UNDERSTANDING TENDINOPATHIES
OF THE HIP & PELVIS

BOOK FOUR:
Iliopsoas and Adductor Related Groin Pain
Introduction

Tendinopathies of the hip and pelvis represent a large burden on both the sporting and ageing populations. Growing evidence is shaping contemporary conservative management of tendinopathy.

This e-book series aims to provide readers with guidance towards a deeper understanding of tendinopathies of the hip and pelvis and more effective clinical management based on an emerging evidence base derived from scientific studies on structure and mechanobiological mechanisms, risk factors, impairments and the available information on effects of intervention.

Book 4 of this series explores two common groin pain clinical entities, adductor-related and iliopsoas-related groin pain. The adductor and iliopsoas tendons play a key role in these clinical entities, either as a pain source or a mechanism by which forces transferred by the tendon to adjacent structures results in pain or injury. A review of impact and prevalence, clinical presentation and local anatomy prepares the reader for the detailed analysis in the following chapters. Data available for pathology, pathoetiology, impairments and diagnostic utility of clinical tests will be examined. The available scientific evidence and 25 years of clinical experience are combined to provide clinically relevant and readily applicable information.

Is this e-book suitable for you?

This book is suitable for anyone involved in management of tendinopathies of the hip and pelvis or prescription of exercise in at-risk groups – such as the athletic population or perimenopausal women. The content assumes readers have a basic knowledge of anatomy and muscle function in this region.

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CHAPTER ONE
IMPACT & PREVALENCE

PREVALENCE
Groin Injury in Sport
Gender Bias
Prevalence of ARGP & IRGP

IMPACT
Severity of Injury & Time Loss
Recurrence
Impact on Sporting Success
Impact on Club
Impact of surgical interventions for IRGP
Prevalence of Groin Pain & Injury

Groin pain is common in athletes, particularly within the football codes and ice hockey (Eckard et al. 2017, Orchard 2015) and may have substantial impacts on both individual and team performance. Injury surveillance data collected over 21 years in the Australian Football League (AFL), indicated that groin injury was the second most common injury sustained in this sport and the second most common reason for missed matches, after hamstring injury (Orchard et al. 2013). Similarly, in professional football (soccer), groin injuries are the second most common musculotendinous injury (Walden et al. 2005), with hip and groin injuries accounting for 12-16% of all injuries across seven seasons of European professional football (Werner et al. 2009). One in every five football players in the Qatar professional football league experienced a groin injury each season (Mosler et al. 2017). Groin injury and particularly adductor injury, is also more prevalent in males compared with females playing the same sports (Eckard et al. 2017, Orchard 2015, Walden et al. 2015).

There are many differing reports and opinions regarding the most common sources of groin pain. This will be addressed more fully in the pathology section. Across the literature, the most prevalent clinical entity associated with groin pain is adductor-related groin pain, with some reporting this entity responsible for 60-70% of all groin pain in athletes (Holmich et al. 2007, Taylor et al. 2017). Iliopsoas-related groin pain is usually rated as the second or third most common cause and is often diagnosed as a second entity where multiple pain sources exist (Holmich et al. 2007, 2014, Mosler et al. 2017, Taylor et al. 2017, Werner et al. 2009). Holmich (2007) assessed 207 athletes with long standing groin pain to determine their primary, secondary and tertiary pain sources. In 36% of these athletes the primary clinical entity was iliopsoas related groin pain, with this entity the secondary or tertiary source in 55% of athletes. In the runners assessed, iliopsoas-related groin pain was the most common primary clinical entity (Holmich et al. 2007).

Painful snapping or impingement of the iliopsoas tendon has also been documented in the literature. Anterior or internal snapping is common in the dance population (Winston et al. 2007). Within a population of 653 injured dancers, the incidence of iliopsoas ‘syndrome’ (pain, weakness, snapping) was 9.2% in female dancers and 3.2% in male dancers. The highest incidence was in student dancers (14%), followed by amateur dancers (7.5%), with professional dancers having the lowest incidence (4.6%) (Laible et al. 2013).

Hip and groin pain associated with impingement of the iliopsoas tendon against the underlying joint structures has been a topic of much investigation and remediation in recent years. Iliopsoas impingement or tendinopathy has been diagnosed in association with labral pathology and femoroacetabular impingement (FAI) and reported as a cause of ongoing hip pain post hip arthroscopy and arthroplasty (Domb et al. 2011, Mardones et al. 2016, Philippon et al. 2011). A 4% prevalence of painful iliopsoas tendinopathy and impingement has been reported following total hip arthroplasty (Henderson & Lachiewicz 2012).
Impact of Groin Pain & Injury

Groin pain reduces an athlete’s ability to accelerate, decelerate and change direction while running, impacting on sports participation and performance. There is a wide spectrum of severity and associated impact, varying from mild symptoms lasting 7 days or less, to more severe injuries lasting for longer than 28 days with career altering potential. Moderate and severe injuries account for 60 - 75% of groin injury in football (lasting from 8 days to more than 28 days) (Holmich et al. 2014, Mosler et al. 2017).

Groin injury also has a propensity for recurrence, with 25% of injured AFL players experiencing recurrent or ongoing problems following the initial injury (Orchard et al. 2013). Subsequent injuries also tend to keep the athlete out of sport for longer. In one large study of professional footballers, an initial groin injury kept an athlete out of sport for an average of 14 days, while reinjuries resulted in an average 23-day absence (Werner et al. 2009).

The impact on a club can be substantial with groin pain resulting in a median loss of 85 days (IDR 35-215) per season for each football club (Mosler et al. 2017). Days out of training and competition has been shown to have a direct impact on performance and achievement. Drew et al. (2017) found strong evidence for an association between availability of team members and risk of failure - the less availability for training and competition, the higher the risk of failure. Similarly, lower injury burden and higher match availability have been associated with increased points per match and higher final football league ranking (Haggland et al. 2013). Player injuries also place a significant financial burden on individual athletes or professional clubs responsible for rehabilitation.

Iliopsoas tendon conditions secondary to snapping hip or associated with underlying joint pathology or prosthetic implant, may result in substantial pain and disability. Brandenburg et al. (2016) reported that patients with painful anterior snapping hip associated with FAI or chondrolabral damage, may progress to surgical release of the iliopsoas tendon if unresponsive to conservative management. Post surgery, the patients in this study were left with a 25% loss of iliopsoas volume and a 19% reduction in seated hip flexion strength at a mean of 21 months post surgery. Unfortunately, no patient rated outcome measures were available to correlate these changes with functional impact, however as the average age for patients in this study was between 30 and 35 years, such significant losses of muscle size and strength are likely to impact on function, muscle balance within the hip flexor synergy and even on muscular protection of the underlying joint.

Arthroscopic release of the iliopsoas tendon increases the risk of hip joint instability and even dislocation post arthroscopic surgery (Austin et al. 2014, Sansone et al. 2013, Yeung et al. 2016). Considering the potential long term negative impact of surgical iliopsoas release, early identification and effective conservative management strategies are required.
Groin Pain

Prevalence

Most common in football codes and ice hockey

Groin injury most common in male athletes

2nd most common injury in football codes

ARGP most common clinical entity in athletes

IRGP 2nd - 3rd most common clinical entity in athletes

IRGP most common entity in runners

Figure 1: Prevalence of groin pain. ARGP: Adductor-Related Groin Pain; IRGP: Iliopsoas-Related Groin Pain
CHAPTER TWO
CLINICAL PRESENTATION

CLINICAL ENTITIES MODEL
Adductor-Related Groin Pain
Iliopsoas-Related Groin Pain
Inguinal-Related Groin Pain
Pubic Related Groin Pain

ADDUCTOR-RELATED GROIN PAIN
Area of Pain
Painful Postures & Activities
History

ILIOPSOAS-RELATED GROIN PAIN
Area of Pain
Painful Postures & Activities
History
Clinical Entities Model

One of the most significant impediments for clinicians and researchers working with groin pain, has been the lack of a common language. A review of groin pain management in 2015 highlighted the disparity in terminology, with 33 different diagnostic terms for groin pain used across 72 studies (Weir et al. 2015). This issue has made it very difficult to compare study results and for clinicians to communicate without misinterpretation.

To address this issue, 24 international experts from 14 countries agreed on a classification system for groin pain (The Doha Agreement, Weir et al. 2015), adopting and developing a clinical entities approach first suggested by Holmich et al. (2007). This approach seeks to describe distinct clinical presentations without determination of the exact underlying pathological structure or pain source, around which there is still inadequate consensus. With a consistent clinical diagnosis, imaging and surgical studies may be able to identify the most common pathologies associated with each clinical entity.

The Doha system has three major divisions:
1. Defined clinical entities for groin pain
2. Hip-related groin pain
3. Other causes of groin pain (e.g. Referred pain from lumbar spine, stress fracture, tumours, intra-abdominal and gynaecological conditions)

Defined Clinical Entities for Groin Pain (Figure 2)

1. Adductor-related groin pain
   **Definition:**
   Adductor tenderness AND pain on resisted adduction testing.

2. Iliopsoas-related groin pain
   **Definition:**
   Iliopsoas tenderness AND pain on resisted hip flexion AND/OR pain on hip flexor stretching.

3. Inguinal related groin pain
   **Definition:**
   Pain in the inguinal canal region AND tenderness of the inguinal canal AND no palpable inguinal hernia. Pain on resistance of the abdominal muscles OR on Valsalva/cough/sneeze.

4. Pubic-related groin pain
   **Definition:**
   Tenderness of the pubic symphysis and immediately adjacent bone.

Figure 2: Clinical Entities for Groin Pain. ARGP: Adductor-Related Groin Pain; IRGP: Iliopsoas-Related Groin Pain; INRGP: Inguinal-Related Groin Pain; PRGP: Pubic-Related Groin Pain
For the purposes of this book, we will focus on the two most common groin pain entities, adductor-related and iliopsoas-related groin pain. In both cases the tendon is implicated in a significant proportion of presentations, but not all. More detail regarding specific pathologies will be provided in Chapter 4.

Adductor-Related Groin Pain

Area of Pain
Adductor-related groin pain is most commonly experienced within the proximal 1/3 of the adductor muscle region and/or at the adductor origin. With long standing pain, the symptomatic region is often less precise and may spread further across the pubic symphysis and into the lower abdomen, inguinal and contralateral adductor region. This reflects a multiple entity presentation.

History
Onset of pain may either be acute or of gradual onset. When acute, the most common mechanisms of injury described include kicking, change of direction, reaching or stretching, running or sprinting, jumping, tackling or sliding (Serner et al. 2017a). Patients complaining of pain of gradual onset may be unable to identify a single precipitating event, but may report increasing difficulty with these types of activities - pain, stiffness or loss of range, reduced performance. Pain and stiffness at the beginning of activity may ease as the athlete warms up. As the condition progresses, the symptoms remain throughout the activity and may persist or worsen after activity.

The clinician should also aim to identify potential contributing factors in the patient history which may include previous injury, a change in loading and general health factors.

Painful Postures & Activities
Following an acute adductor injury, pain may be experienced during many normal daily activities such as walking, standing on one leg, turning or changing direction while weightbearing on the injured leg, lifting the leg to dress or move in and out of the car, coughing or sneezing. Symptoms will vary with injury severity.

With milder, subacute or chronic adductor related groin pain, there is usually little to no pain at rest and during normal activities of daily living. The primary issues are with higher load or dynamic tasks such as running, particularly acceleration, deceleration and direction change, kicking, hopping, bounding, deep split lunges or side lunges. The athlete may be able to participate in sport but full speed and function is hampered by pain or a lack of power.
**Iliopsoas-Related Groin Pain**

**Area of Pain**

Iliopsoas-related groin pain is located more anteriorly over the iliopsoas muscle, lateral to the adductors and across the hip joint in the mid-inguinal region. It may extend into the lower abdomen and distally a short distance into the proximal thigh, usually described as a deep discomfort or tightness as the muscle runs posteriorly to insert on the lesser trochanter.

**Painful Postures & Activities**

Pain related to the iliopsoas is generally experienced either during actions that load the hip flexor complex into flexion or stretch the tissues into extension. For runners with iliopsoas-related pain, the problem is most evident through late stance and early swing phase of running. The runner may complain that the hip tightens up anteriorly during their run, resulting in pain and/or limitation of stride length. Symptoms tend to increase with distance and speed of running, particularly with longer stride lengths. Iliopsoas-related pain may also occur in walkers, again evident particularly in late stance and early swing and with longer stride lengths and higher speeds.

For more severe situations, such as after acute injury or iliopsoas impingement post hip arthroplasty, significant pain may occur during hip flexion tasks such as walking upstairs, dressing or lifting the leg in and out of bed or the car.

**History**

Iliopsoas-related groin pain may also be either acute or more insidious in onset. Acute onset in one study was associated with kicking, sprinting, tackling and sliding. Interestingly, the most common mechanism of injury was changing direction (Serner et al. 2017b).

Onset of symptoms may also be associated with a change in activity, previous surgery (e.g. arthroscopy or total hip arthroplasty) or general health factors. Don’t forget to ask about medication. Ciprofloxacin induced tendinopathy and rupture of iliopsoas tendons has been reported in the literature (Smith et al. 2016).

**Other Symptoms**

Patients with iliopsoas-related groin pain may also complain of a snapping sensation at the anterior hip often accompanied by an audible click. Snapping most commonly occurs while eccentrically lowering a flexed hip, particularly if externally rotated. This may occur when dressing or extending a flexed hip such as in supine abdominal leg loading exercises. For dancers, the snap occurs most frequently during grand battement or passe’ developpe’ (actions that require high hip flexion and external rotation under long lever loads (knee extended or extending during the action).
CHAPTER THREE
REVIEW OF LOCAL ANATOMY

THE ADDUCTOR COMPLEX
Adductor Muscles
Adductor Origins & Connections
The Proximal Tendon of the Adductor Longus

THE ILIOPSOAS COMPLEX
Muscles
Anatomical Relationships of the Psoas Tendon
Functional Anatomy
The Hip Adductor Complex

The adductor synergists include the adductor longus, brevis and magnus, gracilis and pectineus (Figure 3). The short external rotators also have potential for a small secondary adductor function due to their location medial to the hip joint centre (Gudena et al. 2015, Vaarbakken et al. 2015). The adductor longus sits anteriorly and is the most commonly involved muscle in presentations of adductor-related groin pain.

Figure 3: The Hip Adductor Synergy: Adductor Longus (AL); Adductor Brevis (AB); Adductor Magnus (deeper/posterior), Pectineus (P) and Gracilis.

The primary functions of adductor longus are hip adduction and hip flexion. Gait studies have demonstrated that adductor longus is activated in late stance and early - mid swing phases (Lee & Hidler 2008, Green & Morris 1970, Perry 1992). This is consistent with a functional role for adductor longus in assisting the primary hip flexors to eccentrically control extension in the final stage of terminal stance and initiate hip flexion. Not surprisingly, adductor longus is also highly active during a kicking action (Charnock et al. 2009).

The adductors are thought to play an important role in global stability mechanisms of the pelvis, coupling with the abductors to provide mediolateral control. Adductor longus has been shown to be involved in postural balance mechanisms in both the coronal and sagittal planes (Henry, Fung & Horak 1998).

In addition, the adductor longus has strong connections across the pubic symphysis and into the abdominal wall, suggesting that this muscle is involved in the transfer of large forces between the lower limbs and trunk (Robinson et al 2007, Robertson et al 2009).
Figure 4: The adductor origin and connections. Fibrous connections exist between:
- the left and right adductor longus (AL)
- the adductor longus and both ipsilateral and contralateral abdominals
- the adductor longus and rectus abdominis (RA) tendons and the pubic symphysis capsule and disc

All connections flow through a fibrous aponeurotic plate sitting anterior to the pubic symphysis.

Insert depicts the pyramidalis muscle (*).
ADDUCTOR ORIGIN & CONNECTIONS

Detailed cadaveric and imaging studies have described a complex confluence of structures across the pubic symphysis. Robinson et al. (2007) revealed a continuity of fibrous tissue joining the adductor longus tendon and the rectus abdominis over the pubic symphysis. Both tendons also have connections directly into the capsule of the symphysis pubis and even pass through the capsule to attach to the underlying disc and cartilage.

The adductor longus attaches not only to the ipsilateral rectus abdominis, but to the contralateral abdominal wall, and to the contralateral adductor longus, fibres passing through a fibrous aponeurotic plate that sits anterior to the pubic symphysis incorporating the pubic symphysis capsule and all tendinous attachments (Figure 4 & 5). Another small and sometimes inconstant muscle, the pyramidalis, contributes its tendinous fibres to this adductor-abdominal aponeurotic plate. Arising from the linea alba about half way between the umbilicus and the pubis, the muscle is thought to play some role in tensioning the rectus sheath and the linea alba (Natsis et al. 2016). Adductor brevis tendons sometimes, and the gracilis tendons occasionally, also have attachment to the fibrotic plate. Many large forces pass through this fibrous confluence.

Figure 5: Sagittal depiction of the confluence of the rectus abdominis (RA) and adductor longus (AL) tendons and the fibrous aponeurotic plate sitting anteriorly to the pubic symphysis. Pyramidalis *
The Proximal Tendon of the Adductor Longus

The adductor longus inserts onto the pelvis via both a tendinous and a muscular insertion, although the contribution of each to the insertion would appear quite variable, and is perhaps influenced by gender.

The main fibrous tendon sits superficially or anteriorly at the insertion, while the deeper part of the tendon may be more muscular. Strauss and colleagues (2007) in a dissection of 28 cadavers, reported that only 38% of the adductor longus attachment was tendinous, the remaining 62% comprised of muscle. Davis et al. (2011) in a more recent study, reported similar cross sectional areas of the adductor longus attachment at the proximal origin, however they found tendinous fibres comprising 94% of the attaching tissue. Davis et al. (2011) had a smaller sample size and interestingly a much larger distribution of females in their sample, whereas Strauss et al.’s (2007) study was more heavily dominated by male samples (Table 1).

One other earlier cadaveric study, with the largest sample size assessed a more equal distribution of males and females (Tuite et al. 1988). These authors did not provide a percentage of tendon to muscle at the insertion but described a tendinous superficial portion, with the deeper posterior portion of the insertion comprising of more muscular fibres. They noted many anatomical variants, the most significant being that in 25% of their cadavers there was a significant increase in muscular contribution to the lateral aspect of the insertion. This was twice as common in males.

From this information it would seem that in females it is possible to have an almost completely tendinous enthesis, while in males there may be significant variability, with the muscular component comprising more than 50% of the tendon insertion.

<table>
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<td>49.3</td>
<td>37.9</td>
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<tr>
<td>Davis et al 2011</td>
<td>3:7</td>
<td>56.6</td>
<td>93.9</td>
</tr>
<tr>
<td>Tuite et al 1998</td>
<td>18:19</td>
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Muscle on deep surface normal. Anatomic variant in 25% of specimens - increased muscle in lateral insertion. Twice as common in males.

Table 1: Summary of findings of dissection studies assessing adductor longus tendon of origin. CSA:Cross Sectional Area.
On ultrasound, a much longer tendon of insertion is evident on the superficial or anterior aspect of the muscle (Figure 6). The deep surface is much more muscular almost all the way to the bone, but it does appear to have a short fibrous transition zone. This is consistent with the description and diagram provided by Orchard et al. (2004) in their surgical study on adductor tenotomy.

![Image of ultrasound of Adductor Longus Enthesis](image_url)

**Figure 6: Ultrasound of Adductor Longus Enthesis:** Note the superficial tendon of adductor longus inserting into the pubis (outlined) and the short fibrous transition zone connecting the deep muscular component (arrowhead). AL: Adductor Longus; AB: Adductor Brevis; AM: Adductor Magnus; ADL: Adductor Longus Tendon.

If we look further at the specific nature in which the adductor longus attaches proximally into the pubic symphysis capsule, Robinson et al. (2007) describes two patterns of attachment:

1. Both the superficial tendinous and the deeper muscular component attach to the capsule (53% of specimens)
2. The tendon attaches to the pubic tubercle and the muscular attachment inserts predominantly into the capsular tissues (47% of specimens - more common in males).

From Robinson et al.'s (2007) work, we know that the fibres that blend into the capsule may continue through to the cartilage and bone. Davis et al. (2011) reported that histological assessment confirmed that the adductor longus enthesis was fibrocartilaginous in nature, reflecting adaptation to protect the tendon from excessive compression and the bone from shear force.
Adductor Longus Proximal Musculotendinous Junction

From the attachment site, the adductor longus tendon lies superficially on the muscle and generally extends distally 6-7cm on the medial side of the muscle and 1-2 cm on the lateral aspect, resulting in an oblique musculotendinous junction (Figure 7a). Davis and colleagues (2011) dissected the superficial muscle fibres away from the tendon along it’s entire length, to reveal for the first time an intramuscular extension of the tendon (Figure 7b & c). They found the tendon extends on average 11-13cm in length or 20% or more of the femoral length. An intramuscular tendon may provide extra strength and stability for muscles involved in the transmission of large mechanical forces. The biceps femoris long head similarly has an intramuscular tendon. These junctions may fail under high load. Davis et al. (2011)suggests that pathology previously referred to as proximal adductor muscle strain may in fact be pathology of the intramuscular tendon, or a musculotendinous junction injury.

Figure 7: Diagrammatic representation of adductor longus proximal tendon structure and variations. a.tendon from an anterior or superficial view. b & c. side view or profile of the tendon, with the tendon initially sitting superficial and then dropping within the muscle belly. b. depicting greater muscular insertion, more likely in males. c. depicting greater tendinous insertion, more likely in women. AL: Adductor Longus muscle belly; O: Bony Origin of adductor longus
The Iliopsoas Complex

The iliopsoas consists of two muscle bellies, the iliacus and the psoas major (Figure 8). The iliacus arises from the upper two thirds of the iliac fossa and the lateral edge of the proximal sacrum, while the psoas major originates from T12-L5 lumbar vertebra and intervertebral discs. The medial fibres of the iliacus and the psoas merge to form the iliopsoas tendon which inserts into the lesser trochanter. The lateral fibres of the iliacus attach onto the adjacent region of the anterior femur via a more muscular attachment.

The psoas minor, present in 40-60% of people, sits anterior to the major, arising from T12 and L1 and inserting into the pectineal line. It also inserts heavily into the fascia iliaca that hammocks across the muscle bellies of the iliopsoas complex as they run through the pelvis (Neumann & Garcia 2015).

Iliocapsularis, often missing from text books, sits lateral to the iliacus muscle belly at the anterior hip. It originates from the inferior facet of the anterior inferior iliac spine, below the rectus femoris origin and inserts onto the femur adjacent to the lateral iliacus insertion (Walters et al. 2014).

Figure 8: The Iliopsoas Complex: Psoas Major (PS), Psoas Minor (Pm), Iliacus (IL) and Iliocapsularis (IC). a. Anatomy of the region. Pink shadow indicates fascia iliaca (FI), red crescent and arrowhead indicates Psoas Minor bony insertion. b. Closer view of tendinous insertions and iliocapsularis insertion onto capsule (C).
Anatomical relationships of the psoas tendon at the anterior hip

The psoas tendon sits directly adjacent to the iliopsoas bursa, capsule and labrum at the anterior hip (Figure 9). The iliopectineal bursa is the largest synovial bursa in humans, measuring on average 5-7cm long, and 2-4cm wide (Johnston et al. 1998). It lies between the iliopsoas musculotendinous unit and the pelvic brim and may extend proximally into the iliac fossa, and distally over the femoral head and down to the lesser trochanter. It communicates with the hip joint in approximately 14% of adults. In normal imaging studies it is not usually visible but becomes evident if extended with fluid.

Figure 9: Axial MRI and diagrammatic representation of the psoas tendon at the anterior hip.
A: Acetabulum; FH: Femoral Head; *: Anterior acetabular labrum; B: Iliopectineal Bursa; Pink arrowhead indicating psoas tendon; Green line: Capsule.
The iliopsoas unit functions together as the primary hip flexor. It can also work in a reverse origin-insertion action to flex the trunk forward over the femur. Acting unilaterally, the psoas major may create some trunk lateral flexion. There has been some controversy regarding a small role for the iliopsoas in the axial plane. It appears that at least the fibres that insert into the lesser trochanter may have a small moment arm for lateral rotation. (Blankenbaker & Tuite 2008, Rajendran 1989).

In terms of stability function, the psoas major can provide an axial compression force to support the lumbar spine. EMG evidence also suggests the psoas major muscle may be important in maintaining the lumbar lordosis (Park et al. 2013). Fascicles of the psoas major may however vary their influence across the lumbar spine due to their positioning close to the axis of rotation. Small changes in spinal curvature may shift the resultant action of the psoas major (Park et al. 2014). The iliopsoas tendon, the iliacus muscle belly and the iliocapsularis with its capsular attachment, provide anterior support for the hip joint, particularly as the hip moves into extension (Lewis et al. 2009, Walters et al. 2014, Ward et al. 2000).

The psoas minor, although small and inconstant, has been suggested to play a role in mechanically stabilising the underlying iliopsoas. By influencing the tension in the iliac fascia, Neumann & Garceau (2015) propose that this muscle may influence stability of the iliopsoas tendon. Furthermore, this tension may prevent lifting of the iliopsoas muscle bellies within the pelvis as the hip moves into high ranges of hip flexion. Further research is required to provide support for these proposed functions.

**Force couples around the pelvis**

Reflecting on how the iliopsoas works within muscular force couples around the pelvis (Figure 10), can provide direction regarding selection of rehabilitative cues for exercise therapy. This may be particularly important when rehabilitating patients with painful snapping of the iliopsoas tendon. This will be discussed further in subsequent chapters.

![Figure 10: Sagittal representation of hip and pelvis. Iliacus and the erector spinae anteriorly rotate and rectus abdominis posteriorly rotates the pelvis on the femurs. The effect of the psoas major will vary depending on spinal posture.](image-url)
ADDUCTOR RELATED GROIN PAIN
Sites of Adductor Pathology
Acute Groin Injury
Long standing Adductor-Related Groin Pain

ILIOPSOAS RELATED GROIN PAIN
Sites of Iliopsoas Pathology
Acute Hip Flexor Injury
Long standing Iliopsoas-Related Groin Pain
Terminology

As outlined in Chapter 2, the Doha consensus has recommended the clinical entities model for diagnosis of groin pain, reflecting a recognisable pattern of signs and symptoms, rather than a pathological entity (Weir et al. 2015).

The group recommended avoiding the following terms:

- Adductor tendinitis/tendinopathy
- Iliopsoas tendinitis/tendinopathy
- Athletic Groin Pain
- Athletic Pubalgia
- Osteitis Pubis
- Biomechanical Groin Overload
- Gilmore’s Groin
- Groin Disruption
- Hockey-Goalie Syndrome
- Hockey Groin
- Sportsman’s Groin
- Sportsman’s Hernia
- Sports Hernia

The clinical entities model is a useful approach that helps define an international language with which researchers and clinicians can communicate more effectively.

The clinical entities model does not however define underlying pathological processes associated with these presentations.

Is this important? An understanding of pathology and more importantly patho-aetiology, is usually considered one of the foundation stones for building effective strategies for management and prevention of musculoskeletal conditions. While psychosocial drivers of pain have become a large focus in contemporary rehabilitation and should be closely considered, it is important that we do not lose sight of the importance of biological drivers. Lorimer Moseley at IFOMPT 2016 provided the following viewpoint: “…the biopsychosocial model rejects the biomedical model because the medical model is not concerned with the person. But it does not reject the role of structural, biomechanical and functional disturbance of body tissue as potentially powerful drivers of protection.”

The challenge now is to define what structural and biomechanical issues may be related to pain and impairment associated with each of the clinical entities outlined for groin pain. There are many papers describing different structural pathologies in those presenting with various previous diagnoses of groin pain. It is not yet clear where each of these pathologies may fall within the clinical entities model.
Adductor-Related Groin Pain

Sites of Adductor Pathology

Investigation of groin pain in the adductor region reports variable areas of injury or pathology. Damage may occur in the proximal enthesis or tendon of the adductor longus, the musculotendinous junction and the muscle belly itself (Atkinson et al. 2010, Schilders et al. 2009, 2007; Shortt et al. 2008; Orchard et al. 2004; Zoga et al. 2008; Kalebo et al. 1992, Gabbe et al. 2010). Damage may also extend into the aponeurotic connection between the adductor origin and the rectus abdominis insertion, sometimes referred to as the pubic aponeurosis (Falvey et al. 2016). A recent editorial highlighted the issue with inconsistency in radiological terminology used in the groin region. They suggested that global agreement on imaging terminology, together with the clinical entities agreement regarding clinical diagnoses would represent a significant advance in the field (Weir et al. 2017).

Acute Groin Injury

One recent prospective study of 111 acute onset adductor injuries in male athletes, reported on the associated MRI findings (Serner et al. 2017a). Adductor longus was most commonly injured (62/111), followed by adductor brevis (18/111) and pectineus (17/111), with a low injury frequency in obturator externus (9/111), gracilis (4/111) and adductor magnus (1/111). Injury within the adductor longus occurred in three locations - the proximal insertion (26%), the intramuscular musculotendinous junction of the proximal tendon (26%) and the musculotendinous junction of the distal tendon (37%). Intramuscular proximal tendon injury only occurred in one instance in this series. Of the proximal adductor tendon injuries, three quarters of these acute injuries were avulsions. The authors suggest that the high prevalence of avulsions may be a reflection of the study location at a hospital, where those presenting to a hospital for assistance may have more severe injuries.

Although this study excluded patients with gradual onset or exacerbation of ongoing pain, tendon rupture usually reflects some pre-existing underlying weakening of tendon structure. While histopathological studies in groin pain are scarce, Ippolito and Postacchini (1981) did examine a sample from an adductor longus tendon that ruptured from its enthesis. They demonstrated thickening of the proximal fibrocartilage at the tendon insertion, implying that the fibrocartilaginous tissues had extended beyond the normal transition zone, reducing the mechanical efficiency for tensile load and resulting in tendon rupture. Ruptured Achilles tendons have also been shown to be structurally deficient and therefore at risk prior to rupture (Mafulli et al. 2011).
Long standing adductor-related groin pain

Many differing pathologies have been reported in imaging and surgical studies for long standing groin pain. However, often no specific pathologic entity is identified or there is no correlation attempted between specific physical assessment or clinical diagnoses and imaging or surgical findings. A recent review of 73 surgical studies has demonstrated that for 463 of 570 patients undergoing surgery for adductor-related pathology, the specific nature of the pathology was not provided. For the remaining 107 patients, adductor tendon pathology was noted in 84, tendon rupture or avulsion in 7 and a ‘strain’ in 16 patients.

For isolated adductor pathology, it would appear that the adductor longus tendon and its enthesis are common locations for pathology. Ultrasound papers have identified abnormality within the adductor tendon, such as hypoechoic areas and discontinuity of deeper tendon fibres (See Figure 11) (Kålebo et al. 1981, Pesquer et al. 2015), consistent with tendon dysrepair or degenerative change (Cook & Purdam 2009). Adductor tendon pathologies may extend into the pubic aponeurotic plate and coexist with multiple other groin pathologies and clinical entities.

Figure 11: Longitudinal ultrasound of proximal adductor longus tendon. Abnormal hypoechoic area within the deep aspect of the tendon, indicated between pink arrowheads. AL: Adductor Longus; AB: Adductor Brevis; AM: Adductor Magnus; ADL: Adductor Longus Tendon.
Iliopsoas-Related Groin Pain

Sites of Iliopsoas & Related Pathology

Investigation of groin pain in the iliopsoas region reports variable areas of injury or pathology. Iliopsoas pathology has been reported at the proximal tendon, the musculotendinous junction, the muscle belly and the iliopsoas bursa (Bui et al. 2008, Johnston et al. 1998). Hip-related groin pain associated with labral pathology and iliopsoas-related groin pain may also co-exist and share a common aetiological mechanism (Alpert et al 2009, Domb et al. 2011).

Acute Hip Flexor Injury

Serner and colleagues published a companion paper on acute hip flexor injuries from their recent prospective study of MRI pathologies associated with acute onset groin pain (Serner et al. 2017a). Of the 33 hip flexor pathologies detected in male athletes, 16 were located in the rectus femoris, 12 in the iliacus, 7 in psoas major, 4 in sartorius and 1 within the tensor fascia lata.

While rectus femoris injuries predominantly occurred at the proximal tendons, acute iliacus and psoas major injuries were mainly observed at the musculotendinous junction, with only two tendinous injuries. There was only one isolated psoas major injury, iliopsoas injuries usually occurring as an isolated iliacus injury or a combined iliacus-psoas major injury.

The most common mechanism of injury for rectus femoris and iliopsoas was also quite distinct in this series. While the rectus femoris was most likely to be injured when kicking or sprinting, iliopsoas was most commonly injured during change of direction.

The final piece of potentially relevant information from this study was that iliopsoas injuries primarily occurred in isolation. There were no situations where an iliopsoas injury co-existed with an adductor injury. A previous study from the same lead author had found the combination of clinically diagnosed adductor and iliopsoas related injury to be the most common groin injury combination (Serner et al. 2015). On the basis of this more recent imaging information and a related paper that showed hip flexor clinical tests to have poor accuracy, Serner et al. (2017b) now suggest that acute hip flexor-adductor injury combinations are unlikely to occur.
Long standing iliopsoas-related groin pain

Imaging and surgical visualisation of local structures in those with long standing iliopsoas-related groin pain has provided information on associated pathologies. There is consistent reporting in the literature of the presence of iliopsoas tendinopathy, with or without associated bursal thickening in the underlying iliopectineal bursa (Anderson 2016, Blankenbaker & Tuite 2008, Chalmers et al. 2017, Domb et al. 2011, Hain et al. 2013, Yen et al. 2015). This may occur in conjunction with painful snapping of the iliopsoas tendon or impingement against underlying structures.

Iliopsoas impingement is now a well recognised cause of iliopsoas-related groin pain. Labral pathology has been noted at the 3 o’clock, direct anterior region, immediately adjacent to the iliopsoas tendon (Figure 12). Labral injuries such as those associated with femoro-acetabular impingement occur most commonly in the anterosuperior or superior regions from the 11.30-2pm position. Labral pathology at the 3 o’clock position has been noted to range from frank tears, mucoid degeneration and an inflamed appearance without a tear. Pathology in this region is now thought to be caused by impingement of the overlying iliopsoas tendon (Alpert et al 2009, Domb et al 2011). The adjacent tendon on arthroscopic inspection is also noted to be red and inflammed with variable amounts of scarring which may bind the tendon down to the underlying capsule (Domb et al 2011). Tendon pathology and impingement can also occur in the context of femoroacetabular impingement and following total hip arthroplasty.

Tendon pathology may be associated with impingement against prominent bone in those with femoroacetabular impingement or a prominent acetabular component following total hip arthroplasty (Chalmers et al. 2017).
CHAPTER FIVE
PATHO-AETIOLOGY

WORKLOADS & INJURY

ARGP - MECHANICAL FACTORS
Compressive & Tensile Loads
Loads in Sport

IRGP - MECHANICAL FACTORS
Compressive & Tensile Loads
The Effect of Posture & Function
The Impact of Structure
Anterior Snapping Hip
Various models have been developed to help understand the aetiology of injury in athletes, with the ultimate motivation of enhancing injury prevention. Bahr and Krosshaug’s (2005) model outlines intrinsic factors that predispose an athlete to injury, extrinsic factors that then increase susceptibility and an inciting event that finally results in injury. Intrinsic factors encompass age, sex, body composition, previous history of injury or instability, physical fitness including muscle strength and flexibility, anatomy, skill level and psychological factors. Extrinsic risk factors may include sports factors (coaching, rules, referees), protective equipment, sports equipment (e.g. shoes) and environmental conditions (e.g. weather, playing surface). The final injury may be incited by a playing situation, player or opponent behaviour, gross biomechanical loads applied to the whole body or local biomechanical loads applied across a specific tissue. For pain of more gradual onset, there may not be a single definable inciting event, but a gradual accumulation of adverse loading. Workloads, while not addressed specifically in this model, have the potential to influence both extrinsic and intrinsic risk factors for injury (Windt & Gabbett 2017). This chapter will initially discuss workloads and then focus on intrinsic factors associated with physical fitness and biomechanical loads that may incite pain or injury.

Workloads & Injury

Windt and Gabbett’s (2017) recently updated Workload—Injury Aetiology Model explores how workloads may influence injury risk. They believe that are three primary mechanisms:

1. ‘High workloads increase exposure, thereby increasing injury risk.’

The more time an individual spends in an at-risk sporting environment, the more opportunity there is for injury. The same is likely to hold true for other situations of occupational and recreational risk.

2. ‘Workloads which induce high levels of negative changes to modifiable internal risk factors (ie, ‘fatigue’) increase injury risk.’

Fatigue from training at a level to which the individual cannot adequately adapt, may result in both physical and psychological fatigue and subsequent increases in injury risk. Fatigue may compromise both neuromotor control and tissue resilience.

3. ‘Workloads that maximise positive adaptations while minimising fatiguing effects will help make athletes more robust to injury.’
**Total Workloads**

Workload has traditionally been assessed by considering total, absolute workload over a defined period. There is evidence to suggest that total workload significantly influences injury risk. Gabbett (2010) devised an injury prediction model that demonstrated that elite Rugby players that exceeded a defined weekly workload threshold were 70 times more likely to sustain a soft-tissue injury. Adequate workload however is essential to achieve adequate skills and physical conditioning. By this mechanism, low workloads can also increase injury risk.

**Acute vs Chronic Workload**

Workload monitoring then moved to assessing acute:chronic workload ratios that compare the workload over the last week (acute workload) against the workload over the preceding four weeks (chronic workload). Spikes in activity where the acute:chronic ratio exceeds 1.5 has been shown to significantly increase injury risk (Hulin et al. 2014, Gabbett et al. 2016).

**Workload-Injury Paradox**

The most recent investigations have revealed the workload-injury paradox, where higher chronic workloads do not predispose but in fact protect an athlete from injury. This is contingent on appropriate acute:chronic workload ratios. High acute:chronic workload ratios together with high chronic workloads result in high injury risk, however high chronic workload with a moderate acute:chronic workload ratio (0.85–1.35) returns a very low injury risk (Hulin et al. 2016). Statistics from rugby league have shown that the risk of sustaining an in-season injury were decreased by 17% for every 10 preseason training sessions that players completed (Windt et al. 2017).

Consistent with this paradox, lower levels of pre-season sports-specific training has been shown to be a significant risk factor for groin injury in sport (Whittaker et al. 2015).

**What we Know About Workload**

**INJURY RISK INCREASED BY:**

- **Total Workload:** Too much & too little
- **Acute vs Chronic Workload:** (Last week: 4 weeks before) > 1.5
- **Chronic Workload:** Too little

**SO ATHLETES SHOULD:**

- Stay within advised volumes for the sport
- Avoid spikes in activity
- Increase by 10% / week
- Put in the hard work in the preseason
Mechanical Loads
Adductor-Related Groin Pain

Compressive & Tensile Loads

Both compression and tensile loading may play a role in the development of the various pathological entities involved in groin pain. In Book 1 of this series, the adaptations engendered by compression have been discussed. The scant histological evidence that is available relating to adductor pathology does reflect such adaptations to compression (Ippolito & Postacchini 1981). Cook & Purdam (2012) suggest that positions of hip extension and abduction will result in compressive loading of the adductor longus and rectus abdominis tendons as they wrap around the pubic ramus. These positions will also result in tensile loads across the tendons, the musculotendinous junction and the aponeurotic connections across the anterior pubis (Figure 13). Combinations of large range, high speed and high repetition of such movements will represent the most provocative combinations of compressive and tensile loading.

Figure 13: Compression and tension of the adductor longus (AL) and rectus abdominis (RA) tendons and the pubic aponeurosis as the hip moves into extension.
Adductor Loads in Sport

The high prevalence of adductor related groin pain in kicking sports may be associated with the specific challenges kicking presents for the adductor longus. Charnock et al. (2009) have analysed the action of the adductor longus during a soccer instep kick. They found that at the end of the wind up phase, when the hip was in maximal extension, the adductor longus was at its maximum rate of lengthening and maximum activation.

As the leg starts to move forward the path is into flexion and abduction so that maximum length of adductor longus occurred at 65% of the swing phase, at peak abduction (Charnock et al. 2009). The kicking action will therefore involve significant compressive loading at the adductor longus enthesis, both in wind up and swing phase. There will also be high tensile loads transmitted across the adductor-abdominal aponeurosis, and the pubic symphysis. For the adductor longus musculotendinous complex, the rapid, forceful stretch-shortening cycle will be challenging, particularly under conditions of high repetition and fatigue.

Rapid and forceful hip extension and abduction also occurs in many other sports such as ballet, gymnastics, and change of direction sports such as hockey, baseball and all the football codes. The tendon is exposed to compression and the muscle and musculotendinous junction to high velocity eccentric lengthening.
Mechanical Loads
Iliopsoas-Related Groin Pain

Compressive & Tensile Loads

As for other tendinopathies, excessive compression and particularly combinations of compression and tension may have adverse effects on iliopsoas tendon health. At the anterior hip, these loads may also adversely influence any underlying tissues such as the bursa, capsule and acetabular labrum. Compression of the iliopsoas tendon and underlying structures will occur as the tendon wraps around the pelvic brim and then the head of the femur on its course to the lesser trochanter.

Yoshio et al. (2002) performed a detailed cadaveric study on the psoas major, measuring pressure beneath the tendon at multiple sites along the length of the tendon, and through 0° to 90° of hip flexion. Across all bony sites, the highest values for compression were recorded over the femoral head, but this was range specific. Maximum pressure was recorded over the femoral head at 0° of flexion. Pressure on the femoral head reduced as the hip flexed and contact was lost between the head of the femur and the tendon at about 15° of flexion. From an extended hip position and into early flexion, it is the head of the femur rather than the pelvic brim, that acts as the pulley for the psoas tendon. Yoshio et al. (2002) reported that the tendon acts to stabilise the femoral head, creating a posterosuperior force. As the tendon lifts off the femoral head, above 15° of flexion, the pulley mechanism is transferred to the pelvic brim. The tendon then lifts off the pelvis around 60° so that in the higher ranges of hip flexion there is minimal or no bony contact with the tendon (Figure 14).

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Above 60°
No bony contact

15-60° Hip flexion
Pulley transferred to pelvic brim after loss of contact with HOF

0-15° Hip flexion
Maximum pressure HOF
HOF acts as pulley
Tendon stabilises HOF
Posterosuperior force

Figure 14: Psoas tendon bony contact and compression through range.
Based on Yoshio et al (2002). HOF: Head of Femur
Yoshio et al. (2002) only studied the 0°-90° range of motion. It is logical to assume that the compressive loading will continue to increase from 0° into hip extension, so that maximal compression will occur in maximal hip extension. In hip extension, the iliopsoas is thought to provide an important restraint against anterior translation of the head of femur (Retchford et al. 2013). During gait, the iliopsoas is also highly active at end stance phase, presumably supporting the femoral head and storing energy for the subsequent swing phase (Andersson et al. 1997). Through end stance and early swing phase of walking and particularly running, the iliopsoas complex will undergo a high energy storage and release process and exposure to high compressive and tensile loads.

Lewis and colleagues (2009) have also demonstrated through modelling that the highest anterior hip joint loads occur in extension, and that the iliopsoas appears to be involved in controlling this loading. When the iliopsoas was weakened in the model, the joint forces significantly increased. There would appear to be a delicate balance here between the provision of adequate stability while avoiding excessive compression.

The Effect of Posture

Risk of excessive compressive loading of the iliopsoas and related structures is likely to increase with exposure to sustained, repetitive and/or loaded hip extension. The ‘sway’ type posture is characterized by posterior pelvic tilt and anterior translation of the pelvis relative to the base of support (Kendall et al. 2005), both resulting in relative hip extension (Figure 15). Those favouring a sway posture usually present with increased length in the anterior soft tissues. While there is less passive tension of the longer iliopsoas, higher anterior loads may be associated with the higher ranges of hip extension employed. Those with a more lordotic posture will generally have a shorter iliopsoas, presumably then reaching higher levels of compression in lower ranges of hip extension.

Figure 15: Posture type. a. Sway, demonstrating anterior translation of the pelvis relative to the base of support, and resultant hip extension. b. Lordotic, demonstrating increased relative anterior pelvic tilt and resultant hip flexion.
Iliopsoas Loads During Dynamic Function

Although it is often postulated that static posture has little relevance for dynamic function, those with a sway type posture certainly appear to retain their tendency towards excessive hip extension during gait. This may have relevance for both tendon and joint loads, as even a 2° increase in hip extension has been shown to increase anterior hip joint loads by 20% of bodyweight (Lewis et al. 2007, 2010). High ranges of hip extension during gait and other function may significantly increase anterior tendon and joint loading (Figure 16). A combination of tightness of the iliopsoas complex, as might occur with a more lordotic posture, and moderate to high ranges of dynamic hip extension will also result in high anterior loads.

Power walking or running with a long stride length, which is common in those with low cadence, will increase the range and time spent in hip extension. It is a common clinical scenario to record a history of a patient who has recently taken up power walking and subsequently developed iliopsoas-related groin pain. Those involved in ballet, gymnastics and martial arts use larger ranges of extension regularly, often sustained, repetitive and/or at high speed, which may contribute to their higher incidence of iliopsoas-related groin pain.

During a soccer or football kick, high compressive loads will be created as the hip reaches 20° or more of extension at the end of the wind-up phase (Charnock et al. 2009). This usually occurs under high velocity, and with strong hip flexor activity, working first eccentrically as the hip reaches final stages of extension, and then concentrically to bring the thigh powerfully into flexion.

* : Iliacus.
The Impact of Morphology of Underlying Structures

Other factors may also increase the prominence of the femoral head and therefore predisposition to problematic compressive loading. Acetabular dysplasia and/or inadequate capsuloligamentous stability anteriorly may allow greater anterior translation of the femoral head, particularly in hip extension and if the dynamic stability mechanisms are inadequate.

Increased prominence of the head neck junction secondary to femoroacetabular impingement (cam lesion), perthes or slipped capital femoral epiphysis, or due to osteophytosis associated with hip osteoarthritis may also increase the risks of compression of the iliopsoas tendon (Mardones et al. 2016). Iliopsoas impingement against a prominent acetabular component following total hip arthroplasty is also now a well recognised cause of post-arthroplasty iliopsoas-related groin pain (Henderson & Lachiewicz 2012). The orientation of the cup is a key feature and to address the issue successfully, sometimes surgical reorientation of the cup is required. Osteophytosis around the acetabular cup post arthroplasty may also cause issues with compression or friction of the adjacent tendon and bursa (Figure 17).

Figure 17: Impingement of the iliopsoas tendon against the acetabular cup and/or osteophytes may occur post total hip arthroplasty.
Anterior or Internal Snapping Hip

Some patients with iliopsoas-related groin pain present with snapping of the iliopsoas tendon, which may or may not be painful during the action. The relevance of the snap is unclear, as many people exhibit a snap of the iliopsoas tendon in the absence of hip pain, particularly in the dance population (Winston et al. 2007). It is thought that pain may develop from the repetitive snapping and friction of the tendon against the underlying structures. It is also possible that painful pathology develops initially secondary to excessive use of compressive, hip extended postures and once painful, the snap may also become symptomatic.

Traditional theories - what and why

There is still a lack of complete certainty regarding what the tendon is snapping over and why it occurs. The most common theories are that the tendon snaps either over the head of the femur or the iliopectineal eminence, although the evidence for either is not strong (Anderson & Keene 2008, Ilizaliturri et al. 2009, Contreras et al. 2010). These theories suggest that as the hip flexes, abducts and externally rotates, the iliopsoas tendon may slide laterally. As the hip is lowered back down into extension, the snap is thought to occur as the tendon snaps back over the head of the femur or the iliopectineal eminence. Snapping of the tendon over a paralabral cyst and snapping of two portions of a bifid tendon over one another have been demonstrated but are uncommon causes (Deslandes et al. 2008).
Theories as to why the snap occurs are variable. Bony morphological issues such as excessive prominence of the iliopectineal eminence have been suggested. By far the most common assumption however, is that the underlying cause is tightness of the iliopsoas, with all subsequent conservative and surgical measures aimed at lengthening or releasing this structure. Despite this, evidence for tightness does not feature in the literature.

Reports of conservative management of iliopsoas snapping have also failed to produce evidence of iliopsoas tightness in this population. Keskula et al. (1999) in a single case study of painful snapping hip, reported normal length of the hip flexors and pain at end of range extension, and yet the basis of the subsequent treatment was stretching. Johnston et al. (1998) reports a clinical impression of tightness in patients with iliopsoas syndrome, with or without snapping, but no evidence is provided. Recent publications reference older publications, leaving the whole evidence base resting on an assumption.

Much more research in this area is required to clarify comparative hip flexor length in a population with painful snapping hip. It is well documented that dancers have a higher incidence of snapping hip and they fall usually within the most mobile end of the spectrum. Clinically, those presenting with painful iliopsoas snapping do appear to be much more commonly hypermobile than hypomobile. Further research is extremely important as mobile patients undergoing a stretching protocol or surgical iliopsoas release may be at risk of joint instability and even dislocation (Sansone et al. 2013).

New insights

In recent years, a novel theory has emerged around what is causing the snap, also providing new insights into potential underlying drivers. The range of motion in which iliopsoas snapping occurs is usually around 45-60° of hip flexion. Based on Yoshio et al.’s work (2002), the tendon would not be expected to be in contact with the femoral head through this range. There is contact however with the pelvic brim in this range. Deslandes et al. (2008) and Winston et al. (2007) have both described a mechanism whereby the psoas tendon lifts away from the pelvic brim during hip flexion, embedding itself into the iliacus muscle belly, trapping a portion of the muscle belly beneath the tendon. On lowering of the hip into extension, the psoas tendon snaps around the iliacus and down onto the pelvic brim (Figure 18).

Deslandes et al. (2008) reported this finding on dynamic ultrasound assessment, in 14 of their 18 patients with snapping hip. These authors state that they never witnessed the iliopsoas tendon move across the iliopectineal eminence, the tendon always staying lateral to this bony prominence. They also state that although the iliopectineal eminence is a commonly stated site of tendon impingement, no-one has ever published evidence of such impingement. Recent studies have not provided this evidence either, all referring to earlier narrative papers. Back in 1990, Jacobsen and Allen also reported that they had never been able to observe the tendon cross the iliopectineal eminence, even at far extremes of movement.
So why would the psoas tendon snap over the iliacus muscle in some individuals? Deslandes et al. (2008) revert to the tight muscle hypothesis as the explanation for their new snapping mechanism. They hypothesise that the iliacus may be bulky, poorly compressible and confined within a tight fascia.

This is purely hypothesis however, and it could be equally plausible that the iliacus muscle may be inhibited with poor ability to stabilise or resist invasion by the psoas tendon. The deep medial bundle of the iliacus is most likely to have a stabilising action on the psoas tendon. Delayed activation or atrophy of this bundle may result in a relatively less stable psoas tendon. Much further research is required to confirm impairments and provide a sound evidence base for management.

Figure 18: Axial ultrasound at the level of the superior pubic ramus. During hip flexion, abduction, external rotation, the psoas tendon (outlined in pink dots) lifts, rolls over and embeds itself on top of the deep medial bundle of the iliacus (DMB). On descent into hip extension, the tendon snaps back around the iliacus and down onto the pelvic brim. IL-Lateral: Lateral bundle of the iliacus.
CHAPTER SIX
IMPAIRMENTS

DEFICITS ASSOCIATED WITH ARGP
Muscle Strength
Muscle Recruitment (EMG)
Range of Motion

DEFICITS ASSOCIATED WITH IRGP
The Evidence
Clinical Impression
Impairments
Adductor-Related Groin Pain

At present, the research on impairments associated with groin pain has not been consistently divided into that associated with each of the clinical entities. The following information therefore, will contain data that is primarily related to symptoms in the adductor region but may contain subject groups that have varying local pathologies and multiple entity diagnoses e.g. adductor related, pubic-related, iliopsoas-related groin pain. Further research regarding impairments associated with specific entities is required, but the information currently available will provide the clinician with awareness of potential impairments. As is standard clinical practice, each patient’s specific impairments should be addressed on an individual basis.

Hip Adductor Muscle Strength

Hip adductor weakness has been shown to be both a risk factor for developing groin pain (Whittaker et al. 2015) and an impairment in those with adductor-related groin pain (Kłoskowska et al. 2016, Mosler et al. 2015). Tyler et al. (2001) completed a prospective study of male ice hockey players. Eccentric hip adductor strength, measured in sidelying, was found to be 18% lower in ice hockey players who went on to sustain an adductor injury in the subsequent season.

Crow et al. (2010) prospectively screened Australian Football League players each week to evaluate adductor strength with the 45° squeeze test - knees bent 90° and feet on the bed. They reported that players who developed groin pain during the season had tested, on average, around 11% weaker in the week of reporting, and 5% weaker in the week prior to pain onset. They concluded that adductor weakness precedes onset of pain and that the adductor squeeze test could be a useful early screening tool. Various versions of the adductor squeeze test are now being used as a screening tool in team sports, and may provide an early indication that load transference across the pelvis is becoming impaired.

A meta-analysis of all the available pooled data for the adductor squeeze test, demonstrated strong evidence with a large effect size, that those with hip/groin pain have reduced adductor strength on this test (Mosler et al. 2015).

Adductor:Abductor Strength Ratio

The ratio between adductor and abductor strength has also been assessed both prospectively and in painful cohorts. In uninjured ice hockey players Tyler et al. (2001) reported adductor strength to be 95% of abductor strength. In elite male soccer players, Thorborg et al. (2011) showed the adductors were a little stronger than the abductors and Kemp et al. (2012) assessing a non-elite active population reported adductors to be just under 90% of abductor strength (Table 2).

Tyler et al.’s (2001) prospective study found that players whose adductor strength was less than 80% of abductor strength were 17 times more likely to sustain an injury at the adductor origin during the subsequent ice hockey season. The results of this study led to recommendations from the authors that adductor strength should return to at least 90% of abductor strength, and symmetry in strength between sides should be within 10% before return to sport after a groin injury.
In Thorborg et al.’s (2011) study of 86 elite soccer players who were uninjured at the time of testing, 10 players experienced pain during adductor strength testing, reducing their adductor strength to 80% of their abductor strength. Eight out of 10 of these subjects who had pain on testing had experienced hip and/or groin pain in the previous year. The residual pain and weakness may reflect inadequate rehabilitation and help explain the high recurrence rates of adductor injury.

Sixty-nine percent of Thorborg et al.’s (2011) group of soccer players had experienced hip, and/or groin pain in the previous year, and yet those who were non-painful on testing were stronger in their adductors than their abductors (Table 2). It is unclear why, but perhaps the majority of players focussed on adductor strengthening resulting in a slight supercompensation.

Table 2: Hip Abductor:Adductor Ratios in Painfree Populations

<table>
<thead>
<tr>
<th>Study</th>
<th>Ratio</th>
<th>Relative Strengths as a Percentage</th>
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<tr>
<td>Tyler et al. 2011</td>
<td>Abd:Add 1.05</td>
<td>Adductor strength 95% of abductor strength</td>
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<td></td>
<td>Ice hockey players</td>
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<tr>
<td>Thorborg et al. 2011</td>
<td>Abd:Add 0.95</td>
<td>Adductor strength 105% of abductor strength</td>
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<td></td>
<td>Male soccer players</td>
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<tr>
<td>Kemp et al. 2012</td>
<td>Abd:Add 1.13</td>
<td>Adductor strength 88% of abductor strength</td>
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<td></td>
<td>Non elite, active</td>
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Table 2: Hip Abductor:Adductor Ratios in Painfree Populations

Reasons for Reduced Strength?

Surprisingly, despite the number of studies examining adductor strength, there does not appear to have been any exploration of concurrent changes in adductor muscle size or quality. It is unclear then if adductor weakness is underpinned by adductor atrophy. Certainly in the presence of pain, weakness may be reflective of protective inhibition. Crow et al. (2010) reported reductions in strength prior to pain onset, although it is possible the central nervous system was already protective of a subclinical issue. After application of a pelvic belt, Mens et al. (2006) recorded significant increases in adductor squeeze strength in athletes with groin pain. The authors suggested the pain and weakness on adductor loading may be secondary to failed load transfer across the pelvis. Application of a pelvic belt has been shown to have many and varied effects on muscle recruitment around the lumbopelvic and hip region (Arumugam et al. 2012). The effects of a pelvic belt on adductor strength may have some local mechanical effect or the effect may be purely neuromotor.

Together, the information tells us that those with groin pain have consistent weakness in adduction strength and that this weakness may precede symptoms. It does not tell us if the adductors are atrophied or whether the weakness is in fact an indication of failed load transfer across the anterior pelvis, or inhibition to protect failed or failing local soft tissues.
Hip Adductor EMG

Information from EMG studies, although limited, may provide further insight into adductor impairments associated with groin pain. Lovell et al. (2012) looked at adductor EMG levels during six clinical tests, including bilateral squeeze tests and unilateral strength tests, all involving maximum adductor force production. In those who had sustained a previous groin injury, adductor longus recruitment was significantly reduced and yet players were not painful at the time of testing. Lovell et al. (2012) concluded that motor control deficits persist after groin injury, even after successful return to sport.

In a lower load functional task involving standing and lifting one hip to 90 degrees flexion, Morrissey et al. (2012) reported that gluteus medius EMG was reduced and adductor longus EMG relatively increased in those with chronic groin pain. Clinically, patients with adductor-related groin pain do appear to have difficulty relaxing their adductor longus in low load postures and tasks - often referred to as ‘adductor guarding’. This adductor behaviour may contribute to range restrictions in Bent Knee Fall Out, that have been demonstrated in those with groin pain (Mosler et al. 2015).

The evidence base here lacks the depth and quality of information available for other hip conditions. As discussed in Book 2, EMG studies for those with painful gluteal tendinopathy have revealed excess activity and a lack of normal precision and variability in gluteal muscle recruitment during gait, a relatively low load task (Allison et al. 2017, Ganderton et al. 2017). The pattern is one of excessive co-contraction rather than the finesse of a more variable ‘load sharing - load sparing’ pattern. Adductor guarding may reflect a similar recruitment issue.

What does this all mean for rehabilitation and exercise selection?

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**Figure 19: What are the clinical implications of adductor electromyography (EMG) studies? AL: Adductor Longus**
**Clinical Implications**

Reduced adductor strength and lower levels of adductor longus recruitment have been reported under maximal loading conditions for those with groin pain. It is therefore tempting to conclude that our primary aims should be to strengthen the adductors and increase their recruitment by choosing exercises that encourage high levels of EMG. However, there would appear to be a discrepancy when you also consider information from low load tests such as standing hip flexion and bent knee fall out. For those with groin pain, these tests have demonstrated relatively greater levels of adductor EMG and an inability to completely relax into a bent knee fall out position ([Figure 19](#)). This information would therefore suggest that we should be teaching those with groin pain to relax their adductors and choose exercises that encourage reduction of adductor longus recruitment.

This apparent discrepancy can perhaps be explained as a motor control deficit where the adductor longus has both low load and high load dysfunction ([Figure 20](#)). Both are likely to be protective in nature – the guarding to prevent end range movements that may place high passive loads across the anterior pelvic structures and the apparent high load weakness, a cortical inhibition reflecting an unwillingness of the neuro-motor system to place maximal active load across potentially at-risk structures.

![Figure 20: Graphical representation of co-existing high load and low load dysfunction in Adductor Longus recruitment.](#)
Trunk Muscle Impairments

Can trunk muscle function predict groin injury? In a small cohort of Australian Football League players, one study found that the ability to draw in the abdominal corset was not predictive of hip, groin or thigh injuries (Hides et al. 2011). However, preseason size of multifidus at L3-5 was smaller in those who developed more severe hip, thigh or groin injuries that resulted in missing four or more training sessions. Half of the injuries sustained were groin injuries. The authors suggest that smaller multifidus muscles may negatively effect neuromuscular control of the lumbar lordosis and efficient distribution of forces between the lumbopelvic region and the lower limbs. They did however concede that the results would need to be replicated in a larger cohort to improve confidence in this measure as a risk factor for hip, groin and thigh injury.

Cross-sectional studies have also looked at abdominal muscle size and function in those with long standing groin pain. One fine wire EMG study of Australian Football League players with long standing groin pain, demonstrated a delay in transversus abdominis onset during an active straight leg raise task (Cowan et al. 2004). Jansen et al. (2010) found resting muscle thickness of transversus abdominis in athletes with long standing adductor-related groin pain was reduced, but thickness during active tasks such as an active straight leg raise or a squeeze test was not.

Isokinetic dynamometry has revealed significantly lower concentric back extensor and eccentric abdominal strength and a higher concentric abdominal:back extensor ratio in those with groin pain (Osteitis Pubis) compared with painfree controls (Mohammad et al. 2014). Much research is required to clarify impairments for each of the clinical groin pain entities.

The information to date however indicates a relationship exists between trunk muscle function and groin pain and suggests that assessment and rehabilitation of trunk muscle impairments would be warranted in both prevention and management of groin pain.
Hip Flexor Strength

Limited evidence exists for changes in hip flexor strength in the presence of groin pain. One study that assessed hip muscle strength in subjects with long standing groin pain (osteitis pubis), found that the only significant difference was higher strength in isometric hip flexion and a higher flexor:extensor ratio in those with groin pain compared with controls (Mohammad et al. 2014). In contrast, a group of male soccer players diagnosed with the clinical entity - adductor-related groin pain, showed no change in hip flexor strength compared with a painfree control group. These varying results may reflect differences in presentations of the groups assessed (pubic-related groin pain versus adductor-related groin pain) or the quality of each study (low quality versus high quality (Kloskowska et al.2016)).

Hip Flexor-Adductor Relationships

Adductor longus and Tensor Fascia Lata (TFL) are both known to provide secondary assistance to iliopsoas during hip flexion. Lewis and colleagues (2009), using a sophisticated modelling system, demonstrated that if the iliopsoas was weakened within the model, there would be a subsequent increase in secondary muscle contribution from TFL and the adductor longus muscle during a hip flexion task. Clinically, this is a common scenario in both hip and groin pain presentations - increases in TFL and adductor longus activation during a hip flexion task, associated with iliopsoas atrophy or recruitment delay evident on ultrasound.

The clinical diagnoses of adductor-related and iliopsoas-related groin pain commonly co-exist (Holmich et al. 2007, Taylor et al. 2007). While adductor-related groin pain is the most common primary entity, iliopsoas-related groin pain is the most common secondary entity when more than one clinical entity is diagnosed. Among football players in Holmich et al’s cohort (2007), 60% were diagnosed with iliopsoas-mediated pain as a secondary clinical entity. Similarly, in Taylor et al’s athletes with groin pain, when more than one clinical entity was diagnosed, iliopsoas-related pain was recorded in almost 70% of cases (Taylor et al. 2017). It is highly unlikely however, that imaging studies would confirm iliopsoas pathology in all of these athletes. The evidence suggests that clinical tests used to diagnose iliopsoas-related groin pain are poor indicators of iliopsoas pathology (Serner et al. 2016).

What then does a diagnosis of iliopsoas-related groin pain tell us? Groin pain on resisted hip flexion or passive hip extension may simply emanate from the adductor longus with its significant hip flexor function.

At a minimum, the high prevalence of signs on hip flexor testing suggest that those with groin pain commonly have some form of hip flexor dysfunction and difficulty transferring load across the hip and pelvis in the sagittal plane.

Further research is required to clearly characterise the impairments associated with a clinical entity diagnosis of iliopsoas-related groin pain and the implications for clinical practice. At this point, positive signs on active hip flexion and/or passive hip extension indicate that the clinician should undertake a detailed assessment of hip flexor function and address any impairments as part of the overall management plan.
Range of Hip Motion

A recent systematic review and meta-analysis has determined that hip abduction flexibility is not a risk factor for developing groin pain (Kloskowska et al. 2016). There is however, moderate-strong evidence from two meta-analyses that reduced range on the bent knee fall-out test is associated with groin pain in athletes (Kloskowska et al. 2016, Mosler et al. 2015). As discussed previously, a reduction in bent knee fall-out range may reflect a protective upregulation of adductor longus activity. Stretching of the adductors may be provocative and is generally not recommended in the management of groin pain. With active exercise and resolution of symptoms, adductor length has been shown to return without passive stretching (Holmich et al. 1999).

Limitations of hip rotation range have a complex relationship with groin pain. Significant discrepancy exists in the literature, with some studies finding restriction in one or more aspects of hip rotation range in those with groin pain and others reporting no correlation. Positions of testing, inadequate study numbers and varying diagnoses may influence results. Co-existing femoroacetabular impingement, prevalent in football populations (Nepple et al. 2012, Weir et al. 2011), may influence hip rotation range, particularly at 90° of hip flexion.

One meta-analysis of previous study results for athletes with groin pain, found strong evidence for reduction of hip internal rotation range in prone (neutral hip flexion/extension) and moderate evidence for reduction of internal range in supine (90° hip flexion) (Mosler et al. 2015). In addition, they reported that hip external rotation range in neutral hip flexion/extension did not differentiate athletes with and without groin pain, but there was limited evidence of reduced external rotation at 90° hip flexion. Another meta-analysis reported no significant links between reduced hip internal rotation range or unilateral hip external rotation range and presence of groin pain, but strong evidence of decreased bilateral, total hip external rotation (sum of both legs) (Kloskowska et al. 2016).

A recent report of pre-season screening data for two professional soccer clubs found no association between current groin pain and hip range of motion (Tak et al. 2016). They did however find that players who had a history of hip or groin injury in the previous season and players that scored lowest on the HAGOS (Hip and Groin Outcome Score) had a lower range of hip internal rotation and total rotation range. These associations remained regardless of the presence of a cam deformity.

Although limitation of hip range does not appear to be a significant risk factor for the development of groin injury (Whittaker et al. 2015), soccer/football players, particularly professional or senior athletes exhibit reduced range of motion compared with the general active population (Manning & Hudson 2009). This may reflect adaptive changes in both bone (Agricola et al. 2012) and soft tissues surrounding the joint (Manning & Hudson et al. 2009), likely associated with the particular loading scenarios encountered in this sport.
Impairments
Iliopsoas-Related Groin Pain

The Evidence

Studies on groin pain in athletes have not specifically assessed impairments associated with isolated iliopsoas-related groin pain. Where this clinical entity co-exists with another of the groin pain entities, many of the impairments discussed above may exist.

Turning to the literature on primary iliopsoas related diagnoses, unfortunately very little evidence of any level exists as to the physical deficits associated with these conditions. In a study of 49 dancers with painful snapping of the iliopsoas tendon (referred to as Iliopsoas Syndrome), physical examination results refer to weakness on resisted isometric hip flexion (90°) in external rotation, although no clinical or instrumented measures of strength were recorded (Laible et al. 2013). Pain and/or tightness on passive iliopsoas stretching was also noted but no measures were performed or indications provided regarding their definition of tightness.

This is reflective of the low quality of evidence available for iliopsoas impairments. While papers on management of anterior snapping hip or iliopsoas impingement refer to tightness of the iliopsoas, no length testing studies are available. Reference is made occasionally to hip flexor weakness, and yet no strength testing studies are available for any pre-operative condition. Residual muscle atrophy and hip flexor weakness has been demonstrated for patients on average 21 months post surgical iliopsoas release (Brandenburg et al. 2016). No preoperative data is available however, so the study provides no insight into the influence of the original condition on muscle strength and size, only the influence of the subsequent surgery.

There is a high need for evidence regarding impairments in those with iliopsoas-related hip and groin pain. There is currently no evidence base for conservative management of these conditions. The evidence for surgical management is based purely on assumption and results of previous surgery.
Clinical Impression

In the absence of sound scientific evidence, the clinician is reliant on his or her clinical assessment and reasoning skills. The clinician treating patients with iliopsoas-related hip and groin pain should assess each individual for impairments within the hip flexor synergy and around the whole lumbopelvic region. Clinically, these patients often present with inadequate lumbopelvic control and deficits in trunk and/or gluteal muscle function.

Snapping of the iliopsoas tendon is often associated with movement patterns where the pelvis is moved into a position of relative posterior pelvic tilt. For example, snapping is common in floor-based pilates classes where participants may be encouraged to flatten their back onto the floor for abdominal-hip flexor loading exercises. Similarly, young dancers with snapping hip have often been encouraged to use an excessive amount of ‘tail-tuck’ or posterior pelvic tilt.

As discussed in the functional anatomy of the iliopsoas, the ilacus will be recruited during anterior pelvic tilt/lumbar extension, while the psoas may have either a flexing or extending effect on the lumbar spine and its activation is less likely to be delayed by a posterior pelvic tilt. If a posterior pelvic tilt is employed prior to a hip flexion task, it is possible that iliacus activation may be delayed enough to allow the psoas tendon to rise and embed itself in the iliacus muscle belly. As observed by Deslandes et al. (2008), a snapping may then occur on hip extension as the tendon snaps around the ilacus and back down onto the pelvic brim. Both motor control and strength deficits with respect to active hip flexion and control of the pelvis, particularly in the sagittal plane, may be present and require attention in the management process.

Length of the iliopsoas should be formally assessed in the Modified Thomas Test position. The clinician should not assume that the iliopsoas is short, even in the case of restricted functional hip extension such as reduced stride length in gait. Patients with painful conditions of the iliopsoas will often antalgically avoid positions of hip extension due to provocative compressive loads in such postures. If this has been a long term strategy, they may well be shortened on length testing, but many patients remain long and flexible into hip extension. The particular presentation will influence management approach. Stretching in either situation is not recommended due to potentially adverse loads being transferred to a painful iliopsoas tendon, bursa, capsule or labrum.
CHAPTER SEVEN
DIAGNOSIS

DIAGNOSTIC TESTS FOR ARGP
Adductor Squeeze Tests
Outer Range Adductor Stretch & Resistance
Palpation
Diagnostic Utility of Clinical Tests

DIAGNOSTIC TESTS FOR IRGP
Resisted Hip Flexion
Outer Range Hip Flexor Stretch & Resistance
Palpation
Anterior Snapping Hip Test
Diagnostic Utility of Clinical Tests

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While the Doha agreement (Weir et al. 2015) outlined definitions of the various clinical entities associated with groin pain, the exact technique of physical examination was not discussed. There is no published consensus as yet on how the diagnostic tests should be performed and a limited amount of information on diagnostic accuracy of the various tests for predicting pathologies associated with a diagnosis of groin pain.

## Diagnostic Tests For Adductor-Related Groin Pain

### Adductor Squeeze Tests

Various methods of adductor squeeze testing have been described. The most commonly used squeeze tests are performed at 90°, 45° and 0° of hip flexion, with the 0° position either in neutral hip abduction/adduction or in a position of some abduction with the tester’s forearm positioned between the ankles (Figure 21). Highest adductor longus EMG has been recorded in the ‘hips-45° position’, with high EMG (Lovell et al. 2012) and greatest adductor force production in the ‘hips-0° position’ (Light & Thorborg 2016, Lovell et al. 2012). With the hips at 0°, there will also be more compression of the adductor longus tendon against the underlying pubic bone, which may be useful from a pain provocation perspective.

Figure 21: Squeeze Tests: 90°, 45°, 0° hip flexion, and 0° with slight abduction
Outer Range Adductor Stretch and Resistance

Adductor stretch and adductor resistance in a position of stretch (Figure 22) is also used for assessment of groin pain (Serner et al. 2016, 2018a). Theoretically, this position should provide provocative combinations of compressive and tensile loads.

Figure 22: Outer range adductor stretch and resistance

Palpation

Tenderness on palpation of the adductors is the other criterion for diagnosis of adductor-related groin pain. Palpation is performed along the proximal adductor muscle bellies, through the adductor longus tendon and importantly onto the bony tendon origin or enthesis, just below the pubic tubercle (Figure 23). In the differential diagnosis, palpation would also continue through to the pubic bone, pubic symphysis, rectus abdominis insertion and the inguinal and iliopsoas regions.

Figure 23: Palpation of adductor longus (AL). Follow up along the tendon to the insertion just below the pubic tubercle (*).
**DIAGNOSTIC UTILITY:**

What do these tests tell us? Do they help us determine the painful or pathological structure?

**Acute Groin Injury:**

The tests available are most valuable for diagnosis of acute groin injury. Palpation is most useful for ruling out acute injury of the adductors. One study reported negative predictive values of 91% and the best negative likelihood ratio of 0.08 (Serner et al. 2016). The negative predictive value suggests that if a patient does not have adductor tenderness, there is a 91% chance that there will be no sign of adductor injury on MRI. A negative likelihood ratio of less than 0.1 indicates that this test, when negative, will create a large and often conclusive decrease in the likelihood of a positive MRI.

Three physical tests were shown to be most useful for ruling in adductor injury. When positive, squeeze test at 0° hip flexion (forearm between ankles), resisted outer range adduction and passive adductor stretch showed positive predictive values of 80–81% (probability of an adductor lesion on MRI) and the best positive likelihood ratios (3.04 - 3.30, representing a small increase in the likelihood of presence of an adductor injury on MRI) (Serner et al. 2016).

**Long Standing Groin Pain:**

Current clinical tests are unfortunately much less useful for diagnosing the source of long standing groin pain. A systematic review of imaging and clinical tests for the diagnosis of long standing groin pain in athletes concluded that while clinicians can be confident in the reliability of common clinical tests, most tests may be more useful as clinical tools for monitoring progress, than in the diagnosis of a painful structure (Drew et al. 2014). Positive squeeze tests increase the likelihood of the presence of pubic bone marrow oedema on MRI (Verrall et al. 2005, Falvey et al. 2016), but not necessarily pathology of the adductor origin. One recent study found no correlation between adductor pathology and results of adductor squeeze tests. The authors suggest that pain elicited during a squeeze test represents more global distress of the structures of the anterior pubic area, including both soft tissues (adductor, rectus abdominis and obliques) and bony structures (pubic bone, symphysis pubis) (Falvey et al. 2016).

Their findings indicate that for long standing groin pain, squeeze tests are sensitive to the presence of groin pain in athletes but are not specific to any particular pathology in the region. This is not surprising considering the extensive connections of the adductor longus across the pubic region and into the lower abdomen. As discussed in the previous impairments section, pain and weakness on adductor loading is not necessarily an indication of adductor weakness or even adductor pathology, but highlights an inability or reluctance of the neuromotor system to transfer load across the anterior pelvis.

The addition of palpation to an assessment of long standing groin pain, assists in excluding local pathology of the adductor origin and pubic aponeurosis (Falvey et al. 2016). A negative likelihood ratio of 0.22 for pubic aponeurosis pathology and 0.11 for adductor pathology suggests that local palpation of those structures, when negative, is the best method of excluding these pathologies.
The positive predictive value for adductor palpation however was quite poor. If a patient with long standing groin pain is tender on palpation of the adductor origin, there is only a 23.9% chance that they have pathology of the adductor origin. The positive likelihood ratio of 1.8 was the highest for any test for adductor pathology, but still only represents a minimal increase in the likelihood of adductor pathology being present if the patient is tender on local palpation.

A number of factors may underpin the difficulties in determining the meaning of a positive clinical test when examining a patient with long standing groin pain. Firstly, multiple entities and pathologies may coexist, particularly in situations of ongoing or recurrent groin pain. Secondly, with any test involving active resistance or stretch across the pubic region, force will be transferred widely due to the extensive anatomical connections, potentially producing pain in any number of pathological structures. Thirdly, pain may be referred by local structures to adjacent regions. Drew et al. (2017) reported that experimental pain from injection of hypertonic saline into the adductor longus tendon referred into the lower abdominal region in 33% of cases.

Central mechanisms may also lead to spread of pain. Primary mechanical hyperalgesia over the adductor longus tendon has recently been reported in Australian football players with groin pain, regardless of which clinical entity diagnosis they received (Drew et al. 2016). Further studies using more extensive quantitative sensory measures are required to determine the role of central mechanisms in long standing groin pain. One study using quantitative sensory testing (QST) in patients with chronic patellar tendinopathy reported significant signs of central sensitisation (van Wilgen et al. 2013). The results of a more recent study using QST in subjects with patellar and achilles tendinopathy however, indicated that these conditions are predominantly local pain states, related to loading of tendons and without significant features of central sensitisation (Plinsinga et al. 2018).

Diagnostic tests for long standing groin pain are poor predictors of specific pathologies but are useful indicators of the ability of an individual to transfer mechanical load across the anterior pelvis.

The Doha agreement requires the presence of adductor tenderness AND pain on resisted adduction testing, for the diagnosis of adductor-related groin pain. For acute groin injury, the evidence would largely support this approach. For long standing groin pain, the diagnosis should be used purely as a clinical diagnosis with the understanding that a positive diagnosis has fairly poor predictive value with respect to the presence of underlying pathology.
Diagnostic Tests For Iliopsoas-Related Groin Pain

Resisted Hip Flexion

Common hip flexion resisted tests include resisted isometric straight leg raise and resisted isometric hip flexion at 90° (Figure 24). As a diagnostic test, hip flexion at 90° is usually assessed in supine but may also be assessed in sitting, particularly if dynomometry is used to assess maximum force production or force production to first point of pain.

Outer Range Hip Flexor Stretch & Resistance

Hip flexor stretch is most commonly applied in the Modified Thomas Test position (Figure 25). A stretch applied into hip extension will not only load the iliopsoas but all the hip flexors, including the anterior adductors, and the whole pubic region. This test will also apply torsional load across the entire pelvic ring. The patient should be encouraged to point with one finger to the area or areas of pain reproduction. For iliopsoas-related pain, symptoms familiar to the patient should be reproduced in the iliopsoas region, usually in the mid-inguinal area. Pain in this region may also indicate isolated or co-existing joint pathology.

The addition of active resistance to a position of stretch should increase the provocative nature of the test, due to the combination of high tensile and compressive loads. The patient is asked to resist a hip extending force in this position. Again, there are many structures that will be loaded by this test, so the patient should be as specific as possible as to the location and nature of symptoms.
Provocative combinations of hip extension and resisted hip flexion can also be applied in more functional tasks such as a long striding gait or in a half kneeling hip flexor stretch position (Figure 26).

Figure 26: Outer range hip flexor stretch and resistance in half kneeling hip flexor stretch position. Resistance is self-applied by isometrically pulling the back knee in an anterior direction.

**Palpation**

Palpation will allow access to the iliacus muscle belly at the anterior hip (mid-inguinal region) and the iliopsoas complex medial to the anterior superior iliac spine. Palpation in the latter case is necessarily through the abdominal wall, which is likely to reduce the specificity of any information arising from this test. The psoas and iliopsoas tendons are not directly palpable at the anterior hip due to their location deep to the muscle belly. See Figure 27 below for anatomy.

Figure 27: Anatomy of anterior hip. a. The iliopsoas sits between the femoral pulse medially and the sartorius laterally. The femoral pulse separates the hip flexor group from the adductor group. TFL: Tensor Fascia Lata; IP: Iliopsoas; P: Pectineus; AL: Adductor Longus; S: Sartorius; RF: Rectus Femoris b. Note the relationships and the position of the psoas tendon (*) in this panoramic transverse ultrasound image at the level of the head of the femur (HOF). IC: Iliocapsularis; FA: Femoral Artery.
Anterior Snapping Hip Test

The snapping hip test is not a pain provocation test, although pain is occasionally reproduced. The primary aim of the test is to confirm if the source of the anterior snap is the iliopsoas tendon. The hip is flexed, abduced and externally rotated, and then eccentrically lowered back to the bed, effectively internally rotating and adducting while extending the hip (Figure 28). The test is active, not passive and the examiner should palpate across the anterior hip. The hypothesis is that the tendon is initially preset to a position lateral to the femoral head and iliopectineal eminence. On lowering, the tendon is thought to snap medially over the femoral head or iliopectineal eminence. As discussed in Chapter 5, new theories suggest that the tendon may be snapping over a bundle of iliacus fibres and down onto the pelvic brim.

Figure 28: Anterior Snapping Hip Test. Photos demonstrate test positions in hip flexion and then as the hip is extended. The lower diagrammatic models demonstrate the proposed theory for movement of the psoas tendon from lateral to medial across the femoral head or iliopectineal eminence.
DIAGNOSTIC UTILITY:

What do these tests tell us? Do they help us determine the painful or pathological structure?

Acute Hip Flexor Injury:

As for acute adductor injuries, palpation is most useful as a negative predictive test, where lack of tenderness suggests a low likelihood of acute hip flexor injury in athletes (Serner et al. 2018b). A positive palpation however is no better than chance at predicting a hip flexor injury on MRI (Positive Predictive Value 53%) (Serner et al. 2018b). The authors reported that all hip flexor resistance or stretch tests had poor capacity to predict hip flexor injury. Based on this finding, they suggested that use of the clinical criteria outlined by the Doha agreement for 'iliopsoas-related groin pain' may lead to inaccurate classification of acute injuries in this area. Their recommendation was that imaging would be required to clarify injury location in acute hip flexor injuries.

Long Standing Iliopsoas-Related Groin Pain:

The current literature fails to provide evidence regarding diagnostic utility of clinical tests used to assess non-traumatic or long-standing iliopsoas-related groin pain. The large majority of papers referencing iliopsoas as a pain source are surgical papers related to anterior snapping hip or iliopsoas impingement. Any discussion of clinical tests is of a narrative nature, accompanied in most cases by imaging and often confirmed at the time of surgery.

Assessment of iliopsoas impingement and snapping includes a history of pain on active hip flexion with or without snapping and objective signs of focal tenderness at the anterior hip, pain on resisted hip flexion/Straight Leg Raise, with or without a positive snapping hip test (Daivajna et al. 2014, Domb et al. 2011, Nakano et al. 2017). It has also been noted that the iliopsoas will be impinged by the FADIR (Flexion, Adduction, Internal Rotation) test (Nakano et al. 2017), commonly used for the assessment of intra-articular pathology. This is likely one reason why this test does not hold strong diagnostic properties for diagnosing symptomatic intra-articular pathology (Reiman et al. 2015).

Is it apparent that there are significant deficits in the literature with regard to iliopsoas-related groin pain and associated disorders. Research is required to provide evidence around impairments and the value of diagnostic tests, with important implications for management approaches. Assessment and management strategies for these conditions are currently based on low level evidence, predominantly case studies and expert opinion.
CHAPTER EIGHT
MANAGEMENT

LOAD MANAGEMENT
RAMP Protocol
Specific Loading Advice
Standing Posture Advice
Sitting Posture Advice
Activity Advice

EXERCISE
Low Load Isometrics
Graduated Strengthening
Dynamic Progressions
A recent systematic review of the literature regarding outcomes of physical therapy versus surgical outcomes for groin pain found that evidence was of poor quality overall, with high risk of bias, particularly in surgical studies (King et al. 2015). A review of exercise interventions for groin pain reported that although there was strong evidence from Level 4 studies that exercise therapy was beneficial as a treatment for groin pain, there are a limited amount of studies with low risk of bias. Exercise interventions were also found to be generally poorly described, making evaluation and reproduction difficult (Charlton et al. 2017).

In broad terms, conservative approaches to managing groin pain in athletes involve:

1. Load management, aiming to minimise exposure to provocative loads and graduate activity levels appropriately and
2. A graduated exercise programme.

LOAD MANAGEMENT

Management of groin pain in an athletic population will necessarily involve management of training and competition loads. Minimising exposure to specific adverse loading scenario’s that involve high tensile and or compressive loads across the region, will be an important consideration for all patients with groin pain of musculoskeletal origin.

General Load Management Advice

General load management advice can be summarised into the mnemonic RAMP.

- Rest from Aggravating Activities
- Activity Pyramid
- Monitor Response to Activity
- Progress Gradually

Attend a practical workshop to develop specific clinical skills to optimise your management of groin pain

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REST FROM AGGRAVATING ACTIVITIES

The most provocative activities will be those that place high load across the groin region:
- Change of direction activity
- High speed running, particularly acceleration and deceleration
- High impact, particularly single leg e.g. hopping, bounding
- Activities that involve high range of motion into hip extension and abduction, particularly with high speed or force e.g. kicking, stretching.

With acute onset groin injury, the decision to rest is often easier. With long standing groin pain, the decision regarding whether an athlete should be participating or not, can sometimes be more difficult. The Copenhagen group have recently published an easy to use test with decision making guidelines (Thorborg et al. 2017).

They have used the adductor squeeze test at 0° with the examiners forearm between the ankles, holding for 5 seconds (Figure 28). Numeric pain ratings from players with groin injury were recorded during this test, and then divided according to anticipated risk of further injury:
- Pain score 0 - 2: Safe
- Pain score 3 - 5: Acceptable
- Pain score 6 - 10: High risk

These pain scores correlated well with HAGOS (Hip and Groin Outcome Score) Sport scores. Those with a pain score of 6-10 had the worst (lowest) HAGOS score (median score below 50) reflecting high pain and severe disability. Change in pain on the squeeze test over time also correlated with change in HAGOS scores, indicating the test is responsive to change over time and reflects change in pain and disability as measured by the HAGOS (Sport). Decisions still need to be made, but the test provides a quick screening tool.

The Copenhagen 5s Squeeze Test and Traffic Light Approach (Thorborg et al. 2017)

**Figure 28: The Copenhagen 5s Squeeze Test and Traffic Light Approach (Thorborg et al. 2017)**

- **STOP:** Rest from training and competition
- **ATTENTION:** Review by Health Professional to determine appropriate activity modification
- **GO:** Return to Activity: Review by a Health Professional to determine level of participation

Under direction of a Health Professional
A

ACTIVITY PYRAMID

Athletes should be provided with clear direction as to what activities they may participate in, as appropriate for their level of pain and disability (Figure 29). The Copenhagen 5 second squeeze and the HAGOS questionnaire can assist in staging an athlete. Readiness for each activity should be determined by a health professional on an individual basis, however the pyramid below provides some general guidelines regarding activity progression. Pain of more than 2/10 during and after an activity should be avoided.

FOR THOSE ON GREEN LEVEL:
Kicking - Increase volume/distance
Change of direction - faster, sharper, unpredictable
Higher Impact - Jump, Hop, Bound
Straight line run - increase speed & volume
Sport Specific Rehabilitation

FOR THOSE ON YELLOW LEVEL:
Ball skills - dribbling, low volume/distance kick
Progress to slow predictable change of direction
Work on landing control
Straight line run - intervals, controlled speed
Swim with kick, continue upper body work
Rehabilitation - Strength, High Level Motor Control

FOR THOSE ON RED LEVEL:
Water based activity - Swim no kick, painfree water-run
Walk - If painfree, on flat, short stride length
Upper Body - Arm ergo, gym with modifications
Rehabilitation Program - Pain Relief, Motor Control

*Dependent on pain during & after activity

Figure 29: Activity Pyramid - providing some general guidelines for activities that may be appropriate on red, yellow and green levels. Guidance by a Health Professional is required.
**M**

MONITOR RESPONSE TO ACTIVITY
When any new activity is introduced or an activity is progressed (e.g. increase volume, speed, task complexity), the response to activity should be monitored to provide an indication of whether the athlete is coping with the load or requires further load modification. The Copenhagen 5 second squeeze test can be performed immediately after an activity, that evening and the next day. An athlete can even perform the test independently to check their immediate response to activity. Any increase in pain during or within 24 hours of activity indicates an athlete did not cope with that activity and load should be modified. Any increases in pain levels on a week to week basis, indicate that overall load is too high.

**P**

PROGRESS GRADUALLY
Overall load or activity progression should remain within a 10% window from week to week. An acute:chronic workload ratio of 1.5 or more will significantly increase injury risk. Consider activity scheduling and appropriate rest and recovery. Higher-load days should be followed by lighter-load recovery days. Avoid consecutive days of high loading or potentially provocative activities.
Specific Loading Advice

Specific loading advice additionally considers particular postures or tasks that may impose excess amounts of compression and tension across the groin region in both sport and activities of daily living.

**Adductor - Related Groin Pain**

In general, patients with adductor-related groin pain should minimise sustained, loaded, rapid, or repetitive hip extension and hip abduction, particularly with eccentric activity of the adductor longus. High load hip adduction and flexion will also be provocative in the early stages. Those with co-existing pubic aponeurosis or pubic-related injuries may also not tolerate high rotational loads.

**Iliopsoas - Related Groin Pain**

Patients with iliopsoas-related hip and groin pain should minimise sustained, loaded, rapid, or repetitive hip extension. The application of active flexion loading will be dependent on symptoms during and following loading. In addition, tasks that may cause the psoas tendon to snap or friction across the anterior hip should be minimised. For example, supine abdominal-leg loading exercises should be avoided or modified if snapping is occurring. Dancers with groin pain should avoid the particular actions that induce snapping. It has also been recommended that ‘clams’ or ‘clamshell exercises’ be avoided following hip arthroscopy due to provocation of the iliopsoas tendon as it rubs across the anterior hip (Phillipon et al. 2011). It would be prudent to also avoid this exercise in non-surgical patients.

Standing Posture Advice

Stand with feet hip width apart and grow gently tall, but avoid muscle ‘gripping’. Aim to use minimal muscle effort to achieve a relaxed upright posture. Avoid swaying the pelvis forward or translating the shoulders back behind the hips.
Sitting Posture Advice

Sitting in low chairs or car seats can provoke iliopsoas-related pain due to impingement of the tendon against the underlying joint in positions of high hip flexion.

Avoiding low chairs and using a wedge cushion in sitting and in the car can be helpful.

Some patients with adductor or iliopsoas-related pain may find that, particularly when driving, they have discomfort associated with difficulty relaxing their adductors and flexors.

Wedging rolled towels or a small pillow under the outer thighs can allow the muscles to relax.

Stretching Advice

Adductor-related groin pain: Avoid stretching into hip extension and abduction

Iliopsoas-related groin pain: Avoid stretching into hip extension
Activity Advice

Walking/running modifications

- Reduce stride length *
- Reduce speed
- Reduce impact force
- Reduce volume

* Often patients with iliopsoas-related groin pain have developed pain after taking up long striding ‘power walking’ or walking with a taller partner or friend. Long strides and particularly at speed will impart high compressive and tensile loads across the anterior hip. Similarly stride length should be considered in adductor-related groin pain due to loads imposed on the adductor enthesis and associated structures.

Hip Extension/Abduction during Rehabilitation Exercises

Sustained, loaded, rapid or repetitive hip extension (and hip abduction for adductor-related groin pain) should also be minimised in exercise therapy, particularly in the early stages of rehabilitation.
EXERCISE

Load management advice and a graduated exercise program aim to reduce pain and facilitate graduated return to painfree function. Evidence is very poor with respect to physical impairments associated with groin pain. One thing is clear - for adductor-related groin pain, low strength measures are evident on adductor strength testing. What is unclear is the mechanism that drives the weakness. The mechanism is likely to have important implications for management approach. The most common approach is to assume weakness = atrophy, with a major early and ongoing focus then on loading the adductor musculature. As discussed in Chapter 6, pain and weakness on adductor loading is not necessarily an indication of isolated adductor muscle weakness or even adductor pathology, but highlights an inability or reluctance of the neuromotor system to transfer load across the anterior pelvis. An alternative approach then is to reduce loading across the adductor connections and optimise load transfer across the pelvis (Falvey et al. 2016, Mens et al. 2006).

A recent paper describing a more contemporary model of rehabilitation reported that their participants demonstrated a significant improvement in adductor strength in the absence of any isolated adductor strengthening during rehabilitation (King et al. 2018).

The following information outlines an approach, of first reducing pain and optimising motor control and then gradually reloading the lumbo-pelvic-hip musculature, without early, targeted frontal plane adductor strengthening. Trunk muscle function is important for both adductor and iliopsoas-related groin pain, to optimise lumbopelvic control and provide a more stable base for function of the hip musculature. A graduated hip flexor program is usually also important for both conditions. The anterior adductors will be loaded less provocatively in a graduated hip flexor loading program than in early frontal plane exercise.

The adductor magnus will be loaded within a gluteal strengthening program. Those with both adductor and iliopsoas-related groin pain often present clinically with deficits in gluteal function. As frontal plane loading for the adductors is most provocative, this will be introduced in the final stage of rehabilitation, as required.

Low Load Isometrics & Motor Control

Low load isometric exercise potentially provides benefits via a number of mechanisms:

1. Analgesic response

2. Neuroplastic effect
   Provides improvements in motor control and may assist with reduction of ‘guarding’ and excessive co-contraction strategies. (Boudreau et al. 2010, Rio et al. 2015, Tsao et al. 2010).

3. Local mechanotransduction
   (see Khan & Scott 2009 for review) These mechanisms have been discussed in detail in Book 2.
Isometrics for the Hip Flexors

Hip flexor isometric training can be performed in supported supine, as for the trunk musculature. In patients with groin pain there is often early and excessive recruitment of either the anterolateral hip flexors (TFL, Sartorius, Rectus Femoris) or the adductor longus. Retraining early recruitment of the iliacus and co-ordination with trunk musculature is useful for both iliopsoas and adductor-related groin pain. A belt around the thighs can assist in relaxing the adductors.

Preparation for lift - hip flexion

Isometrics for the Hip Adductors

Isometrics for the hip adductors should be low load and painfree. Co-ordination training with the trunk muscles may be required to optimise function and eliminate pain. Ball squeezing recruits high amounts of adductor activity (Serner et al. 2014) and may be provocative. Ensure complete adductor muscle relaxation between contractions.

Preparation for lift - hip adduction

Isometrics for Trunk & Pelvic Floor Musculature

There may be either downregulation or upregulation of the trunk and pelvic floor musculature in patients with groin pain. For those who have excessive muscle recruitment even in low load postures or tasks, the value of isometrics initially may be in learning again how to relax the muscle and recruit in a more precise manner.

Low load abdominal (abdominal draw-in manoeuvre) contractions and pelvic floor recruitment/relaxation training can be performed in supine, sidelying or upright postures. Real time ultrasound is an excellent tool for biofeedback and enhancing fine motor control (Whittaker & Stokes 2011). A belt around the knees may be used in supine if there is background activity in the adductors.

Multifidus training (isometric trunk extension/‘prepare’ to anteriorly pelvic tilt) is also enhanced by the use of real time ultrasound and is most commonly performed in prone or sitting.

Preparation for lift - hip flexion
Graduated Loading Program

Graduated loading includes components of both movement patterning or motor control training and low velocity, high load strengthening, before progressing to more dynamic function and sports specific loading. Unlike isolated tendinopathy, adductor and iliopsoas-related groin pain are often accompanied by other associated symptomatic pathologies. A loading program should consider the effect of that load, not just on the target musculotendinous structure, but on adjacent and connected structures.

The following exercises represent some examples and principles rather than an all-inclusive set of exercises.

HIP FLEXOR & ABDOMINAL LOADING

Optimise lumbopelvic control
Avoid early posterior pelvic tilt
Avoid excessive anterior pelvic tilt
Early iliacus recruitment
Avoid snapping

- Supine hip flexor-abs loading
- Curl & Plank variations
- High sitting hip flexion
- Standing hip flexion
- Resisted hip flexion - forward lean
- Resisted hip flexion - standing
- Eccentric lean backs for hip flexor lengthening
BRIDGING PROGRESSIONS

Maintain neutral spine
Ensure good gluteal recruitment
Maintain pelvis level
May require belt initially to allow adductor muscle relaxation - aim to decrease excessive adductor muscle contribution

FUNCTIONAL LOADING PROGRESSIONS

Attention to lumbopelvic control
Ensure good gluteal recruitment
Start with low range

Add external challenge e.g. metronome pacing, extra load, perturbation ..
FRONTAL PLANE ABDUCTOR LOADING
Attention to relative muscle recruitment
Trunk position alters recruitment
Start small range, avoid end range abduction
Monitor response to loading

Low load sidestep

Spring resisted bilateral abduction (Upright skating)

Spring resisted bilateral abduction (Skating in squat)

FRONTAL/AXIAL PLANE ADDUCTOR LOADING
Once pain has settled & good strength is achieved in other planes, add frontal plane adductor loading, if a strength deficit persists.
Start low range, load and volume
Monitor response to loading

Bent Knee Fall Outs
Concentric-Eccentric or Eccentric Only

Spring resisted bilateral adductor loading
Lighter springs will load adductors rather than abductors

Band resisted adductor loading
DYNAMIC PROGRESSIONS

Maintain attention to lumbopelvic control
Optimise control of trunk centre of mass
Introduce gradually
Monitor response to loading

Progress to tasks specific to the patients recreational, sporting or occupational requirements

Landing control

Lateral propulsion and landing control

Hip flexor wall/park drills

'A' Drills

Agility Ladder - Hip Flexor Drills

Agility Ladder - Lateral Drills

Change of Direction Drills
<table>
<thead>
<tr>
<th>Exercise</th>
<th>Motor Control Guidelines</th>
<th>Specifics</th>
<th>Criteria for progression</th>
</tr>
</thead>
</table>
| **Isometrics:**  
1. Hip adductors  
+ Address deficits identified in other groups:  
2. Deep hip flexors – iliofemoral & iliocapsularis  
3. Abdominals - TA  
4. Pelvic floor  
5. Multifidus (+/- deep hip abductors & external rotators if deficits identified) | Develop ability to perform:  
- slow, controlled ramp of activation of target muscle/s  
- controlled & complete relaxation between repetitions  
- without significant/early activation of superficial musculature eg TFL, Sartorius, Rectus Femoris, Oblique abdominals, lumbar erector spinae  
- while maintaining relaxation of the adductor longus & brevis (apart from adductor isometrics)  
- while maintaining respiration  
- without bracing or bulging of the abdominal wall | Sets/Reps:  
1 – 2 sets of 5 – 10 reps  
Speed/Hold:  
Ramp slowly, hold 10 - 30secs  
Frequency:  
Performed bd minimum, up to 5 times  
Load:  
Low load, 20-30% MVC, RPE = 3/10  
Pain:  
No pain during or after | - Initially prioritise optimal onset and offset, then add hold time  
- Progress hold time as able to maintain optimal motor control  
- Build reps until endurance to hold improves, then increase hold time & reduce reps  
- Maintain around 5 x 30 second holds |

| Graduated Loading Abdominals and hip flexors:  
1. Curl variations  
2. Plank variations  
3. Hip flexion variations | Develop ability to:  
- perform action without abdominal bracing or breath holding  
- appropriately offset muscles between reps  
1. Curls variations  
- load abdominals without bulging abdominal wall  
- perform controlled movement, not just phasic pulses  
- share flexion throughout whole spine  
2. Plank variations  
- maintain control of lumbopelvic-hip position in a relatively neutral zone, avoiding significant, observable deviations in any plane e.g. more than 5° of hip flexion/extension, loss of mild lumbar lordosis/anterior pelvic tilt either into flexion/ posterior pelvic tilt or increased extension/anterior pelvic tilt  
3. Hip flexion variations  
- move around hip, not lumbopelvic region  
- maintain neutral lumbopelvic position as above  
- move lower limb in pure sagittal plane | Sets/Reps:  
3 sets of 6 – 15reps  
Speed:  
Slow: 3 secs each movement phase  
Holds:  
For planks – build to 2 mins maximum  
Frequency:  
Curls/planks 3 x week. Eccentrics daily.  
Hip flexion – 1-2 x daily for motor control, 3x/week once external load applied  
Load:  
Curls/planks – bodyweight; RPE 3-5, building to 7/10  
Hip flexion – leg load only initially; RPE 3/10, once external load applied  
Build to 60 -70% MVC, RPE = 6-8/10  
Pain:  
Pain ±2/10 during or after exercise. | - Add once has appropriate isometric recruitment pattern of target muscles  
- For planks, once can perform 3 x 30 second holds, add arm/leg perturbations, then continue to build hold time to 2 mins maximum  
- For curls, progress repetitions to 3 x 15, then if further challenge required, add complexity & further range e.g. perform on large ball beginning from extended position. Drop reps initially, then build again to 3 x 15  
- For hip flexion, may start in supine, high sitting or in standing forward lean, then progress to standing; add external load once optimal motor control, can achieve 3 x 15 reps, RPE <7 & no pain during or after exercise. Drop reps initially, then build again to 3 x 15. |

Table 2: Guidelines for exercise prescription. TA: Transversus Abdominis; TFL: Tensor fascia lata; reps: repetitions; secs: seconds; MVC: Maximal voluntary contraction; RPE: Rate of perceived exertion, where 0 = rest and 10 = maximal exertion; bd: twice daily; x: times.
### Graduated Loading Hip and Trunk Extensors, Hip Adductors and Rotators:

#### 1. Bridging Progressions

- Drive hip actions with uniaxial hip musculature rather than thigh musculature e.g. in hip extension, gluteus maximus rather than hamstrings or adductors.
- Maintain required lumbopelvic posture during hip actions.
- Control femoropelvic position in secondary planes while performing primary plane movement e.g. avoid excessive hip adduction or rotation while performing sagittal plane hip flexion/extension task.

#### 2. Functional Loading Progressions – Squats, Lunges, Step Ups, Deadlifts

- Frontal plane abductor loading
- Develop ability to:
  - Drive hip actions with uniarticular hip musculature rather than thigh musculature e.g. in hip extension, gluteus maximus rather than hamstrings or adductors.
  - Maintain required lumbopelvic posture during hip actions.
  - Control femoropelvic position in secondary planes while performing primary plane movement e.g. avoid excessive hip adduction or rotation while performing sagittal plane hip flexion/extension task.

#### 3. Frontal Plane Abductor Loading

- Sets/Reps: 3 sets of 6 – 15 reps
- Speed: Slow: 3 secs each movement phase
- Hold: May build hold time rather than reps if more consistent with an individual’s functional needs.
- Frequency: 1-2 x daily for motor control, 3x/week once external load applied.
- Load: Bodyweight initially, RPE 3-5/10. Once external load applied, build to 60-70% MVC, RPE ≈ 6-8/10.
- Pain: ≤2/10 during or after exercise.

### Graduated Loading Hip Adductors:

- Share load appropriately, especially in sagittal and axial plane hip actions i.e. early and dominant activation of the adductors in these planes may indicate inadequate hip flexor/extensor/rotator function and result in overload of adductors.
- Maintain required lumbopelvic posture during adductor loading.
- Tolerate coronal plane adductor loading and overcome inhibition during high load challenge.

- Sets/Reps: 3 sets of 6 – 15 reps
- Speed: Slow: 3 secs each movement phase
- Frequency: 3x/week
- Load: Test with light load, RPE 3-5/10. If strength remains inadequate, build to 60-70% MVC, RPE ≈ 6-8/10.
- Pain: ≤2/10 during or after exercise.

- Coronal plane loading added only after:
  - No pain during normal activities of daily living.
  - Squeeze test is painfree.
  - Sagittal and axial plane loading (as above) is well tolerated.
  - Low-load dysfunction has been addressed – full bent knee fall-out range and no resting adductor stiffness.
  - Progress reps/load if no pain aggravation, squeeze test remains negative, squeeze strength does not regress, and bent knee fall out remains full range.

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Table 2 continued: Guidelines for exercise prescription. TA: Transversus Abdominis; TFL: Tensor fascia lata; reps: repetitions; secs: seconds; MVC: Maximal voluntary contraction; RPE: Rate of perceived exertion, where 0 = rest and 10 = maximal exertion; bd: twice daily; x: times.
There have been some significant advances in the groin pain arena. There is a high volume of data now available on prevalence of groin injury in athletes, primarily in the football codes. The Doha agreement has been a large step forward in establishment of a common language for clinicians and researchers. These entities however must be regarded as descriptions of clinical presentations, rather than an indication of particular pathologies.

Further research is required to attempt to clarify what pathologies are associated with each clinical diagnosis. This may be challenging considering the co-existence of multiple pathologies on imaging, and inherent difficulties in determining which of these is symptomatic in each individual. An understanding of underlying pathologies and how specific loading scenarios may effect these pathologies is likely to be an important consideration in optimising management, particularly of long standing groin pain and recurrent injuries. The high incidence of re-injury suggests that a rehabilitation model focussed on adductor strengthening may not adequately address underlying mechanisms.

A purely impairment-based model does not necessarily consider underlying pathologies and mechanisms. For example, the underlying driver of weakness on adductor testing is unclear. Falvey et al. (2016) have suggested that a primary focus on adductor strengthening may be misdirected and serve to lengthen the rehabilitation process. This group has since published a successful case series that showed good rates of recovery for ARGP, without isolated adductor strengthening (King 2018). In the presence of a pubic aponeurosis injury, high load adductor strengthening, especially in the frontal plane, may place potentially injurious shearing loads across the already damaged aponeurotic plate.

Ball squeezing engenders high adductor recruitment (Serner et al. 2014). If the only agenda is to reach more than 40% of a maximum voluntary contraction to address a strength deficit, this may be the only consideration. However, a positive adductor squeeze appears most predictive of pubic bone marrow oedema (Verrall et al. 2005, Falvey et al. 2016), indicative of bony overload. While pubic bone marrow oedema occurs in painfree athletes, it is a sign of overload and in the presence of pain, may be an indication to reduce bony load. Forceful, bilateral adductor contraction is likely to place high compressive loads across the pubic symphysis and this should be considered in the development of an exercise strategy.

Clinically, adductor strength often returns without any targeted frontal plane adductor strengthening, again questioning what we can interpret from these tests alone. Do they simply indicate an inability or reluctance of the neuromotor system to transfer load across the anterior pelvis? If so, our search for strategies to optimise pelvic load transfer is critical.
Health professionals and researchers working within the football arena have done an excellent job in moving forward aspects such as load monitoring and the influence of general athletic loads on injury risk. Screening and injury prevention continues to be a focus, although relatively few injury risks have been conclusively identified, particularly factors that can be modified. Further research and a deeper understanding of impairments may in the future flow through to improvements in screening and prevention programs.

The Copenhagen group has provided clinicians with some excellent tools that can be simply applied in the clinical setting - the HAGOS questionnaire and the Copenhagen 5 second adductor squeeze. These tools allow clinicians to screen for early signs of dysfunction, provide an athlete with guidance with respect to sports participation and a mechanism to monitor response to load during rehabilitation and on returning to sport.

For iliopsoas-related hip and groin pain, the evidence base is unfortunately in its infancy. Management approaches appear to be based primarily on assumption, with no physical impairment studies available. A view that iliopsoas tightness is the cause for all issues related to the iliopsoas, dominates the surgical and narrative clinical literature. Yet, there is no evidence of this. Iliopsoas-related issues commonly occur in hypermobile individuals, where excessive rather than restricted mobility is most likely a primary underlying driver for abnormal loading and injury.

Patients with increased anterior pelvic tilt and restricted hip flexor length represent an important subgroup of those who present with anterior hip and groin pain. However, an assumption that this represents all patient presentations is clearly incorrect and management programs built on this assumption may be misdirected and potentially injurious to the patient. Hip flexor stretching is unlikely to be positive for any patients with iliopsoas-related pain and pathology, due to the high loads imposed on the tendon, bursa, capsule and labrum in end-range hip extension. Active eccentric lengthening techniques that avoid moving into end range, hold potential for more effective and safe lengthening. Avoiding the need for surgical release of the iliopsoas is an excellent outcome for any patient facing such surgery and the risk of long term negative sequelae.

While a long journey of discovery around groin pain and tendinopathy lays before us, these are exciting times with high interest in the area and an increasing volume of research building each year. Clinicians should ensure they continue to keep their knowledge and skills updated to provide their patients with optimal physical and psychosocial outcomes.
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Alison completed a Bachelor of Physiotherapy at the University of Queensland in 1990, a Masters of Sports Physiotherapy in 1997, and her Doctorate in Philosophy in the Field of Physiotherapy (PhD) in 2008. Her PhD studies were concerned with improving our understanding of hip muscle function and the relationship with hip joint pathology and weightbearing stimulus. Alison continues to be passionate about extending our understanding of why we develop problems around the hip and pelvis, and what we can do to most effectively prevent and manage these problems. She has ongoing involvement in research studies investigating lateral hip pain, proximal hamstring tendinopathy, groin pain and function of the deep hip flexors and rotators.

It is one of Alison’s core beliefs that research should be relevant to clinical practice and helping the patients we treat every day, and that physiotherapists in the community should have access to this valuable information to allow them to transfer this knowledge into clinical practice as quickly as possible. To this end, Alison continues to publish, present and provide practical workshops for other health professionals. Alison has published many peer-reviewed papers in scientific journals, has contributed detailed information freely accessible via podcasts by PhysioEdge (itunes) and the British Journal of Sports Medicine (SoundCloud), and has recently contributed to 3 leading physiotherapy and sports medicine text books. She has presented her research and clinical teachings in Australia, New Zealand, England, Ireland, Scotland, Wales, Singapore, HongKong, the Netherlands, France, Belgium, the Unites States of America, Canada and the United Arab Emirates.