

Medial Joint Forces are Elevated during Running in Dysplastic Hips

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INTRODUCTION: Developmental dysplasia of the hip (DDH) is an orthopaedic condition characterized by a shallow hip socket that lateralizes hip joint centers and increases loading on the joint.^{1,2} The increased loads can lead to chondrolabral damage and early onset osteoarthritis.³ Many patients with symptomatic DDH are young, active individuals who regularly participate in demanding exercise or sport but become limited by pain that increases with activity.⁴ Additionally, symptom onset tends to occur at younger ages in patients with high activity scores than those who are less active.⁴ This younger presentation of symptoms is thought to occur due to the repeated high impact loading that comes with participation in exercise or sports.⁵ However, most studies of hip joint loading in DDH have been limited to the lower impact activities of gait or squatting.⁶⁻⁸ It remains unknown if there is abnormal hip loading such as elevated joint reaction forces (JRFs) in dysplastic hips during high impact activities, and their potential effect on symptoms remains unclear. Therefore, the objective of this study was to compare hip JRFs and joint angles between patients with DDH and healthy controls during running.

METHODS: Fifteen female patients with DDH (age = 24.3±7.1, BMI = 22.4±2.5) and fifteen healthy controls (age = 25.1±6.3, BMI = 22.4±2.2) were included with IRB approval and informed consent. Patients were diagnosed with DDH by an orthopaedic surgeon based on a lateral center edge angle <20° and unilateral hip/groin pain for 3+ months. Kinematic running gait data (200 Hz) was collected using 70 reflective markers and 10 infrared cameras (Vicon) at 2.5 m/s after a 90 second acclimation period. Ground reaction forces (2000 Hz) were collected from an instrumented treadmill (Bertec). Surface electromyography (2000 Hz) was used to record muscle activity from 8 muscles of the lower limb and back (Motion Lab Systems). A baseline OpenSim musculoskeletal model was updated for each subject with three-dimensional reconstructions of the pelvis and femurs from MRI.⁶ Kinematics, ground reaction forces, and muscle activations were incorporated using the OpenSim Moco direct collocation optimizer to calculate joint angles, muscle forces, and hip JRFs.⁹ Moco minimizes marker error and squared muscle activations while subject to ground reaction forces and electromyography activations. All JRFs were normalized to bodyweight (xBW) and JRFs and joint angles from representative running cycles (foot strike to foot strike) were compared between the DDH and control groups. Inter-group differences were tested for significance across the running cycle using one-dimensional independent samples t-test statistical parametric mapping¹⁰ as well as Hedge's g effect sizes.

RESULTS: Average and [95% Confidence Interval] JRF peaks for DDH patients were 1.81 [1.52, 2.10] xBW in the anterior direction, 8.19 [7.67, 8.70] xBW in the superior direction, 1.55 [1.22, 1.88] xBW in the medial direction, and 8.49 [7.95, 9.03] xBW overall. For controls, JRF peaks were 1.84 [1.60, 2.05] xBW anteriorly, 8.67 [8.12, 9.20] xBW superiorly, 1.06 [0.75, 1.47] xBW medially, and 8.94 [8.32, 9.55] xBW overall. Hip joint angles during running were not statistically significantly different between patients and controls. Patients had statistically significantly larger medial hip JRF components than controls between 94-100% of the running gait cycle (Fig. 1). Additionally, there were large effect sizes (g > 0.8) between 7-22% and 89-100% of the running gait cycle in the medial JRF component (Fig. 1). There were no statistically significant differences in any other JRF components.

DISCUSSION: Hip JRF magnitudes and joint angles were consistent with previous reports of running kinematics and kinetics in healthy hips.¹¹ The higher medial JRFs during running in patients with DDH, especially during single limb loading (stance phase) are of interest as similar trends have been found in walking and are thought to contribute to medial femoral head cartilage damage in these patients.^{1,6,7} Medial JRF differences in walking have been suggested to be due to lateralized hip joint centers in patients with DDH which result in larger abductor muscle forces necessary to move and stabilize the hip,¹ a phenomenon that likely exists in running as well. The significant differences at the end of the gait cycle (Fig. 1) may occur due to an anticipatory effect of limb loading that leads to activation of the abductor muscles and drives increased JRFs in patients with DDH. It is important to note that this study is currently underpowered and there is a possibility that differences may change when the sample is increased, an area of future work.

SIGNIFICANCE/CLINICAL RELEVANCE: This study helps to provide a more complete picture to how damage may occur in patients with DDH. Clinicians may use this information to determine if surgical or non-surgical treatment has been successful in reducing damaging hip joint loads for this active population. Additionally, patient specific hip JRFs during these type of activities may also help provide a risk assessment for potential future cartilage degeneration or osteoarthritis.

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IMAGES:

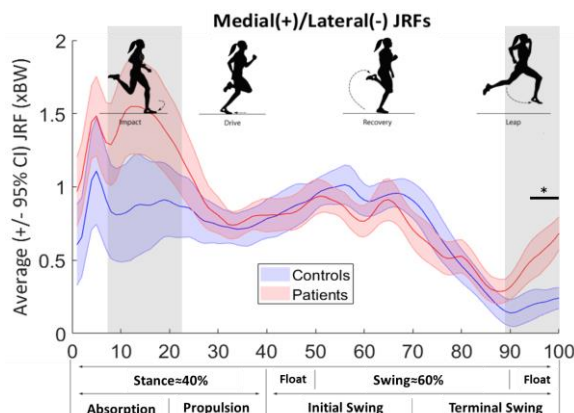


Figure 1. Average medial/lateral joint reaction force (JRF) components across the running gait cycle for controls (blue) and patients (red). Region of significant differences is denoted with an *. Grey shaded regions depict large effect sizes (g > 0.8).