The „Berlin method“

Application recommendations for tendon training

Improvement in performance, prevention and therapy
Background

Tendons transfer muscle force to the skeleton and thus are important in human locomotion. The characteristics of a tendon such as being resistant or rather compliant directly influence the functioning and hence the force potential of the muscle. Especially the resistance (stiffness) is associated with improved performance of sprints and jumps, running economy, balance as well as prevention and rehabilitation of tendon injuries (fig. 1).

![Selective tendon training diagram](image)

**Figure 1:** Relevance of tendon characteristics for physical capacity and purposeful improvement through special tendon training.

Nowadays it is well known that tendons adapt to mechanical loading (e.g. training). The key-stimulus therefore is an elongation (strain) as a result of forceful contractions of the corresponding muscle. Thus a retarding of structure reduction and/or a promotion of structure building processes is initiated by mechanical transduction to cells through deforming the tendon. Adaptations show up as a change in material characteristics (amount of collagen and molecular networks) and/or hypertrophy in long term perspective. Both mechanisms result in an increased resistance of the tendon (i.e. stiffness). An improvement of stiffness can be seen positively because it reduces the risk of tissue harm during high intensity strains where the elongation of the tendon may lead to inflammations or injuries (fig. 2). Facing these aspects, a balanced adaptation of muscle and tendon should be pursued.
Basically speaking, muscle and tendon adapt differently. Especially tendons show less blood circulation as well as a lower metabolism which leads to slower adaptation compared to muscle tissue. Above that, reaction-inducing loads differ between both structures. On the one hand muscles show an increased strength as a result of plyometric training (e.g. jumps) and strength training in moderate intensities whereas, on the other hand, tendons are rather unaffected. Those two important aspects have to be considered if both structures should be developed in balance (fig. 2).

**Figure 2:** If the force that is applied to the tendon by a muscle increases without a concomitant increase of tendon stiffness, the mechanical demand and, thus, the risk of injury increases as well (left). With a balanced adaptation on the other hand, the mechanical demand placed upon the tendon remains constant, despite an increase of absolute load (right).
Regarding an increased demand on tendons, it is likely that the risk of tendon injuries is higher (fig. 2). Mainly athletes performing in sprinting and jumping disciplines as well as endurance runners are predestinated to have painful and restricting complaints. In order to avoid clinical symptoms because of unbalanced adaptation of tendon and muscle an additional and early tendon training aiming at an increased stiffness is recommended as a preventive action for all age groups.

Purposeful tendon training is also important when it comes to rehabilitation of tendon injuries such as tendinopathies, ruptures and partial ruptures. Following chronic pain and the time after acute injuries the tissue is particularly weak and less resilient. In this case a restoration of resistance should be the main goal. Based on literature, it can be argued that tendon training offers convincing advantages in comparison to medicamentous therapy or pure physiotherapy. Concluding, it is an appropriate rehabilitation therapy approach after the wound-healing phase.

**Tendon Training**

Most important for tendon adaptation is a repeated strain produced by a contraction of the corresponding muscle. The resulting elongation (strain) of the tendon is characterized by four factors: magnitude (height of elongation), frequency (amount of repetitions of the load per time sequence), duration (time of single stimulus) and rate (elongation-growth per time sequence). Due to investigations the following configuration can be identified as ideal tendon training (fig. 3).

**Concept „Berlin method“:**

1. Training protocols should include high muscle force usage: \( \geq 85\% \) of isometric voluntary force maximum (iMVC). Thus the needed elongation (strain) of the tendon will be given. Besides the form of muscle contraction (eccentric, isometric, concentric) is not decisive.
2. The duration and the corresponding elongation of the tendon should be kept for approx. 3 seconds. The amount of time is essential for an effective transfer of the elongation to tendon cells which are responsible for adaptation.
3. Repetitive loads are more useful than constantly held loads. Higher elongation rates as used in plyometric training are less effective for tendon adaptation.

4. The angularity of the joint has to be considered to keep an optimal force-elongation-potential. For the Achilles tendon an angle of approx. 90° at the foot joint is best applicable, for patellar tendon it takes approx. 70° at the knee joint.

5. A high training effectivity shows at 5 series with a change of 3 seconds load and 3 seconds relaxation for 4 times. In between the series a break of 1 to 2 minutes is recommended.

6. In order to achieve obvious effects on resistance the training should be performed for at least 3 months. During introductory phase, the patient should train 2 times per week, increasing to 4 times per week.

**Figure 3:** Evidence-based recommendations for an effective training stimulus of tendons. High loads through powerful muscle contraction should be applied in 5 sets à 4 repetitions with a stress and relaxation duration of approx. 3 seconds and breaks of 1-2 minutes. Trainings is recommended 3-4 times/week for at least 3 months.

Including tendon training in established force trainings or regular workouts will be possible. Due to controllable training circumstances an application using static machines is recommended but not mandatory. A stepwise increase of the loading should be considered during the first three to four weeks in order to avoid overstressing the tissues. If there are no maximum values (MVCs) available, subjective perceived maximum contractions can be used. Reaching an appropriate training period reducing the volume to 2 times per week is enough to keep the adaptations (no proven findings yet). Generally speaking, this concept of training can be applied on any tendon as for example at the shoulder joint.
Practical instructions according to the “Berlin method”:

In the following, several examples for training the Achilles tendon and patellar tendon are provided.

Achilles Tendon

Exemplary exercises for strengthening the Achilles tendon. Repetitive isometric plantar flexions at high contraction intensities (≥ 85% of voluntary maximum; 3 s contraction duration) in a neutral ankle joint position (and extended knee) provide an efficient and easily controllable mode of loading that can be performed, for example, on strength machines (1a) or using non-elastic strings (2). Alternatives are dynamic exercises as classical concentric-eccentric series or with an emphasis on the eccentric phase (both legs lift the load in the concentric phase, yet only one bear the load during the eccentric part; 1b). The dynamic exercises should be performed slowly to ensure an adequate loading duration in the joint angle range where the necessary high tendon forces occur (i.e., we recommend an overall movement duration of 6 s to achieve a high magnitude strain duration of ~3 s).
**Patellar Tendon:**

**Figure 4:** Exemplary exercises for strengthening the patellar tendon on a leg press machine (1), leg extension machine (2) or using free weights (3). Repetitive isometric knee extensions at high contractions intensities (≥85% of voluntary maximum; 3s contraction duration) and ≈70° knee joint angle provide an efficient and easily controllable mode of loading (a). Alternatives are dynamic exercises as classical concentric-eccentric series (1b, 2b), squats (3b) or series with an emphasis on the eccentric phase (both legs lift the load in the concentric phase, yet only one bears the load during the eccentric part; 1c, 2c). The dynamic exercises should be performed slowly to ensure an adequate duration in the joint angle range where the necessary high tendon forces occur (i.e., we recommend an overall movement duration of 6 s to achieve a high-magnitude strain duration of ≈3s).
Regarding the principles of the training concept further exercises can be developed easily. It is absolutely recommended to give technical instructions when using dynamic exercises in high intensities.

**Further exercises for Achilles tendon:**

- Slow single-leg heel lifts (dynamic and static) with toes on a step, if applicable with extra weights (barbell, kettlebells, weights, piggyback with a partner)
- Powerful single-leg foot extensions while sitting, using a sling around the hip and ball of the foot (counter bearing)
- Static powerful foot extensions while sitting with extended knee (e.g. in a door case)

**Further exercises for patellar tendon**

- Single leg squats with slow lowering (if necessary with support)
- Slow single-leg rises onto a bench
- Slow squats with high extra weights (barbells, kettlebells, weights, piggyback with a partner)
- Slowly getting into a squat position (frontal or lateral lunges) with emphasis on the front leg and extra weights
- Isometric forceful leg extensions while sitting in a door case as a counter bearing
- Slow squats, lifting one side of a bench (eventually someone sitting on it), single or partner exercise
Impressum

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