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Effects of Dynamic, Static Stretch, and Proprioceptive Neuromuscular Facilitation on Running Velocity, Step Length, and Step Rate

William Todd Lane

EFFECTS OF DYNAMIC, STATIC STRETCH, AND PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION ON RUNNING VELOCITY, STEP LENGTH, AND STEP RATE

by

TODD WILLIAM LANE

(Under the Direction of Barry Munkasy)

ABSTRACT

The purpose of this study was to analyze the possible effects of three different types of stretch protocols and a no stretch protocol on collegiate female sprinters on the velocity, step length and step rate. Ten NCAA Division I female sprinters ranging in age from 18 to 22 participated in the study. A forty five meter sprint was performed with the section from thirty to forty meters digitally recorded and later analyzed for velocity, step length, and step rate. The sprint was performed before the stretch protocol was applied and then again after it was applied. The participants were tested on non consecutive days during a normal part of their practice sessions. Protocols were randomized for each participant.

Pre and post measurements for each protocol and each individual were taken. Paired samples t-tests were performed on the mean pre and post of each group and then mean differences were compared for significances between groups.

INDEX WORDS: Stretch, Sprinters, Static stretch, Dynamic stretch, Proprioceptive Neuromuscular facilitation

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by

TODD WILLIAM LANE

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TODD WILLIAM LANE

Major Professor: Barry Munkasy

Committee: Jim McMillan
Helen Graf

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DEDICATION

To my wife, Turena, who puts up with me on a daily basis, yet still provides unending support and love. Love you Turena.

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CHAPTER 1

INTRODUCTION

Purpose of the Study

Stretching has long been a part of athlete's training programs and long believed to reduce in injury and to prepare and athlete for more intense exercise. Research has shown that stretching prior to activity can have negative effects on power output in exercise (Avela, Kyrolainen, & Komi, 1999; Fowles, Sale, McDougall, 2000; Kokkonen, Nelson, Cornwell, 1998; Nelson, Allen, Cornwell, & Kokkonen, 2001; Nelson, Guillory, Cornwell, & Kokknen, 2001; Nelson & Kokkonen, 2001; Young & Behm, 2003). The purpose of the study was to evaluate the effect of different stretching exercise protocols on sprint performance. The specific stretching protocols include: static stretching; PNF stretching; dynamic stretching; and a no stretch group when combined with a common warm-up on sprint performances.

Need for Study

The athletics world is much different than that of the laboratory world. Bridging the gap from the laboratory to the athletic field is an important bridge for coaches. Many of the studies in the area of stretching and power production include stretch protocols that go far beyond what the author has typically seen in sport setting, in both duration and intensity. The tests for measuring power output and the effects of stretch protocols have typically included one repetition maximum tests or one effort tests such as vertical leap. As a track and field coach, it is important to the author to set protocols that closely resemble what is typically seen at track and field practices and competitions. It is also important to the author to perform tests that are directly part of the sport that the athlete competes within.

Significance

This study deals specifically with collegiate sprinters and stretch protocols that the author has observed and read about for several competitive collegiate track and field programs. The participants in this study were female NCAA Division I Intercollegiate sprinters between the ages of 18 to 22.

Questions

This research is guided by the following questions:

1) Are there significant changes pre to post in each protocol?

2) Is there a stretch protocol which has a more positive effect on sprint performance when combined with a warm up routine?

3) What are the mechanisms which may change in relation to stretch protocol interventions?

Assumptions

The participants are assumed to have performed the runs to a self-reported maximum.

Limitations

The total number of participants is small because of the specific requirements of being an NCAA Division I sprinter.

Delimitations

Females were the participants in the study. This provided the researcher a matter of convenience as he worked daily with the participants as their coach. The university did not have a men's team.

CHAPTER 2

REVIEW OF LITERATURE

Stretching as part of a warm-up prior to exercise has long been utilized to serve the purpose of decreasing the possibility of muscle or connective tissue injury. This can be found in textbooks, magazines, and scientific study. A literature review of flexibility research concluded that elite athletes and social exercisers as part of warm-up routines commonly practice stretching. Stretching as part of a warm-up and cool-down routine is referred to as acute. A flexibility program that is performed on a regular basis over time is referred to as chronic. The literature review also found it generally accepted that prior to exercise, an adequate warm-up can reduce muscle and tendon injuries (Smith, 1994). Reviews of literature have concluded that some sports benefit from improved flexibility, however others may benefit from having less flexibility (Gleim and McHugh,1997).

Mechanism of Stretching

Flexibility is generally defined as the range of motion available about a joint or a group of joints (Alter, 3). The process of applying flexibility treatments causes change that allows an increase or decrease range of motion about the joint or group of joints. Three important neurological mechanisms play a major in role in flexibility.

Muscle spindles are located deep within the belly of the muscle and lie parallel to the muscle fibers. The spindles detect changes in the muscle or joints such as changes in muscle length and muscle tension and then send nerve impulses to the spinal cord to stimulate a motor response (Hamill & Knutzen, 125). A stretch on the muscle activates the muscle spindle and sensory neurons that are contained within the spindle.

Type I sensory neurons are sensitive to stretch and changes in length in the muscle. Type I neurons will send impulses to the spinal cord that are proportional to the rate of the stretch. An impulse is sent back to the muscle to contract. This is called the stretch reflex. As the stretch reaches a fixed position, the impulses drop to a lower and more constant level. This lower and more constant level allows a stretch to be held at a position with less resistance. Type I sensory neurons have a lower threshold and are the first to respond to changes to muscle stretch. (Hamill & Knutzen)

Type II sensory neurons produce a sensory input in response to a change in length in the muscle. Type II neurons continue to send impulses even when the muscle is held in a stationary position. An inhibitory graded potential is enacted which lowers the excitability in the muscle being stretched, which can cause relaxation of the muscle if the stretch is great enough. A relaxation of the muscle allows a greater length to be achieved. Type II neurons have a greater threshold than that of Type I.

The third neurological mechanism that is involved is the Golgi Tendon Organ (GTO). The GTO is located junction of the muscle-tendon. It monitors force or tension during stretch and contraction of the muscle. The GTO generates an inhibitory reaction to changes in tension or force. This inhibition is known as the inverse stretch reflex. The reflex serves as a protective mechanism, by inhibiting contraction of a muscle. Stretching allows a greater length to be achieved.

The goal of a flexibility program is to positively have an effect on the three neurological mechanisms, so that a great length can occur in the muscle-tendon unit.

Finally, muscle and tendon properties act in what is called viscoelasticity. When viscoelastic properties are stretched and held at a constant length, the stress at that length will gradually begin to decline. This is called stress relaxation. Viscoelastic properties also have strain rate dependences. A faster strain creates a higher tensile force. Slower strains on the property allow for lower tensile forces to develop (Taylor, Brooks, and Ryan, 1997).

Improved flexibility, both short term and long term, has been cited in the literature as important to athletes (Shellock & Prentice, 1985; Smith, 1994). Short term, when combined with a warm-up, stretching provides several benefits. The two most cited benefits being an enhancement of physical performance and prevention of sport related injuries (Shellock & Prentice; Smith). Long term, these same reasons are stated, but only the enhancement of range of motion occurs permanently over time with the goal of reducing sport related injuries. Two military companies, during basic military training were compared when a stretch treatment was applied over a 13-week period to one company, but not the other. The company with the applied treatment showed a significant improvement in range of motion and had a significantly less amount of lower extremity injuries than the no stretch company (Cross & Worrell, 1999). Stretching treatments applied during one season of a Division III football team, but not applied during another, were contrasted for injuries. A reduction in musculotendinous injuries occurred during the season in which a stretching treatment was applied (Hartig & Henderson, 1999).

<u>Techniques</u>

Flexibility itself can be increased through several different techniques. The two most common are static stretching and proprioceptive neuromuscular facilitation (PNF). Static flexibility involves slowly stretching to a position just short of where pain occurs and holding it for a given time. This position is maintained for duration of time usually lasting at least six seconds up to 60 seconds and can be repeated several times on the same muscle group. Static stretching invokes several different mechanisms discussed earlier to lower the resistance to the stretch. As the stretch is held, the viscoelastic properties of the muscle allow for it to lessen the tension. The Type I sensory neurons lower their impulses as the stretch reaches its end point and the tension is no longer increasing. The Type II sensory neurons assist in producing relaxation through inhibition as the muscle continues to lengthen. PNF, involves the static stretch of a muscle group, with assistance of someone, followed by an isometric contraction of the opposing muscle group to be stretched, followed by a relaxation of the opposing muscle group, followed by a static stretch of the muscle group. The PNF technique enhances the stretch through the utilization of the GTO inverse stretch reflex, which is stimulated during the isometric contraction. Both techniques have been demonstrated to produce significant improvements long term (Prentice, 1983).

A third stretching technique, which is considered less effective at producing gains in flexibility, is called ballistic stretching. Ballistic stretching relies on bouncing or bobbing movements repeated typically ten to twenty times performed in a rhythmic nature. These movements are performed quickly and the stretch portion last for a short duration (< 1 sec). The speed of stretch, magnitude, and lack of a constant tension, causes the contraction of the muscle, because of the stretch reflex. Some authors would call a no stretchled and sport specific type of ballistic stretching, dynamic stretching (Fletcher & Jones, 2004). Dynamic stretching uses a gradual increase in the range of motion through each repetition of the performance of the stretch.

<u>Effects of Stretching</u>

Improvements that occur in long term stretching programs are attributed to an improvement in the stretch tolerance (Magnusson, Simonsen, Aagaard, Sorenson & Kjaer, 1996; Halbertsma & Goeken, 1994). Stretch tolerance is the ability to withstand the sensation of pain or force of stretch. There have been found to be no changes in the tissue itself (Magnusson et al., 1996).

Short term stretching has been shown to reduce musculotendinous unit stiffness and cause a more compliant musculotendunous unit after short term stretching. (Rosenbaum & Hennig, 1995; Taylor et al, 1997; Magnusson, Simonsen, Aagaard, & Kjaer, 1996). This reduction in stiffness and more compliance has been theorized to diminish the likelihood of injury through a reduction in force rate and peak force (Rosenbaum & Hennig). One study showed an increase in musculotendinous unit length (Taylor et al). DeVries (1962) looked at short term stretching effects on 100-yard sprint times. There were no significant differences found in the recorded times. Dintiman (1964) found that an eight-week static flexibility program, when combined with sprint training, did not produce significantly better times over a 50 yard distance than a sprint only training program.

Studies recently have looked more closely at the effects of short term flexibility and its immediate outcomes (Avela, Kyrolainen, & Komi, 1999; Behm, Button & Butt, 2001; Cornwell, Nelson & Sidaway, 2002; Fowles, Sale, & MacDougall, 2000; Kokkonen, Nelson & Cornwell, 1998; Nelson, Cornwell & Heise 1996; Nelson, Guillory, Cornwell, & Kokkonen, 2001). A decrease of maximal voluntary force (MVC) following a session of acute flexibility has been demonstrated (Avela at al., 1999; Behm et al., 2001; Fowles et al., 2000). A lack of activation of neuromuscular feedback responses has been hypothesized to explain the result of decreased MVC. Stretching is believed to "turn off" the feedback responses. (Behm, Button & Butt, 2001; Fowles, Sale & McDougall, 2000). Another hypothesis is that the lowered force capability may be caused by a more compliant MTU (Rosenbaum, Sale & MacDougall, 2000). The compliancy and decreased force could be attributed to an increase in tendon slack. The slack must be taken up before contraction and force can occur. The increased slack theory then suggests that there is an increase in time to reach peak force, as the slack is picked up. The effects of acute flexibility treatments have been shown to decrease maximal voluntary contraction for up to an hour after termination of stretches (Fowles et al, 2000; Magnusson et al, 1996).

Flexibility treatments can lower maximal force output, in voluntary contractions, at different angles. In identical protocol studies of ballistic and static flexibility, a significant decrease in one repetition maximal of knee extension and flexion following a session of acute flexibility treatments have been found (Fowles et al, 2000; Nelson, Allen, Cornwell, & Kokkonen, 2001; Nelson & Kokkonen, 2001; Nelson et al., 1996; Magnusson, Simonsen, Aagard, Kjaer, 1996). The angle in which maximal contractions are decreased by treatments, was found to be significant at joint angles of 162 degrees and greater (Nelson et al., 2001). In sprinting joint angles of 162 degrees or greater are regularly achieved.

Vertical jump appears to be negatively affected when a PNF treatment is applied before testing when compared to a non- stretch treatment (Church, Wiggins, Moode, & Crist; 2001). In another study, vertical jump was performed following a stretching treatment and following a non-stretch treatment. Squat jump and counter movement jump were performed. Both jumps were significantly lower after the stretch treatment than that of the non-stretch treatment. A comparison of squat jump and counter movement jump between each individual also was used to estimate stored elastic energy contribution. There was no significant difference found between stretch and non-stretch treatments on stored elastic energy. The authors concluded that the elastic properties of the muscles were thus unchanged (Nelson et al, 1996).

Vertical jump, when performed fifteen minutes and thirty minutes after acute flexibility treatments of static and ballistic stretching, remained unchanged on trained women (Unick, Kieffer, Cheesman & Feeney, 2005). The authors concluded that trained women in vertical jumping may elicit a different response than a population of non trained women.

The elevation of body temperature plays an important role in flexibility. An elevated body temperature allows the body to do physical work, appears to reduce incidence and likelihood of musculoskeletal injuries, and the joint range of motion is improved (Shellock & Prentice, 1985). It has been found that a muscle warmed by isometric contractions required greater force and was stretched to greater lengths before failure than that of non-warmed muscles (Safran, Garrett, Seaber, Glisson, & Ribbeck, 1988). Research has used tendon tap reflex to measure force output (Rosenbaum & Hennig, 1995). This was measured prior to a stretching treatment, after a stretching treatment, and then following a 10 minute run after the stretching treatment. Passive peak force was significantly lower after stretching, active peak force was lower after stretching, and the time to active peak force was lower after stretching. A decrease in the musculotendinous stiffness was confirmed by the reduction in peak force. The time to active peak force was significantly lower after running when compared to both stretching and prior to stretching measurements. It was hypothesized that one of the reasons for the lower rate was due to a rise in muscle temperature.

Studies that combine a warm-up treatment with a stretch treatment, replicate what is commonly found on the athletic field. The theory behind warm-up activity, prior to applying flexibility treatments, is that the body temperature is elevated and allows a greater joint range of motion. When a warm-up run and stretch protocol were compared to a warm-up run only on vertical jump, the warm-up run only produced a significantly better vertical jump height. (Young & Behm, 2003). It was hypothesized that a warm-up run had positive effects for performance and that stretching had negative effects. A warm-up run and stretch cancelled each other out, where as a warm-up run only leaves the athlete with positive effects before performance (Young & Behm). A warm-up of general body weight exercise and PNF stretching, performed significantly lower on vertical jump heights than a warm-up only routine and a warm-up and static stretch routine (Church et al, 2001). The participants warmed-up with five minutes of jogging (Young and Elliott, 2001). Jogging was then followed by a treatment of PNF, static stretch, maximum voluntary contractions, and a no stretch group. A vertical jump test was administered, followed by a drop jump from a 30 cm box. The vertical jump heights showed no significant difference. Drop jump heights, when divided by contact time, were significantly different than for the static stretch group when compared to the other three treatments. The authors conclude that static stretching could be detrimental for activities that require a shorter stretch shorten cycle response. Sprinting would be one of these types of activities.

A rebound bench press and a purely concentric bench press were compared over an eight week period (Wilson, Elliott, & Wood, 1992). Half the subjects were given a flexibility treatment over the eight week period. The rebound bench press showed a significantly better performance in the flexibility treatment group after eight weeks. Musculotendinous stiffness was measured pre and post treatment and was shown to be significantly different between the flexibility and no stretch group, with the flexibility group having a more compliant musculotendinous unit. The rebound bench press in the flexibility group was significantly better than the no stretch group on lift loads and power time curves. The power time curve was improved for the first 220 ms of the lift post treatment, but after this, the power time curve was very similar to the pre treatment. The authors concluded that a decrease in maximal series elastic component stiffness helps in utilizing elastic strain energy.

The authors of the previous study noted that their results, might only apply to activities that are relatively slow. In other research, it has been found that muscle contractions performed slowly showed a significant decrement when compared with faster contractions when preceded by a stretch protocol (Nelson, Guillory et al., 2001). In sprinting contractions are performed at a fast rate. A maximum bench press requires up to two seconds to complete the concentric part of the lift. They note that in sprinting, the role of the stretch shorten cycle involves much faster contact times and thus may not benefit in the same way as bench press. Ground contact time during sprinting in elite sprinters is often from 0.08 to 0.10 (Mero, Komi, & Gregor, 1992). Ground contact is the only time through the sprint cycle in which the sprinter is applying force. A stiffer musculotendinous unit, resulted in greater performance in concentric and isometric actions (Wilson et al., 1994).

Specific Studies of Acute Stretching and Sprinting

Decreases in 20 m sprint time have been found in warm-up that incorporates dynamic flexibility exercises, while a warm-up with static stretch exercises showed increases in 20 m sprint time (Fletcher & Jones, 2004). Pre and posttests showed significant difference in the runs of the two groups. The reasons hypothesized for static group were derived from other research previously mentioned. An increase in compliance of the MTU and neural inhibition being the two possible reasons cited. The dynamic groups decrease in time was hypothesized to be a continual warming of the muscle through the activity of the dynamic and a possible effect of rehearsing the activity, which stimulated neural patterns to be performed. This research utilized rugby players, was run for 20 m, and only time data was recorded. The stretch protocols were performed once for approximately 20 seconds each.

Static stretching on one limb or two limbs in sprint athletes has a significant increase on 20 m time when compared to non stretching (Nelson, Driscoll, Landin, Young & Schexnayder, 2005). A protocol of non stretching after a warm up was significantly better than protocols that stretched both legs, the front leg in the starting blocks in isolation and the back leg in the starting blocks in isolation on 20 m time. The stretch protocols of this study involved stretches of 30 seconds, repeated four times per leg.

The research shows contradicting evidence of positive and negative effects of the same treatments. The two studies in this section are the few found by the author dealing with sprinting and acute stretching. The purpose of this research was to identify how flexibility treatments affect sprint running performance.

CHAPTER 3

METHODOLOGY

The purpose of this study is to study the effects of four different protocols on velocity, step length, and step rate in collegiate female sprinters. The areas discussed in this chapter are the subjects, instrumentation, procedures, and statistical analysis.

Participants

Participants were all members of a NCAA Division I track and field program. The ten participants were all females, with ages from 18 to 22 and had backgrounds as track and field sprint athletes. Informed written and verbal consent was obtained from each participant before taking part in the research study. Each participant completed a brief questionnaire indicating previous leg injuries which may exclude them from the study as decided on by the researcher and athletic trainer. The Ball State University Institutional Review Board committee approved the use of human subjects and protocols for the study.

Instrumentation

All subjects signed a consent form (Appendix A) and also filled out a injury history questionnaire, identifying any possible injuries that would disqualify the subjects from participation (Appendix B).

Step length, step rate, and running velocity was obtained through video capture and analyzed with DartTrainer, version 2.5.3.62 (DartFish, Atlanta, GA) at 60 frames per second on the playback.

Procedures

Participants participated in five sessions. The first was to demonstrate and have the participants accommodate to the warm-up procedure to be used and the stretch treatments applied. The participants completed the four tests on non-consecutive days, separated by 48 hours. All tests were completed in a two week period. The tests were performed as part of the normal daily practice session. The treatments were randomly assigned to each subject. Each flexibility treatment targeted the hamstring, quadriceps, hip flexor, and tricep surae muscle groups.

Participants entered the testing area and performed a warm-up as described later in the methodologies. A 45 m sprint with a self-reported maximal effort was performed following the warm-up with the 30 to 40 segment captured on video. A cone was placed at 30 m and another at 40 m, with two cones set at the 45 m mark, to allow the participant to see the end of the run. The participant was instructed to run as close to the cones as possible. It was felt that by setting two cones at the 45 m, that the participant would focus solely on those cones and any slowly that may occur would occur closer to those cones and outside of the 30m to 40 m section. A stretch protocol or no stretch was performed and then another 45 m sprint was performed as before. A 45 m sprint was selected because it allowed the participant to reach a maintained velocity. The 30 to 40 m zone was used for analysis because it is believed that the maintenance of velocity is achieved at this point.

A no stretch group performed the warm-up and then walked slowly for five minutes. A dynamic group performed the warm-up and then performed five dynamic exercises, performing 20 repetitions for each exercise. A static stretch group performed the warm-up and then performed four static stretches on both legs for 20 seconds. A PNF group utilized a stretch of the targeted muscles group for ten seconds, a contraction of the opposing muscle group for six seconds, and then a further stretch of the targeted muscle group, three times on each leg. The total time of each stretch protocol, was attempted to be similar across all protocols. Exercises were selected that were similar for all protocols and the order of the muscles groups being stretched was similar for all participants.

After completion of a treatment, the participant waited one minute and then performed a 45 m sprint with a self-reported maximal effort. Instructions were given to the participants that no other stretching, other exercises, or sitting was to take place during the one minute period between the end of the treatment and the beginning of the run. The 30 to 40 m segment was captured on video.

The warm-up for all participants consisted of a 400 m jog at a self-selected speed. The participant then skipped, side shuffled with swinging arms, cariocaed, and backward ran for a distance of 30 m, all repeated twice. Sprinting for 40 m with the intensity reaching a self reported 80% of maximal effort was performed twice with a walk back to the start between each attempt. The participant then put on track spike shoes. A common warm-up drill for track athletes, called the ‘A’ march was performed, followed by an ‘A’ skip, followed by ‘A’ run, all repeated for 30 m performed twice. A further description of all warm-up exercises can be found in Appendix C.

The final part of the warm-up involved a 40 m sprint to a self-reported 90% of maximal effort. Three minutes of walking and standing was performed.

Pre evaluation test

The participants were in a crouched position, behind the start line. They began the run at their ready. They performed a 45 m run with 30 to 40 m segment video taped and captured from a location that was normal to the plane of movement. Three minutes were then taken before the treatments were applied.

Treatments

The dynamic group utilized five exercises, performing 20 repetitions of each exercise. The exercises used were a body weight squat, calf raises, leg swings in the frontal plane and sagittal plane, and what the author refers to as a front and back eagle. A further description of all exercises can be found in Appendix C.

The static stretch group utilized four stretches each performed once for 20 seconds. These stretches included a modified hurdler stretch (see Alter, 311 #10 for further description); a lunge stretch. (see Alter, 314 # 21 for further description); a quadriceps stretch (see Alter, 313 # 17 for further description); and a gastrocnemius stretch. (see Alter, 311 # 7 for further description). A further description of all stretches can be found in Appendix C.

The PNF exercises utilized were performed two times. A hamstring, a gastrocnemius, and a quadriceps and hip flexors stretch were used. The stretch was held for ten seconds, an isometric contraction was performed for six seconds, followed by a relaxation of the stretched muscles, and the series was repeated for a total of two times. A further description of all exercises can be located in Appendix C.

Post Evaluation Test

One minute was taken between the stretch protocol and the post evaluation test. The participants were in a crouched position, behind the start line. They began the run at their ready. They performed a 45 m run with 30 to 40 m segment which was video taped and captured from a location that was normal to the plane of movement.

Statistical Analysis

A paired sample t-test was run to determine if there were significant differences in the mean differences of each protocol pre to post for rate, length, and velocity. A separate paired sample t-test was run to determine if the differences of each protocol pre to post, were significantly different than the other protocols differences for pre to post. A value of $p \leq 0.05$ was set for significance.

CHAPTER 4

RESULTS

A paired samples t-test was run to determine if there was a significant difference for each protocol pre to post for rate, length, and velocity. A paired samples t-test was also run to determine if there were significant differences in the mean differences of the protocols pre to post when compare to other protocols. A value of $p \leq 0.05$ was set for significance.

Rate

No significant differences were found within the protocols from pre to post. When the difference of each rate was compared in a paired samples t-test, none of the protocols were significantly better. Figure 4.1 shows the change in rate for each protocol.

Length

The no stretch group showed a significant difference from pre to post on length. The post length was shorter than the pre length.

When the difference of each length was compared in a paired samples t-test, against other protocols, significant differences were found between the dynamic stretch and static stretch groups and the dynamic and no stretch group. Figure 4.2 shows the change in length for each of the protocols.

Velocity

PNF stretch showed a significant difference from pre to post on velocity. The stretch protocol intervention resulted in slower velocity.

When the difference of each velocity was compared in a paired samples t-tests, against other protocols, no significant differences were found. Figure 4.3 in shows the changes in velocity for each of the protocols.

Figures

Figure 4.1

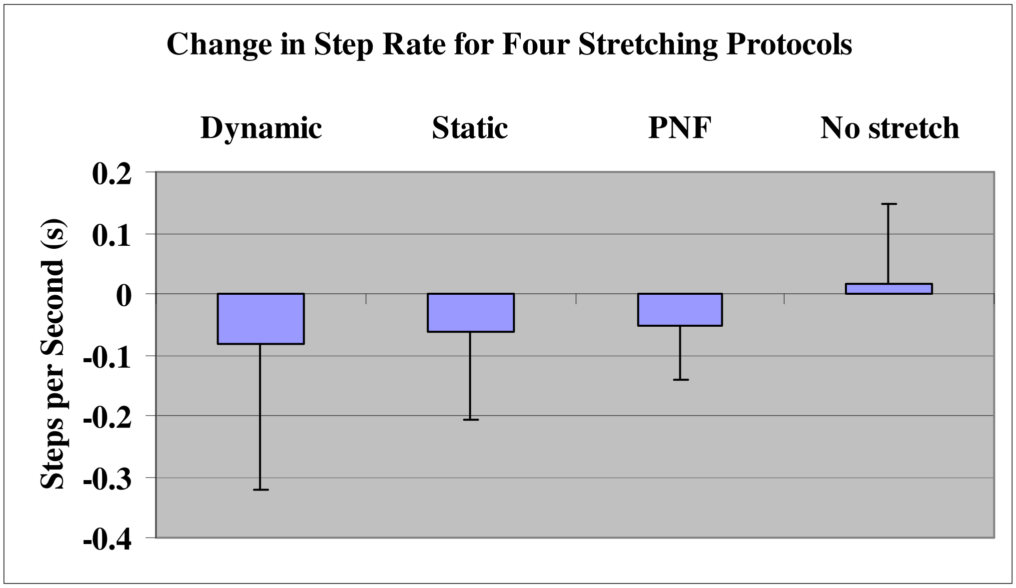
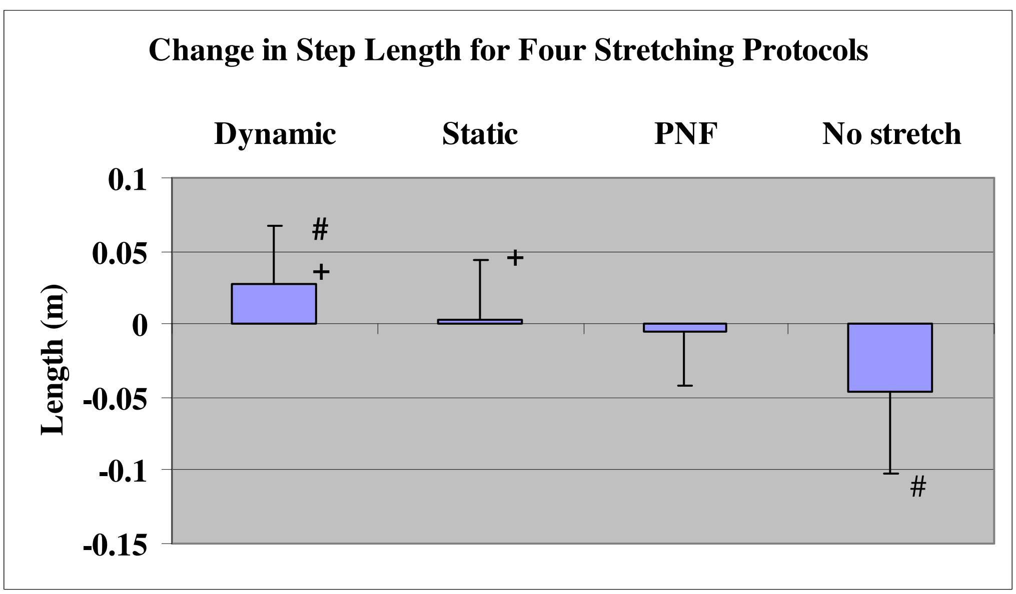


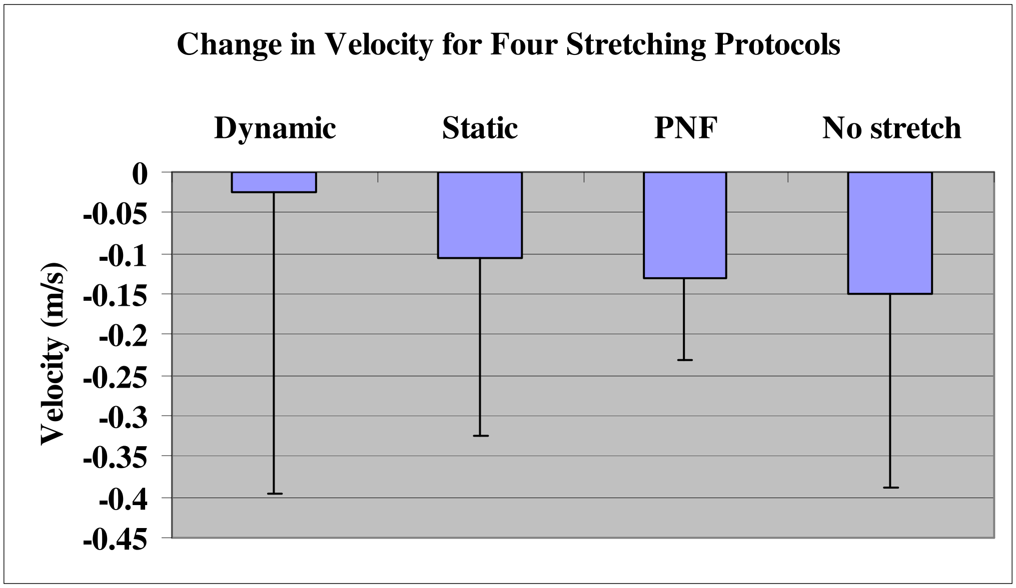
Figure 4.2



- Dynamic and no stretch showed a significant difference between the groups ($p \leq 0.05$).

+ - Dynamic and static showed a significant difference between the groups ($p \leq 0.05$).

Figure 4.3


Change in Velocity for Four Stretching Protocols
Dynamic
Static
PNF
No stretch
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
-0.35
-0.4
-0.45
Velocity (m/s)

CHAPTER 5

DISCUSSION

The purpose of this study was to determine if one type of stretching had more benefit or detriment on sprinters. Step length and step rate were analyzed to determine where changes might occur in the velocity of the participants.

Changes in step length and step rate have a direct correlation to velocity as step length times the step rate would derive the instantaneous velocity at that point. Step length and step rate also have an inverse relationship to each other when the same velocity is maintained. A change in one variable would bring about a change in the other variable in proportion to maintain that velocity. An unequal change from either will result in a change in the velocity.

All protocols had a change on the velocity, resulting in a slower velocity. The one minute that was allowed between the end of the stretch protocol and the run, may not have been a long enough time for the appropriate energy systems to be ready to work at full capacity again. However, the biggest change in velocity came from the no stretch group.

The changes seen in this study are consistent with those found in other studies. The pre to post change in velocity found with the PNF stretch, has been found in other studies for PNF. However, the lack of significant change in velocity with static stretching was not consistent with other studies and their results. These studies utilized sprinting as a test measurement (Fletcher & Jones, 2004; Nelson et al., 2005) or vertical jump or drop jump as a test measurement (Church et al., 200l; Kokkonen et al., 1998; Young & Behm, 2003; Young & Elliot, 2001). The tests of sprint times (Fletcher &

Jones) & (Nelson et al), were measured from a start to 20 m and 30 m respectively. The start of a sprint run, exhibits similar qualities to a vertical leap or drop jump, in that a countermovement occurs and inertia is overcome to allow the body to move. Decrements in sprint performance produced by runs from a zero initial velocity could possibly come within the first step or two of the run. The question of, would results continue to be changed if measured beyond the initial 30 m was proposed by Nelson, et al, in the discussion of their research. A run that is analyzed such as in the present study, was done after 30 m, and may allow whatever possible decrements in performance to not be measured. The mechanisms of change that possibly occurred in the other studies may be "reset" through the first 30 m of running in the present study.

The intensity and duration of stretch protocols in this study, varied greatly from many of the studies within this section. The author attempted to keep all stretching intensities and durations similar to those observed at various track and field and other athletic teams practice routines. Many other studies have utilized several more repetitions and intensities of stretch than this study did. Two up to four repetitions repeated from 15 s to 30 s were found to be the parameters for studies that involve the tests of a performance that seeks to duplicate sporting activities (Nelson et al., 2005; Young & Behm, 2003; Young & Elliot, 2001). A co-author of one such study, who is also a track and field coach, commented to this author, that the stretches performed were of greater duration and intensity than he had seen in a typical track and field practice situation. It has been demonstrated that acute stretching protocols can have negative effects on the ability to produce maximal force (Fowles et al., 2000; Kokkonen et al., 1998). Drop jumps, which require a rapid eccentric to concentric muscle activity, have been shown to have negative result when a stretch is performed prior (Young & Behm, 2003).

No stretch when compared to a stretch of one leg or both legs was found to be significantly better on velocity (Nelson et al., 2005). The current study found that no stretch produced the slowest velocities. The author hypothesizes that the stretch protocols were short enough in duration that a more favorable outcome was found with an intervention than with no stretch.

Studies have theorized that stretching can cause the MTU to have a length that does not allow for optimal stiffness (Rosebaum & Hennig, 1995). The viscoelastic property of the MTU, changes with stretch over a period of time such as with static or PNF protocols. One of the changes is deformation or change resulting from force the MTU occurs and lasts for an unknown period of time (Taylor, et al., 1997; Taylor, Dalton, Seaber, Garrett, 1990). The suggestion is that "slack" occurs in the MTU, causing a delay in the time that the unit has before it begins to produce force. The "slack" is not allowing forces to be transmitted as it is picked up. The author suggests that the proposed "slack" created by a stretching protocol may be reset by the initial 30 m run before measurement occurred. This should be investigated in further research.

The no stretch group had the biggest average change in pre to post measurement on velocity. The dynamic had the least average change in pre to post measurement on velocity. The author concludes that the possibilities exist that specific activity to the event, may produce a better performance. The no stretch group was allowed to stand or walk while the other protocols were performed. The dynamic group was performing movement throughout the protocol, movement which was possibly more specific to the sprinting.

When females only were measured on a vertical jump test after static and ballistic stretching, no significant differences was found on pre to post jumps (Unick, Kieffer, Cheesman, & Feeney, 2005). The current study used only trained female athletes. Other studies have used trained athletes before, so the author believes that the training state of the athletes is not significant. However a possible gender difference may exist for trained athletes and may want to be explored further.

The author draws the conclusion that PNF stretching should not be part of a routine to prepare for fast sprinting activities. Dynamic did seem to produce the best results in velocity, it was however not significant. Further investigation should look at the differences in various stages of a sprint run on velocity.

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APPENDICES

APPENDIX A

Consent to Participate

The purpose of this research is to examine the effects of several different types of stretching protocols when applied to track and field sprint athletes. You will be asked to perform a warm up that closely resembles a warm up you currently perform for your track and field activities. You will then be asked to run 45 meters at your maximal effort. You will then be asked to perform one of three stretch protocols or to stand. At the completion of the stretching you will then perform another 45 meter run at your maximal effort. It will take approximately 40 minutes to complete the activity and you will be asked to participate four separate times.

All data will be maintained as confidential. Data will be stored in the locked office of the researcher.

The risks to you will be minimal as the activities are those that you perform on a daily basis in your track and field activities. If you should feel soreness, light headed, or other physical symptoms that are not normally associated with a normal practice, you should let the researcher know and consult with the athletic trainer for your sport.

Your participation in this study is completely voluntary and you are free to withdraw from the study at anytime for any reason without penalty or prejudice from the researcher. Please feel free to ask any questions of the investigator before signing the Informed Consent form and beginning the study, and at any time during the study.

As the researcher also serves as the assistant track and field coach, it is important that you understand that your standing with the track and field team will not be impacted by your decision to participate or not participate in this study.

For one's rights as a research subject, the following person may be contacted:, Coordinator of Research Compliance, Office of Academic Research and Sponsored Programs, Ball State University, Muncie, IN 47306, (765) 285-5070.

I, ___________________________________, agree to participate in this research project entitled, "Effects of Dynamic Stretch, Static Stretch, and Proprioceptive Neuromuscular Facilitation on Running Velocity, Step Length, and Step Rate." I have had the study explained to me and my questions have been answered to my satisfaction. I have read the description of this project and give my consent to participate. I understand that I will receive a copy of this informed consent to keep for future reference.

______________________________________   _______________________

Participant's Signature   Date

____
Investigator's Signature

Todd Lane
Assistant Track and Field Coach
Ball State University
Muncie, IN 47306
Telephone: 765.285.5133
Email: twlane@bsu.edu

Edition Date: 2/20/05

APPENDIX B

Pre-Participation Questionnaire

1) Have you had any leg injury within the last 12 months that has resulted in you not being able to fully participate in sprinting?

   If yes, please list.

   Have you been cleared to participate in intercollegiate track and field by a doctor?

2) Do you currently have any leg injuries that prevent you from sprinting?

3) Do you have any recurring leg injuries which limit your participation in intercollegiate track and field?

   If yes, please list.

APPENDIX C

Description of Warm-up and Treatment Exercises

Warm Up Exercises

Side Shuffle with arms

Participant turned perpendicular to track, with feet should width apart. A shuffle or skipping rhythm was used as the participant moved laterally through the frontal plane. Arms crossed in front of body, while legs were brought together. Arms then moved in a vertical direction, abducting at the shoulder with hands meeting above the head. Arms then were brought back to starting point. Legs were adducted and abducted, moving the body down the track. Legs were together at the same time arms were together in front of the body. This was repeated with the body facing the same direction, but moving laterally to the original starting point.

Carioca

Participant turned perpendicular to normal. Arms were held out to the side of the body with extension at the elbows, creating a 90-degree angle with the torso. The front leg was kept straight. The back leg was flexed at the hip and knee as it was brought in front of the front leg. The body moved laterally down the track. This was repeated moving back to the starting point with the body facing the same direction.

A Skip

Participant faced forward on the running track. Feet were shoulder width apart. A skip begins with one leg being lifted with flexion at the hip and knee. The foot was dorsal flexed. The thigh was brought to parallel with the foot under the knee. The back leg was extended and the foot planter flexed to project the body in a horizontal direction.

The front leg was then extended to the ground and the back leg is brought forward and up. A skipping rhythm was utilized.

A Run

Participant achieved same motion as in A skip, but activity was done in a running rhythm.

Fast Leg Continuous

Participant achieved same motion as in A run. One leg was kept extended, while the opposite leg continuously performed A run motion. This was repeated on the opposite leg.

Figure C.1 shows the ‘A’ action that is described for the above exercises.

Dyanamic Stretch

Squat

Participant assumed a position with feet shoulder width apart. A squat maneuver was performed with hands resting on the hips.

Leg Swings

Participant stood with feet shoulder width apart with body facing the wall. Both arms were extended and placed on the wall to serve as support and balance for the body. One leg remained straight in support with the ground. The other leg was swung in front of the body side to side adducting and abducting. This was then repeated with the opposite leg.

Leg Swing

Participant stood with feet shoulder width apart perpendicular to a wall. One arm was extended and placed on the wall to serve as support and balance for the body. The leg furthest from the wall, was slightly flexed and in support with the ground. The leg closest to the wall, was slight flexed and was swung back and forth, flexing and hyper extending at the hip. The body turned was turned and faced the opposite direction and the leg swing was repeated.

Front Eagle

Participant lay in a supine position, with arms extended and abducted out to their side. A single leg was flexed at the hip and raised to a 90-degree angle. The leg was then abducted and the angle of the hip flexion increased as the participant placed the foot on the ground.

Back Eagle

Participant lay in a prone position, with arms extended out to their side. A single leg was extended at the hip, raised, and adduction occurred with lateral flexion of the lower back as the participant attempted to touch the floor with their foot.

Calf Raise

The participant stood with feet shoulder width apart and hands placed on their hips. They then raised their heels off the ground, by plantar flexing the ankle joint. This was repeated twenty times.

Static Stretch

Modified Hurdler Stretch

Participant sat upright on the ground with legs extended. One knee was flexed and the heel slid into the inner thigh of the opposite leg. The participant then extended the arms forward reaching towards the toe of the extended leg with the torso flexing at the hip. The participant held the stretch at a position where the stretch was felt in the hamstring and before pain was felt. Participant then performed the same stretch in the same position on the opposite leg.

Lunge

Participant stood upright with feet placed shoulder width apart with the hands placed on hips. The feet were then separated in the sagittal plane with one leg placed in front of the body and the other placed behind the body. The front knee was flexed and the opposite knee was placed on the ground. The front knee was flexed at approximately 90 degrees with the foot keep directly under the knee. The foot in the back was rolled so that the top of the foot was on the ground. The hips were pushed forwards with the torso remaining in an upright position and extension of the hip of the back leg occurred. Participant then performed the same stretch in the same position on the opposite leg.

Quadriceps Stretch

Participant stood with feet shoulder width apart. One leg remained extended and in contact with the ground as the support leg. The arm on the side of the body of the leg to be stretched was extended behind the body to assist in holding the foot. Flexion at the knee allowed the foot to be pulled to the buttocks. The stretch was applied as the arm and hand of the opposite arm grabbed the top of the foot and increased the flexion. Participant then performed the same stretch in the same position on the opposite leg.

Gastrocnemius Stretch

Participant faced a wall and stood approximately an arms length away from the wall. One leg was placed behind the body, the other in front. Participant leaned against the wall with both arms extended out to support body weight. The hip and knee of the leg placed behind the body were extended. The knee was in full extension. The ankle joint was dorsal flexed with the heel of the foot being in contact with the ground. The front leg was flexed at the hip and knee and dorsal flexed.

Proprioceptive Neuromuscular Facilitation

Hamstring

Participant lay in supine position with both legs extended on the ground. One leg was raised, by flexion at the hip while the other leg remained extended and placed on the ground. The knee joint of the raised leg remained extended. The leg was moved to a point of flexion at the hip that did not produce pain in the subject, but allowed the subject to feel a stretch occur in the hamstring. This was held for 10 seconds. An isometric contraction was then performed with the participant pushing the raised leg firmly against the researcher's shoulder. This was performed for 10 seconds. The participant then relaxed for three seconds. The leg was then slowly flexed further at the hip by the researched to a position where a stretch was felt in the hamstring but pain did not occur. The isometric contraction and stretch were repeated for a total of three times. The other leg remained extended on the ground. Both legs received the same treatment.

Quadriceps & Hip Flexors

The participant lay in a prone position. The researcher placed one hand on the lower back of the leg to be stretched and grabbed the knee of the leg to be stretched. The knee was flexed with the foot curled close to the buttocks. The knee was then pulled vertically, creating extension of the hip flexors. This was done until just before the participant felt pain. The stretch was held for 10 seconds. The participant then pushed the knee down to the ground with the researcher providing resistance. This was done for six seconds and repeated for a total of three time on both legs.

Tricep Surae

In a supine position, one leg remained on the ground, extended straight, while the other was raised to approximately a 90 degree angle at the hip. The researcher placed a hand on the bottom of the participants shoe and pushed the foot into dorsal flexion. This was done for 10 seconds. The participant then pushed the foot towards plantar flexion, with the researcher providing resistance. This was done for six seconds and repeated three times.

Figure C.1 ‘A’ Action of A March, A Skip, & A Run