Lower daily step count precedes persistent opioid use in opioid-naive adults with chronic spine pain: an All of Us cohort study

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QUESTION

Does behavior recorded before opioid prescribing precede persistent use—and add predictive information beyond routine clinical data?

METHODS & COHORT

Retrospective All of Us Controlled Tier cohort; wearable activity and sleep (Fitbit).
Pain: ≥2 diagnosis dates ≥90 days apart; 1,676 concepts from 13 ICD-10-CM prefixes.

164,264 Chronic-pain phenotype › **17,334** Wearable-linked participants › **8,624** Eligible adults

232 / 8,624 (2.7%) persistent-use cases
Prescriptions in ≥2 distinct 90-day outcome blocks

Mean age 57.8 years · 69.2% female
66.9% low back pain · 8.4% prior pain procedure

LANDMARK DESIGN

Wearable exposure	Blanking	Outcome window
Days 0–90	Days 90–120	Days 120–485

No opioid prescription record: day −180 to <120.

T0: later of phenotype qualification and first valid wearable day. Windows shown schematically.

Required ≥30 valid wear days across ≥6 weeks and ≥1 encounter during outcome ascertainment.

MAIN FINDING

Lower activity preceded persistent opioid prescribing.

The signal was in activity level, not the step-count trajectory.

DISCRIMINATION (AUROC)

Clinical	Wearable	Combined
0.590	0.602	0.613

ΔAUROC +0.023 (95% CI, 0.000–0.048)

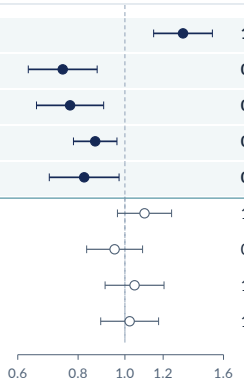
Repeated 10-fold cross-validation

Not sufficient for individual risk stratification.

Adjusted associations

Five of nine wearable features met q < 0.05.

Feature	Adjusted OR (95% CI)	q
Proportion of days <5,000 steps	**1.32 (1.15–1.52)**	**0.001**
Mean daily steps	**0.74 (0.63–0.88)**	**0.002**
Step variability (SD)	**0.77 (0.66–0.90)**	**0.004**
Mean sleep efficiency	**0.87 (0.78–0.96)**	**0.017**
10th-percentile daily steps	**0.82 (0.70–0.97)**	**0.040**
Sleep duration variability (SD)	1.10 (0.97–1.25)	0.233
Weekly step-count trend	0.95 (0.83–1.09)	0.586
Proportion of nights <6 hours	1.05 (0.91–1.21)	0.586
Mean sleep duration	1.02 (0.89–1.17)	0.748



Adjusted OR per 1-SD increase (log scale)

Filled markers: q < 0.05. Separate logistic regressions adjusted for 12 clinical covariates including baseline PROMIS pain intensity, plus its missingness indicator. Benjamini–Hochberg correction across nine tests.

Observed-pain sensitivity (n = 4,967)

Mean steps: adjusted OR 1.41 per SD decrease (95% CI, 1.10–1.80).

INTERPRETATION & LIMITATIONS

Prescription records do not establish medication consumption. Among 1,798 dispensing-linked participants, 25 of 96 (26%) primary cases did not meet dispensing-based persistence.

Baseline pain missing: 42.4%; sleep missing: 10.7% (median-imputed). Residual confounding and a disproportionately female/non-Hispanic White wearable sample limit interpretation and generalizability.

References: 1. Denny JC, et al. N Engl J Med. 2019;381:668–676. 2. Brummett CM, et al. JAMA Surg. 2017;152:e170504.

We thank All of Us participants and the NIH All of Us Research Program. Data: Controlled Tier C2025Q4R6, available to authorized users on the Researcher Workbench.