Average step count for consecutive weeks preoperatively to postoperatively (vertical dashed line signifies date of surgery), **(B)** average percentage of preoperative step count by week (horizontal dashed line signifies preoperative value, * indicates significance at $p < 0.05$ relative to preoperative level, **(C)** percentage weekly change in average step count postoperatively.

Results: Step Length Trendline

- Compared to baseline, Step Length significantly **reduced postop weeks 1-4**
- Significant **improvement** on baseline **step length weeks 16 & 20**
- Most significant change between **weeks 1 to 2 (35.8% increase)**

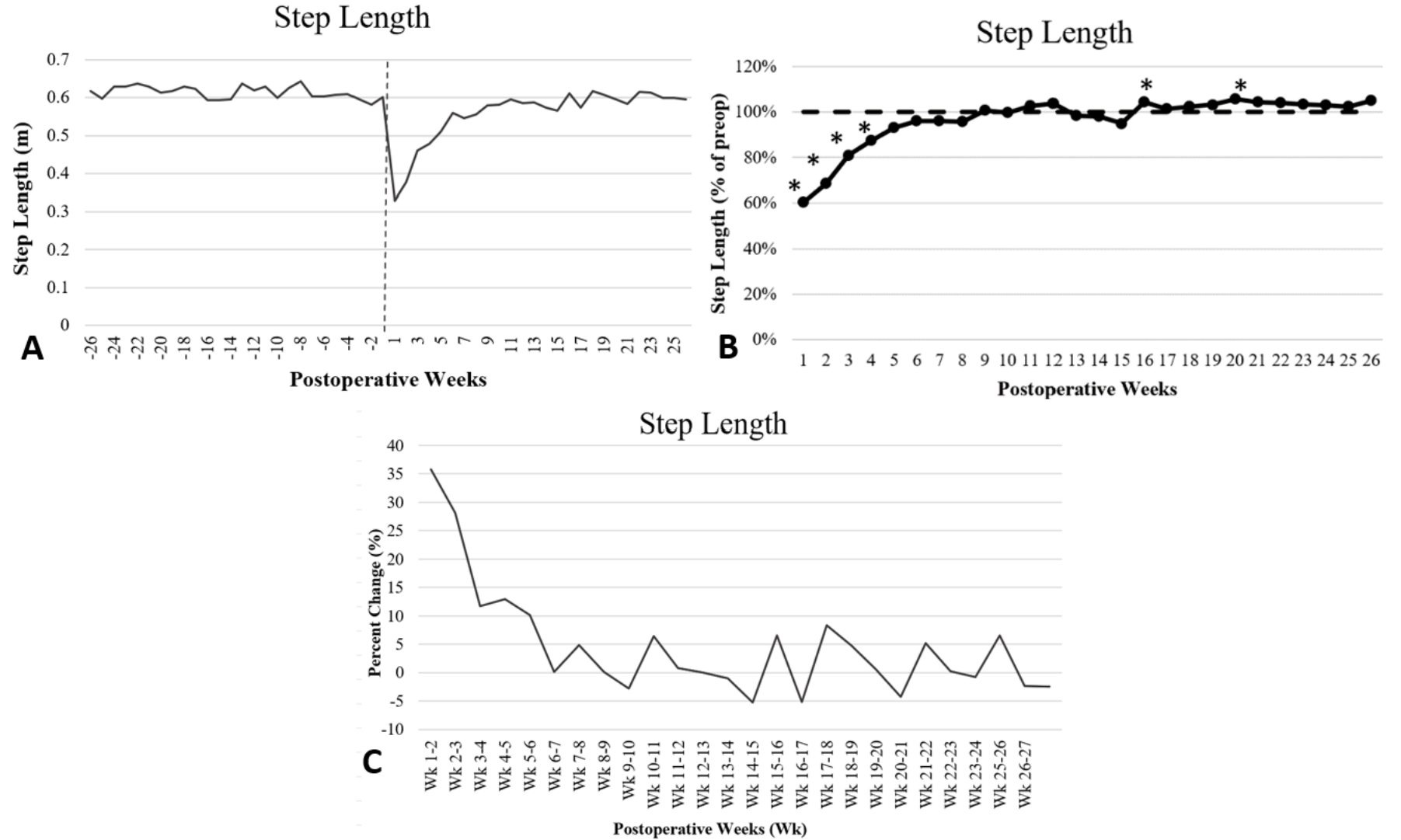


Figure 2, (A) Average step length for consecutive weeks preoperatively to postoperatively (vertical dashed line signifies date of surgery), **(B)** average percentage of preoperative step length by week (horizontal dashed line signifies preoperative value, * indicates significance at $p < 0.05$ relative to preoperative level, **(C)** percentage weekly change in average step length postoperatively.

Results: Walking Speed Trendline

- Compared to baseline, Walking Speed significantly **reduced postop weeks 1-6**
- Significant **improvement** on baseline **walking speed at week 20**
- Most significant change between **weeks 2 to 3 (46.8% increase)**

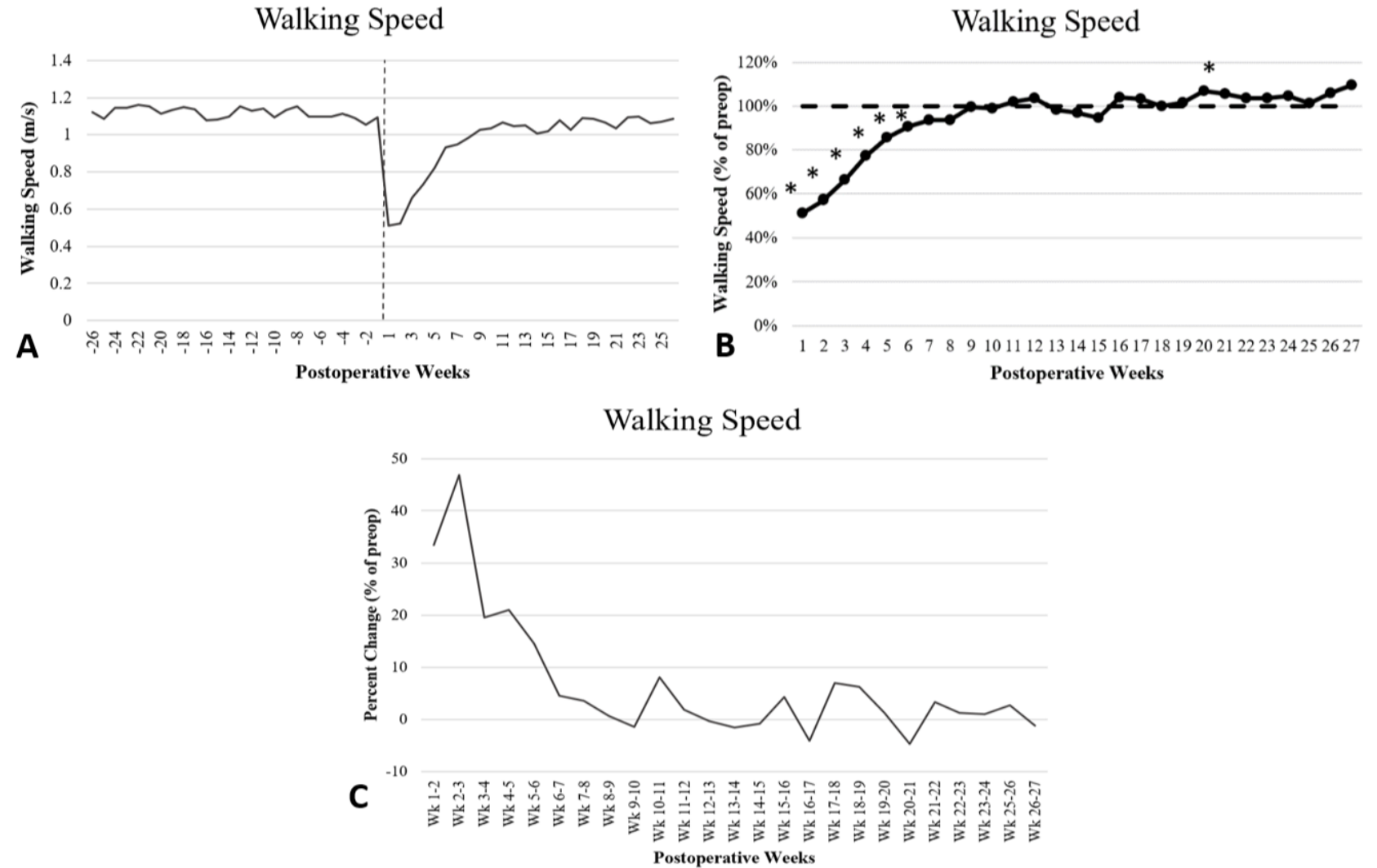


Figure 3, (A) Average walking speed for consecutive weeks preoperatively to postoperatively (vertical dashed line signifies date of surgery), **(B)** average percentage of preoperative walking speed by week (horizontal dashed line signifies preoperative value, * indicates significance at $p < 0.05$ relative to preoperative level), **(C)** percentage weekly change in average walking speed postoperatively.

Results: Patient Reported Outcomes



Table 2. Patient reported outcome scores at preoperative baseline and at 3- and 6-months postoperatively

Except for HOS-SS/PROMIS-PF at 3-months, significant improvements at 3- and 6-months for all measures

No significant changes between 3- and 6-month time-points

	Timepoint			Post Hoc Analysis			
	Preoperative	3-months Postoperative	6-months Postoperative	ANOVA	Pre vs 3 mo.	Pre vs 6 mo.	3 mo. vs 6 mo.
HOS-ADL	55.9 ± 17.3	75.8 ± 17.9	79.6 ± 18.7	<0.001*	<0.001*	<0.001*	0.198
HOS-SS	35.2 ± 19.2	44.8 ± 27.3	59.3 ± 28.1	0.037*	0.134	<0.010*	0.055
iHOT-12	43.3 ± 19.6	56.5 ± 25.0	67.1 ± 25.3	<0.001*	0.013*	0.002*	0.061
PROMIS PF	40.7 ± 5.8	43.2 ± 4.9	46.4 ± 8.2	0.047*	0.141	0.024*	0.295
PROMIS Pain	61.7 ± 5.4	56.2 ± 8.8	55.7 ± 7.7	0.004*	0.046*	0.013*	0.998

** Indicates statistical significance at a level of 0.05.

Results: Preoperative Correlations



Step length
significantly correlated
to PROMIS-PF and
PROMIS-Pain

Table 3. Preoperative Gait Metrics and PRO Correlations

	Step Count (p-value)	Step Length (p-value)	Walking Speed (p-value)
HOS-ADL	0.022 (0.891)	0.295 (0.065)	0.335 (0.028)*
HOS-SS	0.048 (0.772)	0.245 (0.133)	0.226 (0.167)
iHOT-12	-0.044 (0.774)	0.011 (0.943)	0.045 (0.770)
PROMIS PF	0.242 (0.114)	0.306 (0.044)*	0.273 (0.073)
PROMIS Pain	-0.106 (0.487)	-0.352 (0.018)*	-0.386 (0.009)**

‘*’ Indicates statistical significance at a level of 0.05. ‘***’ Indicates statistical significance at a level of <0.01.

Results: 3-month Correlations



Step count significantly correlated to HOS-ADL, iHOT-12, PROMIS-PF/Pain

Step length significantly correlated to HOS-ADL, PROMIS-PF/Pain

Walking speed significantly correlated to HOS-ADL, iHOT-12, PROMIS-PF/Pain

Table 4. 3-month Gait Metrics and PRO Correlations

	Step Count (p-value)	Step Length (p-value)	Walking Speed (p-value)
HOS-ADL	0.440 (0.005)**	0.549 (<0.001)**	0.602 (<0.001)**
HOS-SS	0.238 (0.144)	0.145 (0.377)	0.189 (0.249)
iHOT-12	0.414 (0.008)**	0.363 (0.021)	0.401 (0.010)*
PROMIS PF	0.376 (0.016)*	0.448 (0.004)**	0.458 (0.003)**
PROMIS Pain	-0.379 (0.014)*	-0.376 (0.017)*	-0.406 (0.009)**

‘*’ Indicates statistical significance at a level of 0.05. ‘**’ Indicates statistical significance at a level of <0.01.

Results: 6-month Correlations



Table 5. 6-month Gait Metrics and PRO Correlations

	Step Count (p-value)	Step Length (p-value)	Walking Speed (p-value)	
Step count, Step Length, Walking Speed significantly correlated to HOS-ADL	HOS-ADL	0.339 (0.03)*	0.466 (0.008)**	0.448 (0.011)*
	HOS-SS	-0.018 (0.923)	0.220 (0.234)	0.230 (0.214)
	iHOT-12	0.085 (0.643)	0.241 (0.185)	0.210 (0.248)
	PROMIS PF	0.186 (0.317)	0.276 (0.133)	0.307 (0.093)
	PROMIS Pain	-0.218 (0.239)	-0.220 (0.234)	-0.228 (0.217)

‘*’ Indicates statistical significance at a level of 0.05. ‘**’ Indicates statistical significance at a level of <0.01.

Discussion: Gait Metric Trends



- Each gait metric **returned to baseline** by **postoperative week 6** (end of phase 1 rehabilitation)
 - Most **significant improvements** in gait metrics occurred **early in postoperative period** (postop week 1-3)
 - Coincides with time weaning from crutches
 - Gait metrics not only returned to preoperative levels, but also **exceeded baseline later in recovery**
 - Pain reduction may lead to improved mobility
 - Useful for patients to **self-track progress** and provides **quantitative daily data** to assess recovery
-

Discussion: Correlations



- Several **weak to moderate correlations** exist between PROs and gait metrics depending on the perioperative time frame
 - **Step Length** and **Walking speed** most consistent correlation with **baseline metrics**
 - Patients able to retain greater preoperative step length and higher walking speed may have better function prior to surgery
 - Consistent moderate correlations of **Step Count, Step Length, and Walking Speed** to **several PRO measures at 3-months**
 - Improvement in gait metrics may reflect **hip range of motion restoration** and **improvement in pelvic biomechanics**, implicating improvement in functional capacity and reduction in pain
 - Moderate correlations between **Step Count, Step Length, Walking Speed** with **HOS-ADL at 6-months**
 - Overall **gait quantity** and **quality** returning to baseline may be a **marker of daily functional capacity**
-

Conclusion



- A smartphone app was capable of capturing gait metrics
 - Patients undergoing hip arthroscopy for FAIS demonstrate **return to baseline levels** in step count, step length, and walking speed **after phase I** (six weeks) of rehabilitation
 - Most consistent correlations between gait metrics and step count were seen at 3-months, *although only weak to moderate*
 - Gait metrics similarly had *weak to moderate* correlations with HOS-ADL at 6-months
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**THANK
YOU**



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