



2022 NSCA *NATIONAL* CONFERENCE

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#NSCACon22

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› *ADVANCEMENT*
› *COMMUNITY*

CONFLICT OF INTEREST STATEMENT

I have no actual or potential conflict of interest in relation to this presentation.

I received an ~20% discount on products from Exxentric when purchasing

All views are my own and not subject to any corporate censure



College of
Education

Kinesiology and Health Promotion

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Bollinger, PhD, ACSM-CEP
Translating Research Findings to Program Design for FIT



**2022 NSCA
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Objectives

By the end of this session, you should be able to:

1. Describe how resistance is supplied during FIT and how this compares to other resistance training systems
2. Understand how exercise technique and moment of inertia interact to affect resistance training stimulus during FIT
3. Discuss potential benefits and limitations to FIT as an exercise modality
4. Provide technique coaching for FIT to achieve eccentric overload
5. Understand how to use FIT in a periodized resistance training plan to meet specific training goals

FIT Principles

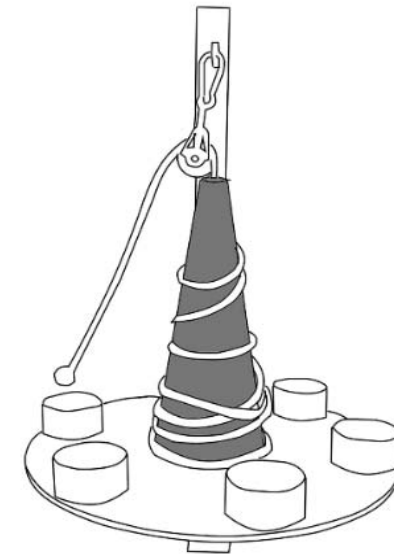
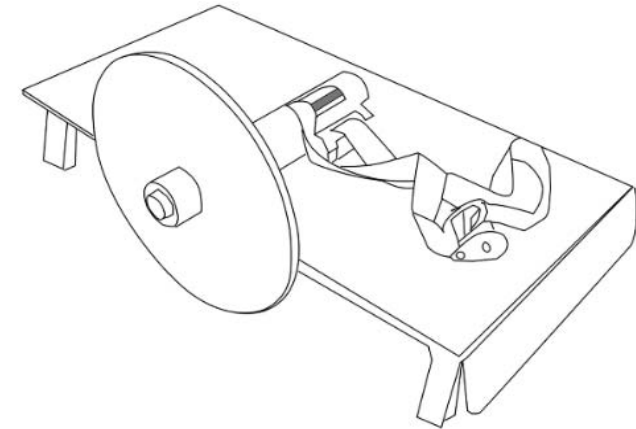
Objective 1: How does FIT supply resistance?

Flywheel-based Inertial Training (FIT)

Resistance primarily based on Moment of Inertia (MOI) and rotational velocity/acceleration

Gravity in-dependent resistance

- First patent: 1796; popularized in early 90's for spaceflight
- Becoming increasingly popular
 - Sports Performance
 - Rehabilitation
 - Health and Wellness
- Moment of Inertia ($\text{kg}\cdot\text{m}^2$)
 - Cylinder: $\text{MOI} = \frac{1}{2} mr^2$
 - Cone: $\text{MOI} = 0.3mr^2$



Munoz-Lopez et al. J Human Kinetics 2022

FIT Principles

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FIT Principles

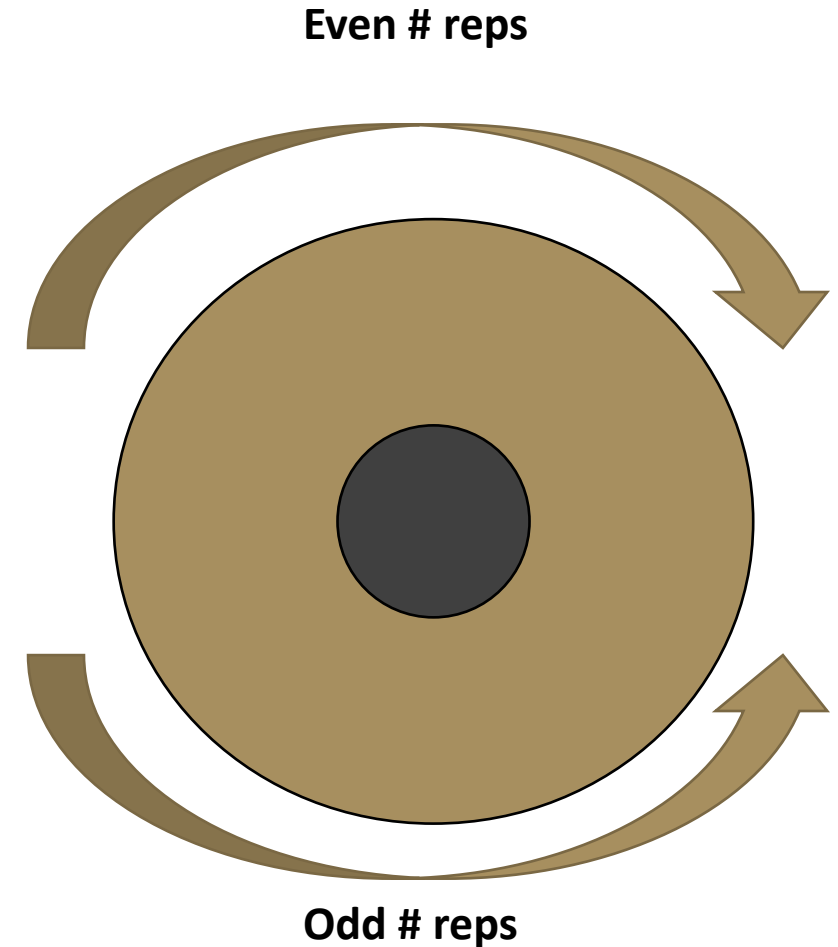
Objective 1: How does FIT supply resistance?

Flywheel-based Inertial Training (FIT)

Resistance based on Moment of Inertia (MOI) and rotational velocity/acceleration

Gravity in-dependent resistance

- CON action accelerates disk(s)
- Energy returned during ECC phase
- ECC force brakes FW
 - FW rotation changes direction for each repetition
- Force = product of MOI and rotational velocity!



FIT Principles

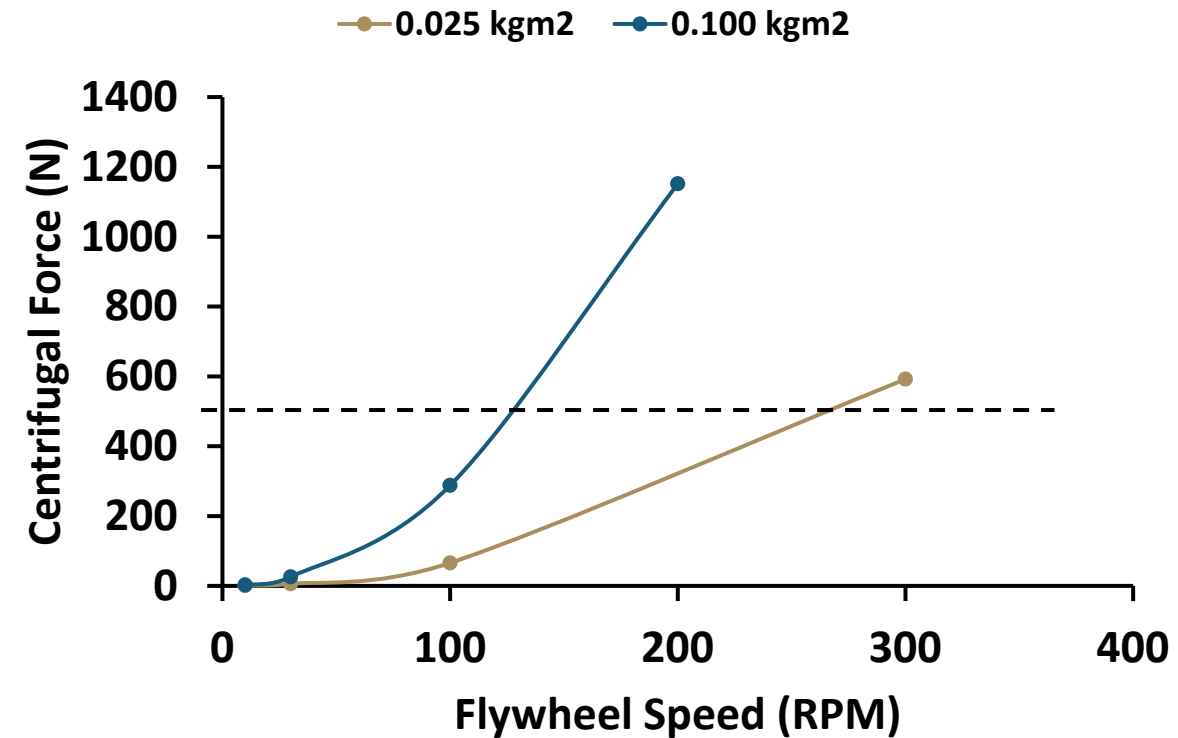
Objective 1: How does FIT supply resistance?

Flywheel-based Inertial Training (FIT)

Resistance primarily based on Moment of Inertia (MOI) and rotational velocity/acceleration

Gravity in-dependent resistance

- Greater MOI = higher force at any given velocity
- Can achieve similar (or greater) force with smaller MOI and higher rotational velocity
 - Have to move faster!



FIT Principles

0.005 kg·m²

0.200 kg·m²

Objective 1: How does FIT supply resistance?

Newton's 1st law of motion: Law of Inertia

“Object at rest or in constant motion will remain in that state unless acted upon by an external force.”

- If force > 0; FW will spin!
- Implications:
 - **NO 1RM**
 - **Can't prescribe exercise as % 1RM**
 - **Speed, not just MOI, affects exercise stimulus**

FIT Principles

Objective 1: How does FIT supply resistance?

Newton's 1st law of motion: Law of Inertia

“Object at rest or in constant motion will remain in that state unless acted upon by an external force.”

- If force > 0 ; FW will spin!
- Implications:
 - **NO Point of Failure**
 - **Need to determine when to stop each set of exercise**

FIT Principles

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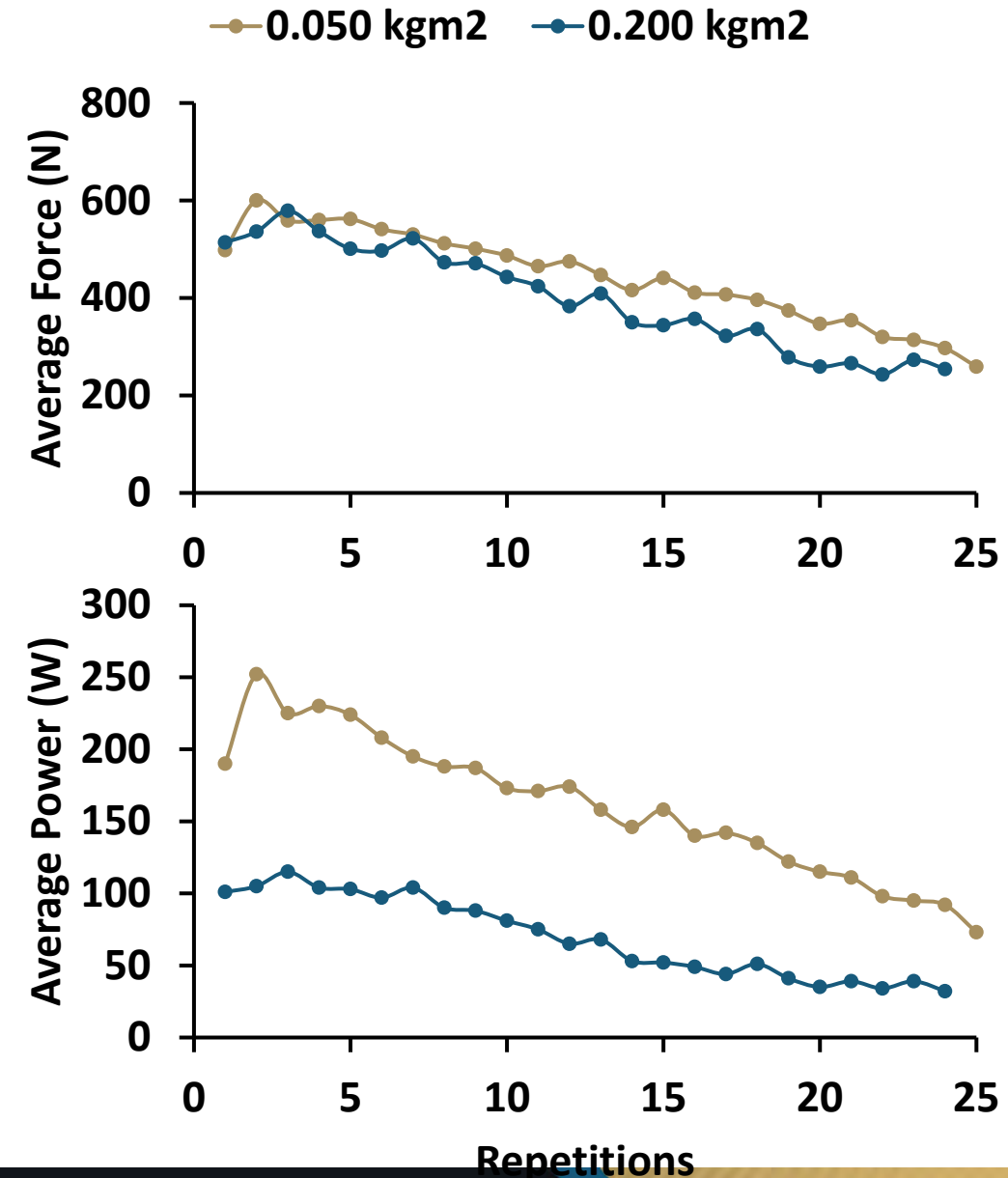
FIT Principles

Objective 1: How does FIT supply resistance?

Newton's 1st law of motion: Law of Inertia

“Object at rest or in constant motion will remain in that state unless acted upon by an external force.”

- If force > 0; FW will spin!
- Implications:
 - NO Point of Failure
 - Need to determine when to stop each set of exercise
- **Data: Bent-over-row; 25 reps**
 - Ave. Force similar between loads
 - Ave. Power much greater with lower load
 - Average power loss > 70%; still moving!



FIT exercise technique

Objective 2: Interaction of technique and MOI on FIT intensity

CON action spins wheel;

Energy returned during ECC phase

Implications:

1. All exercises start with Concentric phase
2. NO Pausing between phases!
3. Greater Concentric Effort = Greater Eccentric Stimulus
4. Rapid deceleration = Eccentric Overload

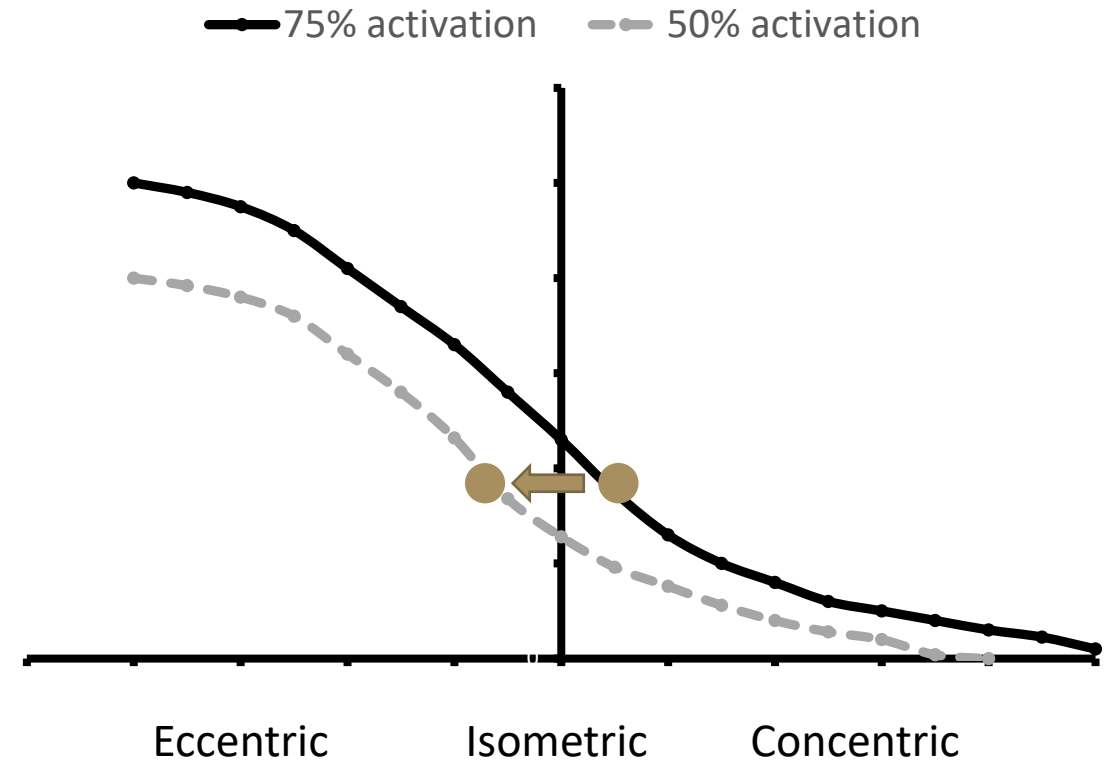
FIT exercise technique

Objective 1-2: Comparing FIT and DCER stimuli

Traditional DCER: Resistance supplied primarily by gravity

FIT: Resistance supplied by MOI and acceleration

1. DCER: Fixed load means ECC F-V corresponds to different activation level



Adopted from: Chow and Darling 1999,
Camilleri and Hull 2005, Reeves et al 2008

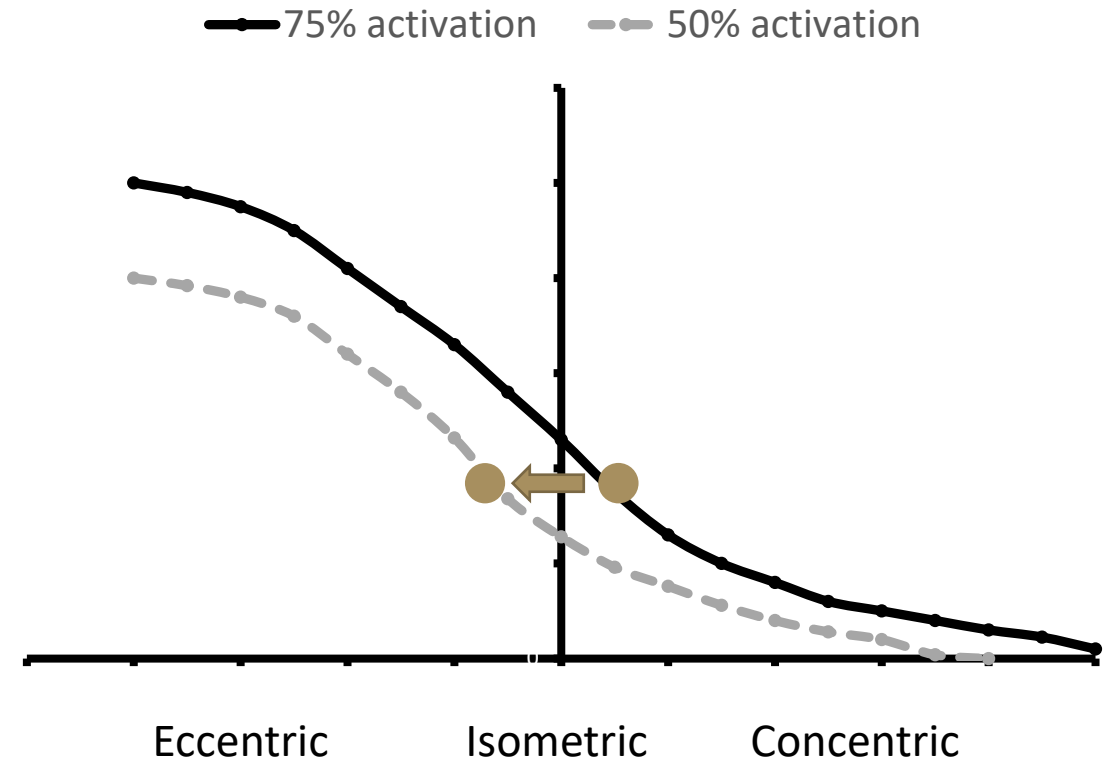
FIT exercise technique

Objective 1-2: Comparing FIT and DCER stimuli

Traditional DCER: Resistance supplied primarily by gravity

FIT: Resistance supplied by MOI and acceleration

1. DCER: Fixed load means ECC F-V corresponds to different (lesser) activation level
2. **FIT: Goal is to adopt technique to allow ECC F-V of same (or greater) level**



Adopted from: Chow and Darling 1999,
Camilleri and Hull 2005, Reeves et al 2008

Benefits of FIT

Objective 3: potential benefits and limitations to FIT

Benefits

- Portable Equipment
 - Small Physical Footprint
 - Transport easily
 - Low total weight
- Versatility
 - Perform many different exercises with single device
 - Limited by imagination!
- Cost
 - Varies by device/manufacturer/features
- Novelty
 - New NM stimulus; ECC overload

Limitations

- Familiarity
 - May need several session to learn modality
- Intensity dependent on effort
- Unintuitive data (MOI, Newtons, kJ)
- Difficulty adopting some exercises
 - Lower body = closed chain
 - Upper body = open chain
- Adjusting belt length settings between exercises / users
- DOMS
- Exercise technique/instruction
 - “As hard as possible” v. “Rapid Deceleration”
 - Muscle v. Skeletal loading

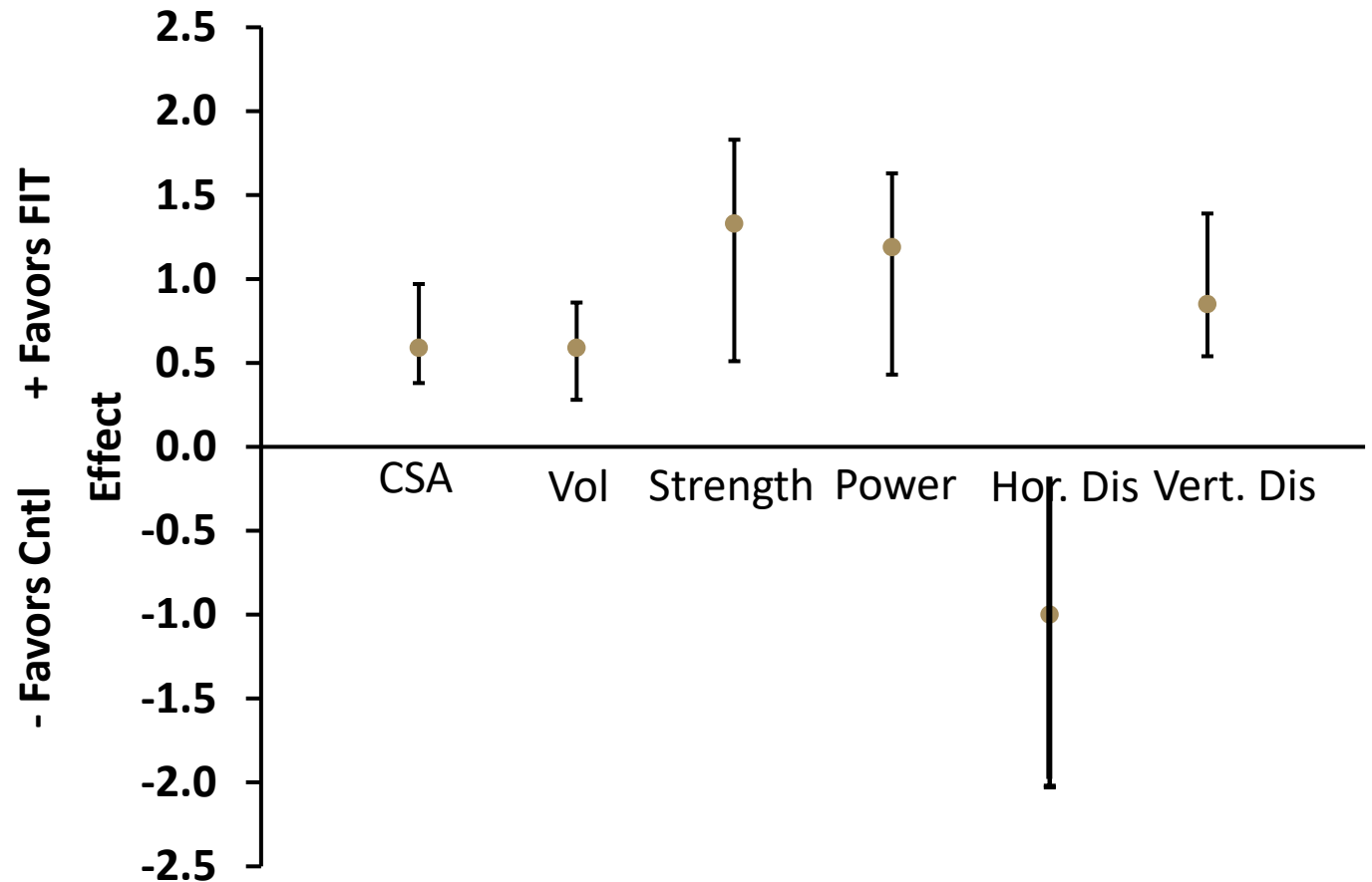
Benefits of FIT

Objective 3: potential benefits and limitations to FIT

Meta-Analysis of Literature (n = 20)

Petre et al. Sports Med Open 2018

- Hypertrophy
- Strength
- Power
- Performance
 - Horizontal
 - Vertical



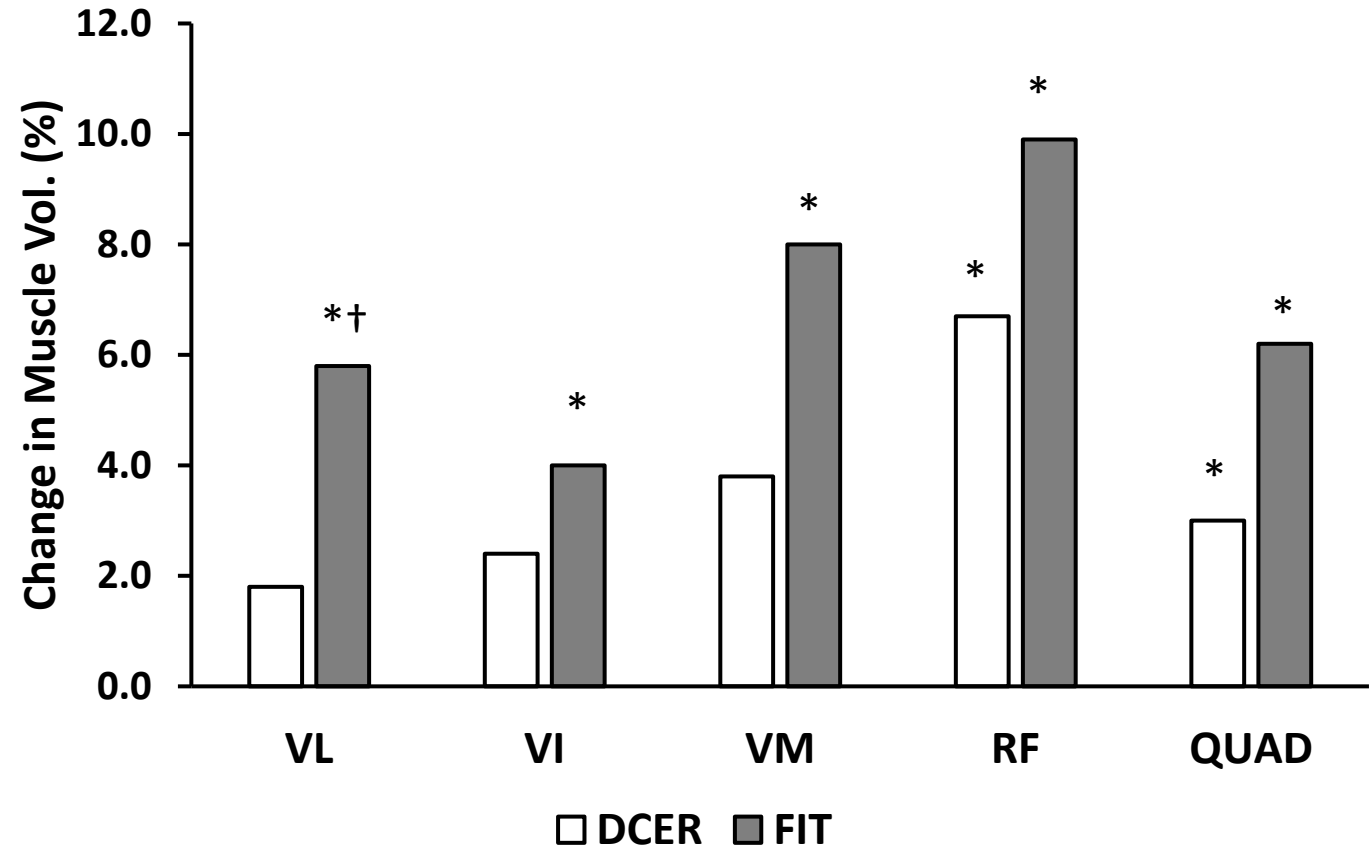
Benefits of FIT

Objective 3: potential benefits and limitations to FIT

Comparing FIT to DCER

Norrbrand et al. EJAP 2008

- **Hypertrophy**
- Strength
- Power
- Performance
 - Sprint
 - Vertical Jump



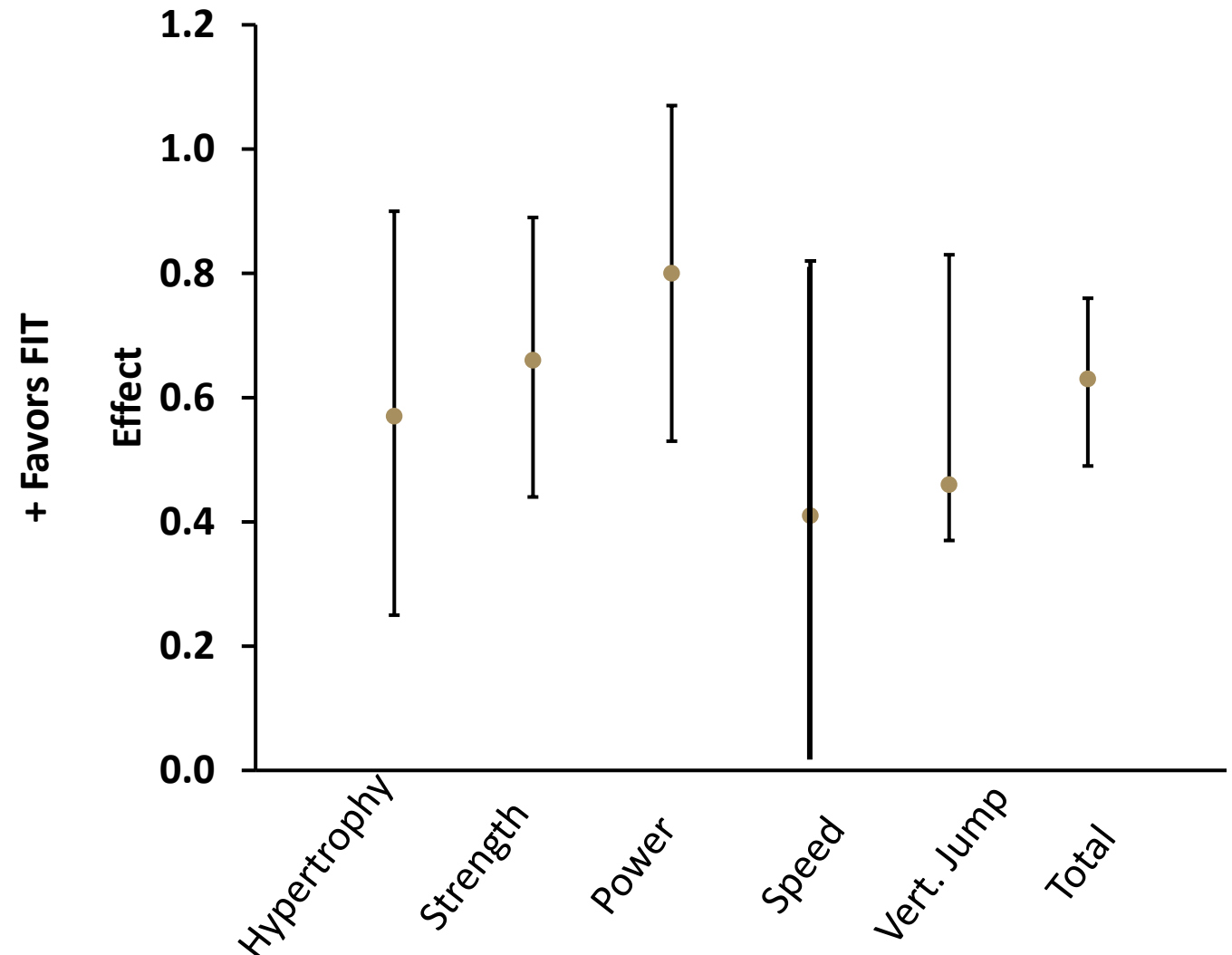
Benefits of FIT

Objective 3: potential benefits and limitations to FIT

Comparing FIT to DCER

Maroto Izquierdo JSAMS 2017 (n = 9)

- Hypertrophy
- Strength
- Power
- Performance
 - Sprint
 - Vertical Jump



Benefits of FIT

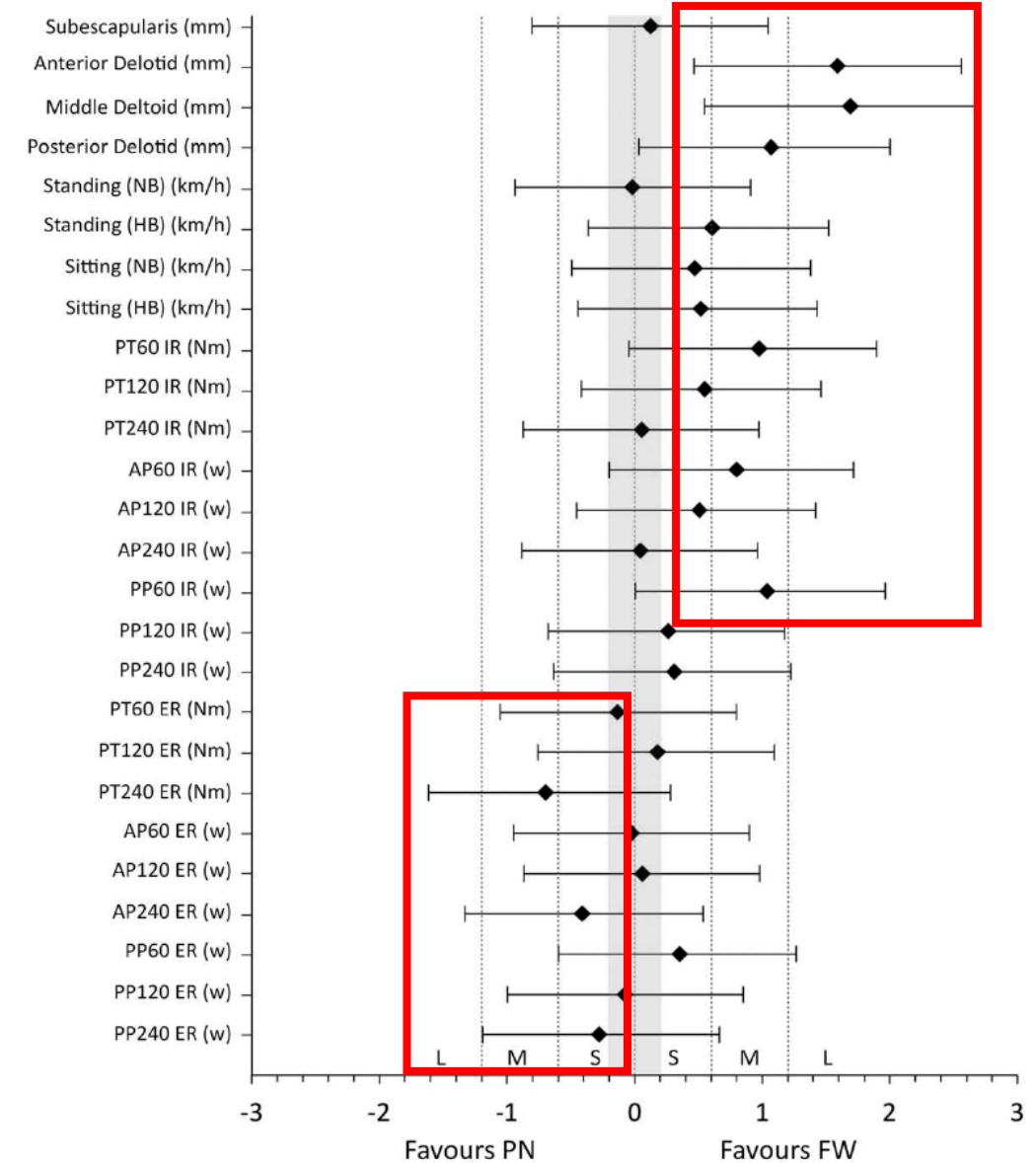
Objective 3: potential benefits and limitations to FIT

Comparing FIT to Pneumatic Resistance

Maroto Izquierdo RQES 2022

- FIT tends to perform better for increasing
 - Muscle thickness (M – L effect)
 - Throwing speed (S – M effect)
 - Peak Torque (S – M effect)
 - Ave and Peak Power (S – M effect)
- PN tended to perform better for increasing ext rot performance
 - Peak torque, Ave Power (high vel)

Esp. low vel



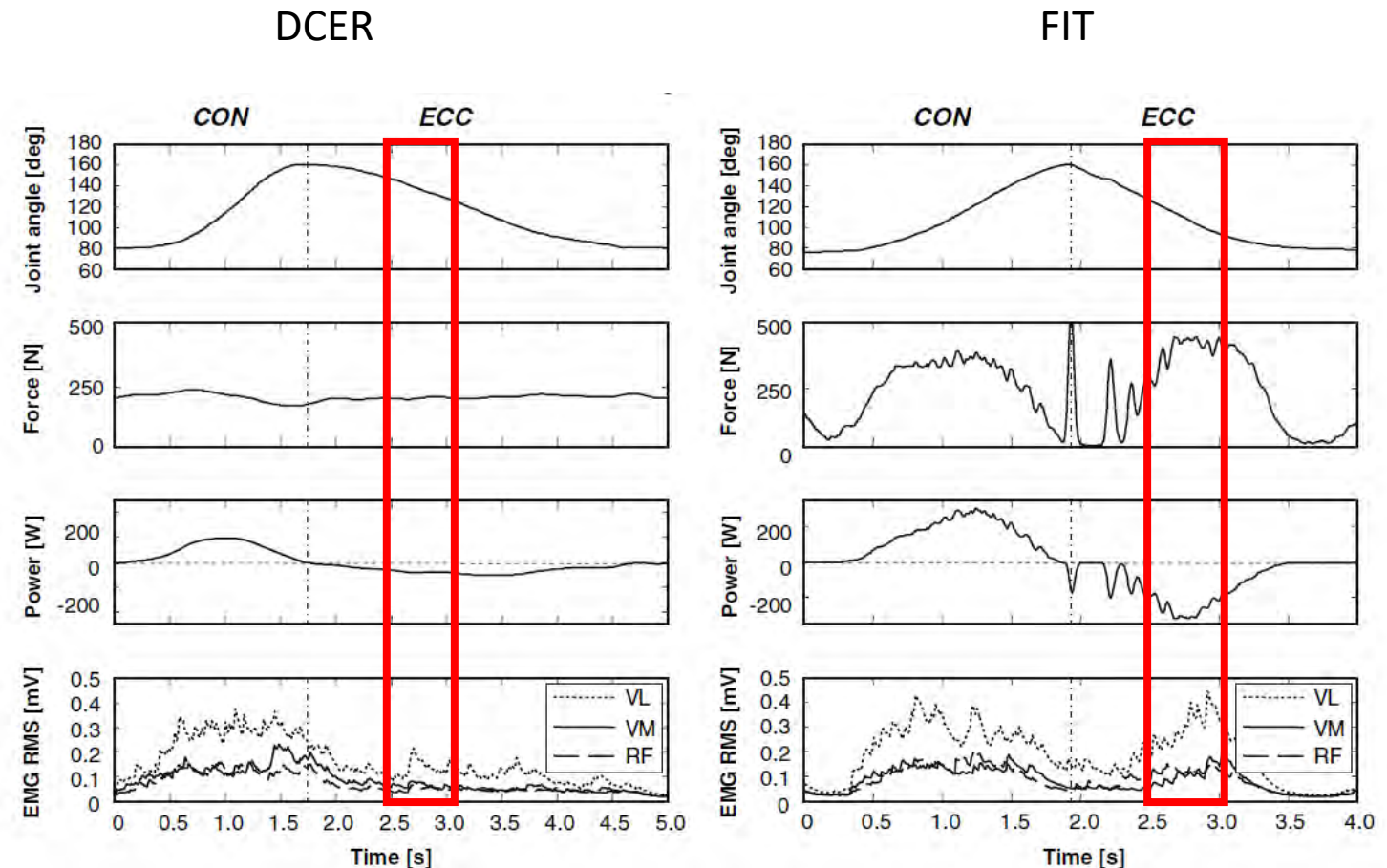
Benefits of FIT

Objective 3: potential benefits and limitations to FIT

How might FIT provide greater/faster adaptations?

Norrbrand EJAP 2008

- Note different tracings in ECC
- Rapid deceleration of flywheel during ECC phase
 - MUCH greater Force, Power, EMG activity during FIT
 - Esp. at end of ROM

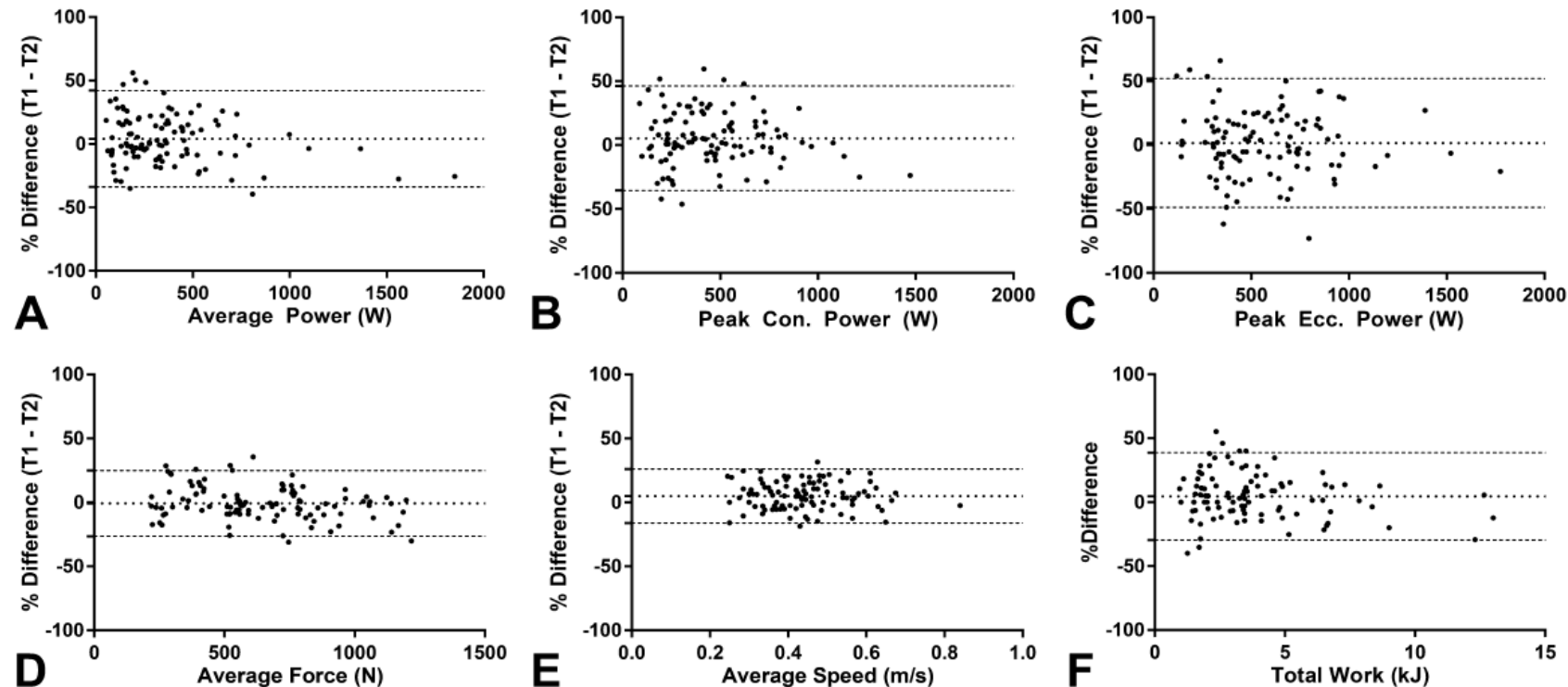


Benefits of FIT

Objective 3: potential benefits and limitations to FIT

Real-time data collection; Calculated by flywheel rotation (NOT GRF!)

- Power
 - Ave
 - PCP
 - PEP
- Total work
- ECC overload
 - PEP/PCP
- Force
- Velocity
- ROM



Bollinger et al. JSCR 2020

Achieving Eccentric Overload

Objective 4: Technique Coaching for ECC Overload

Essential for many of FIT's purported benefits

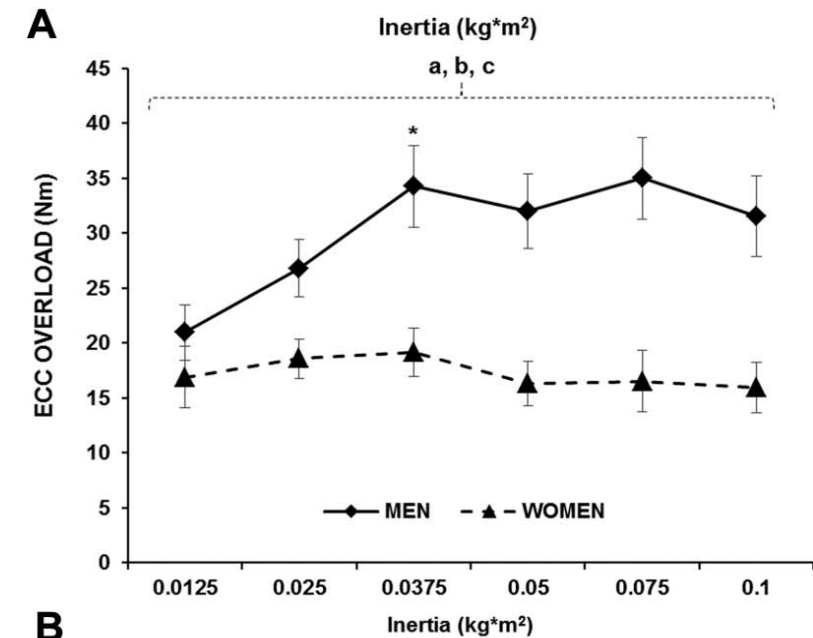
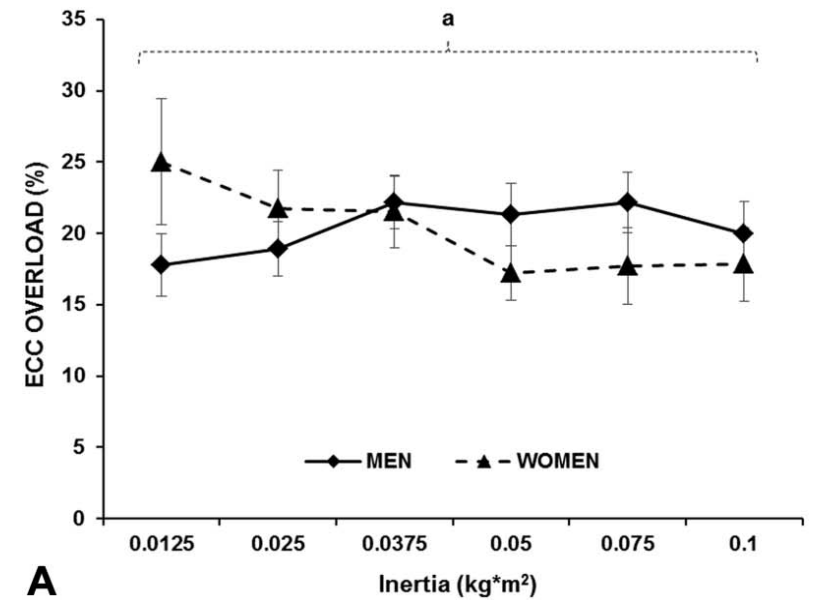
- Requires RAPID deceleration during ECC phase
- Easier to achieve on some exercises than others
 - Single v. multi-joint
- Max. CON effort
 - More energy in = more ECC energy!
 - Maybe even cheat in CON phase
- First third to half of eccentric phase unloaded
- Then, STOP flywheel rapidly at end of ECC phase

Achieving Eccentric Overload

Objective 4: Technique Coaching for ECC Overload

Concerns with ECC overload:

- ECC Overload commonly calculated as PEP / PCP
 - ECC Overload > 1.0 means PEP greater than PCP
 - May not tell the whole story...
- Total ECC load dependent on CON effort AND rapid deceleration
 - Submax CON effort makes it difficult to achieve high ECC load
- DOMS / rhabdomyolysis
 - Esp. for novice exercisers



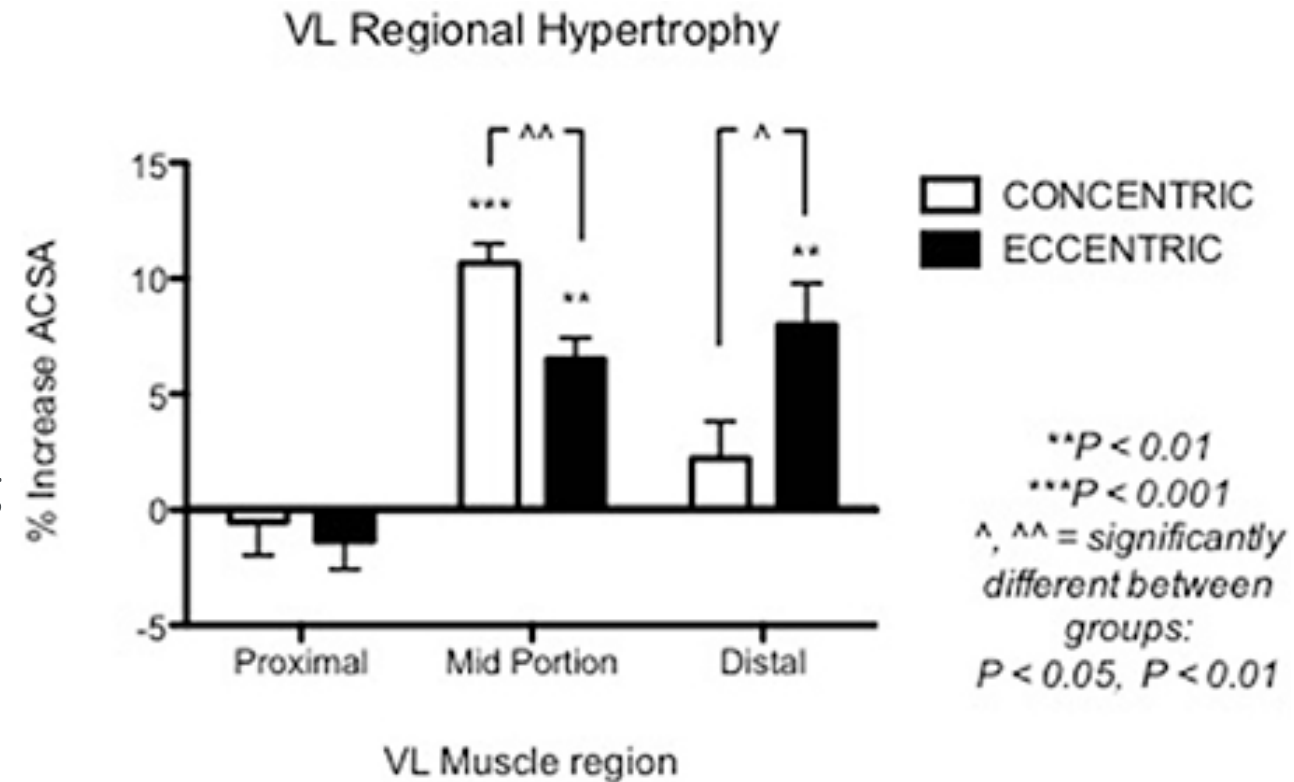
Martinez-Aranda et al. JSCR 2016

Achieving Eccentric Overload

Objective 4: Technique Coaching for ECC Overload

Concerns with ECC overload:

- ECC and CON RT remodel muscle differently
- ECC loading preferentially induces hypertrophy at distal region of muscle
- Effect may be exaggerated by ECC loading exclusively at long muscle lengths?
- ECC overload with limited ROM to target proximal regions of muscle?



Franchi et al. *Acta Physiol* 2014

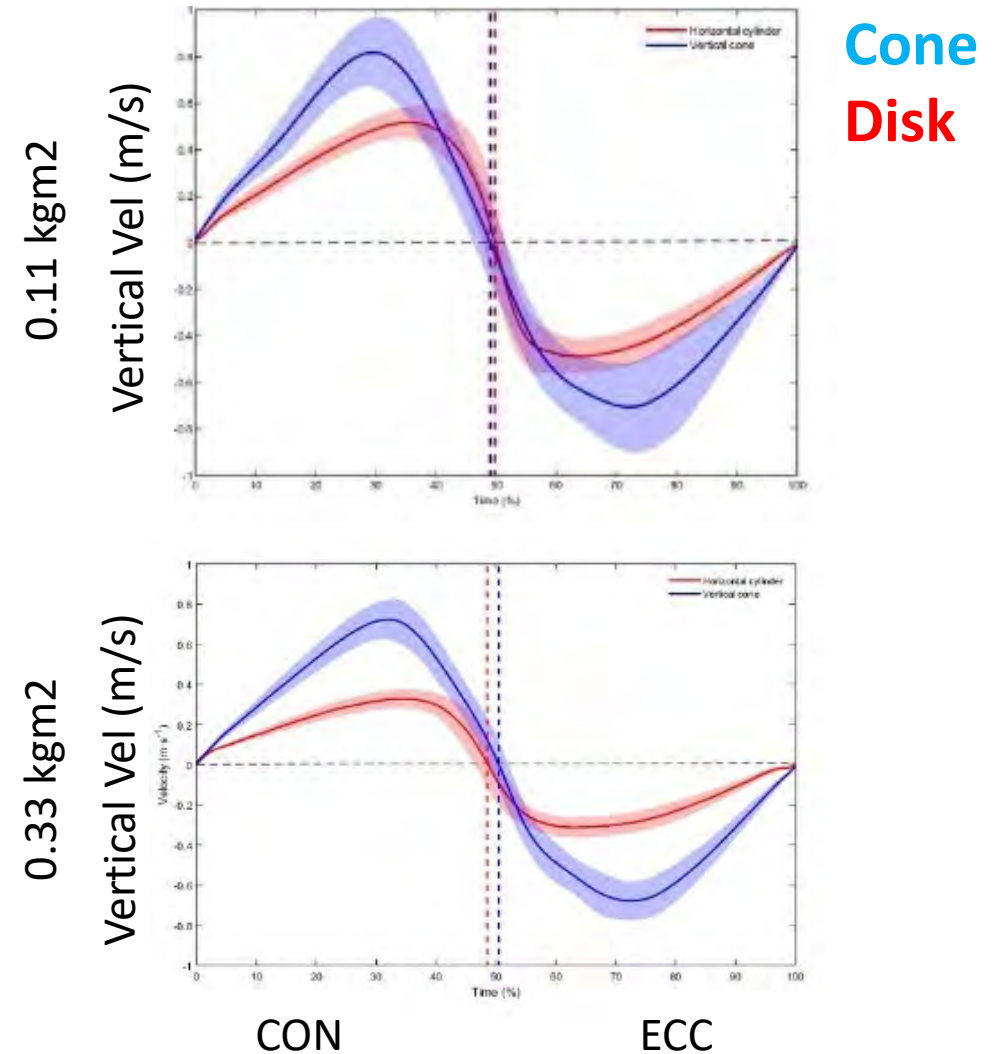
Choosing a FIT system

Objective 5: Implementing FIT to achieve training goals

Not all FIT devices are similar

Considerations:

1. Single v. Multi-joint devices
2. Horizontal v. Vertical motion
 - Direction of loading may impact functional outcomes
 - Mount devices to wall/floor
3. Disk v. Cone
 - And Direction of Rotation
4. MOI capacity
5. Data capacity?



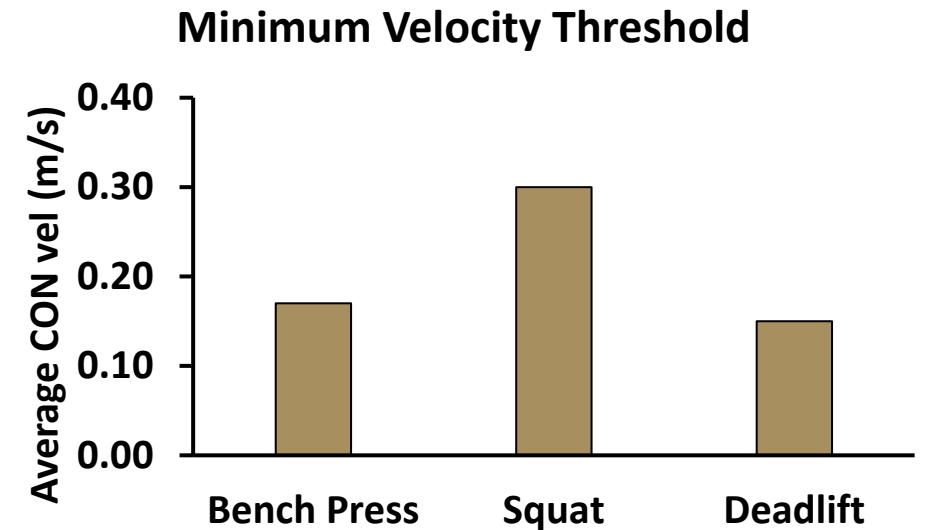
Munoz-Lopez J Hum Kinetics 2022

Choosing appropriate workloads

Objective 5: Implementing FIT to achieve training goals

Determining appropriate load and repetitions

- Problems:
 - No 1RM to determine appropriate load
 - No point of failure to determine rep number
- Solution: Use principles of Velocity-Based Training (VBT)
 - May allow training at ultra-slow velocities



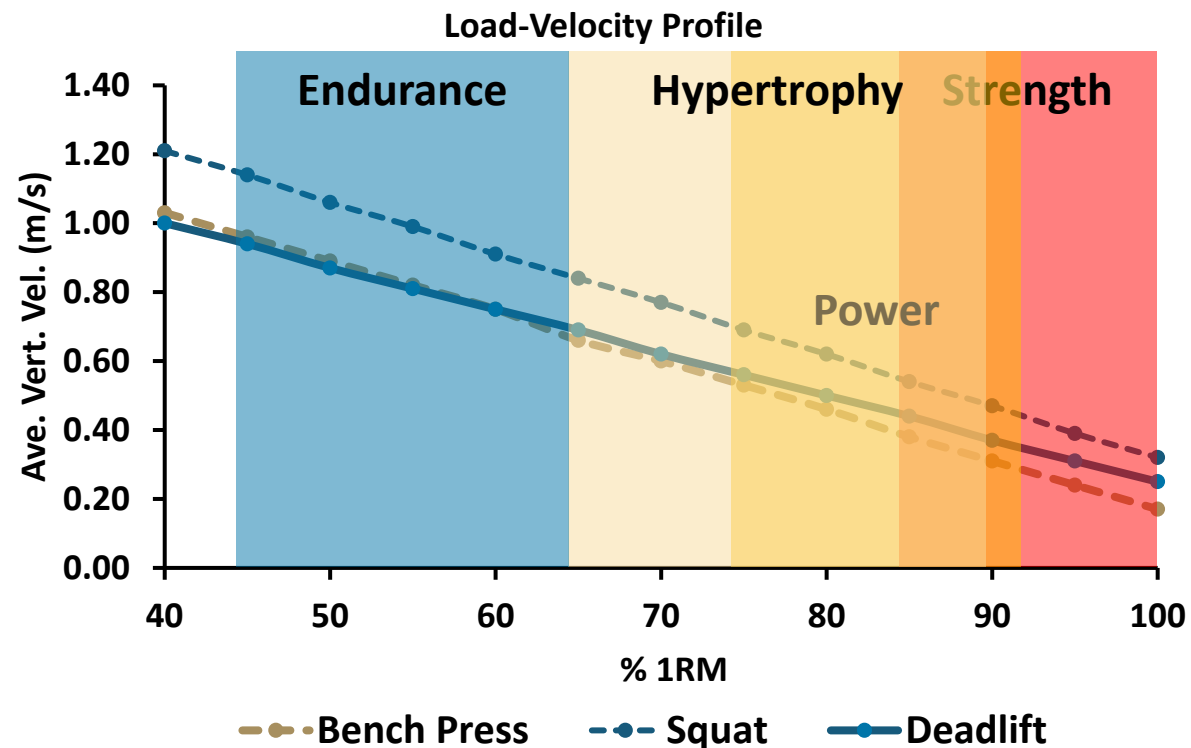
Weakley et al. SCJ 2020

Choosing appropriate workloads

Objective 5: Implementing FIT to achieve training goals

Determining appropriate load and repetitions

- Use principles of Velocity-Based Training (VBT)
 - Train within appropriate domain
 - May be difficult to use with some exercises
 - Lack of VBT data/training domains
 - Velocity data may be inconsistent in FIT (based on FW rot)



Balsalobre-Fernandez et al. Sports 2021

Choosing appropriate workloads

Objective 5: Implementing FIT to achieve training goals

Determining appropriate load and repetitions

- Use principles of Velocity-Based Training (VBT)
 1. Train within appropriate domain
 2. May be difficult to use with some exercises
 3. Lack of VBT data/training domains
 4. Velocity data may be inconsistent in FIT (based on FW rot)
 5. Example Domain Ranges Table

% 1RM	Bench Press	Squat	Deadlift	Domain
40	1.03	1.21	1.00	Endurance
45	0.96	1.14	0.94	Endurance
50	0.89	1.06	0.87	Endurance
55	0.82	0.99	0.81	Endurance
60	0.75	0.91	0.75	Endurance
65	0.66	0.84	0.69	Endurance
70	0.60	0.77	0.62	Hypertrophy
75	0.53	0.69	0.56	Hypertrophy / Power
80	0.46	0.62	0.50	Hypertrophy / Power
85	0.38	0.54	0.44	Hypertrophy / Power / Strength
90	0.31	0.47	0.37	Hypertrophy / Power / Strength
95	0.24	0.39	0.31	Strength
100	0.17	0.32	0.25	Strength

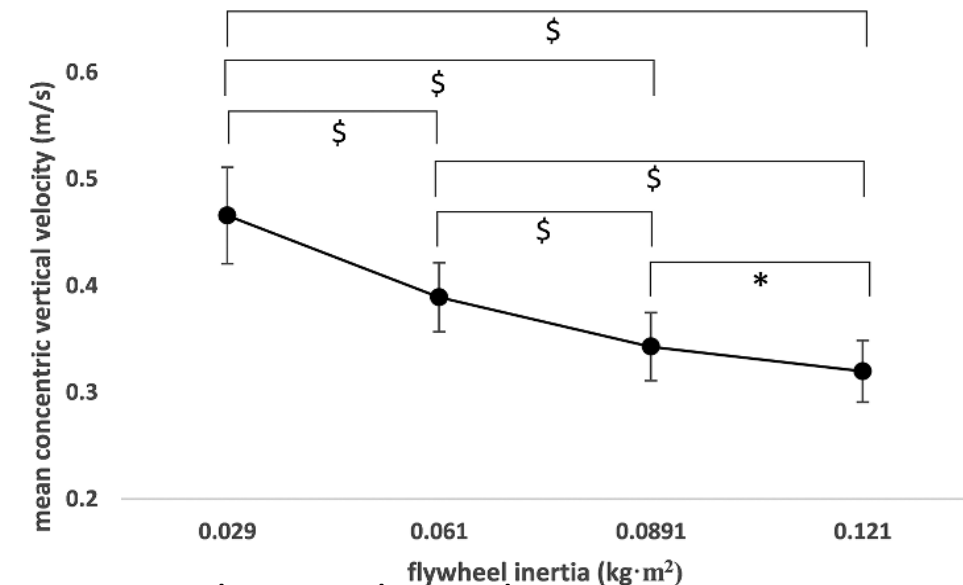
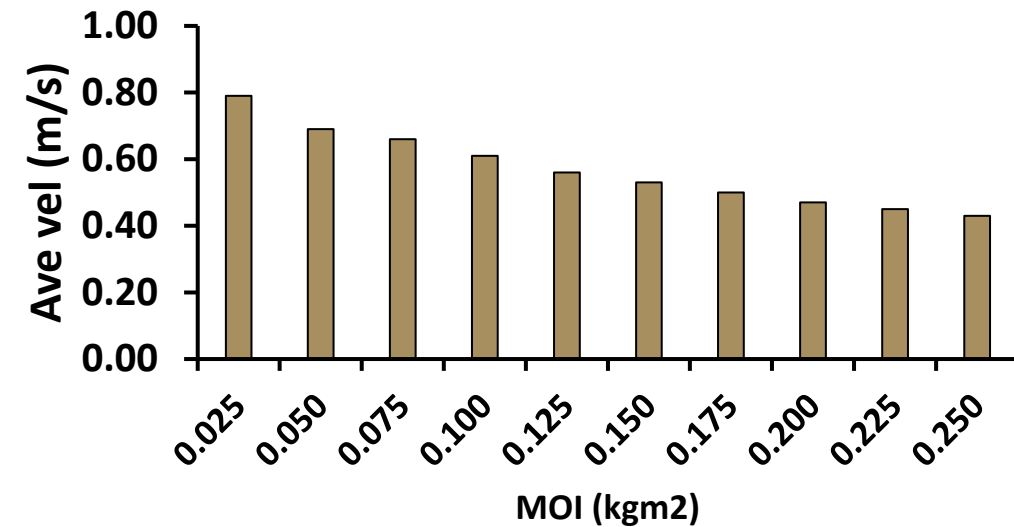
Balsalobre-Fernandez et al. Sports 2021

Choosing appropriate workloads

Objective 5: Implementing FIT to achieve training goals

Determining appropriate load and repetitions

- Greater MOI = Slower max velocity
 - Shift training domain to right
 - Lower Power Output
 - Greater Force
 - Greater TOTAL (but not peak) EMG activity
 - Large variation in MOI-Vel relationship
 - Need to establish on individual basis



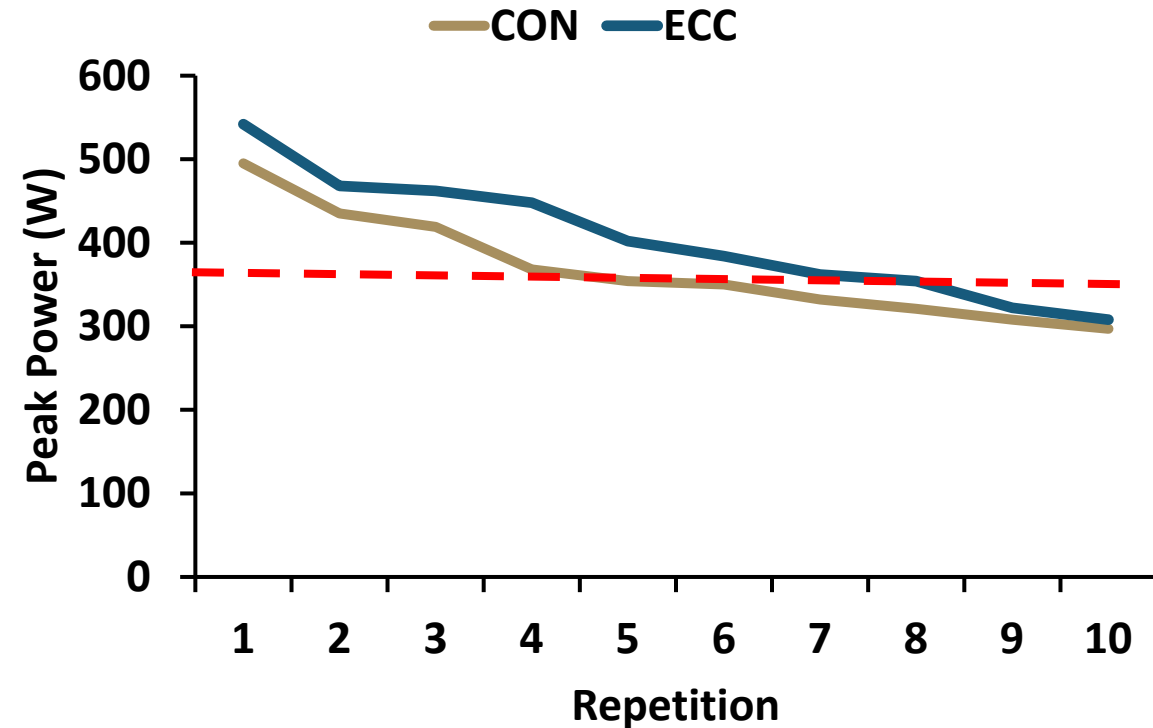
McErlain-Naylor and Beato. J Sport Sci 2021

Choosing appropriate workloads

Objective 5: Implementing FIT to achieve training goals

Determining appropriate load and repetitions

- Velocity / Power decreases with each rep
 - Keep velocity/Power in specified training domain!
 - Ex. 25% loss
 - Subsequent sets will have lower velocity/power
 - Adjust MOI to keep reps in training domain
 - Rely on Perceived Effort?

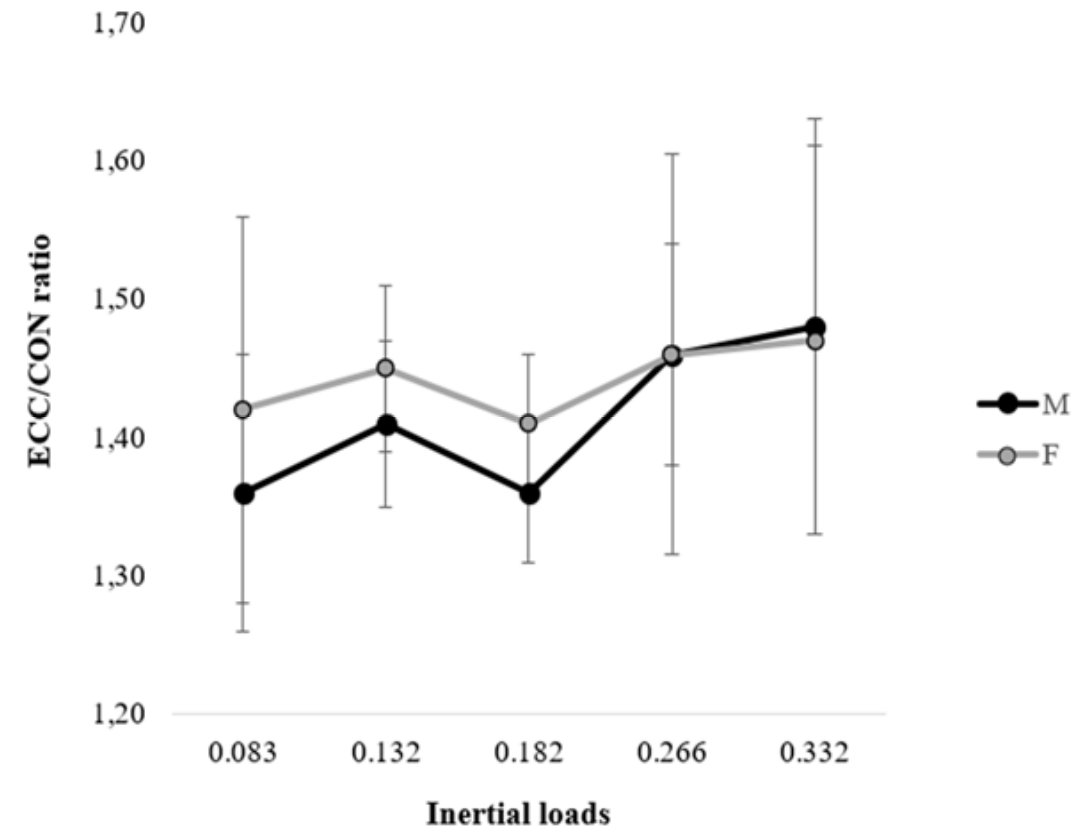


Choosing appropriate workloads

Objective 5: Implementing FIT to achieve training goals

Determining appropriate load and repetitions

- Greater MOI = Greater ECC Overload
 - Greater ECC Overload



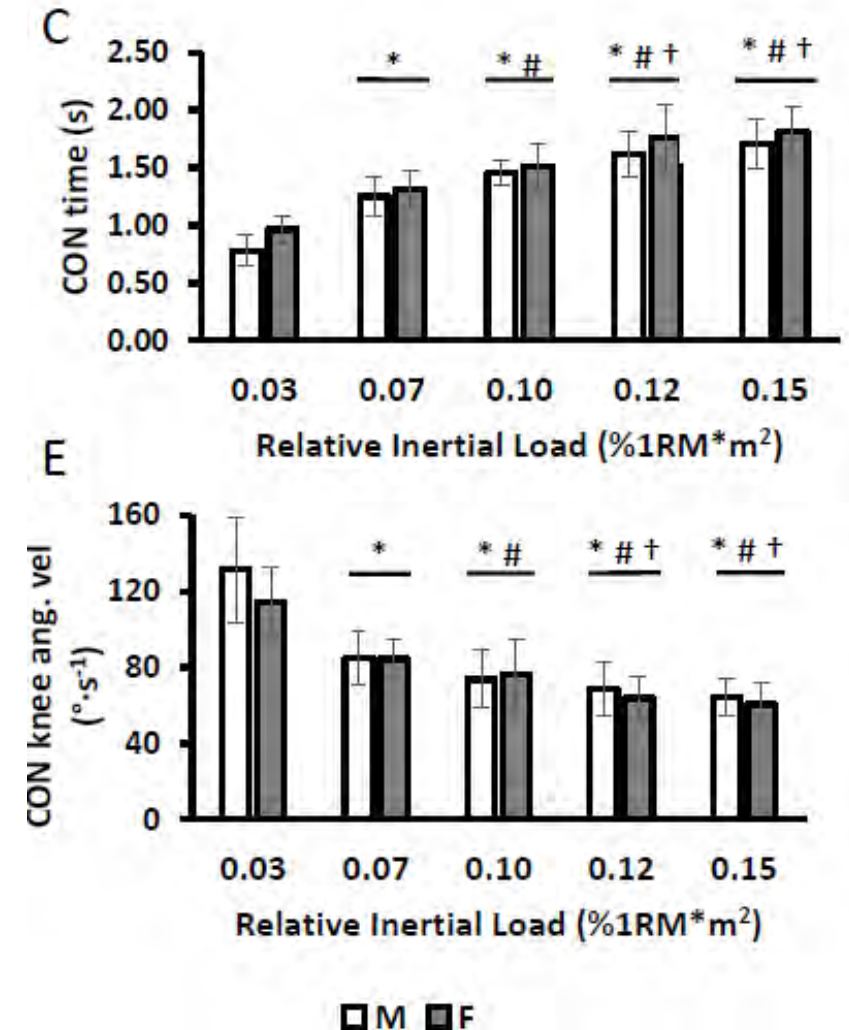
Piqueras-Sanchiz et al. J Human Kinetics 2020

Choosing appropriate workloads

Objective 5: Implementing FIT to achieve training goals

Other methods for choosing workload

- Relative Inertial Load?
 - Preliminary (unpublished) work from our lab
 - Quantify MOI relative to 1RM using DCER exercise
 - Linear increase in rep time; Linear decrease in knee angular velocity



Bollinger, unpublished; under review

Recommendations for FIT

Objective 5: Implementing FIT to achieve training goals

What does all of this mean for me?

1. Familiarization and experimentation are key
 - New Participants
 - New Exercises
 - Start slowly
2. Keep belt in line with axis of rotation
3. Balance
4. No pause between CON and ECC
5. Use data to make real-time training decisions
 - MOI
 - Rep number
 - Set number
 - Do Not rely on data for testing purposes...yet

Recommendations for FIT

Objective 5: Implementing FIT to achieve training goals

What does all of this mean for me?

1. Compared to DCER, FIT appears to offer several benefits
 - Esp. Hypertrophy
 - May be most appropriate for specific training seasons
2. Not all exercises transfer easily to FIT
 - Upper body = open chain
 - Lower body = closed chain
3. Use as adjuvant exercise; not nec. a replacement for other modalities

Recommendations for FIT

Objective 5: Implementing FIT to achieve training goals

What does all of this mean for me?

- General FIT protocol
- Choose MOI and rep number consistent with desired effects
 - Exercise and training season-specific
- 2-5 sets per exercise
- 4-7 maximal effort repetitions
 - Allow 1-2 warm-up reps
 - PAPE?
 - More familiar starting position for some exercises
 - Peak power achieved in first 5 reps
- Use Perceived Effort and Vel. Loss to terminate set of exercise

Recommendations for FIT

Objective 5: Implementing FIT to achieve training goals

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Pre-season	OFF	Sport-spec	FIT: 3 x 5 reps High MOI/Low Vel	Sport-spec	FIT: 2 x 6 reps Mod MOI / High Vel	Sport-spec	Scrimmage
In-season (weekly match)	OFF	FIT: 3 x 5 reps High MOI/Low Vel (NS only)	FIT: 3 x 5 Mod MOI / High Vel	Sport-spec	FIT: 2 x 4 Low MOI / High Vel Select ex. only	Sport-spec	Match
In-season (twice weekly match)	OFF	FIT: 3 x 6 Mod MOI / High Vel	Sport-spec	Match	FIT: 2 x 4 Low MOI / High Vel Select ex. only	Sport-spec	Match

Modified from Beato et al. Front Physiol 2021

Acknowledgements

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1. NSCA
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Questions / Comments

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Translating Research Findings to Program Design for FIT



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