the physician and sportsmedicine

Myths and Truths of Stretching

Individualized Recommendations for Healthy Muscles

Ian Shrier, MD, PhD; Kav Gossal, MD

THE PHYSICIAN AND SPORTSMEDICINE - VOL 28 - NO. 8 - AUGUST 2000

In Brief: Stretching recommendations are clouded by misconceptions and conflicting research reports. This review of the current literature on stretching and range-of-motion increases finds that one static stretch of 15 to 30 seconds per day is sufficient for most patients, but some require longer durations. Heat and ice improve the effectiveness of static stretching only if applied during the stretch. Physicians should know the demands of different stretching techniques on muscles when making recommendations to patients. An individualized approach may be most effective based on intersubject variation and differences between healthy and injured tissues.

Despite limited evidence, stretching has been promoted for years as an integral part of fitness programs to decrease the risk of injury (1-6), relieve pain associated with "stiffness" (5), and improve sport performance (4-6). Many different stretching recommendations have come out of the medical literature, and new research has challenged some long-held concepts about common stretching practices. As a result, misconceptions and misinterpretations are common--not just among patients, but among healthcare professionals, as well. Thus, many clinicians are at a difficult crossroads when making sound recommendations to patients.

Proposed Stretching Benefits

Proposed mechanisms are thought to be either (1) a direct decrease in muscle stiffness (defined as the force required to produce a given change in length) via passive viscoelastic changes or (2) an indirect decrease due to reflex inhibition and consequent viscoelasticity changes from decreased actin-myosin cross-bridging. Decreased muscle stiffness would then allow for increased joint range of motion.

New evidence suggests that stretching immediately before exercise does not prevent overuse or acute injuries (7,8). However, results from animal studies suggest that *continuous* stretching (ie, 24 hours per day) over days, compared with *intermittent* stretching of only minutes per day, outside of exercise periods may produce muscle hypertrophy (9-11), which could theoretically reduce the risk of injury (9,12). However, clinical research on stretching minutes per day is still inconclusive (13,14), and more research is needed before definitive conclusions can be made.

With respect to alleviating the pain associated with stiffness, the weight of the evidence suggests that the decrease in stiffness is not as important as the increase in "stretch tolerance" (15-17). Briefly, an increase in stretch tolerance means that patients feel less pain for the same force applied to the muscle. The result is increased range of motion, even though true stiffness does not change. This could occur through increased tissue strength or analgesia; however, increased stretch tolerance that occurs immediately after stretching must be caused by an analgesic effect because tissue strength does not increase during 2 minutes of stretching. Unfortunately, evidence of a possible analgesic effect is recent, and the underlying mechanism is unknown. After weeks of stretching, increases in stretch tolerance could theoretically occur because stretch-induced hypertrophy may increase tissue strength (9-11), and/or an analgesia effect may be present.

A Search for Answers

Despite the controversies mentioned previously, stretching still decreases pain and may provide substantial benefits if used under appropriate conditions. However, the problem remains on how to choose an appropriate stretching protocol. Most authors now believe ballistic stretching (ie, bouncing) is dangerous (4-6,18). Time recommendations for holding a stretch vary between 10 and 60 seconds (5,19-24). Clinicians are also faced with choosing a method that may improve the effectiveness of stretching: superficial heat, superficial ice, deep heat, and warm-up (25-30).

To determine which stretching techniques are most effective, we reviewed all studies cited on MEDLINE and SPORTDiscus that compared stretching protocols for increasing range of motion. We chose range of motion as the end point because it is the tangible objective most people use when they stretch and because most studies have not addressed true muscle stiffness.

We addressed the following questions: (1) How long and how many times should a stretch be performed to obtain maximum benefit?, (2) Does temperature alter the effectiveness of stretching?, and (3) Which stretching method is most effective: static, ballistic, or proprioceptive neuromuscular facilitation (PNF) stretching?

Our review includes only studies of range of motion involving healthy muscle-tendon units--not diseased or abnormal capsular or ligamentous restrictions such as adhesive capsulitis that may require a different duration and frequency of stretching to increase range of motion (31,32). In addition, we could not find any papers that investigated the effects of stretching on injured patients. Any extrapolations of our review to injured patients should be performed with caution.

Duration and Frequency

Before discussing the evidence on how long to hold a stretch, it is necessary to explain the concept of viscoelasticity. Stretches must be held to obtain maximum range of motion because muscles are not purely elastic, but rather viscoelastic. An elastic substance such as a rubber band lengthens for a given force and returns to its original length immediately upon release. The effect is not dependent on time. On the other hand, the flow and movement of a viscous substance such as molasses depends on time (33). A viscoelastic substance exhibits both properties. Therefore, muscle length increases over time if a constant force is applied (creep, figure 1A: not shown), or the force decreases over time if the muscle is stretched to a constant length and held (stress-relaxation, figure 1B: not shown). When the force is removed, the substance slowly returns to its original length. This is different from plastic deformation, in which a material such as a plastic bag remains permanently elongated even after the force is removed (33). Note that though stretches also affect tendons and other connective tissue, within the context of normal stretching, the stiffness of the overall motion is mostly related to the least stiff section (ie, resting muscle) and is minimally affected by the stiffness of tendons.

Patients are given many common protocols on stretch duration. In summary, for both the immediate (within 60 minutes) and long-term (over weeks) range-of-motion increases, research shows that one 15- to 30-second stretch per muscle group is sufficient for most people, but some people or muscle groups require longer duration or more repetitions. For immediate effects, stretching increases range of motion through both a decrease in viscoelasticity and an increase in stretch tolerance (ie, the analgesic effect previously discussed). With long-term stretching, viscoelasticity remains constant and the increased range of motion occurs only because more force can be applied to the muscle before the subject feels pain (ie, increased stretch tolerance).

Immediate effects. The immediate effects of stretching on range of motion have been studied in animals and humans. In isolated rabbit extensor digitorum and anterior tibialis muscles that were stretched for 30 seconds, viscoelastic effects increased muscle length until the fourth stretch (34). These results are consistent with those of human hamstring muscles that showed decreased stiffness with five repeated stretches (35).

However, Madding et al (24) found that increased hip abduction range of motion did not differ between 15, 45, or 120 seconds of stretching. Although these results may appear contradictory, viscoelasticity may vary by muscle group. In support of this theory, Henricson et al (27) found that muscles differed in their response to heat plus stretching. If true, the optimal duration and frequency for stretching may also vary by muscle group. Alternatively, range of motion in humans might be primarily limited by pain (15-17). If this theory is true, any smaller benefits obtained from decreased viscoelasticity with longer-duration stretches would be overshadowed by the large changes in range of motion from stretch-induced analgesia (stretch tolerance).

Long-term effects. The long-term effects of stretching on range of motion have been studied in humans only. After 6 weeks, individuals randomized to stretch for 30 seconds per muscle each day increased their range of motion much more than those who stretched 15 seconds per muscle each day. (A small increase in range of motion in the 15-second group was not statistically significant.) No further increase was seen in the group that stretched for 60 seconds (19).

In another study conducted over 6 weeks, the same researchers (22) found that one hamstring stretch of 30 seconds each day produced the same results as three stretches of 30 seconds. However, the results of Borms et al (36) appear to contradict these findings because 10-second stretches were as effective as 20- or 30-second stretches. Closer inspection of Borms' data, however, reveals large variation among individuals, and the study was performed over 10 weeks instead of 6 weeks. If one examines the data for trends, it appears that the 20-second and 30-second groups reached a plateau after 7 weeks, but the 10-second group increased gradually over the entire 10 weeks. Therefore, 30-second stretches are likely to achieve the maximum benefit quicker (within 6 to 7 weeks) than 10-second stretches, but the two programs eventually achieve similar results by 10 weeks.

Rationale for individualized programs. The above studies support the use of 30-second stretches as part of a general fitness program. This may be appropriate for group exercise classes in which one would want to use a duration that would benefit most individuals--similar to the recommended dietary allowance for vitamins and minerals. However, physicians and physical therapists usually treat individuals rather than groups.

In the animal study (34) that showed maximum benefit with four stretches, response varied depending on the individual experimental muscle. Consequently, some muscles must have achieved maximum benefit after two to three stretches, whereas others required five to six stretches. In human long-term studies, some individuals gained much range of motion with only 15 seconds of stretching, while others gained very little with 45 seconds (24).

Finally, all of the current research has been done on healthy tissue. Because muscle fatigue decreases viscoelasticity (37), it is reasonable to predict that injuries (with torn tissue, deposition of scar tissue, tissue reorganization, and muscle atrophy and weakness) will also change viscoelasticity, though the direction of the change is not clear. Therefore, healthcare professionals should be cautious about extrapolating these results to injured athletes, who may require longer stretches to increase range of motion. (See "Safety Concerns in Stretching," below.)

Rather than give everyone the same stretching recipe, we prefer to individualize our prescription to account for intersubject variation and differences between healthy and injured tissues. We advise patients to stretch until they feel a certain amount of tension or slight pulling associated with this length, but no pain. As the stretch is held, stress-relaxation occurs, and the force on the muscle decreases. When patients feels less tension because of changes in viscoelasticity and an analgesic effect, they can then simply increase the muscle length again until they feel the original tension. The second part of the stretch is held until patients feel no further increase.

If patients return for follow-up and have not gained any range of motion, and they are not overstretching (forcing a stretch, causing muscle spasm or pain), intersubject variability cited above may be the reason, and the clinician should consider recommending that the stretch be held longer. The effectiveness of this approach, however, remains to be tested.

Temperature Effects

In summary, passive warming of a muscle before stretching or icing during the stretch can be used to increase the range of motion but will not prevent injury. Patients who include an active warm-up period prior to stretching obtain the greatest range of motion. Contrary to popular belief, warm-up performed without stretching does not increase range of motion.

Most of the research in this area has been done on animals using passive warming devices such as heat lamps. Research in humans often uses activity to warm the muscle, but activity affects the muscle in many ways--for example, calcium release and motor unit recruitment patterns--besides simply raising the temperature. This may explain the different results observed in animals and humans.

Passive warm-up and icing. Several studies examined the effect of temperature on range of motion. When applied before a static stretch, neither heat nor ice significantly affected the range of motion during active knee extension--a test of hamstring range of motion--when compared with stretching alone (38). Though heat alone did not improve range of motion, stretch plus heat was superior to stretch alone with respect to increases in hip flexion, abduction, and external rotation (27); shoulder range of motion (30); and triceps surae range of motion (25). Ice applied during a static stretch was the most effective method for increasing range of motion during a passive static stretch (29), but only when applied during the earlier stages of the stretch (30). Cold application during PNF stretching did not improve range of motion above the normal PNF technique (26).

In summary, despite some conflicting results, applying either ice or heat during a static stretch increases the range of motion compared with static stretch alone, but it has no effect during PNF stretches. Because ice and heat both increase range of motion and decrease pain, but have opposite effects on stiffness, the mechanism for the increased range of motion is probably analgesia rather than decreased stiffness.

Active warm-up. Most people believe that the light activity performed during warm-up will increase muscle temperature, decrease muscle stiffness, and increase range of motion. Animal studies consistently show a decrease in stiffness if the muscle or tendon is preheated (39-41). However, the range of temperatures studied is usually outside the normal physiologic range in humans (39-41).

In humans, the effectiveness of active warm-up to decrease stiffness appears to be related to the type of warm-up exercise and the muscle tested. For example, running appears to decrease the stiffness of the calf muscles (42) but not the hamstring muscles (43); running had no effect on range of motion in these studies. Stretching added after warm-up decreases hamstring muscle stiffness (range of motion not reported); however, the effect lasts less than 30 minutes, even if exercise continues after stretching (43). In the only study that measured the effect of cycling, hamstring or quadriceps range of motion did not change, although ankle range of motion increased (stiffness not measured) (44). In another study, 15 minutes of cycling increased passive hip flexion and extension (stiffness was not measured) (45), but the pelvis was not properly stabilized during range-of-motion measurement.

Although activity by itself does not have a major effect on range of motion, studies consistently show greater range-of-motion increases after warm-up followed by stretching than after stretching alone (42,44). This research has probably been the basis for the recommendation to always warm up before stretching. The problem is that most people interpret it to mean that stretching before exercise prevents injuries, even though the clinical and basic science research suggests otherwise (7,8). A more precise interpretation is that warm-up prevents injury (46-49), whereas stretching has no effect on injury (7,8). Therefore, if injury prevention is the primary objective (eg, recreational athletes who consider performance a secondary issue) and the range of motion necessary for an activity is not extreme, the evidence suggests that athletes should drop the stretching before exercise and increase warm-up.

Which Method Is Most Effective?

In general, PNF stretching has resulted in greater increases in range of motion compared with static or ballistic stretching (26,50-56), though some results have not been statistically significant (57-59).

Of the different types of PNF techniques, the agonist-contract-relax method (the hip flexors, including quadriceps muscles, actively stretch the hamstrings, followed by a maximal quadriceps contraction and passive holding) appears superior to the contract-relax method (muscle contraction followed by passive stretching) (50,54-56), which appears superior to the hold-relax technique (isometric contraction with resistance gradually applied over 9 seconds) (50,54-56,60).

For those who prefer the simplicity of static stretching, one study (61) reported that static stretching (continuous stretching without rest) is superior to cyclic stretching (applying a stretch, relaxing, and reapplying the stretch), whereas two studies (62,63) suggested no difference. All of these studies involved stretching the hamstring muscles, and methodological reasons for the discrepancy were not apparent. More research is needed before definitive conclusions can be made.

Take-Home Points

Many of the different proposed protocols for stretching have some support from the published literature. The major points for clinical practice are:

- Heat, ice, and warm-up all increase the effectiveness of stretching to increase range of motion, but only warm-up is likely to prevent injury.
- Although one 30-second stretch per muscle group is sufficient to increase range of motion in

most healthy people, it is likely that longer periods or more repetitions are required in some people, injuries, and/or muscle groups.

- Individuals should determine a strategy for themselves by simply holding a stretch until no additional benefit is obtained.
- Though PNF stretching is the most effective technique for increasing range of motion, the mechanism is an increase in stretch tolerance, and the muscle actually undergoes an eccentric contraction during the stretch. The increased analgesia may aid in performance but theoretically increases the risk of injury when compared with static stretches.

References

1. Best TM: Muscle-tendon injuries in young athletes. Clin Sports Med 1995;14(3):669-686
2. Garrett WE Jr: Muscle strain injuries: clinical and basic aspects. Med Sci Sports Exerc 1990;22(4):436-443
3. Safran MR, Seaber AV, Garrett WE Jr: Warm-up and muscular injury prevention: an update. Sports Med 1989;8(4):239-249
4. Shellock FG, Prentice WE: Warming-up and stretching for improved physical performance and prevention of sports-related injuries. Sports Med 1985;2(4):267-278
5. Beaulieu JE: Developing a stretching program. Phys Sportsmed 1981;9(11):59-65
6. Stamford B: Flexibility and stretching. Phys Sportsmed 1984;12(2):171
7. Pope RP, Herbert RD, Kirwan JD, et al: A randomized trial of preexercise stretching for prevention of lower-limb injury. Med Sci Sports Exerc 2000;32(2):271-277
8. Shrier I: Stretching before exercise does not reduce the risk of local muscle injury: a critical review of the clinical and basic science literature. Clin J Sport Med 1999;9(4):221-227
9. Alway SE: Force and contractile characteristics after stretch overload in quail anterior latissimus dorsi muscle. J Appl Physiol 1994:77(1):135-141
10. Leterme D, Cordonnier C, Mounier Y, et al: Influence of chronic stretching upon rat soleus muscle during non-weight-bearing conditions. Pflügers Arch 1994;429(2):274-279
11. Goldspink DF, Cox VM, Smith SK, et al: Muscle growth in response to mechanical stimuli. Am J Physiol 1995;268(2 pt 1):E288-E297
12. Yang H, Alnaqeeb M, Simpson H, et al: Changes in muscle fibre type, muscle mass and IGF-I gene expression in rabbit skeletal muscle subjected to stretch. J Anat 1997;190(pt 4):613-622
13. Hartig DE, Henderson JM: Increasing hamstring flexibility decreases lower extremity overuse injuries in military basic trainees. Am J Sports Med 1999;27(2):173-176
14. Hilyer JC, Brown KC, Sirles AT, et al: A flexibility intervention to reduce the incidence and severity of joint injuries among municipal firefighters. J Occup Med 1990;32(7):631-637
15. Halbertsma JP, Mulder I, Goeken LN, et al: Repeated passive stretching: acute effect on the passive muscle moment and extensibility of short hamstrings. Arch Phys Med Rehabil 1999;80(4):407-414
16. Magnusson SP, Simonsen EB, Aagaard P, et al: Mechanical and physical responses to stretching with and without preisometric contraction in human skeletal muscle. Arch Phys Med Rehabil 1996;77(4):373-378
17. Halbertsma JP, van Bolhuis AI, Goeken LN: Sport stretching: effect on passive muscle stiffness

of short hamstrings. Arch Phys Med Rehabil 1996;77(7):688-692
18. Stark SD: Stretching techniques, in The Stark Reality of Stretching. Richmond, BC: Stark Reality Publishing, 1997, pp 73-80
19. Bandy WD, Irion JM: The effect of time on static stretch on the flexibility of the hamstring muscles. Phys Ther 1994:74(9):845-852
20. Bohannon RW: Effect of repeated eight-minute muscle loading on the angle of straight-leg raising. Phys Ther 1984;64(4):491-497
21. Anderson B, Burke E: Scientific, medical, and practical aspects of stretching. Clin Sports Med 1991;10(1):63-86
22. Bandy WD, Irion JM, Briggler M: The effect of time and frequency of static stretching on flexibility of the hamstring muscles. Phys Ther 1997;77(10):1090-1096
23. Zito M, Driver D, Parker C, et al: Lasting effects of one bout of two 15-second passive stretches on ankle dorsiflexion range of motion. J Orthop Sports Phys Ther 1997;26(4):214-221
24. Madding SW, Wong JG, Hallum A, et al: Effect of duration of passive stretch on hip abduction range of motion. J Orthop Sports Phys Ther 1987;8:409-416
25. Wessling KC, DeVane DA, Hylton CR: Effects of static stretch versus static stretch and ultrasound combined on triceps surae muscle extensibility in healthy women. Phys Ther 1987;67(5):674-679
26. Cornelius WL, Ebrahim K, Watson J, et al: The effects of cold application and modified PNF stretching techniques on hip joint flexibility in college males. Res Q Exerc Sport 1992;63(3):311-314
27. Henricson AS, Fredriksson K, Persson I, et al: The effect of heat and stretching on the range of hip motion. J Orthop Sports Phys Ther 1984:110-115
28. Williford HN, East JB, Smith FH, et al: Evaluation of warm-up for improvement in flexibility. Am J Sports Med 1986;14(4):316-319
29. Brodowicz GR, Welsch R, Wallis J: Comparison of stretching with ice, stretching with heat, or stretching alone on hamstring flexibility. J Ath Training 1996;31:324-327
30. Lentell G, Hetherington T, Eagan J, et al: The use of thermal agents to influence the effectiveness of a low-load prolonged stretch. J Orthop Sports Phys Ther 1992;16:200-207
31. Tardieu C, Lespargot A, Tabary C, et al: For how long must the soleus muscle be stretched each day to prevent contracture? Dev Med Child Neurol 1988;30(1):3-10
32. Kottke FJ, Pauley DL, Ptak RA: The rationale for prolonged stretching for correction of shortening of connective tissue. Arch Phys Med Rehabil 1966;47(6):345-352
33. Caro CG, Pedley TJ, Schroter RC, et al: The Mechanics of the Circulation. New York City, Oxford University Press, 1978
34. Taylor DC, Dalton JD Jr, Seaber AV, et al: Viscoelastic properties of muscle-tendon units: the biomechanical effects of stretching. Am J Sports Med 1990;18(3):300-309
35. Magnusson SP, Simonsen EB, Aagaard P, et al: Biomechanial responses to repeated stretches in human hamstring muscle in vivo. Am J Sports Med 1996;24(5):622-628
36. Borms J, Van Roy P, Santens JP, et al: Optimal duration of static stretching exercises for improvement of coxo-femoral flexibility. J Sports Sci 1987;5(1):39-47
37. Taylor DC, Brooks DE, Ryan JB: Viscoelastic characteristics of muscle: passive stretching versus muscular contractions. Med Sci Sports Exerc 1997;29(12):1619-1624

38. Taylor BF, Waring CA, Brashear TA: The effects of therapeutic application of heat or cold followed by static stretch on hamstring muscle length. J Orthop Sports Phys Ther 1995;21(5):283-286
39. Warren CG, Lehmann JF, Koblanski JN: Heat and stretch procedures: an evaluation using rat tail tendon. Arch Phys Med Rehabil 1976;57(3):122-126
40. Strickler T, Malone T, Garrett WE: The effects of passive warming on muscle injury. Am J Sports Med 1990;18(2):141-145
41. Noonan TJ, Best TM, Seaber AV, et al: Thermal effects on skeletal muscle tensile behavior. Am J Sports Med 1993;21(4):517-522
42. McNair PJ, Stanley SN: Effect of passive stretching and jogging on the series elastic muscle stiffness and range of motion of the ankle joint. Br J Sports Med 1996;30(4):313-318
43. Magnusson SP, Aagaard P, Larsson B, et al: Passive energy absorption by human muscle-tendon unit is unaffected by increase in intramuscular temperature. J Appl Physiol 2000;88(4):1215-1220
44. Wiktorsson-Möller M, Öberg BA, Ekstrand J, et al: Effects of warming up, massage, and stretching on range of motion and muscle strength in the lower extremity. Am J Sports Med 1983;11(4):249-252
45. Hubley CL, Kozey JW, Stanish WD: The effects of static stretching exercises and stationary cycling on range of motion at the hip joint. J Orthop Sports Phys Ther 1984:104-109
46. Safran MR, Garrett WE Jr, Seaber AV, et al: The role of warmup in muscular injury prevention. Am J Sports Med 1988;16(2):123-129
47. Ekstrand J, Gillquist J, Liljedahl SO: Prevention of soccer injuries: supervision by doctor and physiotherapist. Am J Sports Med 1983;11(3):116-120
48. Ekstrand J, Gillquist J, Moller M, et al: Incidence of soccer injuries and their relation to training and team success. Am J Sports Med 1983;11(2):63-67
49. Bixler B, Jones RL: High-school football injuries: effects of a post-halftime warm-up and stretching routine. Fam Pract Res J 1992;12(2):131-139
50. Etnyre BR, Lee EJ: Chronic and acute flexibility of men and women using three different stretching techniques. Res Q 1988;59:222-228
51. Wallin D, Ekblom B, Grahn R, et al: Improvement of muscle flexibility: a comparison between two techniques. Am J Sports Med 1985;13(4):263-268
52. Tanigawa MC: Comparison of the hold-relax procedure and passive mobilization on increasing muscle length. Phys Ther 1972;52(7):725-735
53. Sady SP, Wortman M, Blanke D: Flexibility training: ballistic, static or proprioceptive neuromuscular facilitation? Arch Phys Med Rehabil 1982;63(6):261-263
54. Etnyre BR, Abraham LD: Gains in range of ankle dorsiflexion using three popular stretching techniques. Am J Phys Med 1986;65(4):189-196
55. Osternig LR, Robertson RN, Troxel RK, et al: Differential responses to proprioceptive neuromuscular facilitation (PNF) stretch techniques. Med Sci Sports Exerc 1990;22(1):106-111
56. Osternig LR, Robertson R, Troxel R, et al: Muscle activation during proprioceptive neuromuscular facilitation (PNF) stretching techniques. Am J Phys Med 1987;66(5):298-307
57. Lucas RC, Koslow R: Comparative study of static, dynamic, and proprioceptive neuromuscular facilitation stretching techniques on flexibility. Percept Mot Skills 1984;58(2):615-618

58. Worrell TW, Smith TL, Winegardner J: Effect of hamstring stretching on hamstring muscle performance. J Orthop Sports Phys Ther 1994;20(3):154-159
59. Sullivan MK, Dejulia JJ, Worrell TW: Effect of pelvic position and stretching method on hamstring muscle flexibility. Med Sci Sports Exerc 1992;24(12):1383-1389
60. Markos PD: Ipsilateral and contralateral effects of proprioceptive neuromuscular facilitation techniques on hip motion and electromyographic activity. Phys Ther 1979;59(11):1366-1373
61. Bandy WD, Irion JM, Briggler M: The effect of static stretch and dynamic range of motion training on the flexibility of the hamstring muscles. J Orthop Sports Phys Ther 1998;27(4):295-300
62. de Vries HA: Evaluation of static stretching procedures for improvement of flexibility. Res Q 1962;32:222-229
63. Starring DT, Gossman MR, Nicholson GG Jr, et al: Comparison of cyclic and sustained passive stretching using a mechanical device to increase resting length of hamstring muscles. Phys Ther 1988;68(3):314-320

Safety Concerns in Stretching

Although the main objective of this article was to compare the effectiveness of different stretching regimens to increase range of motion, we also feel it is important to discuss safety. Follow-up studies have not investigated the safety of different stretching modalities, so all comments here and in the medical literature are theoretical.

Some clinicians believe ballistic stretching is dangerous because the muscle may reflexively contract if restretched quickly following a short relaxation period (ie, eccentric or lengthening contraction) (1), and eccentric contractions are believed to increase the risk of injury (2,3). We agree with this concern, but it is important to add that ballistic stretching is more controlled than most athletic activities. Therefore, it is likely to be much less dangerous than the sport itself if performed properly and not overly aggressively.

The original theory that proprioceptive neuromuscular facilitation (PNF) techniques increase range of motion through reciprocal muscle inhibition, thereby decreasing electromyographic activity, was first disproved in 1979 (4,5) and again more recently (6,7). Muscles are electrically silent during normal stretches until end range of motion nears. Surprisingly, PNF techniques increase electrical activity and muscle stiffness during the stretch (4,5,7), despite the observed increase in range of motion. This means that the muscle eccentrically contracts during the PNF stretch, which most clinicians would consider more dangerous than electrically silent muscle. PNF and ballistic stretching both cause an eccentric contraction, but PNF stretching appears to have a more pronounced analgesic effect. From a safety viewpoint, it does not seem prudent to "anesthetize" a muscle during or immediately before it is required to perform higher-risk eccentric contractions. The benefits of the greater increase in range of motion should be balanced against a theoretical increase in the risk of injury. (There are no data on risk of injury with PNF stretching.)

References

1. Stark SD: Stretching techniques, in The Stark Reality of Stretching. Richmond, BC: Stark Reality Publishing, 1997, pp 73-80
2. Newham DJ, McPhail G, Mills KR, et al: Ultrastructural changes after concentric and eccentric contractions of human muscle. J Neurol Sci 1983;61(1):109-122
3. Hunter KD, Faulkner JA: Pliometric contraction-induced injury of mouse skeletal muscle: effect of initial length. J Appl Physiol 1997;82(1):278-283
4. Markos PD: Ipsilateral and contralateral effects of proprioceptive neuromuscular facilitation techniques on hip motion and electromyographic activity. Phys Ther 1979;59(11):1366-1373
5. Moore MA, Hutton RS: Electromyographic investigation of muscle stretching techniques. Med Sci Sports Exerc 1980;12(5):322-329
6. Magnusson SP, Simonsen EB, Aagaard P, et al: Mechanical and physical responses to stretching with and without preisometric contraction in human skeletal muscle. Arch Phys Med Rehabil 1996;77(4):373-378
7. Osternig LR, Robertson R, Troxel R, et al: Muscle activation during proprioceptive neuromuscular facilitation (PNF) stretching techniques. Am J Phys Med 1987;66(5):298-307

Dr Shrier is director of the Consultation Service Centre for Clinical Epidemiology and Community Studies at Sir Mortimer B. Davis-Jewish General Hospital in Montreal. Dr Gossal is a staff physician in the Department of Family Medicine at Saint Mary's Hospital at McGill University in Montreal. Address correspondence to Ian Shrier, MD, PhD, Centre for Clinical Epidemiology and Community Studies, Lady Davis Institute for Medical Research, SMBD-Jewish General Hospital, 3755 Côte Sainte Catherine Rd, Montreal, QB H3T 1E2; e-mail to ishrier@med.mcgill.ca.
