



Average Daily Step Score as an Objective Surrogate Measure for Physical Functioning and Pain Relief After Epidural Steroid Injections: A Pilot Study Using Patient’s Own Smartwatch

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INTRODUCTION

- Chronic low back pain remains a leading cause of disability and healthcare spending.
- ESI outcomes are usually subjective and rely on subjective patient-reported tools like the Numerical Rating Scale (NRS) and SF-36 physical functioning scores.
 - These tools are vulnerable to bias, inconsistency, and poor validity.
- With the increasing adoption of wearable technology that can track physical activity, step counts offer a promising avenue for objective assessment of treatment efficacy.

AIMS

To assess whether an association exists between changes in functionality and changes in step counts and pain scores, using Kendall’s tau correlation analysis.

MATERIALS AND METHODS

- Prospective observational study enrolled adults (ages 18-65) who owned smartwatches and used them for monitoring daily steps.
- Patients were undergoing fluoroscopically guided ESI for chronic radicular low back pain from lumbar disc herniation or spinal stenosis and signed written informed consent.
 - Patients with neurogenic claudication were excluded.
- Participants provided 7-day average step counts from their personal smartwatches and completed SF-36 physical functioning and NRS assessments prior to and one month after the procedure.
- The study was approved by Yale University IRB, protocol # 2000034806.

RESULTS

- 30 patients were enrolled (Table 1); data was available for 21 patients. 8 patients were unreachable or refused the follow-up questionnaires; 1 patient expired.
- Although median pain score improved at 1 month follow-up, median step count decreased (Table 1 and Table 2, Wilcoxon rank test, $p = 0.07$).
- Consistent negative correlation, although non-significant, between changes in SF scores and changes in pain scores were found (Table 3), with SF6 showing a moderate negative correlation.
 - The results suggest that as pain scores increased, functionality scores decreased. There was no relationship between pain score change and step count change.
- Positive correlations were seen with slight increases in step count with improved functionality for activities like running and climbing stairs. When basic ADL activities such as bending, kneeling and bathing showed improvements, negative correlations implying decreased step count were seen.

Table 1: Baseline Characteristics of Participants

Demographic and Clinical Characteristics			
Age (yrs)		Median (Q1, Q3)	56 (44, 60)
BMI		Median (Q1, Q3)	32 (26, 35)
Gender, n (%)			
Female	148 (62%)	Male	11 (38%)
Race, n (%)			
Non-white	13 (45%)	White	16 (55%)
Insurance, n (%)			
Private	20 (69%)	Public	9 (31%)
Smoking, n (%)			
No	17 (59%)	Yes	12 (41%)
Alcohol, n (%)			
No	17 (59%)	Yes	12 (41%)
Opiate use, n (%)			
No	24 (92%)	Yes	2 (7.7%)
Neuropathics, n (%)			
No	6 (22%)	Yes	21 (78%)
Anxiety / Depression, n (%)			
No	19 (70%)	Yes	8 (30%)
Previous procedures, n (%)			
No	9 (31%)	Yes	20 (69%)
Previous Spine Surgery, n (%)			
No	22 (76%)	Yes	7 (24%)
Pain Characteristics		Median (Q1, Q3)	
Pre-injection			
Average Pain score (NRS)		7.00 (5.00, 8.50)	
Average 7-day Step Count		5,338 (2,329, 10,000)	
1-month follow-up			
Average Pain score (NRS)		5.0 (3.0, 7.0)	
Average 7-day Step Count		5,000 (2,200, 9,812)	
Improvement ratio*		0.30 (0.10, 0.60)	

N = 29.

*number of SF36 score questions improved (RSF > SF)/10.

Table 2: Kendall’s tau Correlation between Changes in Functionality and Average Step Count

Characteristic	Correlation*	P-value	Improved	Not Improved	Unknown
SF1 Strenuous activities-running	0.19	0.40	5 (24%)	16 (76%)	8
SF2 Moderate activities-vacuuming	0.13	0.54	7 (33%)	14 (67%)	8
SF3 Lifting groceries	-0.04	0.87	7 (33%)	14 (67%)	8
SF4 Climbing several flights of stairs	0.16	0.47	9 (43%)	12 (57%)	8
SF5 1 flight of stairs	0.11	0.63	9 (43%)	12 (57%)	8
SF6 Bending/kneeling	-0.31	0.16	7 (35%)	13 (65%)	9
SF7 Walking>1 mi	0.08	0.73	7 (37%)	12 (63%)	10
SF8 Walking several blocks	-0.13	0.56	6 (32%)	13 (68%)	10
SF9 Walking 1 block	0.13	0.54	4 (20%)	16 (80%)	9
SF10 Bathing/dressing	-0.03	0.90	6 (30%)	14 (70%)	9
Change in NRS	-0.01	0.96	-	-	9

Correlation: Kendall’s tau correlation coefficient between changes in functionality (SF scores) and changes in average step count.

Improved / Not Improved / Unknown: Number and percentage of participants in each category.

Table 3: Correlation between Changes in Functionality Scores (SF) and Pain Scores (NRS)

Characteristic	Correlation*	P-value	Improved	Not Improved	Unknown
SF1 Strenuous activities-running	-0.43	0.03	5 (24%)	16 (76%)	8
SF2 Moderate activities-vacuuming	-0.13	0.50	7 (33%)	14 (67%)	8
SF3 Lifting groceries	-0.11	0.58	7 (33%)	14 (67%)	8
SF4 Climbing several flights of stairs	-0.12	0.56	9 (43%)	12 (57%)	8
SF5 1 flight of stairs	-0.37	0.06	9 (43%)	12 (57%)	8
SF6 Bending/kneeling	-0.35	0.09	7 (35%)	13 (65%)	9
SF7 Walking>1 mi	-0.35	0.09	7 (37%)	12 (63%)	10
SF8 Walking several blocks	-0.34	0.10	6 (32%)	13 (68%)	10
SF9 Walking 1 block	-0.35	0.09	4 (20%)	16 (80%)	9
SF10 Bathing/dressing	-0.08	0.69	6 (30%)	14 (70%)	9
Change in step counts	-0.01	0.96	-	-	13

Correlation: Kendall’s tau correlation coefficient between functionality scores (SF) and pain scores (NRS).

Improved / Not Improved / Unknown: Number and percentage of participants in each category.

DISCUSSION

- This pilot study found no significant correlation between change in pain scores, SF36 scores, and step count following ESI.
- Although no association was observed between improvement in pain and change in step count, preliminary trends suggest a potential relationship between functionality improvements and step count changes as well as pain reduction.
- High attrition and great subject heteroscedasticity reduced statistical power, limiting the reliability of exploratory regression analyses.
- Larger, adequately powered studies are necessary to determine whether smartwatch-derived metrics can reliably serve as a low-cost, and patient-driven tool for evaluating outcomes after ESI.
- This approach may be able to address a critical gap in pain medicine by moving toward objective, real-world measures to assess efficacy of pain interventions.

REFERENCES

- Chiarotto A, et al. A systematic review highlights the need to investigate the content validity of patient-reported outcome measures for physical functioning in patients with low back pain. J Clin Epidemiol. 2018;95:73-93.
- Manchikanti L, et al. Do epidural injections provide short- and long-term relief for lumbar disc herniation? A systematic review. Clin Orthop Relat Res. 2015;473(6):1940-56.
- Mobbs RJ, et al. Physical activity measured with accelerometer and self-rated disability in lumbar spine surgery: A prospective study. Global Spine J. 2016;6(5):459-64.
- Prince SA, et al. A comparison of direct versus self-report measures for assessing physical activity in adults: A systematic review. Int J Behav Nutr Phys Act. 2008;5:56.
- Twiggs J, et al. Measurement of physical activity in the pre- and early post-operative period after total knee arthroplasty for osteoarthritis using a fitbit flex device. Med Eng Phys. 2018;51:31-40.