We aplogise to the authors of this article, that in the previous issue of Modern Athlete & Coach, the [illegible] was not published. Several paragraphs were omitted, hence we have republished the article in full. *Ed.*

THE SIGNIFICANCE OF STRETCHING IN THE WARM UP BEFORE MAXIMUM PERFORMANCE

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Translated by Jörg Probst

In recent times new research in biology and sport science has challenged the assumed positive links between stretching and injury prevention. This paper is a summary by Jörg Probst of the original German article, 'Die Bedeutung von Dehnen und Stretching in der Aufwärmphase vor Höchstleistungen', which was published in Leistungssport 4/2000.

In the introduction, the authors describe the following fictitious but familiar scenario: An athlete (e.g. a long jumper), in his warm up for a competition takes a long time stretching his thigh muscles. When doing some warm up jumps he feels some muscle stiffness in his left quadriceps (assume the right leg is his take off leg). Fearing he may not have stretched intensely enough, and thinking of the advice from both his coach and physiotherapist of how to get rid of muscle stiffness, he does additional stretching for the quadriceps, in order to be well prepared for his first competition jump. However, during the take off phase of his first competition jump disaster strikes. As he swings his left leg up, the athlete feels a sharp pain in his left quad, which forces him to abandon the jump and the competition.

The authors then describe in great detail the effects of stretching, and the cause/s of injuries similar to that described above. In reaching their conclusions, they draw on new knowledge about the anatomy of muscle fibres, as well as research that has examined the role of stretching in preparing to participate in vigorous physical activity.

The important conclusion that comes from the muscle structure research is that the amount of passive tension the elastic elements of the muscle have to bear is by no means smaller during extreme stretching than during active tension in voluntary maximal isometric contractions. Indeed, the passive tension from stretching can be much higher. Consequently, the forces applied during contractions and stretching in training should have the same or similar effects.

In the discussion on the effects of stretching the authors emphasise the distinction between short term and long term stretch training programs. A short term stretch training program consists of 10-20 minutes stretching with 3-5 sets of 3-10 repetitions, as it is often employed in the warm up or cool down of a training session, or in the warm up to a competition. A long term stretch training program on the other hand is a series of short term stretching programs carried out several times a week over a period of several weeks or months. The authors are concerned only with the short term programs. The distinction between intensive stretching (e.g. stretching to the maximal tolerable tension) and light, submaximal stretching is made.

The benefits of stretching on the range of motion at the joints (movement amplitude) are not questioned. Short term stretching has been found to increase the amplitude by at least 8%. The authors refer to a review on stretching research conducted by Wydra (1997) who found that the conventional rhythmical-ballistic stretching (out of vogue for some time) has at least the same, and in some cases a superior effect on joint amplitude compared with that of static stretching. What is interesting is that the most gains in movement amplitude are reached in the first 3-5 repetitions, with only slight increases with additional repetitions.

The increase in movement amplitude was until recently explained by a decrease in the muscle's passive resistance to tension in the course of a stretching program. However, recent research has shown that the tolerated stretch-tension of the muscle increased as the amplitude increased. The authors conclude that during the short term stretching program the movement amplitude increases due to the capacity of the athlete to tolerate higher maximum stretch tension as they progress from repetition to repetition. The adaptations thus seem to occur mainly at a neural level, but it remains unclear whether this happens at the level of the pain receptors and the nervous system, or at the information processing and perceptual level.

The authors further conclude that systematic maximal stretching to the limit of the movement amplitude (or the maximal tolerance of muscle tension) promotes tension to the passive structures of the muscle fibres. Smith, Brunetz, Chenier, McCammon, Houmand, Franklin, and Isreal (1993) showed that this tension can be so great that stretching alone can cause muscle soreness, which is more likely to occur during static stretching than during ballistic stretching!

A study by Wiemann (1995) showed that female gymnasts, who were performing eccentric training for both legs targeting the rectus femoris, reported significantly greater muscles soreness in the leg that they stretched statically between the sets, two days after the training session. Thus static stretching appears to cause micro trauma to the myofibrils leading to muscle soreness similar to that caused by strength training.

Other studies have shown a short term negative effect of static stretching on speed strength performances. For example, Wiemann & Klee (1992) conducted a study in which active sportspeople performed 40m sprints. The first group, who participated in 15 minutes of stretching the hip extensors and hip flexors between the 40m sprints, performed worse by approximately 0.14s. In comparison, the second group who did some jogging in the 15 minutes between sprints improved their times by 0.03s. Güllich and Schmidtbleicher (2000) found a performance reduction in drop jumps after static stretching that lasted for 30 minutes after the stretching. They suggested that the reduced neural activation in the muscles might have caused the decrement in performance.

The authors proceed to assess the process of stretching in preparing for competitions, and argue that the high tension load of the muscles during intensive stretching is sufficient to warrant caution in the use of static stretching in the warm up phase. Some exceptions might include preparing for activities in which flexibility is of paramount importance and part of the performance, such as gymnastics, or even sprint hurdles. However, the authors emphasise that intensive static stretching causes a loss in speed strength performance, which lasts for some time.

The use of intense static stretching as a means of reducing the risk of injury has not been proven, hence its place in the warm up cannot be justified on that premise. Static stretching also causes the interruption of the blood flow to the muscle (Alter, 1996), which means that stretching does not even achieve the aim of warming up the musculature, as is commonly believed. Static stretching should be conducted separate to the warm up.

The effect of short term stretch programs during a strength training session should also be considered. During a strength training session the metabolic resources are depleted more and more, which means that the maximum possible contraction force decreases from repetition to repetition. The tension the passive tissues of the muscle fibres have to bear therefore decreases towards the end of the training. However, in a short term stretch training session the tension on the passive structures of the muscles fibres increase. In stretching the muscle, the athlete becomes accustomed to the stretch pain, which allows an increased tolerance of higher movement amplitudes. Consequently, the athlete can reach or exceed the load limit of the passive structures of the muscle fibres without knowing it.

To date we do not know which of the passive structures are the weakest links. The adaptations occur at a neural (central nervous system) level, and subsequently a higher psychological stress might increase the pain adaptation further. This may occur before competitions where an athlete through stretching exceeds the limits of the passive structures of the muscles causing micro trauma.

The authors return to the fictitious long jumper and explain his injury as follows: The athlete may have over stretched in the warm up, which caused micro trauma in his rectus femoris. At the moment the right leg plants on the take off board the rectus femoris of the take off leg is in an extremely stretched position, which produces high passive tension. What follows is a high active tension as the leg swings up, adding to the passive tension and causing the injury.

The authors conclude that the perceived benefits of intense static stretching before a maximum performance have not been proven. On the contrary, intense static stretching prior to vigorous physical activity is responsible for a reduced performance in addition to producing a higher risk of injury. This is not to say that regular stretch training will not improve performance by an increase in joint flexibility. The issue is when to participate in static stretching sessions. The authors argue that static stretching should be performed in separate training sessions. In the warm up phase immediately before maximal performances only submaximal stretching should be used. Five light, but dynamic, stretches are sufficient to prepare the body for action.

I would like to add my own observation from the warm up field, which seems to support the views expressed in this article. Sprinters and jumpers are the athletes who spend the most time on what certainly looks like intense stretching before their competitions, yet ironically there seems to be a much higher rate of injuries amongst those athletes during competition than for instance the throwers. It would certainly be advisable to introduce separate maximum static stretch training sessions into the training program of athletes whose events require explosive power, in order to reduce the risk of injury during training and competition.

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