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SSE #104: Should Athletes Stretch Before Exercise?

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SHOULD ATHLETES STRETCH BEFORE EXERCISE?

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KEY POINTS

■ Traditional stretching routines performed during warm-up procedures before exercise can increase flexibility for a short time, but there is little scientific evidence that such routines can improve exercise performance, reduce delayed-onset muscular soreness, or prevent injuries.

n Stretching on a regular basis, e.g., 3-5 days/week, away from the exercise environment may be effective in improving flexibility and some types of exercise performance, and it may reduce injury risk, but further research is required to validate this concept.

n Passive stretching for 15–30 seconds is more effective for increasing flexibility than stretching for shorter durations and is equally effective as stretching for longer periods.

n Increased flexibility is important for sports like ballet, gymnastics, and swimming, but it may decrease running economy and be inappropriate for line play in American football and for certain other sports activities where joint stability is critical.

n Stretching just before exercise may cause temporary strength deficits.

n Risk of injury to muscles, tendons, and ligaments appears to be lessened in athletes who are more aerobically fit.

n There is some evidence that traditional warm-up procedures that do not include stretching may improve certain types of exercise performance and reduce the risk of sports injuries.

INTRODUCTION

Each day at sporting venues throughout the world, athletes prepare for competition with a familiar ritual of stretching the major muscle groups used in their sports. These preexercise routines usually incorporate a variety of stretching techniques and warm-up exercises. Sports medicine texts, journal articles for health professionals and coaches, and lay publications tout stretching as a key to reducing injury risk.

With such widespread acceptance of pre-exercise stretching, one might assume that strong scientifi c evidence supports its effectiveness for injury prevention or improved performance. However, many scientifi c publications question the conventional wisdom of pre-exercise stretching. This article summarizes recent research fi ndings on stretching, fl exibility, and warm-up.

RESEARCH REVIEW

Stretching Technique

A wide variety of types of stretching have been proposed. *Active* or *dynamic* stretching requires individual athletes to contract certain muscles to cause stretching of others. Sub-types of active stretching include *static, isometric*, and *ballistic*. *Passive* stretching and stretching by *proprioceptive neuromuscular facilitation* usually involve a partner who assists with the activity. Regardless of the type of stretching used, it appears that stretching is most effective for increasing range of motion when performed after the muscle is warmed by preliminary exercise or by passive heating, e.g., with hot packs or ultrasound (Knight et al., 2001).

Static stretching. Static stretching is a slow, sustained muscle lengthening that most athletes hold for 15–60 s. An example is stretching the hamstrings and back by slowly reaching forward to grasp and hold the ankles or feet while sitting with the legs fully extended in front. Static stretching is used by most athletes and is incorporated into many pre-competition regimens.

Isometric stretching. Athletes using isometric stretching (a form of static stretching) attempt to contract the muscle while exerting against a fi xed resistance. In the example of static stretching in the previous paragraph, if the athlete were to contract the hamstrings while holding the stretch, some of the fibers in the contracting hamstrings would be further lengthened as other fi bers attempted to shorten. The concept is that holding the isometric contraction for a few seconds would then allow increased static stretching to further lengthen the muscle.

Ballistic stretching. Ballistic stretching involves rapid muscle lengthening, often with bouncing or repetitive motions. A typical example is the hamstring stretch of repeated bouncing movements to touch the toes while standing with the legs straightened. Few athletes use ballistic stretching, but the technique remains in favor in certain sports. Anecdotal reports of soft tissue injury during ballistic stretching have led many fitness instructors and therapists to condemn its use.

Passive stretching. During passive stretching, one of the assisted stretching techniques, the athlete does not actively contract muscles to stretch antagonists. Rather, gravity, a machine or, more typically, a partner applies steady pressure to cause a movement that slowly increases the range of motion. Assisted hamstring stretching, wherein an athlete is seated with legs outstretched and a partner slowly pushes on the athlete's back, is a common practice and a good example of this technique.

Proprioceptive neuromuscular facilitation. Proprioceptive neuromuscular facilitation (PNF), another assisted stretching technique, utilizes a partner who briefly resists contraction of stretched muscle groups, after which the muscles are relaxed while the partner passively stretches the muscle group beyond its normal range of motion. Again using the example of a hamstring stretch, with the athlete lying on her back, an assistant raises the athlete's extended legs upward and toward the trunk to stretch the hamstrings for about 20–30 s. Next, the athlete attempts to contract the stretched hamstrings (i.e., tries to lower the legs) for 5–6 s while the assistant (or perhaps a wall) resists the contraction to inhibit movement. The contracted muscle groups are then relaxed and the assistant again slowly stretches the hamstrings, presumably further than the original stretch allowed. This process is repeated 2–4 times.

RESEARCH REVIEW

Stretching and Improved Flexibility

The goal of all stretching techniques is to increase the range of motion of a joint(s) by increasing the fl exibility of targeted muscle groups around the joint(s). (*Flexibility is the extent to which a muscle can be lengthened by a given amount of force. In practice, a change in fl exibility is measured as a change in range of motion, so the two terms, fl exibility and range of motion, are usually considered synonyms.*) For example, improving the flexibility of muscles of the back and of the hamstrings at the backs of the legs can increase the range of motion of the joints of the spine to allow greater trunk flexion, i.e., the ability to bend the trunk forward. All types of stretching achieve greater range of motion around each of the major joints at least temporarily, but there is no clear evidence that any one technique renders superior flexibility.

Bandy et al. (1998) showed that passive stretching of the hamstrings achieved greater trunk flexibility than did active stretching, but this difference was not shown for the hip joint. As reviewed by Thacker et al. (2004), some studies showed greater flexibility produced with PNF compared to other types of stretching, but the results were inconsistent, and the techniques were not standardized.

Roberts and Wilson (1999) reported that duration is important: stretches of 15–30 s accomplished as much muscle lengthening as did longer stretches and were more effective than regimens lasting less than 15 s. However, there are also favorable studies of ballistic stretching protocols that incorporate brief but rapid repetitive motions. For example, Laroche and Connolly (2006) compared 30–s bouts of static hamstring stretches to ballistic hamstring stretches repeated each second for a total of 30 s. The two protocols resulted in similar improvements in range of motion (+9.5% vs. +9.3%)

The improved flexibility from a single session of stretching seems to persist for up to 90 min, whereas stretching regimens performed on a regular basis, e.g., 3–5 days per week, may improve flexibility for several weeks after cessation (Zebas & Rivera, 1985).

Stretching Effects on Strength, Jumping, and Running Economy

Stretching increases flexibility, but does it also improve strength? Probably not. Two studies reported that strength was actually reduced for up to 1 h after a bout of stretching (Fowles et al., 2000; Kokkonen et al., 1998). One study of peak torque during concentric, isokinetic leg extension found that after one active and three passive stretching exercises, strength decreased at both high and low velocities (Cramer et al., 2004). These results are consistent with those of Cornwell et al. (2001), who showed decreased vertical jumping ability after passive muscle stretching.

Young and Behm (2003) compared five "warm-up" protocols used before jumping tests. The protocols were 1) control; 2) 4-minute submaximal run; 3) static stretch; 4) run plus stretch; and 5) run plus stretch plus practice jumps.

Performances for the 16 subjects were poorest after static stretch. The run-plus-stretch group performed no better than controls, but both the run protocol and the run-plus-stretchplus-jump protocol had the highest values of explosive force production. Running alone was clearly superior to running plus stretching for four of six measured variables (drop-jump height, concentric jump height, peak concentric force, and rate of force development). When the fi ve trials were analyzed together, both running and practice jumps had a positive effect on explosive force and jumping performance, but the static stretching impaired performance.

It is likely that increased fl exibility is not desirable in certain sports. Gleim et al. (1990) reported a negative correlation between fl exibility and walking and jogging economy in a group of 38 women and 62 men aged 20–62 years, whom they divided into thirds—most -flexible, normal, and least-fl exible—on 11 range-of-motion measures. For the least flexible group, economy of walking and jogging was directionally better than for the normal group, and significantly better than for the most fl exible group. In a similar study, Craib et al. (1996) examined sub-elite male runners and also found that less-fl exible athletes generally had better running economy. Likewise, when Jones (2002) studied the flexibility of elite international runners on a sit-and-reach test and related it to their running economy, less flexibility was associated with better economy. While these studies focused on running and walking, for certain movements in wrestling, American football, boxing, and other sports where joint stability is important, it is also reasonable to assume that increased flexibility of the critical joints would be contraindicated. If stretching does decrease the maximal force available for jumping and decrease running economy, performing stretching protocols before jumping or running sports is illogical.

Nevertheless, there were limitations in the studies showing a negative association between stretching and strength and between flexibility and economy of movement. Moreover, other research fails to consistently demonstrate either the association of stretching with decreases in strength (Laroche & Connolly) or of a relationship of inflexibility with better running economy (Nelson et al., 2001). Accordingly, it is premature to recommend that jumping and running athletes should never stretch before exercise.

Shrier (2004a) suggested caution in making broad conclusions about the effects of stretching on performance. In his review of the literature, he found differences in the effects of two different types of stretching—acute stretching just before a bout of exercise and regular stretching over a period of days or weeks done outside the exercise environment. He detected no benefi t of acute stretching on isometric force production, isokinetic torque, or jumping height, and studies showed mixed results for the effects of acute stretching on running speed. However, regular stretching seemed to reliably improve strength, jump height, and running speed. This notion that the effects of stretching immediately before exercise are somehow different from the effects of stretching regularly away from exercise is baffling. Intuitively, it suggests either that different types, durations, or intensities of stretching are done in the two environments or that beneficial effects of stretching are negated by subsequent exercise. Clearly, more research is needed to confirm any difference in the effects of stretching before exercise and stretching in non-exercise environments.

Stretching and Delayed Onset Muscle Soreness

A common opinion among athletes, coaches, and health professionals is that stretching before and/or after exercise will prevent or minimize the muscle soreness that is often experienced 24–48 h after exercise. In 2002, Herbert and Gabriel published a meta-analysis of studies that measured the effect of stretching either immediately before or after exercise on muscle soreness. They identified five reports of sufficient quality to merit analysis. The papers analyzed delayed-onset muscle soreness at 24, 48 and 72 h after exercise. Overall, stretching had no significant effect on soreness.

Confirming these earlier results, LaRoche and Connolly (2006) required subjects to undergo four weeks of passive or ballistic stretching of the hamstrings and failed to detect any effect on delayed-onset soreness following eccentric exercise of the hamstrings. Similarly, Dawson et al. (2005) studied Australian footballers and found no effect of stretching immediately after a game on soreness, flexibility, cycling sprint power, or vertical jump ability recorded 48 h later.

Rather than employing stretches before soreness-inducing exercise, Reisman et al. (2005) tested the effects of passively stretching already-sore elbow flexor muscles on subsequent soreness. They found that five passive extensions of the sore elbow fl exors temporarily reduced soreness sensations in those muscles. The authors hypothesized that stretching could enable sore athletes to train at higher levels than might be possible without stretching.

Stretching and Injury Prevention

The widespread use of stretching and the numerous recommendations to use stretching for injury prevention implies that there must be many high-quality studies of stretching and injury prevention in the literature. On the other hand, consider some of the major diffi culties in conducting a definitive experiment on this topic: 1) random assignment of large numbers of athletes with similar physical characteristics in various sports to engage in stretching or non-stretching protocols, 2) duration of the experiment to include a sufficient number of months to accumulate an adequate number of injury reports, 3) strict supervision and control of daily stretching protocols and exercise regimens, and 4) strict control and reliable reporting of injuries. Thus, it should be no surprise that Herbert and Gabriel (2002) found only two studies that would qualify under a standard criterion for methodological quality. These two studies, both authored by Pope et al. (1998, 2000), used male army recruits. The 1284 subjects in stretching groups experienced 181 injuries versus 200 injuries among 1346 soldiers in control groups, a statistically nonsignificant difference. Interestingly, Pope et al. (2000) noted that although stretching had no apparent effect on risk of injury, level of aerobic fi tness proved to be a consistent and powerful predictor of injury risk, so much so that the least fit had a 14-fold greater risk of injury versus the fittest subjects.

Thacker et al. (2004) performed a comprehensive search of literature on stretching for injury prevention, including articles published through 2002. Using a different quality assessment tool than that employed by Herbert and Gabriel, they screened 361 articles and found only six they deemed of sufficient quality to merit analysis. The subjects in four of the studies were military recruits in basic training, whereas American football players were studied in the remaining two. Of the six studies, three randomized trials failed to demonstrate any injury reduction as an effect of a supervised stretching program. Three cohort studies in the analysis suggested weak evidence of a benefi t of stretching, but these were studies rated lower in methodological quality. Thacker et al. (2004) concluded that no convincing evidence existed to continue or discontinue routine pre-exercise stretching.

Thacker's conclusions parallel those stated in reviews by Gleim & McHugh, 1997; Hart, 2005; Park & Chou, 2006; Shrier,1999, 2000, 2004a; Yeung & Yeung, 2001, and Witvrouw et al., 2004. But in a letter to the editor, Shrier (2004b) cautioned that the effects of an acute bout of stretching before exercise may be opposite from the effects of stretching done as a regular routine away from the exercise environment. He cited several studies of regular stretching that suggest a positive effect on injury prevention. Also, both Gleim & McHugh and Witvrouw et al. suggested that different sports activities may benefit from different levels of joint flexibility and that these varying demands may explain the lack of consensus in the literature, most of which does not distinguish among different types of activities.

Warm-Up as a Confounder in Stretching Research

Warm-up activities other than stretching are often uncontrolled factors in stretching research. Thus, it is possible that in some studies showing a positive effect of stretching, it was actually the aerobic exercise, drills, or sport-specifi c exercise in the warm-up, rather than the stretching, that was responsible for the benefit. Fradkin et al. (2006) reviewed randomized controlled trials to assess the current evidence relating warming-up to injury prevention. Analyzing five high-quality studies, they found a benefi t of warm-up in three studies of teenage athletes engaged in team handball and American football but no benefit in two studies of lower-extremity injuries in recreational runners or in military recruits.

Overall, they found the weight of the evidence was in favor of warming-up to decrease injury risk, with no detrimental effects. Potential confounders of this research include the variability of the specific warm-up regimens used, the different sports included, and the heterogeneity of the participants. Faigenbaum et al. (2005) studied dynamic warm-up versus static stretching in different age groups and a variety of athletes. When compared to static stretching, dynamic warm-up and dynamic warm-up plus drop jumps both led to improved performances among children for vertical jump and shuttle runs. Long-jump performance also improved in the dynamic warm-up that included drop jumps. Similarly, dynamic protocols with or without stretching led to better anaerobic activity performance among a group of primarily male, high-school strength athletes than did static stretching protocols. (Faigenbaum et al., 2006a) The authors concluded that pre-event dynamic exercise or dynamic exercise plus static stretching, rather than static stretching alone, should be incorporated into warm-up regimens.

Faigenbaum's group (2006b) also conducted an experiment with high-school female athletes to test the acute effects of four warm-up protocols on performance. After 5 min of jogging, subjects performed either: A) fi ve static stretches, each performed twice for 30 s, B) nine moderate- to high intensity dynamic exercises, C) the same nine dynamic exercises performed with a vest weighted with 2% of body mass, and D) the same nine dynamic exercises performed with a vest weighted with 6% of body mass. Vertical jump performance was signifi cantly greater after treatment B (41.3 ± 5.4 cm) and C (42.1 ± 5.2 cm) compared with A (37.1 ± 5.1 cm), and long jump performance was signifi cantly greater after C (180.5 ± 20.3 cm) compared with A (160.4 ± 20.8 cm).

No significant differences between trials were observed for a seated medicine ball toss or a 10-yard sprint. The authors concluded that a dynamic warm-up performed with a vest weighted with 2% of body mass may be the most effective warm-up protocol for enhancing jumping performance in high school female athletes.

SUMMARY AND DISCUSSION

Clearly, stretching routines performed before exercise can increase flexxibility for up to 90 min, but there is scant scientific evidence to suggest that such routines can improve exercise performance, reduce delayed-onset muscular soreness, or prevent injuries. It remains to be confirmed whether or not stretching on a regular basis away from the exercise environment is effective in improving some types of exercise performance or reducing injury risk.

Even though it increases the range of motion of the joints, stretching just before exercise may cause temporary strength deficits. Epidemiologic data indicate that the risk of injury to muscles, tendons, and ligaments is more closely linked to poor aerobic fitness of the athlete than to insufficient flexibility.

Because the scientific evidence is so weak in support of a benefit to pre-exercise stretching, why do sports medicine texts, medical experts, physiologists, athletic trainers, personal trainers, and coaches continue to recommend this practice? Herbert and Gabriel (2002) estimated that even in the bestcase scenario, the average athlete would need to stretch before activity for 23 years to prevent a single injury. Still, although science is the most objective way to discover truth, it is not the only way. Many experts in health and athletics have had positive clinical and practical experiences with stretching, and there are thousands of anecdotal reports of injuries having occurred on the rare occasions when previously injury-free athletes neglected to stretch before exercise. Also, there are valid criticisms of the scientific data. Studies of stretching have examined varied types, durations, and frequencies of stretching; limited populations of athletes; and only a few sports. For example, much of the negative data about stretching concerned athletes in distance running, a sport inwhich running economy seems to be better with less, not more, flexibility. While stretching may not be useful for endurance runners, would the same assumption apply to hurdlers, gymnasts or dancers, who all traditionally place a premium on flexibility? Finally, as described earlier, to conduct a flawless study on the effect of stretching on injury risk is extremely difficult, if not impossible.

Because stretching does appear to achieve the goal of increased flexibility around joints, perhaps the apparent failure of stretching to prevent injury occurs because the timing of stretching before exercise is incorrect or the application of stretching for all athletes is unnecessary. Maybe athletes should be assessed individually to better understand how to utilize their preparation time before exercise. Inflexible athletes might be encouraged to incorporate some stretching into an overall warm-up routine, whereas other individuals who already have an excellent range of motion would focus on integrating strength, jumping, or other activities into their warm-up.

Ingraham (2003) suggested that most coaches, athletic trainers, and sports medicine experts seem to automatically assume that when an athlete pulls a muscle, the athlete needs improved flexibility to prevent future injuries. She speculated that it would be more important for these athletes to improve their levels of fitness. Certainly the correlation of poor aerobic fitness with greater injury risk seems much stronger than that seen with infl exibility (Herbert & Gabriel, 2002).

Larger randomized controlled trials that incorporate both genders, multiple sports, and adequate length of followup would help clarify the role of stretching. Additional studies should examine the ideal timing of stretching as well as standardizing its quality and duration. Eccentric strengthening, warming-up, and aerobic conditioning all emerged in studies of the effects of stretching on the risk of injury as factors that tend to reduce injury risk. Only when studies adequately control for these variables will the specific contribution of stretching to injury prevention become clear. Until stronger science emerges, sports medicine practitioners and coaches should offer cautious advice to athletes. A practical approach could be to emphasize aerobic fitness and warming-up while allowing the individual athlete to make the choice of whether or not they wish to incorporate stretching into this regimen.

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S U P P L E M E N T

SHOULD YOU STRETCH BEFORE EXERCISE?

Unfortunately, there is no simple answer to the stretching question. What we can say is that there is no solid scientific evidence that stretching, especially just before you exercise, has any benefits. But we can also say that there is no solid evidence that stretching will do any harm. Plus, there is a long medical and coaching tradition of recommending pre-exercise stretching that probably should not be ignored. Thus, athletes wishing to avoid injury may or may not benefi t from stretching as a key component of warming up just before exercise.

One factor that clearly does reduce your risk of injury is to maintain a good level of cardiovascular (aerobic) fitness throughout training, during the offseason, and when you are recovering from injury. The most valuable warm-up practice includes activities such as easy running, swimming, cycling, sports specific drills, jumping, shooting drills, etc. This type of warming up will haveyou ready to play or practice with less risk of a muscle pull or other injury.

It's Your Decision

Should you incorporate stretching into your standard warming up routine? Logically, if you participate in a sport that places a premium on flexibility, for example, gymnastics, hurdling, diving, and dance, you need to ensure that you have excellent rangeof-motion around all of your joints. Particularly, if you know you are inflexible, you should consider incorporating stretching as long as it is integrated into a program that also utilizes aerobic activity as a part of the warm-up. In fact, stretching should always be done after a period of aerobic exercise when your muscles have been warmed. Warm muscles can be more easily stretched, and the stretching effect will last longer than when cold muscles are stretched. If you already have excellent flexibility, you might better utilize your pre-exercise time by increasing aerobic or sport-specific activities in your warm-up procedures.

Rather than stretching before exercise, consider performing your stretches after exercise or at home, away from the training environment. Science indicates that you are more likely to benefit from this type of stretching on a regular basis, perhaps 3–5 days per week.

If you participate in a sport that requires jumping, lifting, throwing, or other types of explosive power, be aware that stretching just before exercise can cause a temporary reduction in strength and should probably be avoided before competition. So if you feel that stretching helps your overall sports performance, consider implementing your stretching regimen after your event, rather than before.

Stretching Tips

■ If you choose to stretch, warm your muscles first by aerobic activities such as jogging, swimming, cycling, and calisthenics. Warm muscles are easier to stretch and less likely to tear. Many experts recommend stretching after your workout, not before.

n Slow stretches held for 15 to 30 seconds and repeated up to three times for each muscle group offer as much benefit as any other regimens. If a partner assists you with stretching, be cautious that the partner does not push too hard, leading to a stretching-related injury. Avoid ballistic or bouncing stretches that may injure your muscles.

n Because scientific studies do not show clearly whether you will benefit from stretching, try different warm-up routines to determine which routine seems to make you most ready to participate in practices and competitions.

n Before returning to strenuous training or competition after injuries, consult with an athletic trainer, personal trainer, sports medicine physician, or knowledgeable coach to make certain you have adequate strength in the previously injured limb(s). It is especially important to be strong in the eccentric phase of movements (for example, lowering a barbell or dumbbell, stepping down stairs, jumping down from heights, lowering yourself from a chin-up.) Also, you should have normal strength of your trunk and abdominal muscles (core strength) and should have regained your normal sense of balance and agility. These factors clearly reduce the risk of becoming re-injured.

SUGGESTED ADDITIONAL RESOURCES

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