Anterior Cruciate Ligament Volume: Analysis of Gender Differences

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Purpose: Female athletes have been found to have a 7 times greater incidence of anterior cruciate ligament (ACL) tear than males involved in similar sports [1]. Various theories have been proposed to explain this phenomenon, including differences in ligament size and laxity, hormonally mediated changes in ligament strength, lower extremity alignment, and hamstring muscle activation [2-4]. We sought to measure the volume of the separate bundles of the ACL using high resolution MR imaging and to test for a relationship to gender, height, weight and body mass index (BMI).

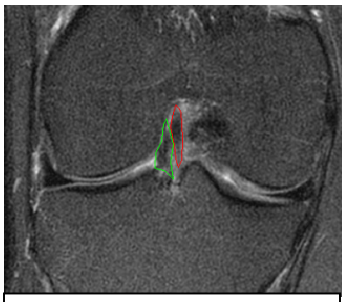


Figure 1a. Outline of ACL bundles drawn on each consecutive coronal FSE-PD image: anteromedial (red line) and posterolateral (green line).

Materials and Methods: Using a 1.5 T Unit (GE Medical Systems, Milwaukee, WI) and a quadrature extremity coil, we collected volume data for the separate bundles of the ACL (anteromedial and posterolateral). Using 3D analysis software (3D-Doctor, Able Software Corp., Lexington, MA) outlines of these structures were drawn (Figure 1a). A shaded surface 3D reconstruction was acquired (figure 1b) and voxel volume measurements were calculated. A standard voxel dimension of 0.0322 mm^3 was used for the calculation of ACL bundles (measured from consecutive fat-suppressed fast spin echo proton density coronal images with the following parameters: TR/TE =2150/26effective, NEX=1, FOV=13cm, matrix 512 x 512, slice thickness 4mm, skip 1mm, echo train length of six). MRI images with artifact precluding the outline algorithm or in patients with fractures or ligament tears were excluded. Body mass index was calculated using weight/$height^2$. The data was divided into subgroups based on gender, height, weight, and BMI for statistical analysis.

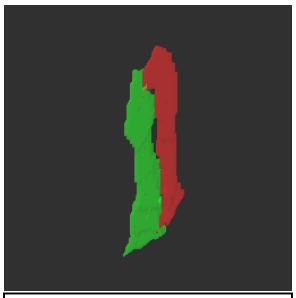
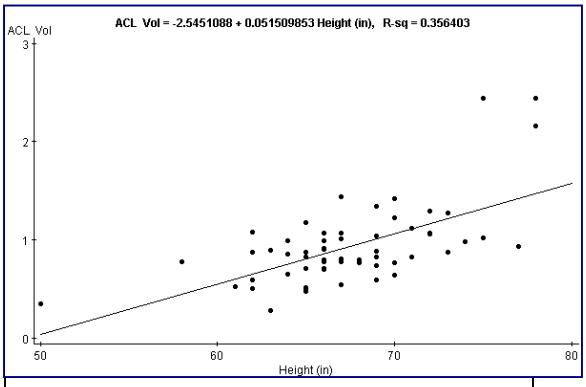


Figure 1c. Shaded surface volumetric reconstruction of ACL bundles.

Results: 63 knees (33 male, 30 female) were studied. Mean ACL volume was 1.07cc for males and 0.77cc for females (Table 1). The difference was significant (P=0.0025). Mean anteromedial bundle volume was smaller than the posterolateral bundle for females (0.33cc vs. 0.44cc) as well as for males (0.49cc vs. 0.58cc). Correlation coefficients for the group overall were highest for height (0.597; see graph 1)

Discussion: Gender differences in ACL volume are present, but may in part be related to height differences in males and females.



Graph 1. Scatter plot of ACL volume relative to height.

Group	ACL males	ACL females
Mean	1.07456279	0.77219893
SD	0.46143256	0.26107224
SEM	0.08032510	0.04766505
N	33	30

Table 1. ACL volume differences in males vs. females. The difference in volume is significant (P=0.0025)

[1] Gwinn DE, et al. *Am J Sports Med* 28: 98-102, 2000
[2] Anderson AF, et al. *Am J Sports Med* 29: 58-66, 2001
[3] Wojtys EM, et al. *Am J Sports Med* 26: 614-619, 1998
[4] Nicholas JA. *JAMA* 212: 2236-2239, 1970