Associations among In-Clinic and Free-Living Gait Outcomes in Patients Awaiting Knee Arthroplasty

Annemarie F Laudanski[1,2], Michael Dunbar[1,2], Glen Richardson[2], Jennifer Leighton[1,2], Janie Astephen Wilson[1,2]
[1]Dalhousie University, Halifax, Canada; [2]Nova Scotia Health, Halifax, Canada
Email: Annemareie.Laudanski@dal.ca

Summary

End-stage knee osteoarthritis (OA) imposes significant limitations on joint function during walking, and these deficits progress with the disease, having implications for clinical decline and response to treatment with arthroplasty surgery [1]. This study examined the relationships among accelerometer-derived gait metrics captured remotely during free-living and gait outcomes from clinic-based overground gait assessments in patients awaiting knee arthroplasty surgery (KAS) to understand the complementary nature of the information on joint function and mobility derived by these two modalities. Significant, clinically relevant associations among free-living and in-clinic gait outcomes were identified, with free-living gait metrics showing greater stride-to-stride and day-to-day variability than in-clinic metrics.

Introduction

Deficits in joint biomechanics with end-stage knee OA are moderately addressed by KAS in some patients; however, upwards of 70% of patients continue to walk with significant biomechanical deficits one year after surgery [2]. The uptake of robotic surgery enables more personalized KAS prescription to address these deficits, requiring efficient data-driven biomechanics protocols and tools to integrate into clinical systems. Advancements in markerless motion capture and inertial measurement units (IMUs) offer this potential. Understanding the complementary nature and differences among gait outcomes from these systems in clinical patients is therefore an important step toward clinical uptake. The objective of this study was to examine the relationships among accelerometer-derived metrics of free-living (FL) gait and in-clinic (IC) markerless motion capture gait outcomes in patients before and after KAS.

Methods

Patients (n = 5 (2F/3M), 73+/-3.7 years) with end-stage knee OA on the arthroplasty waitlist were recruited and tested pre-operatively (pre) and at 3 months post-operatively (post). An IMU sensor (AX6, Axivity) was affixed to the tibia of the OA-affected limb for 7 days to monitor FL activity. Overground knee kinematics during walking were also captured IC for one minute of self-paced walking (10xSony RX0II cameras; Theia, Visual3D software). IMU data were processed for 20 strides randomly chosen in days 2 and 3 for all sessions, and discrete metrics (mean, peak, range) and variability outcomes (standard deviations (SD), coefficient of variations (CV)) of functionally aligned shank frontal and sagittal plane accelerations and frontal plane velocities were calculated. Primary outcomes from the IC assessment included mean, peak and range of adduction angles, peak flexion in stance and peak extension in late stance across 10 strides. Correlations between FL and IC outcomes were examined using Pearson's correlations (α=0.05).

Results and Discussion

Pre-operatively, higher IC peak knee flexion angles during walking were strongly associated with lower FL frontal plane accelerations (r = 0.91), and higher IC peak stance phase knee flexion and extensions angles were associated with higher FL variability in frontal plane early stance accelerations (r = 0.94). Higher IC peak stance phase adduction angles were associated with lower early stance and overall peak FL frontal plane accelerations (r = 0.94, -0.90), higher peak FL sagittal plane accelerations (r = 0.98), and higher FL variability in sagittal plane peak accelerations (0.9), suggesting that those who present with more adducted knees IC walk with more sagittal plane and less frontal plane accelerations (and greater sagittal plane variability) in everyday life. Post-operatively, significant associations differed, with higher IC peak and range of flexion angles associated with higher FL early stance range in sagittal plane accelerations (r = 0.93, 0.96), and with greater variability in FL sagittal plane accelerations (r = 0.91). Also, higher IC peak adduction angles post-operatively were associated with FL lower peak early stance frontal plane (r = -0.89), but higher peak sagittal plane (r = 0.94) accelerations in both early stance and overall, as well as greater variability in sagittal plane minimums in FL (r = -0.93).

Conclusions

IMU-based gait outcomes from free-living data on clinical patients may provide valuable insights into specific gait features that are consistent with in-clinic joint-specific gait features. They also offer the potential to expand our understanding of clinical gait patterns by providing insight into gait variability outside of the clinic snapshot of gait biomechanics. Further research will aim to establish thresholds for stability in inertial outcomes and to create novel, clinically-relevant metrics of stride-to-stride variability to inform clinical patient-specific decisions. Our early results suggest that relationships in the pre- and post-operative periods may differ, which is an important consideration for further development and future studies applying IMUs to free-living motion measurements in clinical populations.

References

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