Morphological characteristics of the distal iliopsoas tendon and its relationship to adjacent osseous structures

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Introduction

The iliopsoas muscle influences lumbo-pelvic posture and gait stability, and distal portions of the muscle contribute to common anterior hip pathologies including psoas syndrome, iliopsoas bursitis, impingement, and tendinopathy. Despite the important role of this muscle, anatomical variation of iliopsoas musculotendinous morphology and its relationship to distal osseous landmarks is poorly described.

Iliopsoas bursitis is defined as inflammation and enlargement of the iliopsoas bursa[1], while iliopsoas impingement refers to inflammation and pain in the iliopsoas muscle resulting in abnormal movement of the hip. Both are common causes of secondary hip disorders including anterior hip pain, labral tears, acetabular articular cartilage damage, and idiopathic arthritis[2]. Previous studies have implicated scarring of the iliopsoas tendon in relation to impingement as a direct mechanism for the development of labral tears and associated anterior hip pain in patients[3]. Psoas syndrome results from overuse or trauma to the iliopsoas muscle and may be seen secondarily with concomitant hip pathologies such as THA and iliopsoas bursitis[4].

The degree to which iliopsoas morphology exists and may contribute to this collection of pathologies has not previously been elucidated, and despite the prevalence of anterior hip pathologies involving the psoas musculotendinous unit, few studies have explored the morphology of this region in any detail. To further an understanding of this region and provide insight into the pathogenesis of anterior hip pathologies, this project aimed to assess distal iliopsoas tendon morphology and its relationship to adjacent osseous structures.

Materials and Methods

Data were collected from 45 body donors at Midwestern University. Categorical data on iliopsoas tendon morphology was generated through observation and blunt dissection of the musculotendinous complex. Linear measurements were collected between the anterior superior iliac spine (ASIS), lesser trochanter (LT), pubic tubercle (PT), and medial and lateral femoral epicondyles. Angles between LT, ASIS, and PT were calculated trigonometrically. Correlation analyses assessed associations between variables, with partial correlation analyses generated treating sex as a covariate. Independent sample t-tests assessed differences between linear and angular variables between sexes, tendon morphotypes, and individuals with and without psoas minor ($p<0.05$). This study was determined to be IRB-exempt by the Midwestern University Institutional Review Board because the project does not meet the definition of human subjects research as defined in 45 CFR 46.102.

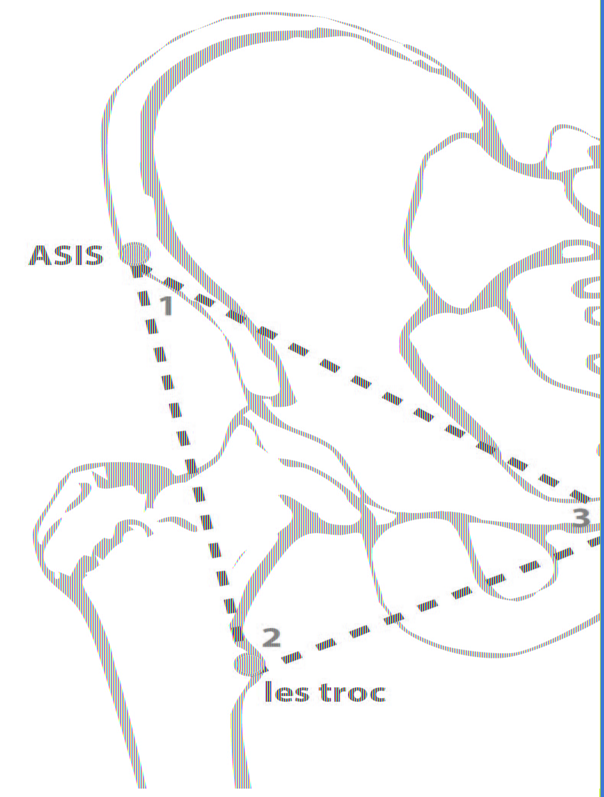

Figure 1. Schematic illustration identifying anatomical landmarks (yellow circles) and angles (between red dotted lines) utilized in the present study. Abbreviations: ASIS = anterior superior iliac spine; les troc= lesser trochanter; pub tub = pubic tubercle. 1= angle from ASIS; 2= angle form lesser trochanter; 3= angle from pubic tubercle. Image adapted from Netter, 2023.

Results

On average, males had higher values for the linear measurements than females (Table 1). However, in the angle measurements, females had a higher mean angle from the lesser trochanter and lower values in the other two angle measures (Table 1; Fig. 2).

Table 1. Descriptive statistics for the linear measurements and angles associated with the psoas major and lesser trochanter in the study sample. Linear dimensions provided in cm. Abbreviations: ASIS= anterior superior iliac spine; Lat epi= lateral epicondyle; Les troc= lesser trochanter; Med epi= medial epicondyle; pub tub= pubic tubercle; sd= standard deviation.

Variable	Mean: Entire sample	Mean: Females	Mean: Males	sd	Range	Variance
ASIS- Med epi	48.9	47.0	50.7	3.6	37.8-57.7	12.7
ASIS- Lat epi	49.0	46.9	51.1	3.7	37.6-57.8	13.3
ASIS- Pub tub	12.9	12.9	12.8	1.3	9.3-15.6	1.7
ASIS- Les troc	16.6	16.1	17.2	1.5	12.8-20.1	2.2
Pub tub- Les troc	10.6	10.0	10.9	1.3	6.1-15.3	1.6
Angle ASIS	39.5°	38.1°	39.3°	5.1°	23.3-56.2°	26.8
Angle Les troc	51.0°	52.9°	47.9°	6.5°	36.0-68.3°	42.7
Angle Pub tub	89.4°	88.9°	92.9°	9.0°	63.3-113.3°	80.1

Results (Cont.)

Correlation analyses revealed significant pairwise relationships between all of the linear variables, whether or not sex was controlled for. For the angles, in the partial correlation analyses controlling for sex, the angle from the lesser trochanter was only significantly correlated with the distance from the pubic tubercle to the lesser trochanter (Table 2), and the angle from the pubic tubercle was only significantly correlated with the distances from the lesser trochanter to the ASIS and pubic tubercle (Table 2).

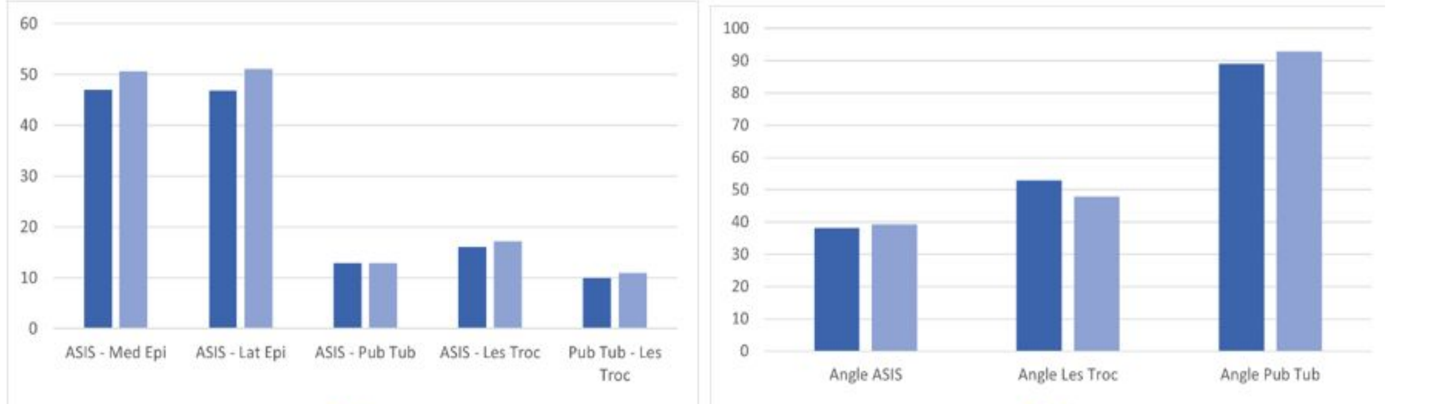

Figure 2. Bar plots showing mean values for variables in both sexes in the study sample: A) Linear dimensions (in cm); B) Angle measures (in degrees). Abbreviations: ASIS= anterior superior iliac spine; Lat epi= lateral epicondyle; F= female; Les troc= lesser trochanter; M= male; Med epi= medial epicondyle; pub tub= pubic tubercle.

The iliopsoas tendon morphotypes included three main categories: narrow (22.4%), notched (53.1%), or fan-shaped (24.5%). Narrow tendons had a single or dual course of bands of tissue running vertically, deep to the anterior femoral muscle mass that inserted onto or proximal to the lesser trochanter (Fig. 3). Notched tendons showed an observable horizontal divot proximal to the tendinous insertion at or around the lesser trochanter (Fig. 3). Fan-shaped tendons had a large tendinous insertion that spanned across the entirety of the surface of the lesser trochanter (Fig. 5). The relative frequencies of each tendon type were similar between sexes (Table 3), although fan-shaped tendon was found in a slightly higher frequency in female donors (33.3% vs. 19.4%; not significant).

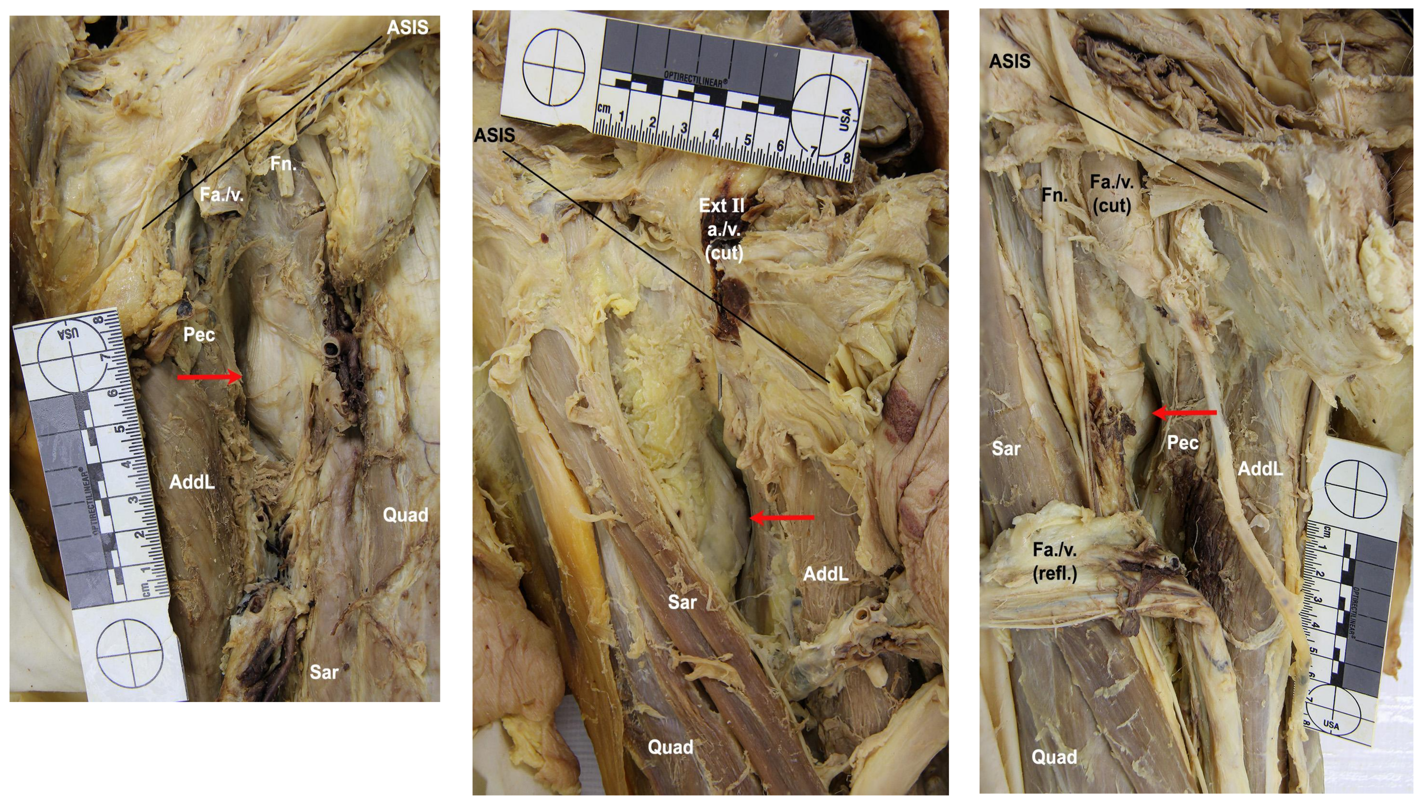

Figure 3. Photographic examples of three iliopsoas tendon types identified in this study: Narrow (left), Notched (center), and Fan-shaped (right). Anterior view of hip region. Red arrow points to the lesser trochanter. Approximate location of the inguinal ligament indicated with black line. Abbreviations: ASIS= anterior superior iliac spine; AddL= adductor longus. Ext Il a./v.= external iliac artery and vein; Quad= quadriceps femoris; Sar= sartorius.

Table 2. Correlation analysis values of statistical significance between angles overlying osteological structures of interest and the collected linear measurements. Bolded values significant after sequential Bonferroni correction.

	Standard correlation		Partial correlation: Controlling for sex	
Variable	**R-value**	**p-value**	**R-value**	**p-value**
Angle from the ASIS:				
ASIS - Med epi	**-0.286**	**0.007**	**-0.351**	**0.002**
ASIS - Lat epi	**-0.240**	**0.024**	**-0.286**	**0.013**
ASIS - Pub tub	0.075	0.486	**-0.263**	**0.024**
ASIS - Les troc	**-0.319**	**0.002**	**-0.328**	**0.004**
Pub tub - Les troc	**0.705**	**<0.001**	**0.674**	**<0.001**
Angle from the les troc:				
ASIS - Med epi	**0.373**	**<0.001**	-0.019	0.870
ASIS - Lat epi	**0.399**	**<0.001**	-0.072	0.540
ASIS - Pub tub	**-0.348**	**<0.001**	**0.606**	**<0.001**
ASIS - Les troc	**0.490**	**<0.001**	-0.214	0.066
Pub tub - Les troc	**-0.309**	**<0.001**	-0.151	0.198
Angle from the pub tub:				
ASIS - Med epi	**-0.284**	**0.007**	0.229	0.050
ASIS - Lat epi	**-0.356**	**<0.001**	0.231	0.047
ASIS - Pub tub	**0.535**	**<0.001**	**-0.315**	**0.006**
ASIS - Les troc	**-0.418**	**<0.001**	**0.369**	**0.001**
Pub tub - Les troc	**-0.309**	**0.003**	**-0.292**	**0.012**

Results (Cont.)

Table 3. Frequencies of the three recognized iliopsoas tendon morphotypes in the study sample, broken down by sex.

	Narrow	Notched	Fan-shaped	Total
Females	3 (16.7%)	9 (50%)	6 (33.3%)	18
Males	8 (25.8%)	17 (25.8%)	6 (19.4%)	31
Total	11 (22.4%)	26 (53.1%)	12 (24.5%)	49

Discussion

We noted that greater angle measured from the ASIS was inversely correlated with the linear length of the corresponding femur. Previous research concluded that pelvic morphology was a product of locomotor, allometric, and phylogenetic influences[5], and has shown that stability throughout the gait cycle is mediated via forces loaded axially through the femur, at the proximal and distal ends of the shaft of the femur, with assistance from pelvic and anterior thigh musculature[6]. We propose the possibility of a functional developmental relationship between the iliopsoas musculotendinous unit and the bony anatomy of the proximal pelvis and femur; as our data showed that wider pelvic osteology, signified via a greater angle measured from the ASIS, is related to decreased length of the adjacent femur. To what degree the morphology of these anatomical structures influence limb development requires further investigation. Our data also showed that larger angles from the lesser trochanter correlate strongly ($p<0.001$) with shorter linear distances along the femur and, by extension, smaller human stature. To what extent this relationship is influenced by the muscles which act upon the lesser trochanter remains unknown.

Statistically significant differences between male and female subjects were noted. Female pelvic/femoral anatomy displayed smaller mean values for both linear distance and calculated angle measurements, except in the angle from the lesser trochanter. Research has shown that male skeletal anatomy is on average larger likely due to gender specific patterns of sex hormone production[7]. While dimorphic pelvic anatomy is typically ascribed to requirements for gestation and childbirth. We hypothesize that these findings may predispose female patients, particularly primiparous and multiparous women, to anterior hip pathology of the iliopsoas tendon.

A correlation was noted between musculoskeletal morphology and wider pelvic osteology, seen as an increased angle measured from the lesser trochanter; donors who possessed a psoas minor had, on average, a greater angle from the lesser trochanter by 10.3°. Morphological variation in the psoas minor may influence the stability and insertion of the underlying iliopsoas muscle; this may be clinically related to inflammation and pathology of the iliopsoas muscle and adjacent anterior hip tissue[8]. Our results demonstrate that the presence or absence of psoas minor may have a tangible influence on the morphology of pelvic anatomy.

Conclusions

The identification of distinct tendon morphotypes and relationships between the musculotendinous complex and osseous landmarks provides novel insight into iliopsoas morphology and illuminates a path for determining the relationship between anterior hip morphology and pathology. Findings may assist clinicians understanding of which anatomical variations predispose patients to symptoms, thus improving screening processes and identification of patients at risk of developing anterior hip pathology.

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References available upon request.