The Role of Eccentric Strength

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SPORT SCIENCE HAS INCREASED OUR AWARENESS OF THE BIO-MECHANICAL DEMANDS OF VARIOUS SPORTS. RESEARCH HAS GIVEN A BETTER UNDERSTANDING OF ECCENTRIC WORK AND ITS FUNCTION IN SPORT PERFORMANCE. MY GOAL HERE IS TO INTERPRET THIS RESEARCH SO COACHES CAN UNDERSTAND AND USE IT TO ENHANCE THE PERFORMANCE OF THEIR ATHLETES, HELP PREVENT INJURY, AND REHABILITATE ATHLETES SHOULD INJURY OCCUR.

Muscle is called upon at various times to function as a motor, a spring, a shock absorber, or a stabilizer. The tendency has been to emphasize the function of muscle as a motor, with the resultant emphasis on shortening and force production. To a lesser extent the stabilizing function was emphasized through the recognition of the role of isometric muscle action.

The work of Curwin and Stanish (2) has made me aware that something essential was being neglected. Awareness of how, when, and where injuries occur as well as the search for additional ways to enhance performance led me to look more closely at the spring and shock absorption of the muscle which occurs in eccentric muscle action.

The popularity of plyometric training has been a major factor in raising awareness of the essential role of eccentric muscle action, due to the fact that plyometrics train the stretch/shortening cycle (SSC) of muscle action. Anyone who has used this method of training is aware of eccentric action on two levels: (a) to control the action and (b) to produce the greatest amount of force in the subsequent concentric action.

■ Types of Muscle Action

Concentric muscle action involves active tension with subsequent shortening of the muscle. Isometric muscle action involves no length change but develops force; no external work is produced. Eccentric action involves active tension and a lengthening action of the muscle.

Albert (1) offers a more functional definition of eccentrics as “a type of muscle loading that involves an external force application with resultant tension increase during the physical lengthening of the musculotendinous unit” (p. 1). Eccentric action does not occur in isolation but as an integrated part of all movement as a component of the stretch/shortening cycle of muscular action.

Functionally, muscle actions perform three key roles: (a) They stabilize or fixate a body part that consists primarily of isometric work. (b) They move a body part that consists primarily of concentric action. (c) They resist or decelerate movement of a body part that consists primarily of eccentric work. This function occurs with gravity and is referred to as the spring and shock absorption function (5).

Velocity is one key difference in the production of muscle tension between eccentric and concentric muscle action. In eccentric work, higher speed will yield higher tension. In concentric work, slow speed will yield high tension.

■ Delayed Onset of Muscle Soreness

Anyone who resumes training after a long layoff, or who sprints or weight trains, is acutely aware of the soreness involved. It is especially apparent from 24 to 72 hours after the exercise. According to Stanton and Purdam (4), “This soreness is associated with reduced dynamic strength and myofibrillar disruption (notably broadening, streaming, or disrup-

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tion of the Z bands, which are a component of the series elastic component of the muscle” (p. 344). Postexercise soreness decreases after 2 to 3 weeks, and after 3 weeks the ability to perform eccentric work is significantly increased.

Stanton and Purdam conclude that “eccentric contraction is capable of producing pathological forces within the unconditioned muscle, and that a period of eccentric training allows the muscle to better withstand these potentially injurious forces” (p. 344).

■ Mechanism of Injury

According to Garrett (3), muscle may be more prone to injury for the following reasons: (a) Greater forces are generated with eccentric contractions. (b) A muscle on a stretch can exert higher force than a muscle that is held at the same length or one that is shortening. (c) More force is produced by the connective tissue portion of the muscle as it is being stretched.

Stanton and Purdam state, “Given that higher tensions are produced for the same amount of motor unit activity with quick eccentric contraction, the series elastic component (SEC) is placed under greater stress than with concentric contraction. Hence, this type of contraction is more likely to produce pathological forces within the SEC” (p. 344).

Garrett (3) also identified certain muscles as being more prone to strains. Especially vulnerable are muscles that cross two joints which place the muscle on a stretch at both joints. The hamstring group is a prime example of this. It is active at both the knee and the hip. Also at high risk are muscles that function eccentrically, primarily to control joint motion or decelerate the limb.

Type II fast-twitch muscle fi-

 bers that produce faster contrac-

tions are also injured more often. “Poor eccentric muscle capabilities may manifest as injury in power based speed events via two mechanisms. The SEC may not have the ability to withstand the forces needed to decelerate the moving limb and if the eccentric/concentric storage and recovery of elastic energy is inefficient, the concentric performance may be less than optimal” (Stanton & Purdam, p. 345).

■ Training to Prevent Injury

The first step in preventing injury is understanding the demands of the sport. Where is the athlete at risk when executing the skill? Where do the greatest eccentric forces occur? In sprinting and jumping, for example, the hamstrings are elongated over both the knee and the hip joint. They work eccentrically to decelerate the hip and lower leg in the latter phases of the swing phase. Logically these muscles should be trained in a multijoint manner. An exercise such as the single-joint hamstring curl, which trains the hamstring as a knee flexor, is nonfunctional because of the slow speed of the exercise and its single-joint nature. That is the opposite of its function in movement.

The second step is to understand the physical qualities the athlete brings to the sport. What are the strengths and weaknesses? Is there good proportional muscle development that minimizes risk during the force reduction phase of movement? Are there technical flaws that would predispose the athlete to injury? What is the training and injury history?

Performance is a constant interplay between force production and reduction. Traditional training and rehabilitation programs have focused on force production by emphasizing concentric work. An athlete’s inability to reduce force is what leads to performance errors, and ultimately to injuries (see Figure 1).

The force reduction phase, which is the shock absorption function of eccentric action, will not only protect muscle but also bone by utilizing the elastic properties of the muscle to reduce impact forces. An example is shin splints. They are caused by improper mechanics of running or jumping, coupled with a lack of eccentric strength in the shock absorber muscles that cross the ankle, knee, and hip. Instead of the muscles absorbing the shock, the force is transmitted through the bone. In order for this shock absorbing quality to be fully utilized, adequate levels of eccentric strength are needed in multijoint muscles. This must be addressed in a sound, well-designed training program.

■ Types of Injuries

Muscle fatigue and weakness predispose muscle to injury and reduce its ability to absorb shock. The most common injuries due to the high forces that occur during eccentric action are Achilles tendinitis, jumper’s knee, shoulder tendinitis, rotator cuff problems, and muscle pulls. The high incidence of tendinitis occurs because the tendon functions to allow the precise application of the force that is generated by the muscle. It is at the point of the muscle tendon junction that the high eccentric force manifests itself most strongly (2).

■ Training Principles

In order to be functional, eccentric work must occur at high speed
which produces a high force component. There is a misconception that to train eccentrically it is necessary to train at slow speed, with 110 to 120% of one-repetition max. The slow speed of this type of training is not specific to the eccentric force production in the ballistic dynamic actions of running, jumping, and throwing.

According to Stanton and Purdam (4), there are two advantages to fast eccentric training: (a) It places greater stress on the series elastic component (SEC) of the muscle. The eccentric/concentric coupling will enhance the subsequent concentric action so that the involved muscles will be better able to handle the forces involved. (b) There will be an increased ability to store and use elastic energy that will improve the power production.

Any volume of this type of training requires a large work capacity base that is very dependent on training age. In my own experience, fast eccentric work does not require a lot of external resistance to be effective. In fact, in many cases body weight is sufficient.

Practically speaking, we need to train movements, not muscles. Functionally, muscles work synergistically with other muscles to stabilize, produce force, or reduce force. They do not work in isolation. As noted, the types of muscles most subject to injury during high-speed eccentric work are two-joint muscles. Therefore it is important to incorporate multijoint movements that are specific to the action of the event.

Toward a Total Conditioning Program

It is not so much a matter of incorporating these ideas into a total program as it is recognizing when, in normal sport and conditioning activities, there is the potential for performance enhancement and injury prevention.

Coaching practice has shown that an eccentric action that immediately precedes a concentric action will significantly increase concentric force production, due to the storage and release of elastic energy in the muscle and to reflex potentiation. The common coaching term for this is plyometrics. What we now know about eccentric muscle action verifies the viability of this method of training as a way to enhance performance and expand its use to preventing and rehabilitating injuries.

References


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