Eccentric Training
What it is and what it isn’t!

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Workshop Structure

1. Theory – Scientific and Otherwise
   - The Hard Science
   - The Applied Science

2. Practical
   - Slow Eccentric Options
   - Fast Eccentric Options
   - Ballistic/SSC Eccentric Options
   - Taper/Detraining
The Hard Science
Definitions

Eccentric (ECC) muscle actions:
- Force exerted on muscle > force generated by muscle.
- ‘Lengthening muscle action’ or ‘active stretch’.

ECC Training (what we think it is):
- Training with a load that accounts for ECC strength.
- In contrast to CONC and traditional (TRAD) modalities.

Enoka, 1996
Why are ECC contractions different?

Molecular

- A number of phenomena indicate that cross-bridge theory of contraction inadequate in explaining ECC contractions:
  1. Greater tension generating capacity \(\text{Linari et al., 2000}\).
  2. Reduced energy cost per unit work \(\text{Dufour et al., 2004}\).
  3. Time-dependent residual force enhancement \(\text{Herzog, 2014}\).

- WHY?? Remains to be determined, but...
  1. Number of cross-bridge binding sites or ‘X-distance’.
  2. Cross-bridges suspended in actively bound state and mechanical detachment.
  3. Titin filament activation and winding (molecular spring).

\(\text{Herzog, 2008}\)
\(\text{Nishikawa et al., 2011}\)
Why are ECC contractions different?

Neural

- Greater, and distinct, activation of the motor cortex (Fang et al., 2001, 2004).

- Reduced activation at the level of the motor unit, esp. discharge rates (Westing et al., 1991).
  - Spinal disfacilitation via possible Renshaw cell inhibition (Duchateau & Baudry, 2014) - the handbrake!

- Postulated reversal of size principle (Nardone & Schiepatti, 1988, 1989)...
  - ...probably not (Duchateau & Baudry, 2014).

Tesch et al., 1990
Acute responses to ECC exercise..

**Metabolic**
- 4-5x < VO2
- 50% < Q
- < Fatigue
- (Session workload..?)

**Neuromuscular**
- 20-60% > torque
- >> torque/MU
- Unique F-V

**Hormonal**
- ~T Response
- ~GH Response
- ~IGF-1 Response (?)
- ~Insulin Response
- ~Cortisol Response
- (How important..?)

**Molecular Signalling**
- > Satellite Cell Response (IL-6?).
- > Protein Synthesis
- Esp. Type II Fibres

**Molecular Damage**
- > EIMD
- > DOMS
- Esp. Type II Fibres

**Novel Adaptive Signal**
Chronic adaptations to ECC training

Muscle Mechanical Function

- ▲ Total strength (NB. mode specificity) > than TRAD (Roig et al., 2009).

- ▲ Large ▲ in ECC strength related to disinhibition – taking the handbrake off! (Aagaard, 2003).

- ▲ Jumping power > TRAD - underpinned by strength and morphological changes (Colliander & Tesch, 1990, Gross et al., 2010).

- ▲ Leg spring stiffness > CONC (Elmer et al., 2012, Lindstedt et al., 2002, Papadopoulos et al., 2014) and SSC performance > TRAD (Elmer et al., 2012, Liu et al., 2013).

- They bounce better!
Muscle Morphology

- ↑ Muscle CSA > CONC (Roig et al., 2009), but similar to TRAD (Friedmann-Bette et al., 2010).
  - But > distal hypertrophy than CONC (Franchi et al., 2014, Seger et al., 1998).
- ↑ Fascicle length (i.e. sarcomeres in series) > CONC (Franchi et al., 2014, Timmins et al., 2015).
  - Implications for muscle shortening velocity.
  - Rightward shift of length-tension curve.
- ↑ Type II Fibre area ≥ TRAD (Hortobagyi et al., 1996, 2000).
- Possible ↑ in Type IIx composition with fast contractions (Paddon-Jones et al., 2001).
  - ...but general shift towards a faster phenotype due to ↑ relative area of Type II fibres (i.e. IIa hypertrophy) and sarcomeres in series.
Chronic adaptations to ECC training

Tendon Morphology & Function

- ↑ Tendon CSA > CONC (Farup et al., 2014).
  - Difficult to achieve with other modes!
- ↑ Tendon stiffness > CONC (Malliaras et al., 2013).
  - NB. Importance of load.
Chronic adaptations to ECC training

Application to Sprint Performance

- ↑ 20-40m sprint performance with ECC training (Cook et al., 2013, de Hoyo et al., 2015, Liu et al., 2013).
  - NB. Sprint perf. only superior to TRAD with inclusion of both fast ECC and CONC phases (Cook et al., 2013, Liu et al., 2015).

- Elite sprinters apply more force in less time during ground contact to attain high Vmax – esp. first half/ECC phase (Clark & Weyand 2014).

- ECC qualities related to leg spring stiffness, contact time and magnitude of potentiation of CONC power in SSC (McCarthy et al., 2012).
A note on detraining from ECC training

- Are the times frames for detraining from ECC training the same as from CONC/TRAD training?
  - Most likely no!

- Better maintenance (possible increase??) of strength, strength endurance and size adaptations with ECC vs CONC & TRAD after 6 weeks detraining (Coratella et al., 2016).

- Extended residual/lag effect with ECC training.. power may peak 8 weeks after cessation of training (with no maintenance load in that time)! (Leong et al., 2014).
† ECC Mechanical Function
(† Strength, Power, Stiffness)

+ 

† Faster Muscle Phenotype
(† Type II Fibre Area/Proportion & Sarcomeres in Series)

+ 

† Muscle-Tendon Unit Stiffness

= 

Rightwards Shift of Force-Velocity Curve
Rightwards Shift of Force-Velocity Curve

i.e. ‘Velocity Dominant’ Profile
Some thoughts so far

1. ECC contractions + acute responses elicit novel adaptations within the neuromuscular system.

2. Heavy ECC load and fast tempo seem to maximise adaptation.

3. Most research has used isokinetic modalities which are difficult to replicate in practice...

4. ...but accessible isoinertial options could be just as effective!
Further reading on the hard science

Eccentric Exercise: Physiological Characteristics and Acute Responses

Jamie Douglas¹², Simon Pearson¹³, Angus Ross², Mike McGuigan¹⁴

Abstract An eccentric contraction involves the active lengthening of muscle under an external load. The molecular and neural mechanisms underpinning eccentric contractions differ from those of concentric and isometric contractions and remain less understood. A number of molecular theories have been put forth to explain the unexplained observations during eccentric contractions that deviate from the predictions of the established theories of muscle contraction. Postulated mechanisms include a strain-induced modulation of actin-myosin interactions at the level of the cross-bridge, the activation of the structural protein titin, and the winding of titin on actin. Accordingly, neural strategies controlling eccentric contractions also differ with a greater, and possibly distinct, cortical activation observed despite an apparently lower activation at damage which is rarely observed in other muscle types. The net result of these characteristics and responses appears to create an unexplained signal within the neuromuscular system.

Key Points

- Eccentric contractions, where muscle actively lengthened under an external load, involve a number of molecular and neural adaptations which distinguish them from concentric contractions.
- The distinct characteristics of eccentric contractions include strain-induced modulation of actin-myosin interactions, activation of structural proteins such as titin, and possible cortical activation.

Chronic Adaptations to Eccentric Training: A Systematic Review

Jamie Douglas¹², Simon Pearson¹³, Angus Ross², Mike McGuigan¹⁴

Abstract Background Resistance training is an integral component of physical preparation for athletes. A growing body of evidence indicates that eccentric strength training methods induce novel stimuli for neuromuscular adaptations.

Objective The purpose of this systematic review was to determine the effects of eccentric training in comparison to concentric-only or traditional (i.e. constrained by concentric strength) resistance training.

Methods Searches were performed using the electronic databases MEDLINE via EBSCO, PubMed and SPORTDiscus via EBSCO. Full journal articles investigating the long-term (≥4 weeks) effects of eccentric training in healthy (absence of injury or illness during the 4 weeks of training) and patient populations (with or without chronic disease) were included.

Conclusions Eccentric training is a potent stimulus for enhancements in muscle mechanical function, and muscle-tendon unit (MTU) morphological and architectural adaptations. The inclusion of eccentric loads not constrained by concentric strength appears to be superior to traditional methods.
Words of warning... DOMS & performance

- As previously mentioned there is more DOMS and more damage with ECC training...
- XS initial muscle stress can impair maximum force qualities for several weeks (Mackey et al., 2004; Sayers & Clarkson, 2001 – pic to RHS)
- Often significant protective effect from 1-2 low vol introductory ECC sessions
- THM: Introduce ECC training progressively

![Graph showing percent initial MVC over time for males and females](image-url)
## A potential periodisation approach for ECC training

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<thead>
<tr>
<th>Phase</th>
<th>Goal</th>
<th>Focus</th>
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<tbody>
<tr>
<td>Train to train</td>
<td>Re-intro to training and DOMS protection</td>
<td>Normal iso-inertial training resumed after time off</td>
</tr>
<tr>
<td>Slow ECC</td>
<td>Hypertrophy (muscle &amp; tendon) and motor control</td>
<td>Slow ECC tempo but load same as CON phase</td>
</tr>
<tr>
<td>Overloaded ECC</td>
<td>Ongoing FT Hypertrophy, ↑sarcomeres in series (?) ECC strength development</td>
<td>Overloaded ECC phase</td>
</tr>
<tr>
<td>Fast ECC</td>
<td>↑ FT muscle, and ↑strength/rigidity in amortization phase</td>
<td>Faster than 180 deg/s in overloaded ECC phase – option to stick isometrically at end of phase in gravity based options</td>
</tr>
<tr>
<td>Ballistic training</td>
<td>Rapid amortization phase and ↑ explosive force production control</td>
<td>Fast down fast up. Reactive focus with lighter loads (with or w/o overloaded ECC)</td>
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What about in Competition or Taper phases?

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<td>Competition or Taper</td>
<td>Freshen up and maximise performance via maximisation of FT muscle overshoot</td>
<td>Dramatic reduction in strength training load. Can be relatively prolonged due to excellent strength maintenance following ECC training</td>
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So what would the adaptations look like in strength and performance terms?
Practical Session aka. The Fun Part!
1. Slow ECC Exercises

Why:
Structural adaptations within MTU + time to develop motor control within patterns before tempo increases.

When:
Early within the periodized plan (duration will be athlete/sport dependent).

Volume:
2-5 sets of 4-8 reps.

Intensity:
ECC 100-130%1RM : CONC 70-85%1RM.

Examples:
1. Assisted Squat (hydraulic or partner).
2. 2-up-1-down Leg Press (affects CONC load).
3. Weight Releasers.
2. Fast ECC Exercises

Why:
Influence muscle phenotype (i.e. faster muscle) + strength and rigidity in amortization phase of SSC.

When:
Intermediate within the periodized plan (again, duration will be athlete/sport dependent).

Volume:
2-5 sets of 3-6 reps.

Intensity:
ECC 120-150%1RM (OR gravitational load) : CONC 30-50%1RM.

Examples:
1. Assisted Squat (as per slow).
2. Partner KB Swing.
3. Ballistic/SSC ECC Exercises

Why:
Transition to performance + facilitate reactive/SSC output.

When:
Late within the periodized plan/pre-competition.

Volume:
2-5 sets of 3-10 reps.

Intensity:
ECC typically not dictated by %1RM, can modify load via drop heights & external mass : CONC body mass or less.

Examples:
1. DB Release Jumps.
2. Drop Jumps.
4. Assisted jumps with partner ECC
4. Taper/detraining

Why:
Maintain developed strength qualities. 
↑FT %age, and ↑ contraction velocity.
Fresh with unrestricted throttle.

When:
Pre comp peak, last 1-12wks? Depends on individual athlete & sport needs.

Volume/Frequency:
Minimal! 1-2x per week or less

Intensity:
Heavy loading removed altogether. Maintenance via low vol of ballistic ex

Examples:
1. DB Release Jumps.
2. Drop Jumps.
4. Assisted jumps with partner ECC
Further reading on the applied aspects...

Blog coming online next couple of days as a guest post on Stu McMillans blog...

http://www.mcmillansspeed.com/