Joint Reaction Forces are Reduced in Symptomatic Femoroacetabular Impingement

Brooklyn L. Vargas[1*], Seth J. Kussow[1], Lindsay L. Schuring[1], Rich J. Lisonbee[1], Jared L. Zitnay[1], Tyler D. Adamson[1], Michael D. Harris[2], Niccolo M. Fiorentino[3], K. Bo Foreman[1], Andrew E. Anderson[1], Scott D. Uhlrich[1]
[1]University of Utah, USA, [2]Washington University School of Medicine in St. Louis, USA, and [3]University of Vermont, USA
*Email: brooklyn.vargas@utah.edu

Summary

Cam-type femoroacetabular impingement syndrome (FAIS) is a leading cause of osteoarthritis (OA). Interestingly, many individuals with cam morphology do not have hip pain or develop OA. To better understand the pathophysiology of FAIS, we compared hip joint reaction forces (JRFs) between symptomatic individuals and individuals with asymptomatic cam morphology (ACM). Compared to individuals with ACM, individuals with FAIS had smaller hip JRFs during incline walking and squatting. Our results indicate that altered joint biomechanics may be a key feature of FAIS.

Introduction

Cam femoroacetabular impingement syndrome (FAIS) is a recognized cause of hip osteoarthritis (OA) and pain, particularly during activities involving a large range of motion [1]. Cam FAIS is characterized by femoral head asphericity and reduced femoral head and acetabulum clearance. Research suggests that cam morphology alone may not be the cause of pain since ~35% of the population exhibits asymptomatic cam morphology (ACM) [2]. Quantification of differences in hip biomechanics, including hip joint reaction forces (JRFs) and muscle forces, between individuals with FAIS and ACM may clarify the pathophysiology of FAIS and identify new ways to treat symptoms. Previous research demonstrated decreased hip JRFs in individuals with FAIS compared to individuals with ACM during squatting [3]. Our study aims to expand upon these findings by evaluating inclined walking in addition to squatting. We hypothesized that individuals with FAIS would have reduced hip JRFs compared to individuals with ACM during inclined walking and squatting. Secondarily, we investigated differences in hip-crossing muscle forces between groups.

Methods

Twelve individuals with FAIS (5F/7M, age: 27.8±7.9 years, BMI: 24.8±3.1 kg/m^2) and twelve matched controls with ACM (5F/7M, age: 27.0±5.0 years, BMI: 23.3±2.1 kg/m^2) participated in this study. A board-certified orthopaedic surgeon confirmed cam morphology on all participants from plain film x-rays. Each participant performed three activities at self-selected speeds on a force-instrumented treadmill with marker-based motion capture: level walking, inclined walking (5º incline), and bilateral squats. JRFs were estimated using OpenSim [4] with a musculoskeletal model having 23 degrees of freedom and 98 musculotendon actuators [5]. Muscle forces were estimated using a custom static optimization implementation [6]. Two-sample *t*-tests (α=0.05) compared peak hip JRFs and muscle forces during early- and late-stance phases of walking, and at peak hip flexion for squatting. Statistical parametric mapping (SPM) evaluated for differences across the entire activity (α=0.05).

Results

The FAIS group had smaller hip JRFs than the ACM group during both squat and incline walk activities, but not level walking. SPM detected decreased superiorly directed hip JRFs during 21–34% of squat descent (Figure 1). Similarly, individuals with cam FAIS had decreased gluteus medius forces during the same range of squat descent. The superiorly directed hip JRF for the FAIS group was 24.9% lower than the ACM group (0.72 bodyweight; p=0.01) during late stance of inclined walking. Gluteus minimus, iliacus, and rectus femoris forces were also smaller in the FAIS group, compared to ACM, during push-off for the inclined walk trial.

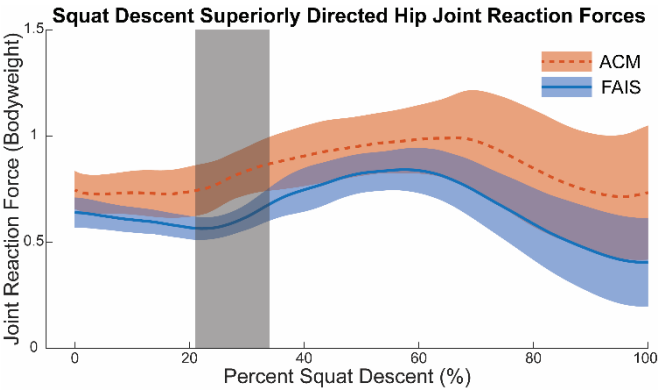

Figure 1: Superiorly directed hip JRFs for bilateral squat trial. The region of statistically significant differences detected via SPM (α=0.05) is shaded in grey.

Discussion and Conclusions

Despite both cohorts displaying cam morphology, individuals with symptoms (FAIS) walked and squatted with reduced hip JRFs, compared to those without symptoms (ACM). Differences observed in our study could be the result of pain alone and/or a compensatory mechanism to offload the hip. We plan to include controls without cam morphology in the future to differentiate the roles of cam morphology, pain, and compensatory movement. Together, these data could inform the design of physical therapy protocols that alleviate symptoms and disrupt the progression to hip OA.

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