

Investigating Eccentric Contraction Mechanism in the Prevention of Sports Injuries

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Abstract

Introduction: Eccentric contraction exercises such as hamstring Nordic have been used nowadays to prevent injury. Maximum force in the muscle happens when the outer force is more than the force made by the muscle. Muscle force can reach its maximum in eccentric contraction and this damages contraction components and cytoskeleton (infraconstruction) of the muscle fiber and weakness and pain happens. But how a contraction which causes pain and injury can help in preventing injury? The goal of the present study was to evaluate the eccentric contraction mechanism in the prevention of sports injuries. **Materials and Methods:** For this study, background research has been done using search engines from 1980 to 2017. Studies including information about eccentric exercises and sports injury prevention have been chosen next after eliminating unrelated articles. **Results:** Eccentric exercises affect muscle morphology and peripheral and central nerve activities. Muscle structure characteristics can create force which include pennation angle, muscle thickness, and fascial length and differ according to mechanical trigger. When the muscles are lengthened, the force attracts the mechanical work and acts as a spring. The energy which has been attracted during muscle and tendon lengthening, is usually wasted as heat and then recovery of stretching combustion energy happens. Stretching and energy recovery depend on the energy and resilience of the muscle. Eccentric contraction respectively causes more stretching of the sarcomeres, detachment of the sarcomeres, cortex damage, localized contraction, muscle fiber inflammation and eventually inflammation and pain which shows injury to the muscle tissue. Moreover eccentric exercises change the call for alpha motor units, sarcomere activity, corticospinal sensitivity and brain activity. Continual muscle adaptation ability to tissue damage is a step for preventing acute injury in the future in eccentric contraction. **Conclusion:** Eccentric exercises have caused small injury in muscle tissue which eventually causes adaptation in the muscle and increases their strength and resistance and this happens by increasing muscle diameter and fascia length and pennation angle. Although it could be damaging but it is better to consider useful as muscle adaptation.

Keywords: Sports Injury, Eccentric Contraction, Preventing Injury, Eccentric Exercises, Nerve-Muscle

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Introduction

Structure of the muscles which determine the force of each muscle can be created (1, 2). Muscle weakness influences individuals function and predisposes muscles to injury (1). So determining proper methods of preventing these injuries is necessary for individuals health.

Proper exercises are the best methods to prevent these injuries. With the least financial cost and consequences, they

have caused individual's health and also strengthen muscles and changed them so that lots of injuries could be prevented. But evaluating which exercises have the most effect on prevention of sports injuries is important.

One popular exercises are eccentric exercises. In the past century lots of studies have been done about the positive effects of these exercises on muscles. Eccentric contraction happens when the muscle has been lengthened and range of motion has been increased. For example if one holds a 2 kg weight in his



Figure 1. Eccentric contraction of the hamstring when walking downhill (3)

hand the force which has been created by the muscle to hold the weight is more than the weight. The reason is the force of gravity on the muscle. Eccentric contraction happens in lots of activities including: walking downhill, skiing and horse riding (4) (Figures 1 & 2).

In eccentric exercises, lactate and ammoniac production is decreased and fatigue happens later. Also metabolism has been increased. So the muscle can continue the exercise longer (5, 6). Three points are important to prevent injury; muscle thickness, fascicle length, and pennation angle. By increasing these three muscles, strength has been increased and the muscle has been adapted to the forces so eccentric exercises have positive effects. Studies are on the relationship with effectiveness of eccentric exercises in preventing injury. Current study's goal is the revision of past studies about the effect of eccentric exercises on preventing muscle injury.

Materials and Methods

Current study is a review of done studies about eccentric exercises' effects on muscles and prevention of sports injury. Data gathering has been done by Persian and English search among articles from 1980 to 2017.

Used databases included PubMed, ISI web of Knowledge, Scopus, Google Scholar, ProQuest, and internal databases included university database, SID, Iranmedex, Magiran, Irandoc and Medlib using search query of sports injury, eccentric contraction, injury prevention, eccentric exercises, and nerve-muscle. Then after eliminating unrelated articles, articles which included information about eccentric exercises and preventing sports injury were chosen.

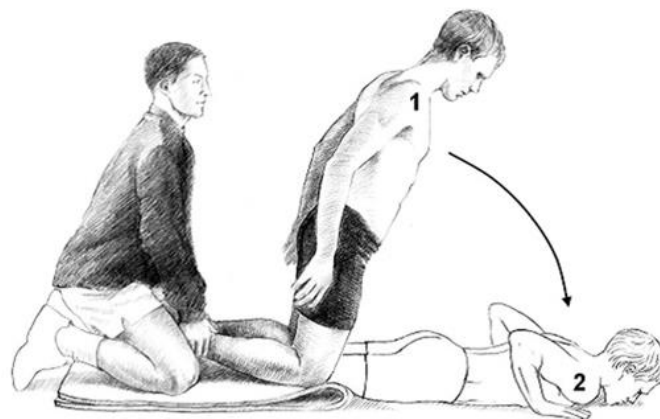


Figure 2. Curl Nordic Hamstring move: An Endurance exercise in which the individual is in position one and with eccentric contraction of hamstring muscle moves to position 2 (7)

Results

Muscle volume increase and injury prevention

Muscle ability to create force is directly related to its structure and muscle thickness and volume is one important characteristic (1, 2, 8). When the muscle is exposed to mechanical stimulants this structural characteristic changes (1, 9-12).

Muscle thickness is the distance between superficial aponeuroses and intermediate aponeuroses. (Picture 4) Increasing muscle thickness and volume will increase muscle power and endurance (1, 13). Muscle thickness affects the increase of muscle function and decrease of muscle injury (8, 9). Intense endurance training causes physiological adaptation of the muscles (14). Mechanical force pressure causes protein synthesis (15). Mechanical tension from intense exercise can increase metabolic stress and stimulate Para cellular pathways that involved in protein synthesis which resulted in muscle volume increase (3, 5, 16-18). It is recommended that stretching with overload is the most effective stimulant for muscle growth (19, 20). Muscle is under stretch and load during eccentric exercises, which damages muscle tissue (20, 21). Cellular damage causes gene expression and muscle hypertrophy (9, 16, 19, 21, 22).

Eccentric contraction is the most effective method for physiological and nerve-muscle adaptation which includes muscle hypertrophy, increase of cortical activity and change in motor unit functions which eventually causes development of muscle function. (23, 24) Proper and high hypertrophy of the muscle happens after intense eccentric exercises. (24, 25) Also increase of muscle volume and recovery is more in eccentric exercises compared to concentric exercises. Probably the reason is more mechanical tension of eccentric exercises. (24, 26, 27) A review of past studies has been proved that eccentric exercises aside from using less energy are effective in increasing muscle volume and power (28, 29).

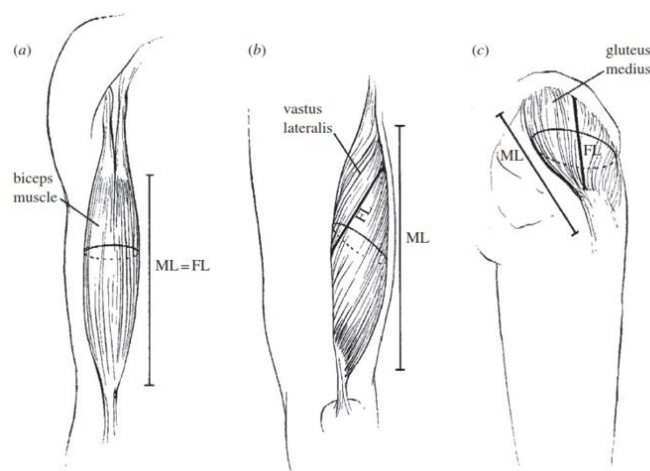


Figure 3. Muscle Length (ML) and Fascicle Length (FL) in 3 different muscles; a) Longitudinal structure: muscle fibers are perpendicular to force axis as in biceps muscle; b) Pennate structure: muscle fibers have the same angle as force axis like lateral quadratus muscle in thigh; c) Multi-pennate structure: muscle fiber has different angles than force axis like medial gluteal muscle (2)

Paddon *et al.* studies have shown that eccentric exercises cause notable increase in muscle volume which results in increase in power and prevention of injury (30).

LaStayo, *et al.* studies have shown that power which is created in eccentric contraction is high while energy use is low. Tendons adapt to high tension of muscles and this can help prevent injury and improve function of the athlete (31).

Fernandez, *et al.* studies in 2017 have shown that muscle volume increase in eccentric exercises can help prevent injury and also is useful in rehabilitation programs (1).

Many studies have been done on eccentric exercises and physiological adaptation (for example muscle hypertrophy) which show the importance of eccentric exercises in preventing injuries (9, 22, 26, 28, 29, 32, 33).

Fascicle length increase and injury prevention

Fascicle length is another structural characteristic which increases muscle strength and endurance (1, 2, 8). Fascicle length is influenced by mechanical tensions and changes (1, 9-12). Muscle fascicle length is the distance between two muscle tendon sheets (Figure 3) (1). An increase in muscle cell calcium increases protein synthesis (24, 34). There is Titin in muscle sarcomere which is the spot for calcium connection and senses mechanical stimulants and changes it to biochemical signals. Therefore, muscle sarcomere numbers are changed and cause tension in long-term muscle contraction (35, 36). The mechanical tension causes muscle ischemia from eccentric exercises (19, 20). Which can cause metabolic adaptation in muscles (15).

Eccentric exercises cause an increase in muscle fascicle

length which is due to an increase in sarcomere number (37). This happens by a process which is named sarcomerogenesis (23). Optimum change in the angle from eccentric exercises can cause an increase in muscle group lengths (40). Different studies have proved that long-term eccentric exercises cause fascicle length increase (9, 24, 39, 40).

It is proved that fascicle length increase from eccentric exercises, can affect individuals function and prevent sports injuries (7, 8). Potier study showed that eccentric exercises for 8 weeks cause fascicle length increase and prevent injury and announced that these exercises can help with rehabilitation (10). Other studies by Baroni showed that 4 weeks of eccentric exercises cause fascicle length increase and thickness of vastus recturalis and rectus femoris and muscle function is improved. It has been also shown that injury in muscles has decreased (43).

Timmins *et al.* studies in 2016 were done with the goal of investigation of structural changes in muscles by eccentric and concentric exercises. Participants were exercised the long head of their thigh biceps muscle with eccentric and concentric exercises for 6 weeks. Changes were measured after 6 weeks. They were rested for 28 days and were measured again to determine the durability of eccentric and concentric exercises. Results showed that fascicle length increase from eccentric exercises last longer than concentric exercises. So, eccentric exercises are more effective for injury prevention and rehabilitation. (7)

Fernandez *et al.* studies in 2017 showed that 8 weeks of eccentric exercises affect fascicle length and increase muscle strength. Therefore, it influences injury prevention and rehabilitation. Based on previous studies, fascicle length increase from eccentric exercises is effective in injury prevention and rehabilitation.

Increasing muscle angle and injury prevention

Another important characteristic which affects muscle strength and endurance is pennation angle (1, 2, 8). Pennation angle (muscle angle) is the angle between intermediate aponeurosis and direction of a muscle fascicle (Figure 4) (1). This angle is another characteristic which changes from mechanical forces (1, 9-11, 40).

Pennation angle is the third factor influencing muscle function and injury (8, 9). Increase in pennation angle has been seen after intense eccentric exercises (24, 25). Potir studies have shown that 8 weeks of eccentric exercises could increase pennation angle and affect injury prevention and rehabilitation (11).

Fernandez *et al.* studies in 2017 showed that 8 weeks of eccentric exercises increase pennation angle and could be used in injury prevention programs (1). Several studies have shown the effectiveness of eccentric exercises on the increase of pennation angle and the effectiveness of these exercises in injury prevention (1, 8, 11).

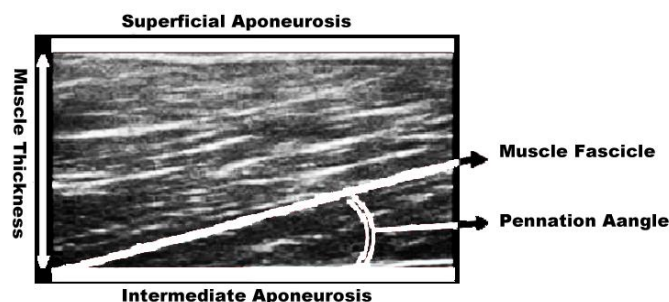


Figure 4. Sonography picture from horizontal axis of thigh long head of biceps (BFLh) (1)

Eccentric exercises and injury prevention and rehabilitation

Asklung *et al.* did a study about effectiveness of eccentric exercises on decreasing hamstring injury in professional soccer players. A group of professional soccer players from Sudan's premier league did eccentric hamstring exercises for 10 weeks, 1-2 sessions per week and another group only did regular exercises. Results have shown that injury in the group of eccentric exercises were much less than the control group. Also strength, speed and function of the eccentric exercises group were improved. Lastly it was shown that eccentric exercises could prevent injury before practice and improve function of the athlete (42).

Arnason's study compared the effectiveness of stretching and eccentric exercises in preventing hamstring muscle injury. Results showed that Nordic hamstring eccentric exercises could prevent hamstring injury but stretching was not effective.

Several studies have shown that eccentric exercises strengthen muscles by changing muscle structure and they are a great method for injury prevention (3, 8, 11, 42-46).

Conclusion

Review of previous studies have shown that eccentric exercises cause changes in muscle structure such as increase muscle volume (muscle thickness), fascicle length and pennation angle. These changes increase muscle strength and strengthen muscle against outer and inner forces. So they help with injury prevention. Also they can be used in rehabilitation programs.

Review article suggestion

It is recommended that considering the goal of the training

session in professional warm-ups, 2-3 sets of eccentric concentrations would be done by the athlete to activate the muscle and his body would be prepared for more intense moves (47).

Conflict of interest:

None

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Authors' contributions:

Both authors made substantial contributions to the conception, design, analysis, and interpretation of data.

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