The return to training and competition after Achilles tendon injuries

© by IAAF
24:3; 79-93, 2009

By Susanne Kroesche

ABSTRACT

Achilles tendon problems comprise a complex of complaints wide-spread in sport, particularly among athletes in the running and jumping events. In an accompanying article, the author provided descriptions from the current sports medicine literature of the biomechanics of the Achilles tendon, the main problems that affect it, the mechanisms at work in injuries and the factors that must be taken into account in the prevention of such injuries and conditions. Drawing on the same literature, this article addresses the rehabilitation that is necessary for an athlete to return to training and competition while minimising the risk of re-injury. The aim is to provide practical information that will be of value to therapists, coaches and athletes as they to work together to plan and structure individualised rehabilitation programmes. It contains an overview of the main types of measures used in the rehabilitation of Achilles tendon injuries and conditions, including training, physical and therapeutic, conditioning, biomechanical and local pharmaceutical means. It then gives abstracts of therapeutic concepts in which these measures are employed that have been developed by five authors. The article concludes with some general advice on the design and implementation of a rehabilitation programme.

AUTHOR

Susanne Kroesche is a graduate of the German Sport University in Cologne and is currently the head of training in a sport therapy centre in Limburg, Germany. After finishing her career as a heptathlete she worked in several institutions as a therapist.

Introduction

Part I of this article provides descriptions from the current sports medicine literature of the biomechanics of the Achilles tendon, the main problems that affect the Achilles tendon, the mechanisms at work in an Achilles tendon injury and the factors that must be taken into account in the prevention of such injuries and conditions.

This second part address the rehabilitation that is necessary for a return to training and competition. The following sections cover the types of measures use in the rehabilitation of Achilles tendon injuries and conditions as well as the main theraputic concepts in which these measures are employed. The aim is to provide practical information that will be of value to therapists, coaches and athletes as they to work together to plan and structure individualised therapy programmes.

It should be kept in mind that the symptoms of Achilles tendon injuries can vary

from those that lead to only minor limitations on the practice of sport to those that cause major restrictions to the day-to-day activities of life. Rehabilitation programmes, therefore, must be adapted according to the individual diagnosis and the status of the injury and there must always be an emphasis on minimising the risk of follow-up injuries.

Overview of rehabilitation measures

Training measures

If training has been determined to be the cause of an Achilles tendon injury, interruption and or modification of the contents and loading would seem to be important initial measures. The corresponding decision should be based on the degree of pain and the duration of the symptoms. In this respect, MYERSON & BIDDINGER (1995) recommend a reduction of training by 50% while PETERSON & RENSTRÖM (2002) and THIEL (1982) suggest a complete interruption. However, MAYER et al. (2000) point out that, generally, recommendations regarding loading are given without proper evidence.

In cases where the training volume can be considered a reliable factor for triggering the injury, SCHEPSIS et al. (2002) advise runners to reduce volume by up to 25% of their average and then gradually increase it again by 10% per week, depending on the improvement of the symptoms. They also recommend a) temporary suspension of interval training and uphill running, b) training on soft rather than hard surfaces and c) the use of orthodic devices in the shoes (see below).

LOHRER (1996) found that the choice of the surface for training is of critical importance. Soft surfaces such as snow or sand and uneven surfaces (grass or frozen grass) could cause movements with either inward (pronation) or outward (supination) turning of the calcaneus and must therefore be avoided. High speed running with pronatated movements on hard surfaces (concrete, asphalt) can also cause pain. WELSH & CLODMAN (1980) warn explicitly about training on indoor surfaces.

MAYER et al. (2000) consider running speed and increased body weight, caused for example by weightlifting, to be an important risk factors for the development of Achilles tendon injuries. In the framework of conservative therapy, the suspension or reduction of such training is essential and could be compensated for by using less stressful exercises to avoid the loss of physical fitness. For this purpose, a number of authors (BRODY, 1987; ALFREDSON & LORENTZON, 2000; KLÜMPER, 2000; MAYER & DICKHUT, 2002; SCHEPSIS, 2002) have found that aqua-jogging, swimming or cycling can be used. As transitional exercises towards the running movement, SCHEPSIS (2002) recommends cross-country skiing and stair climbing.

For LOHRER (1996), the pain-causing load is a criterion for the conceptual set-up of the rehabilitation programme. If the symptoms occurred for first time as the result of a sprinting or jumping load, it can be assumed that micro ruptures in single fibres of the tendon occurred. Consequently, distance running could be used as a training exercise. If the symptoms occurred for the first time as a result of low intensity distance running, it can be assumed that degenerative changes occurred. Consequently, post-recovery training could contain highly intensive exercises (such as sprints or tempo runs), because the increased muscular activity within the upper ankle joint stabilises the functional leg axis.

Physical and physiotherapeutic measures

According to MAYER et al. (2000), successful treatment of many Achilles tendon injuries can be achieved by applying local physical and physiotherapeutic measures. A number of other studies confirm the positive effects of such measures for the purpose of increasing the metabolism and the blood circulation. Specifically:

- KLUEMPER (2000) recommends ultrasound therapy, especially for a chronic irritable condition. The longitudinal waves sent out by an ultra-sound device massage the inner tissue with tensile and compressive forces. Furthermore, they provide a beneficial effect through the transformation of kinetic energy into heat.
- LOHRER (1996) recommends the use of diadynamic electricity ("stimulation current") for which DEUBEL et al. (1998) have determined the following effects: hyperaemia, analgesia, improvement of the cell wall permeability and re-absorption activities, normalisation of the metabolism, the muscle and vascular regulation, improvement of the contractibility of the muscles and the regeneration by increased blood circulation.
- Both LOHRER (1996) and KLUEMPER (2000) suggest treating the affected area with ice after training and, in the case of acute pain, to primarily reduce the turgor (swelling) and the incipient hyperaemia.
- THIEL (1982) and PETERSON & RENSTRÖM (2002) point out the positive effect of cooling applications, which can be applied 2-3 times per day during the acute phase.
- MAIER (1995) emphasises the use of heat application and hyperaemia by massage and brushes.

According to MAYER et al. (2000), painful symptoms can sometimes be explained by an asymmetrical pull of the forces acting on the Achilles tendon. Coordinative measures on the peg top, trampoline or wobble board (see Photos 1 to 10) by using the proprioceptive neuromuscular facilitation (PNF) have been shown to have positive effects (ALFREDSON et al., 1998; BRUCKNER & KHAN, 1993; FYFE & STANISH, 1992).

BRUCKNER & KHAN (1993) FREDERICSON (1996) and GALLOWAY et al. (1992) recommend myofascial techniques, mobilisations and cross-frictional massage for the loosening post-inflammatory adhesions or scars. According to DEUBEL et al. (1998), this massage should be precisely applied above the affected area and the therapist should move his/her fingers with sufficient amplitude and depth across the direction of fibres. It is expected to bring pain relief, mobilisation, a lowering of the tonus, and local blood circulation. MAYER & DICKHUT (2002), MÜLLER (1996) and LOHRER (1996) confirm the positive impact of cross-frictional massage but KLUEMPER (2000) points out that pain and the risk of increased symptoms can be caused.

Conditioning measures

MAYER et al. (2000) stated that "despite the fact that the positive effect of eccentric strength training in combination with stretching exercises for the calf muscles has been well known for many years, it has not been appropriately considered within a physiotherapeutic treatment framework."

However, within the framework of conservative therapy, various authors do recommend measures for the improvement of flexibility and strength. These include stretching exercises for the Achilles tendon, eccentric strength training for the calf muscle and a combination of both. Specifically:

- SCHEPSIS et al. (2002) recommend light intensity stretching using the passive-static method. In the acute phase, it is important that the athlete does not over-stretch and thereby increase the symptoms. Stretching exercises for the calf muscles should be applied before and after training with both a bent and extended knee. It is sometimes helpful to use a splint to give dorsal flexed position of the foot over night, for six to eight weeks in order to maintain and increase passive dorsal flexion.
- KLUEMPER (2000) recommends stretching exercises on inclined ground, under supervision of an experienced physiotherapist. After reduction of the acute inflammatory symptoms, the use of strength training can be considered.
- MYERSON & BIDDINGER (1995) suggest using the isometric method and to develop the load progressively.

Photo 1: Equipment for balance exercises: wobble boards, peg top

Photos 2-5: Movements with the wobble board

Photos 6-9: Peg top exercises

- The use of electro-stimulation at an early stage with a following transition to isotonic and, later on, eccentric strength exercises is recommended by SCHEPSIS et al. (2002).
- The use of eccentric strength training for the calf muscle seems to be especially effective. ALFREDSON et al. (1998) conducted a study with 15 athletes and a control group of similar size (following a conservative therapy). The athletes applied highly intensive eccentric strength training. Almost all were free of pain after 12 weeks. It is assumed that either the effect of the stretch respective to the extension of the muscle-tendon unit with a lowering of the muscle tension or the hypertrophy and the increase of the tensile strength caused the effect. Moreover, eccentric strength training possibly causes structural changes within the tendon.

Photo 10: Trampoline exercise

According to SCHEPSIS et al. (2002), such training measures as mentioned above should be accompanied by anti-inflammatory medications and ice massage. It is also important to keep in mind that any immobilisation phase is kept as short as possible to avoid potential atrophy (NICOL et al.1991).

Biomechanical measures

It is known that the type or the state of the shoes worn can affect the biomechanics of Achilles tendon function during the running stride, which impacts both injury causing factors and rehabilitation. LOHRER (1996) mentions that old and used shoes can force a latent compensating movement, while stable shoes could force the foot into unwanted movements. Therefore it is recommended that athletes change shoes frequently with the occurrence of achillodynia.

Previously GOLLHOFER et al. (1984, 1987) had reported that over the course of an athlete's career the musculoskeletal system adapts to specific shoe types, even brands. However, MAYER et al. (2000) point out the vagueness about the extent to which the construction and form of a shoe cause the symptoms of achillodynia. Different publications assume increased pronation during running, which is not proven in all cases.

A number of authors have found that biomechanical measures, such as use of orthodic devices or shoe inserts, correct inappropriate movements of the foot that may lead to Achilles tendon injury or prevent recovery (CLEMENT et al., 1984; GROSS et al., 1991; JÖRGENSEN, 1990; MYERSON & BIDDINGER, 1995; SEGESSER, 1995, LOHRER, 1996; WEN et al. 1998).

However, LOWDON et al. (1984) found that the use of visco-elastic orthodic inserts is not always advantageous. They can lead to uncontrolled movements after the landing phase of each stride, which could intensify rather than reduce achillodynia. Moreover, DIXON & KERWIN (1998) have identified three different types of runner characterised by the touch down in the landing phase of each stride ("ball", "metatarsal" and "heel" runners). When an orthodic device is used, the mechanical loading for the Achilles tendon (especially because of important changes of the leverages) is counterproductive for metatarsal and heel runners.

Apart from shoes and orthodic devices, muscular deficits and imbalances should be addressed by training of the leg axis using exercises close to the characteristics of the discipline technique (LOHRER 1992, 1996). MAYER et al. (2000) seems to agree, stating that the influence of mechanical elements might not be as important as the change of muscle function through proprioreception.

Local measures

The main local measures for treating Achilles tendon problems consist of antiphlogistic therapy, using tablets or through transdermal administration. Mostly these are measures that are applied when the first symptoms occur.

For transdermal administration many authors (JUNGMICHEL & NAWROTH, 1989; MAIER, 1995; LOHRER, 1996; MÜLLER et al., 1996; KLÜMPER, 2000; SCHEPSIS et al., 2002) recommend the application of creams. Taking into account that the phar-

macological effect could be limited due to an insufficient absorption, creams containing steroids have shown positive effects because of the superficial location of the Achilles tendon (MAYER & DICKHUT, 2002). However, GALLOWAY et al. (1992) state that nowadays treatment with steroid additives can no longer be considered as a meaningful alternative. According to LOHRER (1996), if symptoms have been persistent over several months and other therapies have not shown success, starting a serial infiltration therapy using a highly dosed glucose solution should be considered.

Both LOHRER (1996) and KLUEMPER (2000) recommend deep skin x-ray radiation for anti-inflammatory purposes. However, even if this method has shown satisfying results, the disadvantages of high dosages of radiation may be too great of a disadvantage and this method does not seem to be popular with therapists.

For many authors the application of cortisone medications for achillodynia is seen as critical (KRAHL & PLAUE, 1971; EHRSAM, 1974; HUDLER et al., 1983; ALFREDSON & LORENTZON, 2000; ULREICH et al., 2002). An injection with corticoids could be considered for reducing pain, but it could also suppress the necessary regeneration processes. For this reason, the injection of corticosteroids frequently leads to Achilles tendon ruptures (KLUEMPER, 2000). According to ASTRÖM (1998) a retrospective study of 342 patients with chronic tendopathy showed that injection with corticosteroids led to a certain predictability of partial ruptures. LEPPILATHTI et al. (1991) report that of 150 patients undergoing Achilles tendon operations, 72 were previously treated with corticosteroid injections. However, ALFREDSON & LORENTZON (2000) raised concerns about this finding, saying a cause-effect relationship could not be shown. In any case, it does not seem to be logical to apply corticosteroid injections if there is no clear indication of an inflammation.

Overview of therapeutic concepts

There are, in fact, only a few programmes that specifically address the treatment of achillodynia. Most of the published programmes focus on rehabilitation after Achilles tendon ruptures (EHRICH & GEBEL, 1992; STEININGER & BUCHBAUER, 1994; SCHULTE-FREI, 2003; EHRICH & GEBEL, 2000). However, the main principles of these could also be used for specific programmes for achillodynia.

In this section, the therapeutic concepts for treatment of Achilles tendon injuries developed by five prominent authors are outlined. The concepts each share the aim of full rehabilitation of the Achilles tendon and a return to training and competition. More specifically, they also share the following objectives:

- preservation and recovery of the sport performance ability
- acceleration of the healing process
- prophylaxis of an acute relief syndrome and other subsequent damage
- compensation of irreversible damages
- development and improvement of the intrinsic cognition of the body and senses
- deceleration of the reduction of physical and mental abilities
- prevention of new damage
- increase of individual motor control abilities

BRENKE et al.: Rehabilitation of achillodynia from a sport therapeutic perspective

For BRENKE et al. (1979), an absolute immobilisation for the treatment of achillodynia is not necessary, because a break in training would lead to an involution of the vascular system within the Achilles tendon and consequently a loss of optimal blood circulation (see also FRANKE, 1977). Therefore, the authors recommend the maintenance of cardio-vascular capacities through swimming, cycling and ergometer. It is recommended to not apply any runs, jumps or strength training exercises that

would require intensive plantar flexion. The duration of the programme depends greatly on the degree of the injury and has to be adapted individually.

In swimming, the crawl stroke and the dolphin kick are optimal. This is because in the active phase of leg extension the Achilles tendon is not affected, as the plantar flexion of the foot is performed mostly passively. Fins could be used to increase resistance with a corresponding strengthening effect, provided the athlete is already symptom-free. In cycling and ergometer training, only the heel or the metatarsal should be placed on the pedals. With increasing recovery, the foot placement can be changed towards the ball of the foot. The resistance should be set between 1 – 2.5 watt/kg. It is advantageous to cycle with higher number of revolutions because of the positive cardio-vascular effect.

Photo 11: Training of the shin muscles using elastic rope

In addition to the cardio-vascular training, gymnastics in sitting or lying positions should be used, particularly exercises that involve major parts of the body (e.g. abdominals, back, extensor and flexor loops) are helpful. Exercises for strengthening the legs to avoid atrophy are also recommended. In particular, the shin muscles need to be trained (see Photo 11), as the muscle dysbalances between them and the ankle muscles are frequently an important factor for the occurrence of achillodynia (consistent one-sided pull). A period of up to 10 days with low stimuli before returning to a reduced regular training is recommended.

ALFREDSON et al.: Eccentric calf muscle training for the rehabilitation of Achilles tendon injuries

From the initial experience that ALFREDSON et al. (1998) made with eccentric calf muscle training after Achilles tendon ruptures, they tried to adapt the findings to a concept for therapy of other Achilles tendon conditions, especially tendinosis. Their main objective was to observe the effects of highly intensive eccentric calf muscle training on achillodynia symptoms. It is interesting to note, that up to this point, with one exception STANISH et al. (1986), there were no empirical data available for this kind of therapy concept. The therapy concept ALFREDSON et al. arrived at featured a high degree of efficiency, a simple set-up and low efforts.

A group of 15 athletes autonomously performed such strength training twice a day, seven days a week for 12 weeks in total. Running was permitted during this period, provided there was no pain or very low pain. Therapists controlled the process regularly. Two types of exercises were used. In both exercises the initial position was in the toe-stand (heels up), which was achieved by the healthy leg. While the injured leg performed the exercise without strength effort, the healthy calf muscle was loaded in two different ways. Lowering of the heels a) with an extended knee and b) with a bent knee (to active the m. soleus) (see Photos 12 and 13). Each exercise was performed with 15 repetitions and three sets, with slow speed. The athletes were told that during the first two weeks they could expect pain in the trained muscle group. In the beginning the intensity for the injured leg resulted from body weight and during the eccentric phase only. No con-

Photos 12-13: Strength training of the calf muscle using a strength training machine

centric contraction was performed. The athletes were told to stop if the pain was perceived as too high. When the pain level became less, additional weights were increasingly applied. Later on, a strength-training machine was introduced to apply higher weights.

The result of this study was interesting. The effect of the eccentric strength training was measured on a visual 100mm scale on which the athletes (and a control group) estimated the pain in the affected Achilles tendon. The experimental group showed a significant reduction of pain ($P<0.0001$), measured from week one to week 12. All the athletes in this group returned to training after three months and were able to come back to regular training loads. Within the control group with conservative therapy, no treatment was considered successful. All members eventually needed an operation

SCHULTE-FREI: Training therapy for injures to the Achilles tendon

This concept, developed by SCHULTE-FREI (2003), is divided into four phases. In the first phase the status of functionality and abilities is evaluated. It is very important to identify the acute symptoms (pain, turgor) and to treat them with physiotherapeutic and physical therapies. Water treatment is also recommended to increase blood circulation. Another focus is on the proprioception, to lay the foundation for further coordinative stimuli. Aerobic training using ergometer, upper body ergometer and water training (aqua jogging, swimming) is the third main focus. According to the authors, the primary goal of this phase is the "facilitation and the innervations of the entire muscle groups in the lower leg and foot, including the improvement of the cognition and balance abilities."

In the second phase, when pain and turgor have significantly reduced, it is possible to increase the load. The use of endurance and strength diagnostics is recommended. Isokinetic testing should use predominately isometric and dynamic assisted methods. The muscular abilities can be developed until strength endurance loads can be performed without pain. Here also, isokinetic training is advantageous, because of the possibility to steer training loads more precisely and have stable positioning during the exercise. Training the senso-motor abilities is also a focus, especially balancing exercises. First training of reaction, including discipline specific movements, should be performed in the safe environment of water.

Photos 14-15: Stretching exercise with bent and extended leg

Table 1: Overview of the training concept for the acute phase and long-term therapy (FREESE, 2001)

Therapy Phase	Training Method	Accompanying Measure	Contraindication
Acute Phase	• Interruption of training until freedom of pain (8-14 days) • Relief by using crutches or tape bandages	• Rod massage • Cross-friction massage • Ultra sound • Acupuncture	• Jumps • Stretch of the affected tendon • Cold Therapy • Pain Killers
Long-term Therapy	• Elimination of all stretching residues in the lower leg muscles (m. triceps surae) • Compensation of muscular dysbalances by dynamic and eccentric strength training of the dorsal flexors • Analysis of training and technique including necessary changes • Development of an individual warm-up and cool-down programme	• Compensation of anomalies of the feet by shoe inlays • Adaptation of shoes (for example by better cushioning in the back counter)	• Loads within the area of pain • Injections with cortisone

Table 2a: Phase 1 - Mobilisation Training (EHRICH & GEBEL, 1992)

Objective	Contents	Methods	Volume	Means
• Mobilisation of the ankle joint • Reduction of atrophy of the calf muscles • Approach of normal walking	• Specific mobilisation exercises for the ankle joint • Mobilisation of muscles • Exercises with hand fixation • Ergometer training	• Isometric • Auxotonic strength training	• Daily 2 x 60 min • 2 x 20 min application with ice	• "Sporeg" mat • Wall bars • Ergomter • Soft gym mats

Table 2b: Phase 2 - Stabilisation Training (EHRICH & GEBEL, 1992)

Objective	Contents	Methods	Volume	Means
• Improvement of the mobility of the ankle joint • Strengthening of the calf muscles • Normal walking	• Stabilisation of the muscle activity • Stretching exercises for the lower leg muscles • Ergometer training	• Isometric • Isotonic • Auxotonic (strength training) • Isokinetic	• Daily 2 x 60-70 min • 2 x 20 min application with ice	• "Sporeg" mat • Wall bars • Ergometer • Soft gym mats • Isokinetic diagnostic and training machine

The third phase is characterised by an additional increase of the load. The treatment of the acute symptoms is completed and the new foci are a) coordination and balancing training and b) strength training. Within the coordination training, the load is increased again, while the security measures are reduced by degrees (e.g. wobble board without hand support). In the strength training, the major emphasis is on the development of inter-muscular coordination and hypertrophy training (see Photos 12 and13).

In the fourth phase it is expected that the athlete will be released back into daily life and training, equipped with an individual training programme. In most cases, however, both therapist and athlete neglect this phase, which includes risks for the transition period back into training. The athlete should follow his/her individual programme for an extensive period, to allow the adaptation processes to take place. An exit diagnostics should ensure the adaptation progress.

FREESE: Training therapeutic measures for Achilles tendon injuries

FREESE (2001) recommends interrupting training until the inflammation has subsided. When absence of pain is achieved, intensive stretching should be introduced (see Photos 14 and15). Strength training for the dorsiflexors of the foot (e.g. m. tibialis anterior) is complementary. Jumps should be avoided until walking, running and stretching can be

Table 2c: Phase 3 - Functional Training (EHRICH & GEBEL, 1992)

Objective	Contents	Methods	Volume	Means
• Regain of functionality • Flexibility • Reduction of the inhibition threshold	• Specific exercises for the ankle joint (walking, jogging, running, incl. change of direction), on soft mats • Coordination exercises	• Isometric • Isotonic • Auxotonic (strength training) • Isokinetic	• Daily 2 x 60-80 min • 2 x 20 min application with ice	• "Sporeg" mat • Wall bars • Ergometer • Soft gym mats • Short dumb bells • Strength training machines • Isokinetic diagnostic and training machine

Table 2d: Phase 4 - Muscle Load Training (EHRICH & GEBEL, 1992)

Objective	Contents	Methods	Volume	Means
• Pain free running • Full load of the muscles of the lower leg • Simulation training • Final test	• Specific exercises for the ankle joint (walking, jogging, running, incl. change of direction), on soft mats or soft natural surfaces • Coordination exercises • Conditioning exercises • Reaction exercises • Jumping exercises	• Auxotonic (strength training) • Interval method	• Daily 2 x up to 90 min • 2 x 20 min application with ice	• "Sporeg" mat • Wall bars • Ergometer • Soft gym mats • Short dumb bells • Skipping rope • Strength training machines • Isokinetic diagnostic and training machine

performed without pain. The long-term therapy includes a number of measures designed to avoid future injury (see Table 1) A close cooperation between athlete, coach and therapist is necessary to identify the reasons for the symptoms.

EHRICH & GEBEL: Build-up training after Achilles tendon injuries

EHRICH & GEBEL (1992) also divide their therapy concept into four phases - Mobilisation, Stabilisation, Functional and Muscle Loading – and have elaborated specific

Photos 16-18: Coordinative jumping exercises on a trampoline

training contents for each phase (see Tables 2 a – d).

In the first phase, the focus is on basic mobilisation of the ankle joint using exercises for walking (on mats), isometric exercises for strengthening of the calf muscles, and cardio-vascular training on ergometers.

In the second phase, the focus is on improvement of mobility of the ankle joint and the strengthening of the calf muscle, both of which are achieved through an increase in the complexity and intensity of the exercises. In this phase, the return to the normal walking movement is given more attention.

The aim of the third phase is to achieve control of the roll-off movement of the foot of the injured side. Cardio-vascular and stretching exercises are also continued.

In the fourth phase, the stretching exercises for the lower leg muscles are intensified (Photos 16-18), runs with changes in direction (and rotational movements) and jumps are introduced.

Final notes

Before any therapy concept is applied a thorough review and analysis of the case is essential. This includes the athlete's medical history, acute health status as well as analysis of his/her training, technique and performance abilities. It is very important to dedicate enough time to find out what factors could have influenced the occurrence of the symptoms. For this aspect, cooperation between the therapist, coach and the athlete is critical.

Keep in mind that the training loads within the programmes will always be individual but they should follow the guidelines and care should be taken to avoid counterproductive overload. The various adaption times for the different organ system also need to be considered in planning. For example, muscular

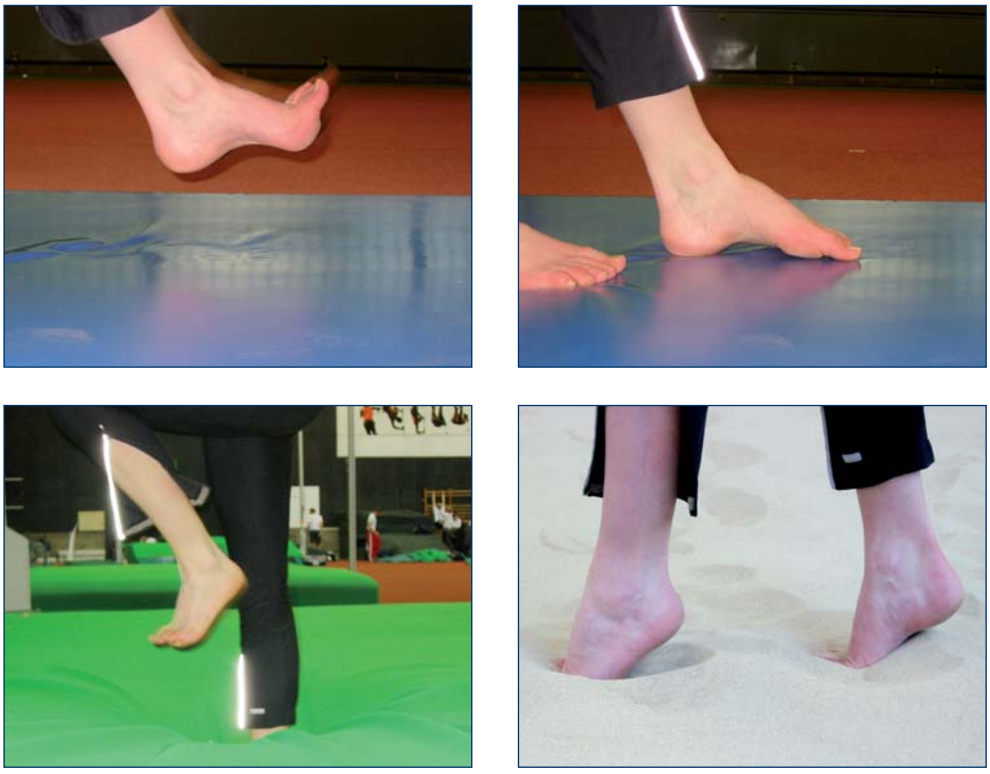

Photo 19-22: Types of soft surfaces: soft mats and sand

structures adapt much quicker than tendons, ligaments or bones.

The expected results of the therapy should then be developed together with the athlete. His/her wishes, expectations and individual disposition will strongly influence the motivation to follow the programme and its success. Understanding of the problem and the set-up of the therapy concept requires educational efforts from the athlete's whole environment.

Please send all correspondence to:
s.kroesche@gmx.de

REFERENCES

ALFREDSON, H. & LORENTZON, R. (2000). Chronic Achilles tendinosis: Recommendations for treatment and prevention, Sports Medicine, Auckland, 29, 2, 135-146.

ALFREDSON, H.; PIETILÄ, T.; JONSSON, P. & LORENTZON, R. (1998). Heavy-load eccentric calf muskle training for the treatment of chronic Achilles tendinosis. American Journal of Sports Medicine, 26, 360-366.

ASTRÖM, M. (1998). Partial rupture in chronic Achilles tendinopathy: a retrospective analysis of 342 cases. Acta Orthopdica Scandinavia, 69 (4), 404-407.

BRENKE, H.; JUNGMICHEL, L.; DIETRICH, L. & WEBER, J. (1979). Zur Prophylaxe und Rehabilitation der Achillodynie aus sportmethodischer Sicht. Medizin und Sport, 11, 337-341.

BRODY, D. (1987). Running injuries: prevention and management. Clinical Symposium, 39, 1- 36.

BRUCKNER, P. & KHAN, K. (1993). Clinical sports medicine. Sydney: McGRAW-HILL Book Co., Australia.

CLEMENT, D.; TAUNTON, J. & SMART, G. (1984). Achilles

tendinitis and peritendinitis: etiology and treatment. American Journal of Sports Medicine, 12, 179-184.

DEUBEL, G.; FELDER, H. & MERKEL, M. (1998). Ambulante Rehabilitation. Stuttgart: Georg Thieme Verlag.

DIXON, S.J. & KERWIN, D.G. (1998). The influence of heel lift manipulation on Achilles tendon loading in running. Journal of Applied Biomechanics, 14 (4) 374-389.

EHRICH, D. & GEBEL, R. (1992). Aufbautraining nach Sportverletzungen: muskuläres Aufbautraining nach Knie-, Fuß- und Muskelverletzungen. Münster: Phillipka-Sportverlag.

EHRICH, D. & GEBEL, R. (2000). Therapie und Aufbautraining nach Sportverletzungen: Grundlagen – Diagnostik – Therapie – Übungen. Münster: Phillipka-Sportverlag.

EHRSAM, R. (1974). Die Achillodynie. Therapeutische Umschau. 31, 266-270.

FRANKE, J.S. (1990). Biomechanische experimentelle Untersuchung zum Rissverhalten der menschlichen Achillessehne, med. Dissertation, TU München.

FREESE, J. (2001). Medizinische Fitness: Das Reha-Manual für Therapie, Fitness und Leistungssport. Münster: Phillipka-Sportverlag.

FREDERICSON, M. (1996). Common injuries in runners. Diagnosis, rehabilitation and prevention. Sports Medicine, 21, 49-72

FYFE, I. & STANISH, W. (1992). The use of eccentric training and stretching in the treatment and prevention of tendon injuries. Clin Sports Med 11, 601-625

GALLOWAY, M.; JOKL, P. & DAYTON O. (1992). Achilles tendon overuse injuries. Clinical Sports Medicine, 11, 771-782.

GROSS, M.; DAVLIN, L. & EVANSKI, P. (1991). Effectiveness of orthotic shoe inserts in the long-distance runner. American Journal of Sports Medicine, 19, 409-412.

HUDLER, J.; SLAVIK, Z. & MATEJOVSKY, Z. (1983). Beschädigung der Achillessehne infolge der lokalen Applikation der Kortikoide. In: Chapchal, P. (ed) Sportverletzungen und Sportschäden. Stuttgart-New York: Thieme.

JUNGMICHEL, D. & NAWROTH, U. (1989). Konservative und operative Therapie der Achillodynie. In: Medizin und Sport, 29 (7) 236-240.

JÖRGENSEN, U. (1990). Body load in heel-strike running: the effect of a firm heel counter. American Journal of Sports Medicine, 18, 177-181.

KLÜMPER, A. (2000). Achillodynie. In: Sporttraumatologie, Handbuch der Sportarten und ihrer typischen Verletzungen, ecomed, III-19.3.

KRAHL, H. & PLAUE, R. (1971). Sehnenrupturen nach Cortisoninjektionen, Medizin und Sport 11, 264-268.

LEPPILAHTI, J.; ORAVA, S.; KARPAKKA, J. et al. (1991). Overuse injuries of the Achilles tendon. Annales Chirurgiae et Gynaecologiae, 80, 202-207.

LOHRER, H. (1992). Die Achillessehne im Sport – ungeliebtes Krankheitsbild Achillodynie. TW Sport-Medizin, 4, 377-381.

LOHRER, H. (1996). Sportorthopädie und Sporttraumatologie, 12 (1) 36-42.

LOWDON, A.; BADER, D. & MOWAT, A. (1984). The effect of heel pads on the treatment of Achilles tendinitis: A double blind trail. American Journal of Sports Medicine, 12, 431-435.

MAIER, T. (1995). Die Achillodynie als leistungslimitierender Faktor im Spitzensport. Schweizerische Zeitschrift für Medizin und Traumatologie, 43 (2) 49- 54.

MAYER, F. & DICKHUT, H.-H. (2002). Chronische Achillessehnenbeschwerden im Sport. Deutsche Zeitschrift für Sportmedizin, 53, 256-257.

MAYER, F.; GRAU, S.; BÄURL, M.; KRAUSS, I.; MAIWALD, C. & BAUR H. (2000). Achillessehnenbeschwerden im Laufsport – eine aktuelle Übersicht aus: Deutsche Zeitschrift für Sportmedizin, 51, 61-167.

MÜLLER, G.; STACOFF, A. & STÜSSI, E. (1996). Mögliche Ursachen von Problemen im Bereich der Achillessehne, Schweizerische Zeitschrift für Medizin und Traumatologie, 44 (1) 27-31.

MYERSON, M.S. & BIDDINGER, K. (1995): Achilles tendon disorders practical management strategies, Physician and Sportsmedicine, 23 (12) 47-54.

NICOL, C.; KOMI, P. & MACRONNET, F. (1991). Fatigue effects of marathon running on neuromuscular perfomance: II. Changes in force, integrated electromyographic activity and endurance capacity. Scandinavian Journal of Medicine and Science in Sports, 110-117.

PETERSON, L. & RENSTRÖM, P. (2002). Verletzungen im Sport. Köln: Deutscher Ärzte-Verlag.

SCHEPSIS, A.; JONES, H. & HAAS, A.L. (2002). Achilles Tendon Disorders in Athletes. American Journal of Sports Medicine, 30 (2) 287-305.

SCHULTE-FREI, B. (2003). Trainingstherapie bei Verletzungen und Erkrankungen des Sprunggelenkes und des Unterschenkels. In: Nellessen G., Froböse I., Wilke C. (eds.), Training in der Therapie. München, Jena: Urban& Fischer Verlag.

SEGESSER, B. & GOESELE, A. (1995). Die Achillessehne im Sport. Orthopädie 24, 252-267.

STANISH, W.; RUBINOVICH, R. & CURWIN, S. (1986). Exzentric exercise in chronic tendinitis. Clinical Orthopaedics, 208, 65-68.

STEININGER, K. & BUCHBAUER J. (1994). Funktionelles Kraftaufbautraining in der Rehabilitation. Oberhaching: Gesundheits-Dialog-Verlag GmbH.

THIEL, A. & KARPF, M. (1973). Bild und Behandlung der Achillodynie. Sportarzt und Sportmedizin 5, 106-107.

THIEL, A. (1982). Verletzungen in der Leichtathletik, in: Jäger, M.; Keyl, W. & Wirth C.J. (eds): Thieme Sportverletzungen in der Praxis.

ULREICH, N.; KAINBERGER, F.; HUBER, W. & NEHRER, S. (2002). Die Achillessehne im Sport. Der Radiologe, Band 42, Heft 10, 811-817.

WEN, D.; PUFFER, J. & SCHMALZRIED, T. (1998). Injuries in runners: a prospective study of alignment. Clinical Journal of Sport Medicine, 8, 187-94.