Short Hamstrings and Stretching
Halbertsma, Jan Pieter Klaas

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Summary

Short Hamstrings & Stretching
A study of muscle elasticity

Chapter 1. Introduction
Stretching programs are widely used in rehabilitation medicine, physical therapy, sports medicine, and physical education. The design and the effects of these stretching programs differ considerably, hence it is unclear what the effects are of stretching exercises.

In most studies the angle between the straight leg and the length-axis of the body is used as an effect parameter of training programs. Recurring doubt about the scale and the importance of the effects of stretching exercises on flexibility, range of motion, and muscle stiffness has led to this study. To get a better insight into this matter, in this thesis the effects of various stretching exercises in subjects with the diagnosis of short hamstrings or tight hamstrings are studied.

Generally, subjects with short hamstrings are characterized by their inability to touch the ground with the finger-tips when bending forward with the knees in extension. In a passive hip flexion test with a straight leg, a limited range of motion can be observed and consequently a diminished flexibility is established. It is generally assumed that stretching exercises decrease muscle stiffness and influence flexibility. A variety of stretching exercises with specific applications and aims have been developed and employed.

The objective of this study is to analyze whether stretching exercises under various conditions can influence muscle extensibility and by that the ROM of the hip joint. If so, secondary questions concern the effect of stretching exercises on muscle elasticity and the mechanism for increasing the range of motion.

In the first chapter concepts of flexibility and muscle stretching are introduced followed by the objective of the study. The general concepts applied in this study are outlined in chapter 2. In the following chapters the effects of therapeutic (long-term) stretching (chapter 3)
and sport (short-term) stretching (chapter 4) on healthy subjects with short hamstrings are described. The acute effects of a series of repeated passive stretching are described in chapter 5. In chapter 6 the elasticity of the hamstrings in patients with non specific low-back pain is compared with the elasticity of subjects with short hamstrings. Finally in chapter 7 the results of the study are discussed and conclusions are drawn.

Chapter 2. Components in stretching programs

Flexibility, a full range of motion, or a functional range of motion are of particular interest in physical education, sports activities, and rehabilitation medicine. Definitions of the concepts are depending on the point of reference. In subjects with a decreased flexibility the therapy is usually aimed at stretching of the muscles involved. For that purpose a variety of stretching exercises have been developed and employed. Each of these stretching programs has its specific application in rehabilitation medicine and physical therapy but also in physical education and sports. The effects of stretching exercises of the hamstrings are mainly assessed by measuring the increase in joint range of motion (ROM) as an effect variable. The increase in ROM is attributed to neurophysiologic and biomechanical mechanisms. The neurophysiologic component is explained by inhibition of the muscles exposed to stretching. The biomechanical component is related to the viscoelastic behavior of the muscle tissue undergoing stretching forces. The hamstrings muscle length and the effects of stretching exercises can be assessed by measuring the range of motion of the hip joint.

The external visible limitation in the ROM of the straight leg is determined by the extensibility of the hamstrings, muscle stiffness, electromyographic activity of the muscles, internal friction and the behavior of the subject. A design for an instrumental straight-leg raising set-up (ISLR) for measuring the effects of stretching exercises is described and proposed. This method is suitable to overcome the deficiencies of manual testing of movement excursions. The method of ISLR enables measurement of the leg excursion and the contribution of the hamstrings to the leg excursion. The effects of stretching exercises on hamstring muscle length can be assessed implicitly. By measuring the
Chapter 3. Effect of therapeutic stretching of short hamstrings

Muscle stretching is common practice in physical therapy and rehabilitation medicine in case of a diminished flexibility or movement restriction. However, in various studies non consistent effects of stretching exercises for increasing flexibility are reported. In our study the effects of a therapeutic (long-term) stretching program of the hamstring muscles have been established with an instrumental straight-leg raising set-up. The measured variables were the range of motion of the hip joint, the extensibility of the hamstrings, the muscle stiffness, the electromyographic activity of the hamstrings, and the first detection of pain. To select subjects with short hamstrings and to eliminate possible pathology, the potential candidates had to meet the following selection criteria: (1) unable to touch the floor with the finger-tips in a bending test; (2) no history of neurologic or orthopedic disorders; (3) no suffering from recent or chronic low back pain; (4) no previous surgery or recent injury of the back, pelvis, or legs. Selected in this way, 14 subjects, aged 20-38 year (mean 27.3), participated in the experiments. One group of 7 subjects was treated during 4 weeks with a daily exercise program according to Janda, aimed at stretching the hamstring muscles. The second group of 7 subjects was used as a control. The stretching routine was supervised by physical therapists. Pre and post measurements were performed in the subjects of both groups. In the stretching group there were significant increases in ROM, extensibility of the hamstrings and a shift of the first detection of pain accompanied with significant increases in the stretching moment tolerated by the passive hamstring muscles. The passive muscle stiffness of the hamstrings however, remained the same. In the control group there were no differences between pre and post measurements. It is concluded that stretching exercises do not make short hamstrings any longer or less stiff, but only influence the stretch tolerance and in consequence the extensibility of the hamstrings.
Chapter 4. Effect of sport stretching on short hamstrings
Muscle stiffness of the lower extremities and subsequent decrease of flexibility are generally considered etiologic factors in musculoskeletal injuries. Stretching exercises preceding sports activities are usually recommended, because it is believed that i.a. stretching exercises can prevent sport injuries. Because the first experiments showed that muscle stiffness did not change after long-term stretching it was expected that the muscle stiffness after short-term stretching would not change either. To evaluate the effects of a 10-minutes session of stretching exercises on muscle stiffness 16 subjects, aged 20-29 year (mean 24.6), participated in the experiments. They were selected according to predetermined short hamstrings selection criteria and were randomly divided into two groups, a stretching group and a control group. In the stretching group 10 subjects performed static stretching exercises during 10 minutes interspersed with relaxing. Pre and post measurements with an instrumental straight-leg raising set-up were performed in the subjects of both groups. The subjects of the control group did not stretch between the measurements. The 10-minutes stretching resulted in a slight but significant increase in the passive ROM, extensibility of the hamstrings, and the passive muscle moment in the subjects of the stretch group. There was no significant change in the course of the passive muscle stiffness curve with respect to the pre stretch stiffness curve. In the control group there were no significant differences in pre and post measurements. It is concluded that short-term stretching in sports does not influence the muscle stiffness. The increase in range of motion and the extensibility of the hamstrings are due to an increase in the stretch tolerance.

Chapter 5. Acute effect of stretching of short hamstrings
It was shown that the effects of long-term (therapeutic) stretching and short-term (sport) stretching were comparable. A change in the stretch tolerance is supposed to be mechanism for the increase in extensibility. The initial stage of stretching exercises must address acute adaptations. To study this aspect more in detail, the acute effects of the hamstrings exposed to one series of 5 repeated stretch tests were studied. The instrumental straight-leg raising set-up was used as a stretch device, to measure extensibility of the hamstrings. Spiral wound springs were used as a power source. The subjects were 16 patients with short hamstrings, aged 20-29 year (mean 24.6), who participated in the experiments. They were selected according to predetermined selection criteria and were randomly divided into two groups, a stretching group and a control group. In the stretching group 10 subjects performed static stretching exercises during 10 minutes interspersed with relaxing. Pre and post measurements with an instrumental straight-leg raising set-up were performed in the subjects of both groups. The subjects of the control group did not stretch between the measurements. The 10-minutes stretching resulted in a slight but significant increase in the passive ROM, extensibility of the hamstrings, and the passive muscle moment in the subjects of the stretch group. There was no significant change in the course of the passive muscle stiffness curve with respect to the pre stretch stiffness curve. In the control group there were no significant differences in pre and post measurements. It is concluded that short-term stretching in sports does not influence the muscle stiffness. The increase in range of motion and the extensibility of the hamstrings are due to an increase in the stretch tolerance.
sequent decrease of extensibility in musculoskeletal activities are usually the result of stretching exercises can be effective. Studies showed that stretching it was effective to stretch the hamstrings would not improve the extensibility of the hamstrings. Aged 20-29 years (mean 21.6), participated in the experiments. Subjects engaged in stretching programs were excluded. In the experiments the hamstring muscles were stretched as far as the subjects allowed. Comparison of the data of the test group after 5 successive passive stretch tests showed no significant changes of the variables; ROM, extensibility of the hamstrings, passive muscle stiffness, the onset of electromyographic activity, maximum muscle moment, and the first sensation of pain. It is therefore concluded that the acute effects of one series of repeated passive stretching of short hamstring muscles are negligible and that a minimum quantity of stretching exercises are required to have any effect on the stretch tolerance.

Chapter 6. Extensibility and stiffness of the hamstrings in patients with non specific low-back pain

Patients with low-back pain often have some symptoms in common with subjects with short hamstrings. They cannot touch the ground with the fingers and the clinical straight-leg raising is limited. In subjects with short hamstrings the usual treatment procedure is to stretch the muscles to increase the ROM. However, in patients with low-back pain it is not clear how far a limited range of motion of the hip joint can be attributed to hamstrings stiffness or diminished extensibility and whether stretching exercises are indicated to increase the ROM. The object of our study is to analyze the role of the hamstring muscles in patients suffering from non specific low-back pain with an instrumental straight-leg raising method. The lift force, leg excursion, pelvic-femoral angle, first sensation of pain, and the electromyogram of the hamstrings are measured. A patient group (n=20) and a healthy control group (n=20), participated in the experiments. From the control group 12 subjects were assigned to a short hamstrings group, selected according to predetermined short hamstrings selection criteria. Comparison of the data of the patient group and the short hamstrings group showed significant differences in ROM and hamstring muscle extensi-
bility, being smallest in the patients. In healthy subjects with short hamstrings the onset of EMG of the hamstrings is close to the maximum leg excursion. The muscle activity increases when the muscle is stretched. In the patient group, however, the onset of the hamstrings EMG is much earlier as a function of hamstrings elongation. After the onset the muscle activity does not increase at once. The passive muscle moment of both group does not differ so it might be concluded that the patient group has a greater muscle stiffness. In other studies no differences were found in muscle stiffness. An explanation for this discrepancy is the possible contribution of EMG activity of the hamstring muscles less than 10% of reference activity to the "passive" muscle stiffness.

No significant differences can be established between the short hamstrings group and patient group in maximum muscle moments. It is concluded that not the magnitude of the muscle moment but the decreased extensibility is the limiting factor in straight-leg raising in patients with non specific low-back pain. The small ROM and extensibility of the hamstrings in the patient group is not caused by a greater muscle stiffness but probably by a limited stretch tolerance. The early muscle activity in the hamstrings, but also in the gluteus maximus and erector spinae is probably caused by factors outside the muscles, like arousal. It is concluded that stretching exercises are not indicated in patients with non specific low-back pain. Relaxation exercises seem more appropriate.

Chapter 7. Discussion and conclusions

The objective of this study was to analyze whether stretching exercises under various conditions (long-term, short-term, and acute) can influence the extensibility in subjects with the clinical diagnosis of short hamstrings. To overcome the deficiencies of manual testing for that purpose an instrumental straight-leg raising set-up has been designed and applied.

An increase in leg excursion has been assessed after both long-term (therapeutic) stretching and short-term (sport) stretching. The increase is, however, small compared with the results of other studies. It is concluded that stretching exercises do not make the hamstrings any
Subjects with short hamstrings show less movement of the muscle at the maximum moments. It is not significant but the decrease in ROM and extensibility is not caused by a greater muscle stiffness. The early activity of the hamstrings and the muscles, like the rectus femoris muscle, is not indicated in any of the studies. Strength exercises seem more appropriate.

One series of successive stretching exercises to the extreme limit does not influence the extensibility, stretch tolerance, the onset of the EMG of the hamstrings, nor the extensibility of the hamstrings. It is concluded that the acute effects of successive stretching are negligible and a minimum number of stretching exercises is required to have any effect on the stretch tolerance.

Patients with non specific low-back pain have less ROM of the hip joint and extensibility of the hamstrings compared to subjects with short hamstrings. The limited ROM of the straight-leg in patients suffering from low-back pain is not caused by a high muscle stiffness but by a lowered stretch tolerance. There is no difference in the perception of the first sensation of pain. The leg excursion is often attended with early muscle activity of the hamstrings. There is also often simultaneous muscle activity in gluteus maximus, and erector spinae. This activity is probably caused by factors outside the hamstring muscles as for example arousal. It is therefore concluded that stretching exercises are not indicated in patients with non specific low-back pain because of the early presence of muscle activity. Instead of stretching exercises, relaxation exercises seem more appropriate.