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Anatomy, physiology and biomechanics of hamstrings injury in football and effective strength and flexibility exercises for its prevention

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ABSTRACT

Ivan Z. Anatomy, physiology and biomechanics of hamstrings injury in football and effective strength and flexibility exercises for its prevention. *J. Hum. Sport Exerc.* Vol. 7, No. Proc1, pp. S208-S217, 2012. The muscles of the back of the thigh with its particular role in movement of athletes and people in general and, therefore, the position of the musculoskeletal system require specific attention in the athlete's training planned procession. As a group of muscles, which has an impact on two joint systems performs multiple missions, it is susceptible to various injuries. They act on the hip joints and knees, which are very important in basic movements of football players. Stabilizing role during movement requires very good coordination among these muscles with the synchronized activity of other muscles. Concentric and especially eccentric movements are very prominent during the movement of the hamstring muscles. Eccentric movements of the muscles lengthen muscle that is contracted and thus require much greater force activity that contributes to a risk of injury. Football as a complex activity has acyclic interval that requires a high degree of development of physical abilities in the modern sport but nobody paid attention to this muscle group. For this reason and many other factors, muscles of the back of the thigh have been frequently injured. Identifying all factors of risk, and trying to remove them is concern of many sports doctors, which is only possible with care and active participation of athletes themselves. **Key words**: EXERCISE, ENDURANCE, TRAINING.

Corresponding author. DRITE- Association of kinesiology students in scholarly work.

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INTRODUCTION

The muscles of the back of the thigh or group of muscles called the hamstrings are the muscles that have a very important role in the stabilization of body posture, movement of the lower extremities and trunk movements in relation to the thigh. When we talk about the trunk, especially lower back in connection with hamstrings muscles and its role, we may think of important role in stabilizing and holding the position of the pelvis and lower back stabilization. Running, jumping, changing speed and direction of movement in everyday life, as well as in sports activities, are carried out with direct and / or assisted participation of these muscles, aren't possible without them. Particular emphasis is on the role of sports (football, handball, basketball, tennis, volleyball, field hockey ...) which use currently listed types of movements for faster and better mastery of space, as much as possible. Football is, with respect to the criterion of structural complexity, in a group of complex acyclic sports. By studying the motions, we observe the typical Sprint (longer or shorter), jumps from a variety of positions, including landings in a different position, step forward, a kick to the ball and sliding tackle in different ways. Due to repeated self-injuries of this muscles during activity in soccer, increasing attention is directed to their prevention and understanding of the reasons why these injuries occur.

The physiological structure of skeletal muscle and anatomical characteristics of hamstrings
Skeletal or cross-striated muscles as their name says, are in close connection with the bones. A long and relatively thin cylindrical cells (lat. *myocytus striatus*), also called muscle fibers, are building cross-striped muscles. The basic unit of each skeletal muscle is a muscle fiber, and it consists of a large number of muscle fiber diameter of 10-80 microns (Guyton and Hall, 2006). Sarcolemma is the cell membrane that surrounds muscle fibers. Their endings are tendon fibers that connect the muscle bundle together and forming the corresponding muscle tendon. Each muscle fiber contains several hundred to several thousand myofibril. Myofibril or contractile fibers are the most important part of cross-striped muscle directly responsible for muscle contraction. It's known that contraction of the muscles is one of the most important things in sport. Each myofibril consists of about 1500 and 3000 myosin and actin threads. These are protein molecules that are responsible for muscle contraction. There are small outgrowths on myosin strands called transverse bridges. Stroke contraction principle or mechanism of thread slip is a result of interaction of transverse bridges and actin threads. The ends of actin threads are attached to the Z-plates. Z-plates pass through each myofibril linking adjacent myofibril throughout the entire muscle fiber. Therefore, the skeletal muscles are called striated muscles. One of the main microscopic characteristics of these muscles is a striped appearance in cross section. Sarcomere is called one part of the myofibril, which is located between two adjacent Z-plates. The basic mechanical ability of the muscle contractility, and each muscle is able to shorten or lengthen by about 1 / 3 of its length. During the muscle contraction, the electrical impulses are broaden previously to the muscle fibers. A force between myosin and actin threads is created during muscle contraction. Adjacent Z-plates are approaching each other because of the dragging of actin threads with which they are connected, and their entering between myosin threads. Finally, the contraction of muscle fibers is a result of the so-called depolarization and changes in membrane muscle fibers or sarcolemma.

After briefly description the basic physiology of striped muscle and its contraction, I will pass through the anatomy of the muscle group of the back of the thigh. Group of muscle back of the thigh consists of three muscles: “musculus biceps femoris” (“longus capitis, capitis brevis”), “musculus semitendinosus and musculus semimembranosus”. Long head of two-headed thigh muscle (“biceps” “femoris caput longum”) and musculus semitendinosus are in the surface layer. In the deep layer there are the short head of two-headed thigh muscle (“biceps femoris caput breve”) and musculus semimembranosus. Two-headed muscle

of the thigh is directed downward and laterally. Muscles semitendinosus and semimembranosus are directed downward and medially. Long head of the double-headed thigh muscle is starting from back and lateral part of the buttocks (tuber ischiadicum) with tendon that is common to semitendinosus muscle (Keros & Cave, 2006). Its vertex is at the fibular head from lateral side (caput fibula). Short head is starting with the middle and lower lateral lip of linea aspera and the lateral intermuscle barrier (Keros & Cave, 2006). Vertex is common with the long head of thigh muscle and they together connect with tendon to the fibular head. Muscles semitendinosus and semimembranosus are starting from the buttocks. Semimembranosus catches the back of the medial tibial condyle, and semitendinosus the upper part of the medial tibial condyle ("medial tibia epicondylus"). Two-head thigh muscle is supplied with three nerves; "nervus ischiadicus", "nervus tibialis" and "nervus peroneus communis". Semimembranosus and semitendinosus are supplied by nervus tibialis muscle. Movements that carry out the back of the thigh muscles are knee flexion and extension of the trunk from bended position. Analyzing each muscle, there are some more movements that allow the muscles of the hamstrings. Looking at the medial and lateral side of the back of the thigh, it can be argued that two-headed thigh muscle lets the knee flexion and extension of leg in the hip joint and also outward rotation of the thigh or pelvis inward, if the foot is fixed. Semitendinosus and semimembranosus muscles also with knee flexion and extension of leg in the hip joint rotates the leg inwards or outwards if the foot is fixed. Due to the diversity of the position of the muscles in the musculoskeletal system, its structure and the type of work performed, each muscle is designed for a particular activity. While one muscle can tighten often with little power ("m. Sartorius"), other muscles are better suited unusual tightening with greater force ("gluetus m. maximus"). The muscles of the back of the thigh with its position work and affect together on two joint system (hip and knee).

Mechanism of injury and risk factors

Frequency of movement, movement style and type of movement (sudden acceleration, stopping, changing directions, jumps, lands ...) in sports such as soccer, handball and basketball used, are one of the basic reasons of frequent muscle injuries in athletes (Cohen & Bradley, 2007). Based on the biomechanics and anatomy, an agonist that works movement in this case is four-head muscle (musculus quadriceps femoris) that extend knee and bend in front position the thigh. The most important patterns of movements for the development of great power and strength in the sprint is hip joint, which allows you to work faster (Pontaga, 2003). The muscles of the back of the thigh at the extension of the knee act as antagonists and slow leg movement in protecting the involved joint (knee, ankle) injury. They help to prevent hyperextension of the knee joint, thus protecting the connective and protective tissues that allow movement, which are located within the knee joint. One of the major role of the back of the thigh muscles is to prevent injury to the anterior cruciate ligament (ACL). Ligaments of anterior cruciate ligament (ACL) control the lower leg to hold the position during the movement. The muscles of the back of the thigh grip on the bone of the tibia prevent anterior tibial translation and direct damage to the ACL when it is in contact with pad foot (Koulouris and Connell, 2005). The forces that ACL must endure during the movement were adapted to his role in the knee. The situation when the back of the thigh muscles are insufficiently involved in overcoming all the forces that occur during the movement because the possible trauma occurred, results in large load ligament of anterior cruciate ligament. In this way, it can appear a serious ACL injuries. Therefore, preventing the injury of the back of the thigh with muscle exercises program of strength and flexibility has very important role. That is because the movement of athletes in the closed and open kinetic chain is exposed to very large forces of the possibility of injury or increased susceptibility to injury (Bennell et al., 1998). Muscle contraction, with previously described mechanisms that occur under the influence of major powers acting in the opposite direction, can greatly affect the muscle injury. Those forces that are submitted back of the thigh muscles are often precisely those that seek to extend the already contracted muscle. According to Guyton and Hall, 2006. power of maintaining muscle length (isometric contraction) is

higher approximately 40% of the force of contraction. Landing after jumping or sudden deceleration from sprint happens on just the same mentioned previously mechanism. This burdens the tendons, joints, ligaments and muscles which can lead to their internal tearing. Strengthening the muscles of the back of the thigh with concentric movements in which the muscle shortens is very important. Equally is important the strengthening of the eccentric motion in which the muscle which is contracted elongates (Sayers and Sayers, 2008). Exercises of eccentric muscle contractions of back of the thigh showed positive results in reducing injuries by 60-70% in various sports during the racing season (Brughelli & Cronin, 2008). In the research of Small et al. 2009th, there were studied the risk factors for injury of the back of the thigh, using the exercise eccentric contraction strength in combination with heat and stretching. They concluded that the chance of injury reduces by 65%. Despite this possibility of injury did not decrease during the soccer game because of the occurrence of muscle fatigue during the later stages. Exercises were carried out while the muscles were relaxed and it can be assumed that despite the increasing strength and muscle strength themselves, during the later phases of the game effects of training were lost. Situational performance muscle is not developed and the possibility of injuries have increased as well with no previous training. According to Woods et al., 2004. 62% of injury to the back of the thigh muscles occurred during the soccer game. Some of the benefits of eccentric contractions of the muscles are: more nervous adaptation to eccentric than concentric training, the greater force production due to greater use of external load, maximal eccentric contractions activates the fast twitch fibers, each motor unit gets more stimulation, and most of microtrauma of muscle cells are induced by eccentric training to serve as a signal to begin the process of adaptation of muscle. It is very important to know how to be conveyed to the exercise eccentric contraction, because despite the many advantages there are also risks. It is known that this type of training leads to structural signs of muscle damage (Proske & Morgan, 2001). Despite the fact that after the first such training currently muscles lose strength, become painful and stiff, and are more susceptible to injury only, exceptional adaptation of muscle cells to such loads, and excellent results in the prevention of injury indicate that it is desirable to carry out such exercises in treninigu (Brockett, 2000; McHugh, 2003; MjOlsnes et al., 2004). During an eccentric contraction the muscles behave like structures that absorb shocks and springs in the musculoskeletal system (LaStayo et al., 2003). According to Kujala et al. (1997) frequently the point at which there is a risk of injury while running exactly before the front, ample leg comes to contact with the ground, because then the rear side of the thigh is stretched the most and exposed to the maximum force a slowdown tibia and quadriceps strength. The minimum force acting on the back of the thigh muscles during running is when the hip and knee are in full extension, and the greatest force to be overcome when the hip is in flexion and when the knee is in flexion of approximately 90° (Waters et al., 1974). According to Guyton (1995) highest degree of susceptibility to injury occurs precisely at the maximum contraction of the muscle. The muscles of the back of the thigh are also, due to its insertion on tuber ishiadicum, involved in controlling the stability of the lower back with the rest of the area of the spinal muscles during movement and correction of troops from front bended positions, so there are also further burdened by the forces that operate continuously. Classification of muscle injuries can be based on the mechanism, the way in which the injury occurred and what the damage was: contusion, lacerations or partially distent, strains, partial rupture and complete rupture (Croisiere, 2004).

Also in football, which is a contact sport, there are non-contact and contact injuries. Contact injuries are injuries that occur in a direct duel with an opponent with a variety of commonly occurring concussion or contusion in the action of external forces of the opponent's body to the muscles. For non-contact injury bind to different strains, distensions and ruptures of the varying degrees. A number of reasons which combined together with their impact on the actual injury lead to non-contact injuries: fatigue, inflexibility in the back of the thigh, poor coordination among muscles of the front and back of the thigh, lack of muscle strength... The basis of causing such injuries are too big forces generated by muscles that they are not prepared.

According to Hawkins et al., 2001. The greatest number of injuries that occurred in the English Premier League in two years are muscle strain, counting the number of 48% of total 2376 football players who were watched in this study (Hawkins et al., 2001). The research by Garrett 1996th found that the strain is the most common form of muscle injury (30%) of athletes registered in sports medicine (Garrett, 1996). Also according to Orchard et al., 2002. research conducted on professional football players by Australian rules, only muscle strains are the most numerous as the types of injuries and muscle group the back of the thigh (Orchard & Seward, 2002). In this group of muscles usually is injured the m. biceps femoris and m. semitendinosus (Ivkovic et al., 1997). According to Koulouris and Connell, 2003. 80.5% of the back of the thigh injury refers to the m. biceps femoris, while according to Woods et al. 2004. 53% relates to the aforementioned hamstring muscle injury. Place of the common injuries of the muscle is the proximal part of the compound muscle and tendon and around the gluteal fold (Comfort et al., 2009). The reason for this is combination of muscles and tendons and the transition from tendon to muscle stretch along its entire length (Gokaraju et al., 2008). Concussion or contusion is an injury that is caused by blow to the muscle with greater or lesser force. Depending on the severity and location of impact can, it can cause damage to muscle fibers, connective tissue and associated nerves and blood vessels. Strains are the mildest type of injury where there are no anatomical changes in the structure of muscle. Lacerations or partially distension injuries are injuries in which the interrupted flow of a small number of muscle fibers is. When the injury occurs, the anatomical changes in the structure of muscle in one part of the muscle fiber happen. Partial rupture and complete rupture are the severest form of muscle injury that occurs when pain is expressed, a large hematoma, visible or tangible place where is made such a injury and long inability to use muscles at full capacity. Factors of risk of injury to the back of the thigh muscles are what is important and necessary to spot. Injuries are multifactorial in its nature. Many scientific papers, especially from the sport medicine, consider this topic as interesting, useful and important. Identifying all factors that affect the injury to the muscle groups is of the most important things because the determination of the causes of preventable injuries can be caused. One of the most important information is that the athletes who had previously injured the muscle group are most at risk of re-injury (Proske et al., 2004). Thus the well-known saying that applies is "Once a strain, always a strain. According to Best et al., 2009. Creation of connective tissue that is not functional after the injury is one of the important factors of return or recovery of injuries. According to Silder et al., 2010. There has been investigated the possibility of the risk factors of re-injury to hamstring muscle group. According to the results of tests, there were no significant differences in relation to the muscles that were not injured. So, there is questionable conclusion that a prior injury is a trigger for re-injury. In studies of Woods et al. (2004), through two years of professional soccer players, tracking the percentage of re-injury was only 12%. The main factors of injury that are investigated and found by many scientists are: inadequate warming up before physical activity (Croisiere, 2004), muscle fatigue created trough improper conduct curriculum training athletes over a long period (Croisiere, 2004), lack of flexibility (Orchard, 2001) , the biological age athletes (Orchard, 2001), imbalances in muscle strength and power of thigh agonists and antagonists (Croisiere, 2004), the power imbalance between the hamstrings muscle groups of right and left leg (Ivkovic et al., 2005), improper running technique and other forms of overcoming space (Orchard, 2001), incomplete and / or aggressive or accelerated rehabilitation (Croisiere, 2004). Some factors in themselves clearly say why, or risk (inadequate warming up before physical activity, muscle fatigue created improper conduct curriculum fitness qualifications of athletes over a long period of time, lack of flexibility), while others will be explained by the results of research and the researchers claim. Imbalance or imbalance in the strength and the strength of the quadriceps and hamstrings is the most common cause of injury (Croisiere, 2004). Injury occurs when the back of the thigh muscles are not able to overcome the large force that was formed due to contraction of the quadriceps because of too much difference in strength and intensity of these two opposing muscle groups. This ratio says about the relative strength of opposing muscle groups. Studies have shown that rear thigh muscles should have 60% power

group front thigh muscles (Ivkovic et al., 2005). Considering the relationship between muscle strength above the left and right legs, some researches assert that as one of the most important factor of injury. In fact the differences in the strength greater than 10% is predisposing factor of occurrence of the syndrome hamstrings (Ivkovic et al., 2005). This is explained in a way that during the activity, if footballer is running at maximum speed, the part who has the stronger muscles will pull his legs stronger and faster. If movements of the left and right leg want to align, weaker leg is forced to track the movements of the opposite leg.

Because of the unequal power, after a time will appear minor muscle damage, or microtraumas in those places that are susceptible to muscle injury. By accumulating small defects that are ignored due to the almost imperceptible pain there can appear serious damage of the muscles that require long-term process of rehabilitation treatment. Long-term opportunities for reasons of difficulty to remove hematoma at the site where blood vessels are cracked, damaged nerve extensions that bring impulses to the muscles, creating a nonelastic connective tissue, muscle or scar tissue that is not functional in the form of contraction and the decrease in muscle function due to the appearance of pain. The emergence of overuse injuries in athletes is much clearer when the biomechanical factors in a particular sport is analyzed (Cave, 2001). In football, repetitive movements, such as kicking and passing a ball, made the great efforts of hamstrings muscles. In these specific movements the muscles are stretched, contractile and tense. When your feet hit the ground running between 800 and 2000 times on the trail a mile long, a reactive force base, depending on their hardness and quality, is between 200 and 300% of body weight (Cave, 2001). Incomplete or aggressive rehabilitation is also one of the problems faced by athletes and sports doctors. To monitor the progress of each athlete in rehabilitation and advice on the basis of the results to determine the further course of recovery is very important. Wishes for a rapid return of athletes themselves, and often other people who want the athlete ready before, are often contradictory to the success of recovery from injury. Insufficient recovery of muscles is often accompanied by a new injury which may be harder from an old injury. But it is not necessarily that the injuries are renewed shortly after return to normal training. Athletes are often used to the kind of pain tolerance and can ignore some indicators that show the lack of recovery from injury (very small and bearable pain in the muscles, gently tightening and stiffness of muscles after heating, light tingling in certain parts of the muscle during the activity...) considering that this is normal. Since football has been a type of contact sports where there is direct duel with an opponent, it develops a certain tolerance for pain because of frequent contacts. Therefore, it is very important to inform your doctor about any changes, and observations. Biological age athletes may also affect the injury to hamstrings muscles. Connection between age and risk of injury to hamstrings muscles was proposed by Orchard (2001). It is based on the fact that older age can lead to the degeneration of the lumbar spine, resulting in nerve pressure that are on that place. With this, innervation of the muscle decreases. Original impulses are decreasing and partially interrupting which causes decreased muscle power and strength. Quadriceps is not affected by this process which leads to an imbalance between agonist and antagonist thigh muscles (Orchard, 2001). Improper running technique athlete damage your entire musculoskeletal system. He hinders movement and with unnatural movements that are against the biomechanics of movement burdens a lot some muscles or muscle groups. Therefore, in every sport must be necessary experts who will teach athletes to maximize the proper use of his opportunities with the possibility of less-injury.

Exercises of prevention

Football is described as a complex acyclic-natured activity interval that requires the highest degree of development of physical abilities (Markovic & Bradić, 2008). Of the four muscle groups of the lower extremities, injuries to the back of the thigh muscle in football are the most common, with the percentage of 37% (Ekstrand et al., 2011). To be able to prevent injuries and minimize the risk factors, it is necessary to observe to certain guidelines while doing physical activities. It is always good to apply the specific forms of

stretching for the initial and final part of physical activity because it is helpful for faster preparation for activity, and it accelerates muscle recovery from fatigue. Stretching increases the muscle flexibility, allowing better muscle work and preventing from the undesirable small microtrauma. Quality heating increases blood flow to the muscles, reduces stress on the muscle tissue and thus the muscle prepares for work. It is necessary to properly do the exercises of power for the entire body in order to enhance the locomotor system. The study of Arnason et al. (2008), has proven that specific strength training exercises for the back thigh muscle group affected the reduction of risk of professional footballer's injury. In this way, the number of injuries has decreased because of the locomotor system, which is ready for more stimulation. It can tolerate larger forces that oppose during the motion. Because the muscle imbalance in the power and strength of agonists and antagonists is one of the main reasons for injury of hamstrings muscles, there are some exercises which can strengthen the mentioned muscle group:

First exercise: raising hips from lying on his back
Description: lying on his back, legs crouch at 90 ° in the knee joint, hands are relaxed and the hips with the palms on the ground, raise your hips as much as we can into the air without moving the rest of the body, the hands are resist on the substrate (isometric contraction) assisting in this way.

Second exercise: lifting the hips from lying on your back with one leg
Description: same as the previous exercise, only one foot in the extension of the body is relaxed and the hip movement upwards in the air, raise your hips with one foot.

Third exercise: leg lifting from lying on his back with the resistance
Description: workout is done in pairs, lying on his back, legs extended, body outstretched, fingers of one foot pulls itself (dorsiflexion), contraction of the quadriceps and lifting your legs in this position as we can, return leg to starting position while our fellow worker providing resistance who holds the heel of the foot, alternating footwork, or every foot specific number of repetitions.

Fourth exercise: leg lifts from lying on your stomach with the resistance
Description: lie on your stomach, your hands are on the neck behind the head, raise both feet alternately as far as we allow the hip joints. It is essential first to raise as much leg work for m. gluteus, and then pull the lower leg.

Fifth exercise: leg pushing behind back while standing, with the resistance
Description: Exercise is working with the expansion strip or along a vertical surface. If the expansion strip is using, each hand holding one end of the lane, center lane is at the bottom of the feet (front), stand up straight, with arms extended, with the body relaxed, your foot, on which the strip is, is bent at the knee at 90°, eject the feet in the back, not extending the knee to the end, hands provide the resistance. If you are working on a vertical surface (wall), then bend the knee at 90 ° and a full foot against the wall, the other leg on which we stand is a bit ahead of the body, with feet on the wall pushes from the wall and slowly coming back.

Sixth Exercise: walking forward when lying on your back on a smooth surface
Description: lying on back feet crouch in the knee at 90°, arms relaxed and laid on her stomach, walking forward and pulling the legs alternately glide over the surface (Exercise is recommended to work on a smooth surface (parquet, parterre wrestling ...) due to friction and possible scratches on the back).

The seventh exercise: lower leg casting with weights in the Movement
Description: stand up, the weights are around the ankles, lower legs alternately toss, we're trying to touch the bottom fifth.

The eighth exercise: pushing the ball with the lower leg while standing
Description: standing upright, the ball (soccer ball pilates or less) is located between the shin and thigh at the back, clutch the ball while trying to make it more extension in the hip joint by pushing the knee back.

Ninth exercise: drag and drop the ball in the supine position
Description: lying on back, legs, crouch in the knee joint, two soccer balls are below your feet, raise your hips, relying on the ball, then slowly straightening knees as much as it is possible, then returning to the initial the position.

Tenth Exercise: Pushups on the knees with thrust to slowly lower to starting position by activating the back of the thigh muscle
Description: The exercise is performed in pairs or with swedish ladders, in position of pushups, but on the knees, shins fellow worker is holding our lower legs or have them hooked to the swedish ladder, descend by bending the elbow, then an explosive movement, than slowly descend body with activation of hamstrings muscles.

Eleventh exercise: Eleventh exercise: walking backwards with a resistance
Description: The exercise is performed in pairs, take the rope or it may be soccer shirts use, each of the pair received with both hands to the ends of the rope or shirts, one providing resistance, while another resistance walks backwards, pulling his fellow worker with rope or shirt.

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