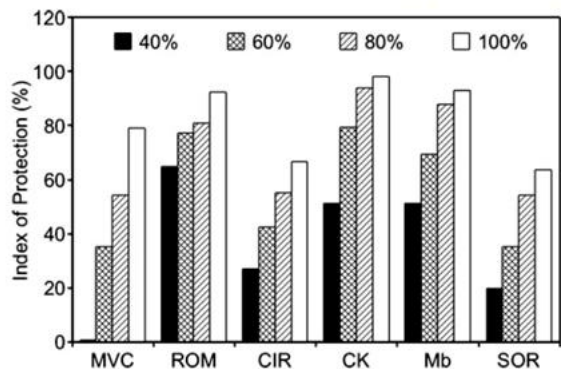


Effect of Initial Bout Intensity (3 weeks)



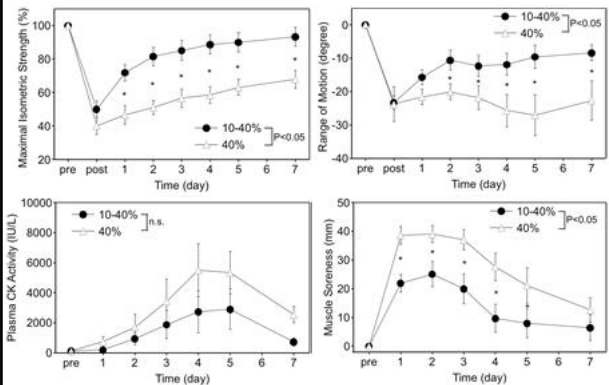
Chen et al. J Appl Physiol. 2007

Effect of 10% ECC on Criterion Measures

	Pre	Post	24 h	48 h
MVC (kg)	24.8±1.0	24.5±1.2	24.7±1.6	24.9±1.2
ROM (°)	142.9±2.8	140.4±3.1	141.0±2.7	140.0±2.8
CIR (mm)	249.7±5.7	253.0±5.3	252.7±5.3	251.4±5.3
CK (IU·L ⁻¹)	131.6±18.4	—	136.8±16.9	141.4±16.7
SOR (mm)	0	2.0±1.4	2.3±1.3	1.1±1.1

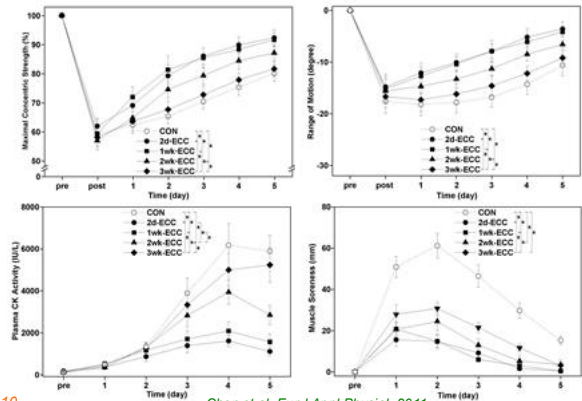
Lavender & Nosaka J Sci Med Sport. 2008.

Comparison between 10-40% and 40% Groups



Lavender & Nosaka J Sci Med Sport. 2008.

Protective effect by 10% ECC (x30)



Chen et al. Eur J Appl Physiol. 2011

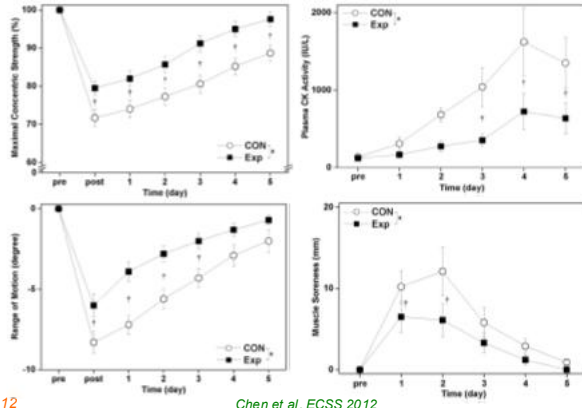
Knee Extensor Study

- 10%ECC: 5 sets of 6 eccentric contractions
 - 3 s contraction (30°/s)
 - 10 s rest between contractions
 - 2 min rest between sets
 - ROM: 10-100°
- MaxECC: 5 sets of 6 maximal isokinetic eccentric contractions
 - 3 s contraction (30°/s)
 - 10 s rest between contractions
 - 2 min rest between sets
 - ROM: 10-100°

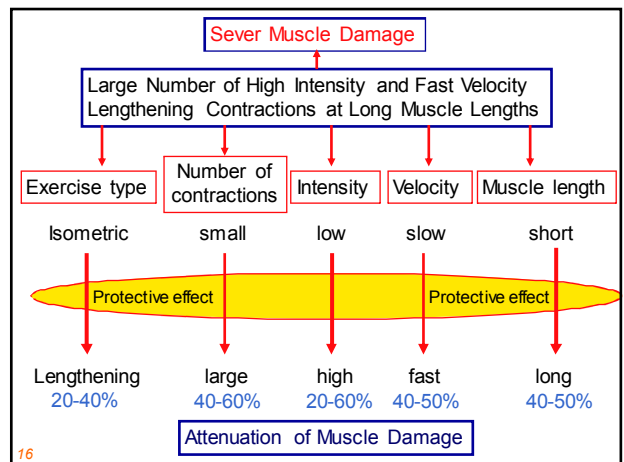
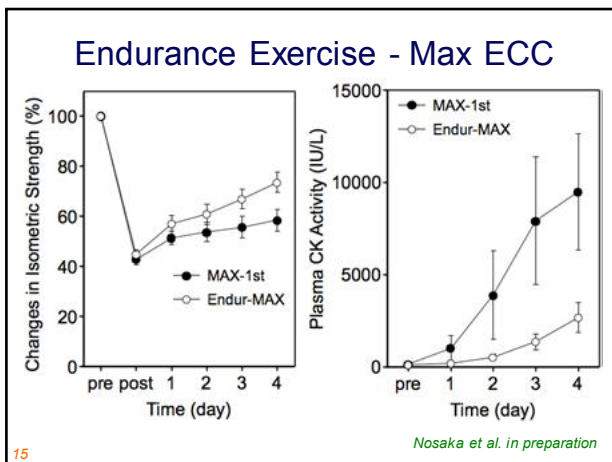
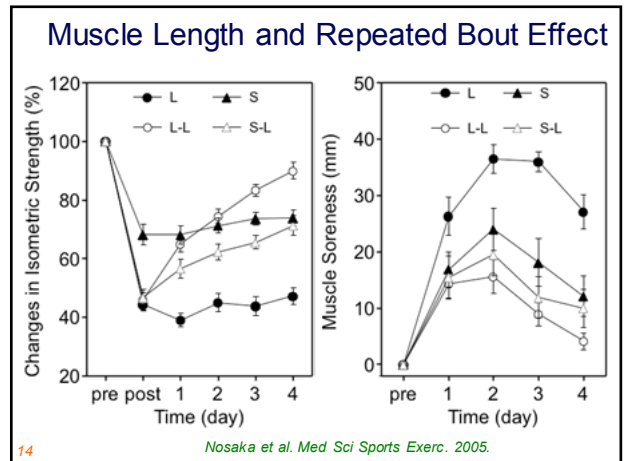
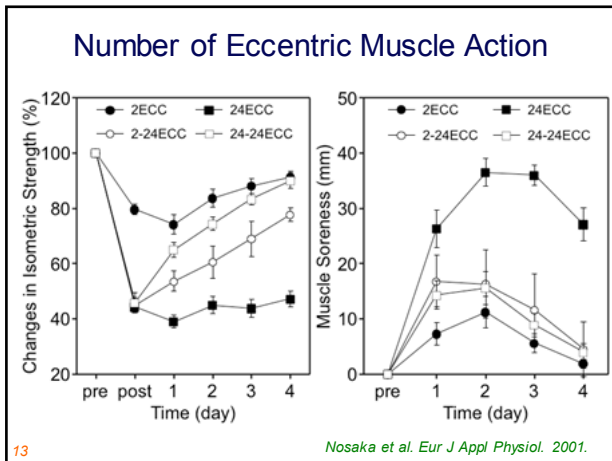
60-74 years old men



Protective effect by 10% ECC



Chen et al. ECSS 2012



Isometric Contractions

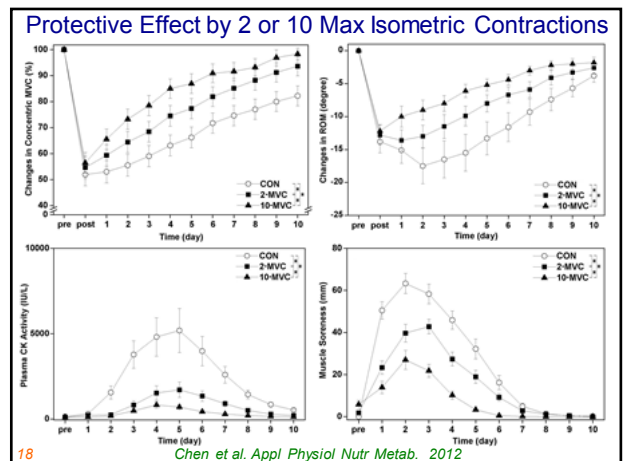
2 or 10 maximal isometric contractions
3 s
45 s between contractions
20° flexion

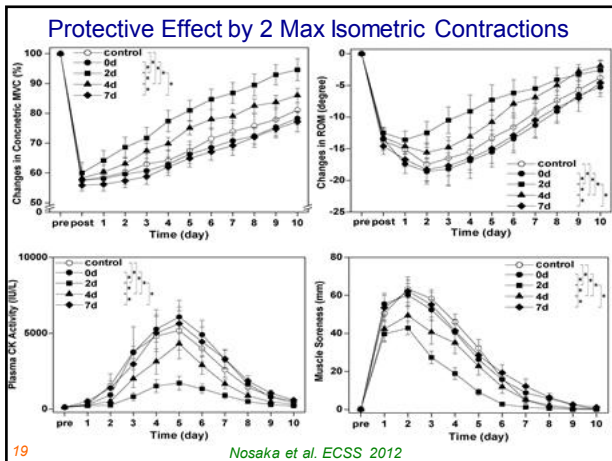
Non-dominant arm

Eccentric Exercise

5 sets of 6 maximal eccentric contractions
10 s between contractions
2 min between sets
ROM: 90°-0°
90° /s

17

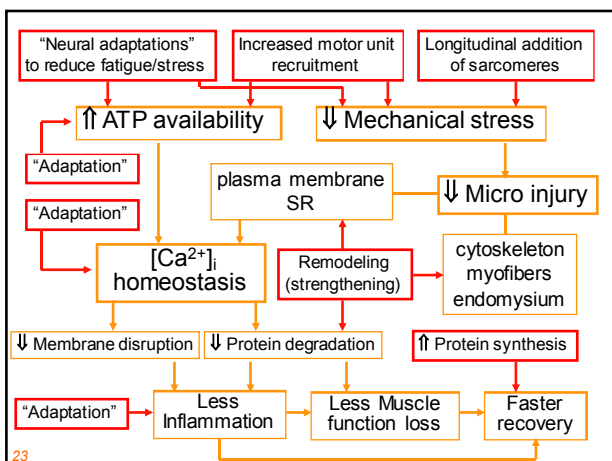
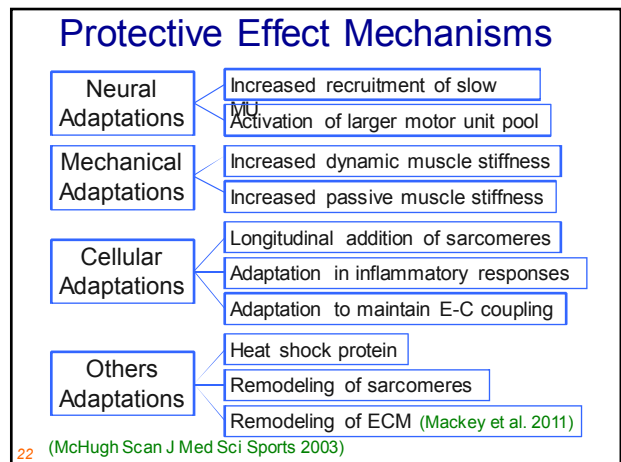
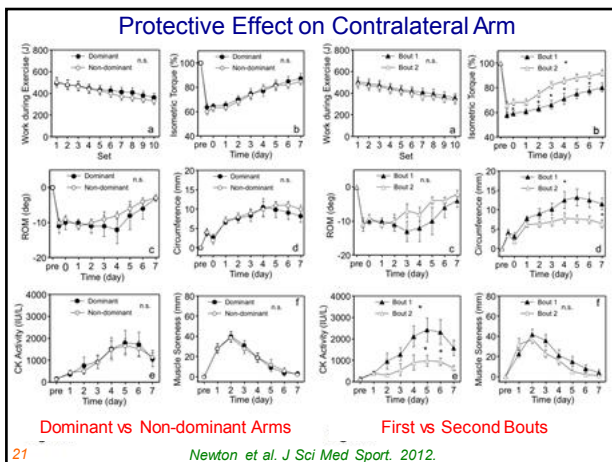




30 contractions, 3 weeks between bouts

	MVIC-D5 (%)	ROM-D5 (°)	CIR-D5 (mm)	CK-peak (IU/L)	Mb-peak (µg/L)	DOMS-peak (mm)
MaxECC -1st	-24.7	-9.0	10.1	6,594	1,453	44.3
MaxECC -2nd	-4.7 (81%)	-2.4 (73%)	3.4 (66%)	138 (98%)	102 (93%)	16.0 (64%)
10%ECC	-22.4 (9%)	-9.5 (0%)	8.7 (14%)	4,201 (36%)	1,003 (31%)	30.8 (31%)
20%ECC	-19.4 (22%)	-7.5 (17%)	7.0 (31%)	2,959 (55%)	987 (32%)	25.6 (42%)
90°ISO	-26.0 (0%)	-10.8 (0%)	9.6 (5%)	6,008 (9%)	1,299 (11%)	40.3 (9%)
20°ISO	-16.9 (32%)	-6.3 (30%)	7.4 (27%)	2,410 (63%)	640 (56%)	23.3 (47%)

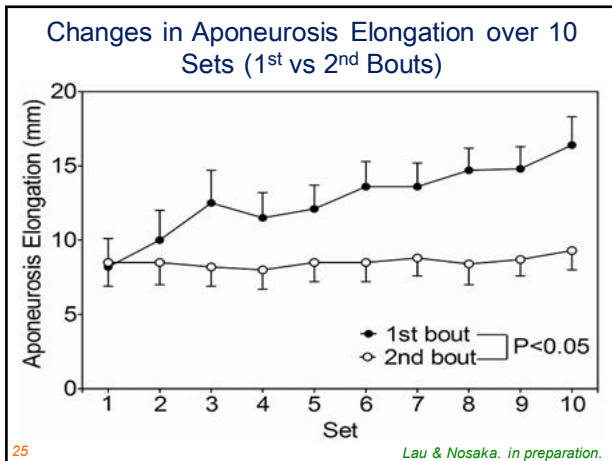
20 *Chen et al. Med Sci Sports Exerc. 2012.*



Ultrasound: Aponeurosis Elongation

- Aloka SSD-α10 with a 10-MHz probe (6 cm) attached to the distal portion of myotendinous junction
- Frame rate: 47 Hz
- Secured by tape and a bandage
- Probe position was identified in the familiarisation session

24



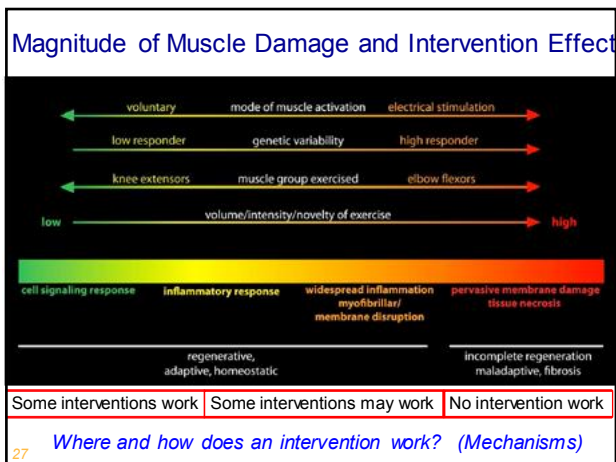
Interventions for Muscle Damage

Prophylactic Modalities
Warm-up, stretching, NSAID, anti-oxidants, massage, taping, icing, EMS/ENS, acupuncture, etc.

Therapeutic Modalities
stretching, NSAID, anti-oxidants, massage, icing, heating, EMS/ENS, acupuncture, vibration, etc.

Combination

26



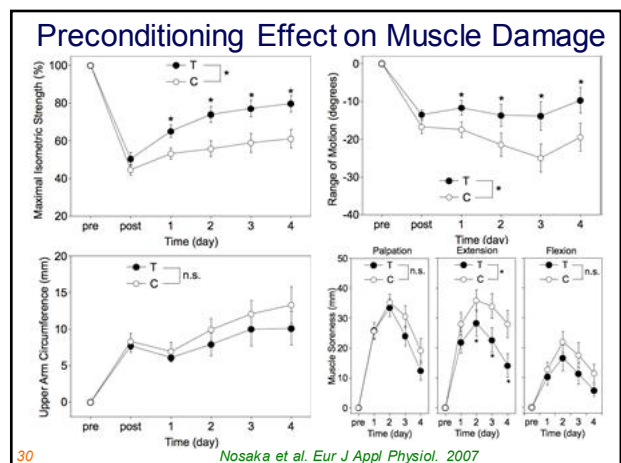
- ### Tips for Designing an “Intervention” Study
- Magnitude of muscle damage
 - What aspect is focused on (e.g. DOMS, muscle function)
 - Criterion measures (e.g. how is the effect judged?)
 - Exercise model
 - What is the level of “physiological” significance (e.g. 20% reduction of peak DOMS)
 - Placebo effect
 - Inter-subject variability
 - Other confounding factors (e.g. diet, age, gender, training, “experience”)
- 28

Microwave Heat Treatment

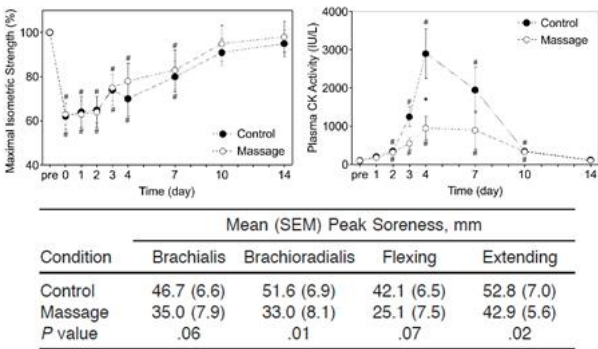
Microwave diathermy
MICRORADOR, Model KTM-250
150W, 20 min
Applied to the upper arm
10-15 cm above the surface
Muscle temperature
YSI N550 Thermometer
YSI N451 Thermister probe

Pre: 33.8 - 34.7 ° C
Post: 40.2 - 42.0 ° C
5 min post: 37.4 - 39.0 ° C

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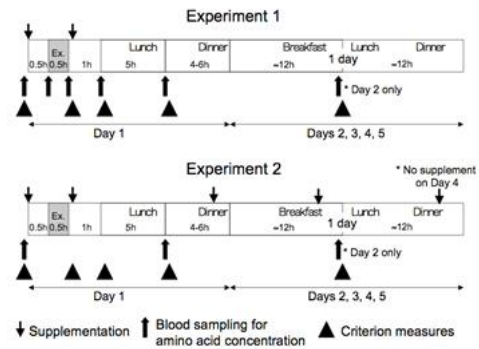
Effect of Massage (10 min) @ 3 h post-Exercise



31

Zainuddin et al. J Athletic Training, 2005.

Effect of Amino Acid Supplementation



32

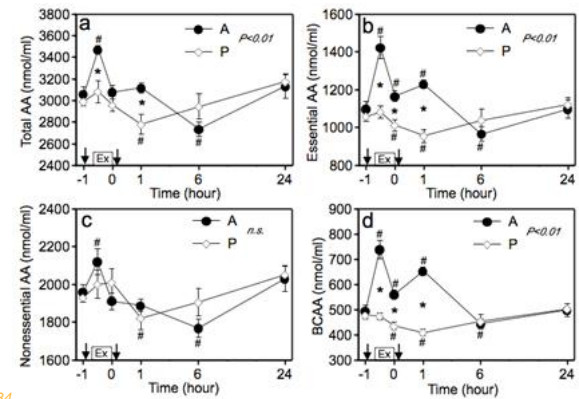
Nosaka et al. Int J Sport Nutr Exerc Metab, 2006.

Amino Acid Supplement

- Amino Acids Mixture (4.5 g) – **Amino Vital Pro**
12 amino acids = 9 EAA + 3 NEAA (3.6 g)
His, **Ile**, **Leu**, Lys, Met, Phe, **Val**, Thr, Trp / Arg, Gln, Pro
10 vitamins (A, B₁, B₂, B₆, B₁₂, C, pantothenic acid, niacin, D, E)
2 minerals (Ca, Fe), carbohydrate (0.5 g), fat (0.045 g)
- Placebo (4.5 g)
maltitol (3.6 g) + other ingredients
- Ingestion with water
multiple occasions
- Double blind crossover design

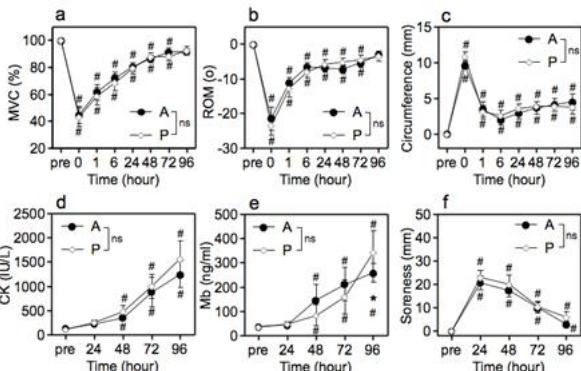
33

Changes in Amino Acids after Supplementation



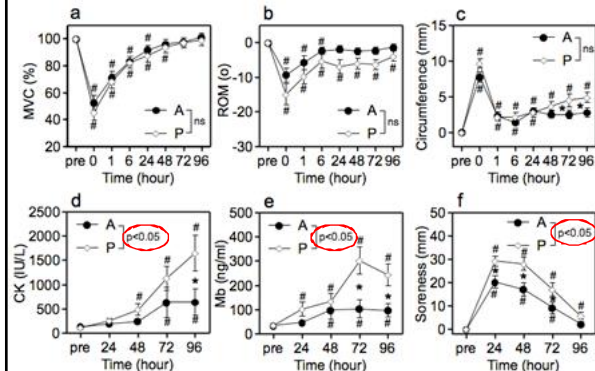
34

Experiment 1

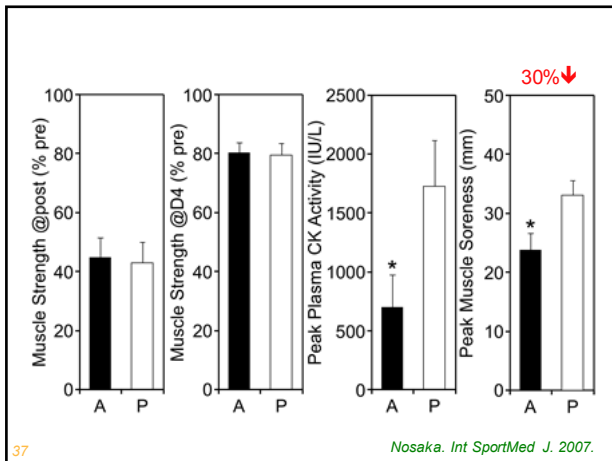


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Experiment 2



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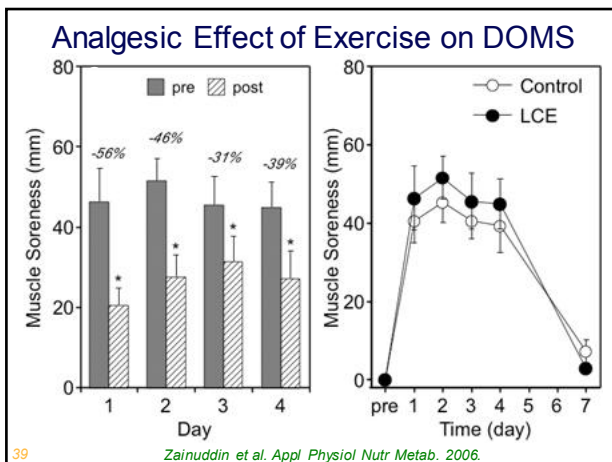


Light Concentric Exercise

10 sets of 60 submaximal elbow flexion and extension rhythmic movements (Cybex 6000)
1-4 days after Max-ECC

ROM: 90-180°
Flx / Ext: 1s / 1s
2 min/set x10sets
Rest :30 s (sets)
Exercise time: ≈25 min
Monitoring: Torque

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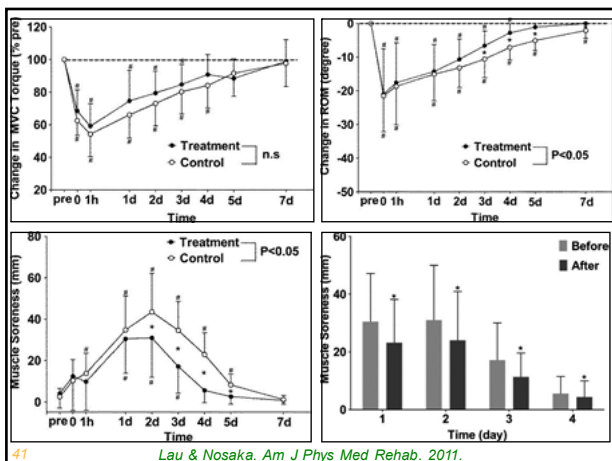


Effect of Vibration Treatment

10 young healthy men

Muscle	FAM		Exercise Day					Post Exercise Days				
	-2	-1	0	0.5h	1h	2	3	4	5	7		
VT	X	X	X	X	X	X	X	X	X	X	X	
CK	X	X	X	X	X	X	X	X	X	X	X	
ROM	X	X	X	X	X	X	X	X	X	X	X	
CIR	X	X	X	X	X	X	X	X	X	X	X	
VAS	X	X	X	X	X	X	X	X	X	X	X	
PPT	X	X	X	X	X	X	X	X	X	X	X	
MVC	X	X	X	X	X	X	X	X	X	X	X	

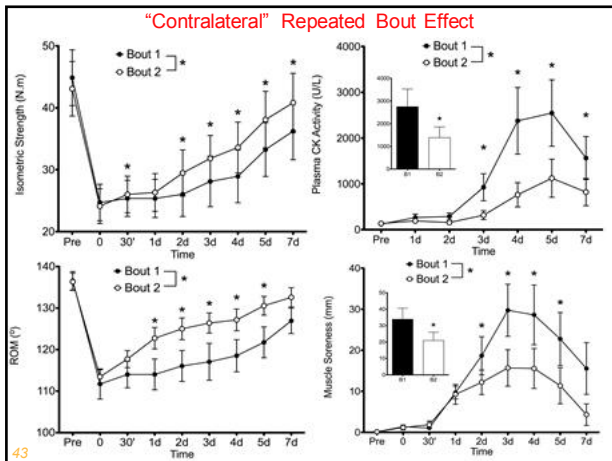
40 *Lau & Nosaka. Am J Phys Med Rehab. 2011.*



Effect of Pulsed Electromagnetic Field Therapy

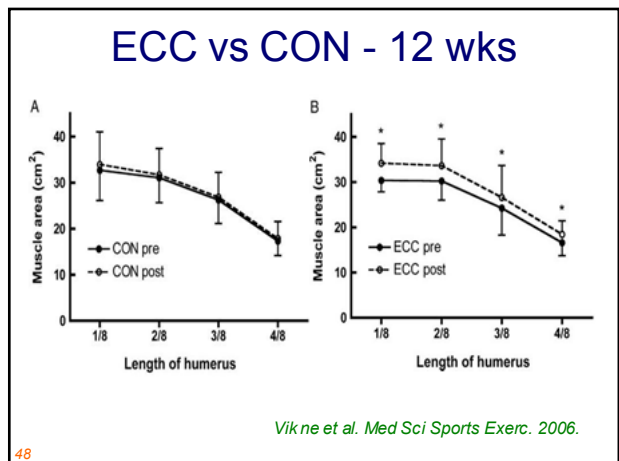
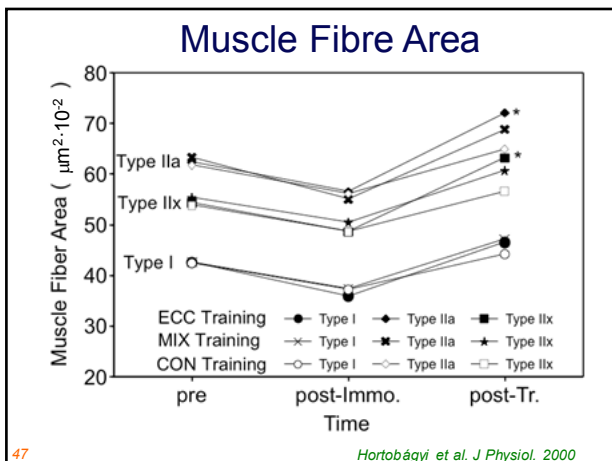
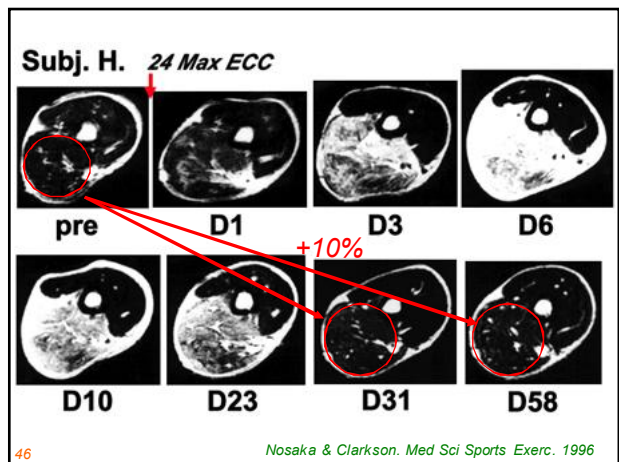
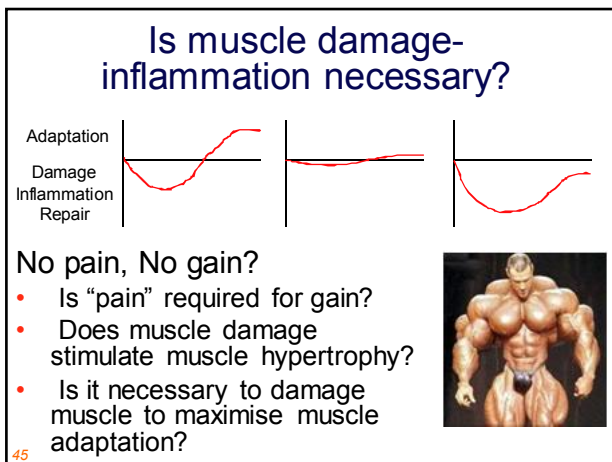
30 min, 1-4 days post-exercise
30 min Treatment Double blind Cross-over

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Should muscle damage be treated?

- Without treatment, DOMS disappears in a week or so (DOMS itself is harmless)
- No "special" treatments are necessary for DOMS for most cases
- Muscle damage is often inevitable (e.g. after competition, training)
- Quicker restoration of muscle function is required
- "Treatment" should consider recovery of muscle function not DOMS



ECC - Greater Stimulus for Muscle Hypertrophy

- Maximal eccentric contractions of the knee extensors activate p70^{S6K} in the vastus lateralis, but maximal concentric contractions do not
- Maximal eccentric contractions are more effective than maximal concentric contractions in stimulating protein synthesis

49

Eliasson et al. Am J Physiol Endocrinol Metab. 2006.

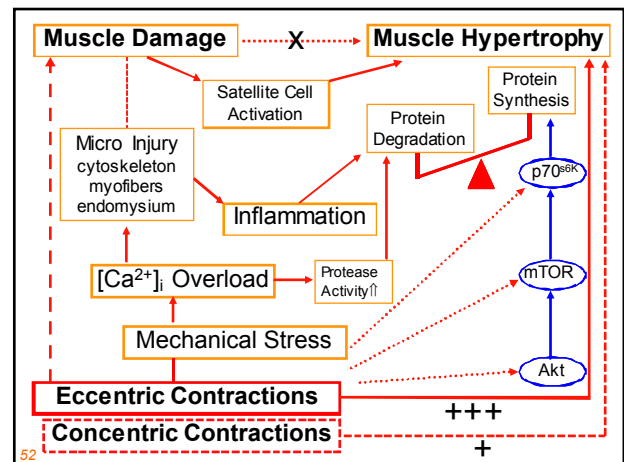
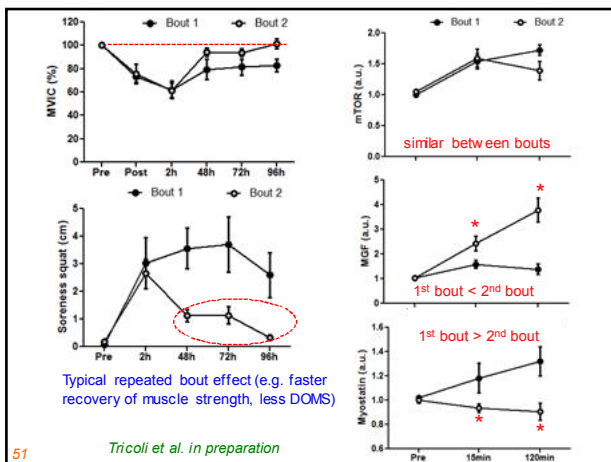
Gene Expression – 1st vs 2nd ECC

Does the magnitude of muscle damage affect gene expression related to muscle hypertrophy?

- 8 non-resistance trained men (33.9 ± 4.0 y)
- 10 sets of 10 maximal eccentric contractions of the knee extensors (30° /s, ROM: 0-100° , Biodex)
- Two bouts separated by 2 weeks (left leg)
- Micro needle muscle biopsy: pre, 15 min, 2 h post



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Importance of Eccentric Exercise

- Eccentric “strength” is required (e.g. athletic performance, prevention of falling)
- Potent stimulus for muscle adaptations (e.g. strength, hypertrophy)
- Effective for tendinopathy treatment
- Suitable for aged population and disease condition (e.g. respiratory disease, cancer)
- Minimising muscle damage, maximising mechanical stimulus

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Cycling Exercise

CONCENTRIC



Tunturi F30R, Australia

ECCENTRIC



EccentricTrainer, Metitur, Finland

- Intensity
– 60% of CON_{max} power output
- Cadence
– 60 rpm
- Duration
– 30 min

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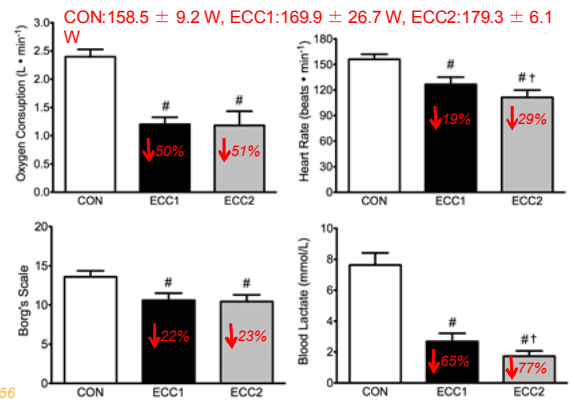
METHODS

- Subjects: 10 healthy men
 - 28.4 ± 8.3 years; 179.0 ± 4.6 cm; 81.6 ± 13.1 kg; 3.1 ± 0.5 L/min
 - not involved in any regular training program for 6 months prior to the study
 - no musculoskeletal or neurological disorder of lower limbs
- Study design



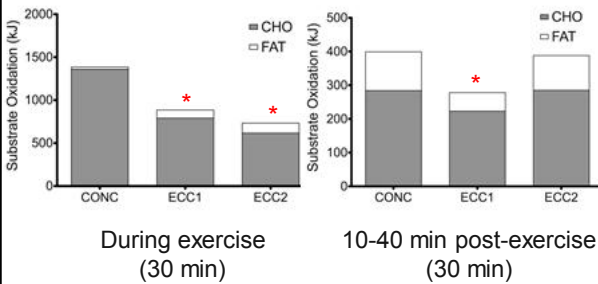
55

RESULTS – Metabolic Cost



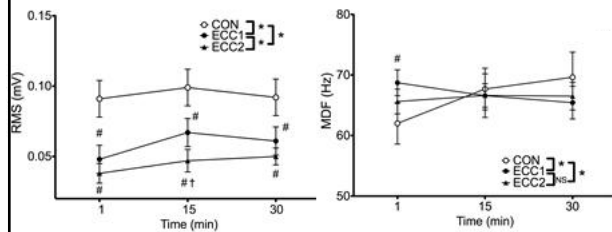
56

Substrate Oxidation During and After ECC and CON Cycling



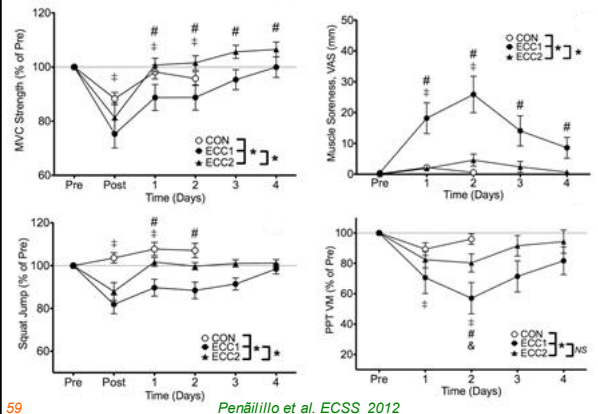
57

sEMG RMS & MDF



58

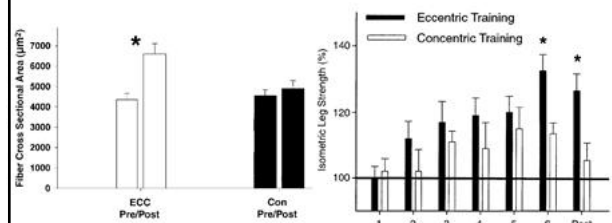
Muscle Damage



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Penáñillo et al. ECSS 2012

Effects of ECC Cycling Training



8-week ECC cycling training at 54-65% HR_{max} increased muscle fiber CSA by 52%, but no increase after CON cycling LaStayo et al. Am J Physiol. 2000.

6-week ECC cycling training increased 36% more isometric strength than after CON cycling LaStayo et al. Am J Physiol. 1999.

60

Effects of ECC Cycling Training

Frail elderly (70-93 years, 11 men, 10 women)
11 week training, 3 times / week, 10-20 min / day, Progressive

	ECC Cycling (n=11)		Weight Training (n=10)	
	Pre	Post	Pre	Post
MVC strength (N)	48.8 ± 6.1	78.1 ± 8.8 60%↑ *	45.5 ± 5.5	52.5 ± 4.3
Muscle fibre area (µm ²)	3295 ± 366	5273 ± 964 60%↑ *	2999 ± 313	4218 ± 367 40%↑
Timed Up and Go (s)	16.7 ± 0.8	12.0 ± 0.7 28%↑ *	17.2 ± 0.9	15.6 ± 1.5 9%↑
Stair Descent (s)	25.3 ± 2.0	20.9 ± 2.1 17%↑ *	21.4 ± 2.3	22.9 ± 4.4
Berg Balance (0-56)	49.7 ± 1.1	53.4 ± 0.6 7%↑	42.0 ± 2.4	44.3 ± 1.4

LaStayo et al. J Gerontol. 2003.

Eccentric Cycling Research



- Elderly Responses to repeated ECC cycling
- ECC cycling application to clinical population (e.g. respiratory disease, cancer, diabetes)
- Effects of ECC cycling on muscle fibres and ECM

Current Research Projects

- Mechanisms of DOMS
- Connective tissue damage markers
- Muscle damage versus fatigue
- Muscle damage in children
- Mechanisms of the repeated bout effect
- Clinical use of eccentric exercise (e.g. respiratory disease, cancer, diabetes)
- Eccentric overload resistance training for athletes



Thank you very much

Questions?
Comments?
Suggestions?
Collaboration?

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