

Preinjury Smartphone-Derived Mobility Metrics Are Associated With Discharge Location After Lower Extremity Fracture

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Background: Early prediction of nonhome discharge after lower extremity fracture treatment may improve care coordination and reduce costs. While preinjury functional status is an established predictor, it is commonly assessed subjectively. We hypothesized that preinjury Apple Health mobility metrics, including step count, walking speed, step length, walking asymmetry, and double support time, would be associated with discharge disposition after fracture management.

Methods: We conducted a retrospective cohort study of adults with lower extremity fractures. Preinjury Apple Health mobility data within 26 weeks of injury were analyzed. The primary outcome was discharge home vs. nonhome. Multivariable logistic regression assessed associations between mobility metrics and discharge location, adjusting for age (<65 vs. ≥65 years) and isolated vs. nonisolated fractures.

Results: The cohort included 249 patients (median age, 39 years; 58% male). Overall, 179 (72%) were discharged home, and 70 (28%) to nonhome facilities. Patients discharged home were younger and more likely to have isolated fractures ($p < 0.001$ for both). In the adjusted model (area under the receiver operating characteristic curve, 0.80; 95% confidence interval [CI], 0.74-0.86), higher preinjury step count was strongly associated with discharge disposition. Compared with <2,500 steps/day, 2,500 to 5,000 steps/day (OR, 2.73; $p = 0.03$) and >5,000 steps/day (OR, 4.21; $p = 0.001$) were associated with increased odds of home discharge. Walking asymmetry <10% (OR, 3.21; $p = 0.01$) and faster walking speed (OR per 0.1 m/s, 1.31; $p = 0.01$) were also associated with higher odds of home discharge. Patients <65 years with isolated injuries and >5,000 steps/day had a 94% probability of home discharge (95% CI, 90%-98%) compared with 8% (95% CI, 1%-16%; $p < 0.001$) among those ≥65 years with nonisolated injuries and <2,500 steps/day.

Conclusions: Preinjury smartphone mobility data were independently associated with discharge disposition after lower extremity fracture treatment. These objective measures may improve perioperative risk stratification and discharge planning in orthopaedic trauma populations.

Level of Evidence: Prognostic Level III. See Instructions for Authors for a complete description of levels of evidence.

Introduction

Discharge home vs. a postacute care (PAC) facility after treatment of lower extremity fracture is a clinically and economically consequential outcome in orthopaedic trauma care. Accurate early prediction of discharge destination improves care coordination, facilitates patient counseling, reduces length of stay, minimizes placement delays, and enables allocation of rehabilitation resources¹⁻³. Predictors of nonhome discharge include

advanced age, higher American Society of Anesthesiologists (ASA) score, and comorbidity burden³⁻⁵.

Preinjury functional status is commonly incorporated into predictive models of discharge disposition; however, current methods are largely indirect. Functional ability is typically estimated through retrospective patient report, clinician judgment, or categorical mobility classification, all subject to recall bias, interobserver variability, and measurement inconsistency.

Disclosure: The **Disclosure of Potential Conflicts of Interest** forms are provided with the online version of the article (<https://links.lww.com/JBJSOA/B340>).

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These limitations reduce precision and reproducibility and highlight the need for objective, continuously collected measures of baseline mobility reflecting real-world function. Smartphone-derived mobility data provide objective measures of ambulatory behavior that may improve consistency and reproducibility of baseline functional assessment.

Ubiquitous smartphone adoption presents a novel opportunity to address these limitations through objective preinjury mobility assessment. Apple Health, integrated into iPhones, passively records step count, walking speed, step length, double support time, and gait asymmetry. Double support time represents the percentage of the gait cycle spent with both feet contacting the ground, whereas gait asymmetry reflects differences in step timing between extremities. These metrics have demonstrated validity and reliability compared with laboratory-based gait analysis⁶. Furthermore, step count and gait parameters have been independently associated with mortality, functional decline, and health status in large cohort studies^{7,8}. Despite the growing use of smartphone-derived mobility data as outcome measures after injury⁹⁻¹¹, no previous study has evaluated whether preinjury smartphone mobility metrics are associated with discharge location. This study aimed to determine whether preinjury Apple Health mobility metrics are associated with discharge disposition. We hypothesized that higher preinjury activity levels would be associated with increased odds of discharge home.

Methods

Study Design

This retrospective cohort study included adult patients with lower extremity fractures who owned iPhones. The study was conducted at a single academic Level I trauma center and enrolled a convenience sample of patients from November 2023 to June 2025. IRB approval was obtained, and reporting follows the Strengthening the Reporting of Observational Studies in Epidemiology guidelines¹².

Study Participants

Patients aged ≥ 18 years with lower extremity fractures (acetabulum, pelvic ring, proximal femur, femoral shaft, distal femur, patella, proximal tibia-fibula, tibial shaft, distal tibia-fibula, ankle/malleolar, talus, midfoot, calcaneus) were included. Exclusion criteria were pathological fractures, preinjury nonambulatory status, inability to consent, inability to communicate in English, or lack of Apple Health mobility data. Eligible patients were screened for availability of mobility data at the time of enrollment. Of the 1,105 patients screened, 493 patients were determined to be eligible for inclusion, and 404 patients were enrolled. Among enrolled patients, 249 patients had sufficient data for analysis. All included patients had at least 26 weeks of preinjury mobility data available. Data were collected and averaged on a per-week basis to account for seasonal and weekly variability. Among screened patients, lack of iPhone ownership or non-English-speaking represented the most common reasons for exclusion.

Outcome Measures

The primary outcome was discharge disposition (home vs. nonhome) from index hospitalization, collected through chart review. Nonhome discharge included rehabilitation or skilled nursing facility.

Study Exposures

Primary exposures were preinjury Apple Health mobility metrics, including step count, walking speed (m/s), step length (cm), walking asymmetry (%), and double support time (%). Data included all available measurements within 26 weeks preinjury. Step counts were categorized as $<2,500$, 2,500 to 5,000, and $>5,000$ steps/day based on previously published activity thresholds to maximize clinical interpretability and avoid overfitting cohort-specific cutoffs^{7,8}.

Mobility data were exported directly from iPhones as XML files or using the OrthoSteps app (Analysis in Motion LLC, Baltimore, MD), which integrates with Apple Health and securely syncs and stores deidentified mobility data when patients access the app.

Mobility data were combined with demographic and injury characteristics, including age (± 65 years), sex, race, obesity, diabetes, tobacco and alcohol use, ASA score, and fracture characteristics.

Statistical Analysis

Based on the available sample size and an assumed 50% home discharge rate in the least mobile group, the study was estimated to have over 90% power to detect a 15% absolute monotonic ordinal increase in home discharge with a two-sided alpha of 5%.

Patient characteristics were summarized as counts and percentages for categorical data and as medians with interquartile ranges (IQRs) for continuous data. Group comparisons were performed using chi-square and Wilcoxon rank-sum tests, as appropriate. Logistic regression models assessed the association between preinjury mobility metrics and discharge destination.

Prognostic performance was evaluated using the area under the receiver operating characteristic curve (AUC) for unadjusted models and models adjusted for age (± 65 years) and isolated vs. nonisolated fractures. Statistical significance was defined as $p < 0.05$ without adjustment for multiplicity. Analyses were performed using R version 4.2.2 (R Foundation for Statistical Computing).

Results

Patient Characteristics

In total, 249 adult patients were included. The median age was 39 years (IQR, 26-58), and 58% were male. Twelve patients (5%) underwent nonoperative management (5 pelvic ring, 3 acetabulum, 3 malleolar, 1 calcaneus). Overall, 179 patients (72%) discharged home and 70 patients (28%) discharged to a nonhome facility (Table I). Patients discharged home were younger (median age, 35 vs. 55 years; $p < 0.001$) and more likely to have ASA class I or II status (73% vs. 31%; $p < 0.001$) and isolated fractures (66% vs. 34%; $p < 0.001$).

Obesity was more common in the nonhome group (47% vs. 30%; $p = 0.01$). There were no significant differences between groups in sex, race, tobacco use, alcohol abuse, diabetes, or open fracture status (Table I).

Step Count and Home Discharge

In the unadjusted logistic regression, a higher preinjury daily step count was associated with progressively higher odds of discharge home (Table II). Compared with patients taking <2,500 steps/day, those taking 2,500 to 5,000 steps/day had 2.48-fold greater odds of home discharge (95% confidence interval [CI], 1.18-5.26; $p = 0.02$) and those taking >5,000 steps/day had 4.39-fold greater odds (95% CI, 2.18-9.01; $p < 0.001$). After adjusting for age (<65 vs. ≥ 65 years) and isolated vs. nonisolated fractures, step count remained independently associated with discharge home. Patients taking >5,000 steps/day had 4.21-fold greater odds of discharge home (95% CI, 1.76-10.40; $p = 0.001$) compared with those taking <2,500

steps/day. Adding age and an indicator for isolated fractures significantly improved the model's prognostic performance ($p < 0.001$), increasing the AUC from 0.65 (95% CI, 0.58-0.72) to 0.80 (95% CI, 0.74-0.86).

A clinically meaningful gradient was observed when mobility and demographic factors were considered jointly. Compared with <2,500 steps/day, 2,500 to 5,000 steps/day (OR, 2.73; $p = 0.03$) and >5,000 steps/day (OR, 4.21; $p = 0.001$) were associated with increased odds of home discharge. Patients younger than 65 years with isolated fractures and >5,000 steps/day had a 94% probability of discharge home (95% CI, 90%-98%), whereas patients 65 years and older with nonisolated fractures and <2,500 steps/day had an 8% probability of discharge home (95% CI, 1%-16%; $p < 0.001$).

Other Mobility Parameters and Home Discharge

Walking asymmetry <10% (OR, 3.21; $p = 0.01$) and faster walking speed (OR per 0.1 m/s increase, 1.31; $p = 0.01$) were

TABLE I. Participant Characteristics

Characteristic	Overall N = 249	Home Discharge, n = 179	Nonhome Discharge, n = 70	p
Age, years, median (IQR)	39 (26-58)	35 (25-51)	55 (32-70)	<0.001
Sex				0.43
Female	104 (42%)	72 (40%)	32 (46%)	
Male	145 (58%)	107 (60%)	38 (54%)	
Race				0.85
White	58 (23%)	40 (22%)	18 (26%)	
Black or African American	36 (14%)	26 (15%)	10 (14%)	
Other	155 (62%)	113 (63%)	42 (60%)	
Obese	86 (35%)	53 (30%)	33 (47%)	0.01
Diabetes	12 (5%)	6 (3%)	6 (9%)	0.10
Tobacco use	70 (28%)	51 (28%)	19 (27%)	0.83
Alcohol abuse	14 (6%)	10 (6%)	4 (6%)	>0.99
ASA physical status score				<0.001
1-2	153 (61%)	131 (73%)	22 (31%)	
3-5	96 (39%)	48 (27%)	48 (69%)	
Isolated fracture	143 (57%)	119 (66%)	24 (34%)	<0.001
Open fracture	66 (27%)	49 (27%)	17 (24%)	0.62
Periarticular fracture				0.03
Periarticular	170 (68%)	115 (64%)	55 (79%)	
Nonperiarticular	79 (32%)	64 (36%)	15 (21%)	
Daily steps, preinjury, median (IQR)	4,946 (2,800-7,081)	5,460 (3,498-7,529)	3,261 (1,952-6,113)	<0.001
Walking asymmetry (%), preinjury, median (IQR)	4 (3-7)	4 (3-6)	7 (3-13)	<0.001
Walking speed (m/s), preinjury, median (IQR)	1.30 (1.21-1.37)	1.31 (1.22-1.38)	1.25 (1.06-1.35)	<0.001
Double support (%), preinjury, median (IQR)	30.5 (29.4-31.7)	30.3 (29.2-31.4)	31.0 (30.1-32.4)	<0.001
Walking step length (cm), preinjury, median (IQR)	70 (65-75)	71 (66-75)	69 (61-74)	0.02
ASA = American Society of Anesthesiologists, and IQR = interquartile range.				

TABLE II. Association of Preinjury Mobility With Home Discharge

Mobility Parameter	Unadjusted			Adjusted*		
	OR (95% CI)	p	AUC (95% CI)	OR (95% CI)	p	AUC (95% CI)
Preinjury step count						
<2,500 per day	Ref (1.00)		0.65 (0.58-0.72)	Ref (1.00)		0.80 (0.74-0.86)
2,500 to 5,000 per day	2.48 (1.18-5.26)	0.02		2.73 (1.11-6.89)	0.03	
>5,000 per day	4.39 (2.18-9.01)	<0.001		4.21 (1.76-10.40)	0.001	
Walking asymmetry						
≥10%	Ref (1.00)		0.60 (0.54-0.66)	Ref (1.00)		0.80 (0.74-0.85)
<10%	3.86 (1.93-7.79)	<0.001		3.21 (1.33-7.81)	0.01	
Walking speed (per 0.1 m/s)	1.43 (1.21-1.72)	<0.001	0.65 (0.57-0.73)	1.31 (1.07-1.62)	0.01	0.80 (0.74-0.86)
Step length (per 10 cm)	1.75 (1.20-2.59)	<0.01	0.60 (0.51-0.68)	1.50 (0.94-2.44)	0.09	0.79 (0.73-0.86)
Double support (per 1%)	0.80 (0.65-0.89)	<0.001	0.64 (0.56-0.72)	0.70 (0.60-0.84)	<0.001	0.82 (0.76-0.87)
AUC = area under the receiver operating characteristic curve. *Models adjust for being less than 65 years of age and isolated vs. nonisolated fractures.						

associated with significantly higher odds of discharge home, whereas greater double support time was inversely associated with home discharge (OR per 1% increase, 0.70; $p < 0.001$) (Table II).

Discussion

Preinjury Apple Health mobility metrics were strongly associated with discharge disposition after lower extremity fracture treatment. Higher preinjury step count, improved gait symmetry, faster walking speed, and reduced double support time were all associated with increased likelihood of discharge home. Our model incorporating these variables demonstrated discrimination comparable with established trauma and hip fracture prediction tools^{1,3,5}. These findings support smartphone-derived mobility metrics as objective measures that may improve discharge risk stratification.

Evidence supporting the importance of preinjury mobility has been most consistently demonstrated in hip fracture populations. Several observational studies and predictive models have shown that prefracture ambulatory status and mobility-based measures improve discrimination for nonhome discharge when added to demographic and clinical variables^{5,13-16}. Commonly used discharge prediction instruments, including the Discharge of Hip Fracture Patients score and registry-derived nomograms, achieve good discrimination (AUC ≈ 0.8) but rely on subjective or retrospectively reported functional status rather than objective baseline mobility data^{5,14}. Similarly, widely used tools such as the Risk Assessment and Prediction Tool and Trauma Rehabilitation and Prediction Tool incorporate functional measures but depend on subjective assessments^{2,17}. Across these approaches, reliance on subjective recall, categorical functional scoring, and heterogeneous measurement instruments limits reproducibility and introduces potential misclassification.

Age and injury severity remain established determinants of discharge disposition. However, smartphone-derived

mobility metrics remained associated with discharge disposition after adjustment for these factors, suggesting that objective mobility data capture aspects of baseline functional status not fully reflected by traditional clinical variables.

This study extends this literature by demonstrating significant associations between objectively measured preinjury smartphone mobility metrics and discharge disposition. Apple Health metrics capture continuous, real-world ambulatory behavior over time, enabling assessment of both mobility volume and gait quality. This multidimensional profile provides a more granular estimate of physiological reserve than traditional single-point or subjective assessments and may explain the independent contribution of multiple gait metrics observed in this study.

Recent evidence suggests that both preinjury ambulatory status and early postoperative mobility are strongly associated with discharge location and recovery of baseline function, potentially mediating the relationship between baseline capacity and postoperative outcomes¹⁸. This supports baseline mobility as an upstream determinant of recovery potential. Smartphone mobility metrics offer a precise, scalable means of measuring physiological baseline and enable individualized risk stratification.

The observed associations are consistent with previous literature identifying walking speed as a robust marker of overall health and predictor of disability and institutionalization¹⁹⁻²². Spatiotemporal gait parameters, including asymmetry and double support time, have been associated with fall risk, functional decline, and adverse outcomes in older adults²³⁻²⁷. Similarly, smartphone step count has been inversely associated with mortality risk in multiple large cohorts and meta-analyses^{7,8}. These findings suggest that the preinjury activity level reflects physiological reserve and influences recovery of functional independence.

Clinically, these findings have useful implications for perioperative decision-making. Current discharge planning

relies on retrospective recall, clinician-estimated baseline function, and inpatient mobility performance, which are subject to bias and affected by hospitalization-related deconditioning. By contrast, smartphone mobility data provide immediate, objective baseline information. This may help identify patients needing PAC, improve shared decision-making, and optimize rehabilitation resource allocation.

The clinical utility of this approach lies in its scalability. Widespread smartphone adoption in the United States and previous validation of smartphone-derived metrics against laboratory-based standards⁶ demonstrate that integration of these data into clinical workflows is feasible²⁸. Automated extraction of preinjury mobility data at admission may be a practical tool for enhancing risk stratification in orthopaedic trauma populations. Future studies are needed to determine the feasibility and clinical utility of incorporating smartphone-derived mobility metrics into discharge-planning workflows.

Strengths of our study include the use of objectively collected preinjury mobility data to provide a novel measure of baseline function. In 249 patients with lower extremity fracture, step count, walking speed, gait asymmetry, and double support time were all strongly associated with discharge disposition, with an adjusted model achieving an AUC of 0.80. By leveraging objective longitudinal data, this approach offers a scalable, noninvasive tool to guide early perioperative discharge planning. Although these findings support the feasibility of smartphone-derived mobility assessment for discharge risk stratification, prospective studies are needed to determine whether incorporating clinically meaningful thresholds or risk stratification tools can improve discharge efficiency.

This study has limitations. Inclusion was limited to iPhone users with preinjury mobility data, introducing selection bias and limiting generalizability. Smartphone ownership correlates with socioeconomic and demographic factors that may independently influence healthcare utilization and discharge disposition^{28,29}. In addition, elderly patients with proximal femur fractures, who are most likely to require PAC, may be under-represented because of lower smartphone use and the study setting. The study was conducted at a single center, and external validation is necessary before broader implementation. We recognize that postoperative factors can influence discharge disposition; however, the study focused on factors available at the time of injury. Future studies integrating baseline and inpatient mobility data may clarify causal pathways and mediation effects¹⁸. Finally, although Apple Health metrics have demonstrated validity in controlled environments⁶, data may be influenced by device-carrying behavior and measurement variability.

Conclusions

Preinjury smartphone-derived mobility metrics were strongly associated with discharge disposition after treatment of lower extremity fractures. In addition to the observed dose-response

relationship between step count and home discharge, gait-derived metrics, including walking asymmetry, walking speed, and double support time, demonstrated independent associations with discharge disposition and captured complementary dimensions of mobility. These findings suggest that digital mobility phenotyping may represent a scalable approach to inform perioperative risk assessment and discharge planning in orthopaedic trauma populations.

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