Journal of Strength and Conditioning Research, 2004, 18(4), 885–888

THE EFFECT OF DIFFERENT WARM-UP STRETCH PROTOCOLS ON 20 METER SPRINT PERFORMANCE IN TRAINED RUGBY UNION PLAYERS

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ABSTRACT. Fletcher, I.M., and B. Jones. The effect of different warm-up stretch protocols on 20-m sprint performance in trained rugby union players. *J. Strength Cond. Res. 18(4):000-000. 2004.*—The purpose of this study was to determine the effect of different static and dynamic stretch protocols on 20-m sprint performance. The 97 male rugby union players were assigned randomly to 4 groups: passive static stretch (PSS; $n = 28$), active dynamic stretch (ADS; $n = 22$), active static stretch (ASST; $n = 24$), and static dynamic stretch (SDS; $n = 23$). All groups performed a standard 10-minute jog warm-up, followed by two 20-m sprints. The 20-m sprints were then repeated after subjects had performed different stretch protocols. The PSS and ASST groups had a significant increase in sprint time ($p \leq 0.05$), while the ADS group had a significant decrease in sprint time ($p \leq 0.05$). The decrease in sprint time, observed in the SDS group, was found to be nonsignificant ($p \geq 0.05$). The decrease in performance for the 2 static stretch groups was attributed to an increase in the musculotendinous unit (MTU) compliance, leading to a decrease in the MTU ability to store elastic energy in its eccentric phase. The reason why the ADS group improved performance is less clear, but could be linked to the rehearsal of specific movement patterns, which may help increase coordination of subsequent movement. It was concluded that static stretching as part of a warm-up may decrease short sprint performance, whereas active dynamic stretching seems to increase 20-m sprint performance.

KEY WORDS. dynamic stretching, static stretching, musculotendinous unit compliance, coordination

INTRODUCTION

Traditionally, athletes have achieved peak performance goals through long-term structured training schedules. Investigations have observed a variety of methods for optimizing training protocols, from increasing strength to improving aerobic endurance. However, until recently, little work has been done on one of the most fundamental parts of training: the stretch component of warm-up.

The “active” component of a warm-up, designed to increase core temperature, blood flow, and prepare the body for exercise, has long been shown to benefit performance (3, 4, 10, 20). However, less is known about the traditional Western warm-up model, and particularly the passive stretches used as part of the warm-up process. Recent research has highlighted that far from helping athletes, passive stretching may inhibit performance by reducing power output (1, 2, 5, 7, 12, 19, 22, 24). The most widely held rationale for this decrement in performance is that passive stretching causes the musculotendinous unit (MTU) to become more compliant, reducing force development by decreasing MTU stiffness (1, 7). This reduction in MTU stiffness leads to acute neural inhibition and a decrease in the neural drive to muscles, resulting in a reduction in power output (1, 11, 13, 19).

These results have led, not surprisingly, to a great deal of interest from coaches, athletes, and sport scientists. However, there appears to be some issues with much of this research when its ecological validity, in terms of practical sports application, is examined. The length stretches are held (ranging from 90 seconds per muscle [12, 17] up to 1 hour [1]) are unlikely to be used by athletes in preparation for competition (where typical stretch routines last no more than 10–15 seconds per muscle group).

The methods of determining power output in studies investigating this area have usually involved maximum voluntary contraction of isolated muscle groups, including maximum knee flexion/extension (2, 12, 17) or plantar flexion (1, 7). However, the ability of tests of muscular function to reflect changes in performance are severely limited (16). It is recommended that the effect of interventions or training should be based on changes in performance, rather than changes in test scores of muscle function (16). Therefore, it is the apparent decrease in power output reported in these studies applicable to the multi-joint, coordinated actions that many athletes perform as part of their sports.

Despite the obvious difficulties of applying much of the research on passive stretching and its effect on sport preparation strategies, many athletes have moved away from the static passive approach to the warm-up in favor of dynamic stretching (defined by this author as a controlled movement through the active range of motion for each joint). This should not be confused with ballistic stretching (repeated small bounces at the end range of movement), which is linked to muscle damage and shortening (18). However, despite the increasing popularity of dynamic stretching, very little research has been done on its effects as part of a warm-up prior to performance.

The aim of this study was to investigate the effect of static and dynamic stretch protocols on the performance of a sport-specific action (20-m sprint running performance) in amateur rugby union players.

METHODS

Experimental Approach to the Problem

Four different stretch protocols (passive static, active dynamic, active static, and static dynamic) were performed in an independent groups design. Time over 20-m was recorded in a pre- and poststretch intervention.

Each group performed a standard pulse-raising activity followed by two 20-m sprints. A set stretch protocol was carried out followed by a repeat of the two 20-m sprints.

Reliability of the 20-m sprint measure was assessed using a coefficient of variation and an intraclass correlation coefficient on pretest measures. A good level of reliability was observed, with a mean coefficient of variation of 1.7% and an intraclass correlation coefficient of 0.94 between the 2 sprint times.

Subjects

The 97 male rugby union players were recruited from local amateur clubs. Subjects had participated in regular training programs and had been playing rugby union for at least 1 year. Subjects' age, height and body mass were 23 ± 8.4 years, 181 ± 8 cm and 86.5 ± 14.4 kg (mean ± *SD*, respectively). The procedures used were approved by a Departmental Committee for Ethics. Subjects were required to read a health questionnaire, complete it, and sign an informed consent document.

Sample size was estimated by Eq. 1, (8)

$$n = 8s^2/d^2, \tag{1}$$

where s = typical error and d = confidence limits. Sample size estimate was 23. Subjects were randomly assigned to 4 groups; passive static stretch (PSS; $n = 28$), active dynamic stretch (ADS; $n = 22$), active static stretch (ASST; $n = 24$), and static dynamic stretch (SDS; $n = 23$).

Testing

All groups performed a standard 10-minute jog warm-up (2,000 m around a rugby pitch). This was followed by 2 sprints over 20 m through Omron portable electronic timing gates (Omron Electronics Ltd., Milton Keynes, UK). A timed recovery between sprints was set at 2 minutes. Researchers chose 20 m because that is the mean sprint distance rugby union players perform in match situations (6). The gates were set 1 m high, 1 m apart, and 1 m from a premarked start point. All sprints were performed from a standing start, in rugby boots, with the dominant foot to the front. No feedback was provided to subjects. This procedure was repeated after the stretch intervention, with the same starting technique employed.

Stretch Interventions

Stretch interventions were carried out immediately upon completion of the 20-m sprints. Supervision of stretch protocols was provided by a qualified sports therapist. The PSS group carried out passive stretches (slowly applied stretch torque to a muscle, maintaining the muscle in a lengthened position) (15) of the lower body (gluteals, hamstrings, quadriceps, adductors, hip flexors, gastrocnemii, and solei). Stretches were held at a point of mild discomfort for 20 seconds per muscle group.

The ADS group carried out a series of lower body dynamic stretches (controlled movement through the active range of motion for each joint) at a jogging pace. Exercises were designed to stretch the same muscles as those in the PSS group: high knees (gluteals and hamstrings), flick backs (quadriceps), hip rolls (adductors), running cycles (hip flexors, gluteals, hamstrings, and quadriceps) and straight leg skipping (gastrocnemii and solei). Participants performed 20 repetitions on each leg independently, with a walk-back recovery.

The ASST group performed active stretches (an active contraction of the agonist muscle to its full inner range, stretching the antagonist's outer range) (18). Stretches were the same as those performed by the PSS group and were held for 20 seconds per muscle group.

Table 1. Mean ± *SD* pre- and poststretch sprint times.

Group	Mean difference (sec)	Mean prestretch (sec)	Mean poststretch (sec)
PSS ($n = 28$)	3.23* ± 0.17	3.27* ± 0.17	0.04
ADS ($n = 22$)	3.24* ± 0.2	3.18* ± 0.18	−0.06
ASST ($n = 24$)	3.24* ± 0.18	3.29* ± 0.2	0.05
SDS ($n = 23$)	3.25 ± 0.22	3.22 ± 0.21	−0.03

* Denotes significant differences before and after stretch intervention ($p \leq 0.05$).
PSS (passive static stretch)
ADS (active dynamic stretch)
ASST (active static stretch)
SDS (static dynamic stretch)

The SDS group performed the same movements, therefore stretching the same muscles, as the ADS group, but in a stationary position for 20 repetitions per leg.

Statistical Analyses

The 2 pre- and 2 postsprint times were averaged. Interactions between groups and differences between pre- and postintervention scores were analyzed using a factorial analysis of variance (ANOVA). Post hoc analysis was carried out using Bonferroni. Statistical analysis was carried out using SPSS 10 for Windows (SPSS, Inc., Chicago, IL). Significance was set at an alpha level of $p \leq 0.05$.

RESULTS

Table 1 shows the mean sprint times pre- and poststretch, and the mean difference in sprint times for each group. When the pre- and poststretch data was analyzed (using a factorial ANOVA), the PSS group showed a significant increase ($p \leq 0.05$) in sprint time after the passive static stretch intervention, matched by a significant increase ($p \leq 0.05$) in sprint time for the ASST group. The ADS group showed a significant decrease ($p \leq 0.05$) in sprint time after the active dynamic stretch intervention, but the SDS group's decrease in sprint time, was found to be nonsignificant ($p \geq 0.05$). There were no significant differences between group data either pre- or postintervention ($p \geq 0.05$).

DISCUSSION

The main finding from this study was a significantly faster sprint time when active dynamic stretching was incorporated into a warm-up, with significantly slower sprint times observed for subjects employing either static active or passive stretching regimes.

The decrease in performance with the use of static passive stretching provides supporting evidence for a number of studies (1, 2, 5, 7, 12, 19, 22, 24). Knudson et al. (11) hypothesized that the decrease in vertical jump performance they saw was the result of a decrease in neural transmission, because they found no change in the kinematics of the movement. They concluded that this was attributable to acute neural inhibition from passive stretching, which decreased the neural drive to the muscle (1, 13, 19). Kubo et al. (13) suggests that passive stretching changes tendon structure, in effect making it more compliant, leading to a lower rate of force production and a delay in muscle activation. This change in muscle stiffness is important; as Kokhonen et al. (12) argue, a stiff MTU allows force generated by muscular contraction to be transmitted more effectively than a compliant MTU. Rosenbaum and Hennig (19) and Avela et al. (1) support this argument by demonstrating a decrease in electromyographic (EMG) excitation with muscle contraction after passive stretching.

However, these studies employed a very slow eccentric component, or none at all, prior to concentric contraction. When sprint running is analyzed, the need for a rapid switch from eccentric to concentric contraction is paramount. Although no studies have looked at running performance, clues to the negative effect of static stretching may be found in the work of Young and Elliot (24). They found that there was a decrease in muscle activation, but that this was particularly important in regard to the preactivation of the MTU (stiffening of the MTU prior to ground impact). This is a vital component in the drop jumps Young and Elliot (24) examined; it is just as important for successful sprint performance. The researchers concluded that passive stretching mainly affects the eccentric phase of movement, reducing the elastic return from the stretch shortening cycle. Cornwell et al. (5) explains that the decreases in performance in the countermovement jumps they employed, caused by passive stretching, was the result of a decreased ability of the MTU to store elastic energy. Interestingly, the amount of elastic energy that can be stored in the MTU is a function of the units' stiffness (9, 21); therefore, the more compliant muscle observed after passive stretching (23) is less able to store elastic energy in its eccentric phase. This may well explain the decrease in performance exhibited in the static stretch groups in this study.

The changes in performance shown by the ASST group have not been demonstrated before. Although active static stretching is considered to be less effective than passive stretching in terms of increasing muscle length (23), the prolonged isometric contraction could lead to reduced sensitivity of neural pathways, reducing muscle spindle sensitivity. This is because this type of stretch occurs when an agonistic muscle contracts while the opposite antagonistic muscle relaxes, thereby decreasing excitatory impulses through the nervous system to the motor units (reciprocal inhibition). Therefore, in a complex movement pattern (such as sprinting) where muscle pairs need to work in conjunction with one another, one set of muscles may be in a position of being "switched off" by a decrease in nervous system stimuli.

The reason active dynamic stretches positively affect performance may be because core temperature has a greater increase than with other forms of stretching. Increases in core temperature have shown an increase in the sensitivity of nerve receptors and an increase in the speed of nerve impulses, encouraging muscle contractions to be more rapid and forceful (20). Core temperature was not recorded in this study; however, all testing was performed on warm summer evenings after a substantial warm-up (2,000-m jog). Any temperature increase was kept to a minimum by the static dynamic stretching being performed in a slow, controlled manner and the active dynamic stretching having built-in walk-back recovery. In addition, active static stretches also involve an amount of isometric muscle contraction, which may affect temperature. In this study, whether temperature differences between interventions would have been great enough to cause the performance changes demonstrated is debatable.

The other possibility for the positive changes in performance observed in the ADS group may be the rehearsal of movement in a more specific pattern than static stretching. Proprioception is required in sprinting, particularly for preactivation to help the rapid switch from eccentric to concentric contraction required to generate running speed. It may be that active dynamic stretching helps rehearsal of movement pattern coordination allow muscles to be exited early and quickly, producing more power and therefore decreasing sprint time. Evidence is available to demonstrate that passive stretching has a negative effect on coordination. Avela et al. (1) attributes the decrease in motoneuron excitability observed after passive stretching to the depression of the H-reflex. There may then be a reduction in discharge from the muscle spindles, because of increased muscle compliance. This may lead to reduced efficiency in self-regulation and adaptation to differences in muscle load and length (14), modifying running mechanics through loss of control and therefore affecting optimum power output.

In conclusion, the results from this study suggest that static stretching (active or passive) has a negative effect on 20-m running time. This could be due to an increase in MTU compliance, because as Cornwell et al. (5) explains, too much "slack" has to be taken up in the initial part of the contraction. However, active dynamic stretching appears to improve 20-m running time. The reasons for the positive increase in performance brought about by allowing active dynamic stretching are not clear, but could be linked to rehearsal of specific movement patterns which may help increase coordination of subsequent movement. There is a clear need for confirmatory studies, as well as for more fundamental research to investigate the mechanisms underlying the effects of warm-up stretch protocols on athletic performance.

PRACTICAL APPLICATIONS

The 20-m sprint performance in trained rugby union players can be improved by using an active dynamic stretch protocol. The use of static stretching appears to decrease 20-m sprint performance (static dynamic stretching was found to have no significant effect on performance). Coaches and athletes need to be aware of the potentially negative effects of both passive and active static stretching on immediate performance of short sprints, as well as the potential positive effect of doing specific movement pattern rehearsal (active dynamic stretching) before performance.

However, though this study demonstrated an increase in performance over 20 m with active dynamic stretching and a decrease in performance with static stretching, it must be remembered this is a mean change recorded for a number of subjects. Some subjects did not follow this trend; a small minority had a decrease in performance through the dynamic intervention and had an increase in performance after the static stretch. It can be concluded, therefore, that for the majority of sports performers needing to optimize sprint performance over a relatively short distance, a dynamic stretch (particularly active dynamic exercises, mimicking specific aspects of the sprint cycle) is advisable instead of the standard static stretch approach. But care should be taken, for a minority of individuals may not exhibit the positive changes in performance that this study has demonstrated.

REFERENCES

1. AVELA, J., H. KYROLAINEN, AND P.V. KOMI. Altered reflex sensitivity after repeated and prolonged passive muscle stretching. *J. Appl. Physiol.* 86:1283–1291. 1999.
2. BEHM. D.G., D.C. BUTTON, AND J.C. BUTT. Factors affecting force loss with prolonged stretching. *Can. J. Appl. Physiol.* 26: 262–272. 2001.
3. BERGH, U., AND B. EKBLOM. Physical performance and peak aerobic power at different body temperatures. *J. Appl. Physiol.* 46:885–889. 1979.
4. BLOMSTRAND, E., V. BERGH, B. ESEEN-GUSTAVSSON, AND B. EKBLOM. The influence of muscle temperature on muscle metabolism during intense dynamic exercise. *Acta Physiol. Scand.* 120:229–236. 1984.
5. CORNWELL, A., A.G. NELSON, G.D. HEISE, AND B. SIDAWAY. Acute effects of passive muscle stretching on vertical jump performance. *J. Hum. Mov. Stud.* 40:307–324. 2001.
6. DEUTSCH, M.U., G.J. MAW, D. JENKINS, AND P. REABURN. Heart rate, blood lactate and kinematic data of elite colts (under 19) rugby union players during competition. *J. Sports Sci.* 16:561–570. 1998.
7. FOWELS J.R., D.G. SALE, AND J.D. MACDOUGALL. Reduced strength after passive stretch of the human plantarflexors. *J. Appl. Physiol.* 89:1179–1188. 2000.
8. HOPKINS. W.G. Measures of reliability in sports medicine and science. *Sports Med.* 30:1–15. 2000.
9. INGEN, G.J. An alternative view of the concept of utilization of elastic energy in human movement. *J. Hum. Mov. Sci.* 3:301–336. 1984.
10. KARVONEN, J. Warming up and its physiological effects. *Pharmacol. Physiol.* 6:31–39. 1978.
11. KNUDSON, D., K. BENNETT, R. CORN, D. LEICK, AND C. SMITH. Acute effects of stretching are not evident in the kinematics of the vertical jump. *J. Strength Cond. Res.* 15:98–101. 2001.
12. KOKKONEN, J., A.G. NELSON, AND A. CORNWELL. Acute muscle stretching inhibits maximal strength performance. *Res. Q. Exerc. Sports* 4:411–415. 1998.
13. KUBO, K., H. KANEHISA, Y. KAWAKAMI, AND T. FUKUNAGA. Influence of static stretching on viscoelastic properties of human tendon structures in vivo. *J. Appl. Physiol.* 90:520–527. 2001.
14. MCARDLE, W.D., F.I. KATCH, AND V.L. KATCH. *Exercise Physiology: Energy Nutrition and Human Performance.* (4th ed.). London: Wilkins & Wilkins, 1997.
15. MOHR, K.J., M.M. PINK, C. ELSNER, AND R.S. KVITNE. Electomyographic investigation of stretching: the effect of warm up. *Clin. J. Sports Med.* 8:215–220. 1998.
16. MURPHY, A.J., AND G.J. WILSON. The ability of tests of muscle function to reflect training-induced changes in performance. *J. Sports Sci.* 15:191–200. 1997.
17. NELSON, A.G., AND J. KOKKONEN. Acute ballistic muscle stretching inhibits maximal strength performance. *Res. Q. Exerc. Sports* 72:415–419. 2001.
18. NORRIS, C.M. *Flexibility: Principles and Practice.* London: A & C Black. 1994.
19. ROSENBAUM, D., AND E.M. HENNIG. The influence of stretching and warm-up exercises on achilles tendon reflex activity. *J. Sports Sci.* 13:481–490. 1995.
20. SHELLOCK, F.G., AND W.E. PRENTICE. Warming up and stretching for improved physical performance and prevention of sports related injuries. *Sports Med.* 2:267–278. 1985.
21. SHORTEN, M.R. Muscle elasticity and human performance. *Med. Sports Sci.* 25:1–18. 1987.
22. WATSON, A.W.S. Sports injuries: incidence, causes, prevention. *Phys. Ther. Rev.* 2:135–151. 1997.
23. WILSON, G.J., G.A. Wood,and B.C. Elliot. The relationship between stiffness of the musculature and static flexibility: an alternative explanation for the occurrence of muscular injury. *Int. J. Sports Med.* 12:403–407. 1991.
24. YOUNG. W., AND S. ELLIOT. Acute effects of static stretching, proprioceptive neuromuscular facilitation stretching and maximum voluntary contractions on explosive force production and jumping performance. *Res. Q. Exerc. Sports* 3:273–279. 2001.

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