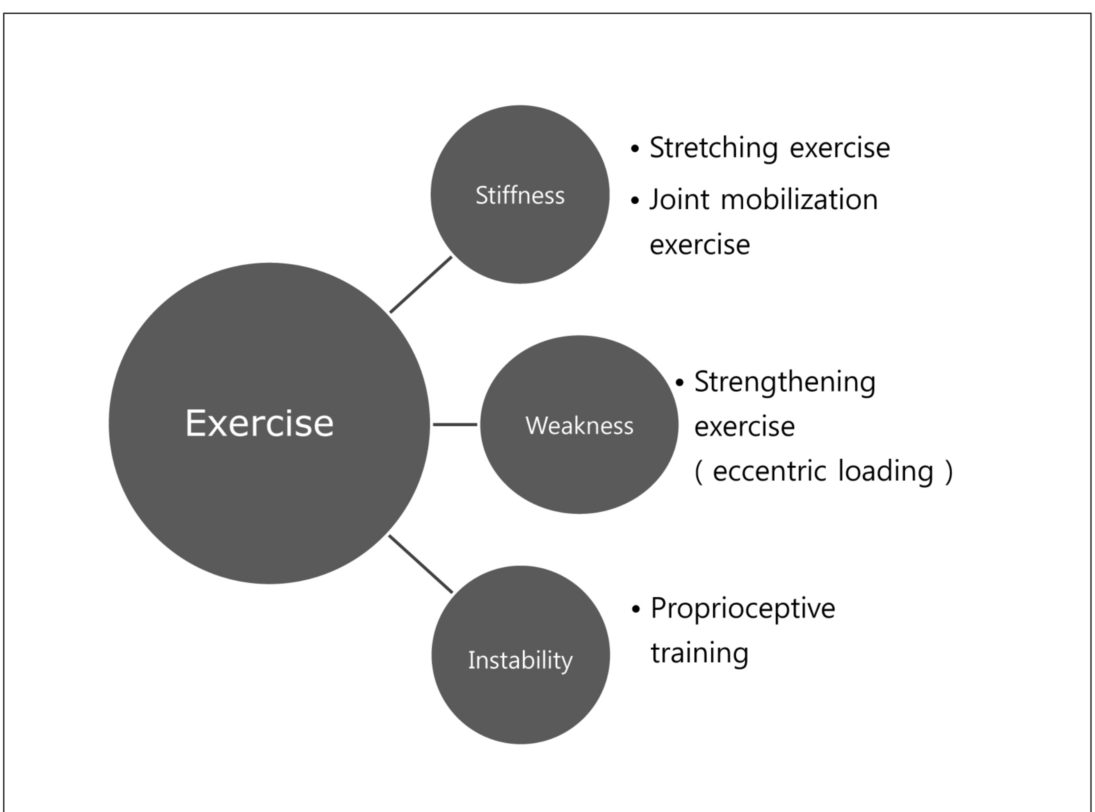
운동치료 처방의 원리는?

분당 제생병원 이 태 임



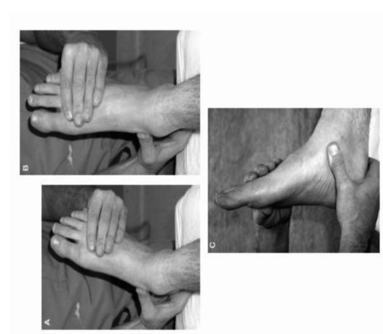
Risk factors for plantar fasciitis

- Reduced ankle dorsiflexion ***
- Obesity (BMI > 30 kg/m2)
- Prolonged wt-bearing at work

Daniel L.R et al JBJS 2003

Ankle Dorsiflexion Range

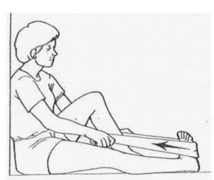
- Measure Angle
  between long axis of fibula
  and 5th metatarsal bone
  from the lateral side
- Short Achilles tendon
  - Equinus status
  - Equinus deformity
  - GCM equinus v.s Soleus equinus
    - Ankle Dorsiflexion range
      with knee extended position
      and with flexed position
- cf. Forefoot equinus

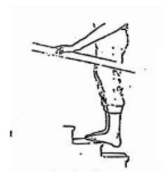


Heelcord Stretching ex.

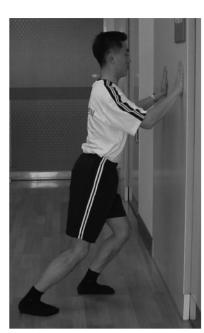
Heel-cord wall stretches

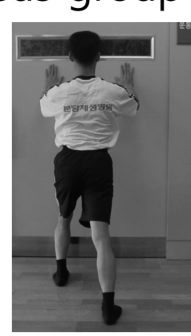
Towel stretches





- Gentle pain-free stretching of heelcord
  - Prolonged stretching (15-30 secs/회)
  - several times/day (5회/ day, bid or tid)
  - after an active or passive warm up with exercise or modalities (H/P & U/S)
  - both gastrocnemius & soleus group ☜





Plantar fascia-specific stretching exercise

- Digiovanni BF et al. JBJS Am 2006

- 2 yrs f/u RCT study with 101 pts
  - Group A ; plantar fascia tissue stretching
  - Group B ; Achilles tendon stretching

- Superior result
  than achilles tendon stretching

Fig. 1
Plantar fascia-stretching exercise. The patient crossed the affected leg over the contralateral leg. While placing the fingers across the base of the toes, the patient pulled the toes back toward the shin until he or she felt a stretch in the arch or plantar fascia. The patient confirmed that the stretch was correct by palpating tension in the plantar fascia. (Reprinted from: DiGiovanni BF, Nawoczenski DA, Lintal ME, Moore EA, Murray JC, Wilding GE, Baumhauer JF. Tissue-specific plantar fascia-stretching exercise enhances outcomes in patients with chronic heel pain. A prospective, randomized study. J Bone Joint Surg Am. 2003;85:1270-7.)

Strengthening exercise

- Open-kinetic chain stengthening with rubber tubing
- Progressive concentric & eccentric exercise
- Closed-kinetic chain ex. with toe-ups using a stair
- Both isotonic & isokinetic exercise

Rehabilitation of Achilles Tendinopathy

Phase I (Acute phase)	Phase II (Subacute phae)	Phase III (pain & tenderness have decreased)	Phase IV (pain free condition & strength and flexibility ; near normal)
Rest as necessary (pain free range) Control of pain & inflammation	Proper footwear with slight heel lift		
	Stretching →		
	Gentle pain-free stretching	more aggressively	
Activity modification		Strengthening →	
Alternate cardiovascular maintenance →			Functional training →
swimming, pool running with flotation device, stationary cycling, UBE			Begin with a walking program

Eccentric loading

- Curwin and Stanish (1984)
  - Pioneered " eccentric training " for tendon injury
  - Prospective study of 200 pts with chronic achilles tendinopathy (1986)
    ; once-daily, 6 week eccentric loading program
    ; 87% improved (complete relief of pain in 44% and a marked improvement in Sx. in a further 43% of pts)
    ; No controls
- Alfredson et al (1998)
  - Confirmation of efficacy of eccentric loading by prospective RCTs in mid-substance lesion of the Achilles tendinopathy
    ; 3*15 rep, 2 times daily, 7 days/week, for 12 weeks. With painful progressive loading
  - 94% improvement

Alfredson's painful heel-drop protocol (180 drops /day)

Number of exercises	Exercise specifics	Exercise progression
3*5 repetitions 2 times daily 7 days/week for 12 weeks	Do exercise both with knee straight (full extended) and knee bent (flexed 45) over edge of a step Lower only (heel drop) from standing on toes (i.e. raise back onto toes using unaffected leg or arms)	Do exercise until they become pain-free Add load until exercises are again painful Progressively add up to 60 kg

Critical modification by Alfredson and colleagues
- Allow pain during exercise program
- Incorporate two types of heel drops into the program
- 180 drops per day – a far greater number than had been recommended previously – but to do them all slowly.

Eccentric Training Protocol

- Eccentric loading, both GCM and soleus
- no following concentric loading of calf m.
- Allow some painful loading and muscle soreness
- Progressive increase load ; initially body weight → back pack
- 15 rep. 3sets, 2 times daily, 7 days/weeks, for 12 weeks
- After 4-6 weeks, allow light jogging on flat ground at a slow pace without pain
- Walking and bicycling with only mild discomfort or pain

Table 3 Effectiveness of eccentric overload training in patients with chronic Achilles tendinopathy according to the studies included

Authors	Participants (n)	Method	Inclusion criteria	Intervention	Outcome measure	Duration of intervention	Result in intervention group	Result in control group
Roos *et al* (2004)[23]	44	RCT	Chronic Achilles tendinopathy	I: Eccentric training C1: Eccentric training with night splint C2: Night splint	FAOS	12 weeks	↓ 37%	C1: ↓ 23% C2: ↓ 13%
Mafi *et al* (2001)[24]	44	RCT	Chronic Achilles tendinopathy	I: Eccentric training C: Concentric training	VAS	12 weeks	↓ 83%	↓ 86%
Niesen-Vertommen *et al* (1992)[25]	17	RCT	Chronic Achilles tendinopathy	I: Eccentric training C: Concentric training	Ordinal Scale	12 weeks	↓ 78%	↓ 46%
Silbernagel *et al* (2001)[4]	40	RCT	Chronic Achilles tendinopathy	I: Eccentric training C: Concentric training	VAS	12 weeks	↓ 29%	↓ 15%
Alfredson *et al* (1998)[18]	30	CT	Chronic Achilles tendinopathy	I: Eccentric training C: Surgery	VAS	12 weeks	↓ 94%	↓ 70%
Fahlström *et al* (2003)[26]	78	CT	Chronic Achilles tendinopathy. (A) Mid-portion of the Achilles tendon and (B) insertion of the Achilles tendon	I: Eccentric training	VAS	12 weeks	A: ↓ 85% B: ↓ 81%	
Shalabi *et al* (2004)[27]	25	CT	Chronic Achilles tendinopathy	I: Eccentric training	Ordinal Scale	12 weeks	↓ 40%	
Alfredson *et al* (2003)[28]	6	CT	Chronic Achilles tendinopathy	I: Eccentric training	VAS	12 weeks	↓ 75%	
Stanish *et al* (1986)[29]	200	CT	Chronic Achilles tendinopathy	I: Eccentric training	Ordinal Scale	6 weeks	↓ 87%	

C, control group; CT, clinical trial; I, intervention group; FAOS, Foot and Ankle Outcome Score; RCT, randomised clinical trial; VAS, visual analogue scale; ↓, improvement in pain score.

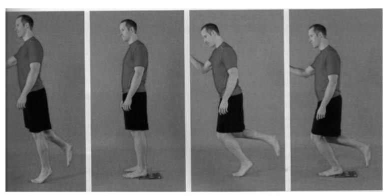
Kingma JJ 2007 Br. J Sports Med

- *Rompe et al (2007)*
  - 75 pts with chronic recalcitrant non-insertional achilles tendinopathy
  - Group 1 ; eccentric loading
  - Group 2 ; repetitive low-energy ESWT
  - Group 3 ; wait and see policy
  - Result
    - At 4 month f/u, eccentric loading and low-energy ESWT showed comparable results (group 1 ; 60%, 2; 53%)
    - The wait and see strategy was ineffective (24%)

- *Rompe et al (2008, JBJS Am)*
  - 50 pts with chronic recalcitrant insertional achilles tendinopathy
  - RCT
    - Group 1 ; eccentric loading
    - Group 2 ; repetitive low-energy ESWT
  - Result
    - At 4 mo f/u, completely recovered or much improved in 28% (group 1), 64% (group 2)

for Insertional tendinopathy.

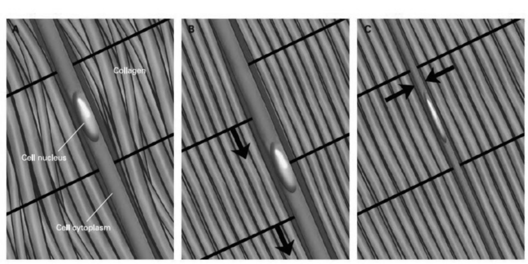
- Alfredson's painful, heel–drop protocol
  ; Only achieve good clinical result in approximately 30% of cases
- Variation of the Alfredson tendon loading program
  - The patients only lowers the heel to the level of the floor (or, in the early stages, onto a small heel raise) to limit irritation of the achilles tendon against local structures.



  - showed increased efficacy ; 70% of patients with long-term symptoms were satisfied and refurned to sports
    (2008. Johnson P et al)
- Repeated stretching
  may not be beneficial for insertional achilles pain .

How does eccentric exercise promote recovery in tendinopathy?

- Mechanotherapy *(Khan 2012)*
  - Heel drops provide mechanical loading, which causes sliding of collagen fibers leading to intracellular communication via gap junctions and communication with the cell nucleus.



Shear and compression force

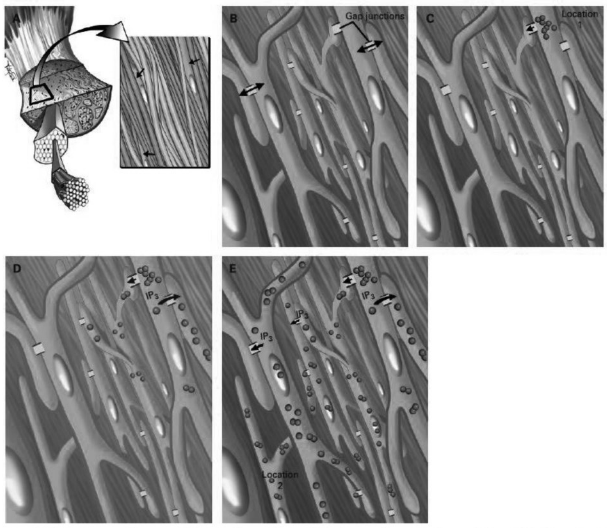


Figure 2 Tendon tissue provides an example of cell–cell communication. (A) The intact tendon consists of extracellular matrix (including collagen) and specialised tendon cells (arrowheads). (B) Tendon with collagen removed to reveal the interconnecting cell network. Cells are physically in contact throughout the tendon, facilitating cell–cell communication. Gap junctions are the specialised regions where cells connect and communicate small charged particles. They can be identified by their specific protein connexin 43. (C–E) Time course of cell–cell communication from (C) beginning, through (D) the midpoint to (E) the end. The signalling proteins for this step include calcium (red spheres) and inositol triphosphate (IP3).

- Mechanocoupling :
  Direct and indirect physical pertubation of the cell
  → variable chemical signals both within and among cells.
- Cell-cell communication
  ; calcium,
  inositol triphosphate

Effector Cell Response

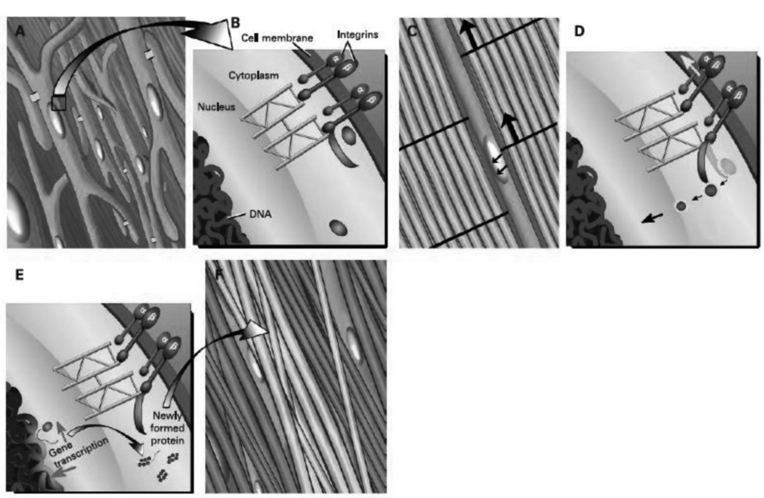


Figure 3 Mechanical loading stimulates protein synthesis at the cellular level. (A) A larger scale image of the tendon cell network for orientation. We focus on one very small region. (B) Zooming in on this region reveals the cell membrane, the integrin proteins that bridge the intracellular and extracellular regions, and the cytoskeleton, which functions to maintain cell integrity and distribute mechanical load. The cell nucleus and the DNA are also illustrated. (C) With movement (shearing is illustrated), the integrin proteins activate at least two distinct pathways. (D) One involves the cytoskeleton that is in direct physical communication with the nucleus (ie, tugging the cytoskeleton sends a physical signal to the cell nucleus). Another pathway is triggered by integrins activating a series of biochemical signalling agents which are illustrated schematically. After a series of intermediate steps those biochemical signals also influence gene expression in the nucleus. (E). Once the cell nucleus receives the appropriate signals, normal cellular processes are engaged. mRNA is transcribed and shuttled to the endoplasmic reticulum in the cell cytoplasm, where it is translated into protein. The protein is secreted and incorporated into extracellular matrix. (F) In sum, the mechanical stimulus on the outside of the cell promotes intracellular processes leading to matrix remodelling.

Several possible explanations for the effectiveness of eccentric exercise

Mechanotherapy ; probably heel drops have
both an immediate and a longer-term influence on tendon

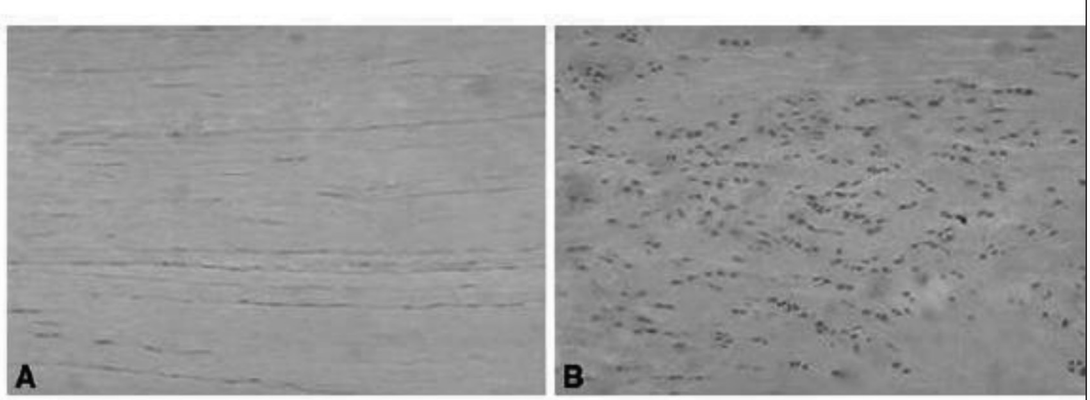
- Short term effect
  ; A single bout of exercise increases tendon volume and signal on MRI .
  (Shalabi A et al. 2004)
  ; Heel drops affect type 1 collagen production and , in the absence of ongoing insult, may decrease tendon volume over the longer term. *(Kjaer M 2005)*
- Thus heel drops may *increase tensile strength* in the tendon over time.

Repetitive loading and a lengthening of the muscle-tendon unit
may improve the capacity of the musculotendinous unit to *effectively absorb load*

Eccentric exercise may be more beneficial than concentric exercise
because of *repeated stretching*

however, it is unclear if the effect is mostly on the tendon
or on the muscle-tendon unit as a whole.

eccentric exercise may also induce more force fluctuations in the tendon,
adding *greater load to the tendon*.



Normal tendon
: parallel, longitudinal architecture
with scattered elongated tenocytes

Tendinopathy tendon
; disorganized collagen architecture.
High cellularity of rounded tenocytes

Effect of mechanical factor on ligament healing

- fibroblasts, when cyclically stretched in culture
  on smooth silicone surfaces ,
  became largely perpendicular in orientation
  to the direction of the applied load.

- To improve the quality of the healing ligament substance,
  it is important to take into consideration
  both cell orientation and mechanical loading

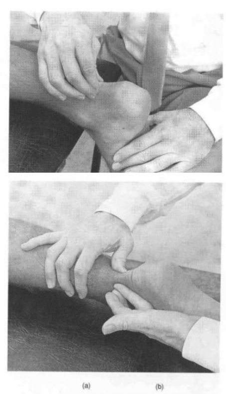
Wang JH et al connect Tissue Res 2000

Effect of mechanical factor on tendon

- *Egerbacher et al 2008*
  - In rat tail tendon cells
  - Stress deprived
    or cyclically loaded (3% strain a 0.17Hz) for 24 hrs
    under tissue culture.
  - Loss of homeostatic tension induces apoptosis
  - So, the mechanical understimulation of tendon cells following microdamage to the extracelluar matrix contributes to the pathogesesis of tendinopathy.

- *Gardner et al 2008*
  - cyclic loading increased the TIMP-1/MMP-13 ratio
  - beneficial in the management of tendinopathy

- Transverse friction massage
  - releasing collagenous adhesions to adjacent tissues
  - promotes an increase in local blood flow
  - provides a longitudinal tension stimulus to the tendon



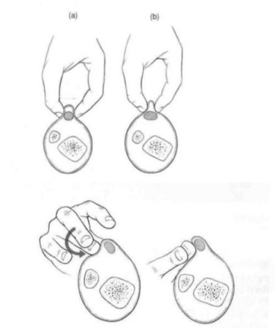


Figure 83.5 Deep friction to the anterior aspect of the Achilles tendon.

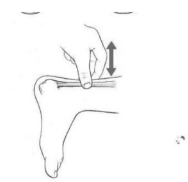


Figure 83.4 Deep friction to the medial and lateral edge of the Achilles tendon.

Figure 83.6 Deep friction to the insertion of the Achilles tendon.

Chronic Lateral Ankle Instability

- Sx ; Insecurity, Instability, giving way

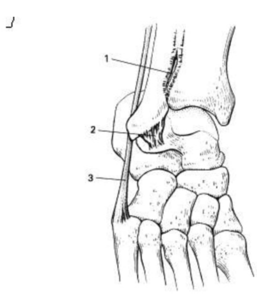
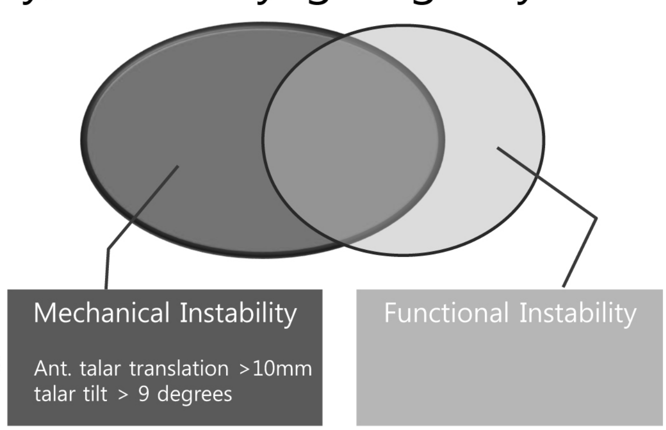


Figure 84.28 Causes of instability at the ankle: 1, lengthened or ruptured distal tibiofibular ligament; 2, lengthened or ruptured anterior talofibular ligament; 3, proprioceptive defects affecting the peroneal muscles.



Pathologic laxity
Impaired arthrokinematics
Synovial and degenerative changes

Functional Instability

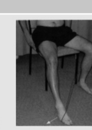
- Articular deafferentation (Freeman, 1965)
  - lesion of mechanoreceptors in the joint capsule and ligaments surrounding the ankle
    - Impaired proprioception
    - Delayed and diminished reflex responses in the evertors (peronei) of affected ankles in reaction to an inversion stress
- Feed-forward motor control of the CNS
  - Inappropriate positioning of the ankle joint before ground contact during walking
    - Lateral shift of body weight
    - More inverted position of the ankle joint before and immediately after heel strike
    - Concentric evertor moment after HS (cf. control ; eccentric invertor moment)

Rehabilitation of Ankle ligament injury

(Acute phase) 48 hrs	(Subacute phase)	able to possible full weight bearing	when pain-free, full ROM and adequete muscle strength and proprioception
RICE (Control of hemorrhage and subsequent edema) Reduction of pain and swelling Early controlled mobilization with brace	Restoration of full range of motion Early partial weight bearing with crutch within pain tolerance		

Muscle conditioning

Active strengthening exercise, including PF, DF, inversion and eversion should begin as soon as pain allows.
Progressively increase load (rubber tubing)
Eversion, shuttle exercise




Proprioceptive training

Should begin early in rehab. → gradually progress in difficulty
BABS board in sitting position
→ Balancing on one leg
→ using rocker board or mini-trampoline
→ ultimately performing functional activities while balancing


Functional training

Jumping, hopping, twisting, figure of eight running