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The Anatomy of the Pubic Region Revisited

Implications for the Pathogenesis and Clinical Management of Chronic Groin Pain in Athletes

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Abstract

Chronic groin pain is a common complaint for athletes participating in sports that involve repetitive sprinting, kicking or twisting movements, such as Australian Rules football, soccer and ice hockey. It is frequently a multi-factorial condition that presents a considerable challenge for the treating sports medicine practitioner. To better understand the pathogenesis of chronic groin pain in athletes, a precise anatomical knowledge of the pubic symphysis and surrounding soft tissues is required. Several alternative descriptions of pubic region structures have been proposed. Traditionally, chronic groin pain in athletes has been described in terms of discrete pathology requiring specific intervention. While this clinical reasoning may apply in some cases, a review of anatomical findings indicates the possibility of multiple pathologies coexisting in athletes with chronic groin pain. An appreciation of these alternative descriptions may assist sports medicine practitioners with diagnostic and clinical decision-making processes. The purpose of this literature review is to reappraise the anatomy of the pubic

region, considering findings from cadaveric dissection and histology studies, as well as those from diagnostic imaging studies in athletes.

Chronic groin pain is a common complaint for athletes participating in sports that involve repetitive sprinting, kicking or twisting movements, such as Australian Rules football, soccer and ice hockey.[1-3] It is typically a multifactorial condition that presents a considerable challenge for the treating sports medicine practitioner.[4] Symptoms are often vague and diffuse, extend between the lower abdomen and medial thigh, and may be attributed to a variety of diagnostic entities.[5-9] Additionally, it is possible that many of these diagnostic entities share a common origin. Recent research[10,11] has challenged several details in the anatomy of the pubic region as described in modern texts. This new information may have important clinical implications. If the textbook descriptions are inaccurate, then models of chronic groin pain pathogenesis based on these descriptions may be inherently flawed. The purpose of this literature review is to reappraise the anatomy of the pubic region. The outcomes will provide a background for further investigation, contribute to the understanding of chronic groin pain pathogenesis, and provide a context for evaluating current management strategies.

1. Aetiology of Chronic Groin Pain

Numerous conditions are reported in the literature as possible causes of acute or chronic groin pain in athletes.[4,12-20] A composite table of these conditions reveals a differential diagnosis algorithm that is impractical for the average clinician (table I). The potential for a medical cause of groin pain in athletes should be recognized and appreciated by clinicians.[5,9,14,15,18,21,22] However, the majority of conditions resulting in chronic groin pain in athletes are indicated as being of musculoskeletal origin.[4,12,14,23,24] The specific source/diagnosis premise may be obscured by vague symptoms or an insidious onset indicating the possibility of sinister pathology. That said, if the presenting symptoms are aggravated by activity and relieved by rest, then symptom behaviour is suggestive of a musculoskeletal disorder. The balance of this review

Table I. Possible causes of groin pain in athletes reported in the literature[4,12-20]

Abdominal aortic aneurysm	Hydrocoele/varicocoele	Postpartum symphysis separation
Acetabular disorders	Inflammatory bowel disease	Prostatitis
Adductor strain	Inguinal or femoral hernia	Pubic instability
Adductor tendinitis	Intra-abdominal abscess	Sacroiliac joint problems
Apophysitis	Legg-Calvé-Perthes disease	Seronegative spondyloarthropathy
Appendicitis	Lumbar spine pathology	Slipped capital femoral epiphysis
Avascular necrosis of femoral head	Lymphadenopathy	Snapping hip syndrome
Avulsion fracture	Muscle strain	Sports hernia
Bursitis	Myositis ossificans	Stress fractures
Conjoined tendon dehiscence	Nerve entrapment	Synovitis
Crohn's disease	Obturator nerve entrapment	Testicular neoplasm
Diverticular disease	Osteitis pubis	Testicular torsion
Epididymitis	Osteoarthritis	Urethritis
Femoroacetabular impingement	Ovarian cyst	Urinary tract infection
Herniated nucleus pulposus	Pelvic inflammatory disease	
Hockey player's syndrome	Pelvic stress fracture	

therefore focuses on chronic sports-related or athletic groin pain that originates from musculoskeletal structures in the pubic region. Specifically, this review addresses the anatomy and relations of the adductor and lower abdominal musculature, the pubic bone, and the pubic symphysis and its capsular tissues.

2. Epidemiology

The incidence of injury to the groin region represents 5–18% of reported athletic injuries.[18,25-28] However, caution is required when interpreting these data, as there are currently no universal standards for the definition or classification of these conditions.[3,4,29] The use of generic classifications such as 'groin injury' or 'groin strain' may identify which athletes have groin symptoms, but the true value of the data is questionable. For example, acute traumatic injuries would not be differentiated from insidious overuse injuries, even though they may have a distinctly different pathogenesis. Furthermore, if an injury is recorded only when it results in a missed training session or match, then players who continue to train and play with groin symptoms would not be included in the data.[20] Additionally, epidemiological studies do not appear to adequately identify which musculoskeletal conditions are most commonly involved in groin injuries. This deficiency could possibly be addressed by adopting the clinical entities approach[7] to classify athletic groin pain in future studies. Within this approach, an injury may be classified as comprising one or more of adductor-related, abdominal wall-related, pubic bone-related or psoas-related clinical entities.[7,30]

3. Musculoskeletal Risk Factors

The musculoskeletal risk factors for groin injury provide a context for evaluating the relevance of disparities identified in the anatomical literature. There are relatively few published studies with prospectively collected data that investigate the risk factors for groin injury in athletes. Similar to the epidemiological studies, there is no consistency in the definition of the groin injuries investigated or in the reporting of their degree of chronicity. Furthermore, these studies involve a limited range of sports, namely soccer,[31-33] ice hockey[34,35] and Australian Rules football.[36] When interpreting the findings of these studies, it is important to consider the task demands of the sport being investigated. For instance, the excursion of movement or the magnitude and velocity of loading may influence the structures at risk.

Reduced hip abduction[31] and total hip rotation[33] range of movement (ROM) have been reported as risk factors for groin strain in soccer players. Reduced total hip rotation ROM was also found to be a risk factor for pubic bone stress injury in Australian Rules footballers.[36] Conversely, reduced hip abduction ROM was reported as having no association with adductor muscle injury in both soccer[32] and ice hockey players.[34,35] Reduced hip adductor strength was reported as a risk factor for adductor strain,[35] but also as having no association with groin strain[34] in ice hockey players. The former study also found that a reduced ratio of hip adductor to hip abductor strength was a risk factor for adductor strain.[35] Although conflicting findings have been reported, the proposed risk factors suggest that musculoskeletal structures in the pubic region are of primary interest in athletic groin pain.[12]

4. Literature Review

4.1 Scope of the Review

The review was limited to descriptive studies that investigated the anatomy of the pubic region in humans. These include studies that performed gross anatomy or histological examination in human cadavers, or diagnostic imaging in athletes. The human cadaver studies provide greater anatomical detail than the imaging studies, yet may be limited in application due to specimen age and athletic development. Conversely, the imaging studies include subjects within an appropriate demographic, but without the strength of evidence provided by dissection or histology. Surgical studies were not included, as their purpose is to describe surgical technique or response to intervention. Subsequently, the review was restricted to primary research studies that applied a standardized procedure in previously uninjured specimens or healthy subjects. The specific focus of the review was the musculoskeletal anatomy of the pubic region, as these are the structures commonly implicated in the pathogenesis of chronic groin pain in athletes.

A number of disparities in the descriptions of pubic region anatomy were identified when comparing relevant research studies with modern anatomical texts.[37-42] Interestingly, some of the recently published data are consistent with anatomical descriptions contained in older texts.[43,44] It is important to note that editors of modern texts are challenged to describe human anatomy both accurately and concisely. However, this review concludes that there are three key disparities in musculoskeletal anatomy descriptions of the pubic region that have important implications for the pathogenesis and clinical management of athletes with chronic groin pain. These disparities relate to: (i) the composition and arrangement of the pubic attachments of the adductor longus (AL) muscle; (ii) the arrangement of the lower fibres of the internal oblique (IO) muscle and the lower part of the transversus abdominis (TrA) aponeurosis; and (iii) the relations of the soft tissue structures anterior to the pubic symphysis. The modern textbook descriptions of these structures will be presented and compared with the relevant research evidence that challenges their accuracy.

4.2 Composition of Adductor Longus at its Pubic Attachment

The AL muscle is described in modern texts as arising by a narrow tendon from the body of the pubis in the angle between the crest and the symphysis[37-41] (figure 1). A dissection study by Tuite et al.[45] (n = 37 elderly cadavers) reported that AL attaches to the pubis by a thin tendon anteriorly, consistent with the textbook description. However, they also found that in 92% of specimens, the deep surface of AL was characterized by muscular fibres attaching to the pubis.

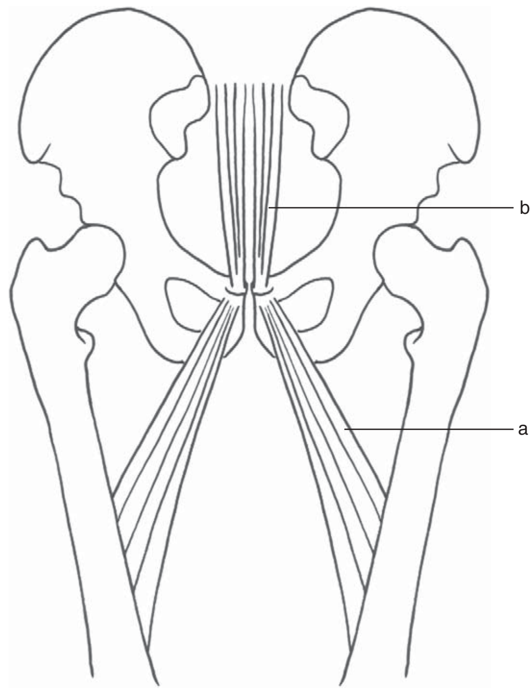

Fig. 1. Pubic attachments of (**a**) adductor longus and (**b**) rectus abdominis, according to textbook descriptions.

Furthermore, in 24% of specimens, the lateral 5–11 mm of the anterior attachment of AL was composed of muscular fibres.

More recently, Strauss et al.[10] undertook a dissection and histological study in 28 elderly cadavers to describe the cross-sectional anatomy of AL at its pubic attachment. The proximal 10 cm of 42 AL muscles were harvested and cut into three cross-sectional samples at 0, 1 and 2 cm from their bony attachment. The cross-sectional area was measured using microcalipers and the fibre composition was determined by microscopic analysis. Consistent with Tuite et al.,[45] the authors found that AL was composed of a thin tendon anteriorly, and muscular fibres on the deep surface of its pubic attachment. The relative contribution of tendon fibres was found to be only 38% (±13.0), and this proportion decreased with further distance from the origin (figure 2). This implies that 62% of the pubic attachment of

AL is composed of muscle fibres, which is in striking contrast with textbook descriptions of an entirely tendinous origin.[37-41]

4.3 Arrangement of the Lower Fibres of Internal Oblique and Transversus Abdominis

The composition and pubic attachments of the IO and TrA muscles are variably described in modern texts.[37,39,40,42] The lower fibres of IO and the lower part of the TrA aponeurosis are described as fusing to form a conjoint tendon, which then turns downward to attach to the pubic crest and pectineal line.[37,39,40,42] Additionally, Hollinshead and Rosse[40] and Sandring et al.[39] describe medial fibres from the conjoint tendon that extend medially to decussate at, and fuse with, the linea alba.[39,40] The reported functions of IO and TrA provide context for determining the clinical relevance of any variation in their description. Previous research has identified that TrA is controlled independently from IO, external oblique, RA and multifidus.[46] Furthermore, its transverse orientation and attachments suggest its potential involvement in lumbo-pelvic stability during postures and movement.[46,47] The onset of TrA activation has been found to occur in a feed-forward manner during lower limb movements in healthy subjects,[48,49] consistent with an anticipatory stabilization function. Interestingly, although it still occurred in a feed-forward manner, this onset was found to be significantly delayed in a cohort of Australian Rules footballers with chronic groin pain.[49]

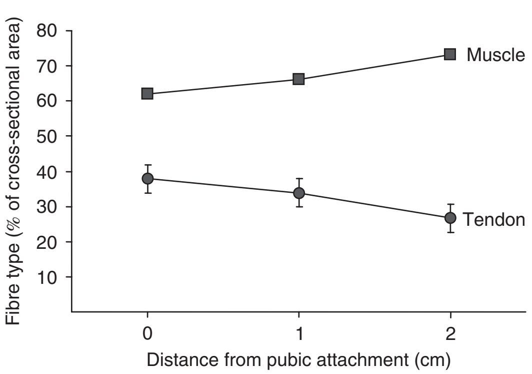

Fig. 2. Fibre composition of adductor longus proximally. Muscle and tendon fibre composition of adductor longus at 0, 1 and 2 cm from its pubic attachment, as reported by Strauss et al.[10]

A precise anatomical description of the attachments of IO and TrA is required to interpret the proposed functions of these muscles. Several authors have questioned the existence of a true conjoint tendon, albeit mainly from surgical observations rather than descriptive anatomical studies.[50-53] Condon[50] performed detailed dissections of the groin unilaterally in 135 male cadavers that were without hernia or previous regional injury. The author found that a true conjoint tendon occurred in only 4 of 135 (3%) specimens. Of the remaining specimens, there were three patterns of attachment noted. A direct pubic attachment of the TrA aponeurosis was identified in 11/135 (8%) specimens. The remaining 120/135 (89%) specimens were found to attach into the rectus sheath, the majority of which (101/120) were attached more than 0.5 cm above the pubic tubercule, as was the (separate) insertion of IO.

4.4 Confluence of Soft Tissue Structures Anterior to the Pubic Symphysis

The relationship of the soft tissues anterior to the pubic symphysis has been briefly described in modern texts.[39,40,42] However, growing clinical interest in the functional stability of the pelvic ring necessitates reassessment of these relations in detail. The stability of the posterior pelvic ring during the transfer of the weight of the trunk from the sacrum to the hips is derived from the arch-like morphology of the pelvic bones.[54-56] The 'pelvic arch' acts to resist shearing forces at the nearly vertical surfaces of the sacroiliac joint. Its strength is provided by fixation of its lateral ends, which requires activation of transversely oriented muscles such as IO, TrA and piriformis.[55,56] Anteriorly, the two pelvic arches are joined at the pubic symphysis.[54] Subsequently, the anatomical arrangement of structures adjacent to the symphysis may be important in developing a comprehensive model of pelvic ring stability.

The rectus sheath has been described to fuse with the periosteum adjacent to its pubic insertion.[39] Additionally, confluence of the rectus abdominis (RA), gracilis and fascia lata attachments has

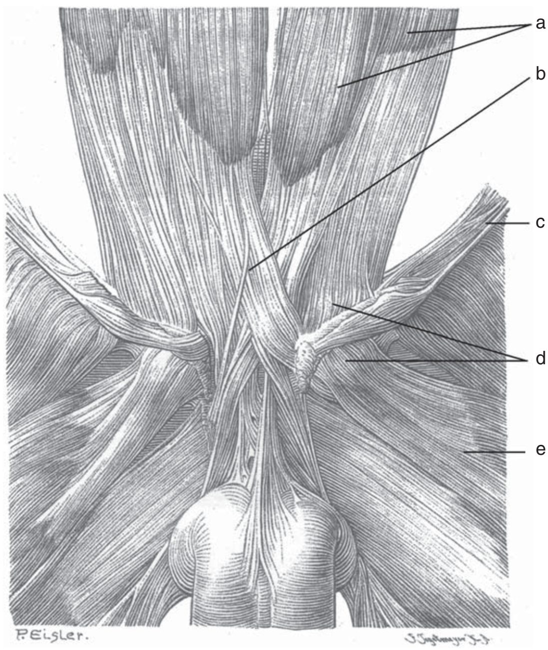

Fig. 3. Muscle attachments in the pubic region: (**a**) rectus abdominis; (**b**) decussating fibres of rectus abdominis; (**c**) inguinal ligament; (**d**) attachments of rectus abdominis and adductor longus in continuity; and (**e**) adductor longus (adapted from Eisler[43]).

also been detailed in the pubic region of males.[39] Schilders[28] reported that the anterior rectus sheath joins the fascia of the common adductors to form an aponeurosis covering the anterior surface of the pubic bone. However, limited details of their methods were provided and findings appear to be based on visual observation only. Similarly, Shortt et al.[57] described the pubic attachments of AL and RA as being continuous both on magnetic resonance imaging (MRI) and in cadaveric specimens. Both AL and RA were reported to fuse in the midline with the capsule of the pubic symphysis,[57] although the study methodology that generated these findings was not reported.

A more detailed study was performed by Robinson et al.,[11] who dissected the pubic region of 17 elderly cadavers (male and female) and then compared the findings with MRIs of the anterior pelvis in a group of ten healthy male athletes (mean age 17 years). Dissection revealed that the pubic attachment of AL consisted of tendon anteriorly and muscle fibre more deeply, in agreement with Strauss et al.[10] and Tuite et al.[45] Additionally, AL was attached to the pubic symphysis capsular tissues in all specimens. The composition of this capsular attachment was mixed tendon and muscle fibre in 53% of specimens, and entirely muscle fibre in 47%. RA was also found to attach to the pubic symphysis capsular tissues in all specimens, becoming continuous with AL. More deeply, the pubic symphysis capsular tissues were found to merge with the anterior surface of the interpubic disc and the articular cartilage. The attachment of the AL and RA muscles to the pubic symphysis capsular tissues was also found to be evident on MRI for all subjects. These findings suggest that an intimate relationship exists between AL, RA and the anterior capsular soft tissues of the pubic symphysis (figures 3 and 4).

4.5 Review Summary

This review has identified three key disparities in descriptions of the musculoskeletal anatomy of the pubic region that have implications for the pathogenesis and clinical management of athletes with chronic groin pain. The proximal attachment of AL may be predominantly muscular, rather than entirely tendinous as previously described. The lower fibres of IO and TrA appear to exist more commonly as separate entities attaching into the rectus sheath than as a ‘conjoint tendon’ into the pubic bone. The AL and RA are

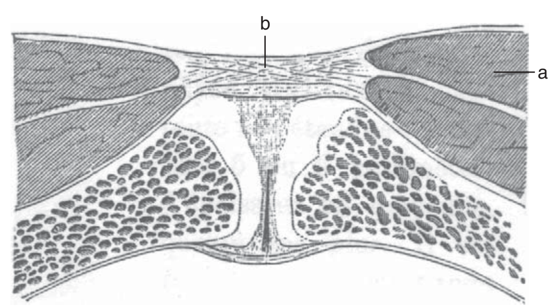

Fig. 4. Pubic symphysis, coronal section: (**a**) adductor longus and (**b**) decussation of adductor longus anterior to the pubic symphysis (adapted from Testut and Latarjet[44]).

reported to attach in continuity via the capsular tissues of the pubic symphysis. These tissues were also reported to merge with the interpubic disc and adjacent articular cartilage. Finally, the rectus sheath is reported to be continuous with AL via the pubic symphysis capsular tissues. This confluence of soft tissue structures anterior to the pubic symphysis may provide the anatomical substrate for a composite stabilizing or force transmission mechanism.

5. Implications for Pathogenesis and Clinical Management

While limited by availability of suitable studies, the findings of this review have several possible implications for the pathogenesis and clinical management of chronic groin pain. The predominantly muscular attachment of AL into the pubic bone implies that the pathogenesis of an adductor-related component of groin pain is likely to be best explained as an enthesopathy, rather than tendinopathy, such as that described for the Achilles or patellar tendons.[58,59] A treatment strategy based exclusively on a tendinopathy paradigm may therefore yield indifferent results. The proximal attachment of AL was also reported to extend beyond the pubic bone to attach in continuity with the RA via the anterior capsular tissues of the pubic symphysis. These descriptions provide a context for evaluating the mechanism of the limited adductor tenotomy procedure, in which the anterior aspect of AL is surgically divided. Orchard et al.[60] hypothesized that this procedure encourages more normal tendon loading, thereby assisting recovery in accordance with a 'stress-shielding' aetiology. However, the predominantly muscular composition of AL at its pubic attachment suggests that this hypothesis requires further consideration.

An alternative explanation for the apparent clinical benefit of the limited adductor tenotomy procedure is that it may disrupt connections between AL and the capsular tissues, and thus reduce stress loading on the anterior pubic symphysis. The anterior relations of the pubic symphysis identify that the AL, RA, IO and TrA muscles have the potential to contribute to a composite mechanism that could provide pelvic ring stability and force transmission (figure 5). These functions are particularly relevant when considering that repeated loading of the pubic region is commonly described in the aetiology of chronic groin pain.[5,14,61] While the functional interaction between these structures has been reported previously,[62,63] the anatomical connections described in this review have further implications. A direct anatomical connection provides a mechanism for overlapping pathologies, thereby strengthening the hypothesis that chronic groin pain is likely to involve multiple structures. If a single musculoskeletal structure was involved, it would be reasonable to expect that symptoms, assessment findings and outcomes would be relatively predictable. However, clinical evidence suggests that chronic groin pain

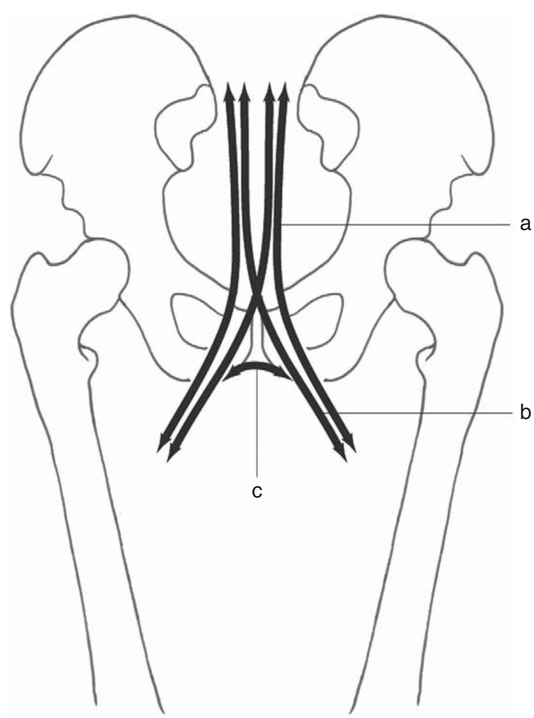

Fig. 5. Potential load transfer pathways. The arrangement of the pubic fibres of adductor longus and rectus abdominis may allow direct load transfer between the muscles ipsilaterally (**a**) and contralaterally (**b**). Decussating fibres of adductor longus may allow load transfer between the muscle pair (**c**).

is often associated with vague, diffuse symptoms, inconsistent clinical findings, and a varied response to interventions.[3,5,14,18,64] In this context, the pathogenesis of chronic groin pain is more consistent with a multiple entities paradigm, perhaps reflecting a common reaction pattern to repetitive pubic region loading.[5,14,61]

The confluence of structures anterior to the pubic symphysis may question the validity of some clinical examination tests used routinely in the assessment of chronic groin pain. The direct anatomical connections between AL, RA, IO and TrA muscles suggest that it is unlikely that pain provocation or stress tests load single anatomical structures in isolation. Active hip adduction against resistance is a test that is commonly performed in the clinical examination of athletes with chronic groin pain. In the authors' experience, this test can in some instances reproduce suprapubic rather than infrapubic pain. This clinical finding may be attributable to synergies between AL and the lower abdominal musculature. Alternatively, the finding may be due to a provocative force initiated by AL, and then delivered to the superior aspect of the pubis via connections with the pubic symphysis capsular tissues and lower abdominals.

The reliability and validity of clinical examination tests commonly used in the assessment of athletes with chronic groin pain have been investigated in a variety of populations.[7,36,63,65-68] However, the diagnostic validity of these tests is yet to be established. The complex, interdependent anatomy revealed in this review suggests that it is challenging for the sports medicine practitioner to precisely diagnose structures associated with chronic groin pain. With the current available evidence, the role of clinical examination in the assessment of chronic groin pain may be limited to identifying the musculoskeletal deficits associated with the condition.

6. Conclusion

This review of the literature has identified several descriptions of pubic region anatomy that differ from those provided in modern texts. These variations have possible implications for understanding the pathogenesis of chronic groin pain and its clinical management. The proximal attachment of AL was reported to be predominantly muscular, rather than fibro-tendinous. Subsequently, the pathogenesis of insertional adductor pain may be best explained as an enthesopathy, rather than tendinopathy. The IO and TrA muscles were found to attach medially into the distal rectus sheath, rather than directly into the pubis. In addition to an extension from AL, the rectus sheath then forms a confluence of aponeurotic structures anterior to the pubic symphysis. While a functional connection between AL, IO, TrA and RA has been previously suggested, a direct anatomical connection has broader implications.

A composite structure anterior to the pubic symphysis provides the anatomical substrate for the multiple clinical entities model of chronic groin pain. It provides an alternative mechanism for the surgical procedure of limited adductor tenotomy, in which disruption of the connections between AL and the capsular tissues may reduce the stress loading on the pubic symphysis. It also suggests that it is unlikely that pain provocation or stress tests load single anatomical structures in isolation. This feature may provide an explanation for the authors' clinical observation that resisted hip adduction can in some instances reproduce suprapubic rather than infrapubic pain. Additionally, the role of clinical examination in the assessment of chronic groin pain may be limited to identifying the musculoskeletal deficits associated with the condition. Subsequently, a functional approach to conservative management may be appropriate in the absence of definitive clinical findings.

The findings of this review have several possible implications for understanding the pathogenesis of chronic groin pain and its clinical management. It is important to note that this review was limited to the small number of descriptive studies that specifically investigated the anatomy of pubic region in humans. Subsequently, the findings of this review should be hypothesis generating, with further anatomical and clinical studies warranted to establish their veracity.

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