Flexibility and the Conditioning Program

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Most strength and conditioning programs place a great deal of emphasis on strength, power and aerobic and anaerobic endurance, often neglecting flexibility training. This is unfortunate because flexibility is required for optimal performance in every sport. Perhaps the primary reason flexibility training is neglected is because of time constraints. However, because it is a critical part of a conditioning program, it is important for the strength and conditioning professional to have a thorough understanding of flexibility.

Flexibility, a function of muscle and tendon tightness, has been defined as the ability of a joint to move freely around its full range of motion (ROM) (32). The importance of flexibility in sports is well recognized, in terms of both injury prevention and performance (17). “Most coaches and sports medicine specialists...recommend stretching exercises as a way of preventing injury and improving performance” (6). Flexibility is an aspect of training in which little research has been done, and is often neglected by athletes (6). As evidence of this, only 39 percent of athletes surveyed (n=238) reported stretching every day and just 35 percent stated they stretched both before and after activity (22).

There are two types of flexibility (10) static and dynamic. DeVries (10) defined static flexibility as the ability to flex and extend a joint through a wide ROM.

Dynamic flexibility is the ability to flex and extend the joint quickly with little resistance to the movement, regardless of the ability to achieve an extreme ROM (10). Because of the nature of the movement, static flexibility is easier to quantify than dynamic flexibility. This may be the result of the difficulty measuring dynamic flexibility, making it impractical to use in most athletic settings (20). There are few sports in which the ability to achieve a high degree of static flexibility is advantageous to performance, though activities such as gymnastics and diving may be exceptions to this rule. Because of the principle of specificity, it seems that dynamic flexibility may be more applicable to athletic performance because the ability to move the joint quickly through its ROM better represents real-life athletic movements (10). However, research conducted in the role of dynamic flexibility in physical education and athletics is inconclusive.

Injury and Performance

The benefits of flexibility to reduce injury rates and improve performance is widely accepted by people who train athletes. Current data on flexibility training programs suggest a positive relationship between stretching exercises and the reduction of muscle injuries in athletics (3, 16, 19). Flexibility can prevent injury in several ways.

“First, flexibility/stretching is a form of warm-up. The athlete who possesses good static flexibility should be less susceptible to muscular-tendon injury if the muscle group and reciprocal muscle group have adequate strength” (16).

Brooks and Fahey (6) suggested that the reduction in injury potential occurs because flexibility training allows the muscular-tendon unit to move through its ROM with less strain. A similar opinion is held by Kornitz and Ringle (20): “freedom of movement permits the limb to move through a plane of motion, and a lack of dynamic flexibility may produce stress to the joint, ligaments, muscles or the connective tissue framework.”

Sharkey (30) expressed a similar opinion, stating that injuries occur when a limb is forced beyond its normal range, and improved flexibility reduces this potential. “The freedom of movement that accompanies improved flexibility may prevent tearing of the muscle-protective tissue complex at the extremes of motion” (19). Flexibility may prevent injury by protecting myofibrillar elements from overstretch during strenuous exercise (20). Several authors (5, 6, 16, 30, 33) believe flexibility training is an important part of the athlete’s fitness program, and that regular stretching may help prevent injuries to the muscles, tendons, ligaments and other connective tissue. However, there is very little scientific evidence to support the contention that flexibility training reduces injuries and improves performance (2).

The role of flexibility in injury prevention is difficult to demonstrate. The
difficulties in structuring an experiment to test the effects of flexibility training on injury rate were addressed by Beaulieu (4). In a study by Levine et al. (22) it was found that while 92 percent of the subjects involved reported stretching their hamstrings, injury surveys revealed numerous hamstring strains. This information casts doubt on the importance of stretching as a method to help prevent injuries (22). Despite disagreement within the scientific community, many involved in preparing athletes for competition agree that flexibility training can decrease the injury rate.

In addition to stretching prior to intense physical activity as a method of reducing injury, it was also suggested that stretching be done post-exercise during the cool down period to reduce muscle soreness (4, 30, 37). Despite widespread support that static stretching will prevent muscle soreness, Knorz et al. (20) stated that the role of flexibility in the prevention of muscle soreness is not known.

Performance

There is little experimental evidence to support the commonly held belief that flexibility enhances performance. Part of the problem is that “it is almost universally accepted that increasing flexibility is valuable in improving athletic performance...but there is no concrete scientific evidence that this is the case” (11). Despite this lack of evidence, several authors suggest that the ability to move efficiently is partly dependent upon a good ROM (11, 20). Limited data and contradictory findings (27) make it difficult to determine the relationship between increased ROM and motor performance. However, Cornelius (8) noted that ROM exercise can be effective for improving motor performance in a particular sport and/or skill because of the increased ability to move freely through the joint’s ROM.

Beaulieu (4) referred to an experiment by Dintiman as evidence indicating flexibility training can be beneficial to performance. In this experiment, sprint time was significantly lowered when the running program was supplemented with a flexibility and weight training program, as compared to a program which was not supplemented by flexibility training. One difficulty in determining the role of flexibility on performance is that a successful performance is dependent upon several factors. It is unclear what effect stretching exercises will have on performance (4). As Dominguez (11) said, however, “I believe that the best way to improve athletic performance to its maximum level...is to have full, normal range of motion.”

Flexibility in the Conditioning Program

While there is support in the literature that stretching should be included as part of the conditioning program, a conflict exists as to when flexibility training should be included in the training session. Many authors believe that stretching should only be performed following a warm-up period (10, 21, 25, 31). According to Shellock (31), elevated core temperatures lower muscle tone, tendon and ligament viscosity, leading to increased ROM, and helping prevent injury.

deVries (10) stated that dynamic flexibility is improved 20 percent when a joint is warmed to 113 degrees, and based on these findings static flexibility might also be affected by temperature changes. Moffatt (25) supported this belief, noting that “when stretching occurs at muscle temperatures within the range of 102 to 110 degrees Fahrenheit, the amount of structural weakening produced by a given amount of tissue elongation varies inversely to the temperature.” Lamb (21) and Brooks and Fahey (16) expressed similar opinions, stating that flexibility training should be completed after a moderate warm-up to take advantage of the many beneficial effects increased temperature has on increasing ROM. The belief supporting the use of warm-up comes from the idea that increased temperature allows for greater tolerance of muscle and connective tissue stretching strong muscular contractions (12). However, Elam (12) and Watthen (35) were not specific as to when during the warm-up period flexibility training should be done.

Murphy noted that some instructors in the fitness profession recommended stretching prior to warming-up. “Their reasoning was that cold muscles are like plastic, and stretching them results in a more permanent stretch, as opposed to stretching the muscles when they are warm and pliable like a rubber band” (26). Dr. Robert P. Nirschl, (26) called this a “ridiculous concept,” stating that there is a higher friction force in muscles when they are cold, and that the risk or injury is much higher when stretching is performed while the muscles are cold.

Even though a significant amount of the scientific evidence supported the importance of flexibility training occurring after increasing core temperature, there are conflicting opinions among investigators. For example, Williford et al. (36) performed a nine-week study to evaluate the effects of a five-minute warm-up period on joint flexibility. Subjects, all of whom were students enrolled in a physical conditioning class, were divided into two groups. The first group participated in a five-minute warm-up prior to stretching, but the second group did not participate in warm-up activities. While this study did confirm that static stretching methods are effective in increasing flexibility, results did not support the theory that warming-up prior to stretching results in significant increases in flexibility for all joint angles evaluated.

Despite equivocal evidence, the benefits of increasing muscle temperature prior to flexibility training are accepted by a majority of strength and conditioning professionals. The physiological responses that occur due to warming-up warrant its continuation as a method to prepare the body for flexibility training.
Factors Affecting Flexibility

Sapega et al. suggested that there are two types of stretches: elastic and plastic. Elastic stretch represents spring-like action in which elongation that occurs during stretching is recovered when the load from the stretch is removed. Therefore, elastic stretch, is a temporary condition. Plastic stretch differs in that the elongation that occurs during stretching remains, even after the load is removed. Muscle has elastic properties and ligaments and tendons have both plastic and elastic properties. When connective tissue is stretched "some of the elongation occurs in the elastic tissue elements, and some occurs in the plastic elements. When the stretch is removed, the elastic deformation recovers, but the plastic deformation remains" (28). ROM exercise techniques should primarily be designed to produce plastic deformation, because a permanent increase in ROM is generally the goal. During the stretch, the proportion of elastic and plastic deformation can vary, depending on how and under what conditions the flexibility training occurs. The primary factors are the amount and duration of applied force and the tissue temperature when stretching is performed (28).

When flexibility training is performed, connective tissue (muscles, ligaments and tendons) is the most important target of ROM exercise. Although muscle is not considered a connective tissue structure, evidence indicates that when a relaxed muscle is stretched, perhaps all of the resistance to stretch is derived from the extensive connective tissue framework and sheathing within and around the muscle. Thus, under normal circumstances, connective tissue is the major structure limiting joint ROM. ROM is primarily limited by one or more connective tissue structures, including ligamentous joint capsules, tendons and muscles (28). Factors affecting flexibility, including the role of the previously mentioned tissues, are presented in Table 1 (9).

The relative contribution of each of the factors in Table 1 to the total resistance varies with different body joints (28). In joints such as the ankle or hip the limitation of ROM is imposed by the soft tissues (10).

In addition to the anatomical and physiological factors that affect flexibility, activity level, gender, age and body fat percentage also play a role in flexibility (10, 25). Studies show that physically active individuals tend to be more flexible than inactive individuals. This is in accord with the fact that connective tissues tend to become less pliable when exposed only to limited ROMs of people with a sedentary lifestyle (10). It has been found that elementary school girls are superior to boys in flexibility, and it is likely this difference exists throughout adult life (10). With regard to age, investigations have found that elementary school children become less flexible over time, reaching a low point between ages 10 and 12. Flexibility improves toward adulthood, but never reaches the level found during early childhood (10). The decreased ROM often seen in individuals as they grow older is primarily due to a decreased activity level. A decrease in activity level will result in an increase in percent body fat and a decrease in the pliability of connective tissue. An increase in fat deposits around the joints creates obstructions in the ROM.

Types and Procedures

The three most common methods for increasing flexibility are 1) ballistic, 2)static and 3) various proprioceptive neuromuscular facilitation (PNF) techniques (13).

Ballistic

The ballistic method consists of "an active bobbing or bouncing action that makes use of the momentum of the moving body part to force the involved tissues to stretch" (24). This method is considered to be both ineffective and dangerous (1, 8). The problem with ballistic stretching is that the increased flexibility is achieved through a series of jerks or pulls on the resistant muscle tissue (27). Because these movements are performed at high speeds, the rate and degree of stretch and the force applied to induce the stretch are difficult to control. Ballistic stretching, though widely used in the past, is no longer considered an acceptable method for increasing ROM in any joint. When comparing static and ballistic stretching techniques, four distinct disadvantages of ballistic stretching should be considered:

1) Increased danger of exceeding the extensibility limits of the tissues involved.
2) Energy requirements are higher.
3) While ballistic stretching is apt to cause muscular soreness, static stretching will not.
4) Activation of the stretch reflex.

The stretch reflex occurs in response to the extent and rapidity of a muscle stretch. An example typically used to explain this reflex is the knee jerk response. When the patellar tendon is struck, the tendon, and consequently the quadriceps muscles, will experience...
a slight but rapid stretch. The induced stretch will result in activation of muscle spindle receptors within the quadriceps. Activation of these receptors will then induce, via a monosynaptic reflex loop, an involuntary shortening contraction of the quadriceps. Because the reflex loop is completed in a very short time (40 minutes) the resulting involuntary shortening could occur while the muscle is being stretched (29). During ballistic stretching movements activation of the muscle spindles is very likely, thus decreasing the effectiveness of the flexibility training on ROM and increasing the chance of injury.

**Static Stretching**

Static stretching is perhaps the most commonly used method to increase flexibility. Static stretching involves passively stretching a given muscle by placing it in a maximal position of stretch and holding for an extended period of time. Achieving the static stretching position should be done slowly and only to a point where minor discomfort is felt. Anderson (1) suggested that the stretch should produce only mild tension. This feeling of tension should diminish as the stretch is held, and if it does not, the stretched position should be reduced slightly. Such a procedure will most likely avoid activation of the stretch reflex (8,18,25). Slow movements associated with flexibility exercises are essential if the connective tissues are to be lengthened and ROM increased (8).

Appropriate sensory mechanisms can be stimulated by holding a stretch position for a minimum of 10 seconds. Golgi tendon organs (GTO) located in the musculo-tendinous junction are activated when muscles are subjected to large increases in tension (i.e., heavy lifting or increases in ROM). Activation of the GTO will result in an inhibitory impulse being sent to the stretched muscle. Thus, GTO's serve as a protective mechanism against possible injury. When the athlete assumes a static stretch position for 10 to 60 seconds GTOs could be activated, resulting in a reduced resistance to stretched connective tissue (8). During ballistic stretching this "relaxation" phenomenon does not occur (8) due to the fact that the GTOs will not be stimulated long enough.

Moffatt (25) suggested the overload principle be applied to stretching programs by increasing the duration of the stretch for each repetition. Each stretch should be repeated five times when starting a flexibility program, and this may increase up to 10 as flexibility increases (18). It is also suggested that relaxation should be considered while moving into and holding the final position of a stretch (8). Exhaling when moving into the stretched position and inhaling while holding the stretched position will assist in achieving this relaxed state. Cornelius (8) recommended stretching to a point of tension, not pain. When pain is experienced, it speculated that muscle spindles acting as tissue length sensors can fire, resulting in contraction rather than relaxation of the involved muscle.

**PNF Stretching**

The proprioceptive neuromuscular facilitation (PNF) technique of gaining flexibility, originated by physical therapists, is widely accepted as an effective method of increasing ROM. The PNF procedure is a technique in which the muscle is slowly placed in a static stretch while keeping the muscle relaxed. Following this static stretch the muscle is contracted isometrically for a brief period of time against an external force acting in the direction of the stretch. The force should be sufficient enough to prevent any movement in the joint. The muscle is then relaxed and a second stretch is performed, potentially resulting in a greater stretch on the muscle. This isometric contraction will result in the stimulation of the respective GTOs which may help to maintain low muscle tension during the terminal stretching maneuver, allowing connective tissue length to further increase and result in increased ROM. Thus, the PNF method attempts to create an environment within the muscle that is advantageous to increasing ROM. Because PNF stretching maneuvers are not performed ballistically, they tend to inhibit muscle spindle activation while inducing activation of GTOs. The result is less resistance to muscle/connective tissue elongation.

In a comparison of increases in ROM resulting from static and PNF stretching procedures, it was found that although both procedures resulted in increased flexibility, subjects using the PNF method gained the most ROM (7). Similar results were found in a study by Lucas and Koslow (23) in which static, dynamic (ballistic) and PNF methods were compared. While each method increased flexibility, the best results were achieved with PNF. Cornelius (8) also supported this position.

Despite the apparent superiority of PNF in increasing ROM, not all athletic trainers agree it is the best method. While some studies suggest PNF produces better results (34), these techniques can be impractical to use. Part of the difficulty of using the PNF method (2), is that a partner is often needed. The partner has to be very careful to not overstretched the muscle. This stretching method can be dangerous unless each person is familiar with the appropriate techniques, because too much emphasis is placed on flexibility in the PNF method and not enough on correct stretching techniques (1).

Cornelius (8) listed three disadvantages of using PNF methods:

1) Initial training and supervision are necessary to maximize effectiveness and safety.
2) The assistance of a partner is required, increasing training time.
3) Close supervision is necessary.

**Evaluation and Measurement**

To make flexibility training more meaningful, the athlete's ROM should periodically be evaluated (5). There are
two reasons for evaluating flexibility. First (14), the athlete should be evaluated to determine if there are any joints that are below normative values. If flexibility around any given joint(s) is significantly below average, a specific program designed to improve ROM of that joint(s) should be implemented. A second reason to evaluate flexibility is to recognize improvements in ROM (14).

The most common method to assess ROM is through the use of a goniometer (24). This instrument measures the number of degrees a body segment moves, enabling the tester to evaluate deficiencies in flexibility and increases in ROM that may occur through flexibility training. Fahey (14) emphasized the importance of repeat evaluations by the same tester so the data gathered are valid. There are also various flexibility tests that can be used to evaluate flexibility. For example, Bliss (5) and Fox (15) have suggested using the Wells Six-and-Reach Test as a method of quickly evaluating flexibility of the low back and hips. However, flexibility is joint-specific. This means that an individual can have excellent flexibility in the shoulder joint, for example, but have very limited ROM in the hips. Therefore, a more comprehensive examination is required to determine what joints, if any, lack ROM.

Flexibility training is accepted as important to injury prevention and performance enhancement, though there is a lack of scientific evidence to substantiate these claims. Although static flexibility is typically the only type of flexibility training that is considered, dynamic flexibility may have more importance in athletics. Unfortunately, the measurement of dynamic flexibility is a difficult task and thus becomes somewhat impractical in the athletic environment.

However, it is important to measure the flexibility levels of each athlete to determine if joints lack adequate levels of flexibility. Once those areas have been identified, a specific flexibility program designed to correct the deficit area can be designed. Additionally, by measuring flexibility on a regular basis, increases in ROM that occur due to flexibility training can be evaluated.

References