THE ACUTE EFFECTS OF STATIC STRETCHING ON THE SPRINT PERFORMANCE OF COLLEGIATE MALES IN THE 60 AND THE 100 METER DASH

by Brandon Michael Kistler

This study used a within-subjects design to investigate the effects of passive static stretching on sprint performance in college track athletes. Eighteen male subjects (Age 20.3±1.4 years; height 183.7±5.5 cm; mass 78.4±6.2 kg) were matched for event and completed both the static stretching and the no stretching (rest) conditions in counter-balanced order. On each day, subjects first completed a generalized dynamic warm-up routine that included a self-paced run, followed by a series of dynamic, sprint, and hurdle drills. Following this warm-up, athletes were assigned to either a static stretching or a no stretching (rest) condition. They then immediately performed two 100 meter trials. Results revealed difference in performance between the rest and static stretching conditions (p<0.039) in the second 20 (20-40) meters of the sprint trials. However, static stretching exhibits no additional inhibition on performance following the first 40 meters of a 100 meter sprint.
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A Thesis

Submitted to the
Faculty of Miami University
in partial fulfillment of
the requirements for the degree of
Masters of Science
Department of Kinesiology and Health

by
Brandon Michael Kistler

Miami University
Oxford, Ohio
2009

Advisor______________________________
Dr. Mark Walsh

Reader______________________________
Dr. Ron Cox

Reader______________________________
Dr. Thelma Horn
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Introduction

Prior to athletic competition athletes commonly engage in static stretching because of the belief that it may increase performance and decrease the risk of injury (Shellock and Prentice, 1985; Alter, 1996; Smith, 1994). However, recent studies have questioned whether static stretching benefits performance. There is increasing evidence that static stretching may actually inhibit performance of isolated muscles on movements requiring maximal force production (Avela et al., 1999; Cornwell et al., 2001; Kokkonen, Nelson and Cornwell, 1998; Nelson et al., 2001). This inhibition has also been found in more complex movements such as the drop jump where success depends on the rate of force production (Young and Elliot, 2001). These studies leave questions as to what effects static stretching may have on performance in events that depend on both repeated maximal force production and rate of force production for movement success.

Events that require both repeated maximal and high rates of force production have been investigated in research studies looking at the effects of static stretching in terms of sprint performance. Nelson and colleagues (2005) recruited 16 collegiate track athletes and stretched either their front or back leg in the starting blocks or both of their legs. They found that all three conditions produced a significant decrement in performance as compared to a non stretch control over the first 20 meters of a race. Similarly, Sayers et al. (2008) conducted a study with 20 female soccer players and compared them on an acceleration phase (0-10 meters) and a maximal velocity phase (10-30 meters) when static stretched or not stretched. They found a 0.1 second increase in sprint time over the entire 30 meters following static stretching, including a significant increase (p<0.05) between the two groups over the first 10 (0.05) and from 10-30 meters (0.07).

Protocols involving static stretching have also been compared to a dynamic warm up. Little and Williams (2006) recruited 18 professional soccer players and engaged them in a either a dynamic, static or no stretch warm up. On a 10 meter standing acceleration they found that a dynamic warm up but not a static stretch provided an improvement in performance. In this study they also tested athletes on a 20 meter fly as a measure of maximum speed. Using this test they found that both dynamic and static stretching protocols resulted in faster times than that found in a no stretch control. However, no significant differences in times were found between the dynamic and static stretching protocols.

Finally, studies have looked at protocols that compare combinations of static and dynamic warm ups. Fletcher and Anness (2007) recruited club track athletes and engaged them in a combinations of static and dynamic warm ups. They then had the athletes complete a 50 meter sprint through timing gates. When a passive static stretch was added to a dynamic warm up it resulted in a significant decrease in performance at 50 meters. Similarly, Fletcher and Jones (2004) compared four different stretching protocols with rugby players. Their results were consistent with previous findings in that the athletes with a static component to their warm up had significantly slower times over a 20 meter sprint. Using a within subject design Winchester et al. (2008) took collegiate track athletes and put them through their normal daily dynamic warm up. Following this warm up they had the athletes either rest or static stretch and then
perform three maximal sprint trials. They found that static stretching had an inhibitory effect over the second 20 meters of the sprint. When they coupled the second twenty meters with the first twenty meters the entire 40 meter sprint was significantly slower (p<0.05, 0.10 second difference) following static stretching.

The combined findings from these studies suggest that static stretching inhibits performance on maximal sprint trials shorter than 50 meters. Based on these research results, two overriding categories of hypotheses have emerged as potential explanations for this phenomenon: a decrease in efficiency of force transfer and acute neural inhibition.

However, up until this point research has only taken into account sprint performance in distances up to 50 meters. These studies have left questions about whether the inhibitory effect exhibited in athletes who have undertaken static stretching would be maintained, magnified or disappear at longer distances such as those seen in competition. Thus, these previous studies have not taken into account the deceleration phase of a sprint event where fatigue of the neural system causes a decrease in power output (Taylor et al., 2006; Mero and Peltola, 1989, Ross et al., 2001). It is possible that the effects of static stretching on neural inhibition may be mitigated in a race that is long enough to significantly fatigue the central neural sources. Finally, leg stiffness has been shown to be important to the acceleration and maximal velocity phases of the sprint, but contrary to expectations, results in the final phase of a 100 meter dash have been more conflicting with some studies showing a greater deceleration later in the race in athletes with the most stiffness (Bret et al., 2002) and others suggesting the opposite (Chelly and Denis, 2001). Thus, it is possible that the benefits experienced in the early portion of the race will not be experienced or could even be reversed later in the race. Therefore, the purpose of this study is to compare the effects of static stretching versus no stretching (rest) following a dynamic warm-up on sprint performances up to 100 meters in college track athletes.

Methods

Experimental Approach to the Problem

A within-subjects experimental design was used, with all athletes completing both a static stretch (S) and a non stretch (NS) condition. Data were collected across two test sessions that were separated by a period of two days. Test order and day were counter-balanced across subjects. The effects of static stretching (S) versus non stretching (NS) were tested by comparing subjects' timed sprint performance across the two conditions.

Participants

Eighteen sprinters, hurdlers, vertical and horizontal jumpers, pole vaulters, and multi event athletes (Age 20.3 ± 1.4 years, height 183.7± 5.5cm, mass 78.4± 6.2kg) were purposively recruited from the Varsity Track and Field team at Miami University. These participants all had extensive experience with both the sprint start and the timing gate system that was used in this study. Prior to participation, the athletes were given a description of the research protocol, after which informed consent was obtained from all athletes. All procedures involved in this study were reviewed and approved by the Institutional Review Board at Miami University prior to initiation of the research.
**Procedures**

The testing procedures took place during an off week designed to peak the athletes prior to an intra-squad meet. The testing sessions were performed outside during the normal practice time, 48 hours from any other structured physical activity. On the first of the two testing days, the athletes first performed their normal daily warm up. This generalized warm up routine consisted of a self paced 800 meter jog followed by dynamic movements intended to mimic those in sprinting. This warm up also included various sprint and hurdle mobility drills. The entire warm up took approximately 25 minutes to complete. Following the generalized warm-up session, the athletes were matched according to their event group and randomly placed into either a static stretching (S) or non stretching (NS) group.

The experimental static stretching (S) procedure used in this study was adopted from Winchester et al (2008). In particular, four passive static stretches that were intended to stretch the calf, hamstring and thigh were used. The stretches were completed in order, and the legs were alternated. The stretches were held for 30 seconds from the time of mild discomfort. The subjects were allowed to rest for 20 seconds between stretches and 30 seconds between sets. Subjects in the non stretching (NS) condition rested during the static stretching time period.

Following the stretch or non stretch condition, the athletes performed two timed test-trials of 100 meters from standard starting blocks. The trials were separated by a minimum of 10 minutes. The blocks were set to the specifications of the athletes. The athletes were allowed to do their normal starting routine as long as it did not involve any static stretching. The trials were timed with an electronic timing system with gates set at 0, 20, 40, 60 and 100 meters (Speedtrap II, Brower Timing Systems, Draper, UT). The time was initiated voluntarily when the athlete's hand left a pressure sensor placed under the fingers of the right hand, and recorded the time when the athlete broke a plane at each of the measurement locations. On the second day of testing, the same protocol was used except that all athletes completed the opposite warm-up condition (static stretch or non stretch) just prior to the sprint performance.

**Statistical Analysis**

Statistical examination of the data began with some preliminary analysis. First, intraclass correlation coefficients were computed to assess the consistency or reliability of the two timed trials within each experimental condition. These obtained coefficients were all equal to, or higher than, 0.86 in all of the distances covered, and at the longest distances (0-100) were as high as 0.98. Given these high correlations, the two trial times were averaged, and this mean value was used for the main study analyses.

Second, because the timed trials were run outside and across two different days, there existed the possibility that environmental conditions might have affected the results. Therefore, a series of repeated measures ANOVAs were run to test for any possible day effects. In addition, a series of mixed model ANOVAs were run to determine if the order in which subjects completed the two experimental conditions (S and NS) affected their sprint performance. The results of these ANOVAs revealed no significant day or order effects and no significant interaction effects. Thus, data were collapsed across day and test order for the main study analyses.
To test for the study’s main hypothesis regarding the effects of stretching (S) and no stretching (NS) on athletes’ sprint performance, a series of paired samples t-tests were conducted. Specifically, these dependent t-tests compared S and NS conditions at each of seven timed distances (0-20, 20-40, 40-60, 60-100, 0-40, 0-60, and 0-100).

**Results**

Descriptive data (means and standard deviations) for the stretch and no stretch conditions are provided in Table 1. The results of the paired samples t-tests comparing these two conditions at each of the four sprint intervals revealed that a statistical difference (p<0.039) existed only for athletes’ performance from 20-40 meters. Specifically, athletes who used the static stretching protocol just prior to the sprint performance were 0.03 seconds slower over this distance than when they did not use the static stretching protocol. Although the static stretching trials were also 0.02 seconds slower over the first twenty meters (0-20), this value was not significantly different (p<0.273) from that found in the non stretching condition. Furthermore, as indicated in Table 1, there was less than 0.01 second difference between the stretch and no stretch conditions at the 40-60 and 60-100 meter times, and these values were not statistically different from each other.

Table 1. The Effect of Stretching Condition on Segment Sprint Time

<table>
<thead>
<tr>
<th>Values are Mean ± SD. Time (Seconds)</th>
<th>0-20 Meters</th>
<th>20-40 Meters</th>
<th>40-60 Meters</th>
<th>60-100 Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stretch</td>
<td>3.10±0.07</td>
<td>2.17±0.06*</td>
<td>2.11±0.07</td>
<td>4.38±0.14</td>
</tr>
<tr>
<td>No Stretch</td>
<td>3.08±0.09</td>
<td>2.14±0.08</td>
<td>2.11±0.08</td>
<td>4.39±0.16</td>
</tr>
</tbody>
</table>

*Significant between stretch and no stretch conditions (P<0.05)

Descriptive data were also calculated for the average cumulative times across the 100 meter sprint performance (see Table 2). Paired samples t-tests comparing the stretch and no stretch conditions at each of these time points revealed no statistically significant differences, but two of them did approach significance. In particular, at the 40 meter interval, a 0.05 second difference existed between the mean times of the two conditions, but this difference was not statistically significant (p<0.086). Similarly, there was also a 0.05 second difference observed at the 0-60 meter interval. This difference came close to statistical significance (p<.051).

Table 2. The effect of Stretching Condition on Cumulative Sprint Time

<table>
<thead>
<tr>
<th>Values are Mean ± SD. Time (Seconds)</th>
<th>0-40 Meters</th>
<th>0-60 Meters</th>
<th>0-100 Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stretch</td>
<td>5.27±0.09</td>
<td>7.38±0.15</td>
<td>11.76±0.27</td>
</tr>
<tr>
<td>No Stretch</td>
<td>5.22±0.14</td>
<td>7.33±0.19</td>
<td>11.71±0.33</td>
</tr>
</tbody>
</table>

*Significant between stretch and no stretch conditions (P<0.05)

**Discussion**

In the present study, we found an inhibitory effect of static stretching over the second twenty meters of a 100 meter sprint following a dynamic warm up. These results are similar to those found by Winchester et al. (2008). However, Winchester also found a statistically
significant difference from 0-40 meters that the present study did not find. This was likely due to their inclusion of both male and female collegiate track athletes and the greater number of subjects in their study. Despite the fact that we did not find a significant difference, static stretching still resulted in a mean difference of 0.05 seconds over the first 40 meters of the race. This finding supports previous work (Fletcher and Anness, 2007; Fletcher and Jones, 2004; Nelson et al., 2005; Sayers et al., 2008; Winchester et al., 2008) that suggested an inhibitory effect of static stretching on performance.

A number of hypotheses have been proposed to explain this phenomenon at the shorter distances that have been covered in previous studies. Many of these hypotheses deal with the stiffness of the system. The musculotendon unit itself has the ability to store energy that can be returned after it is stretched. This process has been termed elastic potentiation, and is likely a function of the unit’s stiffness. However, static stretching has been associated with decreased stiffness of the muscle (Rosenblau and Hennig, 1995). Belli and Bosco (1992) suggested that there may be an optimal stiffness for energy return in different actions. These findings are supported by Bret et al. (2002), who found that the optimal stiffness for performance changed throughout the different phases of the sprint. A second hypothesis dealing with stiffness was proposed by Fletcher and Jones (2004). They proposed that a decrease in preactivation, or the stiffening of the musculotendon unit prior to ground contact, affects the eccentric phases of the movement. The changes in preactivation decrease the amount of energy recovered from the stretch shortening cycle.

This decrease in active stiffness also changes the activation from the spindle reflex. During events such as sprinting that exhibit a stretch reflex, increased compliance of the system that accompanies static stretching may result in less activation of the muscle spindle during the eccentric phase of the movement. This decrease in activation would in turn lead to less activation of the muscles during the following concentric movement, causing a decrease in performance.

The current study set out to look at what would happen to this inhibitory effect at actual racing distances. The results of this study show that there is no significant difference between the two conditions over the last 60 meters (40-100) of the race. In fact, the time in the two conditions was nearly identical. Therefore, it appears that there is no additional inhibitory effect of static stretching at longer distances. These findings support the findings of Nelson et al. (2001) who found that the inhibitory effect of static stretching was only manifested at the slowest contraction velocities such as those that would be seen at the beginning of a race. However, it is interesting to note that the athletes did not recover the time that was lost over the first 40 meters of the race, and were therefore still 0.05 seconds slower at the end of both 60 and 100 meters following static stretching. In the course of a 60 meter dash or a 100 meter dash this decrease in performance could make a considerable difference in the outcome of the event.

While the nature of this study does not lend itself to determining a mechanism it is possible to speculate. Neural mechanisms have been proposed to explain the decrease in performance experienced in athletes with static stretching over the first 40 meters of a sprint. The increased compliance of the muscle decreases the afferent signal of the reflex during the eccentric phase of the sprint. Bret et al. (2002) found that sprinters with the greatest leg stiffness accelerated more during the second phase of a sprint (30-60 meters). However, they also found
that these same athletes decelerated more than athletes with the lowest stiffness during a 100 meter dash. They proposed that the athletes with the greatest stiffness became more fatigued. Central neural fatigue occurs naturally over the course of a 100 meter dash (Mero and Peltola, 1989; Taylor et al., 2006). Since the activation of the muscle is likely a combination of both the central and peripheral activation, it is possible that a greater central fatigue in the non stretched athletes is enough to wash out the peripheral inhibition that is proposed following static stretching.

The spindle reflex itself may also experience fatigue during the course of a 100 meter dash (Horita et al., 1996). If this reflex is the cause of differences in performance over the first 40 meters as has been hypothesized in previous studies, it is possible that as this reflex fatigues the difference in performance may decrease as well allowing for similar performance over the remaining portion of the race.

Hypotheses have also been proposed that deal with the stiffness of the musculotendon system. Chelly and Denis found that leg stiffness was correlated with maximum running velocity ($r=0.68$, $P<0.05$). Other researchers have also found that leg stiffness is beneficial in activities that involve a stretch shortening cycle (Alter, 1999; Belli and Bosco, 1992). While the system should not be viewed as passive, it is hypothesized that a stiffer system would have less “slack” to take up placing the muscle on a more appropriate location on both the force/length and force/velocity curve. This would make a stiff system the most beneficial at high velocities when contact times are the shortest. However, the findings of this study do not support this notion.

A reason the current study may not have echoed previous studies in terms of stiffness is that the effects of stiffness may not be entirely beneficial in the later portions of a race. One way in which this stiffness could be harmful to performance is by increasing the muscular resistance (Alter, 2004; de Vries, 1963). Flexibility, which can be increased acutely by stretching, decreases the body’s muscular resistance. By decreasing the resistance to motion the trial can be carried out more efficiently, allowing more of the force generated to go towards the event goal as well as decreasing the fatigue at the end of the race. If this reduced resistance was to benefit a sprint performance, it would be expected that it would benefit the performance during the maximal speed component of the race where the athlete would experience the highest range of motion, and the most potential to encounter muscular resistance. This argument may be hindered somewhat by the fact that Favero and colleagues (2009) found that athletes with the greatest baseline flexibility were more likely to have a decrease in performance following static stretching over the first 40 meters of a sprint. However, these distances likely did not encompass a significant portion of the maximal velocity stage.

In order to test at 100 meters it was necessary to test subjects outside. While statistically there were no significant differences between day or order effects, it is possible that performances were in some way affected by the external conditions. However, these are the conditions that sprint events commonly take place in and there is something to be said for the ecological validity that this testing environment provided. Another weakness in this study was the lack of a control group that would not have warmed up. While this study could have benefited from a condition in which neither warm up was undertaken, a no warm up control, this was not possible with the population that we used.
While the current study found that there was no additional inhibition during the final 60 meters of a 100 meter dash, it is possible that performance in even longer events could actually benefit from static stretching. Therefore, future research should focus on the effects of static stretching over longer race distances. Furthermore, the field would benefit from research exploring the causes of the decrease in performance that follow static stretching in sprint performance.

**Practical Applications**

This study suggests that static stretching has a negative effect on performance in the first 40 meters of a 100 meter sprint. This decrement in performance is carried over but not increased over the remaining distance in the race. In strict terms of performance it seems unwarranted to engage in static stretching following a dynamic warm up. However, athletes do not static stretch solely for the effect that it has on performance. Athletes also use stretching as a means of injury prevention, and this study does not suggest anything about the effectiveness of static stretching in this regard. However, it does give athletes and professionals additional information to weigh when designing warm up routines prior to competition.
References


