The acute effects of combined static and dynamic stretch protocols on 50m sprint performance in track and field athletes

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ABSTRACT

The purpose of this study was to investigate the effect of manipulating the static and dynamic stretch components associated with a traditional track and field warm-up. 18 experienced sprinters were randomly assigned in a repeated measures within subject design with 3 interventions; Active Dynamic Stretch (ADS), Static Passive Stretch combined with Active Dynamic Stretch (SADS) and Static Dynamic Stretch combined with Active Dynamic Stretch (DADS). A standardized 800m jogged warm-up was performed before each different stretch intervention, followed by two 50m sprints. Results indicated that the SADS intervention had significantly ($p \leq 0.05$) slower 50m sprint times then either the ADS or DADS intervention. The decrease in sprint time observed after the ADS intervention compared to the DADS intervention was found to be non-significant ($p > 0.05$). The decrease in performance post SADS intervention was attributed to a decrease in the musculotendinous units (MTU) stiffness, possibly due to a reduction in muscle activation prior to ground contact, leading to a decrease in the MTU's ability to store and transfer elastic energy after the use of passive static stretch techniques. The improved 50m performance associated with the ADS and DADS interventions was linked to the rehearsal of specific movement patterns, helping proprioception and pre-activation, allowing a more optimum switch from eccentric to concentric muscle contraction. It was concluded that passive static stretching in a warm-up decreases sprint performance, despite being combined with dynamic stretches, when compared to a solely dynamic stretch approach.

Key Words: dynamic stretching, static stretching, musculotendinous unit stiffness, warm-up, pre-activation

INTRODUCTION

Track and field athletes have traditionally employed extensive warm-up and stretch routines as part of their preparation for training and competition, with the belief that this will lead to enhanced performance. In recent years these practices have been brought into question, in particular the value of static stretching as part of a warm-up, with research showing a reduction in muscular performance post stretch intervention (10, 19, 1, 27, 11, 2, 5, 6, 18, 36, 37, 9, 29).

This phenomenon has been linked to two main processes. Static stretching causing a decrease in musculo tendinous unit (MTU) stiffness (34) leading to a lower rate of force production and a delay in muscle activation (19, 1, 20, 8). Possibly resulting in an increase in tendon slack, which would require time to be taken in when muscle attempts to contract (27) leading to a less effective transfer of force from muscle to lever (19, 35). The other theory involves acute neural inhibition, resulting in an increase in autogenic inhibition, decreasing neural drive to the muscle (27, 1, 18, 20, 7) leading to a decrease in muscle activation after a muscle is stretched (14, 1, 31).

However the question has to be raised about the applicability of such research to the actual warm-up regimes athletes carry out prior to performance. Many studies have tended to hold stretches for extended periods, ranging from 90 seconds (19, 25) up to 1 hour per muscle (1). While methods of determining performance have focused on muscular power as determined by maximum voluntary contraction of isolated muscle groups (19, 1, 11, 2, 25, 8, 7), with such tests of muscle function viewed as severely limited in terms of there reflection of performance changes (24). Despite the difficulties of applying this research to the sports environment, many athletes have moved away from the static passive approach to stretching in warm-up, in favor of dynamic stretching, defined as controlled movement through the active range of motion for one or more joints (9).

However, to date, only two studies (29, 9) have looked at the performance changes associated with the acute effects of static and dynamic stretching on running performance. Siatras *et al* (29) found a significant decrease in running speed post static stretch interventions, but no change in running speed after dynamic stretches were used, while Fletcher and Jones (9) found a significant decrease in 20m sprint performance after static stretching and a significant increase in performances post dynamic intervention, compared to warm-up alone.

One area that has not been researched is the combination of both static and dynamic stretching, even though this is considered to be the classical model for a warm-up protocol (17). Here aerobic exercise is used to raise the athlete's core temperature, followed by static stretching and lastly dynamic drills, specific to the event, before competing.

The aim of this study was to investigate the preferred warm-up protocols for track and field sprinters and find out the effect of manipulating static and dynamic stretch components in a sprinters warm-up on 50m sprint performance.

METHODS

Approach to the Problem

Three different stretch protocols, active dynamic, static dynamic combined with active dynamic and static passive combined with active dynamic, were performed in a randomized repeated measures within subject design. Time over 50m was recorded post each intervention. Each subject performed a standard pulse raising activity a randomly ordered stretch protocol followed by two 50m sprints. Reliability of the 50m measure employed was assessed using an intraclass correlation coefficient. With the level of reliability observed at 0.99 between the two sprint times.

Subjects

10 men and 8 women sprinters were recruited from two track and field clubs. Subjects had to have been competitive sprinters with a background in resistance training (plyometrics, weight training and circuits) for at least 2 years and be at least regional standard (men PB 10.69 ±0.19s, women PB 12.05 ±0.18s, mean and ±SD for 100m). Subject's age, height and body mass were (men 19.2 ±1.14 years, 179.3 ±2.27cm and 71.9 ±6.77kg, women 20.2 ±2.86 years, 170.2 ±3.1cm and 61.72 ±3.2kg, mean ±SD). Testing was carried out in January prior to the indoor season to coincide with a decrease in training volume associated with this meso cycle. Protocols carried out were approved by a Departmental Committee for Ethics.

Subjects were required to read and complete a health questionnaire and provide written informed consent prior to participation. Subjects were asked to rest for 2 days prior to testing and to eat and drink as they normally would before a competition. Sample size was estimated by Eq. 1 (15)

[1] $n=8s^2/d^2$

Where s = typical error and d = confidence limits.

Sample size estimate was 16.

Subjects were required to complete 3 randomly assigned interventions; Active Dynamic Stretch (ADS), Static Passive Stretch combined with Active Dynamic Stretch (SADS) and Static Dynamic Stretch combined with Active Dynamic Stretch (DADS).

Procedures

Notational Analysis was used to investigate the athletes' usual warm-up practices. Each athlete was observed twice, length, type and intensity of warm-up; length, type and position of stretches used in their warm-up were recorded. From this information an average warm-up protocol was established as the control intervention. Testing was carried out on a tartan athletic track in an indoor facility. Subjects performed a self passed jogged warm-up of 800m followed by a designated stretching protocol before completing a 50m sprint through Omoron® portable electronic timing gates, designed to mimic the acceleration phase of a 100m sprint (33). After the last stretch 4 minutes was allowed for 2 self passed practice starts before the first sprint was performed. The timing gates were set at a height of 1m, at a standard lane width and 2m from the start line. All sprints were out of blocks, athletes used their normal block set up, in spikes and normal running clothing, with standard track and field instructions and gun used to start subjects. After 2 minutes recovery the sprint was repeated. The fastest sprint time was used for statistical comparisons. A 1 week gap was allocated between stretch interventions.

Stretch Interventions

Each intervention consisted of a self-paced 800m jogged warm-up prior to a stretch component. The SADS protocol (designed as the control intervention) consisted of 3 x 22 seconds of passive stretches (slowly applied stretch torque to a muscle maintaining the muscle in a lengthened position) (22) with 10 second rest between stretches (total time 7 minutes 12 seconds). Stretches employed were a gastrocnemius stretch (against a wall), a hamstring stretch (lying straight leg raise), standing quadriceps stretch, gluteal stretch (lying knee to chest) and hip flexors stretch (static lunge). Each stretch was held at the point of mild discomfort. This was immediately followed by the same stretches as the ADS intervention.

The ADS intervention consisted of a rest period of 7 minutes 12 seconds followed by a series of lower body dynamic stretches (controlled movement through the active range of motion for one or more joints) (9). Drills were repeated twice over 20m with a walked back recovery. Exercises were designed to mimic parts of the sprint cycle and to stretch the lower body musculature mainly used in sprinting (gastrocnemius, gluteals, hamstrings, quadriceps and hip flexors). Straight leg skipping, walking high knees, skipping high knees, running high knees and flick backs were employed before subjects performed 2 x 50m strides at a self paced 80% of maximum velocity.

The DADS protocol consisted of the same movements as the ADS intervention, but in a stationary position. Each stretch was repeated 2 times on each leg consisting of 8 repetitions with a 10 seconds rest, exercises consisting of seated plantar/dorsi flexion of the ankle, standing straight leg raise, standing flick backs and standing high knees raises. Stretches were performed in a controlled manor in a 2 second tempo. The ADS intervention was then performed before the test protocol.

Statistical Analysis

Interactions between stretch interventions were analyzed using a repeated measures analysis of variance (ANOVA). Post Hoc analysis was carried out using Bonferroni. Statistical analysis was carried out using SPSS 12 for windows. Significance was set at an alpha level of $p \leq 0.05$.

RESULTS

Table 1 about here

Table 1 shows the mean (±SD) sprint times for the 3 interventions for men and women. When inter group differences were analyzed using a repeated measures ANOVA, the ADS intervention showed a significant decrease in sprint time (men $p=0.001$, women $p=0.03$), calculated as a mean decrease of 0.16s for men and 0.1s for women over 50m, when compared to the SADS intervention. The DADS intervention showed a significant decrease in sprint time (men *p*=0.002, women *p*=0.043), calculated as a mean decrease of 0.11s for men and 0.09s for women over 50m, when compared to the sprint time of the SADS intervention. The marginal decrease (0.05s for men and 0.01s for women) in 50m time between the ADS and DADS intervention was found to be non significant (men *p*=0.18, women *p*=0.31). No differences in response pattern were shown between male and female subjects.

DISCUSSION

The main findings of this study were that passive static stretching, despite being combined with active dynamic stretching, lead to a significant ($p \leq 0.05$) increase in sprint time, when compared to static dynamic combined with active dynamic or active dynamic stretches alone.

A decrease in performance with the use of static passive stretches has been established in a number of studies (10, 19, 1, 27, 11, 2, 5, 6, 18, 36, 37, 9, 29), while the positive effect of dynamic stretches, though not researched to the same degree as static stretches, has also been shown (29, 9).

The decrease in performance associated with static passive stretch routines has been felt to be the result of a decrease in neural transmission, decreasing the neural drive to the muscle (27, 1, 18, 20). This is supported by the work of Knudson *et al* (18) who showed no effect on kinematic variables during vertical jump performance and by Power *et al* (26) who showed a significant increase in muscle inactivation post static stretch, linked to a significant decrease in isometric force generated by the quadriceps. This was attributed to a neurological deficit caused by static stretching; interestingly Power *et al* (26) found that this did not result in a significant change in jump performance. However, many of these studies have employed an isometric, isokinetic or a very slow or no eccentric component prior to a concentric contraction. How applicable this type of methodology is to the rapid eccentric/concentric coupling vital in sprinting is debatable.

The reasons for a decrease in sprint performance are more likely to be linked to changes in the compliance of the MTU structure. Passive static stretching has been shown to decrease MTU stiffness (34, 27, 1, 20, 36, 8), while the amount of elastic energy that can be stored in the MTU is a function of the units stiffness (16, 28). Young and Elliot (36) found a decrease in muscle activation with regards to the pre activation of the MTU, reducing the stiffness of the MTU prior to ground impact, which helps to explain the decrease in drop jump performance Young and Elliot (36) reported, but could also help explain the results demonstrated in this study, because of the importance of pre activation of muscle prior to ground contact in sprinting. In Cornwell *et al's* (6) work the drop jump performance decreases observed were reported to be the result of the decreased ability of the MTU to store and transfer elastic energy after the use of passive stretch techniques. However some researchers have shown contrary results. Wilson *et al* (35) demonstrated an increase in compliance resulting in an increase in bench press performance. This is also the supposition of Walshe and Wilson (32), who showed an increase in depth jump performance at above 80cm with a more compliant MTU, Walshe and Wilson (32) believed it was the ability to stretch, store and release elastic energy which allowed subjects to mitigate high loads placed on the MTU. However the performance measures used in these studies have a far slower velocity of contraction then the sprint exercise subjects were asked to perform in the present study. Bellie and Bosco (3) showed that stretch shortening actions (like sprinting) were enhanced by a stiffer MTU, though they used hopping as their mode of exercise, this is far closer to the speed and co-ordination required in sprinting then Wilson *et al* (35), or Walshe & Wilson's (32) exercise modalities.

Therefore the more compliant muscle observed after passive stretching (34) is less able to store elastic energy in the rapid eccentric phase associated with sprinting, while changing tendon structure (20) making it more compliant and leading to less efficient force transfer from the muscle to the tendon (19) resulting in a lower rate of force production. This may lead to improved running economy through a decrease in the visco-elasticity of the musculature (30), but at the cost of a decrease in the force and velocity of contraction (21, 4) resulting in an increase in time until external force can be expressed in powerful movements (5).

The phenomenon of active dynamic stretches enhancing performance has been linked to the rehearsal of specific movement patterns, helping proprioception and pre-activation, allowing an optimum switch from the eccentric to concentric muscle contraction required to generate high running speeds (9). Static stretching seems to have the opposite effect, with mechanoreceptors responding to a decrease in muscle stiffness by producing a reflexive inhibition of both agonistic muscles and there synergists (23). The magnitude of this myotatic reflex is related to stretching velocity (13, 12), by increasing stretch speed (as demonstrated in dynamic stretching) greater action potential of the myotatic reflex may result. This could have a high mechanical effect in terms of increasing MTU stiffness helping explain the increased running speeds shown in this study and others (29, 9). Interestingly, combining static dynamic stretches prior to active dynamic stretches had no greater effect on performance over active dynamic stretches alone. It may be that for dynamic stretches to be an aid to an athlete's warm-up the action must involve some form of movement which not only mimics part of the sprint cycle, but also involves ground contact invoking the myotatic stretch reflex.

However, by combining the static and dynamic stretching in a warm-up, many coaches have believed that any negative effects from short duration passive stretching would be mitigated by the post use of dynamic stretches (a normal pattern of warm-up for many athletes (17) that was established by notational analysis as usual for the subjects in this study). However the effects of passive stretching have been shown to be long lasting, with Fowles and Sale (10) demonstrating a decrease in voluntary contraction for up to 1hour post stretch with the neurological deficit linked to static stretching still being present after 2 hours (26). Though these studies used far longer hold times then the present study, they also used far less complex movement patterns to measure performance. Therefore the decrease in motoneuron excitability observed after passive stretching through the depression of the Hoffman reflex (1) could lead to a reduction in discharge from the muscle spindles because of the increase in muscle compliance. This may lead to a reduced efficiency in the self-regulation and adaptation to differences in muscle load and length modifying running mechanics through loss of control and therefore negatively effecting optimum power output. This seems to be the case even with a dynamic stretch routine included in an attempt to offset the apparent acute negative responses associated with passive static stretching.

PRACTICAL APPLICATIONS

50m sprint performance in trained sprinters seems to be optimized by the use of active dynamic stretch protocols in warm-up, while using passive static stretching (even when combined with dynamic stretching) seems to result in an increase in 50m sprint time. The inclusion of static dynamic work (standing drills) seems to have no increased benefit to the athlete's performance beyond active dynamic work alone. It must be remembered, subjects usual warm-up practice was to include static stretching, which could have lead to a reverse placebo effect (18) as they may have felt unable to perform to their best without going through their usual routine, but despite this all subjects, male and female, improved their performance when passive static stretching was removed from their warm-up routines.

It can therefore be concluded, that for athletes wishing to optimize sprint performance active dynamic stretches should be employed, mimicking specific components of the sprint cycle, rather then the traditional static stretch approach, which appears to have a negative effect on sprint performance.

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Table 1. Mean and Standard Deviation Scores for Men and Women after Different Stretch Interventions

Intervention	Mean Time Men (s)	Mean Time Women (s)
ADS	6.33* ±0.32	7.14* ±0.11
SADS	6.49*# ±0.40	7.24* ±0.12
DADS	6.38# ±0.32	7.15* ±0.07

& †‡ Denotes significant differences between stretch intervention ($p \leq 0.05$)