Systematic Review

Is the Iliopsoas a Femoral Head Stabilizer? A Systematic Review

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Purpose: To perform a systematic review of biomechanical and clinical studies to determine whether the iliopsoas is a femoral head stabilizer. **Methods:** A systematic review was conducted using Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines. Inclusion criteria were any human clinical (Levels I-IV evidence) or laboratory studies that investigated the role of the iliopsoas as a stabilizer of the hip. Exclusion criteria included studies that investigated patients undergoing spine surgery or those with a total hip arthroplasty or hip hemiarthroplasty. Study methodologic quality for clinical-outcomes studies were analyzed using the Modified Coleman Methodology Score. Because of the heterogeneity in the participants and interventions, no quantitative assimilative meta-analysis was performed. **Results:** Eight articles were analyzed (3 biomechanical [35 cadavers and 18 healthy subjects]; 5 clinical outcomes studies [537 subjects, 207 arthroscopic iliopsoas tenotomies]). Two in vivo biomechanical studies identified the iliopsoas as an anterior hip stabilizer. One cadaveric study identified the iliopsoas as a femoral head stabilizer at 0^{o}-15^{o} of hip flexion. Two clinical studies demonstrated the role of the iliopsoas as a dynamic hip stabilizer, particularly in patients with increased femoral version (greater than 15°-25°). Two studies reported cases of atraumatic anterior hip dislocations after arthroscopic iliopsoas tenotomies. **Conclusions:** Evidence from biomechanical and clinical studies may suggest that the iliopsoas is a dynamic anterior femoral head stabilizer. **Level of Evidence:** Level IV, systematic review of Level III and IV plus biomechanical studies.

Arthroscopic hip preservation surgery is a rapidly growing orthopedic technique. The most common clinical indications for this surgery include femoroacetabular impingement syndrome and chondrolabral injury.[1] The iliopsoas is anatomically in close proximity to the anterior hip capsule, labrum and femoroacetabular articulation. Therefore, it may play a role in hip symptomatology due to a variety of static and dynamic osseous and soft tissue factors.[2] Recent evidence has shown that iliopsoas tenotomy, at any level, may significantly affect patients' symptoms with increased pain, decreased strength and significant iliopsoas atrophy.[3,4] The reasons for this are multifactorial but are concluded to involve a spectrum of hip instability, ranging from microinstability to dislocation.[5]

There is controversy about whether the iliopsoas is a true femoral head stabilizer and whether releasing or lengthening the iliopsoas may lead to objective hip instability.[2,5] The anterior anatomic location of the iliopsoas relative to the hip joint and its posterior origin (the iliac wing and T12-L5 vertebrae) and posterior insertion (the lesser trochanter) position it as a stabilizer of the hip, resisting anterior femoral head translation. Thus, given this anatomy, the role of the iliopsoas in hip stability may

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be strongly influenced by femoral version, lesser trochanteric version, acetabular version, neck-shaft angle, femoral offset, and pelvic incidence, among others.[6-8] Nevertheless, some studies have shown that excellent outcomes can be achieved in patients undergoing arthroscopic iliopsoas lengthening for symptomatic internal snapping hip syndrome, as long as cam/pincer morphology is corrected, the labrum is preserved, the capsule is managed according to underlying pathology, and femoral version is normal or low.[9-13]

The purpose of this study was to perform a systematic review of biomechanical and clinical studies to determine whether the iliopsoas is a femoral head stabilizer. The authors hypothesized that the iliopsoas is an anterior femoral head stabilizer.

Methods

Design and Search Strategy

A systematic review of the literature was performed according to Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines.[14] The review was registered with international Prospective Register of Systematic Reviews (PROSPERO). Under the PROSPERO registration, similar prior systematic reviews and meta-analyses were sought, and none were identified. The following medical databases were searched on January 24, 2019: PubMed (1966-present), Ovid MEDLINE (1946-present) and SCOPUS (1966-present). To ensure a stringent search strategy of relevant literature, keywords, including “iliopsoas,” “psoas,” “iliacus,” “hip,” and “flexor” were combined with Boolean operators to develop a search protocol ([*]footnote). A hand search of the included reference lists was also performed to further minimize unintentional exclusion of relevant studies.

Eligibility Criteria

Inclusion criteria consisted of studies published in the English language, clinical and cadaveric studies of the biomechanics of the iliopsoas in relation to the hip, and levels I-IV (via Oxford Centre for Evidence Based Medicine clinical outcomes studies (therapeutic, prognostic, diagnostic) of any nonarthroplasty hip procedures involving iliopsoas tenotomy or fractional lengthening or release.[15] The definition of *femoral head stabilizer* used in this study was an anatomic structure preventing or resisting anterior femoral head translation. Exclusion criteria consisted of studies that included hip arthroplasty or spine pathology, animal studies, Level V evidence (i.e., expert opinions), letters to editors, reviews, editorials, and surveys. In the situation of duplicate studies from the same author(s) and/or institution(s) reporting on the same or overlapping subjects, only 1 study was retained: the highest level of evidence, the largest number of subjects, the longest follow-up, the most pertinent primary outcome score (or relevant secondary). The others were excluded.

Data Extraction and Analysis

Two authors independently reviewed all articles by using previous methodology.[16] The study design and subject demographics were identified first. For biomechanical studies, the method of stability measurements and results were extracted. For clinical outcomes studies, the levels of evidence were assigned based on the Oxford Centre for Evidence Based Medicine.[15] Studies' methodologic quality for clinical outcomes studies were analyzed using the Modified Coleman Methodology Score.[17] Extracted data included were: (1) type of intervention, (2) follow-up duration, (3) outcomes scores, (4) outcomes, including complications, and (5) implication on hip stability. For continuous variables (i.e., age and follow-up duration), the mean, standard deviation and/or range were extracted if reported. Because of the heterogeneity of participants and interventions, no quantitative assimilative meta-analysis was performed.

Results

Eight studies were included in the systematic review—3 biomechanical and 5 clinical outcomes studies (Fig 1).[18-25] According to the Modified Coleman Methodology Score, 3 clinical outcomes studies were fair (scores between 55 and 69), and 2 were poor (scores below 55).

Biomechanical Studies

Three biomechanical studies describing 35 cadavers (N = 24 males, 11 females) and 18 healthy subjects

*Footnote:

- Search 1: (iliopsoas[Title/Abstract] OR psoas[Title/Abstract] OR iliacus[Title/AbstraAbstract]/Abstract] AND flexor[All Fields]).
- Search 2: (iliopsoas[Title/Abstract] OR psoas[Title/Abstract] OR iliacus[Title/Abstract])) AND (Hip[Title/Abstract] AND flexor))) NOT arthroplasty[Title/Abstract])) NOT replacement[Title/Abstract]
- Search 3: (iliopsoas[Title/Abstract] OR psoas[Title/Abstract] OR iliacus[Title/Abstract]) AND (Hip [Title/Abstract] AND flexor[All Fields])) NOT arthroplasty[Title/Abstract]) NOT replacement[Title/Abstract] AND "humans"[MeSH Terms]
- Search 4: (iliopsoas[Title/Abstract] OR psoas[Title/Abstract] OR iliacus[Title/Abstract]) AND (Hip[Title/Abstract] AND flexor[All Fields])) NOT arthroplasty [Title/Abstract]) NOT replacement[Title/Abstract] AND ("humans"[MeSH Terms] AND "adult"[MeSH Terms])

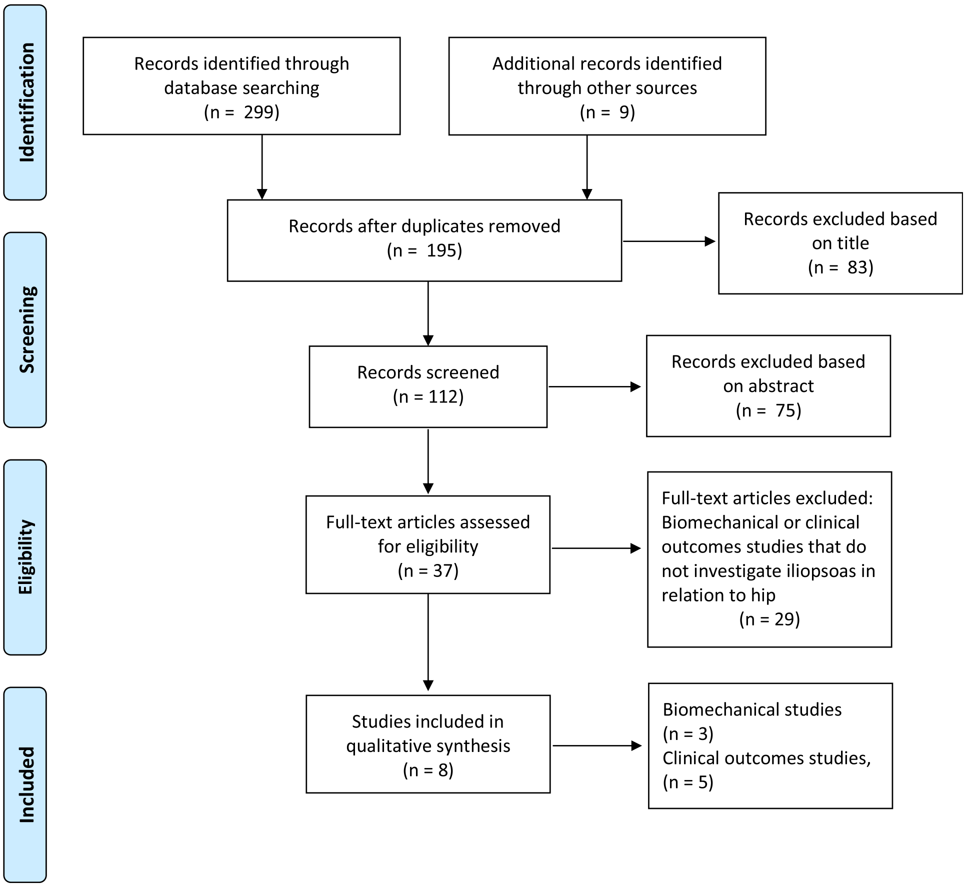

Fig 1. Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) flowchart showing application of selection criteria to the studies identified with the search strategy.

(N = 13 males, 5 females) were analyzed (Table 1).[18-20] Two studies used electromyography readings of the psoas, iliacus and iliopsoas muscles in healthy human subjects.[19,20] One study described the use of tension loading on the psoas muscle in human cadavers to measure stability at the hip joint.[18] All 3 studies concluded that the iliopsoas is a hip stabilizer. One study found that the iliopsoas is a femoral head stabilizer at 0°-15° of hip flexion.[18] Another study found that the iliopsoas stabilizes the hip while standing and at

Table 1. Characteristics and Outcomes of Biomechanical Studies

Author/Year	Study Sample	Gender (M/F)	Age	Method of Stability Measurement	Conclusion
Yoshio et al. 2012	35 cadavers	24/11	> 70 years at death	The tension loading the PMM tendon was measured at 7 different angled positions of hip joint flexion (0°, 15°, 30°, 45°, 60°, 75°, and 90°) using a load cell attached to a traction appliance.	PMM is a femoral head stabilizer in the acetabulum at 0°-15° flexion at the hip joint.
Andersson et al. 1997	11 healthy active subjects	9/2	Mean age 28 years	EMG readings of hip flexor muscles were recorded while walking and running on treadmill.	The PMM is an anterior hip stabilizer at terminal stance and heel strike, at low degrees of hip flexion.
Andersson et al. 1995	7 healthy active subjects	4/3	Mean male age 32 years, mean female age 28 years	EMG readings of PMM and IM were recorded while sitting, standing and lying.	The IPM is a hip stabilizer while standing, at low degrees of hip flexion (iliacus portion).

EMG, electromyography; IM, iliacus muscle; IPM, iliopsoas muscle; PMM, psoas major muscle.

Table 2. Characteristics and Outcomes of Clinical Studies

Author/Year	Level of Evidence	Study Sample	Treatment Groups	Gender (M/F)	Age (Mean ± SD, Range)	Follow-up (months, Mean ± SD)	Intervention	Outcome Scores Used	Outcomes	Implication on Hip Stability
Fabricant et al. 2012	IV	77 patients with FAI and snapping hip syndrome	Femoral version $\leq 25^{o}$ Femoral version $> 25^{o}$	5/43 2/17	24.4 ± 8.8 23.0 ± 7.6	110.8 ± 6.0 13.2 ± 7.2	Arthroscopic iliopsoas tenotomy	mHHS, HOS	Postop mHHS scores were significantly lower in patients with increased femoral anteversion ($P = 0.031$). No complications reported.	The IP is likely an important hip stabilizer, particularly in individuals with increased femoral anteversion
Ferro et al. 2015	IV	180 patients with FAI, 60 with psoas impingement	Femoral version $< 5^{o}$ Femoral version 5^{o}-15^{o} Femoral version $> 15^{o}$	NR NR NR	33 ± 12 35 ± 12 35 ± 13	30.8 ± 6 28.9 ± 5 3. 30.3 ± 7	Arthroscopic rim trim, osteoplasty, acetabular microfracture, capsule repair, and/or iliopsoas tenotomy, labral debridement, reconstruction, and/or repair	mHHS, WOMAC, SF-12 PCS, SF12 MCS,	Increased incidence of psoas release with increased femoral anteversion ($P = 0.005$), though no significant difference in postoperative outcomes. No complications reported	The IP is likely a dynamic anterior hip stabilizer, particularly in individuals with increased femoral anteversion.
Jackson et al. 2015	III	278 patients with FAI (58 patients with concomitant snapping hip syndrome)	Femoral version $< -2^{o}$ Femoral version 0^{o}-17^{o} Femoral version $\geq 18^{o}$	5/17 75/121 7/20	37.9 (14-55) 37.8 (14-66) 38.4 (15-69)	28.4 ± 5.6 28.3 ± 5.8 32.3 ± 6.8	Arthroscopic capsule repair, and/or iliopsoas tenotomy, labral debridement, reconstruction, and/or repair	mHHS, VAS, NAHS, HOS-ADL, HOS-SSS, patient satisfaction	No significant differences in incidence of psoas release or outcome scores with varying femoral anteversion. No complications reported	No evidence that the IP is or is not a hip stabilizer.
Austin et al. 2014	IV	1 patient with FAI, anterior snapping	30	0/1	19	10	Arthroscopic cam resection, iliopsoas tenotomy	NR	Acute atraumatic anterior hip dislocation at 22 weeks post-operatively	IP is an important anterior femoral head stabilizer
Sansone et al. 2013	IV	2 patients with FAI	N/A	1/1	26	8.5	Arthroscopic cam resection, iliopsoas tenotomy	NR	Acute atraumatic anterior hip dislocation at 10 and 12 weeks post-operatively	IP is an important anterior femoral head stabilizer, should be released with great care

ADL, activities of daily living; FAI, femoroacetabular impingement; HOS, Hip Outcome Score; IP, iliopsoas; MCS, mental component summary; mHHS, modified Harris Hip Score; NAHS, Non-Arthritic Hip Score; NR, not recorded; PCS, physical component summary; SF-12, Short Form 12; SSS, Sports Subscale Score; VAS, visual analog scale; WOMAC, Western Ontario and McMaster Universities Arthritis Index.

low degrees of hip flexion (iliacus portion).[19] A study found that the iliopsoas is a dynamic anterior hip stabilizer at the terminal part of swing phase of gait and into heel strike at low degrees of hip flexion with eccentric iliopsoas activity.[20]

Clinical Outcomes Studies

A total of 538 total subjects were assessed by clinical outcomes studies (Table 2).[21-25] All 538 patients had evidence of femoroacetabular impingement syndrome; 136 patients had concomitant snapping hip syndrome, and 60 had psoas impingement. One article had Level III evidence,[23] and 4 articles had Level IV evidence.[21,22,24,25] Three studies investigated the effect of femoral version on the outcomes of primary hip arthroscopy,[21-23] and 2 studies reported a total of 3 cases of atraumatic anterior hip dislocations after iliopsoas tenotomy.[24,25] Of the patients, 209 (38.8%) received arthroscopic iliopsoas tenotomy. No complications or reoperations were reported. One study found that patients with increased femoral version had significantly higher rate of "need" for iliopsoas tenotomy compared with patients with normal or decreased version (68% vs 27%; $P = 0.005$).[22] Similarly, another study found that patients with increased femoral version had a significantly lower modified Harris Hip Score postoperatively compared with patients with normal or decreased version (76.9 ± 16.8 vs 86.1 ± 14.8; $P = 0.031$).[21] One study found that femoral version did not significantly affect postoperative outcomes or the need for iliopsoas tenotomy.[23]

Discussion

The results of this systematic review of eight biomechanical and clinical studies suggest that the iliopsoas is an anterior femoral head stabilizer. Biomechanical studies used cadavers and healthy individuals to find that the iliopsoas stabilizes the hip at low degrees (0°-15°) of hip flexion. Clinical outcomes studies further characterized the importance of the iliopsoas as a femoral head stabilizer.

This investigation studied the controversial subject of whether the iliopsoas is a true dynamic femoral head stabilizer. The study is particularly important in the setting of rapidly advancing techniques and indications for hip arthroscopy, primarily to determine whether releasing or lengthening the iliopsoas will lead to objective hip instability and postoperative complications. Previous biomechanical studies of the iliopsoas focused primarily on the effect on the lumbar spine or characterized the dynamic function of the muscle and largely ignored its role in hip stability.[26-31] Furthermore, most relevant clinical outcomes studies in the past did not study directly the implication of iliopsoas tenotomy on hip instability.[3,9] Iliopsoas lengthening is performed for symptomatic internal snapping hip syndrome and has been shown to have excellent outcomes as long as the cam/pincer morphology is corrected, the labrum is preserved, the capsule is plicated, and femoral version is normal or low.[9] Internal snapping hip syndrome causes a painful snapping of the hip that involves the iliopsoas tendon snapping over the femoral head and the hip capsule when the hip is extended, adducted and internally rotated.[32,33] About 10% of the general population is estimated to have an internal snapping hip; however, the majority of these individuals are found to be asymptomatic.[34]

From a biomechanical standpoint, due to the anatomic relationship of the iliopsoas tendon to the hip, it was hypothesized that that the iliopsoas is a dynamic anterior hip stabilizer. The study by Yoshio et al. demonstrated a significant increase in contact between the femoral head and the iliopsoas between 0° and 15° flexion at the hip joint to show that this extra force is used primarily for the anterior stabilization of the femoral head into the acetabulum.[18] This study further demonstrated that the iliopsoas functions to maintain the erector position between 15° and 45° of hip flexion and functions as a primary hip flexor between 45° and 60°. This result aligned with a previous biomechanical study by Kimura et al., which reported that the iliopsoas functions not only as a hip flexor but also has a unique antigravity function in the upright posture.[27] A study by Andersson et al. found that the iliopsoas is a hip stabilizer, but contributions from the iliacus and psoas portions varied depending on type of activity and position.[19] The study demonstrated that the iliacus portion of the conjoint tendon functions to stabilize the hip during contralateral leg extension while standing; conversely, the psoas portion functions to stabilize the spine during contralateral loading. Another study by Andersson et al. showed that the iliopsoas is a dynamic anterior hip stabilizer.[20] The study found that the psoas portion of the conjoint tendon selectively activates during the swing phase during higher speeds of walking and running, which functions to stabilize the hip.

From a clinical standpoint, because the iliopsoas is an anterior restraint, it was hypothesized that an iliopsoas tenotomy would lead to anterior instability, particularly in the setting of increased femoral version. Fabricant et al. reported that patients with increased femoral version (version greater than 25°) had a significantly lower postoperative modified Harris Hip Score compared with patients with normal or decreased version.[21] This result suggests the role of iliopsoas as a femoral head stabilizer in individuals with increased femoral anteversion due to higher anterior forces from the altered proximal femoral morphology, the loss of anterior capsule static stability or both. Furthermore, Ferro et al. found that patients with increased version had a significantly higher rate of "need" for iliopsoas tenotomy, which further suggests the hip's reliance on the iliopsoas tendon for dynamic anterior stability among this group of patients.[22] Jackson et al. also reported that patients with increased femoral version (version greater than or equal to 18°) had lower postoperative modified Harris Hip Scores compared with patients with retroversion (80.8 ± 16.7 vs 89.2 ± 10.0), but the scores were not statistically significant ($P = 0.104$). However, Jackson et al. found patient threshold for increased version to be greater than 18°, compared to 25° found by Fabricant et al.[23] Austin et al. and Sansone et al. reported 3 cases of atraumatic anterior hip dislocations after iliopsoas tenotomy.[24,25] Sansone et al. stated "the loss of the compressive and adductive forces of the iliopsoas can destabilize the hip enough for a dislocation." Similarly, in Sansone et al., "inherent instability can be one possible cause of psoas muscle-tendon overloading and pain generation. In these cases, iliopsoas tenotomy and sectioning of the anterior ligamentous apparatus might be a risk factor for increased instability. Thus, iliopsoas tenotomy should be practiced with great care." Austin et al. stated, "a partial psoas release contributed to dynamic hip instability because of increased femoral anteversion. A psoas release should be avoided in patients with significant anteversion."

Hip stability is dependent on both static and dynamic stabilizers, and altering these structures predisposes patients to hip instability. Although several studies negate the role of the iliopsoas in hip stability, evidence from this review of biomechanical and clinical studies strongly supports that the iliopsoas is a dynamic anterior femoral head stabilizer. These findings argue against performing an iliopsoas tenotomy on a routine basis, particularly in patients with predisposing factors to hip instability.

Limitations

This review includes limitations. The included clinical and biomechanical studies did not thoroughly investigate all osseous parameters associated with the iliopsoas anatomy and function. In cadaveric investigations, it is incredibly challenging, and sometimes prohibitively expensive, to control for several variables able to be obtained only with advanced imaging (computed tomography, magnetic resonance imaging) and large numbers of cadaveric specimens. Other limitations of this study include the heterogeneity of biomechanical studies including study subjects (i.e., cadaveric vs in vivo) and the methods used to evaluate stability (i.e., electromyography vs tension loading), thus limiting direct comparisons of results. The included clinical outcomes studies were also primarily retrospective Level III or IV evidence. Last, it is possible that our stringent search protocol and limiters may have excluded other relevant studies of this topic, including those published in non-English or for pediatric populations.

Conclusion

Evidence from biomechanical and clinical studies may suggest that the iliopsoas is an anterior femoral head stabilizer.

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