THE ACUTE EFFECTS OF STATIC STRETCHING ON THE SPRINT PERFORMANCE OF COLLEGIATE MEN IN THE 60- AND 100-M DASH AFTER A DYNAMIC WARM-UP

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ABSTRACT

Kistler, BM, Walsh, MS, Horn, TS, and Cox, RH. The acute effects of static stretching on the sprint performance of collegiate men in the 60- and 100-m dash after a dynamic warm-up. *J Strength Cond Res* 24(9): 2280–2284, 2010—Previous research has shown that static stretching has an inhibitory effect on sprinting performances up to 50 m. The purpose of this study was to see what would happen to these effects at longer distances such as those seen in competition. This study used a within-subjects design to investigate the effects of passive static stretching vs. no stretching on the 60- and 100-m sprint performance of college track athletes after a dynamic warm-up. Eighteen male subjects completed both the static stretching and the no stretching conditions in counterbalanced order across 2 days of testing. On each day, all subjects first completed a generalized dynamic warm-up routine that included a self-paced 800-m run, followed by a series of dynamic movements, sprint, and hurdle drills. At the end of this generalized warm-up, athletes were assigned to either a static stretching or a no-stretching condition. They then immediately performed 2 100-m trials with timing gates set up at 20, 40, 60, and 100 m. Results revealed a significant slowing in performance with static stretching ($p < 0.039$) in the second 20 (20–40) m of the sprint trials. After the first 40 m, static stretching exhibited no additional inhibition of performance in a 100-m sprint. However, although there was no additional time loss, athletes never gained back the time that was originally lost in the first portion of the trials. Therefore, in strict terms of performance, it seems harmful to include static stretching in the warm-up protocol of collegiate male sprinters in distances up to 100 m.

KEY WORDS stiffness, neural activation, resistance

INTRODUCTION

Before athletic competition, athletes commonly engage in static stretching because of the belief that it may increase performance and decrease the risk of injury (1,21,22). However, recent studies have questioned whether static stretching benefits performance. There is increasing evidence that static stretching may actually inhibit performance of movements requiring maximal force production (2,7,13,16,17). This inhibition has also been found in more complex movements such as the drop jump (26) and the countermovement jump (24) where success depends on the rate of force production. Although these studies provide information on single movements, they 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 et al. (16) 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 3 conditions produced a significant decrement in performance as compared to a nonstretch (NS) control over the first 20 m of a race. Similarly, Sayers et al. (20) conducted a study with 20 female soccer players and compared them on an acceleration phase (0–10 m) and a maximal velocity phase (10–30 m) when static stretched or not stretched. They found a 0.1-second increase in sprint time over the entire 30 m after static stretching, including a significant increase ($p < 0.05$) between the 2 groups over the first 10 (0.05) and from 10–30 m (0.07).

Protocols involving static stretching have also been compared with a dynamic warm-up. Little and Williams (14) recruited 18 professional soccer players and engaged them in a dynamic, static, or no-stretch warm-up. On a 10-m standing acceleration, they found that a dynamic warm-up but not a static stretch (SS) provided an improvement in performance. In this study, they also tested athletes on a 20-m fly as a measure of maximum speed. Using this test, they

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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 (10) recruited club track athletes and engaged them in a combination of static and dynamic warm-ups. They then had the athletes complete a 50-m sprint through timing gates. When an SS was added to a dynamic warm-up, it resulted in a significant decrease in performance at 50 m. Similarly, Fletcher and Jones (11) compared 4 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-m sprint. Finally, Winchester et al. (25) took collegiate track athletes and put them through their normal daily dynamic warm-up followed by either a rest or static-stretch condition. They then had them perform 3 maximal sprint trials. They found that static stretching had an inhibitory effect over the second 20 m of the sprint. When they coupled the second 20 m with the first 20 m, the entire 40-m sprint was significantly slower ($p < 0.05$, 0.10-second difference) after static stretching.

The combined findings from these studies suggest that static stretching inhibits performance on maximal sprint trials shorter than 50 m. Based on these research results, 2 overriding categories of hypotheses 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 m. These studies have left questions about whether the inhibitory effect exhibited in athletes who have undertaken static stretching would be maintained at longer distances such as those commonly 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 may cause a decrease in power output (15,19,23). If neural inhibition is in fact responsible for the decrease in performance exhibited at shorter distances, 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 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-m dash have been more conflicting with some studies showing a greater deceleration later in the race in athletes with the most stiffness (4) and others suggesting the opposite (5). Thus, it is possible that any detrimental effects observed in the early portion of the race as a result of static stretching will not be experienced later in the event. Therefore, the purpose of this study is to compare the effects of static stretching vs. no stretching (rest) after a dynamic warm-up on sprint performances up to 100 m in college track athletes.

METHODS

Experimental Approach to the Problem

The study used a within-subject experimental design, with all athletes completing both an SS and an NS condition. Data were collected across 2 test sessions that were separated by a period of 2 days. Test order and day were counterbalanced across subjects to prevent any possibility of an order effect. The effects of SS vs. NS were tested by comparing subjects' timed sprint performance across the 2 conditions.

All testing procedures took place during an off week in the Fall designed to peak the athletes before a preseason intrasquad meet. To enhance ecological validity, testing sessions were performed outside during the normal practice time, 48 hours from any other structured physical activity. On the first of the 2 testing days, the athletes performed a typical track warm-up that was also their normal daily warm-up. This generalized warm-up routine consisted of a self-paced 800-m jog followed by dynamic movements intended to mimic those in sprinting, sprint, and hurdle mobility drills. The entire warm-up took approximately 25 minutes to complete. After the generalized warm-up session, the athletes were matched according to their event group and randomly placed into either a SS or NS group. On the second of the 2 testing days, the same general warm-up procedure was used, but athletes then completed the opposite experimental condition (i.e., those who had completed the SS on the first day completed the NS on the second day and vice versa). All athletes then completed, again, the 2 timed 100-m sprints.

Within 2 minutes of completing their daily stretching condition, athletes initiated the first of 2 100-m sprint trials. The trials were started from standard starting blocks set to each athlete's preferences. The trial began when each athlete's hands left a pressure sensor placed under their right hand. The time for each segment of the sprint was taken when the athlete broke a laser light beam. To maximize consistency, the light beams were set to the height of each participant's waist.

Subjects

Eighteen sprinters, hurdlers, vertical and horizontal jumpers, pole vaulters, and multievent athletes (age 20.3 ± 1.4 years, height 183.7 ± 5.5 cm, and mass 78.4 ± 6.2 kg) 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. Before participation, athletes were informed of the experimental risks and signed an informed consent document. All procedures involved in this study were reviewed and approved by the Institutional Review Board at Miami University before initiation of the research.

Procedures

The experimental SS procedure used in this study was adopted from Winchester et al. (25). In particular, 4 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.

After the SS or NS condition, the athletes performed 2 timed test trials of 100 m from standard starting blocks. The trials were separated by a minimum of 10 minutes, and the first trial took place no longer than 2 minutes after they finished warming up. The blocks were set to the specifications of the athletes, and 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 m (Speedtrap II, Brower Timing Systems, Draper, UT, USA). 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 (SS vs. NS) just before the sprint performance.

Statistical Analyses

Statistical examination of the data began with some preliminary analysis. First, intraclass correlation coefficients were computed to assess the consistency or reliability of the 2 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. In short, the cumulative correlations for the NS conditions were 0.875, 0.916, 0.947, and 0.957 at 20, 40, 60, and 100 m, whereas the stretch conditions had correlations of 0.860, 0.883, 0.878, and 0.933. Given these high correlations, the 2 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 2 different days, there existed the possibility that environmental conditions might have affected the results. Therefore, a series of repeated measures analyses of variance (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 2 experimental conditions (SS 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 SS and NS on athletes' sprint performance, a series of paired samples *t*-tests were conducted. Specifically, these dependent *t*-tests compared SS and NS conditions on segment sprint times (0–20, 20–40, 40–60, and 60–100) and on cumulative sprint times (0–40, 0–60, and 0–100). The alpha level for significance for all statistical analyses was set at $p \leq 0.05$.

RESULTS

Descriptive data (mean and *SD*s) for the effects of stretch and no stretch conditions on athletes' segment sprint times are provided in Table 1. The results of the paired samples *t*-tests comparing these 2 conditions at each of the 4 sprint intervals revealed that a statistical difference existed only for athletes' performance from 20 to 40 m ($t(17) = 2.243$, $p < 0.039$). Specifically, athletes who used the static stretching protocol just before the sprint performance were 0.03 seconds slower over this distance than when they did not use the static stretching protocol. The calculated effect size ($d = 0.53$, $r^2 = 0.23$) indicated a medium effect (6). Although the static stretching trials were also 0.02 seconds slower over the first 20 m (0–20), this value was not significantly different ($p < 0.273$) from that found in the nonstretching 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 m times, and these values were not statistically different from each other.

TABLE 1. The effect of stretching condition on segment sprint time.*

Time (s)	0–20 m	20–40 m	40–60 m	60–100 m
Stretch	3.10 ± 0.07	2.17 ± 0.06†	2.11 ± 0.07	4.38 ± 0.14
No-stretch	3.08 ± 0.09	2.14 ± 0.08	2.11 ± 0.08	4.39 ± 0.16

*Values are mean ± *SD*.
†Significant between stretch and no-stretch conditions ($p < 0.05$).

TABLE 2. The effect of stretching condition on cumulative sprint time.*

Time (s)	0–40 m	0–60 m	0–100 m
Stretch	5.27 ± 0.09	7.38 ± 0.15	11.76 ± 0.27
No-stretch	5.22 ± 0.14	7.33 ± 0.19	11.71 ± 0.33

*Values are mean ± *SD*.

Descriptive data were also calculated for the average cumulative times across the 100-m 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 2 of them did approach significance. In particular, at the 40-m interval, a 0.05-second difference existed between the mean times of the 2 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-m interval. This difference came close to statistical significance ($t(17) = 2.098$, $p < 0.051$).

DISCUSSION

In the present study, we found an inhibitory effect of static stretching over the second 20 m of a 100-m sprint after a dynamic warm-up. This finding mimics those by Winchester et al. (25) and supports previous findings (10,11,16,20,25) that suggest an inhibitory effect of static stretching on sprint performance. However, Winchester et al. also found a statistically significant difference from 0 to 40 m that the present study did not find. This was likely because of their larger sample size. The possibility also exists that this value was affected by differences in times from stretch (less than 2 minutes vs. 10 minutes), other activity, baseline flexibility, or their inclusion of both male and female athletes. 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 m.

However, the current study was designed to assess 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 2 conditions over the last 60 m (40–100) of the race. In fact, the time in the 2 conditions was nearly identical. Therefore, it appears that there is no additional inhibitory effect of static stretching at longer distances. However, it is interesting to note that the athletes did not recover the time that was lost over the first 40 m of the race and were therefore still 0.05 seconds slower at distances of both 60 and 100 m after static stretching. In the course of a 60- or 100-m dash, this decrease in performance could still make a considerable difference in the outcome of the event.

Neural mechanisms have been proposed to explain the decrease in performance over the first portions of a sprint that are experienced as a result of static stretching. One of the potential effects of static stretching on sprint performance is an acute neural inhibition of the stretch reflex (2). Furthermore, 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. Both of these findings could cause a decrease in performance during a sprint race. However, it is possible that the spindle reflex itself fatigues over the course of a longer race (12), and this fatigue could potentially cause the difference between the 2 groups to regress.

The stiffness of the system has also been implicated as a potential cause of the differences in performances exhibited in athletes after static stretching. Chelly and Denis (5) 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 (1,3). The musculotendon unit has the ability to store energy that can be returned after it is stretched. This process is likely a function of the unit's stiffness. Static stretching has been associated with decreased stiffness of the muscle (18). This decrease in stiffness, Fletcher and Jones (11) proposed, would cause a decrease in preactivation, or the stiffening of the musculotendon unit before ground contact. This would effect the eccentric phase of the movement by decreasing the amount of energy recovered from the stretch shortening cycle. In other words, the muscle must take up more "slack," placing the muscle on a less appropriate location on the force-length curve. This would appear to make a stiff system the most beneficial during the later portions of a race when contact times are the shortest.

Finally, Belli and Bosco (3) suggested that there may be an optimal stiffness for energy return in different actions. These findings are supported by Bret et al. (4), who found that the optimal stiffness for performance changed throughout the different phases of the sprint. In a study by Bret et al. (4), sprinters with the greatest leg stiffness accelerated more during the second phase of a sprint (30–60 m). However, they also found that these same athletes decelerated more than athletes with the lowest stiffness during the final portion of a 100-m dash. They proposed that the athletes with the greatest stiffness became more fatigued. Some authors have suggested that central neural fatigue occurs naturally over the course of a 100-m dash (15,23). Because 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 nonstretched athletes is enough to wash out the peripheral inhibition that is proposed after static stretching.

Although a stiff system would appear to be the most beneficial at high velocities when the contact times are the shortest, it is also possible that a stiff system will harm performance by increasing the muscular resistance (1,8). 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 toward the event goal and potentially decreasing the fatigue at the end of the race. However, these effects of stretching may be dependent on the baseline flexibility of the individual (9). 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.

Therefore, the effects of static stretching on economy may be enough to outweigh the physiological costs on power early in a race. Although the current study found that there was no additional inhibition during the final 60 m of a 100-m 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 that may still require power such as the 200- or 400-m dash. Furthermore, the field would benefit from research exploring the causes of the decrease in performance that follow static stretching in the sprint events.

To test the effects of the 2 different warm-up conditions across 100 m of sprint time, it was necessary in the current study to test subjects outside. Although no significant statistical differences were found in this study for day or order of experimental condition, it is still possible that performances were in some way affected by the external conditions. However, these are the conditions under which sprint events commonly take place. Thus, the type of testing environment used in this study does have ecological validity. Another weakness in this study was the lack of a true control group (i.e., one in which sprinters were not exposed to any warm-up protocol). Although this study might have benefited from such a true control condition, this option was not possible for the participant population that was used.

PRACTICAL APPLICATIONS

This study suggests that static stretching has a negative effect on performance in the first 40 m of a 100-m 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 damaging to engage in static stretching after a dynamic warm-up. However, athletes do not SS solely for the effect that it has on performance. Athletes also use stretching as a means of injury prevention, and this study does not provide any information 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 before training and competition.

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