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Should Static Stretching Be Used During a Warm-Up for Strength and Power Activities?

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WARM-UP BEFORE PHYSICAL activity is a universally accepted practice with the objective of preparing the athlete physically and mentally for optimum performance and is believed to reduce the risk of injury and enhance performance (15, 25). Warm-ups typically contain 3 components:

- A relatively low-intensity aerobic component that is general in nature such as submaximum running. The rationale given for this is that it increases core and muscle temperature, which improves neuromuscular function (15, 22, 28).
- Some stretching of the specific muscles involved in the subsequent activity. Some athletes may spend 30 minutes or longer systematically stretching each muscle group. There are many variations of stretching protocols such as proprioceptive neuromuscular facilitation (PNF), static, and dynamic methods. These methods are outlined thoroughly in texts such as Alter (1) and Norris (22) and will not be discussed in detail in this study. Although the optimum method for increasing flexibility over a relatively long time may be debatable, passive static stretching remains a popular method used in a pre-exercise or precompetition warm-up routine. This usually involves moving a limb to the end of its range of motion (ROM) and holding it in the stretched position for 15–60 seconds (22). The objective of stretching in a warm-up is usually to achieve a short-term increase in the ROM at a joint (8, 15, 22) or to induce muscle relaxation and therefore decrease the stiffness of the muscle-tendon system (7, 22).
- Rehearsal of the skill about to be performed. This is usually performed at gradually increasing intensities, culminating in some efforts that are equal to or greater than the expected competition intensity. This type of warm-up serves to activate or recruit the specific muscle fibers and neural pathways required to achieve optimum neuromuscular performance (15).

Although the need for a warm-up before maximum effort strength and power exercise is rarely questioned, the precise protocol leading to optimum performance is not well established. The purpose of this article is to discuss warm-up and, in particular, to review recent research that questions the traditional use of static stretching in a warm-up before strength and power activities. For the purpose of this discussion, strength is defined as the maximum force produced in a static maximum voluntary contraction, relatively slow isokinetic contraction, or the maximum weight lifted in a 1 repetition maximum test. Power activities are considered to be any movements requiring significant amounts of both force and speed, such as a vertical jump.

■ Static Stretching in the Warm-Up

Although static stretching has been found to be effective in causing an acute increase in the ROM at a joint (1, 11, 17, 30), research indicating that static stretching can also produce a significant acute decrement, of approximately 5–30%, in strength (2, 6, 12, 18, 19) and power production (4, 5, 16, 31, 32) of the stretched muscle groups has accumulated. These findings have led some researchers to recommend against the practice of stretching before strength or power activities (4, 16). But it is not clear whether the detrimental effects of stretching used in several studies could have a negative effect on strength and power performance in athletes because the protocols used were not representative of the typical warm-up methods used by athletes to prepare for exercise or competition. For example, stretch treatments of 15-minute duration or longer have been used for a single muscle group (2, 6, 12), which is a greater duration than that commonly used by many athletes for stretch treatments. Furthermore, some studies observed performance decrements after stretching—when there was no aerobic component or submaximum exercise preceding the stretching (4, 6, 12, 18, 19) or when there were no practice trials of the test activity (2–4, 6, 18, 19). Although this research design is necessary to isolate the influence of stretching, it is possible that the aerobic or low-intensity exercise and practice components of a warm-up may offset any potential negative effects of stretching. For example, a study by Knudson et al. (10) reported a nonsignificant decrease in vertical jump performance after a static stretching routine. Fifty-five percent of the subjects experienced a decrease in performance, whereas other subjects either experienced no change or an increase in performance after stretching. In this study the participants performed 3 minutes of submaximum cycling and 3 practice vertical jumps before the stretching. It is possible that for 45% of the subjects who exhibited no decrease in performance, the cycling and practice jumps had a positive effect.

A recent study has attempted to identify the influence of submaximum running, static stretching, and practice jump that are components of a warm-up (31). On the basis of a test of concentric vertical jump height, 4 minutes of running was significantly better than a control warm-up, and running plus 4 minutes of total stretching of the quadriceps and gluteals was significantly worse than just running. Furthermore, running plus stretching plus 4 practice jumps was significantly better than the running plus stretching warm-up. These results suggest that stretching produced a negative effect, whereas the run and the practice jumps produced positive effects in the warm-up for vertical jumps. Unfortunately, the study did not examine the effect of a run plus practice jumps warm-up, which may be expected to produce the best results. This study supports previous research and indicates that in more realistic athletic warm-up conditions, as little as 2 minutes of static stretching per muscle group can impair power performance.

■ Mechanisms of Stretch-Induced Performance Decrement

Various authors have speculated about the mechanism that explains the impairment of muscle force. Neural inhibition (2, 6, 29) and increased muscle-tendon compliance leading to a reduced rate of force transmission from the muscle to the skeletal system (4, 12, 18, 19) have been suggested as possible mechanisms. Because static stretching can significantly increase muscle soreness and muscle damage, as indicated by elevated creatine kinase in the blood (27), tissue damage is another possibility to explain acute performance decrement. But the precise mechanism(s) that leads to stretch-induced reductions in strength and power is not clear (2, 6).

There is some evidence that the impairment may be concentrated and related to certain joint angles (18), contraction types (5, 32), or contraction velocities (19). It has also been shown that ballistic stretching can inhibit strength (20), and a PNF stretch protocol produced a greater negative effect on vertical jump performance than that produced after a static stretch warm-up (3), but considerably more research is required to clarify the precise stretching protocols that produce an effect and the performance conditions that are most affected.

■ Stretching and Injury Prevention?

The question that follows is: should static stretching be eliminated from a warm-up before strength and power activities? To answer this, the negative effects should be weighed against the potential injury prevention benefits of static stretching. It has been traditionally believed that static stretching reduces the risk of muscle-tendon injury; however, there is mounting evidence to the contrary (9, 26). For example, Pope et al. (23) reported in a large prospective study that stretching in a warm-up did not significantly reduce the risk of injury in army recruits undergoing high-intensity training.

It is clear that static stretching is effective in causing an acute increase in the ROM at a joint (static flexibility) (1, 17, 30). It is not so clear whether submaximum exercise, e.g., running, cycling, increases ROM (17, 30). But it is thought that the injury prevention benefit of warm-up resides in a short-term reduction in muscle stiffness rather than simply increased joint ROM (7, 8). Reduced stiffness is associated with less resistance (force) to stretch when the muscle is relaxed (passive stiffness) so that there is less likelihood of damage when the muscle is elongated (7). Static stretching has been found to reduce passive muscle-tendon stiffness for up to 1 hour (13, 14), but a reduction has not always been found (30). Furthermore, when muscle-tendon stiffness is measured during muscle contraction (active stiffness), it has been found to be unaffected by stretching (8, 17). In contrast, 10 minutes of running has been found to be effective for reducing the active stiffness of the calf muscles (17). Increased muscle temperature has been shown to increase the resistance to muscle tear (21, 25). Therefore, if active rather than passive stiffness is related to injury risk, this suggests that increasing muscle temperature by submaximum exercise would be more important than stretching for decreasing the risk of soft tissue injury (9). But the effect of running and stretching on passive and active muscle-tendon stiffness and injury prevention in general is still unclear (9).

Summary and Practical Applications

Substantial evidence is now available to state that static stretching can impair strength and power performance, although the duration of the impairment, the exact stretching protocols, and the physiological mechanisms are not yet known. Given the lack of evidence in favor of static stretching during warm-up for injury prevention, it seems justifiable to exclude this component from the warm-up for strength and power activities. Progressive submaximal exercise intended to increase muscle temperature and practice trials of the ensuing activity should be retained.

Some coaches have replaced static stretching with dynamic activities. For example, Rutledge and Faccioni (24) outlined warm up activities for field hockey that consisted of running drills that isolated various joints and were performed with gradually increasing intensity. When an athlete performs run-throughs at progressively increasing intensities, the joints are taken to a new ROM; therefore, the muscles are being stretched dynamically. Whether such a dynamic warm-up has the same effect as static stretching for increasing ROM or influencing the injury risk is not clear, but is worthy of examination. Further experimentation is needed before the optimum warm up protocol can be identified. ▲

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