The Role of Stretching in Rehabilitation of Hamstring Injuries: 80 Athletes Follow-Up

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ABSTRACT

MALLIAROPOULOS, N., S. PAPALEXANDRIS, A. PAPALADA, and E. PAPACOSTAS. The Role of Stretching in Rehabilitation of Hamstring Injuries: 80 Athletes Follow-Up. Med. Sci. Sports Exerc., Vol. 36, No. 5, pp. 756–759, 2004. For years, stretching has been an integral part of fitness, practice, and rehabilitation programs to decrease muscle stiffness and relieve pain associated with it. The increased joint range of motion (ROM), indicating the degree of muscle flexibility, has a benefit of stretching proven for healthy tissues. Purpose: The objective of our study was the assessment of the effects of stretching in the rehabilitation of hamstring injuries. Methods: We followed up 80 Greek athletes, of average age 20.5 yr, with “second-degree” strain of the hamstring muscles. The athletes were divided into two groups, A and B. For both groups, we estimated the time required for the rehabilitation of the decreased knee ROM and the total time before the athletes could return to a full training program. Results: Group B, which carried out a more intensive stretching program, was found to have a statistically significant shorter time of regaining normal ROM (5.57 ± 0.71 d) and rehabilitation period (13.27 ± 0.71 d) in comparison with group A (7.32 ± 0.525 d and 15.05 ± 0.81 d, respectively). Conclusion: Our results suggest that stretching is of great importance in treating muscle strain injuries in that it improves the effectiveness of the rest rehabilitation program. Key Words: MUSCLE STRAIN, FLEXIBILITY, RANGE OF MOTION, STIFFNESS, STRAIN HEALING, VISCOELASTICITY

Hamstring-strain injuries are one of the most common athletic injuries treated by sports medicine physicians and physiotherapists, requiring a prolonged, individualized, and well-prepared rehabilitation program (21). Stretching is part of this program, increasing muscle flexibility and relieving pain occurring due to muscle stiffness (15). Although there are many studies proving the benefits of stretching in healthy tissues, there are fewer dealing with the effects of stretching on injured human muscles. This article is an attempt to study the latter, in athletic injuries in particular.

MATERIALS AND METHODS

The study was based on 80 male and female Greek athletes who visited the medical center of the Greek Athletics Federation in Thessaloniki, Greece, from January 1996 to December 2001. They all presented with a second-degree strain of the hamstring muscles. A total of 52 male and 28 female athletes were examined within the first 48 h postinjury. Diagnosis was based on injury mechanism—indirect muscle strain injury (usually after an eccentric contraction), clinical evaluation, measurement of the active knee extension using goniometry in comparison with the uninjured limb, and the dimensions of the rupture in the ultrasound scan of the muscle. Reduction in the knee extension up to 10–15° and echographic rupture dimensions up to 2.5 cm in width and 3.5 cm in length were diagnostic for a second-degree hamstring strain (10). Free medical history for hamstring, lumbar-spine, or lower-extremity injuries was the major inclusive criterion. All athletes were also informed in detail about the study, were free to withdraw at any time, and signed a written informed consent. The study was approved by the Ethics Committee of the Greek Track and Field Federation.

Knee extension was measured with a double-arm (30 cm) clear plastic goniometer. The subjects lay supine with the opposite lower extremity extended and the lower extremity being measured at 90° of hip flexion. The center of the goniometer was placed at the lateral knee joint line, whereas the greater trochanter, the lateral femoral epicondyle, and the lateral malleolus served as landmarks during measurement (Fig. 1).

During the first 48 h, all athletes underwent the P.R.I.C.E. (protection, rest, ice, compression, elevation) protocol, followed by a reevaluation of the injury. The athletes were randomly assigned in two groups, A (N_A = 40) and B (N_B = 40) and followed the same rehabilitation program. They carried out static stretches of the hamstring muscles, sustained for 30 s, repeated four times. The only difference between the two groups was the number of stretching sessions. Group A had one whereas group B had four sessions daily. Static hamstring stretching was performed in a standing position in an anterior pelvic tilt, with the stretching leg...
on a chair or a table, depending on the athlete’s height. The proposed “preferred stretching technique” consisted of retraction of the shoulders, increase of lumbar lordosis, and maintenance of horizontal head position while flexing forward as far as possible without pain (16,19,21) (Fig. 2). The athletes were advised to stretch until they felt tension or slight pulling, but no pain. During the stretch, stress-relaxation occurs and force on the muscle decreases for the given length. Subsequent viscoelastic changes and an analgesic effect permit more increase of the muscle length until the point of the original tension (15).

Two parameters were measured and studied in order to assess the effectiveness of the stretching programs in the two groups: a) time needed for equalization of active knee extension between injured and healthy sides and b) time required for full rehabilitation.

Statistical analysis. Statistical analyses were performed using the SPSS v. 8.0 software for Windows. A $P$ value of less than or equal to 0.001 was accepted as statistically significant. The $t$-test analysis was used for the comparison between the two groups. The results are expressed as means ± SD.

RESULTS

One of the basic criteria for the evaluation of the effectiveness and progress of the treatment and rehabilitation program was the increase of the impaired knee extension until its equalization with the healthy knee extension. Group A patients returned to normal values of ROM in a mean time of 7.3 d, whereas the respective time for group B was 5.6 d (Table 1). The difference between the two groups was statistically significant ($P < 0.001$). The time required for full, unrestricted athletic activities was also significantly different ($P < 0.001$) between groups. This time was found to be 15 d for group A and 13.3 d for group B (Table 1).

DISCUSSION

A muscle injury occurs when the muscle fails to withstand a certain force or strain. The ability to absorb energy is limited for each muscle and depends on the capacity of the tissues. It is known that the passive component of a muscle, consisting of the connective tissue elements within the muscle, can absorb half the amount of energy of the contractile component until the point of failure (6,7). A small number of muscle fibers begin to tear when the applied force exceeds 80% of the force necessary to disrupt the muscle (6,11). Activated muscle develops 15% higher force than the passively strained to failure muscle, whereas the length of failure is the same in both circumstances (6,7). Eccentric contractions are considered to develop higher forces predisposing muscles to injury (8,12,22,23). Stretching a muscle beyond its limits usually leads to rupture at the muscle-tendon junction (6). When a force is applied to a muscle, its length increases gradually until the point of plastic deformation (15). The force-displacement relationship is not linear, and there is alteration in tissue structure, which finally results in muscle rupture. These findings should be kept in mind while treating a strain injury, to avoid unsuccessful interventions.

After an acute muscle injury, the initial response is an inflammatory stage, during which there is proliferation of white blood cells, increased blood supply, and leakage of plasma proteins. This stage is followed by the fibroblastic stage. The dead and damaged tissue is replaced by collagen and glycosaminoglycans. The fibroblastic activity is stimu-
lated by the stresses to the tissue. Stretching of the muscle determines the stress lines along which collagen will be oriented. If this procedure fails to take place, tensile strength is not regained properly, leading to prolonged pain, limited function, weak, and prone to injury tissue (4,10).

When prescribing a stretching regimen, the type, duration, and frequency of stretches are three factors, which may influence or even determine its effectiveness. According to medical literature, proprioceptive neuromuscular facilitation (PNF) stretching techniques are thought to be more effective in increasing ROM compared with ballistic and static stretching, though some results have not been statistically significant (15). PNF stretching, like ballistic techniques, increases electrical activity and muscle stiffness during the stretch. This electromyographic finding, consistent with the biomechanical data described above, means that the muscle eccentrically contracts during the PNF stretch, producing greater force (15). Under this condition, the result could be aggravation or recurrence of the injury or occurrence of a new one. This possibility must be excluded from a stretching protocol used for the treatment and rehabilitation of a strain injury, at least at the early stages. On the other hand a static stretch is much easier to teach and perform than a PNF one. In choosing the type of stretching, there should be a balance between the theoretically greater benefits of ROM gained with the PNF stretches and the safety and simplicity of static stretches. We preferred the static stretching technique with an anterior pelvic tilt because lengthening of the hamstrings is more marked and is easier to perform. Although the majority of research has been done on healthy tissues, we tried to apply the same regimen to injured athletes. The histological changes, occurring after an injury (torn tissue, formation of scar tissue, tissue reorganization and muscle atrophy) may alter the biomechanical properties of the muscle (13,14). Injured muscles with changed viscoelasticity may require longer stretches or more repetitions to obtain the same benefits as healthy muscles.

In trying to establish a rule about how long stretching should be maintained and how many stretches should be performed we considered the variety of different muscle groups, intersubject variation, changes in the muscle tissue related to age and individualized preparation of the stretching protocol (5,9,20).

The duration of each stretch is determined by a multiplicity of parameters, some of which are listed above. Some recommend holding a static stretch within a range of 10–60 s, but most authors agree that a 30-s stretch is enough for healthy people (1–3,6,15). The same results were achieved with a 10-s stretch, requiring a few more weeks of rehabilitation (15). Some subjects or muscle groups need increased stretching duration or more repetitions. A review of the literature leads to the conclusion that a 30-s static stretch, repeated four times daily is likely to achieve the maximum benefit more rapidly.

Contradictory opinions on this subject in the literature can be explained by considering the issue of viscoelasticity. Elastic substances lengthen for a given force and return to their original length immediately upon release. The effect is not dependent on time. Viscous substances have flow and movement depending on time. Viscoelastic substances, such as muscle tissue, exhibit both properties. Therefore, if a muscle is stretched and held to a constant length, the tension at that length decreases over time. This decrease in tension over time is known as stress relaxation (15). On the other hand, if a constant force is applied to the muscle, its length increases over time. When the force is removed, the muscle slowly returns to its original length (15). Experimental models have proved that there is statistically significant reduction in tension for a given stretching length and an increase in length for a given tensile force between the first four stretches (6,17,18). This is why the immediate effects of stretching are acquired during the first four repetitions.

Immediate and long-term effects on muscle tissue achieve stretching-induced increases in ROM. The immediate effects are those occurring within the first 60 min after a stretch. The proposed mechanisms are passive viscoelastic change, which reduces muscle stiffness and decreased actin-myosin bridging due to reflex inhibition, which also results in viscoelastic changes. The stretch tolerance is the key for relieving pain associated with muscle stiffness. Increased stretch tolerance means that the same force produces less pain and may occur through an increase of muscle stiffness or an analgesic effect. Analgesia is a more plausible mechanism because muscle strength does not increase during the 2 min of stretching. The evidence of a possible analgesic effect is recent and the underlying mechanism is still unknown (15). After several weeks, stretch-induced hypertrophy may increase tissue strength and stretch tolerance consequently (15).

Our stretching program was based upon all these data coming from studies on animals and healthy humans. Despite caution regarding extrapolation from the results on injured tissues, we tried to find out whether stretching has the same influence. Increased frequency of stretching exercises leads to faster rehabilitation without compromising the overall result. In the present study, the enhancing effect of stretching in injured muscles is shown, but further research is needed using different protocols, that is, the beneficial result has been proved but more research is required using different stretching programs. Our results, consistent with those in the international literature, show that increased frequency of static stretching during the rehabilitation period after a second degree hamstring-strain injury increases the impaired knee ROM faster. This accelerates the application of other therapeutic measures and enables athletes to return sooner to their activities, a fact of great importance in treating elite athletes.
REFERENCES


