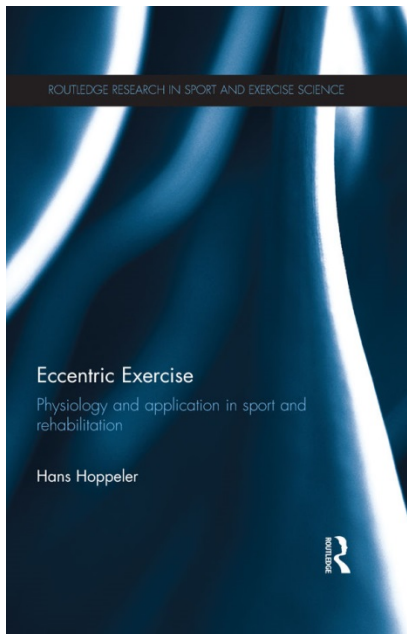


“Exzentrische Muskelkontraktion”

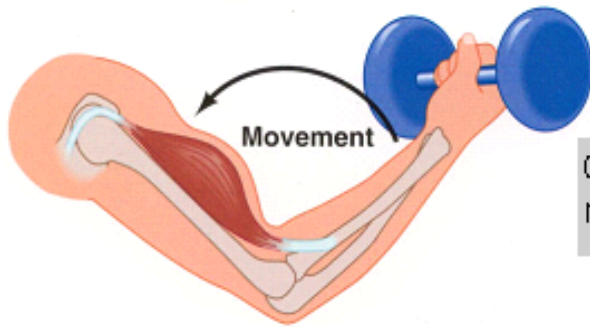
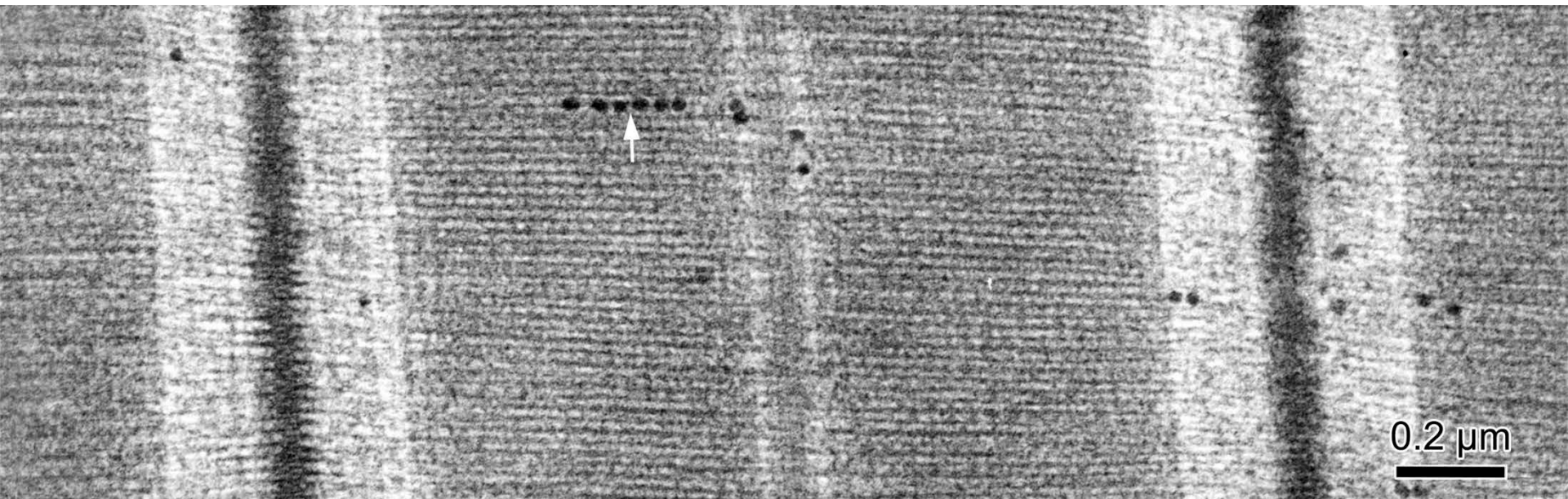
Hans Hoppeler

hoppeler@ana.unibe.ch



u^b

b
UNIVERSITÄT
BERN

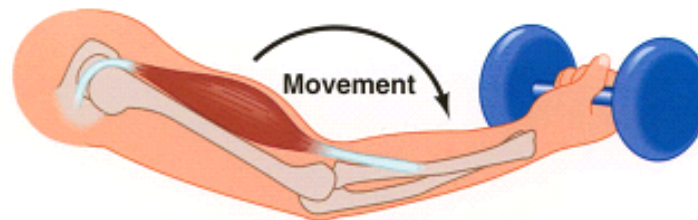


positive work; acceleration

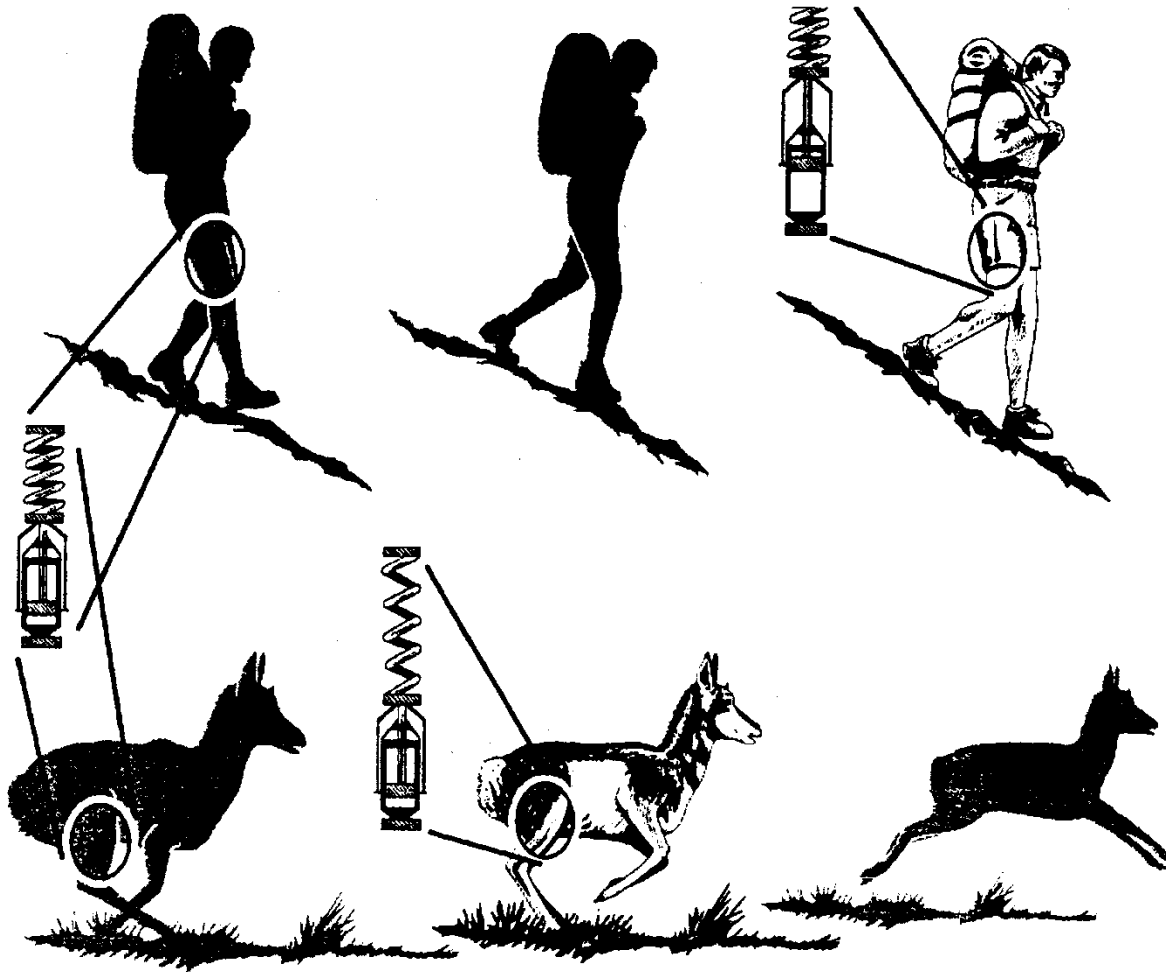
Concentric muscle contraction—The bicep muscle is **shortening** while contracting.

Negative work; deceleration

Eccentric muscle contraction—The bicep muscle is **lengthening** while contracting.



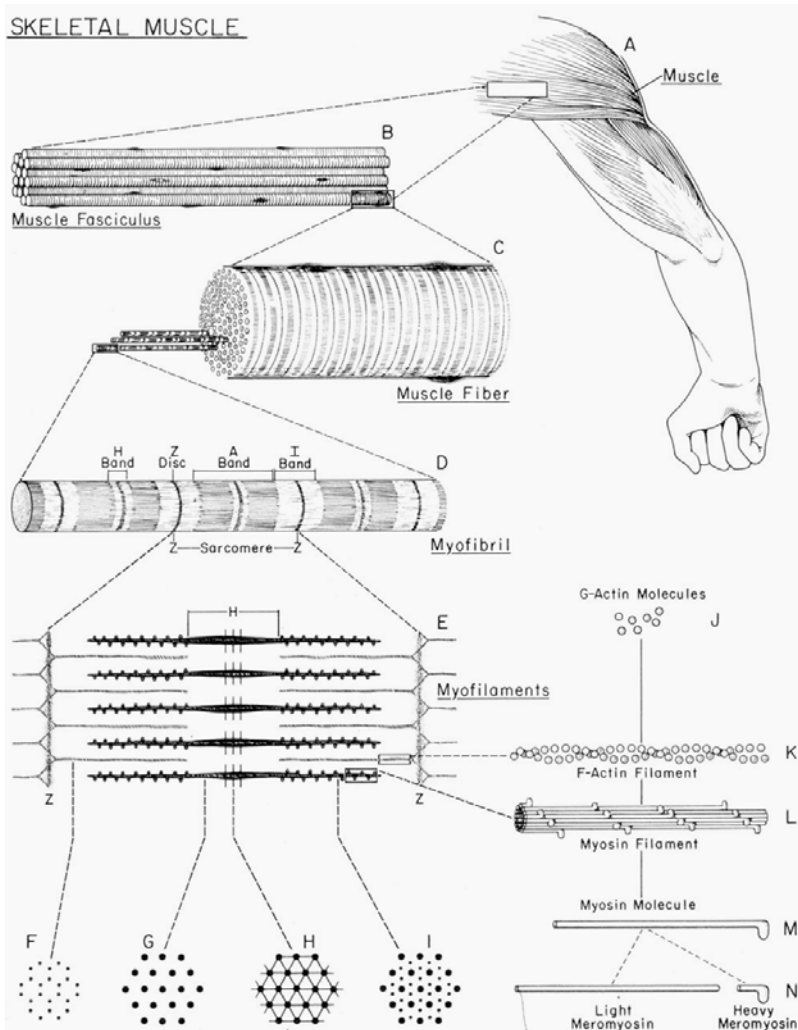
The two main functions of eccentric work



Negative work
i.e. "braking"

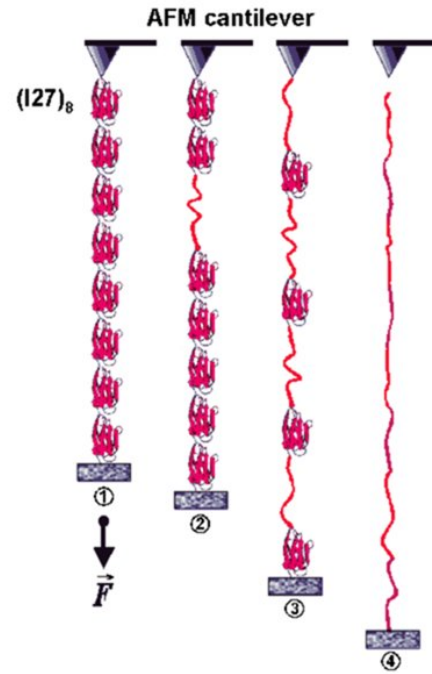
Elastic storage of
energy

SKELETAL MUSCLE



The classical view of muscle
The actin – myosin system

Titin the “third filament”



responsible for
elastic properties
and lengthening
behaviour of muscle

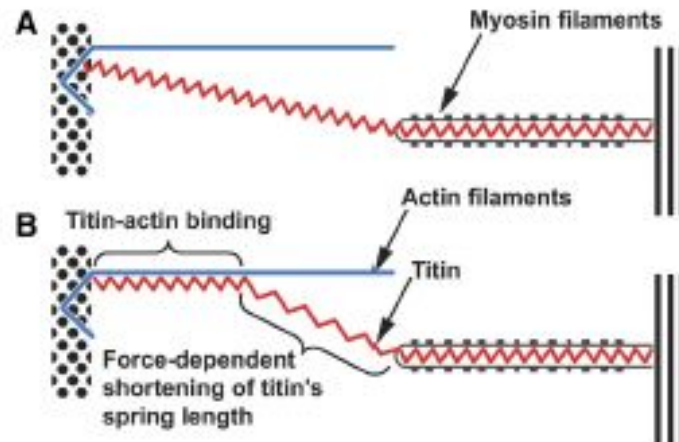
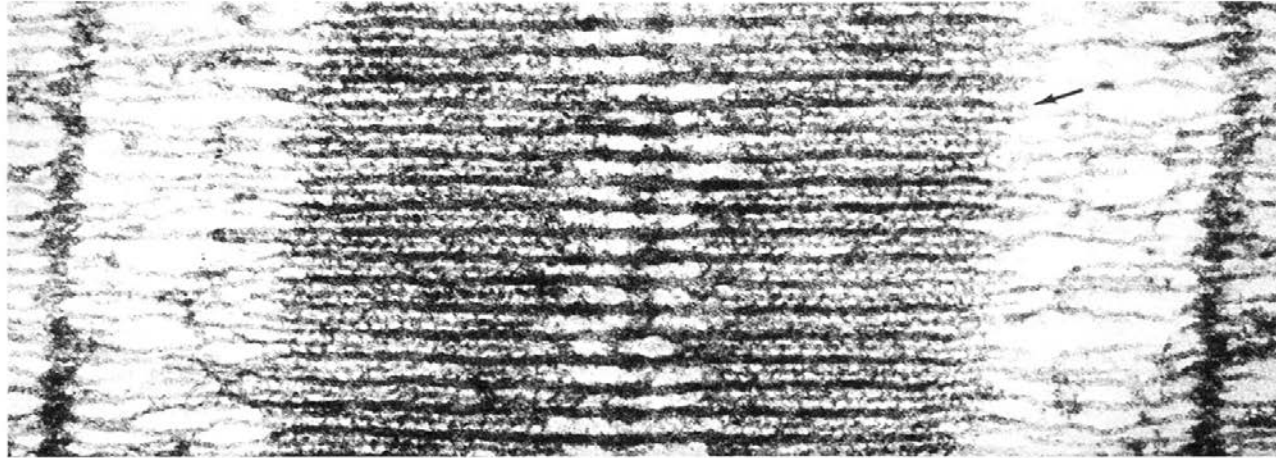
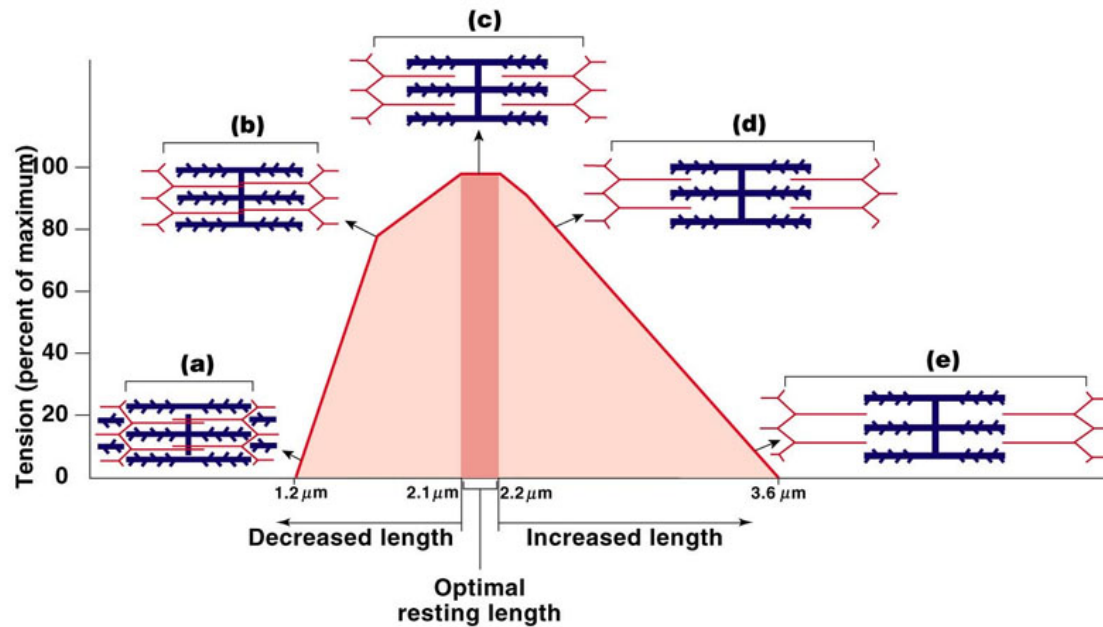
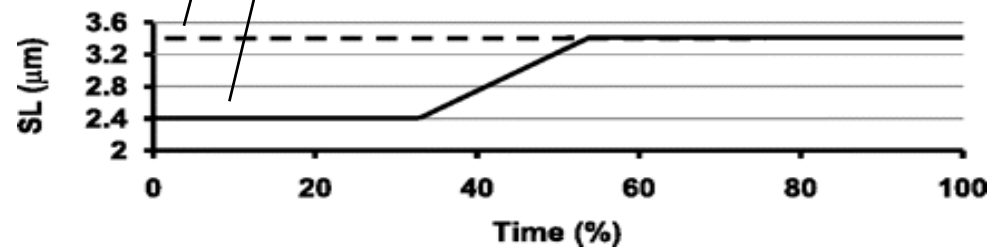
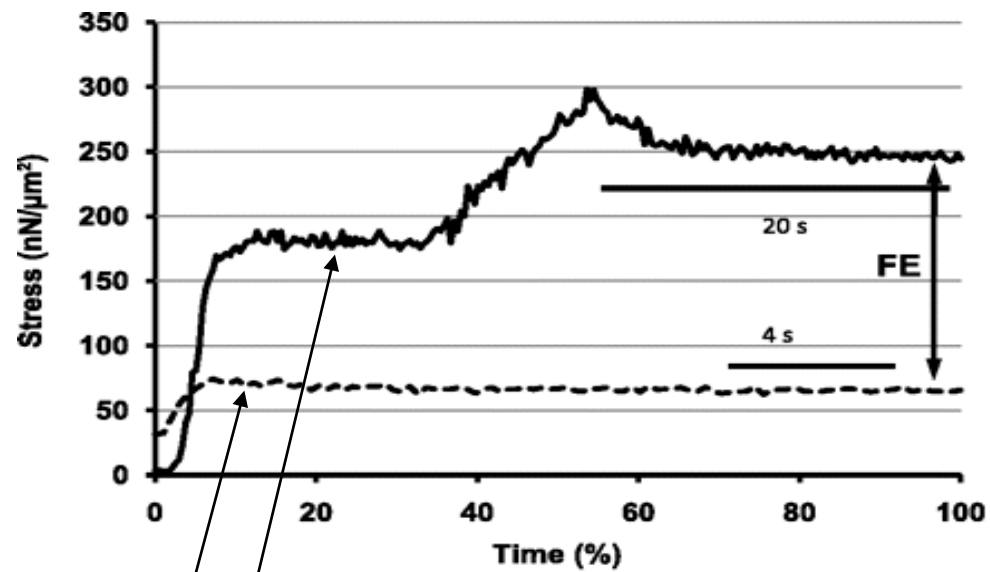
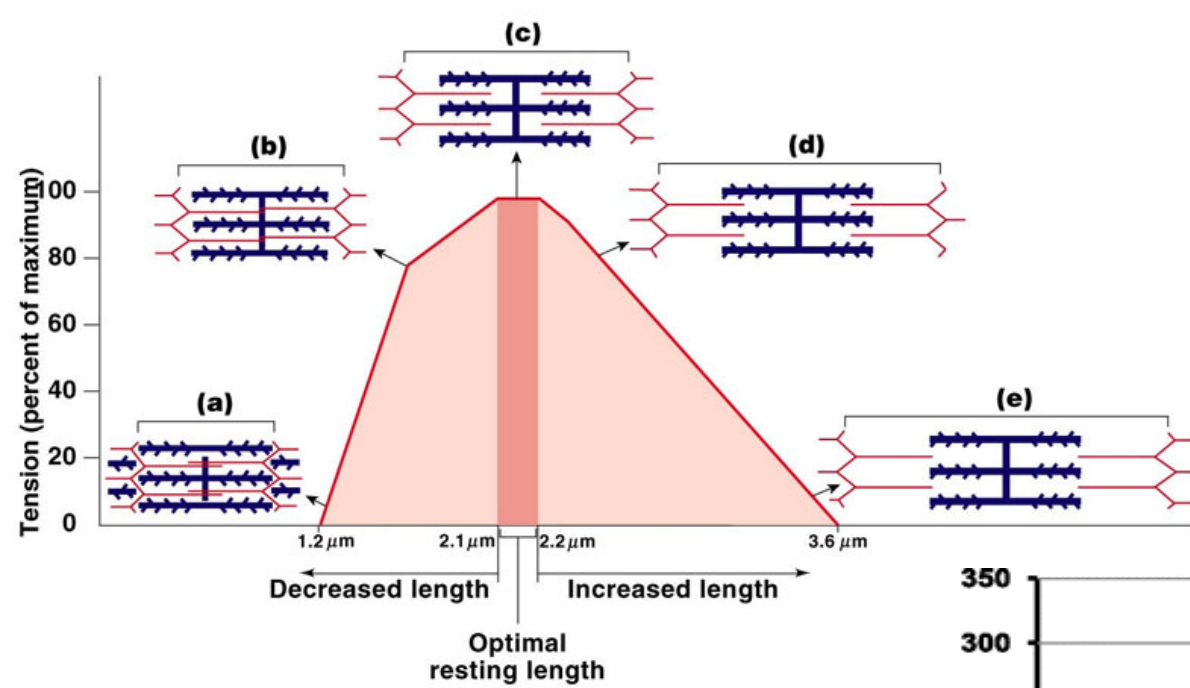


FIGURE 7-6 Sarcomere from rabbit psoas muscle which has been glycerinated removing soluble components of the sarcoplasm. In this type of preparation, it is possible to discern the organization of myofilaments, which constitutes the ultrastructural basis of transverse banding in the myofibril. In the A band, there is a simple alternation of thick and thin filaments in this particular plane of section, and in the I band there are only thin filaments. The thick filaments extend to the limits of the A band, where their ends become tapered (arrow). The thin filaments extend from each Z line through both the I band and A band, but terminate at the H band. Bridgelike structures extend radially from the surfaces of the thick filaments. Six such structures are arranged in a helical pattern which is repeated every 400 Å along the thick filament (see Fig. 7-19). $\times 128,000$. (From H. E. Huxley, 1957.)



H.E. Huxley 1957





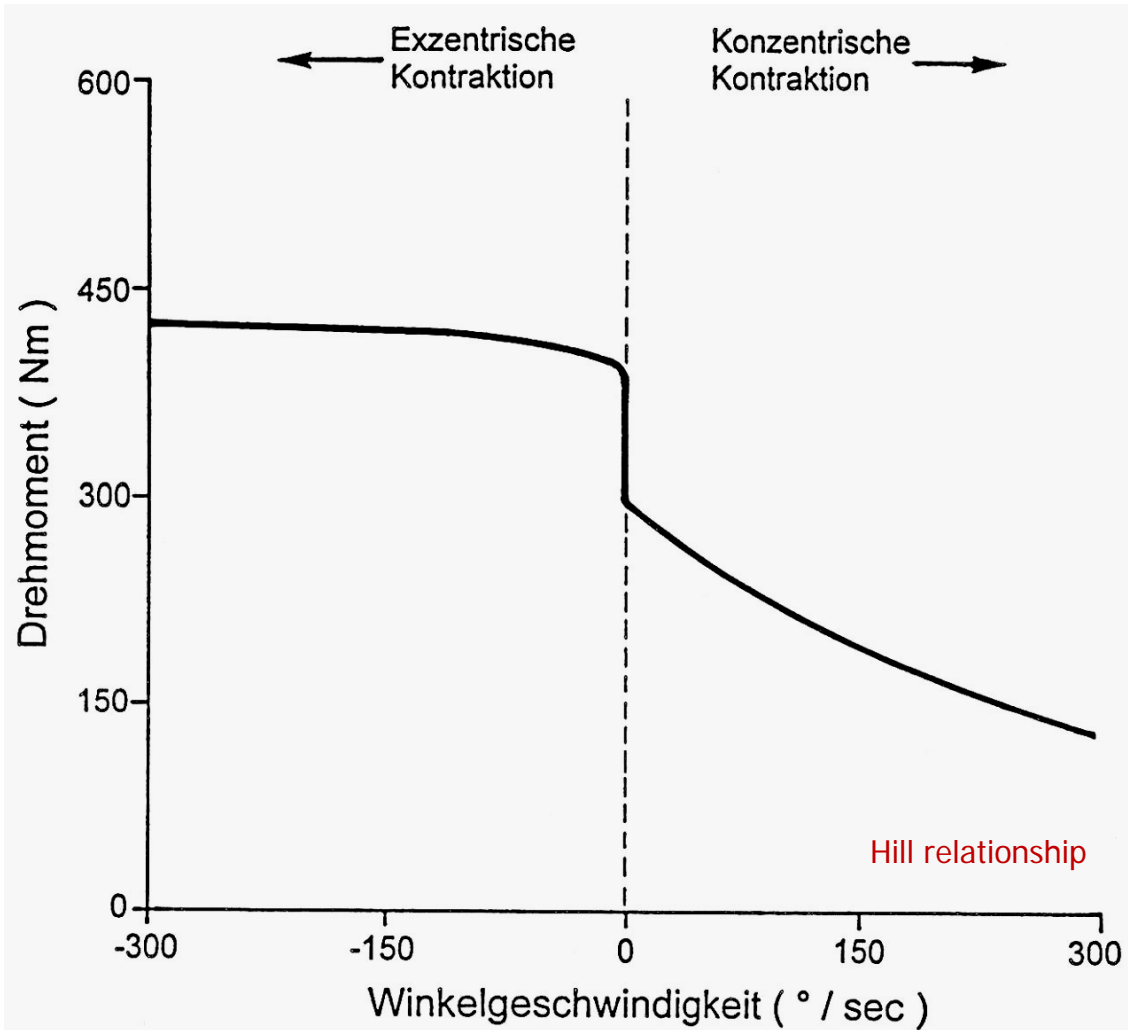


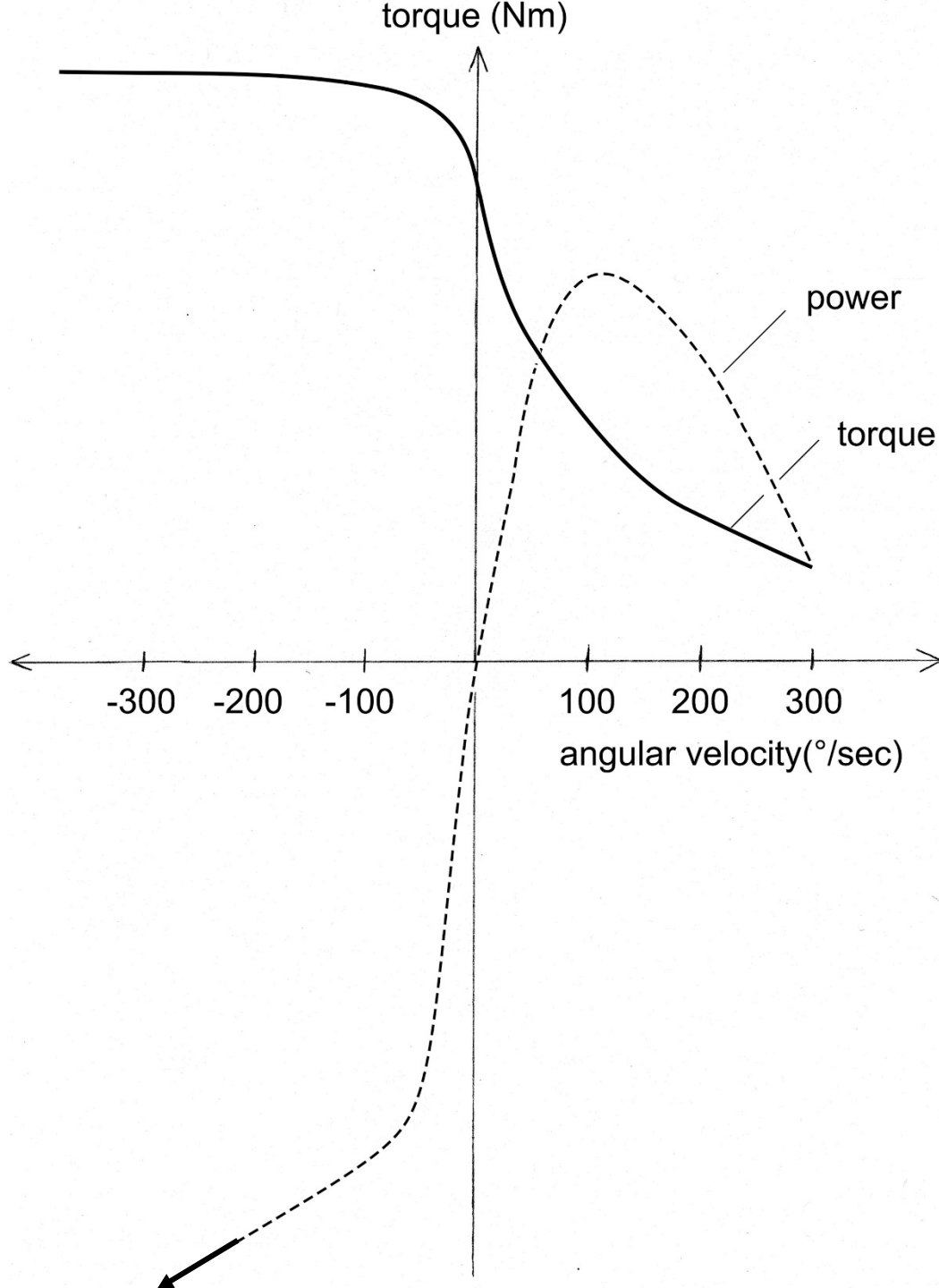
Eccentric exercise has three unique properties

- 1) EE can produce very high torque
- 2) EE has low metabolic requirements
- 3) EE challenges coordination

these properties can be exploited for training and rehabilitation

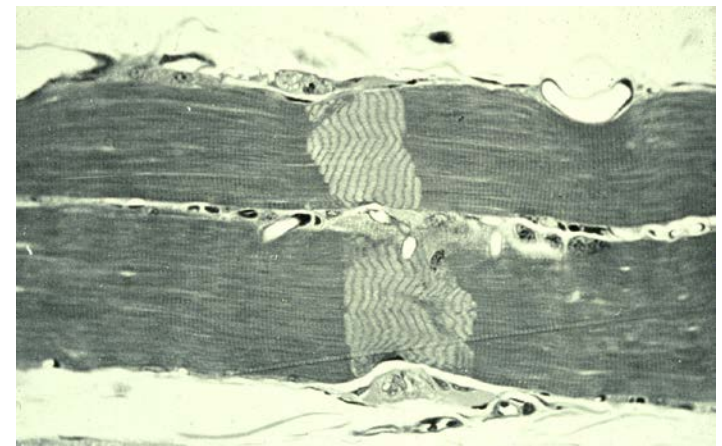
1) High torque





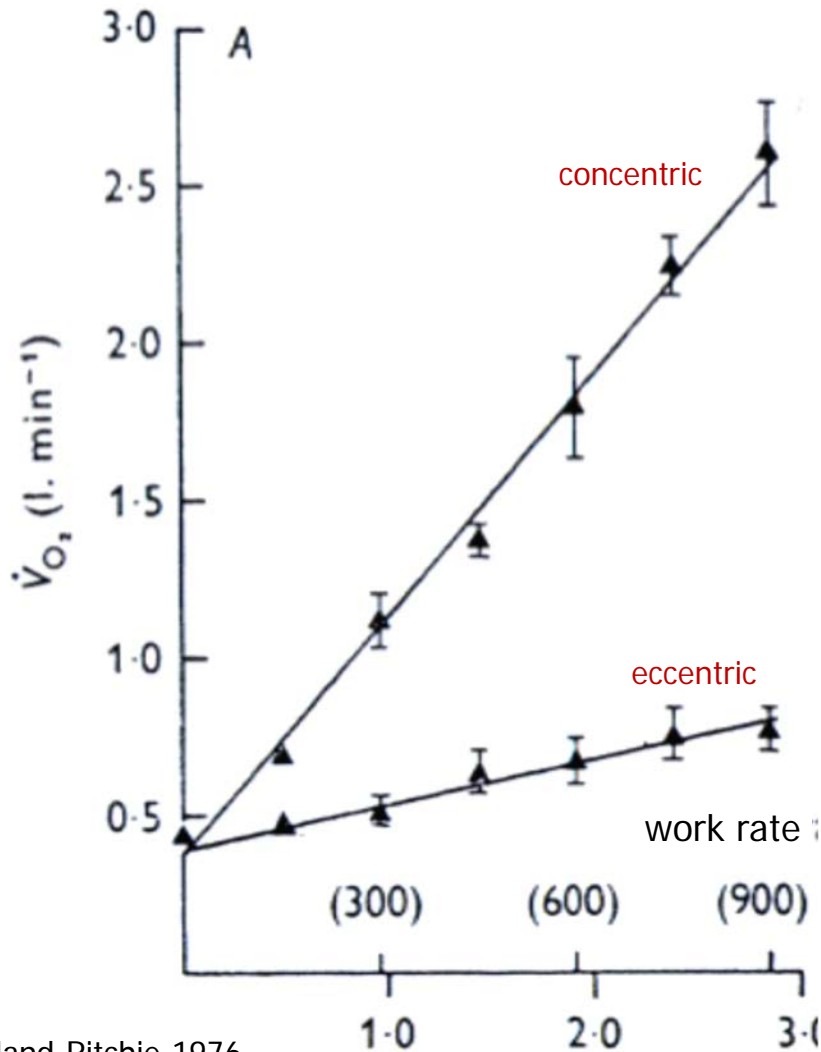
(power = torque x angular velocity)

At negative angular velocities muscle produces high torques and "unlimited" power

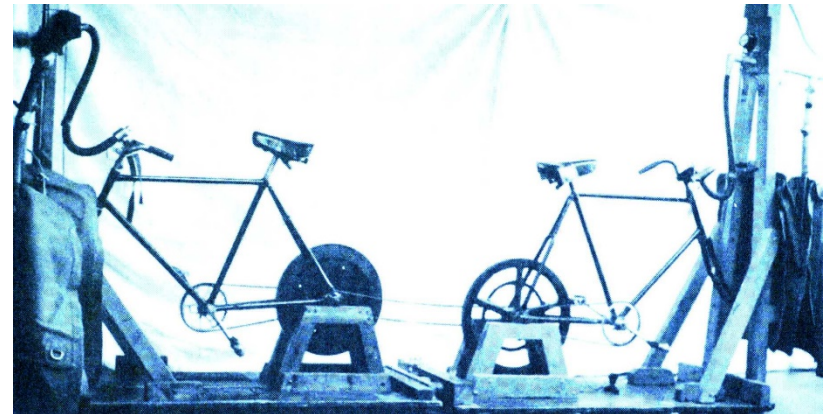


2) Low metabolic requirements

EE uses typically 4 times less metabolic power to produce a given amount of negative mechanical power

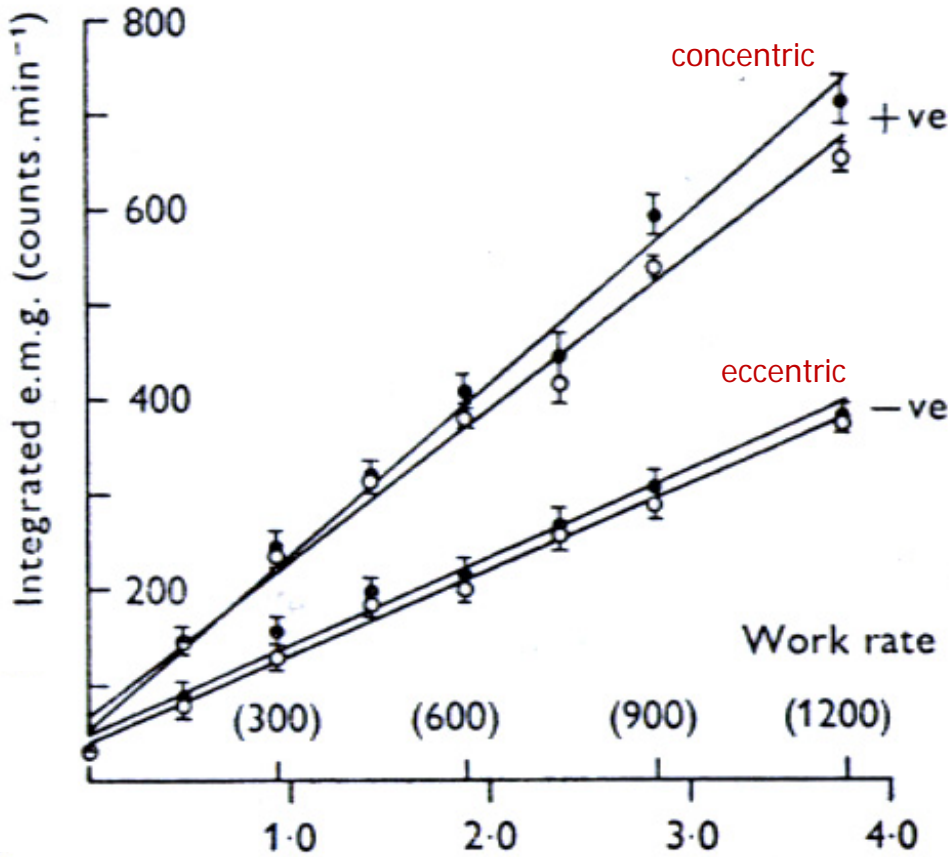


Bigland-Ritchie 1976



Abbott and Bigland-Ritchie 1952

3) Difficult coordination



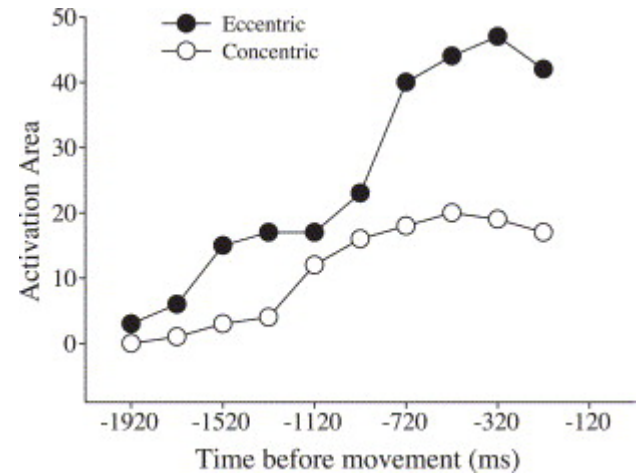
Bigland-Ritchie 1976

PNS

coarser control of torque

CNS ?

larger activated area,
more time for preparation



Fang et al. Brain Research, 2004

Eccentric training modalities:



Drop jumps

$P_{max} > 90 \text{ W/kg}$

Arampatzis et al. Med.Sci.Sport Exerc. 2001; ground contact, 200ms



Eccentric overload

8 – 12 near maximal contractions/session

total load 4 – 6 tons/session



Moderate load eccentric exercise

4 x 5 min @ 100 – 300W, 2-3/week

total load 40 – 60 tons/session

Moderate load eccentric training: technical implementation



Cyclus 2

<http://www.cyclus2.com/de/eccentric-training.htm>

Eccentron BTE

<http://www.btetech.com/product/eccentron>

Why are technical devices useful or necessary:

- reproducible dosage
because of
- lack of load perception



Cyclus 2

<http://www.cyclus2.com/de/eccentric-training.htm>

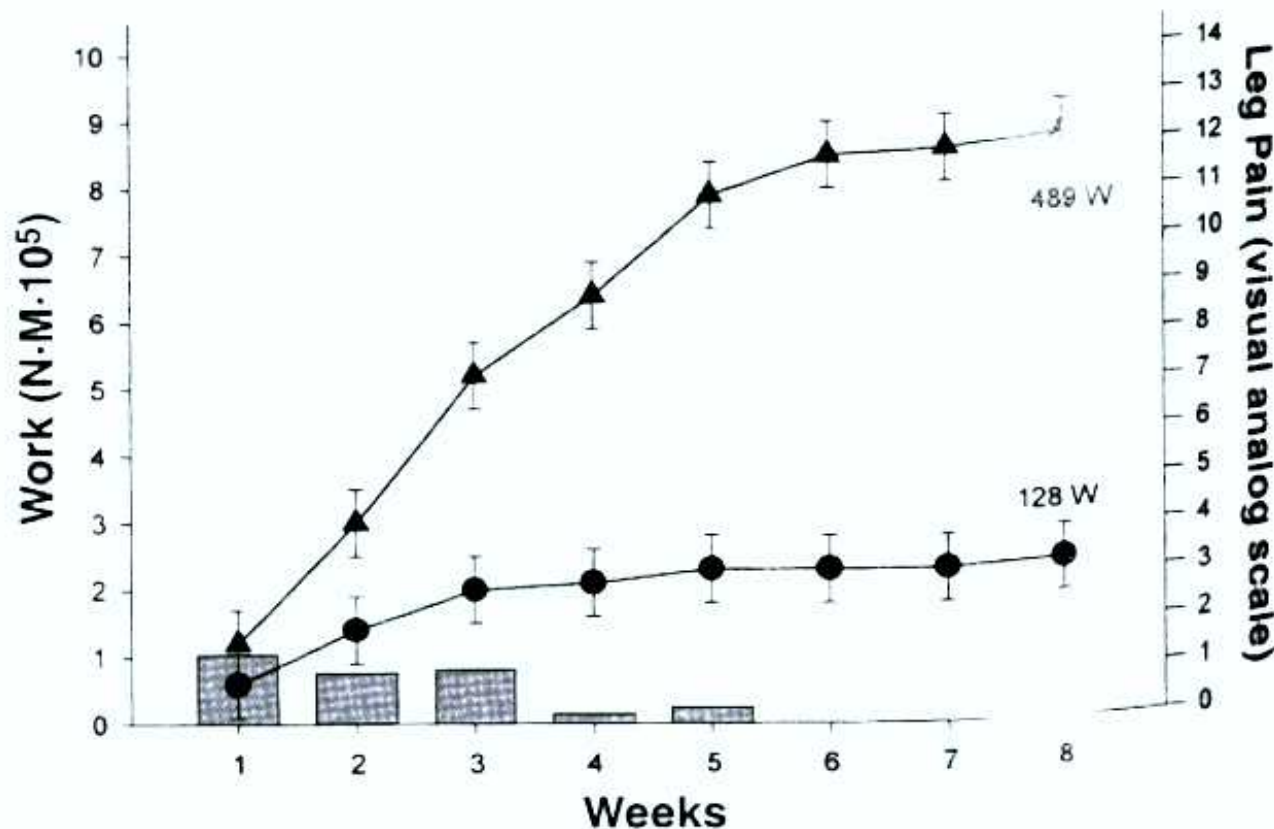


Eccentron BTE

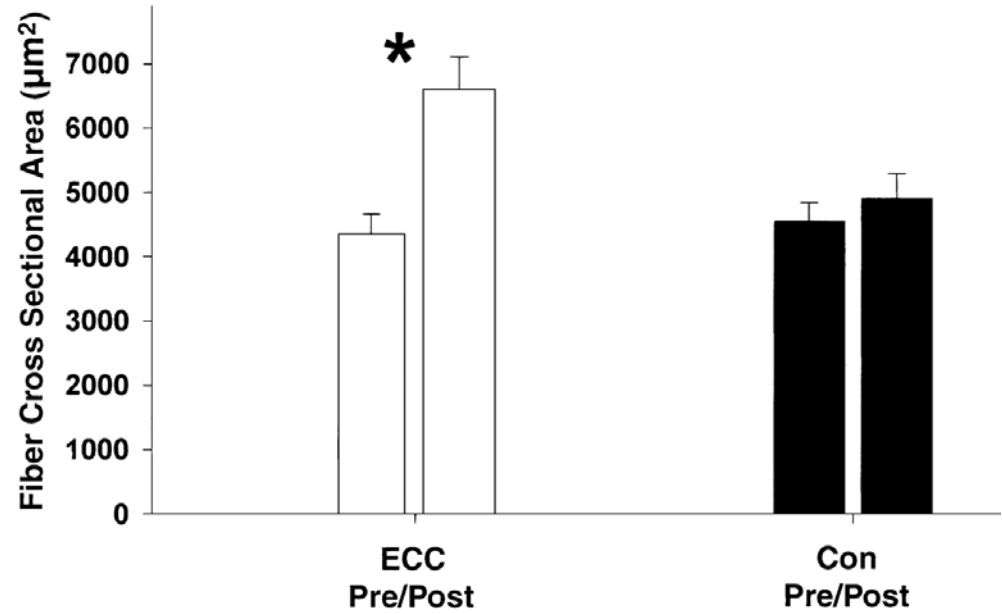
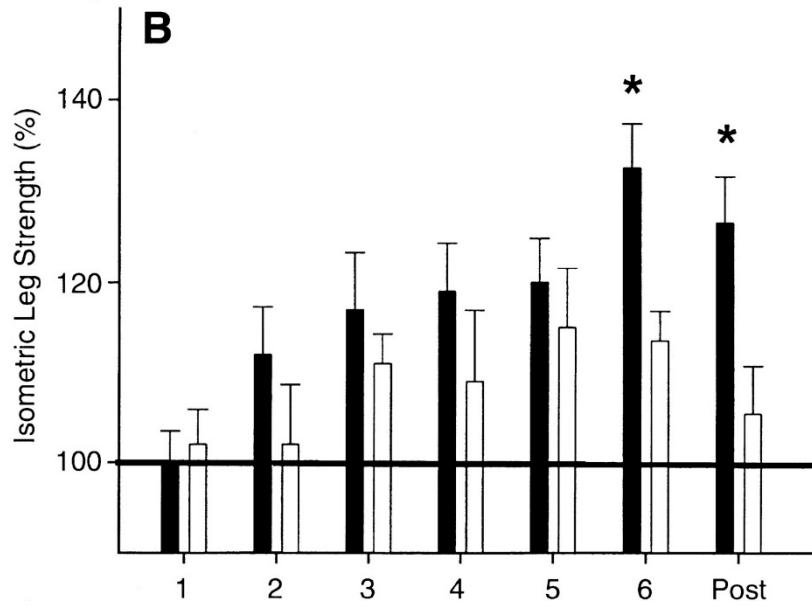
<http://www.btetech.com/product/eccentron>

Proof of Principle study

Concentric vs. eccentric exercise in untrained young subjects at the same oxygen consumption rate



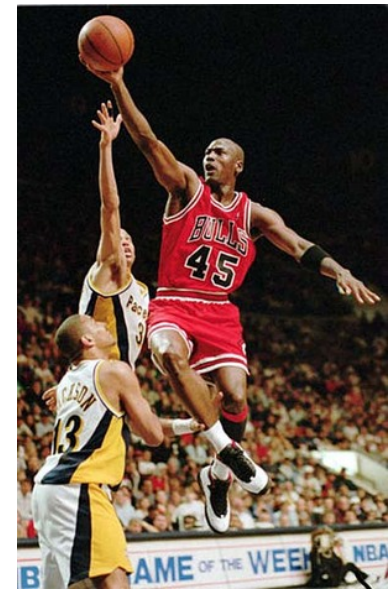
High mechanical load at same metabolic load



Concentric vs. eccentric work

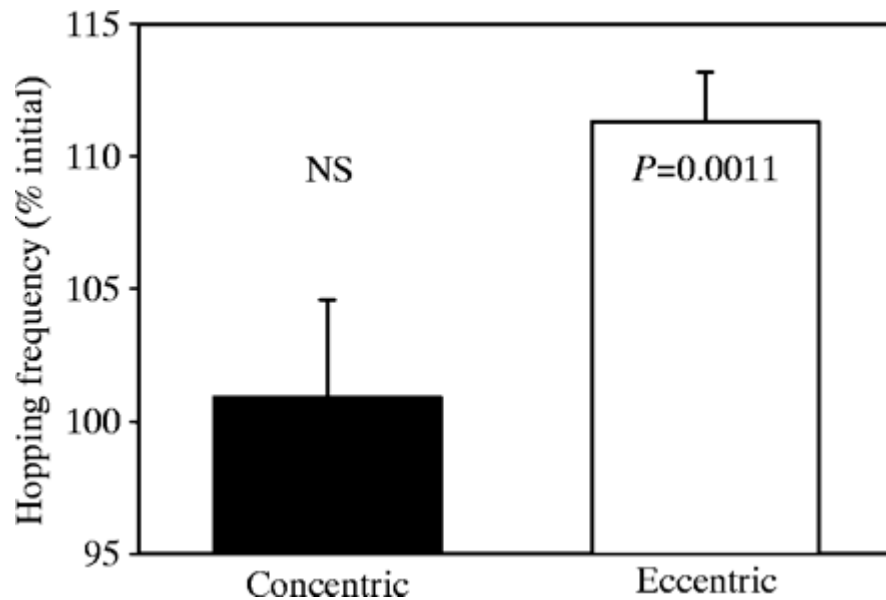
LaStayo et al. Am. J. Physiol. 2000

College level basketball players

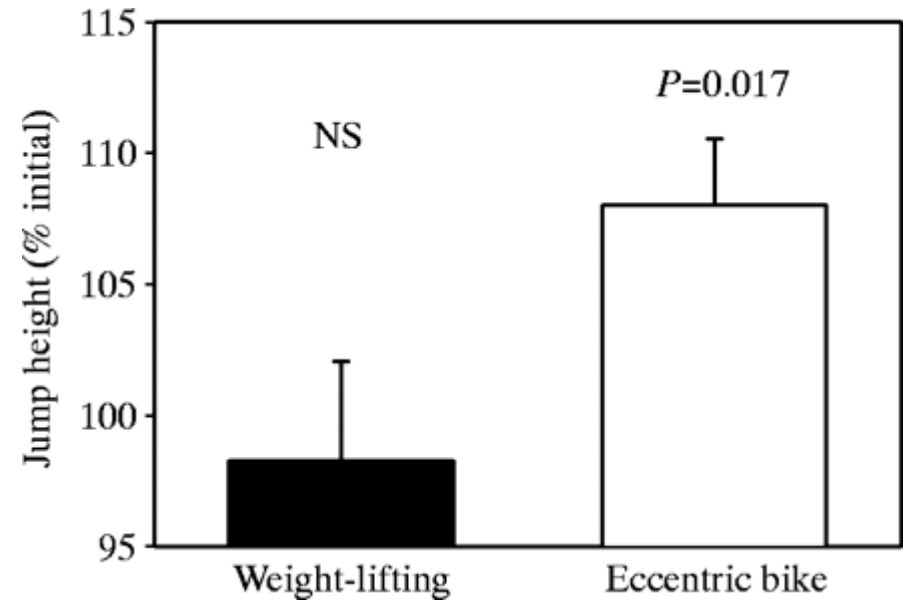


Lindstedt et al., J. Exp. Biol. 2002

6 weeks of eccentric training

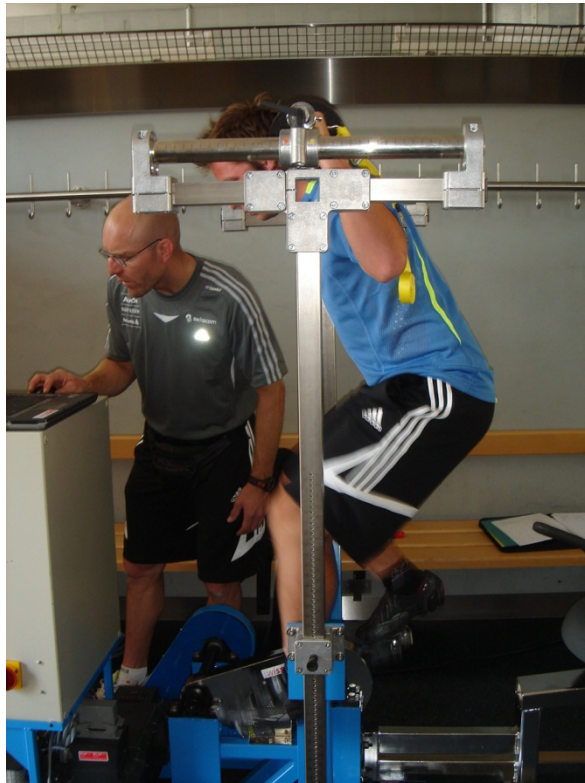


Increased muscle stiffness



Increased jumping performance

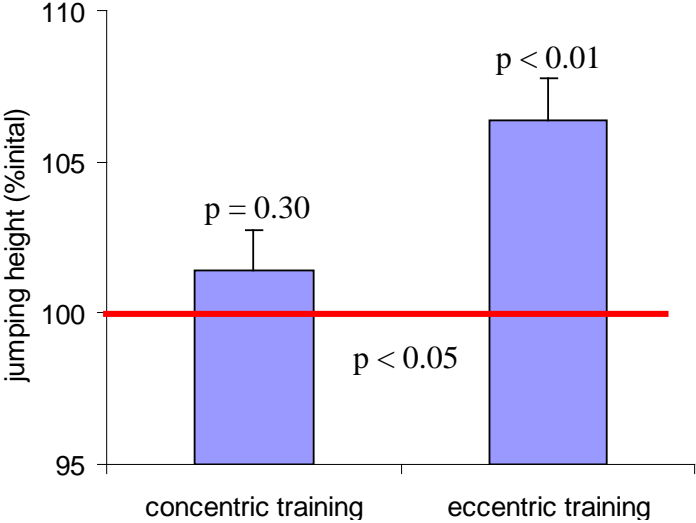




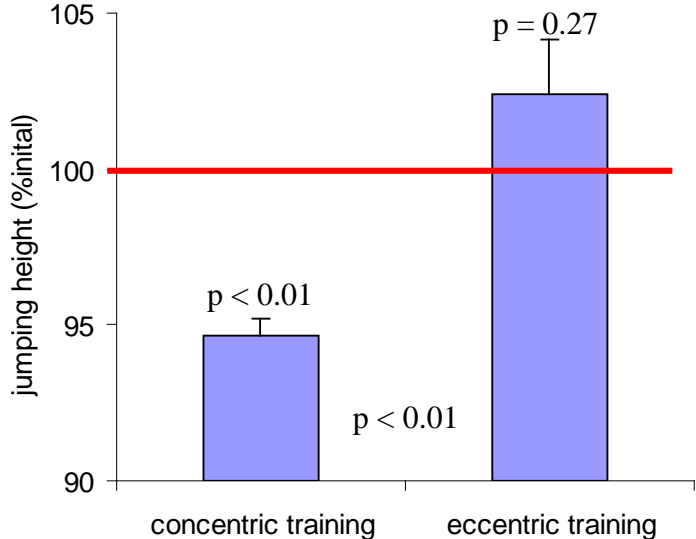
Junior Alpine Skiers, 6 weeks of eccentric exercise

Change in jumping height (mean +/- SE)

CMJ



SJ





- Increased jumping performance (+7%), ecc-group only
- Improved eccentric coordination (+50%), ecc-group only
- ecc-group increased leg muscle mass (+1.9%), ecc-group only
- Improved maximal isometric strength (+10%), both groups

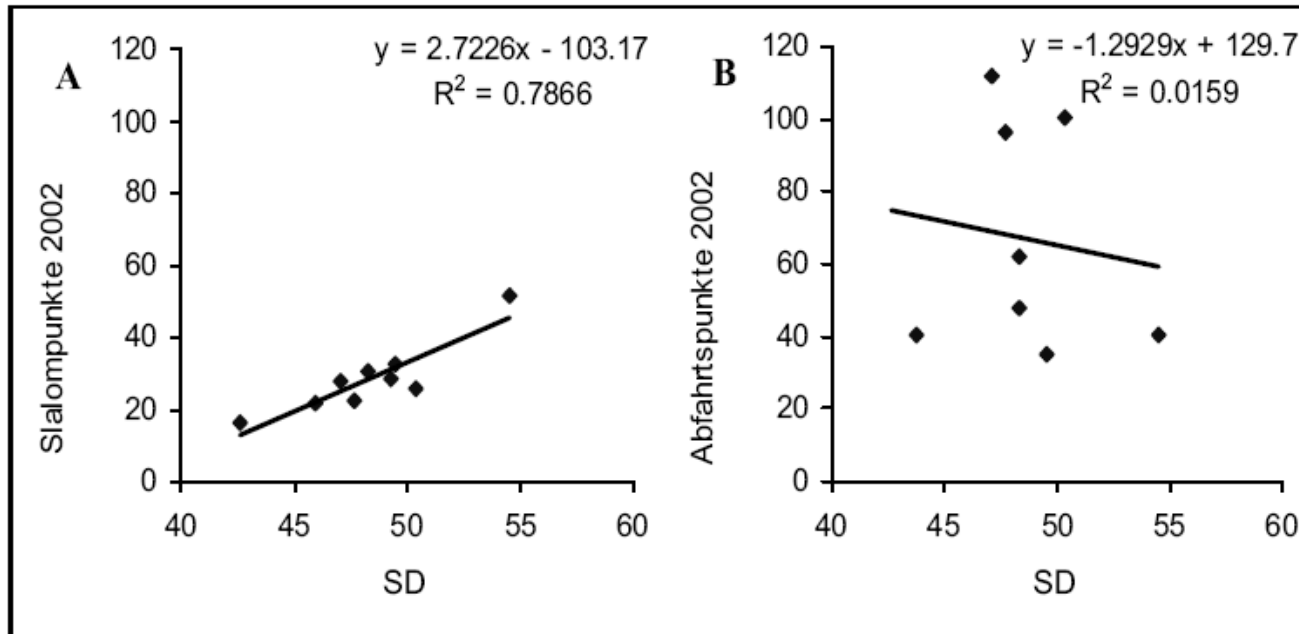
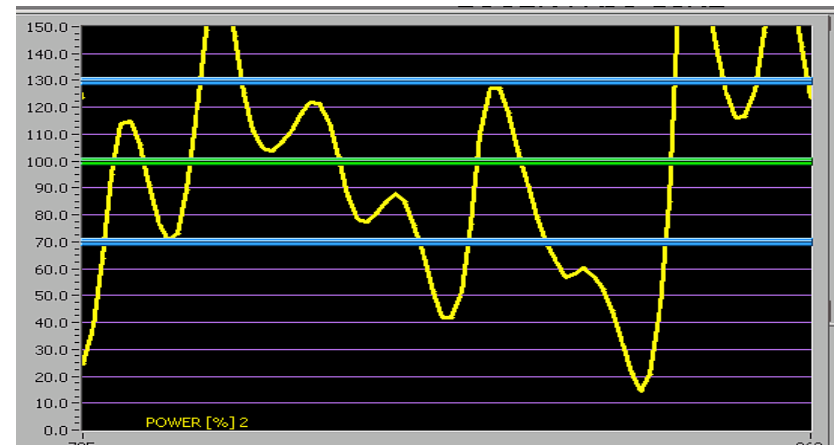
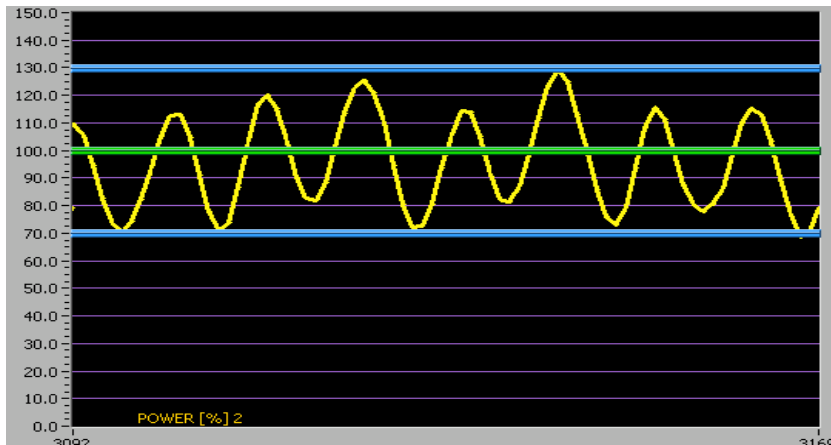


Abbildung 4: Korrelationen zwischen der Standardabweichung (SD, Wert für Abweichung der Bremsleistung des Athleten von der Zielleistung [= 500 W]) bei der 1. Trainingseinheit und den FIS-Punkten der Saison 2001/02 im Slalom (A, n = 9) bzw. in der Abfahrt (B, n = 8).

Eccentric exercise with cardiac patients

- Patients from ambulatory cardiac Rehab-Program
- Prospective randomized intervention
- Age 42-66 y, trainings 30 min, 3/week, 8 weeks
- Right heart catheter after 5th week
- Constant load after catheter

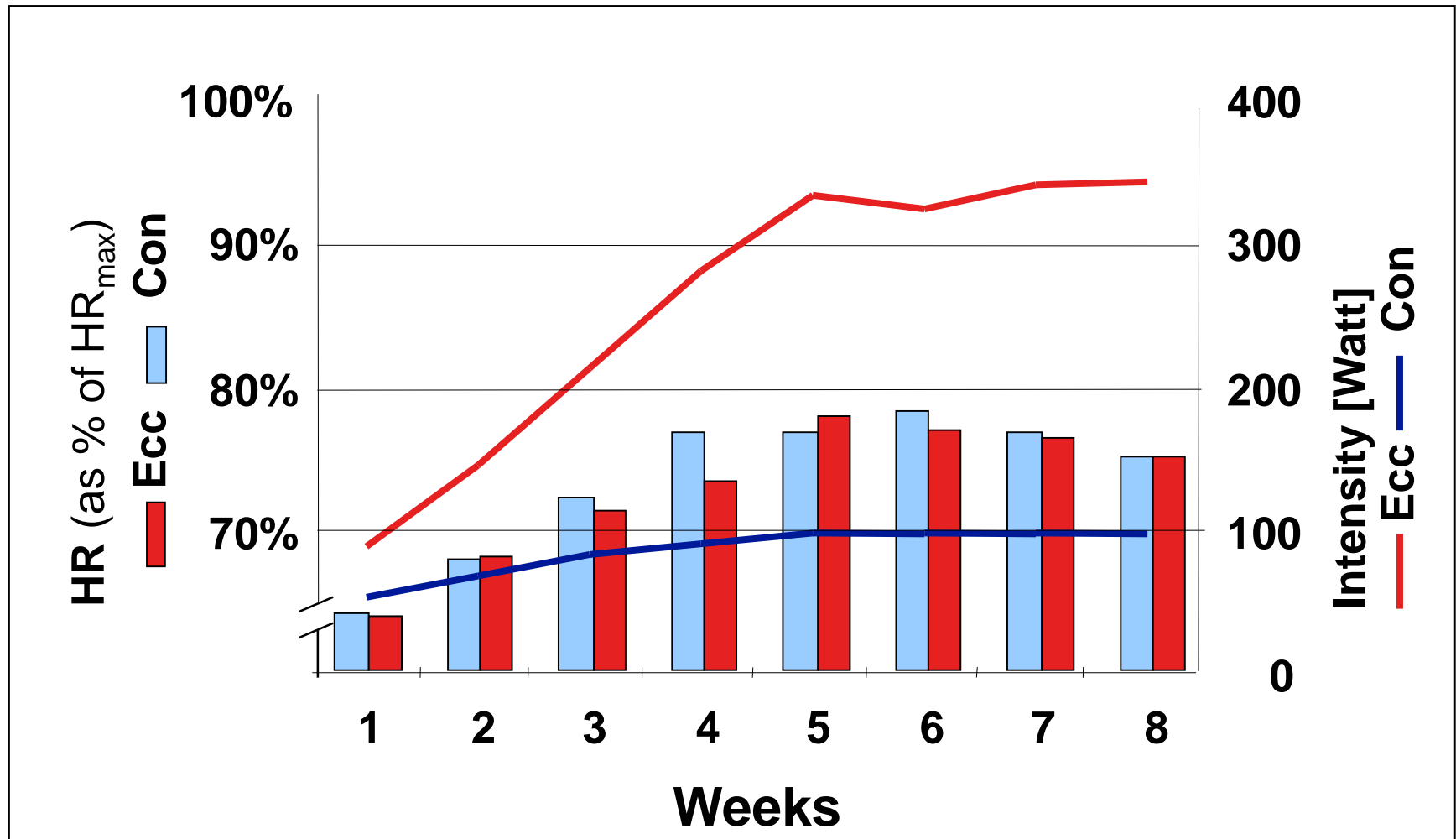


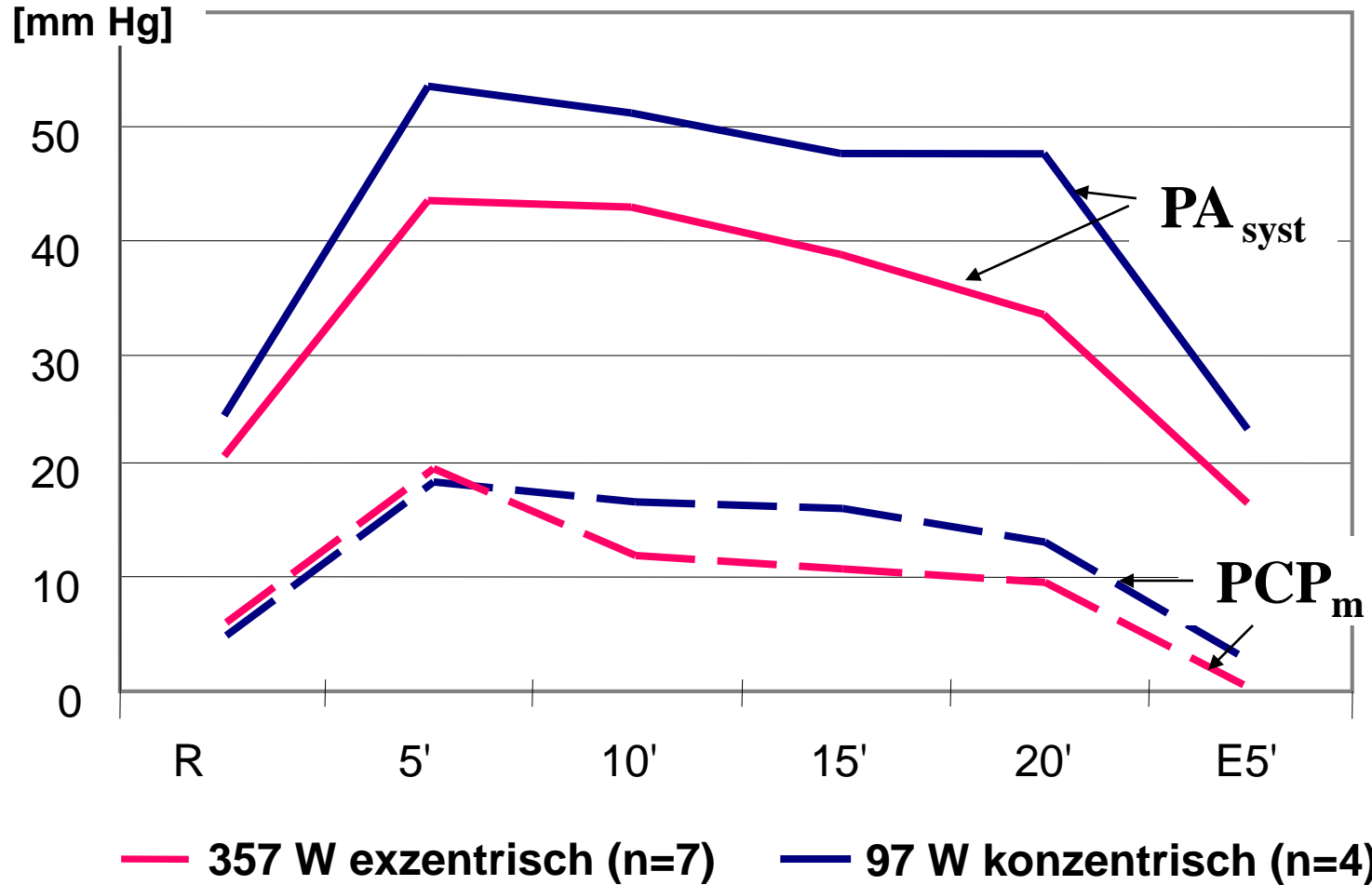
Right heart catheter



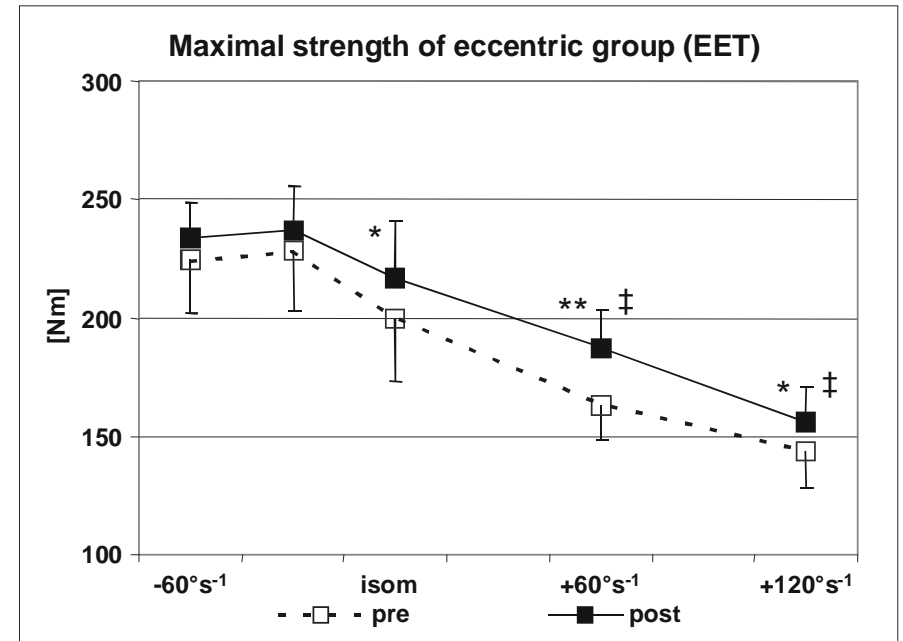
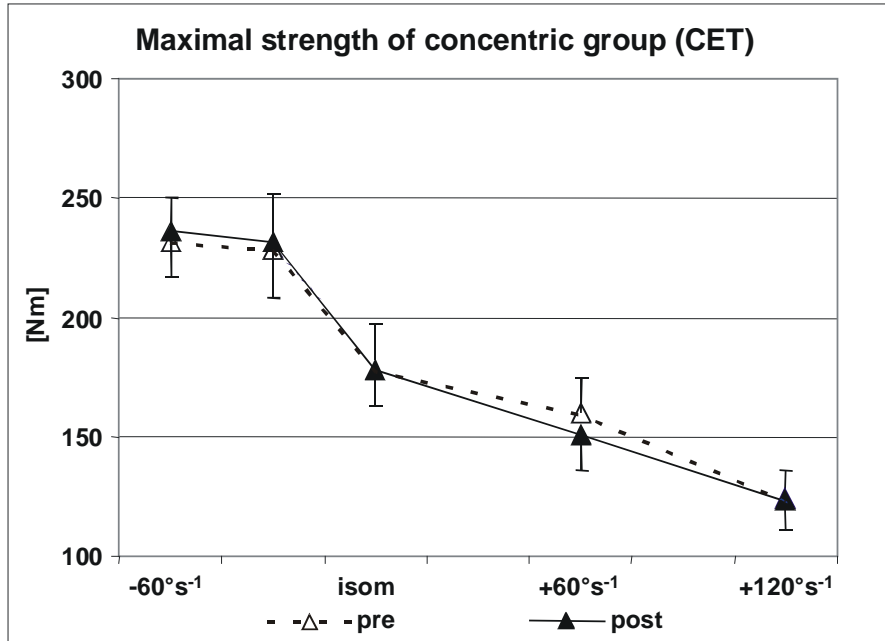
Meyer et al. Med. Sci. Sports Exerc. 2003

Training characteristics



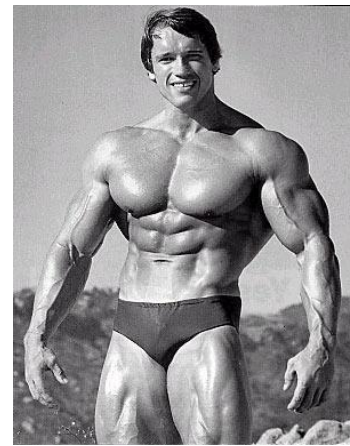


Isokinetic strength of knee extensors



Sarcopenia

NFP-53 Muskuloskeletale Gesundheit –
Chronic Eccentric Exercise Training for the Elderly

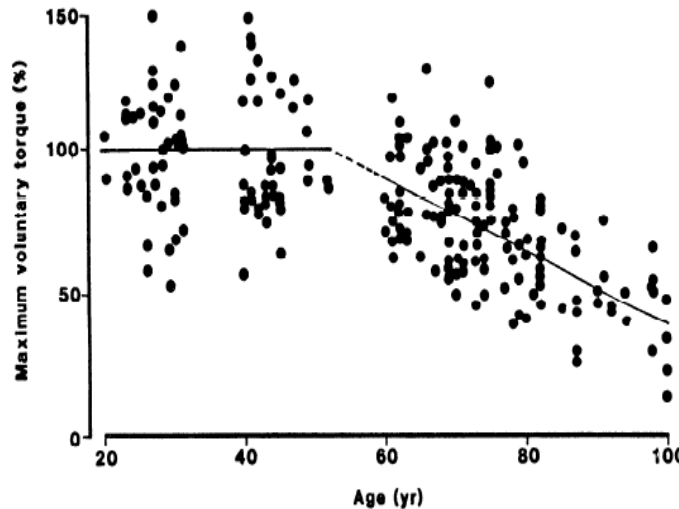


Mister Universe

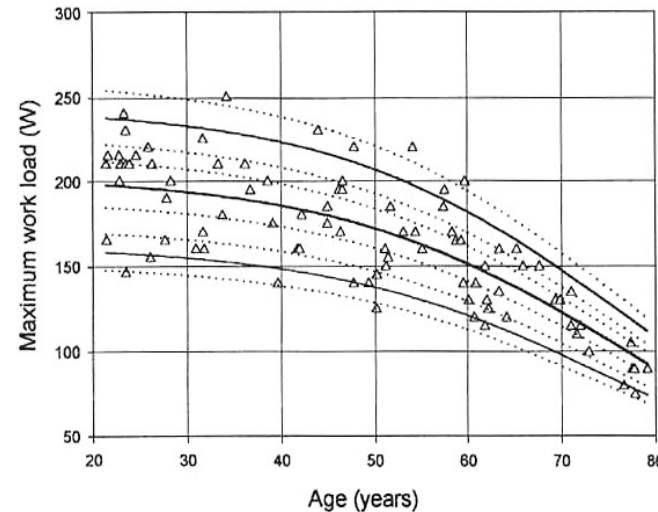


Governor of California

Strength and endurance decrease with age



Vandervoort, 1989, Eur J Appl Physiol
Occup Physiol.



Farazdaghi and Wohlfart, 2001 Clin. Physiol.
6: 682-687 (data on women)

Risk of falls is increased

Studydesign:

Chronic eccentric exercise training for the elderly (n=62)

Pre-test	CT Cognitive training	12 weeks, 2x45min/week	Post-test
	RET Strength training	12 weeks, 2x45min/week	
	EET Eccentric exercise	12 weeks, 2x45min/week	

3 Groups

Cognitive

16 CT



None

Resistance

23 RET



13

Eccentric

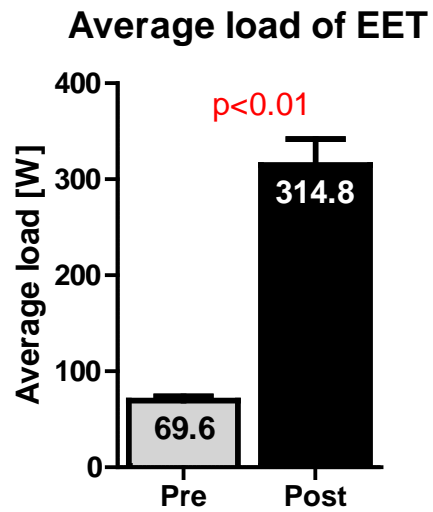
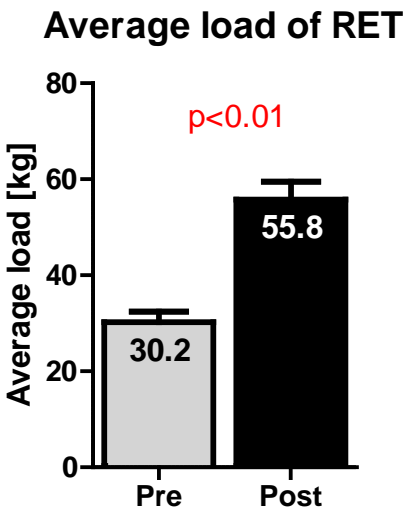
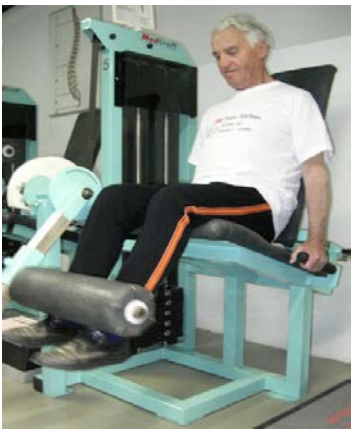
23 EET



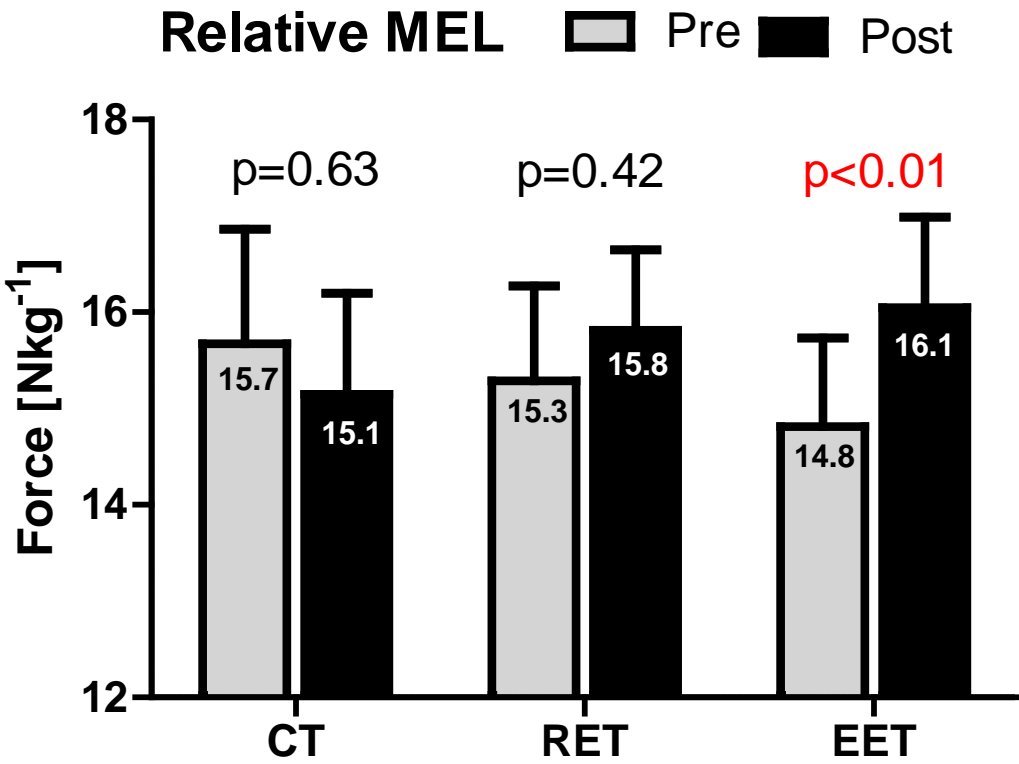
14

Biopsies

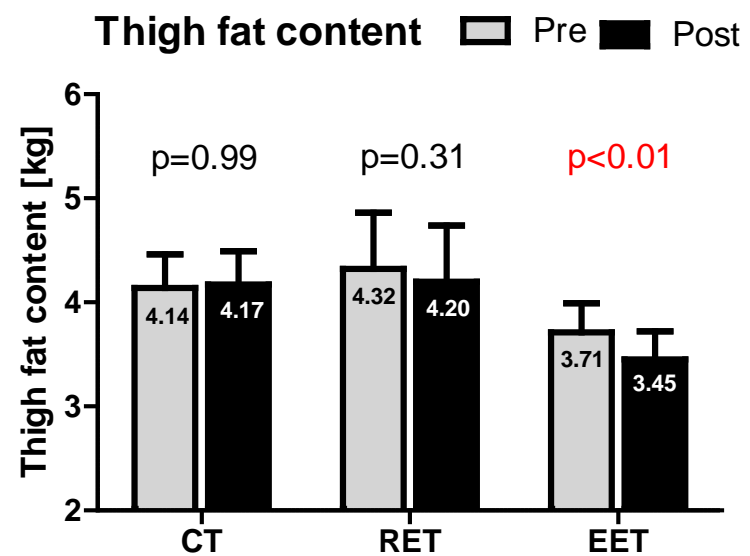
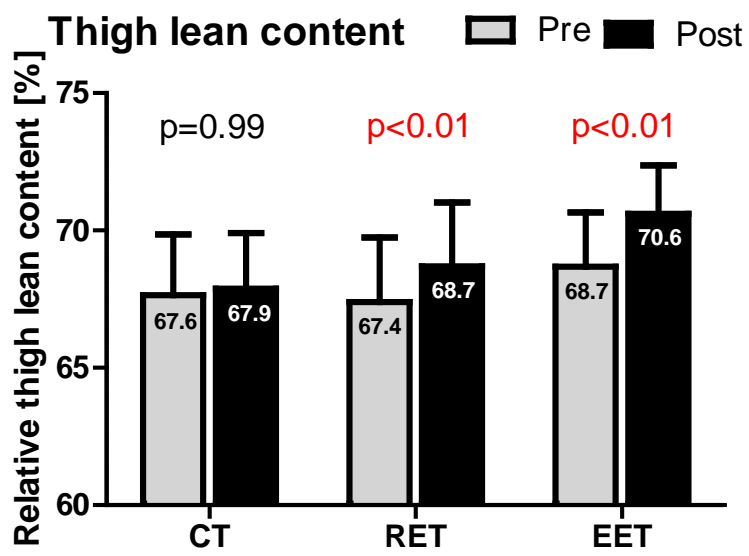
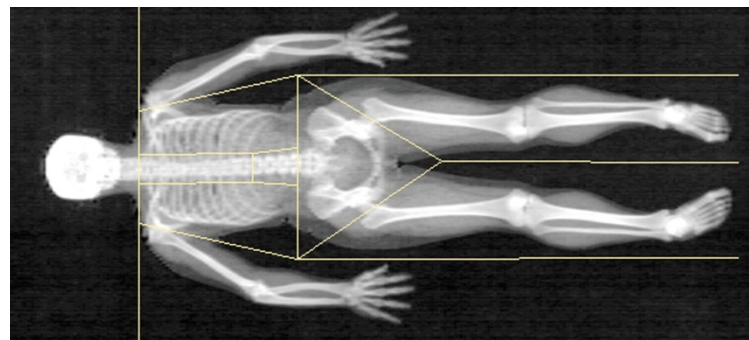
Strength training at respective training device



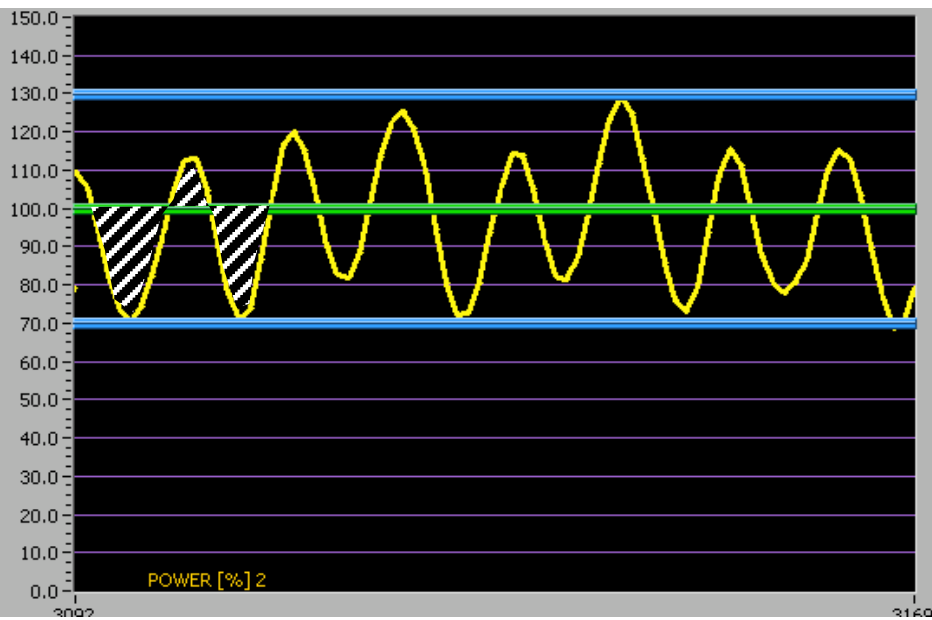
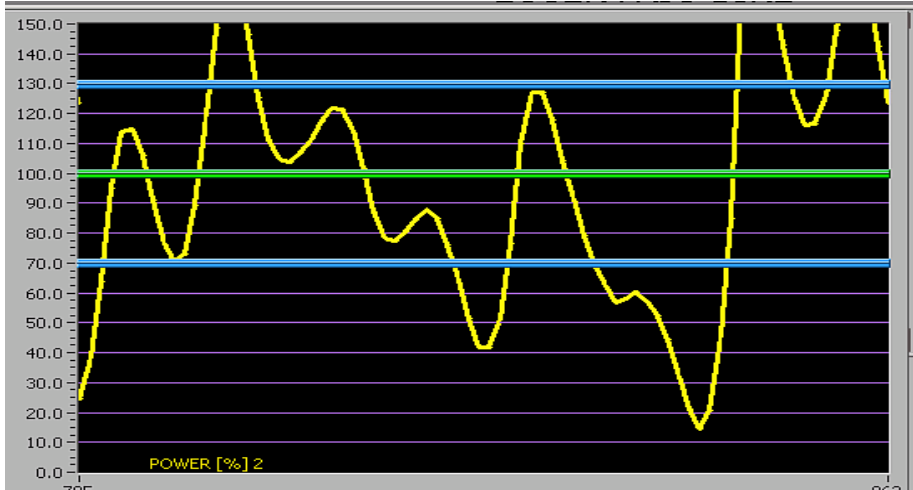
Maximal strength isometric, training independent



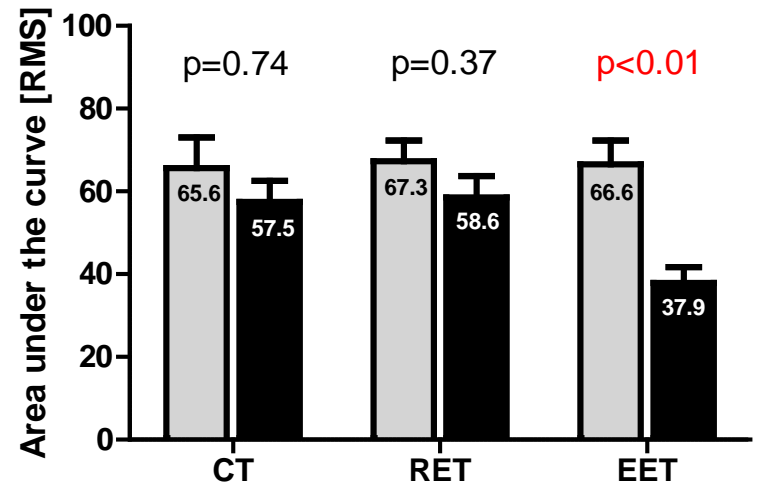
Thigh composition (Dexa)



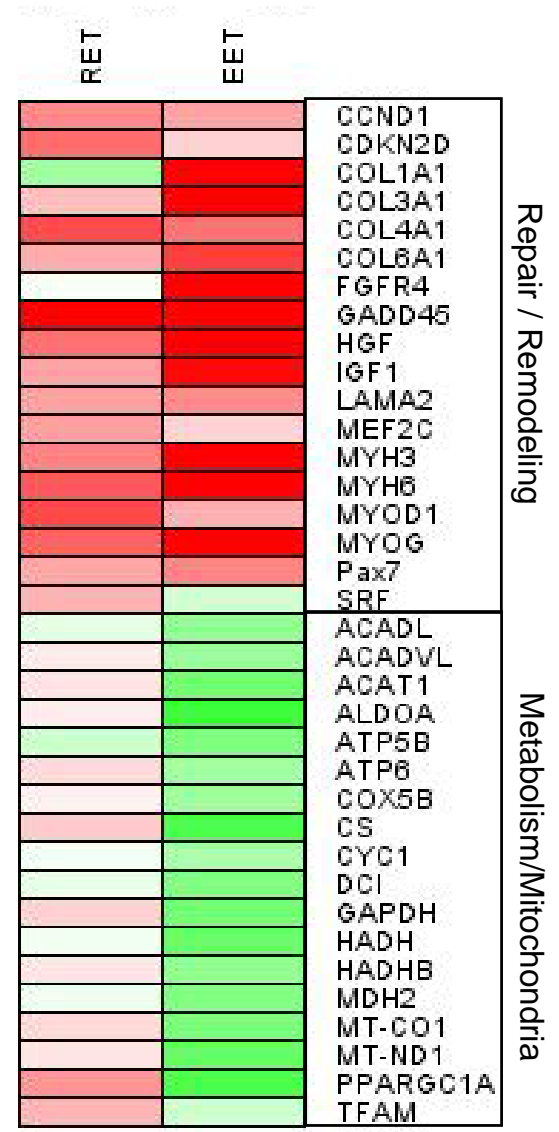
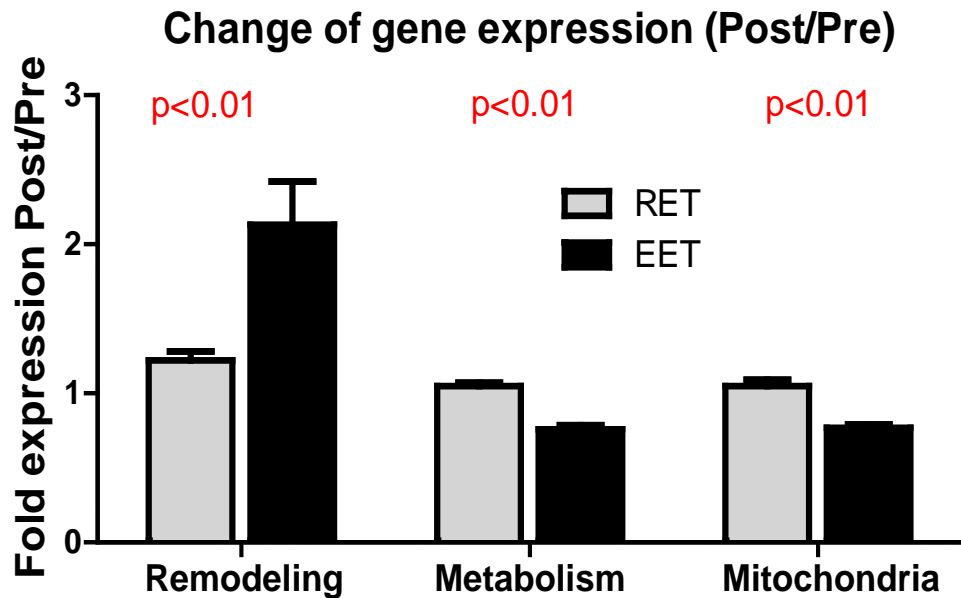
Eccentric coordination



Eccentric Coordination Pre Post



Molecular mechanisms



Rehab after ACL rupture

skiing and pivoting sports



Effects of Early Progressive Eccentric Exercise on Muscle Structure After Anterior Cruciate Ligament Reconstruction

J. Parry Gerber, Robin L. Marcus, Leland E. Dibble, Patrick E. Greis, Robert T. Burks and Paul C. LaStayo
J Bone Joint Surg Am. 2007;89:559-570. doi:10.2106/JBJS.F.00385

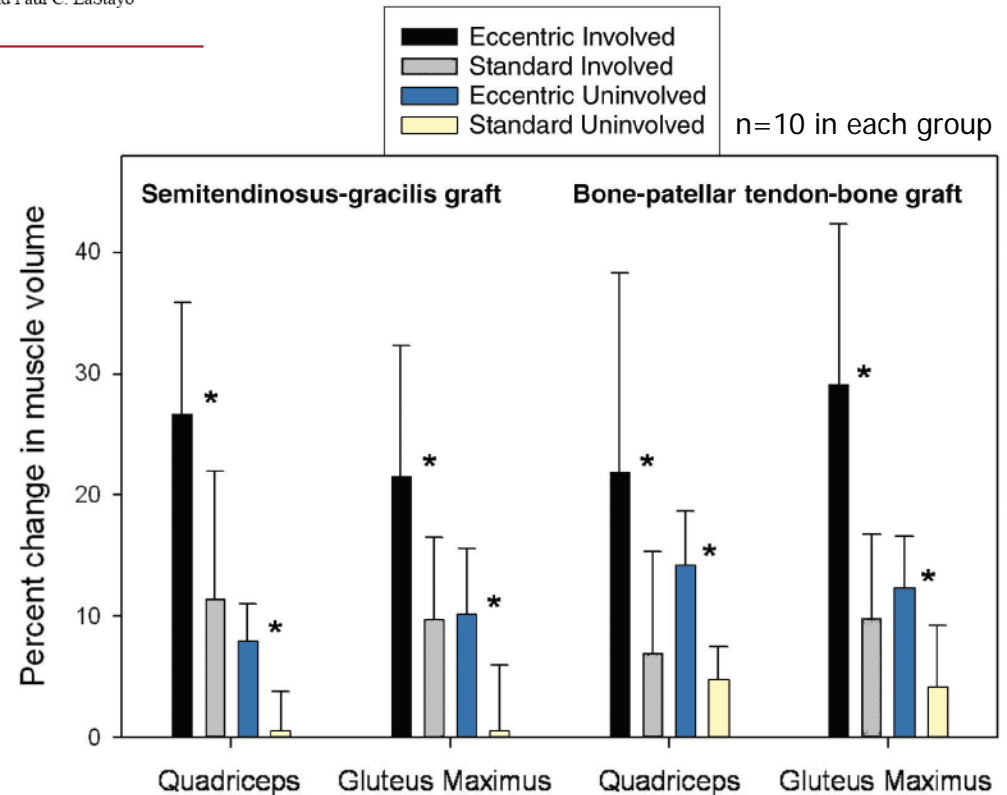


Fig. 3

Changes in the volumes of the quadriceps and gluteus maximus muscle in the involved and uninvolved lower extremities during the twelve-week training period after treatment with a semitendinosus-gracilis or bone-patellar tendon-bone graft. The asterisks indicate a significant difference in muscle-volume improvement between the eccentric and standard-rehabilitation groups ($p \leq 0.005$).



20% reduction in
M. semitend volume
in gracilis-semitend. graft

Pivoting sports

The ACL is essential for sports performance and ruptures during „normal“ sports activity

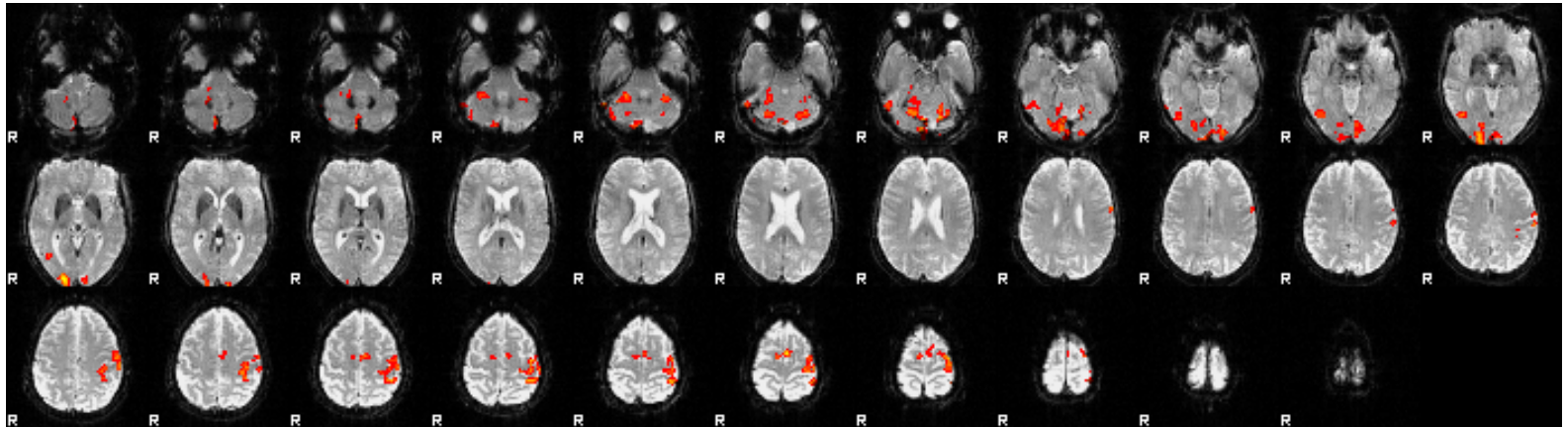


Skiing

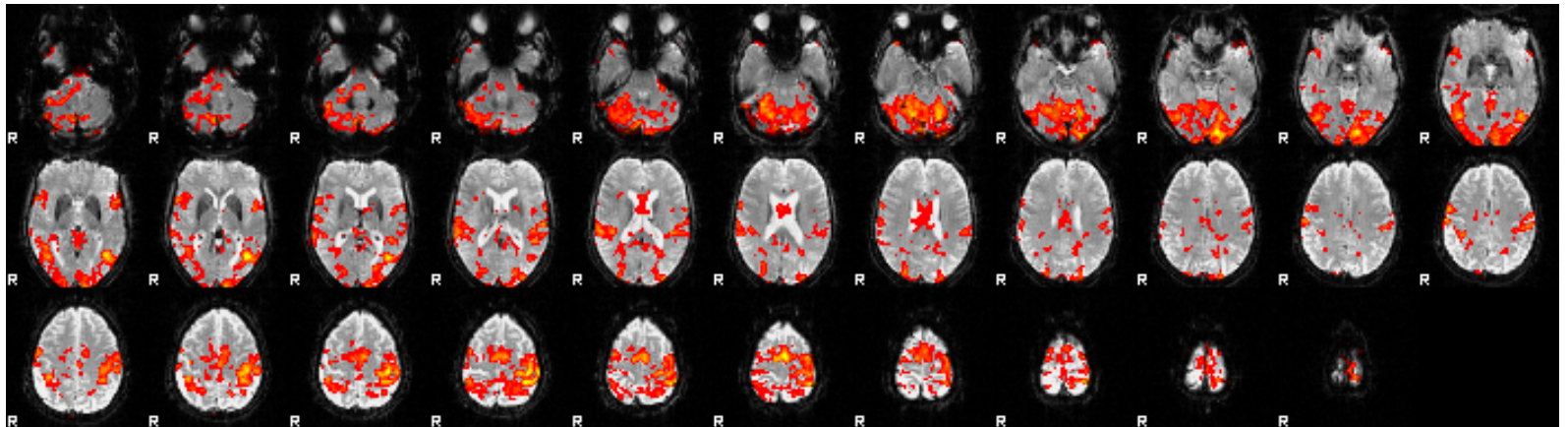
The ACL is not essential for sport and ruptures only with catastrophic control failure



BOLD-fMRI concentric and eccentric movements of the index



concentric activation of right index, BOLD, TR=2000ms, 204vol, Blocklänge 24 sec, $z > 2.3$



eccentric activation of right index, BOLD, TR=2000ms, 204vol, Blocklänge 24 sec, $z > 2.3$

Zusammenfassung

Sofortiger Effekt einer exzentrischen Ueberlastung

Reduktion der Leistungsfähigkeit (-10% CMJ)
Muskelzellschaden (DOMS)

Exzentrisches Training (3 x 20 min/Woche)

Zunahme der Muskelkraft und Muskelquerschnitt
Abnahme des Fettgehalts (local und systemisch)
Verbesserung der Koordination exzentrischer Bewegungen
Zunahme der Stiffness der Muskel-Sehneneinheit
Hohe mechanische Belastungen bei niedrigeren metabolen Belastungen
“Krafttraining” bei geringen Gelenkbelastungen

ABER: Die oxidative Kapazität der Muskulatur nimmt ab

ROUTLEDGE RESEARCH IN SPORT AND EXERCISE SCIENCE

Eccentric Exercise

Physiology and application in sport and
rehabilitation

Hans Hoppeler



