Review Article

Physiotherapy and Occupational Therapy Journal
Volume 6 Number 2, April - June 2013

Short Term Effects on Peak Extensor Torque of Muscle by Multi Modal Method of Stretching: A Review

Saurabh Sharma

Abstract

Stretching is traditionally used as part of a warm-up to increase flexibility or pain-free range of motion (ROM) about a joint in an attempt to promote better performances and/or reduce the risk of injury. Physiotherapist also recommend that their athletes or patients stretch before performing strengthening exercises or strength assessment tests. However, authors of recent systematic reviews have suggested that pre-exercise stretching may temporarily compromise a muscle's ability to produce force and power output. This ''stretching-induced force deficit'' has been reported to affect isometric force , Power, concentric isokinetic peak torque , dynamic constant external resistance (DCER) force , vertical jumping performance and balance different types of PNF techniques have been suggested like static, dynamic , Hold Relax and Contract–Relax, Agonist Contraction and Hold–Relax with Agonist Contraction . Effects of stretching on strength / torque and performance is still in inconclusive with studies showing both increase and decrease in both the variables. There is dearth of evidence related to the subject of peak torque after modal variants of stretching, hence in future there is need for randomized controlled trial on athletes and various patient populations.

Keywords: Stretching; PNF; Torque; Performance.

Introduction

Stretching prior to participation in sports activities is standard protocol for all levels of sports, competitive or recreational.[1] Stretching is traditionally used as part of a warm-up to increase flexibility or pain-free range of motion (ROM) about a joint in an attempt to promote better performances and/ or reduce the risk of injury.[2] Rehearsal of the skill about to be performed is incorporated into the warm-up regime at incremental intensities so that the specific muscle fibers and neural pathways are recruited for optimum performance.[3]

Physiotherapist also recommend that their athletes or patients stretch before performing strengthening exercises or strength assessment tests. However, authors of recent systematic reviews have suggested that pre-exercise stretching may temporarily compromise a muscle's ability to produce force and power output. It may be possible that this short-term effect of stretching on muscle force and power production may have negative effect on performance of various rehabilitation exercises.[2]

This ''stretching-induced force deficit'' has been reported to affect isometric force , Power, concentric isokinetic peak torque , dynamic constant external resistance (DCER) force , vertical jumping performance and balance.[4]

Two main assumptions have been put forward to rationalize the stretching-induced force deficit: (a) mechanical factors, such as decrement in musculotendinous stiffness that may affect the muscle's length – tension relationship and/or sarcomere shortening velocity and (b) neural factors, that may reduce peripheral muscle activation, reduced muscle firing frequency, and/or altered reflex sensitivity. Fowles *et al* (2000) suggested that

Author Affilation: *Assistant Professor, Centre for Physiotherapy and Rehab Sciences, Jamia Millia Islamia, New Delhi - 110025.

Reprint request: Dr. Saurabh Sharma, *Assistant Professor, Centre for Physiotherapy and Rehab Sciences, Jamia Millia Islamia, New Delhi - 110025.

E-mail: senthilparamasivamkumar@gmail.com

stretching-induced decreases in neural drive could only account for a percentage of the force deficit, and thus mechanical as well as neural factors may contribute to the stretching induced force deficit.[4]

Number of researches have examined the effects of static and dynamic stretching preceding strength training, jumping, running and power performance. Static stretching, as the name implies, involves stretching a muscle and holding the stretch with minimal or no movement for a given duration. Many research studies suggest that static stretching before strength training or jumping may result in decrease performances. Static stretching may reduce the nervous system's ability to recruit muscles or it may reduce the ability of the muscle to produce force and power directly.[5] Consequently, a reduction in maximal torque and power output post stretching might be related to a change in neural or mechanical status.[6]

It has also become clear that static stretching may negatively affect immediate physical performance[7] and the "active" component has been shown to benefit performance by increasing core temperature, blood flow, and preparing the body for Exercises[3], Because of this, dynamic stretching has been recommended as an alternative to static stretching for warm-up, as evidence suggests that dynamic stretching positively impacts on immediate physical performance[9]

There has been little research investigating the acute effects of static stretching of the antagonist on the expression of strength and power. Previous research has investigated the effects of stretching on the muscle primarily involved in the movement. Only one published research has attempted to determine the effects of static antagonist stretching of muscle for a given movement. But no known research has attempted to examine and compare the effects of static and dynamic stretching of the antagonist muscle for a given movement. Antagonist muscles provide a braking force to the movement of their opposing muscles, stretching the antagonist muscle could reduce this braking force. This could potentially enhance strength and power following antagonist stretching. Gains in strength may be accompanied with an increase in neural activity of the agonist and neurological inhibition of the antagonist.[10] Stretching the agonists prior to a given movement may decrease the agonist muscle strength and power, perhaps through decreased neural drive.[11] Conversely, stretching the antagonists may result in their inhibition and reciprocally facilitate increased activity of the agonists, with subsequent improvements in strength and power related performance.[5]

Types of stretching

There are three types of stretching: Static, Dynamic, and Proprioceptive neuromuscular facilitation (PNF).

Static stretching

The most common type is static stretching, where the muscle is held to a point of a stretching sensation and repeated. This can be executed passively by a clinician, or actively by the patient or client. Static stretching is frequently used to increase flexibility due to safety and ease of use. This technique is effective in enhancing range of motion. The clinical pearls for effective static stretching are maximum control, little or no movement, and minimal to no velocity of movement.[12]

Dynamic stretching

There are 2 types of dynamic stretching: active and ballistic stretching. Active stretching involves moving an extremity through its full range of motion to the end ranges and repeating several times. Ballistic stretching involves rapid, alternating movements or 'bouncing' at end-range of motion; but because of increased risk for injury, ballistic stretching is no more advised.

Unlike ballistic stretching, active stretching does not increase the risk of injury and the joint of the limb is stretched with a movement that resembles part of a sport skill. Dynamic stretching is considered to elevate core body and deep muscle tissue temperatures, increase post-activation potentiation, and probably reduces the risk of injury. This may increase force and power development and vertical jump performance.[12]

Proprioceptive neuromuscular facilitation (PNF)

Proprioceptive neuromuscular facilitation techniques used for stretching (PNF stretching), also referred to as active stretching or facilitative stretching, accumulate active muscle contractions into stretching maneuvers to facilitate or inhibit muscle activation and to increase the chance that the muscle to be lengthened remains as relaxed as possible as it is stretched. It is believed that when muscle fibers are reflexively inhibited through autogenic or reciprocal inhibition, there is less resistance to elongation by the contractile elements of the muscle. However, inhibition techniques are designed to relax only the contractile structures of muscle, not the connective tissue in and around shortened muscles.[12]

Types of PNF stretching

There are several types of PNF stretching procedures. They include: Hold–relax (HR) or contract–relax (CR) , Agonist contraction (AC) and Hold–relax with agonist contraction (HR-AC).

Hold–relax and Contract–relax

With the hold–relax (HR) procedure, the muscle is first lengthened to the point of limitation or to the extent that is comfortable for the patient. The patient then performs a prestretch, end-range, isometric contraction (for 5 to 10 seconds) followed by voluntary relaxation of the tight muscle. The limb is then passively moved into the new range as the range-limiting muscle is elongated.

Agonist contraction

Another PNF stretching technique is the agonist contraction (AC) procedure. The "agonist" refers to the muscle opposite the range-limiting muscle. "Antagonist," therefore, refers to the range-limiting muscle. As the short muscle (the antagonist) preventing the full movement of the prime mover (the agonist). Dynamic range of motion (DROM) and active stretching are terms that have been used to describe the AC procedure.

To perform the AC procedure the patient concentrically contracts (shortens) the muscle opposite the range limiting muscle and then holds the end-range position for at least several seconds. The movement of the limb is independently controlled by the patient and is deliberate and slow, not ballistic. In most instances the shortening contraction is performed without the addition of resistance.

Hold–relax with agonist contraction

The HR-AC stretching technique combines the HR and AC procedures. The HR-AC technique is also referred to as the slow reversal hold–relax technique. To perform the HR-AC procedure, move the limb to the point that tissue resistance is felt in the tight (range-limiting) muscle; then have the patient perform a resisted, prestretch isometric contraction of the range-limiting muscle followed by relaxation of that muscle and an immediate concentric contraction of the muscle opposite the tight muscle. For example, to stretch knee flexors, extend the patient's knee to a comfortable position and then have the patient perform an isometric contraction of the knee flexors against resistance for 5 to 10 seconds. Tell the patient to relax the knee flexors and then actively extend the knee as far as possible, holding the newly gained range for several Seconds.[13]

Effects of stretching on strength and performance

The majority of studies show that static stretching has either no effect or decreases performance whereas dynamic stretching has either no effect or improved performance. These findings indicate that sports relying on high lower-body power output may benefit from dynamic stretching instead of static stretching prior to activity.

Both neural and mechanical factors have been proposed for stretching-induced decreases. Many different peripheral mechanisms have been put forward to explain reduced muscle activation after stretching. These encompass the autogenic inhibition of the Golgi tendon reflex, mechanoreceptor and nociceptor afferent inhibition, fatigue-induced inhibition, joint pressure feedback inhibition due to excessive ranges of motion during stretching, and stretch reflex inhibition originating from the muscle spindles. A central nervous system mechanism, such as "supraspinal fatigue", has also been suggested as a mechanism. The mechanical factors involve the viscoelastic properties which affect the muscle's length tension[14] and decreasing the amount of elastic energy that can be stored in the musculotendinous unit. However, some studies have found that dynamic stretching has the opposite effect of enhancing performance. This phenomenon has been linked to the rehearsal of specific movement patterns, helping proprioception and preactivation, and allowing an optimum switch from the eccentric to concentric muscle contraction required to generate high running speeds.[15] In one of the repeated measures study of fifty-one moderately to very active subjects, no significant difference was found between the three treatments of static or dynamic stretching and no stretching in 1 repetition maximum for bench and leg presses. The study came to result that if the stretching routine is not intense and long, then pretesting stretching probably will not adversely affect strength tests. In this study, three sets of fifteen seconds were performed for the static stretching and 15 repetitions were performed for the dynamic stretch protocol.[17] Belm *et al* found impairments in balance, reaction time and movement time post-stretch when they used a static stretching protocol involving the quadriceps, hamstrings, and plantar flexion at three sets of forty-five second stretches each.[16] Egan, *et al* measured the peak torque and mean power output of maximal concentric isokinetic leg extensions at 60° and 300° after a bout of static stretching of eleven NCAA DI Women's Basketball players.[17] Four leg extensor stretches were performed four times and held for thirty seconds. This stretch protocol was the same used in studies that found a strength deficit from pre-exercise static stretching, but the results showed that isokinetic peak torque and mean power were not reduced. Egan *et al* concluded that strength in these trained athletes may not be affected by an intense static stretching protocol.[17] Little & Williams evaluated how different stretching protocols during warm-ups effect high speed motor capacities in professional soccer players.[18] Eighteen professional soccer players were examined for countermovement vertical jump, stationary 10-m sprint, flying 20-m sprint and agility performance after each stretch protocol. The three regimes of static, dynamic and no stretch were executed on three nonconsecutive days. Four different static stretches were performed with a 30 second hold and twenty seconds of rest between stretches. Dynamic stretches were performed on alternating legs for 60 seconds with approximately one stretch cycle every 2 seconds or unilaterally for thirty seconds with approximately one stretch cycle every second. The total time spent on stretching was 6 minutes and 20 seconds. All tests were performed in the same order for each protocol with twenty seconds between each test. There was no significant difference among the different stretch protocols for the vertical jump. Both static and dynamic led to better performance than no stretch in the 20m Max speed, but only dynamic was significantly faster than no stretch in the 10 m acceleration. Dynamic was much faster than the static and no stretch regimes in the zig-zag agility. In summary, dynamic stretching produced better performance than static in 1 of the two tests used (agility) and showed a tendency for having more efficacy in 2 of the three other tests. From these results, the authors suggested that the decrements that other studies have seen following static stretching may have been avoided in this study due to the shorter stretch duration. The authors came to a result that dynamic stretching, as opposed to static stretching or no stretching, is probably most effective at preparation for the high-speed performances required in sports such as soccer and that, if static stretching is used, it should be limited to short durations and be followed by further activity to minimize decrements to power-based performance.[18]

Siatras *et al* evaluated vaulting speed in gymnasts after static and dynamic stretching.[19] Eleven healthy prepubescent boys participated in the study. On nonconsecutive days, the athletes performed a general warm-up only, a general warm-up and static stretching exercises, and a general warm-up and dynamic stretching exercises. Two 30 second stretches were performed with each stretch protocol. The static stretches were each held for 30 seconds and the dynamic stretch motions were performed as quickly as possible for 30 seconds. Vault speed was significantly slower in the static stretching and warm-up compared to warm-up only ($P<0.01$). No significant differences were found between the dynamic and static or the dynamic and warm-up protocol. The study suggests that, though stretching is necessary for flexibility, it is not advisable to perform static stretching prior to activities like vaulting.[19] Zakas, *et al* used a Cybex NORM dynamometer at angular velocities of 60, 90, 150, 210 and 270°/seconds to evaluate the peak torque of fourteen semiprofessional soccer players after static stretching sessions.[19] Each player had to complete each of the three sessions within a week of the previous. Static stretching of the quadriceps muscle group was done in all three regimes with the difference being in the number of stretches: 1 x 30 seconds, 10 x 30 seconds and 16 x 30 seconds. All three stretch protocols significantly increased knee flexion from pre to post stretch. There was no clinically significant difference in between group range of motion. Isokinetic peak torque was also measured pre and post stretch with no significant difference was found after the single 30 second stretch protocol, but significant decreases in peak torque were found after the 10 x 30 second and 16 x 30 second protocols. The first four velocities (60, 90, 150, 210°) in the 10 x 30 second and the first two of the 16 x 30 second had a P value of < 0.01 while the 270° for the 10 x 30s and the last four speeds of the 16 x 30 seconds had a P value < 0.001. The authors could not pinpoint a specific mechanism explaining the results, but the neural inhibition and tissue damage could probably explain the decrease caused by the prolonged static stretching.[20]

Marek, *et al* compared the acute effects of static and proprioceptive neuromuscular facilitation stretching on muscle strength, mean power output, active range of motion, passive range of motion, electromyography amplitude of the vastus lateralis and rectus femorus muscles during concentric isokinetic leg extensions at 60 and 300°/ second.[21] Four repetitions of each stretching exercise were held for 30 seconds with a 20 second rest between each stretch. PNF and static protocols were performed in two different visits. Both regimes increased active and passive range of motion and caused similar decrement in strength, power output, and muscle activation at both velocities. The study concluded that effect sizes for these changes were small and that practitioners need to consider a risk-to-benefit ratio when incorporating static or PNF stretching.[22]

Cramer *et al* used a Cybex 6000 dynamometer to evaluate the acute effects of static stretching on leg extensor peak torque at 60 and 240°/second. The authors concluded that these finding support the theory that a central nervous system mechanism, such as “supraspinal fatigue”, may be responsible for the decreases in force following an acute bout of static stretching.[13]

John B. Sandberg studied the effects of static stretching of the antagonist muscles on a variants of strength and power measures.[5] Sixteen active males were tested for vertical jump height and isokinetic torque production in a slow knee extension (KES) at 60°/s and a fast knee extension (KEF) at 300°/s. Electromyography was taken during knee extension tests for the vastus lateralis and the biceps femoris muscles. Subjects executed these tests in a randomized counterbalanced order with and without prior antagonist stretching .Paired samples t tests revealed a significant ($p = .034$) difference between stretch KEF and non-stretch KEF conditions. There was no significant ($p > .05$) difference between KES stretch and non-stretch conditions. Vertical jump power was also higher in the stretch versus the non-stretch condition .These results suggest that stretching the antagonist hamstrings prior to high speed isokinetic knee extension increases torque production. It also demonstrated that stretching the hip flexors and dorsi flexors may enhance jump height and power. Practitioners may use this information to acutely enhance strength and power performances.[5]

Considering the review of the evidence related to the above said topic of generation of peak torque after the static and dynamic stretching , it seems that still there is dearth of evidence related to the subject of peak torque after modal variants of stretching, hence in future there is need for randomized controlled trial on athletes and various patient populations.

References

1. Thacker, SB *et al*. The impact of stretching on sports injury risk: a systematic review of the literature. *Med Sci Sports Exercise.* 2004; 36(3): 371– 378.
2. Sarah M Marek *et al.* Acute effects of static and proprioceptive neuromuscular facilitation stretching on muscle strength and power output. *Journal of Athletic Training.* 2005; 40(2): 94–103.
3. Mary Megan Smart. Acute effects of dynamic and static stretch on the peak torque and ROM of the shoulder internal and external rotators. (2010) unpublished dissertation.
4. Joel T Cramer *et al*. Acute effects of static stretching on characteristics of the isokinetic angle - torque relationship, surface electromyography, and mechanomyography. *Journal of Sports Sciences.* 2007; 25(6): 687–698.
5. Sandberg John B. Acute effects of antagonist stretching on jump height and knee extension peak torque. Utah State University; 2012.
6. Arnold G Nelson, *et al*. Inhibition of maximal voluntary isokinetic torque production following stretching is velocity-specific. *Journal of Strength and Conditioning Research.* 2001; 15(2): 241–246.
7. Kieran O'Sullivan *et al*. The effect of warm-up, static stretching and dynamic stretching on hamstring flexibility in previously injured subjects. *BMC Musculoskeletal Disorders.* 2009; 10:37 /1471-2474-10-37.
8. McMillian, DJ *et al*. Dynamic vs. static-stretching warm up: The effect on power and agility performance. *J Strength Cond Res.* 2006; 20(3): 492–499.
9. Little T, and AG Williams. Effects of differential stretching protocols during warm-ups on high-speed motor capacities in professional soccer players. *J Strength Cond Res*. 2006; 20(1): 203–207.
10. Carolan B, & Cafarelli E. Adaptations in coactivation after isometric training. *Journal of Applied Physiology.* 1992; 73: 911-917.
11. Cornwell A *et al*. Acute effects of stretching on the neuromechanical properties of the triceps surae muscle complex. *European Journal of Applied Physiology.* 2012; 86: 428-434.
12. Current Concepts In Muscle Stretching For Exercise And Rehabilitation. *Int J Sports Phys Ther*. 2012; 7(1): 109–119.
13. Cramer JT, *et al*. Acute effects of static stretching on peak torque in women. *Journal of Strength and Conditioning Research.* 2004; 18(2): 236-241.
14. Fletcher, IM & Anness, R. The acute effects of combined static and dynamic stretch protocols on fifty-meter sprint performance in track-and-field athletes. *Journal of Strength and Conditioning Research.* 2007; 21(3): 784-787.
15. Beedle B, Rytter SJ, Healy RC & Ward TR. Pretesting static and dynamic stretching does not affect maximal strength. *Journal of Strength*

and Conditioning Research. 22(6): 1838-1843.

16. Belm DG, *et al*. Effect of acute static stretching on force, balance, reaction time, and movement time. *Medicine and Science in Sports and Exercise.* 2004; 36(8): 1397-1402.
17. Egan AD *et al*. Acute effects of static stretching on peak torque and mean power output in National Collegiate Athletic Association Division I women's basketball players. *Journal of Strength & Conditioning Research.* 2006; 20(4): 778-782.
18. Little, T & Williams. Effects of differential stretching protocols during warm-ups on high speed motor capacities in professional soccer players. *Journal of Strength & Conditioning Research.* 2006; 20(1): 203-207.
19. Siatras T *et al*. Static and dynamic acute stretching effect on gymnasts' speed in vaulting. *Pediatric Exercise Science.* 2003; 15: 383-391.
20. Zakas A *et al*. Acute effects of static stretching duration on isokinetic peak torque production of soccer players. *Journal of Bodywork and Movement Therapies.* 2006; 10: 89-95.
21. Marek SM, *et al*. Acute effect of static proprioceptive neuromuscular facilitation stretching on muscle strength and power output. *Journal of Athletic T raining.* 2005; 40(2): 94-103.
22. Nagarwal, *et al*. Improvement of hamstring flexibility: a comparison between two PNF stretching techniques. *International Journal of Sports Science and Engineering.* 2010; 04(01): 025-033.