Influence of Pre-Exercise Stretching on Force Production

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Stretching is commonly promoted as a method to improve performance in various sports and recreational activities. However, recent reviews have suggested stretching may not enhance performance as previously believed (15, 16). These equivocal views may be attributed to a lack of differentiation between pre-exercise stretching and flexibility training (11). Within this article, pre-exercise stretching focuses on short-term adaptations prior to participating in an activity, whereas flexibility training focuses on long-term adaptations associated with a stretching program designed to improve range of motion. Even though both approaches attempt to increase the range of motion at a joint, the physiological responses in the musculoskeletal system are different. These differences impact musculoskeletal system force production capabilities, but the biggest concerns arise when stretching precedes activities requiring strength or power. Therefore, the purpose of this article is to explore how pre-exercise stretching influences force production.

Pre-Exercise Stretching Techniques

When determining the optimal pre-exercise stretching techniques for activities that emphasize force production, it is essential to differentiate between active and passive muscle activity. Active muscles refer to continuous muscle tension through a range of motion. Passive muscles refer to relaxation of the muscle to permit a greater range of motion (ROM).

There are three common pre-exercise stretching techniques that vary in their utilization of active and passive muscle activity. The traditional approach is static stretching, or a slow and controlled passive movement that places the muscle under slight tension until it relaxes. Proprioceptive neuromuscular facilitation (PNF) is similar to static stretching, but it is more effective at increasing flexibility as a partner resists an active muscle and assists a passive muscle to achieve greater ROM (17). A recently popularized technique is dynamic stretching, where an exaggerated and controlled movement lengthens the muscle while it remains active. Force production may be attributed to the variation in active and passive muscle activity observed during these common pre-exercise stretching techniques.

Force Production

Generally, nerves stimulate muscles causing the fibers to contract with tension placed on their adjoining connective tissues. Since muscle contractions create the forces necessary to overcome resistance, the nerves represent the control center, whereas the connective tissues transfer the forces to the skeletal system. Ultimately, it is the ability of the muscle to generate forces that determines whether it will perform a movement effectively.

The loss in muscle stiffness after stretching appears to increase connective tissue and muscle compliance along with a reduction in neural stimulation. Normally, a stretched muscle triggers neural reflexes (e.g., myotatic reflex) to resist tearing. However, prolonged stretching may inhibit myotatic reflex activity (14), allowing the muscle-tendon unit to lengthen with minimal resistance from the muscle and connective tissues (18). Hence, an inability to generate forces after stretching results from a lack of neural activation and greater muscle compliance, which implies muscle stiffness may be diminished following pre-exercise stretching. For this reason, it is important to consider a pre-exercise stretching technique that maintains muscle stiffness.

Pre-Exercise Stretching Influence on Force Production

A warm-up is designed to increase the temperature of muscles that will be recruited during an activity. Keeping this in mind, we will discuss the effectiveness of static, PNF, and dynamic stretching when incorporated into a warm-up.

Elevating body temperature requires movement, which may provide an explanation for the passive muscle activity of static stretching causing a reduction in strength and power production (2, 4, 5, 7, 8, 9, 10). Coincidentally, Kokkonen et al (10) suggested avoiding static stretching during a warm-up that precedes strength or power activities. As previously discussed, the basis for this recommendation is the reduced neural activation and enhanced muscle compliance following passive stretching

(9, 14, 18). However, these proposed physiological responses may not completely rule out the use of static stretching during a warm-up. For instance, studies have found no loss in power performance capabilities following static stretching (1, 19), but Yamaguchi and Ishii (19) did identify a tendency for greater losses in power production among athletes incorporating this technique into their warm-up. It has also been found that sprint performance was much slower following passive static stretching (7, 8). Interestingly, Young and Elliot (20) attributed this to an ineffective eccentric phase during the stretch-shortening cycle because of a loss in elastic energy. Their conclusion was based on the finding of no loss in force production following static stretching (20).

Since there appears to be controversy with pre-exercise static stretching techniques, the combination of passive and active muscle activity during PNF stretching may be a logical alternative. In addition to offering an ability to increase ROM, PNF stretching utilizes muscle contractions. The primary muscle (agonist) is actively resisted isometrically prior to a passive stretch during the contract-relax method, whereas the antagonist contract-agonist relax method uses an opposing active muscle to trigger the agonist to achieve a further stretch (reciprocal inhibition). Fletcher and Jones (7) found the antagonist contract-agonist relax method decreased sprint performance. However, the use of a contract-relax method either reduced or maintained force production and jump performance (4, 20). Since the agonist is contracted during the contract relax method, it has been proposed that the lingering effects of the active muscle has the potential to maintain its stiffness (12, 20). Therefore, active muscle activity does appear to play a role in maintaining muscle stiffness.

When a muscle is active, specific movement patterns along with an increased body temperature can serve as a warm-up. Shellock and Prentice (13) suggested that an increased body temperature enhances neural activity, while Fletcher and Jones (7) proposed active muscles stretched with the specific exaggerated movements of dynamic stretching cause enhanced body awareness. The potential for greater neural activity causing greater muscle stiffness may explain the enhanced force production and speed performance following dynamic stretching (7, 8, 19). Furthermore, Faigenbaum et al (6) discovered dynamic stretching while wearing a vest weighted at 2% of body mass may improve jumping performance better than dynamic stretching alone. As long as fatigue is avoided during active dynamic stretching (3), dynamic stretching appears to be an effective pre-exercise warm-up since it maintains muscle stiffness along with an ability to generate greater force production and explosiveness.

In general, warm-ups that incorporate dynamic stretching appear to improve force production and explosiveness, whereas static and PNF stretching either maintain or decrease performance capabilities. Even the combination of static and dynamic stretching was not as effective as dynamic stretching alone (8), which is similar to an inability to improve performance by alternating between active and passive muscle activity with PNF stretching. Overall, the specific active muscle recruitment of dynamic stretching seems to be the most effective technique for warming-up the body while seeking improvements in force production and explosiveness.

Conclusion

The influence of pre-exercise stretching on force production must be considered for improved performance potential. Stretching prior to an activity has been attributed to passive relaxation of the muscle because of reduced neural activation and greater connective tissue compliance. Conversely, keeping the muscle active during a dynamic warm-up, where continuous movements become progressively exaggerated, causes an increase in body temperature along with neural activity and specific movement pattern muscle fiber recruitment. Fatigue must be avoided during the dynamic warm-up or the inability of the muscle to achieve sufficient force production will resemble the effects of static and PNF stretching. Therefore, incorporating pre-exercise stretching utilizing non-fatiguing dynamic movements prior to performing explosive activities appears to result in an effectively warmed-up muscle that excels in force production.

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