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Muscle injuries in Athletes. The relationship between H / Q ratio (Hamstring / Quadriceps ratio)

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Abstract

Background. *Hamstring injuries are the most common muscle injury in amateur and professional athletes. Reinjury is a concern. The relationship of force between the knee flexors and extensors is known in the literature as H / Q ratio (Hamstring / Quadriceps ratio). This has been extensively examined in the training fields sports, prevention and rehabilitation, to describe functional and biomechanical expressiveness of the knee joint.* ***Objectives.*** *With this systematic, retroactive and quantitative review of the of the knee joint. With this review of the literature, we want to correlate the conventional and functional relationship of the Hamstring / quadriceps the increase in traumatic sports conditions, especially with muscle injuries.* ***Method.*** *We performed a systematic analysis of the literature based on the reporting articles. For this purpose the PubMed, Medline databases were viewed using the following keyword combinations: Hamstring / Quadriceps ratio, hamstring injury, muscle strain, ACL injury, muscle imbalance. For this review, I took into consideration the articles from 1983 to 2018, which reflected the objectives scientific documents that can be linked to the inclusion criteria of authors.* ***Results.*** *The report conventional is defined, in the literature, as the relationship between the knee flexor force peak and the quadriceps and is generally measured during a concentric contraction. The H / Q, functional is defined as the percentage ratio between peak force of flexors during an eccentric contraction and the peak force of the quadriceps during a concentric contraction (Hams / Quads). The relationship of strength between the agonist / antagonist for the extension and flexion of the knee, however, be described better from the most functional relationships during: a) Knee extension phase: eccentric force of the Hamstring and concentric quadriceps (H.ecc / Q.con). b) Knee flexion phase: concentric force of the flexors (Hamstring) and eccentric force of the Quadriceps (H.con / Q ecc.). asserting how asymmetries / imbalances in the functional H / Q ratio have been shown to affect them significant on the incidence of muscle injuries. Athletes with strength imbalances, persistent, have showed a significant increase in muscle injuries equal to 4.66 times. Altered values of the relationship of force H / Q (<0.6 for 60 ° s^{-1}) can increase the risk factors even of injuries to the load Anterior Cruciate Ligament (ACL).* ***Conclusions.*** *It is noticeable that the asymmetries / imbalances in the relationship Functional H / Q have a significant impact on the incidence of muscle injury. It is reported in literature like muscle imbalance can increase the risk factors of muscle injuries especially against the Hamstring. Final conclusions. In recent years, scientific literature has reported higher incidence of muscle injury.* ***Study Design.*** *A Review.* *(Jaymin H Bhatt, Rosario D'Onofrio, Mehul Padasala, Marko Joksimovi, Cosimo Bruno, Domenico Melino and Vincenzo Manzi* - Muscle injuries in Athletes. The relationship between H / Q ratio (Hamstring / Quadriceps ratio) Ita. J. Sports Reh. Po.; 2020; 7; 1; 1479 -1498; ISSN 2385-1988 [online] IBSN 007-111-19 - 55; CGI J OAJI:0,101).

Key words: Hamstring / Quadriceps ratio, Hamstring injury, Muscle Strain, Muscle Strain Overview , Muscle Imbalance, ACL Injury.

Introduction

Muscle lesions are the most common category of injuries in athletes and comprise approximately 10% to 55% of all injuries [68].
Hamstring injuries are the most common muscle injury in amateur and professional athletes. This Injuries can range from acute hamstring muscle strains and ruptures to chronic proximal hamstring tendinopathy. Acute hamstring strains are the most common muscle strain, have high rates of recurrence and can lead to prolonged absence from sports. The reinjury rate for hamstring injuries has been found to be 12–31% [64]. Over 1/4 of the injuries in football are muscle injuries, mainly located in the quadriceps (14%), in Hamstring muscles (28%) and adductors (8%) [64]. They are the most common injury reported in professional soccer and account for 29% of track and field injuries in sprinters [66]. These injuries are represented in sports:

a) soccer 31% of all injuries [69]

b) track and field athletes (16%) [70]

c) rugby (10.4%) [71]

d) basketball (17.7%) [72]

e) american football (46%/22% practice/games) [73]

Several authors have identified that the best predictor for a hamstring injury is a prior hamstring injury. Age and previous injury are supported in the literature as risk factors for hamstring injury; nonetheless, debate exists regarding modifiable risk factors [63].
Possible etiological factors relating to injury to the hamstrings, including (a) inadequate flexibility of the muscles, (b) inadequate muscle strength and/or endurance, (c) dyssynergic muscle contraction, (d) insufficient warm-up and stretching before activity, (e) an awkward running style, and (f) a return to activity before complete rehabilitation. According Sugiura [75] neuromuscular control deficits and flexibility problems contribute to the incidence of hamstring injuries.
Making a diagnosis of hamstring injuries should start with an accurate history describing the mechanism of injury and a thorough physical examination. Magnetic resonance imaging and ultrasound are considered the modalities of choice for both the diagnosis and classification of these injuries.

Asymmetries/dysbalance "in the Quadriceps / Hamstring functional relationship demonstrate a significant impact on the incidence of the injuries.

Normal strength values between agonists and antagonists are essential for modulating functionality and the articular biomechanics of the knee during movement [1]. This perfect mechanism is described in the literature as "muscle balance" [2]. On the other hand, in contrast, a " muscle imbalance "occurs when the muscles offer tension in the directional abnormalities different due to the weakness and / or shortening of the same muscle [2,3,16,17]. When a muscle is too "shortened" the joint loses the harmonicity, the expressiveness of his movement so as to limit the functionality and width of its articular range. The quadriceps and the hamstring manage the analytic functionality

of the articulation of the knee; an imbalance between the extensor / flexors group muscles in postural syndromes (Janda's Crossed Syndromes), in overuse diseases and acute injuries of the muscle skeletal. A complete pre-season assessment of the muscular system is advisable it should include screening to identify "overactivity" and the quality of movement. The specific sports technical repetitiveness can determine an alteration in relationships muscle chains, with imbalances in terms of flexibility and strength. The international scientific literature today demonstrates how important it is to have a balanced and functional relationship between the muscle chains and the agonist and antagonist muscles [36,39].

Hamstring / Quadriceps ratio

The objective of this review is to study the relationship between Quadriceps and Hamstring (ratio: H / Q ratio - Hamstring / Quadriceps ratio) and the correlation with muscular lesions and anterior cruciate ligament injuries. Asymmetries in the quadriceps /Hamstring relationship and its correlations with traumatic sports pathologies. Most athletes express a dominant limb in their sports specific task [4]. This preference associated with a functional movement repetitiveness, stimulates muscular imbalances of strength and of flexibility [5,36,39] that associated with asymmetrical postural contribute to elevate the risk factors for injuries and re-injury are very significant [6,7]. During the sports specific task, both simple and complex, the muscles of the "core", they contribute to stabilize the functionality of the kinetic, functional chains, which are the main causes of flexion, laterality and rotation of the trunk during sports. So, studies [6,7,8] support and value as an asymmetric muscle hypertrophy of the core is correlated with an increase in muscle injuries and diseases to load of the pubic symphysis. In contact / contrast sports such as calcium, the decrease in core stability has been suggested to be associated with a dysfunctional status of the pelvic girdle and to an abnormal one alignment of the lower limb which has clinical implications expressed for example through a "Knee Pain Syndrome" or a "Low Back Pain [8,9,10]. Irland [11] stressed how a "knee pain syndrome" is associated with a "weakness" of the abductors of the hip. D'Onofrio R. [6] states that a deficit of hip rotation correlates with an anterior knee pain. Also, Powers [12] reports that a mobility restriction of the coxo-femoral joint can change the pressure and the type of contact on the medial articular and lateral facets of the patella correlating, in a first phase, clinical and functional, with a patellofemoral pain. Recently [2,6,7,10] imbalances of force of the adductor muscles have been associated with restrictions of mobility of the ileo - sacral joint and a "knee pain syndrome". It is known that the hip adductor / abductor functional relationship plays an important role in to determine a functional stability of the pelvic girdle during specific task. An ipsilateral decrease of the values of force create postural compensation, which will result in one subsequent, secondary, adaptive dysfunction of the pelvic girdle, the true fulcrum of expressiveness gestural biomechanics. It has been formulated in the literature that repetitive movements related to the athletic task on one dysfunctional movement, cause a "cumulative" microtrauma raising the possibility of a muscle - tendon injury. Previous international studies on football/soccer [4,8,13,33,35] demonstrated an association between force and flexibility and their correlation in adductor injuries (long adductor, short adductor, adductor magnus, gracile and external obturator), in various athletic populations. Ekstrand [13] found, in the pre - season phase, that the players who

presented a decrease of flexibility of hip adductors, they were facing overuse diseases in the region symphysis. On the other hand, [14.15] can be highlighted as functional and biomechanical deficits (decrease of flexibility, strength asymmetries, previous histories of muscle injuries, etc.) if not smoothed they represent additional and important risk factors. The scientific literature today, highlights, how important it is to have a relationship of balanced, functional force between the muscle chains and between the agonist and antagonist muscles. So, comforted by studies [16,17] it is possible to state as muscle groups of the extensors and the knee flexors are those that often suffer, given the intense and prolonged physical activity Specific, negative adjustments in terms of strength and flexibility. Costa [76] showed that static stretching (static stretching: Four repetitions of each stretch were held for 30 s with 15-s rest periods between repetitions) decreases functional H/Q muscle strength ratio. So, he claims that Quadriceps-only and hamstrings and quadriceps stretching decreased the functional ratios ($P<0.05$). The alteration of the functional balance between the quadriceps and the Hamstring compromises and affects negatively on intra and intermuscular coordination and consequently on control neuromuscular knee joint [7]. The ability to "protect" the knee from an injurious event depends primarily on the activity of the knee flexors and its strategic role in controlling the tibio femoral anterior translation [7]. And yet true, an alteration of the "Hamstring / Quadriceps ratio" (H / Q ratio) is suggested as a risk factor for injury traumatic to the inferior limb [16,17]. In fact, Futsal 5 - football athletes, for example, they show lower quadriceps strength values than football athletes and beach soccer [18]. It is possible to state how, in five-a-side football, it denotes the importance of excellent mobility of the coxo femoral joint. Reduced mobility of the coxo femoral joint correlates negatively on the relationship of strength and flexibility between H: Q, thus increasing the risk factors of acute and skeletal musculoskeletal injuries, above all, of the lower limb.

Hamstring and quadriceps functional dysfunction in sports gestuality

The conventional and functional relationship between Quadriceps /Hamstring. The physiological muscular balance must be sought not only in the quadriceps /Hamstring relationship, because it would be physiologically reductive, but within the various functional chains [6,10]. It is thus advisable not to neglect, among other things, for example, a muscular "activation" of the buttocks, whose functional synergy is known, together with the hamstring, on the control and stability of the knee. It is particularly relevant in this. The role of the intra and extra-rotators of the knee on the control of valgus movements and in varus. The force ratio between extenders and knee flexors is used to estimate the functional ability of the joint and the relative equilibrium existing between agonists and antagonists [19,20]. The conventional percentage ratio H / Q is defined as the ratio between the peak of force of the knee flexors and quadriceps and is generally measured during a contraction concentric. While the functional H / Q is defined as the percentage ratio between peak of force of the flexors during an eccentric contraction and the peak force of the quadriceps during a concentric contraction (H.ecc / Q.con) [7,10,16,17]. Altered values of the H / Q strength ratio (<0.6 to 60 ° s^{-1}) may increase the risk of muscular lesions of the hamstring and the Anterior Cruciate Ligament (ACL) [7,10]. Decrease in force levels of the level of strength of the quadriceps and hamstring muscles, decreased active hamstring stiffness, delayed hamstring activation decreased

knee joint proprioception and decreased hamstring: quadriceps (H:Q) ratio are all neuromuscular factors that have been identified that place females at increased risk of ACL injuries. Co-activation of the quadriceps and hamstrings is important to provide stability to the knee joint and reduce the amount of tensile force placed on the ACL [65]. Increasing quadriceps: hamstring muscular co-contraction at the knee may reduce the risk of Anterior Cruciate Ligament (ACL) injury. A common way to measure co-activation of the Quadriceps and Hamstrings is by calculating the H:Q ratio. H:Q ratios of 0.6 and greater have been reported to decrease the risk of hamstring and ACL injuries, and ratios closer to indicate higher activation of the hamstring muscles, which aids the ACL in providing additional passive resistance to anterior translation increasing the stability of the knee. Therefore, H:Q ratios of greater than 0.6 are considered adequate, while those less than 0.6 are considered poor for this review. In order to reduce the risk of ACL injury, it is important to adequately train the hamstring muscles through exercises that produce adequate H: Q co-activation ratios. Quadriceps weakness often occurs after ACL tears, it remains unclear whether hamstring strength and hamstring-to-quadriceps ratio increase in ACL deficient knees. A study of Hyun-Jung Kim [74], were observed in both the quadriceps and hamstring muscles of patients with ACL tear, with the decrease in quadriceps strength being 3-fold greater. These uneven reductions slightly increase the hamstring-to-quadriceps ratio in ACL deficient knees [74]. In recent years, some authors [7,21,27,34] have correlated a higher incidence of ACL injuries in women at an altered H / Q strength ratio. For Aagaard [20, 22] the "Hamstring / Quadriceps (H / Q)" force ratio is calculated by dividing the peak force of the knee flexors, with the peak force of the knee extensors. The relationship of force between agonists / antagonists during knee extension and flexion can, however, be better described by the most functional relationships during:

1. Knee extension phase: between the eccentric force of the Hamstring and concentric quadriceps (F.ecc. / Q.con.)

2. Knee flexion phase: concentric force of the flexors and eccentric force of the quadriceps (F.con. / Q. ecc.).

According to Elliott [23] we talk about muscular imbalance of force between extensors and knee flexors. when the difference of the peak of the moment of force, in the analysis of the functional relationships, exceeds 10%. Davies [24] states that the peak of the isokinetic force moment of the hamstring should be anchored around 66-69% compared to that of the extensors at an angular velocity of 60 ° / sec. For greater clarity we could say that the ideal ratio of isokinetic strength should be anchored on a 100: 67% ratio (Q: H ratio). Orberg [25] comparing, a group of professional footballers and non-practicing sports activities, have detected, through a battery of isokinetic tests, performed at angular speeds of 30 ° / sec and 180 ° / sec, that the ideal ratio of strength between the extensors and knee flexors should be oriented in the players around 100: 55% (Q: H ratio). Ekstrand [26] indicates in 1.55 the ideal value for when it concerns the functional relationship between extensors / flexors. The Quadriceps / Hamstring isokinetic functional relationship varies with the variation of the angular velocity of movement. This behavior can be attributed to a different decrease in strength between quadriceps and Hamstring in particular, flexors at high angular rates tend to maintain a relatively higher performance compared to knee extensors. The muscular

imbalances [36,39] vary according to the models or specific characteristics inherent in the technical / athletic gesture and in relation, also, to the position occupied in the field by the athlete. The reduced function [27] of the flexor muscles is due to the activity that emphasizes workloads oriented and aimed exclusively at improving the force of the knee extensors. This gives rise to muscular imbalances between the knee flexors and the quadriceps, thus predisposing the athletes to an injury mainly of a muscular nature [10,16,27]. This predisposition may be due, as stated previously, to a further decrease of the contraction of the antagonist during the co-activation of both muscle groups and during the execution of exercises in CKC (Closed kinetic Chain), with overloads, in extension [28]. This tendency can be the result of the anomalous activity of co-activation of the flexors, of the knee, which play the role of antagonists, during the loading in extension, in CKC, in the whole articular excursus. For Baratta [29] the important thing is to quantify, through electromyographic studies, the activity models' muscle of the flexors and extensors of the knee both taken in isolation and during simultaneous co-activation. The athletes with quadriceps hypertrophy, show a greater inhibitory effect on the ability to co-activate knee flexors [29]. Athletes who usually "enhance" hamstring, they have a co-activating response similar to that of normal subjects, or non-individuals' sports. Reduction of the ability to recruit flexor muscle groups at the same time and extensors of the knee is due to the antagonist muscle. For example, in cycling, during the cycling cycle, the Q / H ratio is closer to 50/50%, while the quadriceps generally dominate the hamstrings with a few percentages [58,61,62]. However, pedaling techniques and muscle activation vary a lot because of the power, the speed of pedaling, the position of the body, the support of the pedal, of the state of training and fatigue [60]. It does not seem clear, what is the most effective technique. In fact, it has been seen that the problem common to many cyclists is that they have quadriceps muscles too much developed and weak hamstrings, and the role of the cramped Hamstring muscles during pedaling it is generally underestimated. The pedaling carried out in dominance of the quadriceps leads to a loss of power due to fatigue and greater possibility of pain in the lumbar spine or even muscle injury seen the link with the biceps femoris [59]. Through the observation and the EMG analysis during the pedaling it has been seen that in bike the muscles of the legs are activated cyclically during the gait cycle. This means that the muscles are they activate and then relax before the new activation cycle. Repeated muscle activations in the end they cause fatigue if performed for long periods or with high intensity. A Proper relaxation between activation cycles is essential for effective muscle function. Short Bermuda with EMG, of the latest generation are used to evaluate in real time, the muscle status of the cyclic gestural expressions. Recent studies [30,31,32] have shown that tensiomyography is an easy tool applicability, on-invasive, provides important information on muscle activity. In this regard, Rey E. [33] in a work of 2012 wanted to analyze, through the analysis tensiomyography (TMG) the different muscular responses and the mechanical characteristics of the lower limb, depending on their position in the field. The analysis was performed on 78 Spanish professional soccer players (age 26.6 ± 4.4 years; height: 179.2 ± 5.3 cm; weight: 75.8 ± 5.3 kg) and directed to document, expressiveness muscular, in particular, of the biceps femoris and the rectus femoris. In football players, object of the study, there were no significant differences in the activity of the biceps femoris (T (c), contraction time T (r) and half-relaxation time T (s) sustain time. Also, significant differences were observed in the activity of the rectus femoris related to the positions on the pitch occupied by the players. Another study [35]

through a screening carried out at the beginning of the pre - season phase, wanted to determine, in football players, the mechanical and neuromuscular profile of the extensor and flexor muscles of the knee examining any differences related to the position / role occupied in the field. Thus, the Vastus medialis oblique (VMO), Vastus Lateralis (VL), Rectus Femoris (RF) and Biceps Femoris (BF) of 16 professional footballers were evaluated by tensiomyography (TMG). The study showed that the movement repetition of the different roles occupied on the playing field helps to create significant relative asymmetries between athletes in BF, RF, VM and in the relationship between VL and VMO. A decrease in the force values of the extensor / flexor muscles is easily found after the reconstruction of the Anterior Cruciate Ligament (ACL). Maeda [34] in a recent work has evaluated, through a tensiomyographic test mechanical and contractile characteristics of the quadriceps and of the hamstring muscles after the reconstruction of the anterior cruciate ligament. In the conclusions of the study, significant imbalances in the Vastus Medialis (VM) e in Biceps Femoral (BF) when comparing the results between the post-surgery group reconstruction of the ACL and the control group ($p = 0.034$, $p = 0.043$, respectively).

A review by D'Onofrio [36] underlined how, through surface tensiomyography we can actually "intercept" muscular imbalances by evaluating the flexor and extensor of the knee, of the dominant limb. This will allow to identify athletes a risk of reoccurring muscle injuries. So, 83 professional footballers of different nationalities and participants in the Series A and 1157 Italian “Series B”, (average age 26 ± 4.80 weight 77.70 ± 6.90 kg height 181 ± 5.92 cm) were observed and analyzed during the pre - season phase from 2007 to 2010. Through the analysis of the data from the rectus femoris, vastus lateralis, vastus medialis and biceps femoris was able to evaluate any muscular imbalances referred to the CT and TS in both limbs. It is possible to state, says the author, as 86.7% of the tested footballers presented a deficit of strength to one of the two lower limbs or to both. This deficit ranged between 10% and 50% and was represented in the Roi [57] table as a mild and medium risk deficit. It was also highlighted in this research that 39.7% had a medium deficit (1/3 of the 27-player squad). We can therefore consider that the risk of incurring an injury will be greater as the deficit of strength. Baratta [29] states that athletes, with hypertrophy of the quadriceps show a strong inhibition on the co-activation of the knee flexors. An altered co-activation increases the risk of capsule-ligament and muscle injury [29]. Begalle [37] argues that exercises with moments of co-activation of the more balanced quadriceps-hamstring can promote rehabilitation and prevention programs of Anterior cruciate ligament injuries. In contrast, exercises that use a dominant quadriceps activation can negatively affect the balanced biomechanical function of the knee by increasing the tibio-femoral translation and therefore stress on the anterior cruciate ligament [37]. Thus, an alteration of the ratio of force Hamstring / Quadricepsis (Hamstring-to-Quadriceps H: Q) both conventional and functional seems to be a predictor of both muscle lesions to the hamstring and both to the Anterior Cruciate Ligament (ACL) [56].

The quadriceps /Hamstring relationship and their connections with muscular lesions.

Many team games, like basketball, handball or soccer, are contact / contrast sports high torsional risk [7,10]. In these sports, simple and complex athletic technical gestures favor an important hypertrophy of some muscle groups (rectus femoris, gastrosoleum, hamstring, iliopsoas). Muscular

and postural imbalances, [10.16,36,39] in this context, if not compensated, predispose the athlete to pathologies from functional overload or muscle injuries acute [38]. An alteration of the relationship of strength and flexibility between knee extensors / flexors remains a clear predictor of traumatic injuries not only in the knee and ankle, but also and above all on the Hamstring muscles [16,36.38]. This is also confirmed by Fousekis [41] in a 2010 study, performed on 100 players professional football, highlighted as muscle structural asymmetries, related to alteration of the functional Q / H ratio, increased the risk of muscle injuries to the flexors of the knee [41]. According to Aquilar [42] a Dynamic Warm Up (D.W.U.) is the first alternative to static stretching in the pre-season phase. Thus, is detected as a Dynamic Warm-Up (5 'and 10' of dynamic stretching and running) significantly improves the eccentric strength of the quadriceps and the flexibility of the knee flexors [42]. It is scientific opinion that muscle injuries by the Hamstring, which occur during the diversified phases of running most of them involve the biceps femoris (bi-articular muscle), during the phase of thrust, and the semitendinosus during the hip flexion phase [6,10,16,17]. Critically we can state as a test to evaluate the Hamstring-to-Quadriceps relationship H: Q are thick performed in a non-muscle fatigue status. Thus, we can state how current data [39] suggest that the evaluation of the H: Q ratio during a fatigue test (HQ Fatigue) it provides completely different results compared to traditional H: Q^{CR} (conventional ratio). Muscle fatigue, observed in the flexors of the knee and the difference in the correlation between conventional H: Q_ H: Q^{CR} and H: Q Fatigue indicate [39] important risk factors in the prediction of muscle lesions of the Hamstring. Muscle fatigue and asymmetric strength pictures of the lower limbs are known factors for influence the risk of muscle injury to the cropped ischium of the knee [40]. For the evaluation and analysis of the extensor / flexor ratio in athletes operated on reconstruction of the ACL.

Daniel [44] proposed this evaluation criterion:

1. Quadriceps index (Q.I.: Quadricipital Index = maximum peak force in extension of pathological limb / healthy limb x 100

2. Hamstring index (Index of the Hamstring = maximum peak of force in flexion of pathological limb / healthy limb x 100.

Kannus [45] reported that, in the extensor / flexor ratio, the force deficit in pathological knees is certainly higher at the angular velocity of 180 degrees / sec. In contrast Zaccherotti [46] in a prospective study with a 5-year follow-up, in two groups of patients operated of ACL with bone patellar tendon bone (BPTB) and semitendinosus and gracilis tendon graft (STGD). Marder [47] had already highlighted: a deficit in the significant DSTG group of the flexor strength measured at 60 degrees / sec (equal to 17%), compared to the group of patients operated with BPTB. The authors, who had all the patients perform the same rehabilitation procedure. They concluded affirming that the hamstring presented a more significant force deficit following the withdrawal of the semitendinosus and gracilis tendon graft (STGD) with respect to the quadriceps after collection of the central third of the patellar tendon (TR). Lee [48] studied the knee flexors / extensors ratio to identify in the pre-stage season, of the sports season possible risk factors of muscle injuries. The author highlighted that the eccentric force deficit of the hamstring associated with an altered flexor

and knee extensors (Hamstring: Quadriceps, H: Q) exponentially raise factors of risk of muscle injury. Harter [49], evaluated the ratio of strength of the quadriceps and of the hamstring in the post-reconstruction of the ACL. The score of the subjects evaluated, highlighted a hamstring a significantly lower long-term strength deficit (41 to 101 months <1.9%) than to the mid-term evaluation (24 to 40 months <2.1%). The results suggest that they are necessary long periods of time to reach a symmetrical picture of strength in the muscles hamstrings after ACL reconstruction.

Further persistent muscle imbalances they can be linked to an incomplete "Rehabilitation" or an improper "Reconditioning" [49]. He aims at injuries of the Hamstring in football, Woods [51] conducted a statistical survey detailed in the English Professional Football League for two competitive seasons consecutive. The muscular lesions of the Hamstring accounted for 12% of the total lesions within the two seasons, with almost half (53%) of the biceps femoris. An average of 5 muscle injuries per club of knee flexors was observed pre-season phase. In 57% of cases, the injury occurred during the race. Injuries to the Hamstring were observed most during the race (62%) with an increase at the end of each time ($p < 0.01$). The damaging events were more interesting:

1. external players ($p < 0.01$)

2. players of ethnic and black origin ($p < 0.05$)

3. "elderly" players ($p < 0.01$).

The percentage of re - injury, of the hamstring, was 12%. The biceps femoris was the most injured muscle in the hamstring complex (53%).

Arnason [52] confirmed that age and previous histories of injuries elevate the risk factors in Icelandic elite football. In the study, out of 306 football players, the following conclusions were reported:

1. "elderly" players were, in general, at higher risk of injury

2. for knee flexor injuries, significant risk factors were age

previous stories of injuries and flexibility deficits.

The alteration of the extensor / flexor balance of the knee can also contribute to injuries to the adductors [52]. For this we must carefully study the functional relationships between the quadriceps and the Hamstring. The functional evaluation according to Dauty [50] must be oriented to the

knowledge of:

1. ipsilateral ratios of flexor force (H) extensors (Q) of the knee:

   a) concentric force of the hamstring / concentric force of the quadriceps
   b) eccentric force of the hamstring / concentric force of the quadriceps.

2. Functional relationships of bilateral force of the knee flexors:

a) concentric force of the right flexors / concentric force of the left flexors
b) eccentric force of the right flexors / eccentric force of the left flexors.

This evaluation will allow us to identify the risk factors for healthy athletes and with previous stories of muscle injuries [50].

Withrouw [53.54], has emphasized how, in footballers, the constant decrease in flexibility of the Hamstring is due to the typical sports specific task. This "shortening" it helps to establish an imbalance of the intra and inter muscular coordination moment. It significantly increasing the risk of a muscle injury in this district muscle.

The author highlighted, as a lack of flexibility of the Hamstring and of the quadriceps in the pre-season phase can help identify football players at risk of injury of extensor muscle groups and knee flexors. In study [53] they examined and followed for the entire 1999-2000 season, 146 professional soccer players participants in the Belgian soccer league. None of the players interested in the study had to tell a story of muscle injuries in the lower limb in the last 2 years. The tests of flexibility for hamstring (straight-leg-raising test, sit and reach test) quadriceps, adductors, and gastrocnemius were carried out before the competitive sports season.

In the arc of the championship there were 31 players with injuries of the hamstring and 13 with muscle injury of the quadriceps. It was noted that:

a) the injured players showed a significant deficit in the flexibility, in the pre-season phase, of these muscle groups in comparison with the group of healthy athletes,

b) no significant difference in flexibility, was found for the 13 players, who incurred a lesion of the adductor muscle and for the 10, who suffered a muscular injury affecting the gastrocnemius and the group of healthy footballers.

These results indicate, among other things, that soccer players with an abnormal flexibility of the knee flexors, alter the functional relationship Q: H and exponentially increase the risk of injury to the musculoskeletal system. Poor muscle flexibility is identified, by the authors being an important intrinsic risk factor for the development of frequent muscular lesions [16.17 36].

Askling [55] states that eccentric training performed on the knee flexors in the pre-season phase involves a noticeable decrease in muscle injuries. These considerations arise from a study carried out on 30 players participating in the Swedish Premier League. In the study the players were divided into two groups:

1. in the first the athletes carried out a specific extra eccentric training concerning the knee flexors

2. in the second they did not perform any training and therefore emerged as a control group additional training was performed 1-2 times a week for 10 weeks. Statistically, the numbers showed that the lesion event affecting the knee flexors was clearly lower in the training group (3/15) than in the control group (10/15).

Conclusions

The knee represents an articulation, biomechanically complex, subjected to diversified stresses of various entities in relation to the sporting typology. An alteration of the status of strength and flexibility, of the muscles that control the functional biomechanics of the knee, determines, through muscular play, both static and dynamic compensations within functional kinetic chains. A number of potential risk factors have been proposed for hamstring strain, among them fatigue, lack of flexibility, imbalance of muscular strength with a low hamstring to quadriceps ratio, and insufficient warm-up. The differences in the H / Q ratio ratios between athletes, depend on the chosen discipline, the level of competition or both. We must therefore always seek, if we reason in an analytical way, an excellent physiology of the hamstring in order to optimize muscle performance and avoid ipsilateral muscle imbalances that may compromise the physical integrity of the athlete during the sports season. It is useful to remind the inverse that traumatic events related to the lower limb, are the first factor that alters the normal functional relationship between quadriceps and hamstring and predisposes the athlete to considerable risk of injury. Prevention and rehabilitation of lesions of the hamstring should be part of an interdisciplinary, systematic approach based on the evidence proposed and validated by scientific literature. Unbalanced strength and flexibility, are estimated to be predisposing factors for both acute and chronic injuries of joint. It has been shown that age, training and injuries affect the delicate relationship between conventional and functional H / Q. Based on this review, we can state how an altered Hamstring / Quadriceps ratio (H: Q ratio) can predict future muscle injuries, especially to the knee flexors. Finally, we should not forget how the literature claims that non-contact injuries to the knee joint can be linked to a dysfunctional pattern affecting the hamstring and quadriceps muscles. It remains important in the pre-season phase to monitor the "H: Q ratio" values (Hamstring : Quadriceps ratio) in order to identify players at risk of damaging events, and to prepare training to recover normal physiological functions.

Reference

1. *D'Onofrio R. Tucciarone A. Godente L, Fabbrini R. ; Ritorno allo sport dopo ricostruzione del LCA : terminologie e definizioni delle funzioni. Ita. J. Sports Reh. Po.; 2019 ; 6 ; 3 ;1348 - 1375]*

2. *Fredericson M. Muscular Balance, Core Stability, and Injury Prevention for Middle- and Long-Distance Runners Phys Med Rehabil Clin N Am 2005 ; 16 (669–689*

3. *Cuthberts SC. "What Are You Doing About Muscle Weakness?" Dynamic Chiropractic, May 6, 2009;27(25).*

4. *Rahnama N, Lees A, Bambaecichi E. Comparison of muscle strength and flexibility between the preferred and non-preferred leg in English soccer players. Ergonomics. 2005;48:1568–1575.*

5. *Raty HP, Kujala U, Videman T, Koskinen SK, Karppi SL, et al. Associations of isometric and isoinertial trunk muscle strength measurements and lumbar paraspinal muscle cross-sectional areas. J Spinal Disord. 1999;12:266–270*

6. *R. D'Onofrio, P. Tamburrino, G. Papa, G. Rando, A. Tucciarone, V. Manzi, A. Pintus, A. Bovenzi, L.. Febbrari, J. Van de Rakt Meccaniche posturali del Lumbo-Pelvic-Hip Complex in atleti con Low Back Pain. Implicazioni per un corretto approccio riabilitativo – funzionale. Ita J Sports Reh Po 2018; 5 ; 1 814 – 840 ISSN 2385-1988 [online] IBSN 007-111-19-55 CGIJ OAJI :0,101*

7. *R D'Onofrio, P Tamburrino, V Manzi, A Tucciarone, R Tavana, Bhatt, J, Training neuromuscolari in età pediatrica. Valutazione della letteratura per un corretto protocollo applicativo nella prevenzione delle lesioni del LCA in soggetti scheletricamente immaturi. Ita J Sports Reh Po 2018 ; 5 (2), 990 -1012*

8. *Kubo T, Muramatsu M, Hoshikawa Y, Kanehisa H. Profiles of trunk and thigh muscularity in youth and professional soccer players. J Strength Cond Res. 2010;24:1472–1479*

9. *Robertson BA, Barker PJ, Fahrer M, Schache AG. The anatomy of the pubic region revisited: implications for the pathogenesis and clinical management of chronic groin pain in athletes. Sports Med. 2009;39:225–234*

10. *R. D'Onofrio,V. Manzi, A.Pintus ,S. D'Ottavio Le lesioni muscolari nel calcio internazionale. SdS,70, Luglio Settembre 2006 ; 51- 58*

11. *Ireland ML, Willson JD, Ballantyne BT, Davis IM. Hip strength in females with and without patellofemoral pain. J Orthop Sports Phys Ther.2003; 33:671–676*

12. *Powers CM, Ward SR, Fredericson M, et al. Patellofemoral kinematics during weight-bearing and non-weight-bearing knee extension in persons with lateral subluxation of the patella: a preliminary study. J Orthop Sports Phys Ther.2003; 33:677–685.*

13. *Ekstrand J, Gillquist J. The availability of soccer injuries. Int J Sports Med 1983; 4: 124-8*

14. *Timothy F. Tyler, PT The Association of Hip Strength and Flexibility With the Incidence of Adductor Muscle Strains in Professional Ice Hockey Players American Journal of Sports Medicine (2001)29:124-128*

15. *Powers CM. The influence of altered lower-extremity kinematics on patellofemoral joint dysfunction: a theoretical perspective. J Orthop Sports Phys Ther.2003; 33:639–646 10,13*

16. *R. D'Onofrio P. Tamburrino, A. Tucciarone, G. Tamburrino L'incidenza delle lesioni muscolari nel calcio. Una review retroattiva, della letteratura Scientifica internazionale. Il Medico Dello Sportivo 2016; 15, 1,: 16 -20*

17. *R. D'Onofrio Indagine epidemiologica delle lesioni muscolari nel calcio. Analisi retroattiva delle letteratura. Ita J Sports Reh Po 2015; 2; 4 ; 345- 367 ; doi 10.17385/ItaJSRP.015.3007 ; ISSN 2385-1988 [online] IBSN 007-111-19-55*

18. *De Lira CAB Isokinetic Knee Muscle Strength Profile In Brazilian Male Soccer, Fustal, and Beach Soccer Players: a cross sectional study Int. J.Sports Phys Ther. . 2017 Dec;12(7):1103-1110.*

19. *Holmes, JR. & Alderink, GJ. (1984). Isokinetic strength characteristics of the quadriceps femoris and hamstrings muscles in high school students Phys Ther 64, 914-918)*

20. *Aagaard, P., Simonsen, EB., Trolle, M., Bangsbo, J., & Klausen, K. Isokinetic hamstring/quadriceps strength ratio: influence from joint angular velocity, gravity correction and contraction mode Acta Physiol Scand , 1995. 154, 421 427)*

21. *Askling, J. Karlsson, A.Thorstensson Hamstring injury occurrence in elite soccer players after preseason strength training with eccentric overload Scand J. Med Sci Sports 13,2003, 244 -250*

22. *Aagaard, P., Simonsen, EB., Beyer, N., Larsson, B., Magnusson, P., & Kjaer, M. (1997). Isokinetic muscle strength and capacity for muscular knee joint stabilization in elite sailors Int J Sports Med 18, 521525*

23. *Elliot J. Assessing muscle strength isokinetically JAMA 1978, 240: 2408 –2409*

24. *Davies G J: Rehabilitation of the surgical knee. Ronkonkoma N. Y. 1984.*

25. *Oberg B, Moller M, Gillquist J, Ekstrand J. Isokinetic torque levels for knee extensors and knee flexors in soccer players. Int J Sports Med. 1986 ; Feb;7(1):50-3*

26. *Ekstrand J Gillquist J. Prevention of soccer injuries 1983; Am. J sport med 11 116- 120*

27. *Lund-Hanssen, H., Gannon, J., Engebretsen, L., Holen, K., & Hammer, S. Isokinetic muscle performance in healthy female handball players and players with a unilateral anterior cruciate ligament reconstruction 1996; Scand J Med Sci Sports 6, 172-175*

28. *Hewett, TE., Lindenfeld, TN., Riccobene, JV., & Noyes, FR. (The effect of neuromuscular training on the incidence of knee injury in female athletes: a prospective study Am J Sports Med 1999 ; 27, 699-705*

29. *Baratta, R., Solomonow, M., Zhou, BH., Letson, D., Chuinard, R., & D'Ambrosia, R. Muscular coactivation: the role of the antagonist musculature in maintaining knee stability 1988; Am J Sports Med 16, 113122*

30. *Rusu L D Tensiomyography method used for neuromuscular assessment of muscle training Journal of NeuroEngineering and Rehabilitation 2013, 10:67*

31. *Grabljevec k.; Šimunič B. Detection of contractile properties of chronically spastic muscles in subjects after traumatic brain injury with Tensiomyography (TMG) method International journal of rehabilitation research, Vol. 27, Suppl. 1 (June 2004), str. 132-133*

32. *García-Manso JM, Rodríguez-Matoso D, Sarmiento S, de Saa Y, Vaamonde D, Rodríguez-Ruiz D, Da Silva-Grigoletto M EEffect of high-load and high-volume resistance exercise on the tensiomyographic twitch response of biceps brachii. - J Electromyogr Kinesiol. 2012 Aug;22(4):612-9. doi: 10.1016/j.jelekin.2012.01.005. Epub 2012 Feb 15*

33. *Rey E, Lago-Peñas C, Lago-Ballesteros J. Tensiomyography of selected lower-limb muscles in professional soccer players. J Electromyogr Kinesiol. 2012 Dec;22(6):866-72. doi: 10.1016/j.jelekin.2012.06.003. Epub 2012 Jul 7.*

34. *Maeda N. Symmetry tensiomyographic neuromuscular response after chronic anterior cruciate ligament (ACL) reconstruction. Knee Surg Sports traumatol Arthrosc 2017 Mar 2. doi: 10.1007/s00167-017-4460-7. [Epub ahead of print]*

35. *Garcia O. Baseline Mechanical and Neuromuscular Profile of Knee Extensor and Flexor Muscles in Professional Soccer Players at the Start of the Pre-Season., J Hum Kinet 2017 Aug 1;58:23-34*

36. *R. D'Onofrio, S. Bruno A. Pintus , G. Ventrone - Muscle Imbalance asimmetrie nei rapporti Quadricipite/ischio crurali 2° parte Scienze & Sport 2014– gennaio –Marzo 21, -78.-81*

37. *R. L. Begalle , Quadriceps and Hamstrings Coactivation During Common Therapeutic ExercisesJournal of Athletic Training 2012;47(4):396–405*

38. *R. D'Onofrio, Epidemiologia degli infortuni nel Calcio - Professione Fitness 2003,3;64-66*

39. *Pinto MD, Hamstring-to-quadriceps fatigue ratio offers new and different muscle function information than the conventional non-fatigued ratio. Scand J Med Sci Sport . 2018 Jan;28(1):282-293.*

40. *Lord C .Change in knee flexor torque after fatiguing exercise identifies previous hamstring injury in football player Scand J Med Sci Sports 2017 Nov 8. doi: 10.1111/sms.13007. [Epub ahead of print]*

41. *.Fousekis K. Intrinsic risk factors of non-contact quadriceps and hamstring strains in soccer: a prospective study of 100 professional players. Br J Sports Med 2010 45(9):709-14 · November 2010 doi:10.1136/bjsm.*

42. *Aguilar AJ, Di Stefano LJ, Brown CN, Herman DC, Guskiewicz KM, Padua DA.A dynamic warm-up model increases quadriceps strength and hamstring flexibility. J Strength Cond Res. 2012 Apr;26(4):1130-41*

43. *R D Hawkins M A Hulse, C Wilkinson The association football medical research programme: an audit of injuries in professional football Br J Sports Med 2001; 35:43-47*

44. *Daniel DM Stone ML the one leg hop for distance, Am J. Knee surg, 1: 212 – 213,1988*

45. *Kannus, P. (Ratio of hamstrings to quadriceps femoris muscles' strength in the anterior cruciate ligament insufficient knee: relationship to long-term recovery Phys Ther 1988 ; 69, 961 - 965*

46. *G. Zaccherotti, Aglietti P. et.al. A comparision between patellar tendon and doubled semitendinous/graciliis tendon for Anterior cruciate ligament reconstruction. A minimum five – years follow – up J. Sports Traum. 19,2,57 1997)*

47. *Marder R.A. Raskind J.R. Carroll M. Prospective evolution of Arthroscopically assisted anterior cruciate ligament reconstruction Am. J. Sports Med ,19,478,1991 .*

48. *Lee JWY Eccentric hamstring strength deficit and poor hamstring-to-quadriceps ratio are risk factors for hamstring strain injury in football: A prospective study of 146 professional players. J. Sci Med Sport 2017 Dec 5. pii: S1440-2440(17)31822-4.*

49. *Harter RA, Osternig LR, Standifer LW. Isokinetic evaluation of quadriceps and hamstrings symmetry following anterior cruciate ligament reconstruction.: Arch Phys Med Rehabil. 1990 Jun;71(7):465-8.*

50. *Dauty M, Potiron-Josse M, Rochcongar P. Consequences and prediction of hamstring muscle injury with concentric and eccentric isokinetic parameters in elite soccer players] Ann Readapt Med Phys. 2003 Dec;46(9):601-6.*

51. *Woods C, Hawkins RD, Maltby S, Hulse M, Thomas A, Hodson A; The Football Association Medical Research Programme: an audit of injuries in professional football--analysis of hamstring injuries. Br J Sports Med. 2004 Feb;38(1):36-41*

52. *Arnason A, Sigurdsson SB, Gudmundsson A, Holme I, Engebretsen L, Bahr R. Risk factors for injuries in football. Am J Sports Med. 2004 Jan-Feb;32(1 Suppl):5S-16S*

53. *Witvrouw E, Danneels L, Asselman P, D'Have T, Cambier D. Muscle flexibility as a risk factor for developing muscle injuries in male professional soccer players. A prospective study. Am J Sports Med. 2003 Jan-Feb;31(1):41-6.*

54. *Witvrouw E, Mahieu N, Danneels L, McNair P. Stretching and injury prevention: an obscure relationship. Sports Med. 2004;34(7):443-9.)*

55. *Askling C, Karlsson J, Thorstensson A. Hamstring injury occurrence in elite soccer players after preseason strength training with eccentric overload. Scand J Med Sci Sports. 2003 Aug;13(4):244-50.*

56. *Willadsen EM, Zahn AB, Durall CJ. What is the Most Effective Training Approach for Preventing Noncontact ACL Injuries in High School Aged Female Athletes? J Sport Rehabil. 2017 Sep 5:1-15. doi: 10.1123/jsr.2017-0055. [Epub ahead of print]*

57. *Roi GS I protocolli GISMI per il test isocinetico del ginocchio Notiziario GISMI 1:1 marzo 1993*

58. *Camic C.L., Kovacs A. J., Enquist E. A., McLain T. A. & Hill E. C. (2015). Muscle activation of the quadriceps and hamstrings during incremental running. Muscle & Nerve 52 (6); 1023-1029.*

59. *Furya E. (2011) (editor). The big book of bicycling: Everything you need to know, from buying your first bike to riding your best. Rodale Inc. USA.*

60. *Hug F. & Dorel S. Electromyographic analysis of pedaling: A review. Journal of Electromyography and Kinesiology 19 (2009); 182–198.*

61. *Knapik J.J., Bauman C.L., Jones B.H., Harris J.M. & Vaughan L. Preseason strength and flexibility imbalances associated with athletic injuries in female collegiate athletes. Am J Sports Med (1991). 19 (1); 76-81.*

62. *Sundby Q.H. & Gorelick M. (2014). Relationship between functional hamstring: quadriceps ratios and running economy in highly trained and recreational female runners. Journal of strength and conditioning research 28 (8); 2214-27.*

63. *. Orchard J, Best TM, Verrall GM Clin J Sport Med. 2005 Nov; 15(6):436-41.*

64. *Woods C, Hawkins RD, Maltby S, et al. The football association medical research programme: an audit of injuries in professional football: analysis of hamstring injuries. Br J Sports Med 2004;38:36–41.*

65. *Flaxman TE, Smith AJ, Benoit DL Sex-related differences in neuromuscular control: Implications for injury mechanisms or healthy stabilisation strategies? J Orthop Res. 2014 Feb; 32(2):310-7.*

66. *Brughelli M, Cronin J, Levin G, Chaouachi A Understanding change of direction ability in sport: a review of resistance training studies. Sports Med. 2008; 38(12):1045-63.*

67. *Foreman TK Addy T Baker S Burns J Hill N Madden T Prospective studies into the causation of hamstring injuries in sport: a systematic review. Phys Ther in Sport. 2006;7:101-109.*

68. *Järvinen TA, Järvinen TL, Kääriäinen M, Kalimo H, Järvinen Muscle injuries: biology and treatment. M Am J Sports Med. 2005 May; 33(5):745-64.*

69. *Walden M, Hagglund M, Ekstrand J. UEFA Champions League study: a prospective study of injuries in professional football during the 2001–2002 season. Br J Sports Med 2005;39:542–6.*

70. *Malliaropoulos N, Papacostas E, Kiritsi O, et al. Posterior thigh muscle injuries in elite track and field athletes. Am J Sports Med 2010;38:1813–19.*

71. *Lopez V Jr, Galano GJ, Black CM, et al. Pro file of an American amateur rugby union sevens series. Am J Sports Med 2012;40:179–84.*

72. *Borowski LA, Yard EE, Fields SK, et al. The epidemiology of US high school basketball injuries, 2005–2007. Am J Sports Med 2008;36:2328–35. 13*

73. *Feeley BT, Kennelly S, Barnes RP, et al. Epidemiology of National Football League training camp injuries from 1998 to 2007. Am J Sports Med 2008;36:1597–603.*

74. *Hyun-Jung Kim, Jin-Hyuck Lee, Sung-Eun Ahn, Min-Ji Park, and Dae-Hee Lee, Influence of Anterior Cruciate Ligament Tear on Thigh Muscle Strength and Hamstring-to-Quadriceps Ratio: A Meta-Analysis PLoS One. 2016; 11(1): e0146234 Published online 2016 Jan 8. doi: 10.1371/journal.pone.0146234*

75. *Sugiura Y, Saito T, Sakuraba K, Sakuma K, Suzuki E. Strength deficits identified with concentric action of the hip extensors and eccentric action of the hamstrings predispose to hamstring injury in elite sprinters. J Orthop Sports Phys Ther. 2008;38:457–464*

76. .Costa PB, Ryan ED, Herda TJ, Walter AA, Defreitas JM, Stout JR, Cramer JT Acute effects of static stretching on peak torque and the hamstrings-to-quadriceps conventional and functional ratios Scand J Med Sci Sports. 2013 Feb; 23(1):38-45.

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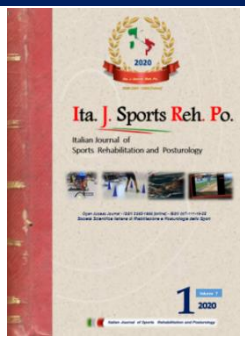

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Declaration of interest

The authors declare that they have no financial, consulting, and personal relationships with other people or organizations that could influence the author's work.

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