

ORIGINAL RESEARCH

THE ACUTE EFFECTS OF VARIOUS TYPES OF STRETCHING STATIC, DYNAMIC, BALLISTIC, AND NO STRETCH OF THE ILIOPSOAS ON 40-YARD SPRINT TIMES IN RECREATIONAL RUNNERS

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ABSTRACT

Background and Purpose: The potential adverse effects of static stretching on athletic performance are well documented, but still appear to be controversial, especially as they relate to sprinting. The prevalence of this practice is demonstrated by the number of competitive and recreational athletes who regularly engage in stretching immediately prior to sprinting with the mindset of optimizing their performance. The purpose of this study was to examine the effects of acute static, dynamic, and ballistic stretching, and no stretching of the iliopsoas muscle on 40-yard sprint times in 18-37 year-old non-competitive, recreational runners.

Methods: Twenty-five healthy recreational runners (16 male and 9 female) between the ages of 24 and 35 (Mean = 26.76 yrs., SD = 2.42 yrs.) completed this study. A repeated measures design was used, which consisted of running a 40-yard sprint trial immediately following each of 4 different stretching conditions aimed at the iliopsoas muscle and lasting 1 minute each. The 4 conditions were completed in a randomized order within a 2-week time period, allowing 48-72 hours between each condition. Prior to each 40-yard sprint trial, a 5-minute walking warm-up was performed at 3.5 mph on a treadmill. The subject then ran a baseline 40-yard sprint. After a 10-minute self-paced walk, each subject performed one of the 4 stretching conditions (ballistic, dynamic, static, and no stretch) and then immediately ran a timed 40-yard sprint.

Results: There was a significant interaction between stretching conditions and their effects on sprint times, $F(3,72) = 9.422$, $p < .0005$. To break down this interaction, simple main effects were performed with 2 repeated measures ANOVAs and 4 paired t-tests using a Bonferroni corrected alpha ($\alpha = .0083$). There were no significant differences between the 4 pre-condition times, $p = 0.103$ (Greenhouse-Geisser) or the post-condition times, $p = 0.029$. In the no stretch condition, subjects improved significantly from pre- to post- sprint times ($p < 0.0005$). There were no statistically significant differences in pre- and post-stretch condition sprint times among the static ($p = 0.804$), ballistic ($p = 0.217$), and dynamic ($p = 0.022$) stretching conditions.

Conclusions: Sprint performance may show greatest improvement without stretching and through the use of a walking generalized warmup on a treadmill. These findings have clinically meaningful implications for runners who include iliopsoas muscle stretching as a component of the warm-up.

Level of Evidence: Level 2

Key words: Recreational runners, sprinting, stretching, warm-up

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This study was approved by the university's biomedical institutional review board and an approved informed consent form was signed by each of the subjects prior to testing.

INTRODUCTION

Stretching as a means of improving athletic performance is a commonly held belief despite a lack of support in current literature.¹ The evidence regarding the adverse effects of static stretching on athletic performance is well documented and readily available,²⁻⁵ but still appears to be controversial in its acceptance by the athletic and fitness communities, especially as it relates to sprinting. The prevalence of this practice is demonstrated by the number of athletes and non-competitive physically active individuals who regularly engage in stretching immediately prior to activity with the mindset of optimizing their physical capabilities.⁵

This mindset can be seen when sprinters and recreational runners stretch various muscles immediately before a race based upon the perception that greater flexibility will improve their performance and perhaps reduce their potential risk for injury.⁵ The reason behind this common practice is perhaps tied to tradition. Whereas, some research has indicated no difference in performance as a result of different types of stretching,⁶⁻¹⁰ many authors have shown that certain forms of stretching, most notably static stretching, immediately prior to activity may actually adversely affect performance.^{1,3,5,11-13}

Nelson et al¹² examined the effect of partner-assisted static stretching of the calf and thigh musculature on 20-meter sprint performance and observed significantly slower times among post-stretch trials when compared to no-stretch trials. The prevailing rationale behind these and many other similar findings implicates a decrease in musculotendinous elasticity and subsequent reduction in force production capacity.^{5,14} Kokkonen et al¹ found that maximal muscle strength (one repetition maximum knee flexion and extension) was decreased immediately following static stretching. Additionally, Wilson et al¹⁵ concluded that a stiffer musculotendinous unit resulted in greater force production than one that has decreased stiffness as a result of stretching due to an increased rate of shortening and initial force transmission.

In reviewing the literature on stretching and performance, it seems that the most prominent muscles/muscle groups of the lower limb (quadriceps, hamstrings, gluteus maximus, gastrocnemius) have received much of the attention from researchers, most likely

because of their visual and literary prominence.¹⁶ The investigation into the actions of these muscles/muscle groups provides an understanding of muscular contributors to sprinting in terms of many of its major biomechanical components (hip and knee extension, knee flexion, ankle plantarflexion), but fails to address hip flexion. This neglect is unfortunate as hip flexion may have the greatest influence on sprint speed of any segmental body movement and should therefore be the recipient of greater scrutiny.¹⁶ For these reasons, the muscle complex primarily responsible for flexion of the hip, the iliopsoas (IP), is important to focus on during future research concerning stretching and sprint performance.

Illustrating the importance of primary hip flexors in dynamic activity, Yokozawa et al¹⁷ concluded that IP was more active than the gluteus maximus, hamstrings, adductors, rectus femoris, gastrocnemius, soleus, tibialis anterior, and the vasti muscles in running at low, medium, and high speeds. The IP has also been shown to have a greater influence on improving one's running speed than any other muscle/muscle group and is one of three primary muscles/muscle groups (hip extensors, rectus femoris, and iliopsoas) important for generation of power during sprinting.^{16,18} With this knowledge in mind, it comes as no surprise that Deane et al¹⁴ found that a hip flexor strengthening protocol improved 40-yard sprint times by 0.233 seconds, thereby enhancing performance, in untrained, yet physically active individuals.

While much of the available research has focused on static stretching, other stretching methods may influence performance differently.¹¹ In competitive sprinters, active dynamic stretching of the major muscle groups of the lower limb has been shown to be advantageous in terms of decreasing 50 meter sprint times.¹¹ Additionally, dynamic stretching of the lower limbs in professional soccer players has produced faster 10 meter sprint times and greater maximal speed over 20 meters in comparison to no-stretch conditions.⁶ In contrast, Shrier conducted a systematic literature review concerning stretching and performance and found conflicting results in examining the effect of dynamic stretching on running speed.¹⁹

Although there are studies documenting the detrimental effects of static stretching and useful effects of dynamic exercises, to date, no studies have researched

the acute effects of different stretching protocols, specifically for the iliopsoas muscle, on sprint performance. Given the relative controversy and paucity of literature in this area of study, it was the purpose of this study to examine the effects of acute static, dynamic, and ballistic stretching, and no stretching of the IP on 40-yard sprint times in 18-37 year-old non-competitive, recreational runners.

METHODS

Subjects

Thirty-five students (non-competitive, recreational runners) volunteered for the study, 10 of which were unable to complete the study due to soreness from sprinting. The final pool of 25 subjects included 16 males and 9 females between the ages of 24 and 35 (Mean = 26.76 yrs., SD = 2.42 yrs.). Subjects were not allowed to participate if they were pregnant, currently had a musculoskeletal injury, or a health condition that would affect performance or put the subject at risk for injury. The subjects were asked to maintain normal activity throughout the duration of the study, but were asked to avoid any strenuous work 2 hours prior to any of the 40-yard sprint trials. The study was approved by the university's biomedical institutional review board and an approved informed consent form was signed by each of the subjects prior to testing.

Procedures

This study was a repeated measures design, which consisted of running a 40-yard sprint trial immediately following each of 4 different stretching protocols. The study was performed on an indoor basketball court in order to standardize environmental conditions. Times were taken using an electronic timing system (Lafayette Instrument Co., Lafayette, IN) mounted to two sets of tripods (one pair each for start and finish). Each pair of tripods had one laser and one reflector connected to a timer which would start/stop when the subject ran through each respective laser beam. Measurements for the 40-yards were made using a standard field tape measure. The trials were completed within a 2 week time period allowing 48-72 hours between each trial.

Prior to each 40-yard sprint trial, a 5-minute warm-up walk was performed at 3.5 mph on a treadmill.

Following the warm-up and prior to each of the 4 different stretching protocols targeting the IP muscle, a maximal effort, 40-yard sprint was performed and timed using the electronic timing system. The stretching protocols were no stretch (NS), ballistic stretch (BS), static stretch (SS) or dynamic stretch (DS), and the order of the stretching conditions was randomized.

After the baseline time was collected, the subjects walked at a self-selected comfortable pace for 10 minutes around the perimeter of the basketball courts. During the 10-minute self-paced walk, one of the researchers demonstrated to each of the subjects their randomly selected stretching protocol for the day while the subjects maintained their walking speed. Upon completion of the 10-minute self-paced walk, the subjects performed the designated stretching protocol for 1 minute, and within 60 seconds following the designated stretching condition performed a post-stretch maximal effort, 40-yard sprint.

The pre- and post-stretching 40-yard sprint times were compared to determine the acute effects of stretching the IP on 40-yard sprint times. Results were also compared between conditions to determine if differences existed regarding changes in sprint times between the types of stretching. The subjects were blinded to all 40-yard sprint times until the study was completed.

Stretching Techniques

Stretching was supervised by the investigators for each of the stretching conditions.^{9,12,20} The holding point for each static stretch was arbitrarily selected by each subject as the point before discomfort. For the NS condition, instructions emphasized that the subjects were not to perform any type of stretching during this time, and subjects were asked to stand at the starting line for 1 minute before the 40-yard dash trial. In the DS condition (Figures 1 and 2), subjects stood parallel to a wall while using the wall to stabilize the body during the stretch. Subjects then flexed the hip and knee as close to the chest as possible. When maximum knee height was reached, subjects forcefully brought the hip into extension. Maintenance of upright trunk posture and avoidance of internal and external rotation of the hip throughout the motion was stressed in order to isolate the IP

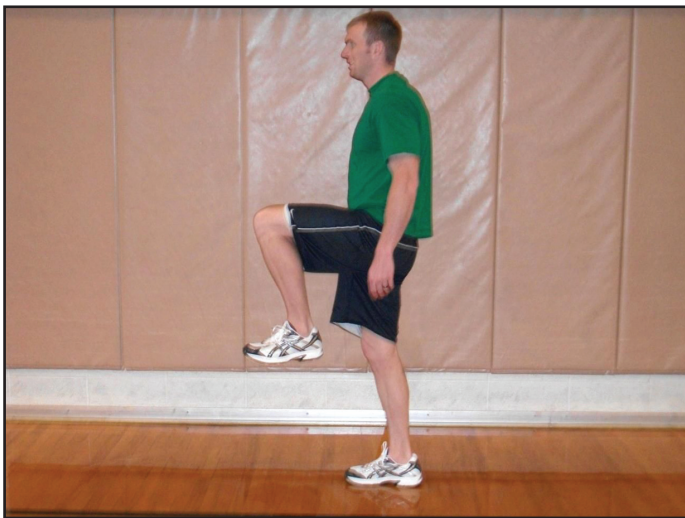


Figure 1. Starting position for dynamic stretch.

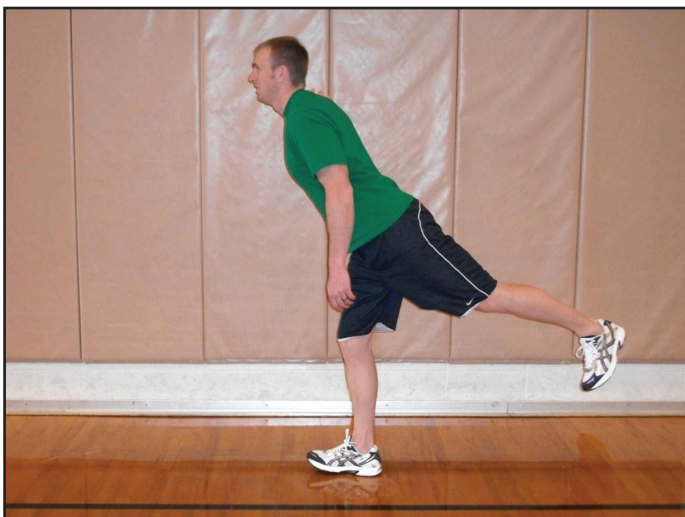


Figure 2. End position for dynamic stretch.

muscle. This motion was performed for 15 seconds on one leg and then the subject switched legs and performed the same motion on the other leg; this was repeated one more time for each leg for a total of 2 repetitions of 15 seconds for each leg.

In the BS condition (Figures 3 and 4) subjects went into a lunge stance with the leg of the hip being stretched behind the subject and minimal knee flexion. While in the lunge position, the subjects lowered their hips until they felt a moderate stretch in their IP muscle. With the subject's IP muscle in the elongated position, the subject oscillated inferiorly for 15 seconds on each leg twice, alternating between legs being stretched. In the SS condition (Figures 3 and



Figure 3. Starting position for BS and SS (Lunge position, prior to lowering hips).

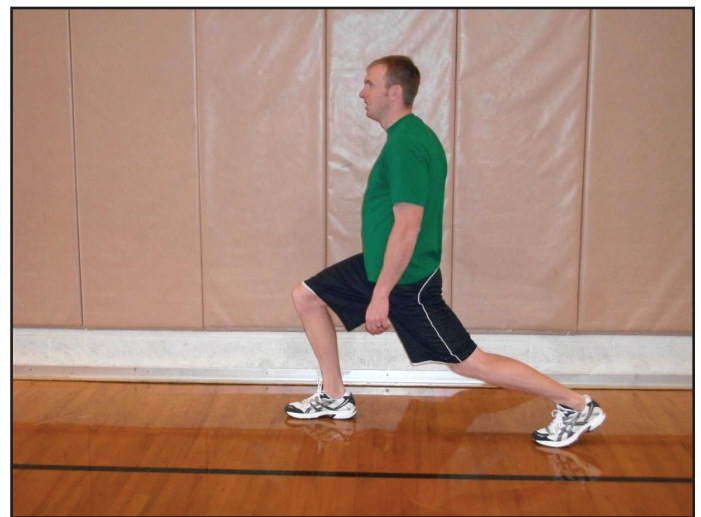


Figure 4. End position for BS and SS (for BS, oscillation is performed at this position).

4), subjects assumed the same position as described in the BS, but maintained a single repetition 30 second stretch without oscillating.

STATISTICAL METHODS

To determine the acute effects of various types of stretching on 40-yard sprint times a 2 (time: pre and post-stretch condition) by 4 (stretch condition: NS, SS, BS, and DS) repeated measures analysis of variance (ANOVA) was performed to determine if there was an interaction in the data. In the event an interaction was discovered, post-hoc testing using 2 repeated measures ANOVAs to compare between stretching conditions, and 4 paired t-tests were used

Table 1. Comparison of sprint times by condition.

Condition (N=25)	Mean +/- SD (Pre)	Mean +/- SD (Post)	P-Value
No Stretch	5.85+/- 0.53	5.74+/- 0.51	< 0.0005*
Static	5.80+/- 0.51	5.81+/- 0.51	0.804
Ballistic	5.82+/- 0.52	5.80 +/- 0.52	0.217
Dynamic	5.78+/- 0.50	5.83+/- 0.53	0.022†
* p < .05			
† Bonferroni corrected			

to compare pre- and post-condition 40-yard sprint times, using a Bonferroni corrected alpha ($\alpha = .0083$), to determine where the significant differences were located. In addition, a chi-square analysis was done to determine if there was a statistically significant association between soreness/injury and stretching protocol in the total of 10 participants who dropped out due to severe soreness.

RESULTS

There was a significant interaction between stretching conditions and their effects on sprint times, $F(3,72) = 9.422$, $p < .0005$ (Table 1). In order to further examine this interaction, simple main effects calculations were performed with 2 repeated measures ANOVAs and four paired t-tests using a Bonferroni corrected alpha ($\alpha = .0083$). There were no significant differences between the four pre-condition times, $p = 0.103$ (Greenhouse-Geisser) or the post-condition times, $p = 0.029$. There was a statistically significant difference between pre- and post-stretch condition times in the NS condition, $p < 0.0005$, suggesting that sprint times improved in this condition. There were no statistically significant differences in pre- and post-stretch condition times between the pre- and post-times for the static ($p = 0.804$), ballistic ($p = 0.217$), and dynamic ($p = 0.022$) stretching conditions, suggesting that sprint times were unchanged between the 2 trials for each of the 3 stretching conditions. Chi-square analysis revealed no significant difference in sprint times, $\chi^2(3) = .533$, $p = .912$ between subjects who dropped out secondary to soreness and stretching condition and the subjects who completed the study.

DISCUSSION

The purpose of this study was to examine the acute effects of various types of stretching conditions of the IP muscle on 40-yard sprint times in recreational runners. The authors found that the SS condition did not adversely affect performance nor were there significant changes in pre-post sprint times in the BS or DS conditions. However, a significant improvement in time from pre- to post-condition was observed in the NS condition. As such, the present study supports other studies found in the literature regarding no effects of acute static stretching immediately prior to sprint performance,^{5,11,20} but appears to contradict other studies where static stretching was shown to adversely affect sprint times.^{2,4,21}

Because the authors were intent on investigating the acute effects of stretching, we focused our research on one major muscle group (the IP muscle), which has been described by previous authors in the literature to be one of the most important muscles involved in sprinting.¹⁶⁻¹⁸ The protocol employed during the current study differs somewhat when compared to other studies found in the literature, in that, the authors of the current study measured the effects of stretching on a dynamic event immediately after stretching (0-60 seconds), whereas other studies investigated the effects of stretching on performance approximately 3-10 minutes following the performance of stretching.^{3,5,6,11,22,23}

Contrary to other research, which included multiple muscles in the stretching protocol, the authors did not find a significant difference between pre- and post-measures of 40-yard sprint times when subjects were stretched using BS, DS, or SS methods.^{4-6,11,20} In contrast to the current study, Winchester et al reported a 3% decrease in sprint performance for track and field athletes after participating in a static stretching protocol, which was conducted after a 30 minute dynamic warm-up.⁵ Likewise, Fletcher et al reported an increase in 50-m sprint time (decrease in sprint performance) in a group of competitive track and field athletes after passive static stretching, despite being combined with active dynamic stretching. Conversely, they observed a decrease in 50-m sprint time (improvement in performance) after warm-ups involving static dynamic stretches combined with active dynamic stretches or with the

active dynamic stretches alone.¹¹ Sim et al reported increases in 20-m sprint times (decrease in sprint performance) when static stretching was performed after dynamic activities in the warm-up, but found that static stretching followed by dynamic activities resulted in repeated sprint performance similar to that obtained when dynamic activities alone were performed.⁴

Little and Williams reported that a static-stretch protocol produced significantly faster runs than did the no-stretch protocol for the 20 m sprint.⁶ However, in their study, subjects performed further warm-up activity after the stretching, which may have affected the immediate adverse effects of static stretching that have been previously reported. Vetter reported no changes on a 30-m sprint after static stretching.²⁰

The subjects in the current study showed significantly faster post 40-yard sprint times when compared to pre 40-yard sprint times only after the NS condition. One possible reason for this improved performance could be that the baseline sprint served as a dynamic warm-up and dynamic warm-ups without stretching have been reported to improve sport specific skills such as sprinting.²⁴ As such, the rehearsal of specific movement patterns may have helped increase coordination of the subsequent sprint, especially in untrained recreational runners who did not use sprinting as a training method. McMillian et al revealed that warming the muscle up prior to an activity by engaging in dynamic warm-up exercise facilitates physiological changes that may result in modest performance enhancement.²⁵ They showed that dynamic warm-up resulted in better performance scores on selected measures of power and agility (T-shuttle run, underhand medicine ball throw for distance, and 5-step jump) relative to static stretching warm-up or no warm-up.²⁵ In the case of the NS group, the baseline 40-yard sprint may have been enough to facilitate performance enhancement, thereby improving the post NS condition sprint time in the present study.

Another possible reason for improved performance in the NS condition could be that lack of stretching after a dynamic activity may have contributed to a stiffer tendon, which may have correlated with increased performance in force production.²⁶ A possible reason for this mechanism was proposed by Wilson et al.¹⁵

The authors suggested that for concentric muscle actions, a stiffer musculotendinous system would improve contractile component force production, thus allowing more favorable length and velocity conditions. In other words, a stiffer musculotendinous unit should allow the contractile component to be at a more optimal point on both the force/velocity and force/length curve in terms of force production. Additionally, Rosenbaum et al concluded that stretching impaired force production and hypothesized that the decreased force production was due to mechanical changes such as increased tendon slack.²⁶

Burkett et al pointed to neurophysiological changes as a potential reason for improved performance; their research suggests that warm-ups increase power production and performance by activating neuromuscular functions.²⁷ Other researchers have cited this phenomenon as post-activation potentiation (PAP), which has been defined as the temporary increase in the contractile ability of muscles after a previous contraction session.²⁸

One limitation of this study was the use of a small group of untrained, recreational, non-competitive runners instead of trained runners. Consequently, it becomes important not to generalize the findings to competitive runners. Yet, the results of this study may be more relevant for trained runners than recreational runners due, in part, to stringent training regimens, warm-up routines, and stretching protocols as well as potential differences in parameters such as height, weight, and BMI. Conversely, the findings from the present study may have value in generalizing to recreational runners commonly seen in physical therapy practice. Another limitation was soreness reported by the participants. Many of the participants complained of muscle soreness due to previous trials, and 10 participants cited muscular soreness as the reason for dropping out of the study. This may be related to the fact that the current subjects were recreational runners and therefore less accustomed to the higher muscular forces generated during sprinting than in other forms of running.

Future research should include the use of trained runners to see if these same effects are seen in these athletes as well. Further study might address the effects of stretching mode on return to sprinting activity among recreational runners, which is an important

consideration when taking patients through a full spectrum of rehabilitation and the resumption of prior activity levels. Research could also be conducted to see if there are any differences between sexes and use of multiple trials examining the effects over time in each condition should be considered.

CONCLUSIONS

The results of this study indicate that the NS condition was the only stretching condition in which statistically significant improvements were found in acute or short-term measurements of sprint times in non-trained, recreational runners. The SS, BS, and DS stretching conditions did not affect acute measurements of sprint times. Although performed by all groups, the baseline 40-yard sprint may have been enough to facilitate performance enhancement, thereby improving the post NS condition sprint time. This suggests that 40-yard sprint performance may show greatest improvement without stretching and performance of a generalized "warm-up" task. These findings have clinically meaningful implications for untrained recreational runners who include IP stretching as a component of their warm-up, particularly prior to sprinting.

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