COMPARING IN-CLINIC AND FREE-LIVING GAIT METRICS: SENSITIVITY TO CHANGE AFTER JOINT REPLACEMENT

Matthew C. Ruder[1], Vincenzo E. Di Bacco[1], Kim Madden[2], Anthony Adili[2], Dylan Kobsar[1]
[1]Department of Kinesiology, McMaster University, Hamilton, ON, Canada
[2]Department of Surgery, McMaster University, Hamilton, ON, Canada
Email: ruderm@mcmaster.ca

Summary

Osteoarthritis limits mobility for millions, and gait analysis may enhance surgical decision-making. This study assessed the longitudinal sensitivity of motion capture and wearable sensor gait metrics in an osteoarthritis population before and after surgery. Motion capture measures appeared more sensitive to changes than similar wearable sensors metrics.

Introduction

Osteoarthritis (OA) is a debilitating disease characterized by cartilage degradation and functional loss, with total knee arthroplasty (TKA) or total hip arthroplasty (THA) as the primary end-stage treatments [1]. Kinematic gait analysis may provide clinicians with valuable functional insights prior to surgery [2]. While in-lab motion capture offers a detailed snapshot of movement, it may not fully reflect a patient's functional capacity in daily life. Wearable sensors offer a way to continuously track real world kinematics over an extended period, but their sensitivity to detecting gait changes in patient populations, compared to in-lab motion capture, remains largely unknown. Therefore, the purpose of this study was to assess the sensitivity of motion capture and wearable sensors to detect functional changes in patients with end-stage OA before and after joint replacement surgery.

Methods

This ongoing study recruited 21 OA patients (13F; 67 ± 7 years) from the St. Joseph's Fracture and Orthopedics Clinic at the time of their surgical decision (4 THA, 17 TKA). Approximately two weeks prior to their scheduled surgery, patients underwent a markerless motion capture assessment in a clinically adjacent hallway. Two wearable sensors (Axivity AX6, 100 Hz) were placed medial and inferior to each tibial tuberosity with adhesive tape. Patients then completed the following tasks: 60 second walk, 30 second "fast" walk, 5x sit-to-stand task, and ascending and descending two stairs. During each task, patients were recorded using 10 cameras (Sony RX0-II, 60 Hz). Patients continued wearing wearable sensors for seven days and were instructed to maintain their normal day-to-day routine before removing to return by mail.

Data Processing. Video data was processed into kinematic data using Theia Markerless (V2023.1.0.3161) and segmented to stride-level variables in Visual3D (e.g. stride time, stride length, peak knee adduction angle). Wearable sensor data was downloaded and processed with a custom Python script to identify walking bouts of ≥5 seconds and extract stride-level variables (e.g. stride time, total number of bout strides, peak mediolateral (ML) acceleration). These procedures were repeated at three and/or six months post-operatively. A linear mixed model was used to evaluate the effect of time on each measure from pre-surgery (PRE) and post-surgery (POST). Paired Cohen's *d* was calculated to estimate effect sizes each variable from both measurement systems pre- to post-surgery.

Results and Discussion

Patients completed PRE assessments an average of 17 ± 10 days before their surgeries and POST assessments 136 ± 49 days after surgery. Five patients completed assessments at all three timepoints, three at PRE and six months POST, and the remaining 13 at PRE and three months POST. Effect sizes from motion capture ranged from medium to large, whereas wearable sensors effect sizes were small to medium. Despite capturing a greater number of strides and potentially providing a more representative measure of their day-to-day activity, the selected wearable sensors metrics generally exhibited lower sensitivity than motion capture.

Conclusions

While assessing fewer strides and being in-clinic, motion capture may provide a more sensitive measure of change compared to wearable sensors in an osteoarthritis population.

Acknowledgments

Arthritis Society of Canada provided salary support for MR through Training Graduate PhD Salary Award.

References

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Table 1: Linear mixed model results and effect sizes for each variable from motion capture (in-lab) and wearable sensors (free-living).

	Motion Capture			**Wearable Sensor**		
	Stride Time (s)	**Stride Length (m)**	**Peak Knee Add Angle (°)**	**Stride Time (s)**	**Total Bout Strides**	**Peak ML (m/s^2)**
PRE	1.14 ± 0.32	1.23 ± 0.25	4.33 ± 3.89	1.25 ± 0.13	11019 ± 7266	0.66 ± 0.25
POST	1.05 ± 0.18	1.32 ± 0.26	1.08 ± 2.18	1.22 ± 0.17	14911 ± 7720	0.60 ± 0.22
P-Value	0.02*	0.001*	< 0.001*	0.60	0.008*	0.31
Effect Size	0.51	0.73	0.86	0.14	0.62	0.30