INTRODUCTION:
Athletic pubalgia, also known as sports hernia, is a common clinical presentation of localized groin pain, which can affect several locations including: adductor origin, inguinal region, acetabular/hip region and at the pubic symphysis [1]. Femoroacetabular Impingement (FAI) has been suspected as a major cause of groin pain in athletes, but a clear linkage has yet to be established. The linkage between FAI and athletic pubalgia could change the algorithm of diagnosis and treatment of patients with athletic pubalgia. This connection could also be used for early identification of labral lesions and osteoarthritis [2]. Dalstra et al. have shown that a significant portion of the load from the upper body is transferred across the pubic bone during motion. They have also shown that the load is concentrated in the anterior-superior quadrant of the acetabular rim as imparted by the femur [3]. This location on the acetabular rim is consistent with the location where femoroacetabular cam lesions are most commonly found [3].

The objectives of this study were to develop a fresh human cadaveric model of cam-type FAI and investigate the relationship between FAI, hip version, the amount of load transmitted through the pubic symphysis, and symphysis movement. Extreme maneuver of combined internal rotation and flexion of the hip joint was simulated in the model as it is known to provoke groin pain in FAI patients.

METHODS:
To develop the in vitro FAI model, a fresh frozen human cadaveric specimen of a whole pelvis down to the distal femurs from a female donor (age 57) was obtained. The specimen did not have any visceral organs but did include all related musculature and skin. The specimen was prescreened by the vendor and did not have any history of bone or joint diseases including arthritis. Cam-type FAI was simulated by implanting different artificial bumps at the femoral head-neck junction through an open osteotomy procedure as described in Espinosa et al [4].

The lesion site was prepared by planing flat the head-neck junction (to normalize the head to neck offset) with the center located so that the artificial Cam lesion could be anchored to the femur and still allow it to contact the acetabulum at the 1:30 position, in a clock-faced representation, when internally rotated.

A custom-designed loading jig allowed the pelvis to be suspended vertically in an upright position by anchoring the contralateral iliac wing to the jig frame. This was accomplished by bolting a metal bracket to each wing and reinforcing it with dental cement while not altering the relative stability of the pelvis. On the tested side, the femoral epicondyles were exposed and potted in dental cement with a special Plexiglas plate attachment which was used later for mounting a six-axis load cell (Model M3, AMTI, Watertown, MA). During the potting process, care was taken to ensure the Plexiglas plate was positioned in the transverse plane of the femur. Line of projection of the posterior-most surfaces of the distal condyles was marked on the Plexiglas plate. This line was later used in the measurement of the version angle of the native hip.

Once one wing was secured, the contralateral leg could be freely manipulated for surgical exposure, recording of the native neck angle with a spatial point probe, and finally implantation of the artificial Cam. Once all procedures were completed, the same leg was raised to 90° of flexion and neutral adduction and supported with an adjustable frame. With the 0° load cell mounted to the distal end of the femur, internal rotation of the hip joint was performed to 30°, 40°, and 50°, and the corresponding torque was recorded. Internal rotation greater than 30° was considered to have a significant impact on the proximal femur. To evaluate the load transmitted through the symphysis pubis, a needle-mounted miniaturized pressure transducer (Robert A Denton, Inc, Rochester Hills, MI) was installed into the center of the symphysis. Meantime, active marker triads from a motion tracking system (Optotrak Certus Motion Tracking System, Northern Digital Inc, Waterloo, Ontario, Canada) was mounted onto each side of the symphysis pubis to track the three-dimensional movement of the joint. Euler angles were derived from the load cell and the pressure transducer were collected through a built-in data acquisition board of the Optotrak system, and were in synchronization with the tracking of the symphysis pubis movement. All data were collected at a rate of 60 Hz.

RESULTS:
The cadaver donor had 17.5 degrees of anteversion of the proximal femur. Preliminary results of the peak pressure at the symphysis pubis are presented in Fig 1. Compare FAI to the native hip, the symphysis pressure increased only slightly with 30° of internal rotation. However, with a Cam, the pressure rose exponentially at greater rotations. A representative plot of symphysis pressure versus hip internal rotation is shown in Fig 2. The primary movement generated at the symphysis pubis in response to internal rotation of the hip is in the coronal plane, in the direction of internal rotation of the superior symphysis. The secondary rotation is in the transverse plane, also in the direction of internal rotation, but has a magnitude of approximately 1/3 of the primary rotation. The magnitude of the symphysis movement increased with the FAI and hip rotation (Fig.3). At 30° hip internal rotation, the primary rotation increased from 1.28° in the native hip to 1.64° in FAI model. The symphysis movement reached the 2.72° with 50° hip rotation in the FAI model. The torque generated at the hip joint was also affected by the FAI (Fig.4).

DISCUSSION:
This study presented a cadaveric FAI model that can be used to investigate the biomechanical effects of the FAI and hip version on the symphysis pubis. Preliminary results showed that FAI had a measurable impact on internal rotation torque generated at the hip as well as the internal pressure generated at the symphysis pubis. Collaborating with the findings of internal pressure at the symphysis pubis, rotations at the symphysis pubis were also affected by FAI. In the future, we will apply this cadaveric model to study how the size of the FAI affects the load transmission and movement at the symphysis pubis.

REFERENCES: