Characterizing real-world gait biomechanics in adults with and without knee osteoarthritis

Jocelyn F. Hafer[1,2], Julien A. Mihy[2], Spencer M. Miller[3], Mayumi Wagatsuma[2], Stephen M. Cain[3]
[1]Department of Kinesiology and Applied Physiology and [2]Biomechanics and Movement Science Program, University of Delaware, Newark, DE, USA; [3]Department of Chemical and Biomedical Engineering, West Virginia University, Morgantown, WV, USA
Email: jfhafer@udel.edu

Summary

Real-world gait may provide novel insight into function and joint health, particularly if we are able to estimate joint-level biomechanics during daily activity. In this study, we compared IMU-derived spatiotemporal variables and joint mechanics between in-lab and real-world gait in young and older adults with and without knee osteoarthritis. Joint mechanics differed by setting or group but spatiotemporal variables did not. Applying a real-world approach in longitudinal or intervention studies could reveal new mechanisms of functional decline or targets for intervention.

Introduction

Gait biomechanics provide information about function and joint health. Such information is used to understand the mechanisms behind decreased mobility with aging and design interventions for knee osteoarthritis (OA). Historically, gait has been studied in lab settings, limiting our understanding of fundamental mechanisms and intervention effects that play out in response to the large number of strides of real-world activity. In the real world, individuals walk slower with shorter stride lengths and less variation than in the lab [1,2]. To date, real-world gait studies of spatiotemporal outcomes suggest that biomechanics differ in and out of the lab but do not provide insight at the joint level. The purpose of this study was to compare spatiotemporal outcomes and joint biomechanics between gait captured in the lab and during unobserved real-world activity in young and older healthy adults and older adults with knee OA.

Methods

Nine young (25±3 yrs), 10 healthy older (61±5 yrs), and 10 older adults with knee OA (64±3 yrs, KOOS 72.5±13.6) completed in-lab gait analysis and 3 days of real-world gait collection. Gait in both settings was captured with inertial measurement units (IMUs) on the foot, shank, and thigh. We identified bouts of gait and gait events using the motion or frequency of thigh, shank, or foot data [3]. Spatiotemporal outcomes were calculated using a ZUPT algorithm [4] and used to select steady-state gait. We estimated segment angular velocities about medial-lateral axes and integrated these stride-by-stride to estimate segment ranges of motion (ROMs) [5]. Stride speed and length, stance knee ROM, and propulsive ankle angular velocity were compared between groups using ANOVAs and the absolute difference in outcomes between settings was compared to 0 using t-tests.

Results and Discussion

Between-setting differences were significantly greater than 0 for all outcome measures for all groups (all $p<0.02$) and between-setting differences did not differ across groups (all $p>0.4$). Between-setting differences were in different directions (positive vs negative) for individual participants (ex: individual lines in Fig 1). This is in contrast to previous studies that found consistent decreases in speed or stride length for real-world vs. in-lab gait. Our findings demonstrate that there is considerable inter-individual variability in the relationship between in-lab and real-world gait.

Stance phase knee ROM differed between groups ($p=0.01$) [Fig 1]. As expected from in-lab studies, adults with knee OA had smaller knee ROM than young adults (post-hoc $p=0.01$). This finding suggests that meaningful differences in joint biomechanics that have been identified in-lab persist at the group level when individuals walk in daily life.

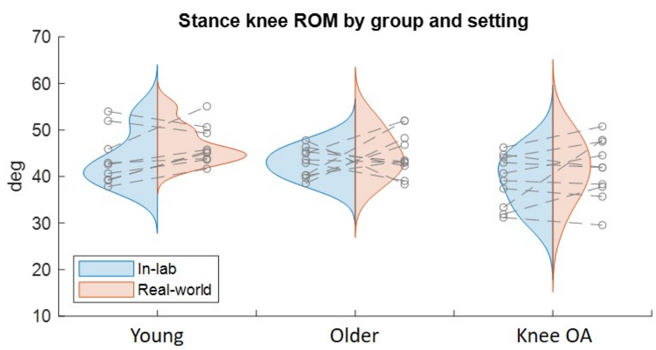

Fig 1. Stance phase knee ROM across participants within settings (violin plots) and by individual (dots and lines).

Conclusions

To our knowledge, this is the first comparison of joint-level gait biomechanics between in-lab and real-world settings in adults with and without knee OA. The inter-individual variation in how gait differed between settings suggests that, at least for some individuals, real-world gait may describe a different level of function or joint health than in-lab gait. Investigating the implications of this inter-individual variation in longer-term studies may provide new insight into the mechanisms behind longitudinal declines in function or the effectiveness of interventions.

Acknowledgments

This work was supported by a grant from the National Institute on Aging (R21AG076989) from NIH

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