Biomechanical differences between male and female sacroiliac joint: A finite element study

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ABSTRACT INTRODUCTION: Low back pain (LBP) is a common reason for primary care with approximately 90% of adults being impacted by this condition at some time in their lives. Majority of LBP is perceived to originate from the lumbar spine, while more recent studies have estimated that the sacroiliac joint (SIJ) is the actual source of pain in 15-30% of cases [1]. Much like the other regions of the spine, it is essential that we understand the SIJ mechanics. There are anatomical differences between male and female SIJs [2]. In this study, the biomechanical differences between male and female SIJ were studied using finite element analysis.

METHODS: The ligamentous L1- pelvis FE model was developed from the CT scans of a 55 year old female. Isotropic elastic, hyperelastic, and hypoelastic material properties were used for cortical and cancellous bone and nucleus, annulus, and ligaments, as detailed for the male model elsewhere [3]. The Holzapfel model was used to simulate anisotropic properties of annulus fibers. The model was fixed at the hip joint and subjected to 10 Nm moment and 400 N follower load to simulate flexion-extension, lateral bending and axial rotation. In all six loading modes, the range of motion of sacroiliac joint was calculated and compared to SIJ the range of motion of a previously developed and validated lumbo-pelvic male model, Figure 1 [3].

RESULTS SECTION: The range of motion of the female SIJ was higher than the male SIJ range of motion in flexion, extension, and lateral bending up to 41%, Table 1. For right rotation, the range of motion of male and female were similar, but the range of motion of the female model was about three times higher than the male model in left axial rotation. The stresses were higher for the female model compared to the male model in all loading modes, Table 2 (up to two times greater).

DISCUSSION: The magnitude of the motions in various loading loads are small suggesting that the female SIJ, like the male SIJ is inherently stable. However, our data show that sacroiliac joint has relatively higher mobility in the females compared to males. This increased mobility of the SIJ in women can be attributed to certain anatomical correlations such as curvature of the SIJ surfaces and a greater pubic angle compared to those of males. Having greater pubic angle facilitates the parturition in females, followed by ligaments laxity which leads to increased mobility. This unique aspect of the SIJ provides females with the ability to give birth and it may also predispose females to a greater risk of experiencing pelvic pain. One factor that plays an important role in determining the severity of this predisposition involves the laxity of the female SI joints during pregnancy [2]. The stress values for the female model were also higher than the male model which implies that females are at higher risk of pelvic injury. Some gender-related differences in the SIJ can lead to a higher rate of SIJ misalignment in young women [2]. Due to the anatomical differences and effect of pregnancy, women are more susceptible to develop pelvic girdle pain, and are therefore at greater risk of experiencing low back pain. One limitation of the present study is use of the material properties for the female model as is male model due to lack of experimental data.

SIGNIFICANCE: This study would provide a better insight in understanding the differences in biomechanics of male and female SIJ that may lead to differences in LBP and may warrant gender specific treatment approaches.

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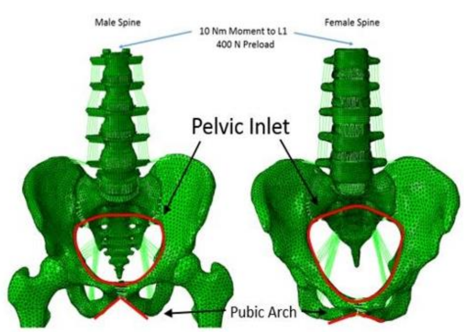

Fig. 1: Finite element models of the male and female SIJs. Female model shows wider pelvic inlet and pelvic outlet, and greater pubic arch angle than male model

Table 1: Male and female model range of motion data at the left and right SIJ in response to 10 Nm moment and 400 N follower load

	Range of Motion (Degree)			
Motion	Male Left SIJ	Female Left SIJ	Male Right SIJ	Female Right SIJ
Flexion	0.92	1.2	0.89	1.22
Extension	1.76	2.48	2.02	2.63
Right Bending	0.7	0.8	0.6	0.8
Left Bending	0.32	0.97	0.49	0.97
Right Rotation	0.58	0.53	0.526	0.53
Left Rotation	0.46	1.37	0.526	1.45

Table 2: Male and female model maximum von Mises stress data at SIJ in response to 10 Nm moment and 400 N follower load

	Maximum von Mises Stress (MPa)	
Motion	Male SIJ	Female SIJ
Flexion	15.8	21.4
Extension	30.5	41.6
Right Bending	11.9	22.7
Left Bending	16.9	37.8
Right Rotation	16.9	32.3
Left Rotation	17.53	27.8