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EXTERNAL HIP ROTATORS ANATOMIC VARIATIONS - BIBLIOGRAPHIC REVIEW

ROTADORES EXTERNOS DO QUADRIL VARIAÇÕES ANATOMICAS - REVISÃO BIBLIOGRÁFICA

ROTADORES EXTERNOS DE LA CADERA: VARIACIONES ANATÓMICAS - REVISIÓN BIBLIOGRÁFICA

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ABSTRACT
The literature review for this study demonstrated that the hip external rotator muscle group is composed of a complex architecture that remains difficult to fully understand. By analyzing key articles from the last five years, we concluded that variations primarily occurred in the piriformis and its correlation with the sciatic nerve, make these variations essential for understanding and correcting compressions along this pathway.Understanding regional anatomy is essential to avoid impacting the biomechanical balance of the hip in clinical and surgical contexts.

Keywords: Hip Rotator Muscles. Anatomy.

RESUMO
A revisão bibliográfica do presente estudo demonstrou que o grupo de músculos rotadores externos do quadril é composto de uma arquitetura complexa e ainda de difícil compreensão na sua totalidade. Através da análise de artigos preferenciais dos últimos cinco anos, concluímos que principalmente o músculo Piriforme e sua correlação com o nervo ciático torna tais variações imprescindíveis para entendimento e correções em compressões nesse trajeto. O entendimento da anatomia regional é fundamental para não impactar no equilíbrio biomecânico do quadril tanto em contextos clínicos como cirúrgicos.

Palavras-chave: Músculos Rotadores do Quadril. Anatomia.

RESUMEN
La revisión bibliográfica de este estudio demostró que el grupo de músculos rotadores externos de la cadera presenta una arquitectura compleja y aún resulta difícil de comprender en su totalidad. Mediante el análisis de artículos seleccionados de los últimos cinco años, concluimos que el músculo piriforme y su correlación con el nervio ciático hacen que dichas

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variaciones sean esenciales para comprender y corregir las compresiones a lo largo de su trayecto. Comprender la anatomía regional es fundamental para evitar alteraciones en el equilibrio biomecánico de la cadera, tanto en el ámbito clínico como quirúrgico.

Palabras clave: Músculos Rotadores de la Cadera. Anatomía.

1 INTRODUCTION

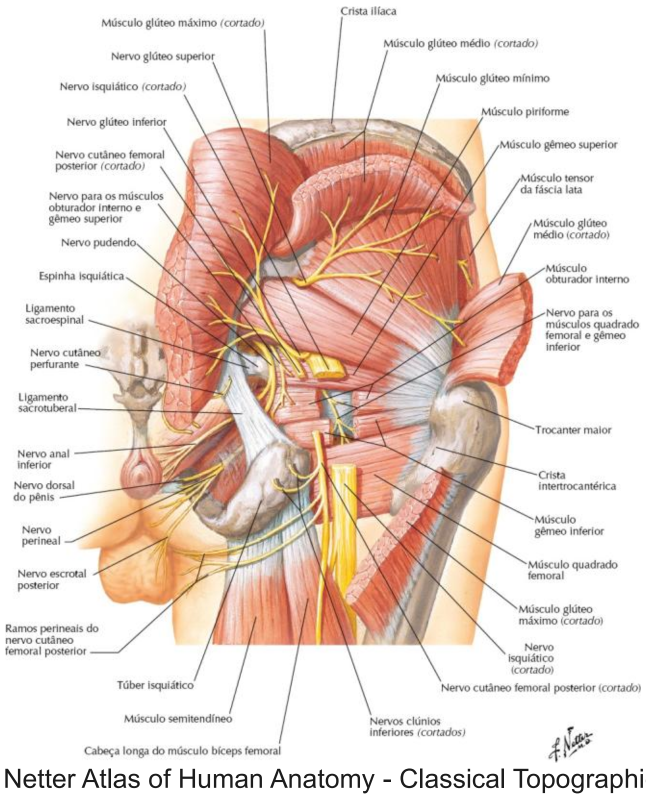
The hip external rotator group is made up of piriformis muscle, obturator internus muscle, superior and inferior gemellus muscle, quadratus femoris, and obturator external muscle.

These muscles, synergistically, promote lateral rotation of the thigh, contributing to the dynamic stabilization of the hip joint. During gait, external rotators play an essential role in postural control, keeping the femur coapt to the acetabulum, avoiding unwanted rotation of the pelvis in the stance phase and ensuring that the foot remains parallel to the line of advancement in the swing phase.

Thus, they act in a balanced and antagonistic way to the medial rotators, ensuring the efficiency of movement and the protection of the joint.[1](Figure 1)

Figure 1

Region of the external rotator muscles of the hip.[2]



Source: NETTER, Frank H. Netter Atlas of Human Anatomy - Classical Topographic Approach. 8. ed. Rio de Janeiro: GEN Guanabara Koogan, 2024. *Electronic book.* p. 671.[2]

We will verify, through a literature review, the specific composition of the external rotators of the hip, analyzing the number of structures in this region.

In this context, the objectives of this work were:

- Collection of classic and contemporary literature on the subject.
- Identification of how many and which components make up this anatomical set/region.

2 METHODOLOGY

The methodology of choice for the following research was a bibliographic review with an exploratory approach.

For Marconi and Lakatos (2019), bibliographic reviews are intended to put the researcher in direct contact with everything that has been written, said or filmed on the subject. Not being a mere repetition of the subject, but providing analysis of the theme from another perspective or approach, to reach new conclusions.[3]

The research followed the recommended methods, after choosing the theme and preliminary research. The researched samples were read, selected, evaluated and analyzed. The characteristics of the research were defined in order to discuss, interpret and present the results achieved.

The guiding question was: Are there variations in its composition?

For a bibliographic review of the theme, searches were carried out in printed bibliographies and digitized articles. The Anatomical Laboratory of the University of Contestado (UNC) was also used to complement and analyze "in loco" its structures.

The articles were collected until August 2025, preferably up to 5 years old, surveying works specifically related to the proposed theme and resulted in 35 articles

In the researched articles, a pattern was noticed in the problem addressed, that is, the authors also had the same doubt as in the present study with the object of the research.

Understanding this subject is of great importance for physicians and professionals who work in both the field of orthopedics and radiology.

3 HISTORY

3.1 ANATOMICAL NAME

According to Tatsuo Sakai in his revisional article "Historical evolution of anatomical terminology from a cient to modern" the history of *the anatomical nomina* can be divided into five stages.[4]

The first is represented by the oldest extant anatomical treatises by Galen of Pergamon in the Roman Empire, where he used a limited number of anatomical terms that were essentially colloquial words in the Greek of that period.[5]

The second stage, Andreas Vesalius in the early sixteenth century described anatomical structures in his book De Humani Corporis Fabrica Libri Septem5 known as the first modern book on anatomy,6 which presented magnificent details and illustrations, although he did not coin substantially any anatomical terms he developed a system that distinguished anatomy structures with ordinal numbers, [5] Andreas Vesalius was considered, while still alive, as the creator of modern anatomy.[6]

The third stage at the end of the sixteenth century he calls being marked by a great innovation in the development of specific anatomical terms, especially muscles, vessels and nerves. Thus marking a great advance in the anatomical nomina. The main figures were Jacobus Sylvius in Paris and Gaspard Bauhin in Basel, Switzerland.[5.6]

Between Bauhin and international anatomical terminology, many anatomy textbooks were written mainly in Latin in the seventeenth century, and in modern languages in the eighteenth and nineteenth centuries.[5] Thus, anatomical terms of the same structure have been expressed with different names by different authors.

Faced with the diverse terminology in numerous anatomical forms and books, anatomists came together to try to create terms that were logically consistent, intelligible in themselves, clear in meaning and compact in form.[4.5]

It took six years to reach the establishment of guidelines and it was at the ninth conference of the AnatomischeGessellschaft held in Basel, Switzerland that the international anatomical terminology in Latin was published as Anatomical Basel Nomina5. It is important to note that each country could have the freedom to translate the official Latin terms into its own language for teaching purposes.[7] The anatomical Basel Nomina was not a new terminology, but rather a careful selection of existing names7, the product of an international group of anatomists working together.[4.5]

As science progressed, the terminology was revised several times until the current Anatomical Terminology, both in Latin and English.[4.5] The first English edition of the Eycleshymer, published in 1917, records the results of the work at the Basel Conference. In the preface, it states that they searched from 50,000 names to 5,000 structures,5 reducing them to 5,000. They did so, and currently, the convention has had several subsequent editions that counts 7,000 terms.[4]

4 RESULTS AND DISCUSSION

The muscle group of the external rotators of the hip is composed of: Piriformis Muscle, Obturator Internus Muscle, Superior Gemini Muscle, Inferior Gemini Muscle, Quadratus Femoris Muscle, and Obturator External Muscle.

For a better understanding, we will individually detail the component elements of the external rotators of the hip in the studies surveyed:

4.1 PIRIFORMIS MUSCLE

The piriformis muscle has a pyramidal or pear shape, being a flat and oblique muscle.[8]

Its classic origin is found on the anterior aspect of the sacrum (typically S2-S4) or on the superior gluteal surface of the ilium.

It crosses the sciatic foramen (sciatica) and inserts distally on the upper border of the greater trochanter of the femur, and its innervation occurs in the branches of the anterior rami of S1 and S2 and, in some case studies, L5.[1.8]

Its main action is performed in lateral rotation of the femur during hip extension and abduction of the same bone during hip flexion, allowing precise movements of the leg during gait, running, and trunk rotation over the thigh.

Essentially, it is of paramount importance in stabilizing the body in its femoral abduction during walks because it transfers the weight of the body to the opposite side, also contributing to its function as a postural aid and helping to prevent falls. It also serves as a landmark of the gluteal and pelvic region and is closely associated with the gluteus medius and maximus muscles, obturator internus and the gemelli muscles, being important to improve the results of total hip arthroplasty surgery and reduce complications.[8,9,10]

This muscle can suffer from physiological variants, such as differences in patterns, innervation, or abnormal duplications and insertions. In some dissections and anatomical studies, it is observed that the piriformis muscle may be absent unilaterally or bilaterally or be partially fused to the gluteus medius or minimus, sharing fibers or aponeuroses, in addition to allowing passage of the superior gluteal nerve and vessels between the fused fibers. [9,10,11]

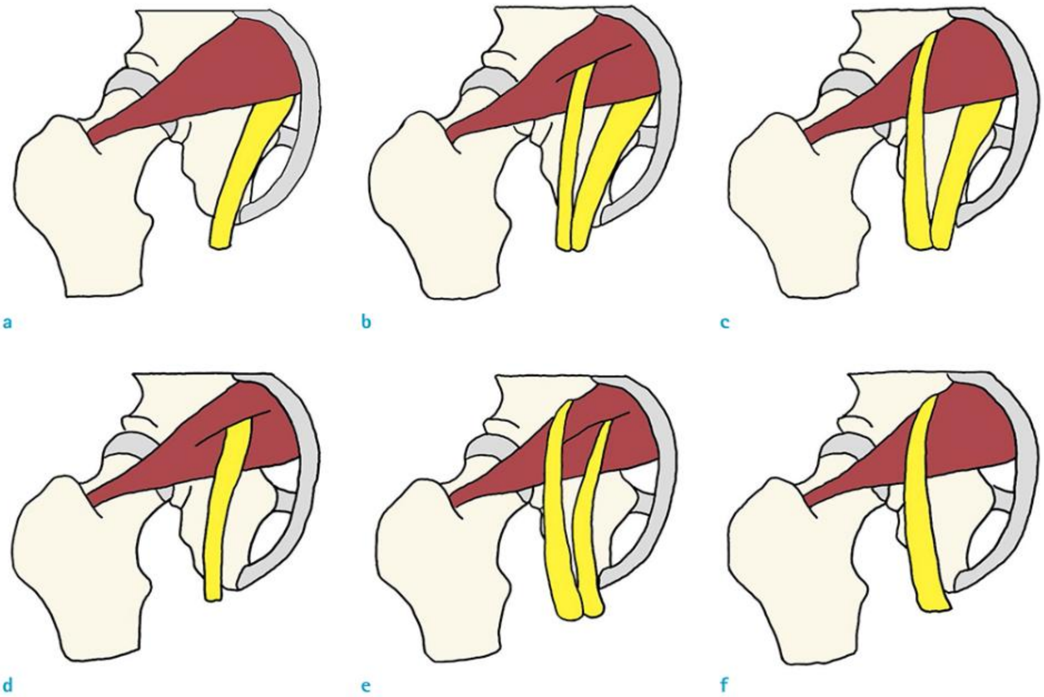
In addition, among the first anatomical variations, those regarding the origin of the piriformis muscle are presented. Therefore, research indicates that in addition to its commonly observed origin, on the superior gluteal surface of the ilium, adjacent to the margin of the greater sciatic notch or on the anterior surface of the sacrum, there are situations in which they can originate in the spinal part of the gluteal muscles, in the capsule of the adjacent sacroiliac joint and, occasionally, in the sacrotuberal ligament.[9]

In view of other physiological and anatomical variants, the sciatic nerve stands out, whose deformation affects at least 1/5 of the population, and, in addition to neurovascular associations of the superior gluteal nerve, inferior gluteal, posterior cutaneous nerve of the thigh, and superior and inferior gluteal artery, the muscle may present 1 or 2 insertions in the sacrum or capsule of the hip joint.[9,12,13]

With a deeper understanding of piriformis syndrome, 6 types of anatomical variations between piriformis muscle and sciatic nerve were observed in studies by Beaton and Anson:

Figure 2

Anatomical variations between piriformis muscle and sciatic nerve according to Beaton and Anson.[14,15] Variants of the sciatic nerve represented in yellow, while the piriformis nerve in red: (a) Type A variation - The undivided sciatic nerve emerges from the pelvis passing inferiorly to the piriformis muscle. (b) Type B variation - The sciatic nerve divides further in the pelvis; The common peroneal nerve runs through the piriformis muscle, while the tibial nerve runs deep into it. (c) Type C variation - After pelvic division of the sciatic nerve, the common peroneal nerve runs superior to the piriformis, and the tibial nerve maintains its deep course. (d) Type D variation - The undivided sciatic nerve directly pierces the piriformis muscle as it emerges from the pelvis. (e) Type E variation - After pelvic division, the common peroneal nerve crosses the piriformis muscle, and the tibial nerve perforates its fibers. (f) Type F variation - The undivided sciatic nerve emerges from the pelvis and travels through the interior of the piriformis muscle.



Source: Kim HJ, Lee SY, Park HJ, Kim KW, Lee YT. Accessory Belly of the Piriformis Muscle as a Cause of Piriformis Syndrome: a Case Report with Magnetic Resonance Imaging and Magnetic Resonance Neurography Imaging Findings. Investig Magn Reson Imaging. 2019 Jun; 23(2):142-147.[15]

However, 3 other variations not yet classified were identified: In the right subgluteal region, an anatomical variation characterized by the presence of a double piriformis muscle was observed. The sciatic nerve was sectioned, and the common peroneal nerve crossed the space between the superficial and deep bellies of this double piriformis, while the tibial nerve ran inferior to the muscle, and the inferior gluteal vein was also located below the muscle, but crossed a modified branch of the tibial nerve.[16]

Another unclassified variation was identified in the presence of a bilateral supernumerary muscle, located immediately above the piriformis muscle, in the suprapiriform foramen. In this configuration, the sciatic nerve traveled inferior to the piriformis muscle.[16]

In a third case, an accessory belly located on the inferior surface and proximal portion of the main piriformis muscle, which extended laterally and inserted independently into the greater trochanter. The undivided sciatic nerve emerged from the pelvis inferior to the main piriformis muscle, passing over the accessory belly, and, concomitantly with this diagnosis, hypertrophy of the left piriformis muscle was detected, associated with an increase in caliber and hypersignal on T2-weighted images of the infrapiriformis portion of the left sciatic nerve, suggesting alterations compatible with nerve compression or irritation.[15]

Also in this sense, an unusual anatomical variation was identified, characterized by the presence of a double belly of the piriformis muscle, between whose fibers the superior gluteal nerve was trapped. Thus, this configuration may also be related to or represent a rare cause of piriformis syndrome, associated with chronic gluteal pain that is difficult to diagnose.[13]

In rarer patterns, when its variation is found in a bifurcated tendon, the main tendon usually inserts on the apex of the greater trochanter and the second band on the superolateral surface of the greater trochanter. Since, even rarer than bifurcation, it can present in a trifurcated tendon, the main one is perceived in the upper part of the greater trochanter, the second fused with the gluteus minimus muscle, and the consequent fused with the superior gemellus muscle.[17]

4.2 OBTURATOR INTERNUS MUSCLE

The obturator internus (OI) muscle is one of the six deep lateral rotator muscles of the hip, and although it is traditionally classified as belonging to the lower limb, it is also part of the pelvic wall.[18]

It originates from the inner surface of the obturator membrane and the bony margins of the obturator foramen, crossing the lesser sciatic foramen below the sacrotuberous ligament. It is situated in a deep position both in the pelvis and in the gluteal region.

It is a deep laminar muscle, whose length can vary between individuals. On average, it has a total length of about 16 cm, and the muscle belly has fibers with measurements that vary approximately between 4.0 cm and 7.5 cm, while the tendon contributes to most of its structure.[18]

Functionally, the obturator internus acts primarily on the external rotation of the thigh when it is in extension, and as an accessory abductor when the thigh is flexed. In addition, it plays a stabilizing role in the hip, helping to maintain the femoral head inside the acetabulum.[19]

Another aspect of clinical relevance is its close relationship with the pelvic floor muscles, especially with the levator ani, to which it provides lateral support through the tendon arch. This anatomical connection shows that the contraction of the internal obturator contributes to the function of the pelvic floor, reinforcing pelvic stability and indirectly influencing processes such as urinary continence and evacuation.[20]

Aung's study of the obturator internus, geminis, and quadratus femoris muscles shows significant anatomical variations in the pelvic region. Observations of fetal development indicate that the obturator internus tendon may fuse with the superior and inferior twin muscles, forming a joint insertion in the trochanteric fossa, highlighting the muscle variability relevant to surgical approaches.[Question 21-22]

4.3 SUPERIOR GEMELLI MUSCLE

The superior gemellus muscle (*GS)* is one of the lateral rotators of the hip, occupying a strategic position in the transition between the pelvis and the gluteal region. It originates from the ischial spine, and is directed laterally to insert itself on the medial aspect of the greater trochanter of the femur,23 sharing a common insertion tendon with the obturator internus,23,24 in some cases the superior twin may present additional bundles that insert directly into the hip joint capsule, suggesting an additional role in the dynamic stabilization of the joint.[25]

Due to its location, the superior gemellus muscle is superior to the obturator internus and inferior to the piriformis, being partially covered by the gluteus maximus muscle, together with the obturator internus and the inferior gemellus, it makes up the so-called coxal triceps. This muscle set is considered a functional unit, responsible for assisting the lateral rotation of the hip joint and contributing to the coaptation of the femoral head in the acetabulum.[23]

It acts primarily on the external rotation of the thigh when the hip is extended. During flexion, it can act as an aid in abduction, in addition to playing a stabilizing role, reinforcing the fit of the femoral head inside the acetabulum. Unlike more robust muscles such as the obturator internus, the GS has reduced dimensions and short fibers, being considered a support muscle rather than a power one.[26]

In hip surgeries, such as total arthroplasty or endoscopic procedures, the muscle can be sectioned or manipulated, impacting the postoperative stability of the joint, and postoperative functional stability.[27]

In anatomical studies, variations in the twin–obturator complex, including tendon fusion between the superior gemellus muscle and the obturator internus, have been reported, forming a joint tendon that inserts into the trochanteric fossa. This configuration contrasts with the classic pattern, in which the upper twin has an independent insertion of the internal obturator, with important clinical-surgical implications in the deep hip. In addition, although extremely rare, there are reports of complete absence of the superior gemellus muscle.[28.35].

4.4 INFERIOR GEMELLI MUSCLE

The inferior gemellus muscle (GI) is a small deep muscle of the gluteal region. It originates from the ischial tuberosity and inserts on the medial aspect of the greater trochanter of the femur, through a tendon common to the obturator internus. Together with the superior gemus and the obturator internus, it makes up the so-called coxal triceps, considered a functional unit of lateral rotation of the hip.[29]

It is located inferior to the obturator internus, being partially covered by the falciform process of the sacrotuberous ligament, and is integrated into the set of short lateral rotators of the hip, a group that also includes the quadratus femoris and the obturator internus itself.[30]

From a functional point of view, the inferior twinus acts on the external rotation of the thigh in extension and assists in abduction when the hip is flexed, in addition to participating in the stabilization of the femoral head in the acetabulum.[29]

As for length, it is a short and thick muscle, whose exact measurement is not often described in recent studies, but classic anatomical descriptions highlight its compact character and its function integrated into the obturator internus.[1.30]

Clinically, the lower twin has been associated with Deep Gluteal Syndrome (DGS), which can contribute to compression of the sciatic nerve, a condition that can mimic piriformis syndrome.[31.32]

Studies also show that the sciatic nerve undergoes movement changes in the deep gluteal space during hip rotation maneuvers, which reinforces the clinical importance of GI in neuromuscular dynamics.[33]

In hip surgeries, such as total arthroplasty, this muscle can be manipulated or sectioned, which influences the postoperative stability of the joint.[34]

Such evidence highlights the importance of the inferior twin both in the biomechanical balance of the hip and in clinical and surgical contexts.

After a study in a female cadaver, bilateral absence of the superior and inferior gemellus muscles was observed, with fusion of the tendon of the internal obturator to the tendon of the piriformis, inserting together in the greater trochanter of the femur. This configuration suggests that the twins' function was partially taken over by this tendon union. The variation can have an embryonic origin, by fusion or resorption of the twins in adjacent muscles. Although rare, it is of clinical importance, as the twins act as short rotators and anatomical reference for joint stability.[35]

4.5 QUADRATUS FEMORIS MUSCLE

The quadratus femoris muscle has a short and quadrilateral shape, being a flat and deep muscle of the gluteal region.

It originates from the superior lateral margin of the ischial tubercle and inserts on the quadrate tubercle of the intertrochanteric crest of the femur, with innervation coming from the nerve to the quadratus femoris, derived from the L5 and S1 roots.[36]

Its main action is lateral rotation of the thigh, maintaining this function at all angles of hip flexion, unlike other muscles that can modify their function in certain amplitudes. Thus, the quadratus femoris is considered a constant external rotator, also contributing to the stabilization of the femoral head in the acetabulum during functional and body weight bearing activities.[37]

Morphologically, the quadratus femoris may present anatomical variations. In an analysis of a cadaveric study with 92 limbs, a classification into three types was identified: Type I (a single muscle belly), most frequent (78.3%); Type II (two bellies), in 17.4%; and Type III (three wombs), in 4.3% of cases. These variations can have an impact on the interpretation of imaging tests, surgical planning, and even predisposition to conditions such as the impact on ischiofemoral syndrome.[38]

Likewise, agenesis of the quadratus femoris muscle is an extremely rare anatomical variation, with few reports available in the literature. When identified, unilaterally or bilaterally, they can result in not only weakening the external rotation of the hip, but also an alteration in the stability of the posterior-medial knee, interfering with its flexion. Even so, recent anatomical studies emphasize that complete absence is exceptional, and it is more common to find variations in insertion, volume, or presence of accessory bundles.[39,40,41]

Therefore, an anatomical variation of the quadratus femoris was observed originating in the lateral margin of the sciatic tuber and insertion in the pectineal line and in the third trochanter, below the lesser trochanter of the femur, characterizing a variation in the insertion of this muscle.[42]

4.6 OBTURATOR EXTERNAL MUSCLE

The obturator externalus (EO) muscle is a flat, triangular skeletal muscle located deep to the pectineus and adductor longus, in the medial region of the thigh. It originates in the external bony margin of the obturator foramen and, by means of a cylindrical tendon that passes inferiorly to the femoral neck, inserts into the trochanteric fossa, about 25 to 38 mm distally to the piriformis fossa.[43]

Its trajectory is different from that of the other lateral rotators of the hip.

From a topographic point of view, it is anteriorly related to the iliopsoas, pectineus, gracilis, adductor brevis, and adductor major muscles, as well as the femoral neck and joint capsule. It is also arranged anteriorly to the obturator membrane and the quadratus femoris. Innervation is performed by the obturator nerve.[1,2,44]

According to classic descriptions by Moore (2019) and Netter (2022), it is a short, flattened, triangular muscle. Although reference works do not present standardized measurements, anatomical studies indicate that its average length is between 6 and 8 cm, its width can vary between 2 and 3 cm, and its thickness is reduced, around 0.5 to 1 cm. [43.44]

Functionally, its main action is lateral rotation of the hip. In addition, it helps in the adduction of the thigh when the hip is flexed — unlike the obturator internus, which participates in abduction in the same position.[44]

Clinically, lesions in the external obturator are uncommon and difficult to diagnose, since the muscle is in a deep position and cannot be palpated directly or easily isolated in clinical tests.[45,46,47] When there is a rupture, it usually manifests as sharp pain in the groin and anterior aspect of the hip, and is more reported in athletes, especially soccer players.[48]

Adequate recognition of these injuries is essential to establish a more accurate prognosis and guide effective rehabilitation protocols.[45.46]

Juan José et al. described an anatomical variant associated with obturator nerve compression when there is the presence of a supernumerary external obturator muscle, which traps the nerve at the exit of the pelvic region.[49]

As a didactic summary of the bibliographic research, we have the following exposition (Table 1).

Table 1

Comparison of Classical Anatomy with current bibliographic survey

Muscles of the External Rotators of the Hip	Classical Anatomy	Bibliographic Survey
Piriformis	Unique	Double, Belly Accessory, Supernumerary muscle, Bi- or trifurcated tendon
Internal Shutter	Unique	Tendinous fusion with superior twin or Piriformis
Superior Twin	Unique	Bilateral agenesis Tendinous fusion with internal obturator
Lower Twin	Unique	Bilateral agenesis
Femoral Square	Unique	Agenesis, one, two or three bellies
External Shutter	Unique	Supernumerary muscle

Source: Authors.

5 CONCLUSION

The literature review of the present study demonstrated that the group of external rotators of the hip is composed of a complex architecture that is still difficult to understand in its entirety.

Through the analysis of preferred articles from the last five years, we concluded that mainly the Piriformis and Quadratus Femoris muscles presented described variations. In particular, the Piriformis muscle and its correlation with the sciatic nerve make such variations essential for understanding and correcting compressions in this pathway.

Understanding the regional anatomy is essential in order not to impact the biomechanical balance of the hip as well as in clinical contexts such as surgery.

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