Functional Mobility Profiles in Pre-Operative Knee Osteoarthritis Patients: A Cluster Analysis of Self-Report, In-Clinic, and Free-Living Measures

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Summary

This study identified three pre-operative mobility clusters in knee osteoarthritis (OA) patients, where in-clinic and self-reported measures distinguished low- from high-mobility groups, while free-living mobility captured subtle differences within high-mobility patients. Some patients classified as low mobility in-clinic did not exhibit the same limitations in real-world settings. These findings underscore the importance of comprehensive mobility assessments in patient profiling.

Introduction

The knee is the most commonly affected joint in OA, often leading to pain, functional limitations, and mobility impairments [1]. Total knee arthroplasty (TKA) is performed to reduce pain, restore knee function, and improve mobility and quality of life. However, patient responses to TKA vary, suggesting a need for a more comprehensive understanding of patient function and mobility. A unified mobility framework integrating perception (e.g., self-reported function), ability (e.g., in-clinic gait analysis), and capacity (e.g., free-living wearable monitors) may provide a more complete picture of patient functional mobility [2]. Improving our understanding of these three mobility components in the pre-surgical phase could enhance clinical decision-making and post-operative tracking. Therefore, this study aimed to classify pre-operative patients into clusters based on metrics spanning this unified framework of mobility.

Methods

Thirty-three patients with knee OA (Age: 64 ± 8 years; BMI: 33 ± 7 kg/m^2) scheduled for a TKA were recruited from St. Joseph's Healthcare. Self-reported data were collected via online questionnaires to assess joint pain and function (OKS), depression (PHQ-8), and quality of life (EQ-5D). In-clinic mobility was evaluated using a 10-camera markerless motion capture system (Theia Markerless Inc.) while patients completed a 60-second preferred-paced walk, 30-second fast-paced walk, sit-to-stand, and quiet standing task, capturing joint kinematics and spatiotemporal gait parameters. Free-living mobility was monitored using inertial sensors (Axivity AX6, 100 Hz) placed on each tibia for continuous tracking. A hierarchical cluster analysis using Ward's minimum variance method was conducted on participant means across 19 mobility metrics to classify pre-operative patients. One-way ANOVA tested for differences between clusters ($p < 0.05$).

Results and Discussion

Three clusters were identified: a small low-mobility group ($n = 5$) and two larger, similar high-mobility groups ($n = 14$ each, Figure 1). Self-reported and in-clinic mobility were poorer in cluster 1 compared to clusters 2 and 3 (Table 1). Interestingly, only one in-clinic measure (sit-to-stand trunk flexion) and free-living mobility significantly differentiated the two higher-mobility clusters, with cluster 3 showing greater mobility. In contrast, cluster 1 did not differ from clusters 2 and 3 in free-living mobility.

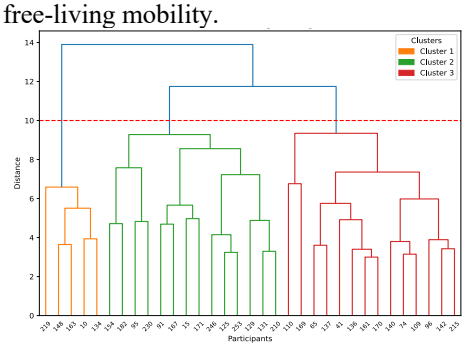

Figure 1: Dendrogram of the hierarchical cluster analysis.

While self-reported and in-clinic measures effectively distinguished low- from high-mobility patients, free-living mobility may capture more subtle differences within higher-mobility groups. Additionally, in-clinic assessments clearly identified low mobility, but these differences did not necessarily translate to real-world mobility limitations, as seen in cluster 1.

Table 1. Mean and standard deviation (SD) for each cluster and post-hoc results indicting significant differences between clusters.

Measure	Cluster 1 Mean±SD	Cluster 2 Mean±SD	Cluster 3 Mean±SD	Tukey HSD
Oxford knee score	14.6 ± 4.0	24.2 ± 6.4	26.4 ± 4.9	1 < 2; 1 < 3
PHQ-8 (depression)	9.0 ± 1.4	4.8 ± 3.7	4.1 ± 3.3	1 > 3
EQ5D Utility Canada	0.54 ± 0.07	0.66 ± 0.07	0.69 ± 0.07	1 < 2; 1 < 3
60 walk gait speed (m/s)	0.71 ± 0.03	0.98 ± 0.17	1.04 ± 0.18	1 < 2; 1 < 3
60 walk knee peak stance flexion (°)	17.7 ± 2.0	20.1 ± 4.6	23.8 ± 4.0	1 < 3
60 walk knee peak swing flexion (°)	44.7 ± 14.6	58.8 ± 5.2	64.7 ± 4.1	1 < 2; 1 < 3
30 fast gait speed (m/s)	0.99 ± 0.10	1.26 ± 0.22	1.32 ± 0.21	1 < 2; 1 < 3
Sit-to-stand peak trunk flexion (°)	54.2 ± 6.8	48.4 ± 13.2	35.1 ± 11.5	1 > 3; 2 > 3
Free-living stride time (s)	1.25 ± 0.10	1.29 ± 0.09	1.18 ± 0.07	2 > 3
Free-living cadence (steps/min)	98.0 ± 8.0	94.9 ± 6.6	104.1 ± 5.9	2 < 3
Female, male (*n*)	5,0	3,11	13,1	

Conclusions

This study identified three distinct clusters in pre-operative knee OA patients, emphasizing the value of a three-pronged mobility assessment. Future work will expand the cohort and incorporate additional free-living mobility measures to further refine mobility profiling.

Acknowledgments

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References

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