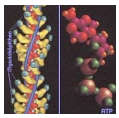
CARDIAC REHABILITATION PHASE IV

Theoretical Background of Strength Exercises in the Context of Cardiac Rehab



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PROGRESSIVE OVERLOAD

A WRESTLER MILO FROM CROTON OF ANCIENT GREECE STARTED CARRYING A CALF ON HIS SHOULDERS EVERYDAY.

AS THE CALF GREW TO FULL GROWN BULL, MILO ALSO GREW STRONGER TO CARRY BULL ON HIS SHOULDERS.

SUCH PROGRESSION OF LOAD (WEIGHTS) RESULTS IN ADAPTATION. YOU CONSTANTLY INCREASE LOAD, MUSCLES CONTINUOUSLY ADAPT TO BEAR INCREASED WEIGHT.

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Why Strength [Resistance] Train in the Context of Health?

- Skeletal muscles are effectors for posture and movement
- Muscles are responsible for 40% of the total metabolic activity (during rest)
- During work muscles take up 80% of the blood volume and the metabolic rate
- As a "muscle pump" (feet and calves) they contribute significantly towards the flow of venous blood from the extremities back to the heart and thereby supports the cardiovascular function
- Muscle activity supports breathing, cardio vascular and hormonal function

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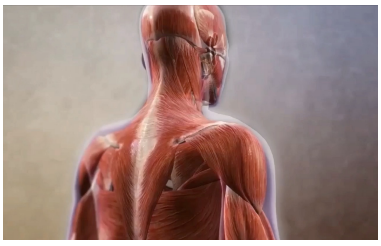
Resistance Training in Cardiac Rehabilitation??



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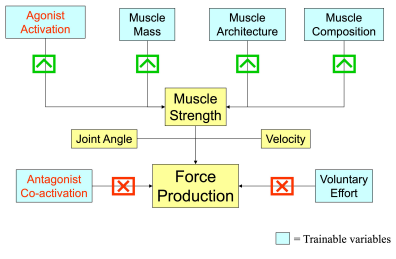
Force production by muscle potential effects



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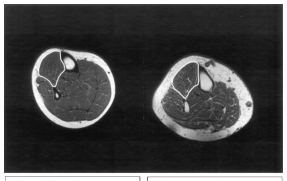
Muscle Mass
Cross sectional area



26 yr old female CSA = 10.2 cm^2 leg circumference = 37.7 cm	67 yr old female CSA = 8.7 cm^2 leg circumference = 44.0 cm

Leg MRI of a young and an elderly woman, with anterior compartment outlined. *Kent-Braun, 1999*

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Theories of Muscle Hypertrophy

1. ~~ATP-lack theory~~, 2. ~~Muscle tonus theory,~~ 3. Protein replacement theory

The most likely theory seems to be the protein replacement theory [protein structures are used and/or destroyed by training strains and are replaced by more proteins according to the super-compensation model ► stronger structure] or a mixture of all three.

ATP-lack theory ►

- extraordinary high muscular demand
- ↓
- greater demand of the energetic phosphates [ATP, CrP]
- ↓
- activation of the genetic cell apparatus
- ↓
- RNA-multiplying increase of ribosomes
- ↓
- Hypertrophy of the cell– relative reduction of the energetic phosphate demand at the same workload

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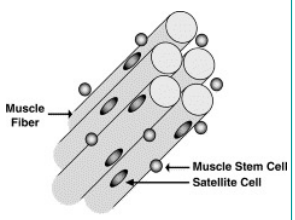
- satellite cells = small number of stem cells that remain in muscle of an adult
- Satellite cells may fuse to torn or damaged existing cells to
  - assist repair
  - hypertrophy
- Satellite cells can proliferate and fuse to form new multinucleate myofibrils



Skeletal Muscle
Adaptation

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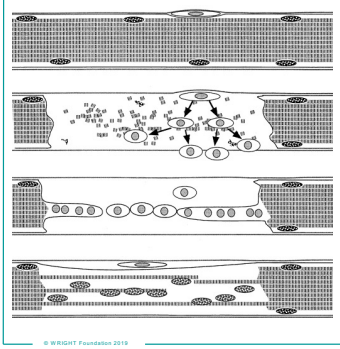

(A) Normal muscle fibre with myonuclei and a satellite cell.

(B) Damaged muscle fibre. The satellite cell has become activated and proliferated in response to the damaged fibre.

(C) Muscle precursor cells derived from the satellite cell have fused together to repair the damaged muscle fibre.

(D) Regenerated muscle fibre, with a new satellite cell and centrally-placed, newly-regenerated myonuclei.

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Recovery processes

End of workload

- **Acidosis**
- **Changes in electrolytes** (potassium; magnesium)
- **Reduced energy depots** (glycogen)
- **Used muscle proteins** (actin/myosin)
- **Damaged cell organella (mitochondrium)**

0 h — 1 h — up to 6 h — 1-2 days — up to 8 days

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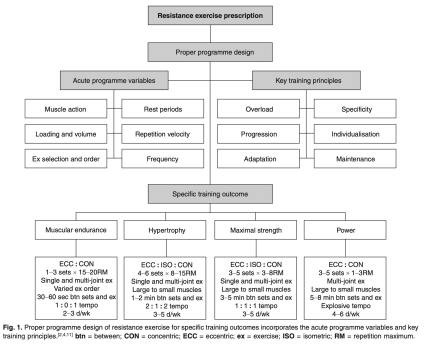

Fig. 1. Proper programme design of resistance exercise for specific training outcomes incorporates the acute programme variables and key training principles.[2,4,13] **btn** = between; **CON** = concentric; **ECC** = eccentric; **ex** = exercise; **ISO** = isometric; **RM** = repetition maximum.

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Muscle Response to Training

- Increase strength, flexibility, thickness and elasticity of ligaments, cartilage and tendons
- Antagonistic muscle action improved
- Hypertrophy of FTor ST at the expense of the other
- Increased cross-sectional area/muscle force
- Increased number and size of myofibrils per fibre
- Increased amounts of myosin and actin
- Increased fibre size and possibly number
- Increased strength and amounts of connective tissue
- Increase in body weight
- Can produce more forceful contractions
- Increased resting length of the muscles, increased range of joint movement

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Cellular Response

- Increased ATP/PC stores
- Increased stores of muscle and liver glycogen
- Increased enzyme activity
- Increased enhancement of lactic/aerobic threshold
- Increased cellular respiration to meet energy demands
- Increase in oxygen used by muscles/an increase in the metabolic rate

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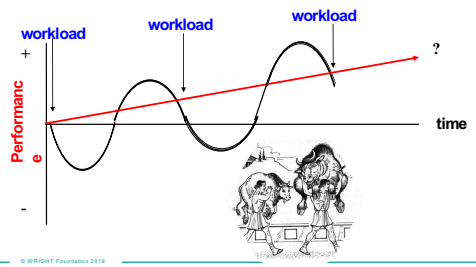
The misunderstanding of the super compensation model??



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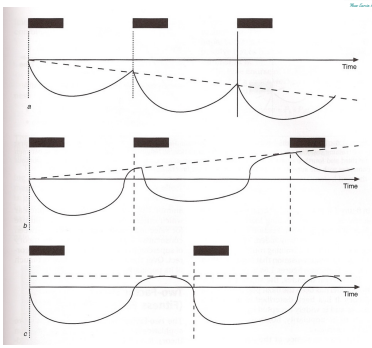
- (a) Too little
- (b) Just right
- (c) Too much



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Mc Cartney, Mc Kelvie, Haslam, Jones: Am J Cardiol 1991 May 1; 67(11):939-45

Usefulness of weightlifting training in improving strength and maximal power output in coronary artery disease

10 weeks incl. 20 TU	single-arm curl 1 RPMax	single-leg press 1 RPMax	single-knee extension 1 RPMax	Max. rep. 1 RPM (after treat.)	Ergometry Maximum Power Output
Strength + Endurance n = 10	43% (12.2 to 17.4kg; *)	21% 99.0 to 120.0kg; *)	24% (29.0 to 36.0kg; *)	14	15% (1.030 to 1.180 kpm/min)
Endurance n = 8	13% (11.8 to 13.3kg; *)	4% (97.0 to 101.0kg)	5% (28.2 to 29.7kg)	7	2% (1.088 to 1.113 kpm/min)

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Benefits of resistance training in cardiovascular disease

- Reduction in cardiac risk factors:
  - hypertension,
  - visceral obesity,
  - hyperinsulinemia,
  - insulin resistance,
  - dyslipidemia,
  - Sedentariness
- Improvement in ischemic symptoms:
  - claudication
  - angina

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Benefits of resistance training in CV disease cont…..

- Less need for medications:
  - angina
  - diabetes
  - hypertension
  - lipid lowering agents
  - depression
- Improvement in functional and exercise capacity:
  - increased sub-maximal and maximal cardiovascular exercise capacity
  - increased anaerobic threshold
  - decreased double product (HR x SP=BP)
  - decreased perceived exertion
  - improved performance of activities of daily living

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Benefits of resistance training in CV disease cont….

- Improvement in peripheral skeletal muscle morphology and function:
  - mass,
  - strength,
  - oxidative capacity,
  - glycogen storage,
  - glucose transport
  - blood flow,
  - amino acid uptake and protein synthesis,
  - A/V O_2 extraction
- Antidote to glucocorticoid side-effects in organ transplant recipients:
  - myopathy
  - osteopenia

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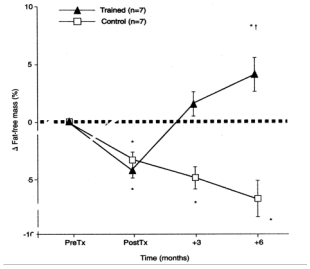
Strength training after cardiac transplantation: Effect on muscle mass (Braith, MSSE 30:483-89 1998)



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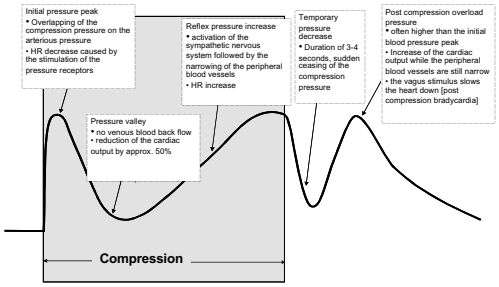
Blood Pressure Peaks in the Vasalva Manoeuvre



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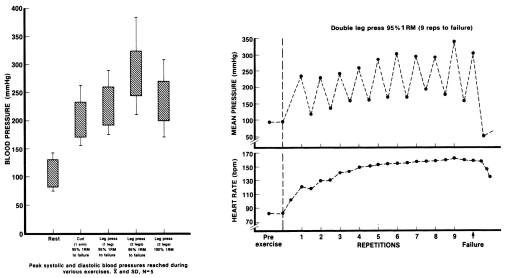
Arterial blood pressure response to heavy resistance exercise



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Training Methods

Anatomical Adaptation Training

By this training method the body is customised to the new strain. This means using sub maximal weights and just working until a significant exertion is felt, but no muscular exhaustion.

Generally the characteristics of this method are a relatively low intensity and a higher number of reps plus short breaks between sets.

Example
Sets per exercise: 2 – 3
Reps: 15-20
Break: 1 minute
Movement: rhythmic, slow

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Training Methods cont…..

Hypertrophy training

A muscle hypertrophy is provoked by using very specific training strains regarding intensity, duration and frequency. Therefore, maximal weights are used for a certain number of repetitions in order to provoke a muscular exhaustion.

This training not only leads to an increase of muscle mass, but also results in neuronal adaptations.

Example
Sets per exercise: 2 – 5
Reps: 8 - 15
Breaks: 2 - 3 minutes
Movement: rhythmic; slow to very slow (HIT)

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Training Methods cont….

Strength endurance training

This training results in an increased number of capillary vessels and therefore an increased blood flow in the working muscles as well as in a higher number of mitochondria per muscle cell and a higher tissue density. Muscle hypertrophy is also provoked, but not to the same extend as by the previous method.

The training intensity is usually sub maximal with short breaks between sets, but in certain strength endurance methods it can reach a maximal level (e.g. burn out training).

Example
Sets per exercise: 2 – 4
Reps: a minimum of 20
Breaks: 1 Minute, depending on the no. of reps
Movement: rhythmic, fast

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Training Methods cont…..

Pyramid training- not suitable for cardiac populations

This method is a combination of previously described methods. Usually, specific methods are used containing strength endurance, hypertrophy and IC-training.

By using a pyramid training a further adaptation regarding hypertrophy can be achieved in experienced athletes, while maintaining a certain level of strength endurance (e.g. in rowers).

Example

Sets per exercise: 3
Reps: 20–10–5
Breaks: 2-4 minutes
Movement: rhythmic; fast, slow and explosive

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Training Methods cont…..

Circuit training

This training method is characterised by relatively low intensities, a constant change of exercises and long working time meanwhile breaks are very short.

Circuit training is specifically used to improve strength endurance and the performance of the cardiovascular system as well as the metabolic characteristics relevant to the endurance athlete.

It is of relatively short duration and very motivating at the same time.

Example

Sets: 1 set per exercise
No. of exercises: 8 - 15
Reps: 15- 30 or 30-90 sec.
Break: max. 30 sec.
No of circuits: 2-6
Movement: fast
5 min. endurance exercises might be also included in the circuit.

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Evidence for the Effects of Resistance Training in the Treatment of Cardiac Conditions

Since the mid-1980's resistance training has become an accepted part of cardiac rehabilitation phases III and IV, and more recently, phase II.

Evidence is consistent that this form of training provokes fewer signs and symptoms of myocardial ischaemia than aerobic training.

Studies show that resistance training may result in improved self efficacy and improved quality of life parameters (depression/dejection, fatigue, etc)

There are encouraging reports that resistance training may increase glucose tolerance and insulin sensitivity, independent of changes in body fat or aerobic capacity

Investigations of the acute circulatory responses to resistance exercise have noted a lower rate-pressure product and heart rate, a higher diastolic pressure and reduced ischaemia compared with compared with changes which occur during cycling at the same relative intensity

There is now an acceptance of resistance training as part of cardiac rehabilitation and it is endorsed by agencies such as ACSM.

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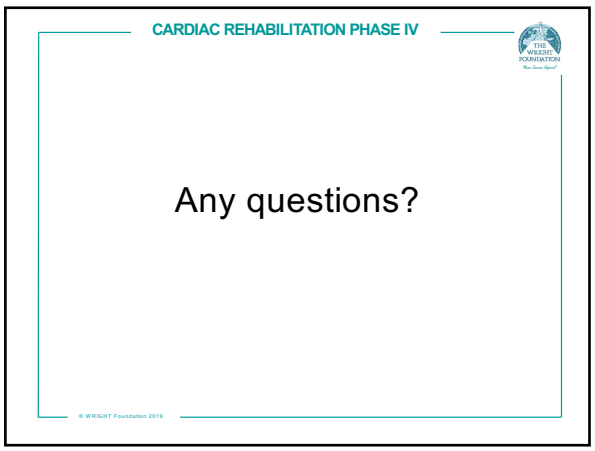
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Any questions?
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