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EVALUATING PELVIS DYNAMICS IN PATIENTS WITH ACETABULAR LABRAL TEARS

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Introduction

Common forms of hip disease include labral tears, synovitis, chondromalacia, or femoroacetabular impingement [1, 2]. Most patients with one of these medical conditions seek treatment to alleviate the pain. However, in addition to the pain, dynamic control of hip joint movement may also be impaired. This impairment may result from damage to proprioceptive organs or alterations in sensory capability caused by inflammation. Reduced biofeedback can lead to a loss of joint control that may result in additional injuries due to excessive tissue strain or falling due to a loss of balance. Our hypothesis is that acetabular labral tears alter normal pelvic movement and reduce subject balance control placing the patient at increased risk for additional injuries.

Methods

Ten healthy controls without hip pain or any history of lower extremity trauma, surgery, or injury and 10 hip pain patients were recruited for the study. The patients had no radiographic evidence of arthritic changes, and had no previous lower extremity surgeries or injuries. Acetabular labral tears in the patients were confirmed by MRI arthrography prior to study participation.

Study participants initially completed 20 seconds of single leg squats followed by 60 seconds of static single leg standing on a force plate, while a motion capture system tracked their movements (Figure 1). A total of 6 trials were completed for each side, alternating between sides and separated by 1 minute of rest to avoid excessive fatigue. Data were collected using Cortex software (Motion Analysis, Inc. Santa Rosa, CA.) and were then processed using Visual 3D Biomechanics software (C-Motion, Inc., Germantown, MD) to calculate kinematics during squatting and center of pressure during quiet stance. Calculations were performed using custom MATLAB® software (MathWorks, Natick, MA USA). Auto-detection methods were developed to detect the beginning of each pelvic movement cycle during each trial (Figure 2).

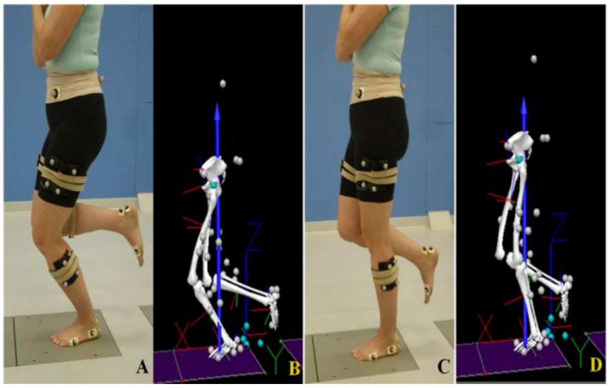

Figure 1: Participant performing (A) single leg squat and (B) computer-generated model. Participant conducting (C) single leg standing postural sway test and (D) computer-generated model.

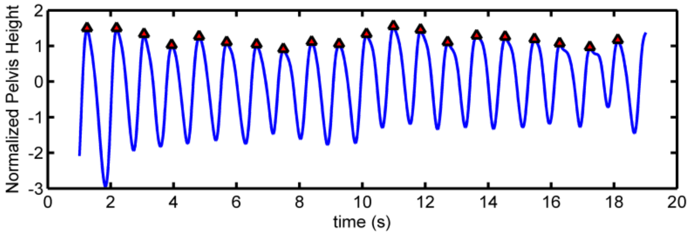

Figure 2: Automated peak detection method implemented in MATLAB®

A large matrix was generated containing all cycle data for each participant's leg (typically 40-100 cycles). The center of mass (COM) of the pelvis (Figure 3a) and the pelvis velocity, acceleration, and frontal plane angle were calculated. Bilateral symmetry was evaluated by calculating the root-mean-square of the difference between the pathologic leg and the non-pathologic leg at each point in the pelvic movement cycle (Figure 3b).

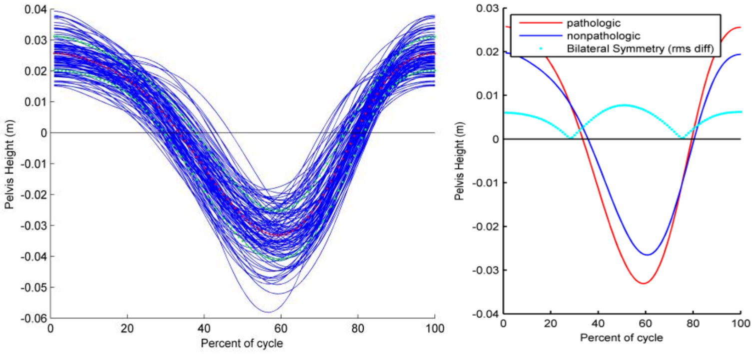

Figure 3: Typical pelvic dynamics for the center of mass. (a) Individual cycles (solid blue) and mean (central red dotted line) and range (green dots, mean ± SD). (b) Comparison of pathologic and non-pathologic movement patterns.

Phase plots were generated to show the relationship between the pelvic position (q) and velocity ($\dot{q}$) (Figure 4a). These data were combined into a complex number, $z = q + \dot{q}i$, so that the accumulated phase angle and phase amplitude could be calculated as it varied over the pelvic movement cycle.

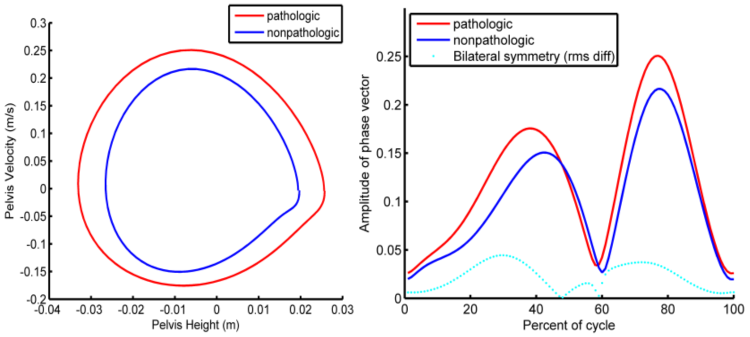

Figure 4: (a) Comparison of pathologic and non-pathologic movement patterns using a phase plot. (b) Bilateral symmetry of the complex function amplitude.

In addition, the cross correlation between the pelvis acceleration ($\ddot{q}$) and frontal angle (θ) were evaluated,

$$(\ddot{q}\star\theta)t = \int_{-\infty}^{\infty} \ddot{q}^{*}(\tau)\,\theta(t+\tau)\,d\tau.$$

This analysis was performed to determine if there was a connection between the movement of the pelvis which was driven on one side by the hip joint and the angle of the pelvis in the frontal plane. Larger shifts in the cross correlation indicate larger time delays between the application of force at the hip and pelvis movement. Thus, a very stiff joint would have little time delay. Finally, the 95% ellipse area was calculated to quantify the standing postural sway data.

Results

Independent t-tests were used to evaluate differences in bilateral symmetry between patients and controls for each parameter. There was found to be a difference in bilateral symmetry for the COM velocity, acceleration, accumulated phase angle and phase amplitude (Table 1).

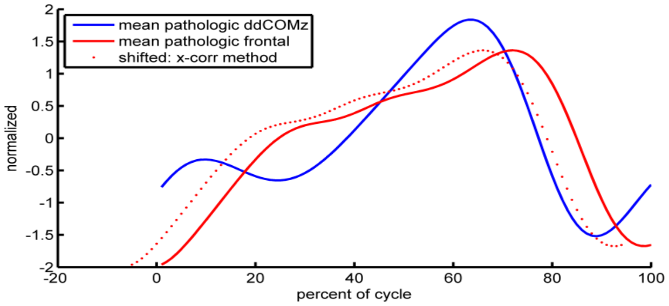

Figure 5: Cross correlation function used to determine the time delay between pelvis acceleration and frontal angle.

Matched paired t-tests of patients (Table 2) revealed no significant difference between the pathologic and the non-pathologic sides indicating that no general trends could be made about the parameter values other than they were different as shown above. In addition, independent t-tests showed no differences between mean values for patients and the controls when evaluated as a group. Differences in the cross correlation results for pathologic sides (4.8% of cycle) and the non-pathologic sides (5.5% of cycle) were not significant (p=.435) and there were no difference (p=.350) in patient's pathologic legs and controls (3.89% of cycle). Likewise, for standing postural sway no significant difference (p=.248) was found between pathologic (737 mm^2) and non-pathologic (684 mm^2) in the 95% ellipse area.

Table 1: Bilateral symmetry

Description	**Patients**	**Controls**	**p**
COM Position	.00401	.00228	.089
COM Velocity	.0212	.0098	**.008**
COM Acceleration	.150	.087	**.039**
Frontal Angle	4.22	2.97	.406
Accumulated Angle	.120	.055	**.023**
Phase Amplitude	.0189	.0086	**.005**

Established a priori α=0.05

Table 2: Comparison of means within patients

Description	**Pathologic**	**Non-Pathologic**	**p**
COM Position	.0264	.0274	.375
COM Velocity	.0936	.0999	.148
COM Acceleration	.456	.496	.085
Frontal Angle	4.09	2.21	.208
Accumulated Angle	2.932	2.934	.954
Phase Amplitude	.103	.110	.162

Discussion and Conclusions

Contrary to our expectations, we did not observe consistent differences in parameter values between patient's pathologic sides and non-pathologic sides. However, decreased levels of bilateral symmetry between for patients indicate that some change in dynamics has occurred. This may be due to differences in compensatory mechanisms used by patient and requires further investigation.

References

1. Enseki, K.R., et al., *The hip joint: arthroscopic procedures and postoperative rehabilitation.* J Orthop Sports Phys Ther, 2006. **36**(7): p. 516-25.
2. Zebala, L.P., P.L. Schoenecker, and J.C. Clohisy, *Anterior femoroacetabular impingement: a diverse disease with evolving treatment options.* Iowa Orthop J, 2007. **27**: p. 71-81.