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Operative Techniques in

Sports Medicine

Anatomic Basis for Evaluation of Abdominal and Groin Pain in Athletes

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The term *athletic pubalgia* describes a group of sometimes surgically correctable syndromes that are relatively common in athletes. In this article, we aim to highlight key parts of the pelvic anatomy that are involved in these types of syndromes. One important concept deserves special emphasis. Most exertional abdominal and groin pains in high performance athletes have no association with actual hernias. The term *sports hernia* mischaracterizes the pathology and misleads surgeons to perform incorrect operations. Therefore, we recommend the latter term be abandoned. The athletic pubalgia syndrome is not associated with abdominal wall defects that resemble hernias. Unlike hernias, the pain of athletic pubalgia occurs in a variety of locations consistent with multiple sets of forces interacting pathophysiologically around a fulcrum—a concept that helps define joint instability. We refer to the joint involved in this case as the "pubic joint." While hernias certainly can occur in athletes, most abdominal and groin pain in athletes have nothing to do with hernias and do, in fact, have specific mechanisms of injury.

Like the knee and other joints, the "pubic joint" has a number of musculoskeletal attachments that serve as ligaments and functionally stabilize this joint. The pubic joint is undoubtedly complex, which probably explains why these syndromes have remained mysterious for so long.

The purpose of this article is twofold: (1) to depict the pelvic anatomy pertinent to the clinical problems, and (2) to correlate this anatomy with a number of syndrome variants that we have come to recognize in an experience of over 4,000 athletes. While these diagnoses are for the most part empiric, they result from multiple observations on multiple fresh and fixed cadaveric dissections as well as careful follow-up of large contingents of patients who have had various operations designed with the above concepts in mind.

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Pertinent Anatomy

The bony pelvis has two main functions: (1) to transfer weight from the upper body to the axial skeleton, and (2) to withstand compression forces resulting from its support of body weight. To fulfill both functions, the bony pelvis depends on the attachments of powerful muscles. Four bones comprise the pelvis: two hip bones, the sacrum, and the coccyx (Fig. 1). The hip bones are joined anteriorly at the pubic symphysis and posteriorly at the sacrum. Together, the bony pelvis with its junctions is called the "pelvis girdle."

Besides the junctions of the major bones, the pelvis also contains many joints that allow it to articulate and shift positions in many ways with muscle contractions. The joints of the pelvis include: the lumbosacral joints, the sacrococcygeal joint, the sacroiliac joints, and the pubic symphyseal joint. Most of the focus in this set of injuries is on the anterior half of the pelvis. The obturator canal has its own set of unusual syndromes that are not addressed in this chapter. The rectus abdominis attachment onto the pubis is key. The anterior edge of the inferior pubic ramus has some spiny projections that can rub anteriorly against the adductor muscles and tendons, causing considerable pain. The lesser trochanter, the site of attachment of the psoas tendon, is also a relatively common site for pain in both sexes.

A number of functional ligaments (Fig. 2) help stabilize these complex joints. Any of these ligaments can be the source of compensatory pain or inflammation complicating diagnoses of the primary problems. For example, attachments such as the iliofemoral ligament, the iliotibial tract, the pubofemoral ligament, and the iliopsoas tendon act somewhat like "strap" muscles that stabilize the anterior pelvis that is the focus of many athletic problems.

A key part of anterior pelvic anatomy that forms the fulcrum for many of the movements is the pubic symphysis (Figs. 3 and 4). The 2 sides of the pubic symphysis join via a fibrocartilaginous disc. The traditional ligaments that stabilize this joint are the superior pubic ligament and inferior pubic ligament. The joint is also strengthened by the decussating fibers of the rectus abdominis and the external oblique muscles. The muscles that attach to the pubic symphysis probably play more of a role in stabilization of the joint

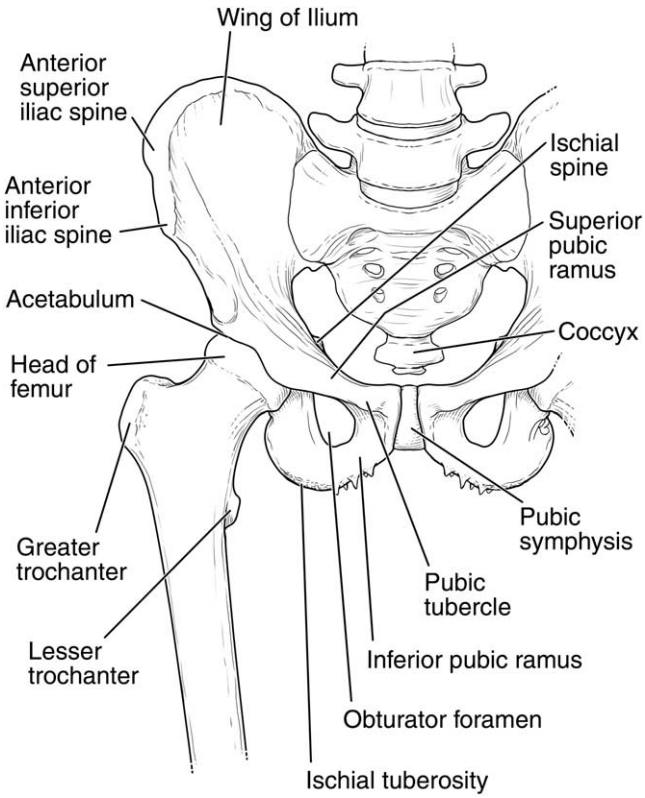

Figure 1 Anterior view of bony anatomy of pelvis and proximal femur.

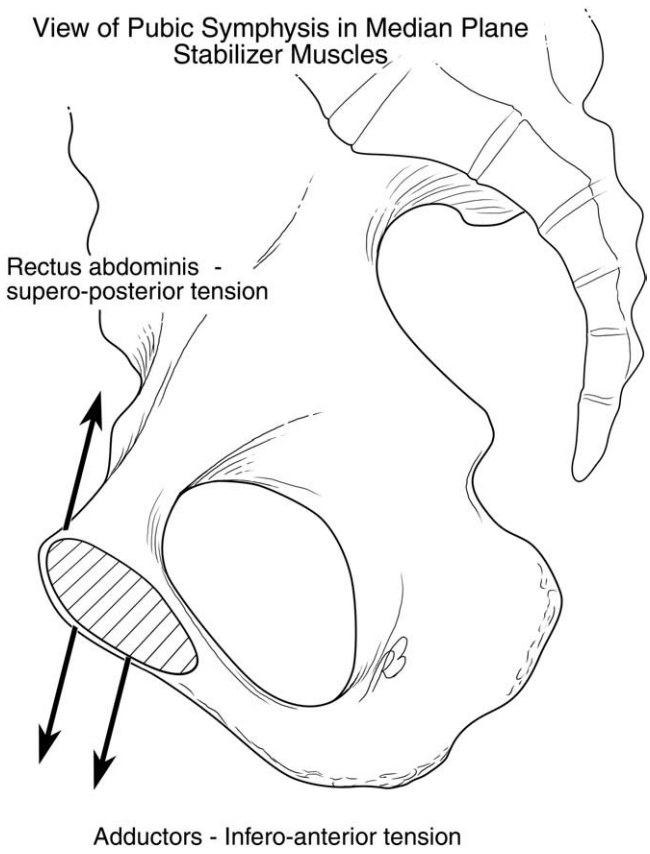

Figure 3 Cross-sectional view through the pubic symphysis showing the main opposing forces acting on the pubic joint.

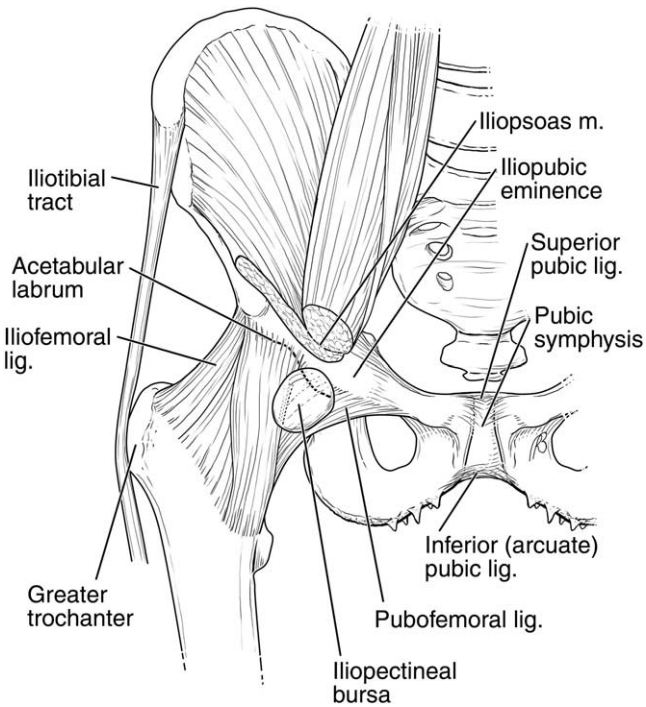

Figure 2 Ligamentous anatomy of pelvis and proximal femur. The iliopsoas muscle tendon, which inserts on the lesser trochanter, is cut.

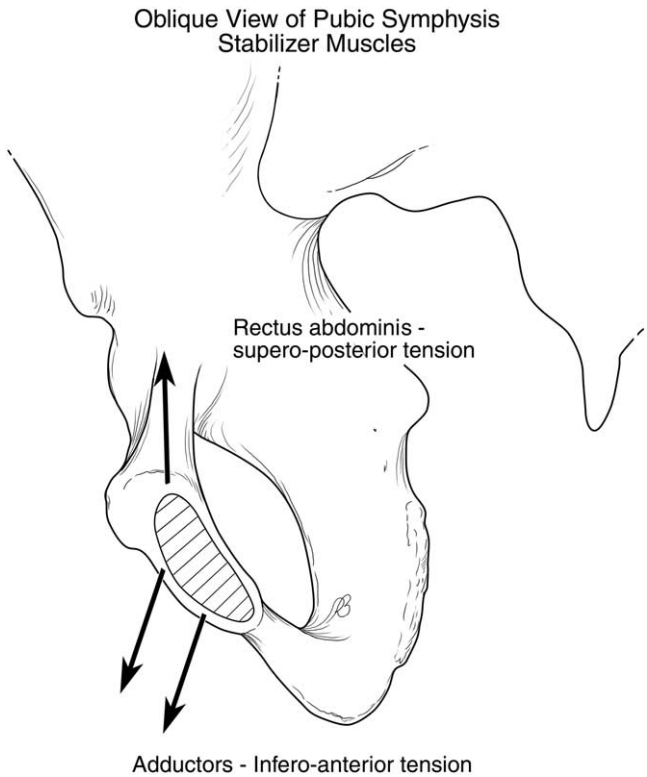

Figure 4 Oblique view of the pubic symphysis showing the direction of opposing forces exerted on the pubic joint by the rectus abdominis and the adductors.

than the fibrocartilaginous disc. Note in the median plane (Fig. 3) that the rectus abdominis muscle attachments almost directly oppose the adductor attachments. The rectus creates supero-posterior tension while the adductors create infero-anterior tension. When one considers the entire pelvis (Fig. 4), contraction of these muscles together creates an anterior tilt. Action of the latter two muscle groups together creates tremendous force, an action that has been previously underappreciated in the literature.

Many muscles that play important roles in pelvic stability originate and/or insert on the bony pelvis (Table 1 and Figs. 5 and 6). Also, these muscles functionally anchor the pelvis so that other parts of the body can move. The rectus abdominis on each side flexes the trunk as it compresses the abdominal viscera and forms the anchor for considerable abduction and adduction, as well as internal and external hip rotation. The rectus abdominis originates at the pubic symphysis and pubic crest and inserts on the xiphoid process and costal cartilages. Superiorly, the fibers of the rectus abdominis interdigitate with the intercostal muscles to form a complex musculotendinous insertion on the ribs and costochondral cartilages. In the thigh, one can think in terms of 3 compartments of muscles.

The posterior compartment is probably the least important in terms of direct stability of the anterior pelvis. The posterior compartment is comprised primarily of the hamstring muscles: the long and short heads of the biceps femoris, the semitendinosus, and the semimembranosus. Additional structures include a portion of the adductor magnus, several nerves, and the profunda femoris artery.

The medial compartment is the most important thigh compartment in these injuries, and comprises the following muscles: the gracilis; the adductor longus, magnus, and brevis; and the obturator externus. The gracilis is a 2-joint muscle and arises from the pubic arch and inserts on the proximal medial tibia. The adductors all originate from the inferior pubic ramus and insert onto the linea aspera of the femur. The anterior obturator nerve innervates all the latter adductors except the adductor magnus.

The anterior compartment is particularly important with respect to many of the relatively uncommon variants of the athletic pubalgia syndrome. The anterior compartment comprises the following muscles: sartorius, iliacus, psoas, pectineus, vastus lateralis, vastus medialis, vastus intermedius, and rectus femoris. The sartorius arises from the anterior superior iliac spine and inserts onto the proximal medial tibia to form part of the pes anserinus. The relatively lateral location of the sartorius may account for an apparently more important role in stabilization of the female pelvis. The lateral femoral cutaneous nerve exits the bony pelvis near the origin of the sartorius. The rectus femoris has two heads. Distally, the rectus femoris fibers blend with the vastus intermedius. The iliacus and psoas interidigitate and insert onto the lesser trochanter of the femur. The pectineus arises from the pubis and inserts onto the pectineal line of the femur.

The muscles that attach to the pelvis can be divided into groups according to their actions. The first group is the adductors. The principal muscles here are the adductor longus, adductor brevis, adductor magnus, the gracilis, and the pectineus. As shown in Figures 5 and 6, all of the adductor muscles originate on the pelvis at the pubic ramus. When these muscles contract, the thigh moves towards the midline.

A particularly important point is that the action of the adductor longus directly opposes the rectus abdominis muscle (Figs. 7 and 8). When the rectus weakens, the adductor longus pulls in a relatively unopposed fashion, which can create a painful compartment syndrome. Figures 7 and 8 depict slightly different views of the forces that the various important pelvic muscles exert on this "pubic joint."

Another group of muscles laterally rotates the thigh. The obturator externus originates at the obturator foramen and inserts on the trochanteric fossa of the femur. The obturator internus originates at pelvic ilium and ischium and inserts on the trochanteric crest of the femur. The last muscle of this group is the quadratus femoris. It originates at the ischial tuberosity and inserts on the trochanteric crest of the femur.

The psoas major and minor act conjointly in flexing the thigh at the hip joint. The psoas major originates at T12-L5 vertebrae and inserts on the lesser trochanter of the femur. The psoas minor originates at T12-L1 vertebrae and inserts at the iliopectineal eminence. These muscles do not directly attach to the pelvis. Their actions can be thought either to create important stability or to cause the pelvis tremendous stress.

The term "pelvic floor" has two different meanings. Traditionally, and from the viewpoint of a laparoscopic surgeon, the pelvic floor is made up of several muscles that include the pubococcygeus, puborectalis, and iliococcygeus muscles. Collectively, the latter muscles are known as the levator ani. These muscles originate from the body of the pubis, the tendinous arch of obturator fascia, and the ischial spine. They insert on the coccyx, walls of prostate, vagina, and rectum. The action of the levator ani complex is to support the pelvis viscera and resist increased intra-abdominal pressure.

From a laparoscopic standpoint, the pelvic floor represents the entire inferior, saccular muscle-organ complex that holds the intra-abdominal viscera inside the peritoneal cavity as well as other retroperitoneal structures above the pelvis. By this definition, the pelvic floor includes the levator ani apparatus and other organs, including the bladder, rectum, and uterus, that form the "floor" or inferior portion of the pelvis, as if the person were standing in the normal anatomic position. A second meaning to the term pelvic floor reflects just the anterior aspect of this floor, ie, including the rectus abdominis tendon insertions to the pubis and the pubic symphysis. The latter concept is important for understanding the "pubic joint" described below.

The next important groups of muscles extend the thigh and flex the leg at the knee. The semimembranosus originates at the ischial tuberosity and inserts on the medial condyle of the tibia. It has the additional action of extending the trunk at the hip. The biceps femoris originates at the ischial tuberosity (long head) and the linea aspera (short head) of the femur and inserts on the head of the fibula. The rectus femoris originates at the anterior inferior iliac spine (AIIS) and ileum and inserts at the tibial tuberosity.

Table 1 Muscles Attaching to and Stabilizing the Pelvis

Muscle	Origin	Insertion	Main Action
Rectus abdominis	Pubic symphysis and pubic crest	Xiphoid process and costal cartilage 5-7	Flexes trunk and compresses abdominal viscera
Adductor longus	Body of pubis inferior to pubic crest	Middle third of linea aspera of femur	Adducts thigh
Adductor brevis	Body and inferior ramus of pubis	Pectineal line and proximal part of linea aspera of femur	Adducts thigh and to some extent flexes it
Adductor magnus	Adductor part; inferior ramus of pubis, ramus of ischium Hamstrings part; ischial tuberosity	Adductor part; gluteal tuberosity, linea aspera, medial supracondylar line Hamstrings part; adductor tubercle of femur	Adducts thigh Adductor part; flexes thigh Hamstring part; extends thigh
Gracilis	Body and inferior ramus of pubis	Superior part of medial surface of tibia	Adducts thigh, flexes leg, and helps rotate it medially
Obturator externus	Margins of obturator foramen and obturator membrane	Trochanteric fossa of femur	Laterally rotates thigh, steadies head of femur in acetabulum
Pectineus	Superior ramus of pubis	Pectineal line of femur, just inferior to lesser trochanter	Adducts and flexes thigh; assists with medial rotation of thigh
Psoas major	Sides of T12-L5 vertebrae and discs between them; transverse processes of all lumbar vertebrae	Lesser trochanter of femur	Acts cojointly in flexing thigh at hip joint and stabilizing this joint
Psoas minor	Sides of T12-L5 vertebrae and discs	Pectineal line, iliopectineal eminence via iliopectineal arch	
Quadratus femoris	Ischial tuberosity	Intertrochanteric crest of femur	Laterally rotates thigh; stabilizes femoral head
Levator ani (pubococcygeus, puborectalis, and iliococcygeus)	Body of pubis, tendinous arch of obturator fascia, and ischial spine	Perineal body, coccyx, anococcygeal ligament, walls of protate or vagina, rectum, and anal canal	Helps support pelvic viscera and resists increase in abdominal pressure
Obturator internus	Pelvic surfaces of ilium and ischium; obturator membrane	Greater trochanter of femur	Rotates thigh laterally; assists in holding head of femur in acetabulum
Semimembranosus	Ischial tuberosity	Medial condyle of tibia	Extend thigh; flex leg when knee is flexed; extend trunk
Biceps femoris	Long head; ischial tuberosity Short head; linea aspera of femur	Head of fibula	Extend thigh; flex leg and rotates it laterally when knee is flexed
Rectus femoris	Reflected head; superior acetabulum Straight head; anterior inferior iliac spine	Patella	Flexes thigh
Sartorius	Anterior inferior iliac spine	Proximal medial tibia	Flexes, adducts, and laterally rotates thigh

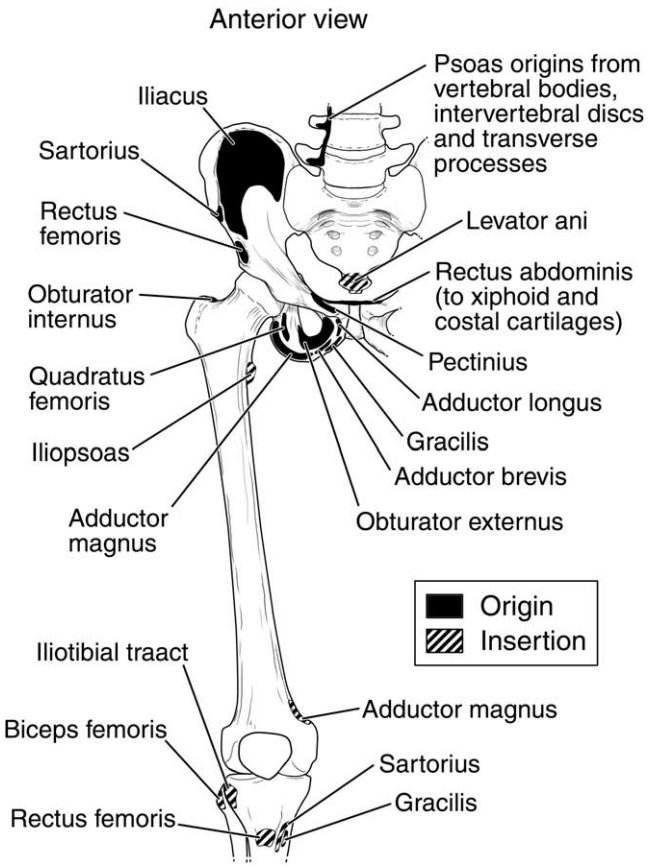

Figure 5 Anterior view of muscle origins and insertions. Note that all adductors originate on the pubic ramus.

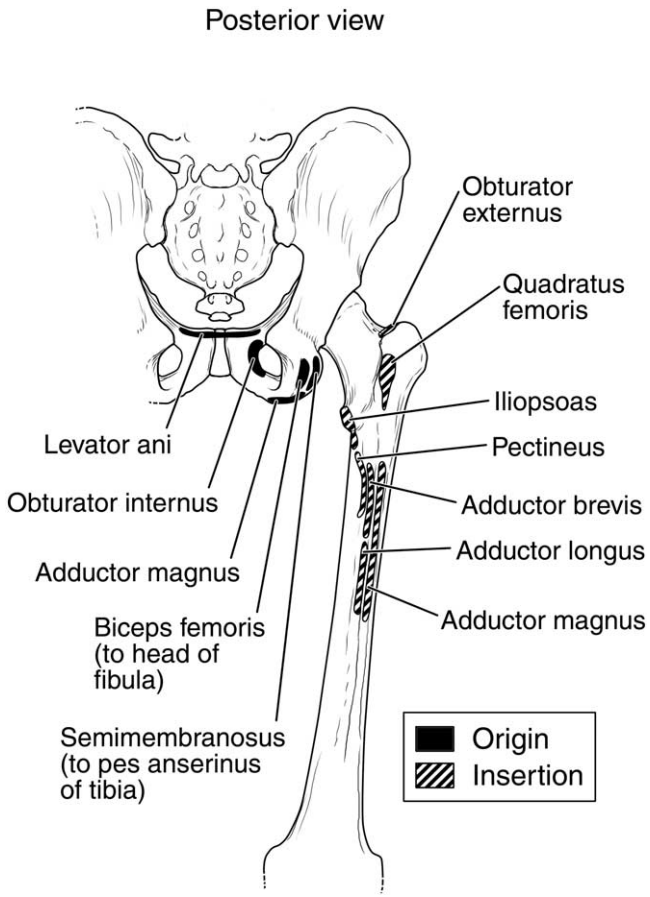

Figure 6 Posterior view of muscle origins and insertions. The adductors all insert on the linea aspera of the posterior femur.

The final muscle that originates from the pelvis is the sartorius. The sartorius acts to flex, abduct, and laterally rotate the thigh at the hip. It also acts to flex the leg at the knee. It originates at the anterior superior iliac spine (ASIS) and inserts at the superior surface of the tibia. One can think also in terms of the sartorius and psoas muscles as "strap" muscles of the pubic joint that help maintain that joint's stability.

In athletes, tremendous torque occurs at the level of the pelvis. The anterior pelvis takes the brunt of most of the forces, and the pubic bone functionally serves as a fulcrum around which many of the forces are exerted. Contraction of many of the above muscles, especially the rectus abdominis, adductor longus and psoas major, can create tremendous force on the pelvis. Some of these forces actually oppose each other depending on the degree and direction of exertion (Figs. 7 and 8). When one of these muscles weakens, it results in an inequality of forces on the pelvis, which can lead to painful syndromes such as with athletic pubalgia.

The most common mechanism of injury in the latter syndrome involves a weakening of the rectus muscle pubic insertion site, which leads to relatively unopposed action of the adductor longus muscle (Fig. 9). This results in increased pressure in the adductor compartment. In some cases, the spiny processes on the anterior aspect of the inferior pubic ramus cause significant pain in the adductor region.

Many of the latter injuries occur only in the most physi-

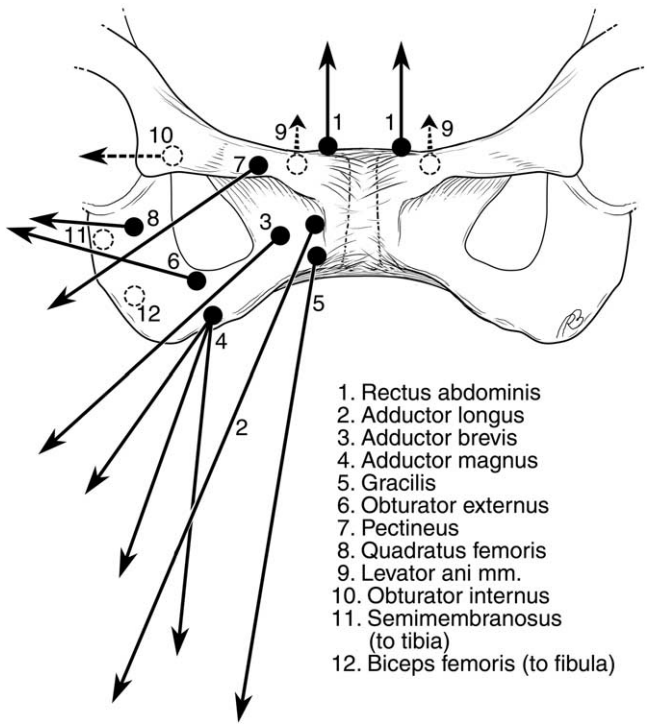

Figure 7 Anterior view of the pubic ramus with schematic depiction of the many forces acting on the pubic joint.

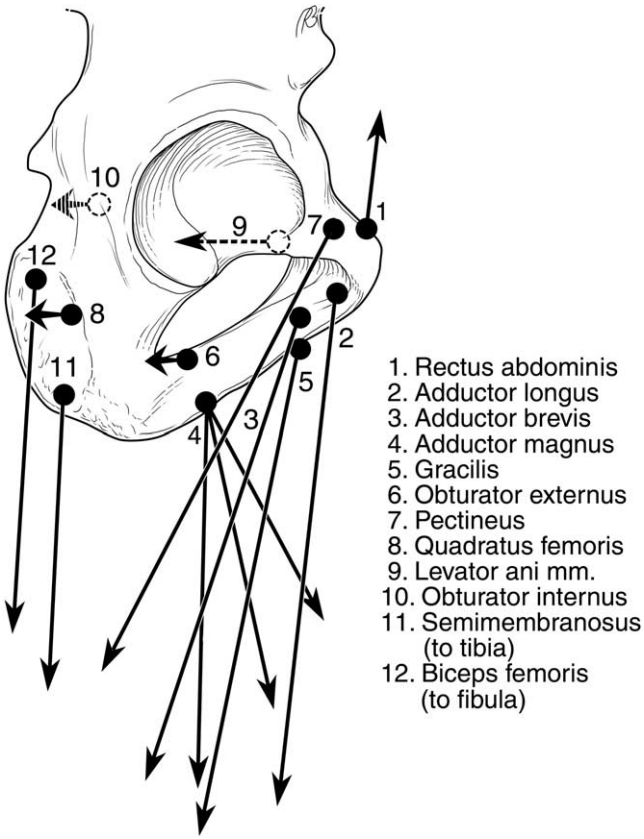

Figure 8 Medial view of the pelvis depicting the direction of forces acting on the pelvis and influencing pelvic tilt.

cally fit patients. One can think of the anterior pelvis basically as a joint, which we call the pubic joint. The principal attachments that stabilize this joint are the rectus abdominis muscles and tendons from the superior (abdominal) side and the adductor longus muscles and tendons from the inferior (adductor) side. Forces in the pelvis increase as the muscle strength increases. The latter observation probably explains why the most fit athletes are the ones most likely to develop many of the syndromes.

Differences in the male and female pelvis probably explain why males develop the athletic pubalgia syndrome more often than women. These differences may include: the thicker, heavier male pelvis causing greater shifts in force, the narrower male subpubic angle leading to a different distribution of force, the narrower pubic symphysis disc in males leading to decreased flexibility of the pelvis, and the narrower, probably less stable pelvis of the male in general. Females are more likely to develop sartorius, psoas, or other more lateral, anterior pelvic pain, probably reflecting the wider pelvis and greater dependence on these "strap" muscles for stability.

Athletic Pubalgia Syndromes

The syndrome that we call *athletic pubalgia* includes a number of variants. Each variant probably has a slightly different mechanism of injury or different method of musculoskeletal compensation that accounts for the difference in symptoms. In this article we list 17 different variants and correlate their signs and symptoms with the afore-mentioned anatomy. It should be noted that even this list of 17 variants is not complete. For example, we do not discuss the obturator and the piriformis syndromes. Nor do we discuss recurrent adductor strains, which are probably the most common pathology seen in this area.

1. Classic Athletic Pubalgia. This refers to the most common form of the syndrome of chronic, severe, exertional, and lateral rectus abdominis pain related to the latter muscle's tendinous insertion onto the pubis. Classically, a tear or an attenuation of the rectus abdominis insertion causes the syndrome as well as possibly secondary pain near the adductor insertion sites onto the pubis.

2. Adductor Longus Variant. In this variant the adductor longus pain predominates or is a principal component of the

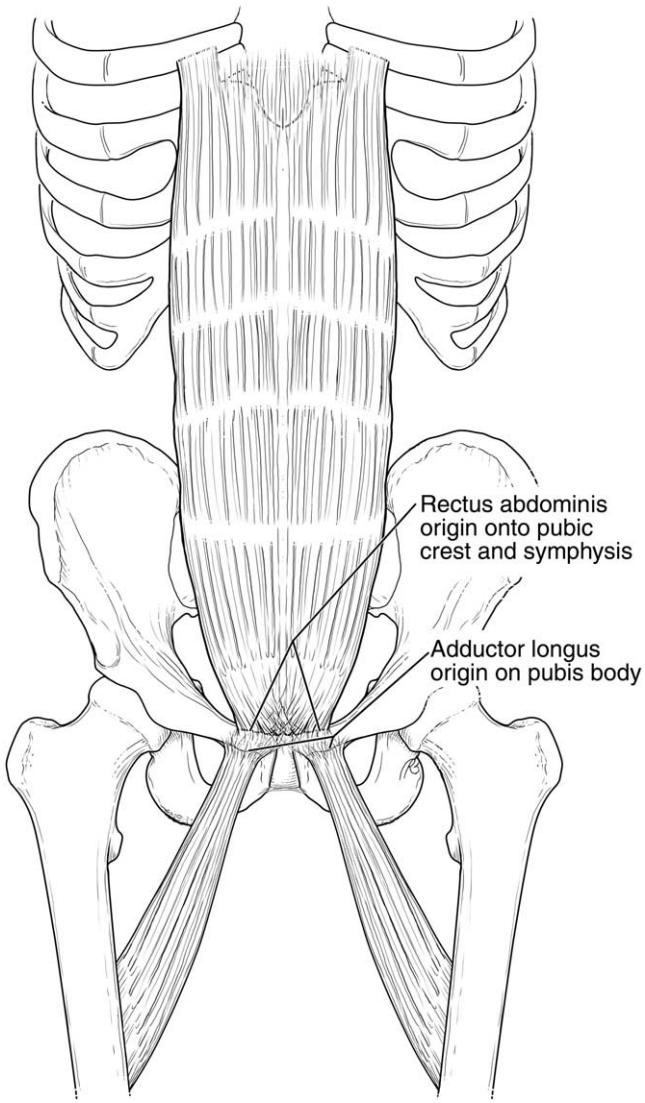

Figure 9 Anterior view of the origins of the rectus abdominis and adductor longus around the pubic joint. Weakening of the rectus about the pubic joint leads to relatively unopposed inferior pulling forces exerted by the adductor longus.

pain. In some cases, the adductor longus pain occurs without any rectus abdominis pain. The pain is at the insertion site on the pubis and is most likely due to a medial thigh compartment syndrome due to a relatively unopposed action of the adductors since the rectus abdominis is weak.

3. Iliopsoas Variant. In this case the pain is principally near the psoas insertion site onto the lesser trochanter. The pain results from a psoas bursitis that is secondary to the instability caused by the weak rectus abdominis attachment.

4. Snapping Hip Variant. This variant is similar to the iliopsoas variant but in this, the pronounced pain is in association with illicitation of a "hip snap" on physical examination or with a similar maneuver. This variant tends to occur in runners and in women.

5. Spigelian Variant. In this case there is pronounced pain in the Spigelian area, the same site where hernias can occur, ie, laterally, where the posterior rectus abdominis sheath disappears about two-thirds of the way up from the pubis towards the umbilicus. In this case, the pain is not due to a hernia. Instead, it is due to vertical extension of the same musculofascial shredding that characterizes the more classic athletic pubalgia.

6. Gracilis Variant. The gracilis, in this case, is more involved than the adductor longus in the pain resulting from a compartment syndrome due to relatively unopposed action of the adductors with respect to the pubic joint.

7. Baseball Pitcher/Hockey Goalie Syndrome. This may or may not be a variant of the classic athletic pubalgia syndrome defined by rectus abdominis insertional weakening. This syndrome tends to occur in the above-mentioned athletes, and involves primarily a muscular hernia through the fascia or epimysium investing the belly of the adductor longus muscle. A distinct nerve tends to be entangled in the resultant inflammation.

8. Athlete's Rib Syndrome. In this injury that tends to involve rowers, tennis players, and boxers, the rectus abominis fibers that interdigitate with the lower-most intercostals muscles sublux the 11th and 12th ribs and/or cartilages. This subluxation occurs in extremes of activity and causes pain.

9. Superior Rectus Variant. This syndrome is an intermediate between the Spigelian and the Athlete's Rib Variant.

10. Sartorius Variant. This variant tends to occur in women, perhaps related to their differences in pelvic anatomy. There is considerable pain at the sartorius insertion site in addition to lower rectus abdominis pain.

11. Labral Tear/ Snapping Hip Variant. The symptoms and findings of these 2 entities can be very similar, and in fact the 2 problems often coexist, perhaps suggesting a similar mechanism of injury. This syndrome has been seen most often in hockey players and gymnasts.

12. Round Ligament Syndrome. Distinguishing athletic pubalgia from endometriosis can be difficult, and there seems to be a definite syndrome in female athletes involving exertion and pain related to the round ligament itself. This pain can be difficult to discern from athletic pubalgia and perhaps coexists with the latter syndrome.

13. Adductor Avulsion Variants. In fact, the adductor longus (in most cases) can partially or completely avulse from the pubis resulting in considerable pain. A weakening of the rectus abdominis insertion probably also accounts for these extreme variants.

14. Adductor Calcification Syndromes. We have seen these problems most commonly in bull riders. Often years after the injury, the calcification that results from this severe trauma ends up in severe inflammation and pain.

15. Osteitis Pubis Variants. In many cases in athletes, there is some degree of osteitis pubis associated with the athletic pubalgia syndrome. Most of the time, the former pain will resolve with appropriate treatment of the athletic pubalgia. However, in some cases, the osteitis pubis pain is so diffuse and painful that the pain takes longer to resolve than hoped. One must also beware of the possibility of primary osteitis pubis, which in general is more difficult to treat.

16. Iliotibial Tract Syndromes. Pain in this area can be secondary to compensation from a primary rectus abdominis problem.

17. Rectus femoris, Quadratus, or Pectinues Syndromes. Pain can occur either primarily or secondarily along other insertion sites or bursae related to these muscles and tendons.