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Review Article

Functional Anatomy of the Hamstring Muscle and Its Correlation with the Various Yogic Postures: A Narrative Review

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ABSTRACT

Yoga is believed to be a safe practice; nonetheless, as the number of yoga practitioners has grown, so has the incidence of yoga-related injuries. Overall, lower extremity injuries comprised 64% of total injuries; specifically, the hip, hamstring, knee, ankle, feet and toe. Although a few research studies have quantified the hamstring muscle activities in various yoga asanas, evidence correlating it to functional anatomy is scarce. Therefore, the objective of this narrative review is to examine the literature and analyse hamstrings activity and its relationship to yogic postures, as well as yoga-related injuries, to establish which poses provide the most risk of damage, and to suggest injury-prevention techniques. The following electronic databases were used to conduct the literature search: Cochrane Library, PubMed, Google Scholar, EMBASE, and Web of Science. hamstring muscle injuries OR yoga and rehabilitation OR intervention AND electromyography was among the search phrases utilized. Such information is important for yoga teachers, yoga therapists to help selecting yoga posture for hamstring muscle imbalance condition and avoiding posture to prevent hamstring muscle injury.

KEY WORDS: Hamstring Muscle Activation and Injuries, Yoga Posture.

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INTRODUCTION

Yoga is believed to be a safe practice; nonetheless, as the number of yoga practitioners has grown, so has the incidence of yoga-related injuries. Overall, lower extremity injuries comprised 64% of total injuries; specifically, the hip, hamstring, knee, ankle, feet, and toe [1].

Yoga practitioners are prone to overstretching their hamstring muscles in various asanas. As a result, the connecting tendon is torn. The semimembranosus (SM), Semitendinosus (ST), biceps femoris long head (BFlh), and biceps femoris short head (BFsh) are the four muscles that make up the posterior compartment of the thigh (BFsh). These muscles are multi-articular and prone to recurrent strain injuries [2]. Yoga related injuries commonly occur in the lower limbs, particularly in the hamstring muscles. The hamstrings, abdominals, erector spinae, and hip flexors are important for supporting and maintaining the pelvis in its natural alignments in the static

standing position, provided the muscular action is balanced. When there is an imbalance between these muscle groups or a change in posture, the pelvis will tilt anteriorly or posteriorly, with anterior pelvic tilting being more common due to weaker and lengthened hamstring muscles [3]. Spinopelvic rhythm (lumbar pelvic motion/pelvic motion) relates to low back discomfort, and spino-pelvic rhythm is disrupted by tight hamstrings, according to research [4].

Given its increasing popularity, describing the types and frequency of possible injuries is crucial. To reduce the frequency with which these injuries occur, it is necessary to identify specific risk factors and damage mechanisms. We evaluate the research on the hamstring muscle and its relationship to yogic postures, as well as the topic of yoga-related injuries, to establish which poses provide the most risk of damage, and to suggest injury-prevention techniques [5].

Table 1: Effect on yoga posture due to hamstring shortness and its adaptation.

Hamstring muscle shortness	Forward bending asanas	backward bending asanas
Effect	Flexion of the lumbar spine more efficientaly , but not the hip joint	Hip extension is spontanenous , but not lumbar extension
Adaptation	To start with bending of the knee	To start with the expanding the chest & extending the lumbar spine.

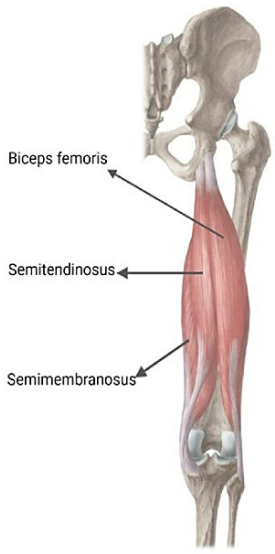

Fig. 1: Hamstring Muscle.

Fig. 2: Effect of shortness of hamstring muscle.

LITERATURE SEARCH

The following electronic databases were used to conduct the literature search: Cochrane Library, PubMed, Google Scholar, EMBASE, and Web of Science. hamstring muscle damage OR yoga and rehabilitation OR intervention AND electromyography was among the search phrases utilized. The current review only considered papers that matched the following criteria: (A) Studies had to be published inEnglish, (B) publications had to be peer reviewed, and (C) the experimental groupreceived yoga and physical exercise modules as an intervention treatment. Some of the research included in the review no direct link to yogic asana. Based on existing literature and the author's understanding of numerous asanas, the exercise mentioned in the selected research was compared to similar yogic asana/ exercise and connected with functional anatomy.

Functional anatomy of the hamstring muscle: The Semitendinosus (ST), Semimembranosus (SM) , and Biceps femoris (BF) (long head-BFlh; short head-BFsh) (Figure 1) are the muscles of the posterior compartment of the thigh that attach proximally to the ischial tuberosity

(the BFsh). The ST, SM, and BFlh are biarticular muscles that stretch the hip and flex and rotate the knee (medially and laterally). Both heads of the BF adhere to the fibula, while the ST and SM attach to the tibia.

BF is a fusiform muscle with two heads. The ischial tuberosity gave rise to BFlh, while the rear of the femur gave rise to BFsh. On the lateral side of the knee, both heads join to form a single tendon insertion on the head of the fibula bone. In the flexed knee, the BF flexes the straight knee and externally rotates the tibia. In marichyasana, the BFs contract, flexing the knee and externally twisting the tibia. This external rotation manifests as internal hip rotation, highlighting the trunk twist. The BFs are stretched and awakened in Adho mukha svanasana. The inner hamstrings are made up of the ST and SM. The SM has a large, flattened belly. ST is fusiform in shape (tapered at both ends), with a lengthy tendon at the distal end. The ischial tuberosity gives rise to both muscles. On the proximal tibia, they have two different insertions, one on the inside of the back of the tibia (SM) and one on the inside of the front of the tibia (F) (ST). The ST insertion joins the sartorius and gracilis muscles to produce the pes anserinus, a broad duck-like insertion on the anterior tibia. ST & SM stretch and awaken the supta padangusthasana B by flexing the straight knee and inward rotating the lower leg in the bend knee.

The quadriceps are antagonists' muscle of the hamstring, and it is part of the anterior muscles of the thigh.

Straight Leg Raise (SLR) Test-

Effects on Yoga Posture due to Shortening of Hamstrings: Faulty postures due to sedentary lifestyle and continuous sitting cause shortening of the hamstring causes hamstring shortening, which is known as the "computer-desk sitting" condition. Shortened hamstrings (Figure 2) reduce pelvic and lumbar spine mobility and can set the stage for spinal disc injury by dragging the ischial tuberosities (sitting bone) down and forcing a posterior pelvic tilt. The flattening of the lumbar spine curve makes it difficult to securely hinge into front fold yoga postures like uttanasana, prasarita padottanasana, and Dandasana. During the practice of forward bending yoga asanas, hamstring injuries occur over time, mainly where the hamstring joins to the sit bone. Each small rip in the tendon is trivial on its own, but because it does not fully heal, repeated injuries accumulate over time, until an ill-advised piece of overstretching occurs. Overstretching the hamstring in the case of a hamstring rupture will slow healing and may even worsen the condition. In a forward bend, the hamstring stretches eccentrically, acting as a brake as it lengthens, thus balancing strength and suppleness while sparing yourself from hamstring tendonitis. A proper balance between engaging the quadriceps and drawing the sit bones towards the backs of knee, toes and protects the hamstring attachments. (Table 1)

Good posture comes about through balanced tone between the quadriceps and the hamstrings. Bad posture throws off this balance, causing tightness and chronic hypercontraction either at the front or the back of the hip joint.

The BF's shortness restricts forward bends and certain standing poses, particularly those that require internal leg rotation. The forward bend and several standing asanas that require external rotation of the leg are also limited by the SM & ST's shortness. In forward bending yoga asanas, short hamstring muscles also disrupt spinopelvic rhythm and restrict hip movement, increasing lumbar spine motion [6], leading to chronic lower back discomfort [4,7]. assessed spino-pelvic rhythm in healthy subjects with varied degrees of hamstring tightness and discovered that those with flexible hamstrings had more pelvic motion than those with tight hamstrings.

In forward bending asanas, those with tight hamstrings do not flex their spine. Instead, patients can sit on a blanket to minimize hip flexion and allow for the re-creation of normal lumbar Lordosis, which reduces the risk of intervertebral disc injury. Another change, such as bending their knee in forward bends, reduces hamstring and sciatic nerve irritation, in back bending asanas, it is difficult to extend the lumbar spine if the extension

commences from the hip joints. A more effective way of preparation is to start with expanding the chest and extending the lumbar area. such adjustments in the yoga asanas reduces the injuries in the hamstring muscle.

Correctly done yoga stretches can improve hamstring flexibility. The quadriceps should be kept engaged during hamstring stretches in order to keep the knee completely extended and provide reciprocal relaxation to the hamstring. Increase the distance between the proximal and distal attachments of the hamstrings group by increasing anterior pelvic tilt rather than spinal flexion to increase the intensity of the hamstring stretch. Forward bending postures can benefit from hip flexor activation.

· Standing hamstring stretch such as parsvottanasana

· The supine hamstring stretches such as supta padangusthasana.

Straight Leg Raising Test (SLR)

Equipment:

Table or floor.

Folded blanket may be used, but not soft padding.

(The examiner cannot confirm that the low back and sacrum are flat if they are on a soft pad.)

Goniometer to measure the angle between the straight leg and the table.

Pillow or towel roll (in case of hip flexor shortness).

Chart to record findings.

Starting Position: Supine with the legs extended and the low back and sacrum flat on the table. (Standardization of the test requires that the knee be in extension, and that the low back and pelvis have a fixed position to control the variables created by excessive anterior or posterior pelvic tilt.) When the low back and sacrum are flat, hold one thigh firmly down, making use of passive restraint by the hip flexors to prevent excessive posterior pelvic tilt before starting to raise the other leg in the straight-leg-raising test. **Test Movement:** With the low back and sacrum flat on the table and one leg held firmly down, have the subject (figure 3)

raise the other leg with the knee straight and the foot relaxed.

Reasons: The knee is kept straight to control this variable. The foot is kept relaxed to avoid gastrocnemius involvement at the knee. (If the gastrocnemius is tight, dorsiflexion of the foot will cause the knee to flex, thereby interfering with the test of the hamstrings.) If the knee starts to bend, lower the leg slightly and have the subject fully extends the knee and again raise the leg until some restraint is felt and the subject feels slight discomfort [8].

Effects of Hamstring Weakness: The hamstrings are the primary knee flexors and are the antagonists of the quadriceps muscle. Muscle imbalance commonly refers to a modification of the strength balance between agonist and antagonist muscles. The relationship between muscle injury and agonist-antagonist balance disruption has been frequently reviewed in the literature [9].

contraction of the quadriceps results in knee extension, while contraction of the quadriceps results in flexion of the knee joint [10].

Knee flexion strength is significantly reduced when the hamstring muscle is weak. Knee flexion weakness in an upright posture causes little discomfort. However, hamstring insufficiency may result in more functional damage at the hips, where the hamstrings provide a significant portion of extension strength. A flexion moment at the hip is created by the superimposed weight that induces a flexion moment at the knee during a squat. A muscular extension moment generated in part by the hamstring muscles resists this flexion moment. As a result, hamstring weakness can cause severe difficulty in bending and lifting.

The yogic asanas involve the extensive hip flexion with simultaneous knee extension, such as uttanasana could be responsible for the stretch type of hamstring injuries. Hip -flexion angle influenced hamstrings peak torque in all muscular contraction type; as hip flexion increased, hamstring peak torque increases. The forward trunk lean can be caused by poor activation and control of the

muscles of the core and hip, thereby increasing the strain and injury risk of the hamstrings [11]. Askling et al. proposed two scenarios in which a hamstring injury may occur: during either high-speed running or stretching movements. The high-speed running type of injury typically affects the long head of the biceps femoris (BFlh) and has a shorter recovery time than the stretching type of injury, which commonly affects the semimembranosus (SM). The running type of injury is the most frequent and, in Australian football, 81% of hamstring injuries occur during sprinting, while kicking (stretching type) accounts for 19% of injuries.

For this reason, in-depth knowledge of this type of injury prevention and rehabilitation program focuses on hip and core strengthening exercises in addition to traditional hamstring exercises.

Hamstrings work synergistically with the anterior cruciate ligaments (ACL). The ability to create a co-activation of the hamstrings with quadriceps is crucial to the stability of the knee joint [12]. The most ruptured knee ligaments are the anterior cruciate ligaments (ACL) and medial collateral ligaments (MCL). Rupture of the ACL & MCL leads to anteromedial instability of the knee joint complex [13].

Hamstring muscle weakening has been seen in patients with knee OA (osteoarthritis) [14]. Controlling varus-valgus laxity is largely due to quadriceps and hamstring muscle co- contraction. The knee's ability to resist external stresses is weakened when the hamstring muscles are weak, which can lead to symptoms of knee instability. Different muscular activation patterns have been linked to muscle strength imbalance in the knees. People with knee OA who improved their hamstring strength between baseline and 18 months showed less deterioration in function [12]. Therefore, in case of an ACL tear or rupture, strength and control of the hamstring is very important for aiding recovery and preventing further damage.

Activation of the Hamstring muscle in the various Yoga posture: The hamstring is the vital muscle in the lower extremity to maintain various day to day activities. And its imbalance leads to various musculoskeletal disorders and lower extremity injuries. Therefore, proper hamstring activation is essential to keep harmony in the joint. The literature review suggested that the different yoga asanas activate the hamstring muscle. Knowledge of these activation analyses can design rehabilitation programs for musculoskeletal disorders and prevent injuries.

Liu et al. [15] Studied the Utkatasana, Vrikshasana , and Virabhadrasana 1,2 and 3 yoga pose. And their results revealed significant differences in the hip, knee, and ankle JMOFs and varying degrees of muscle activation among the poses. Among this pose, rectus femoris activation during the Utkatasana pose was highest. Virabhadrasana 2 produced the highest muscle activation in the vastus lateralis of the front limb, while Virabhadrasana 1 had the highest muscle activation in the vastus medialis of the back limb. Therefore, all three poses can possibly be suggested as a therapeutic intervention for quadriceps strengthening. Warrior 1 was possibly suggested as a therapeutic intervention in order to reduce the excessive lateral overload of the patella, but the possible adverse effects of Warrior 2 with the highest knee adductor JMOF in the back limb could raise joint reaction forces across the medial condyles. In single-leg balance postures, Warrior 3 had unique training effects on the hamstring and is therefore suggested as a part of hamstring rehabilitation exercises. The Tree pose induced low lower-extremity JMOFs and a low level of thigh muscle activations when it was performed by senior instructors with excellent balance control (Liu et al., 2021).

LaSala TT, et.al. (2021) conducted a study to determine the effect of a 7-week Hatha yoga intervention on hamstrings flexibility using a digital goniometer. and found hamstring flexibility will increase in a young healthy adult population. may be used as a modality to improve flexibility and function in activities of daily living as well as athletic performance.

Hegyi et al.[16] showed that straight-knee bridge (variation of setubandhasana), upright hip extension and leg curls exhibited the highest hamstring activity in both eccentric (40%-54% MVIC) and Concentric phases (69% -85%

MVIC)(16) while Within ST, lower distal than middle/proximal activity was found in the bent-knee bridge (Similar to setubandhasana) and leg curl exercises (d range = 0.53-1.20).

A review study by Bourne et al. [17] and stated that typically, relatively higher levels of biceps femoris long head and semimembranosus activity have been observed during hip extension-oriented movements, whereas preferential semitendinosus and biceps femoris short head activation has been reported during knee flexion-oriented movements such as These findings may have implications for targeting specific muscles in injury prevention programmes. Bourne et al. [17] highlight the heterogeneity of the hamstring activation patterns in the different exercises. 45-degree Hip extension exercise & Lung posture similar to Anjaneyasana selectively activates the long hamstring such as BFlh and medial hamstrings.

Yu et. Al. [18] studied the physical demands of Vrikshasana and Utthitahasta Padangustha-sana pose performed by senior people revealed that typical EMG signals of hamstrings in Vrikshasana were 48.05 % ±10.60 % MVIC and 94.78 % ±13.55 % MVIC, respectively. Wang et. al., (2012) The biomechanical demands of standing yoga pose in the elderly were also tested, and it was discovered that the one leg balance posture (Uttita Hasta Padangustha-sana) (85.9% MVIC) had considerably higher average EMG activity of the hamstring. Because the hamstrings muscle opposes potentially harmful actions, boosting its strength and activation through yogic postures like those mentioned above can be an important part of injury and rehabilitation regimens.

Fishman et al. [19] 1336 yoga practitioners were surveyed about injury. They said that the neck, shoulder, lower back, knee, wrist, back or spine (any place), hamstring, hip, leg, and groyne were all harmed, in that order. Hyper competition and ego were the most common reasons for injury, followed by excessive effort, poor technique, inadequate coaching, and inappropriate instruction. Sprains and strains of the hamstrings are some of the most common yoga injuries. Hamstring tension and overuse can be caused by repeated forward bending positions. When standing or sitting, knee problems might occur. Wide-legged stances, such as warrior pose, necessitate a lot of hip stretch, which can put unnecessary strain on the knees if not done appropriately. Although there is scant evidence linking yoga and certain asanas to hip joint issues, Kang et al. [20] 2009 In a case series on acetabular labral tears in sports injuries, one patient's damage was linked to regular yoga practice.

Ekstrom et. al. [21] conducted study on the muscle activation pattern of the hamstring is significantly higher in the unilateral bridge (similar to a variation of Setu Bandhasana) (40 % ±17 % MVIC) and Quadruped arm/lower extremity lift (similar to a variation of Marjariasana) (39 % ±14 % MVIC), according to researchers who studied the muscle activation pattern in various muscle in rehabilitation exercise modules. Ni et. al., (2014) also compared muscle activation patterns in 14 dominant side muscles during different yogic poses across three skill levels and noticed that the BF produced significantly higher EMG signals during Utkaasana, Urdhva Mukha Svanasana, Dandasana, Chaturanga Dandasana, Virabhadrasana-1 than Utthanasana.

CONCLUSION

To the best of knowledge this is the first review study to clarify the concept of various yogic postures effect on hamstring muscle. Present review study is informative for yoga teachers, yoga therapists and beginners to help selecting posture for hamstring muscle activation, muscle imbalance condition and avoiding posture to prevent hamstring muscle injury. Present review article covered an evidence-based study which stated functional anatomy of hamstring muscle with deep explanation of yogic postures and its mechanism related to hamstring muscle groups.

Conflicts of Interests: **None**

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