NEUROMUSCULAR FUNCTION | research group

MARCIALONGA® SCIENCE

by research center - Rovereto CeRiSM Mountain Sport Health

Scuola universitaria professionale della Svizzera italiana SUPSI

Central and peripheral fatigue in lower and upper limbs after cross-country ski race

12/11/2015 – Rovereto

G. Boccia, D. Dardanello, C. Zoppirolli, L. Bortolan, C. Cescon, A. Schneebeli, G. Vernillo, B. Pellegrini, F. Schena, A. Rainoldi

Known in the literature

Introduction
Participants and Race
Protocol
Results MVC & RFD
Results Fatigue
Results EMG
Conclusions

- **Strength loss from 8 to 12 %** in the knee extensors (Forsberg 1979, Viitasalo 1982, Millet 2003) and elbow extensors (Millet 2003)
- Signs of peripheral, but not central, fatigue in knee extensors (Millet 2003)

Known in the literature

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Gap to fill in the literature

- Very few studies
- Focused mainly on knee estensors
- Lack of focus on rate of force development

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Aim:

to provide an **overall outline** of the *origin* and *effects* of fatigue induced by cross country ski race

Participants

- MARCIALONGA® ski race (56 km)
- 19 skiers aged 30±6 years (16 completed the study)
- Final race time: 2h14 – 3h10
- Final race rank: 52nd to 1088th

Altimetry

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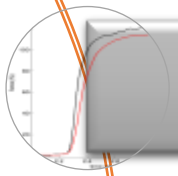
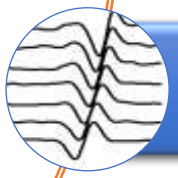
Maximum voluntary contraction

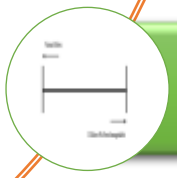


Rate of force development

Central and peripheral fatigue



Muscle fiber conduction velocity



Percepetion of fatigue

Set up and tests

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NEUROMUSCULAR TESTING

- 2 x RFD (1' rest)
- 2 x MVC + twitch interpolation (1' rest)

Knee extensors

Elbow extensors

Protocol and timing

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- PRE: 2 – 5 days before the race
- POST: **5 – 10 minutes after the race**

PRE

- 15 minutes incrementral warm-up **with ski**
- Temperature + RPE
- Selection of electrical stimulation intensity
- NEUROMUSCULAR TESTING

POST

- Temperature + RPE
- NEUROMUSCULAR TESTING

Rate of force development (RFD)

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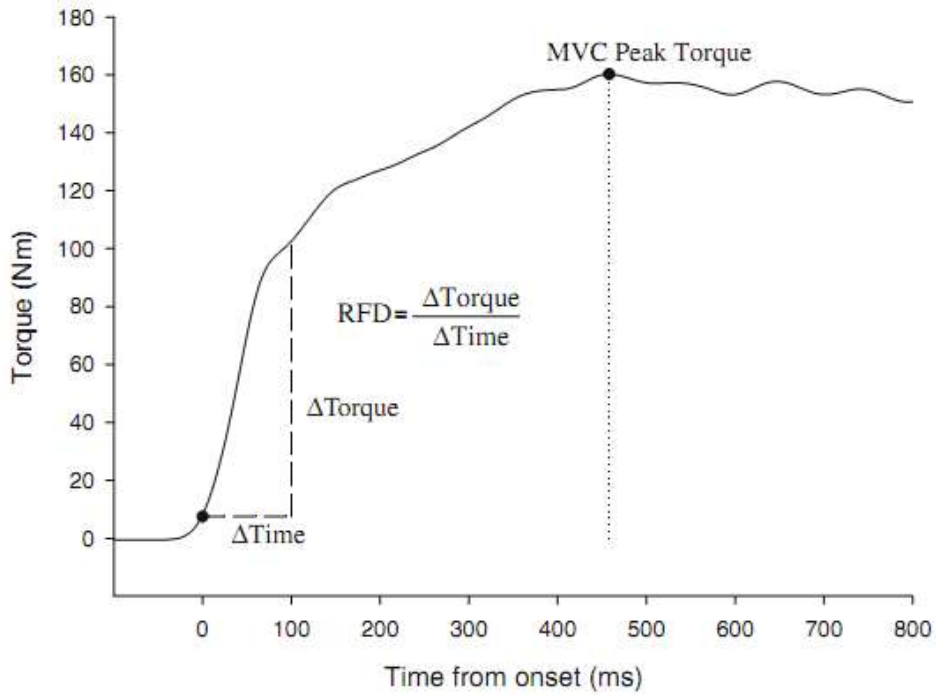
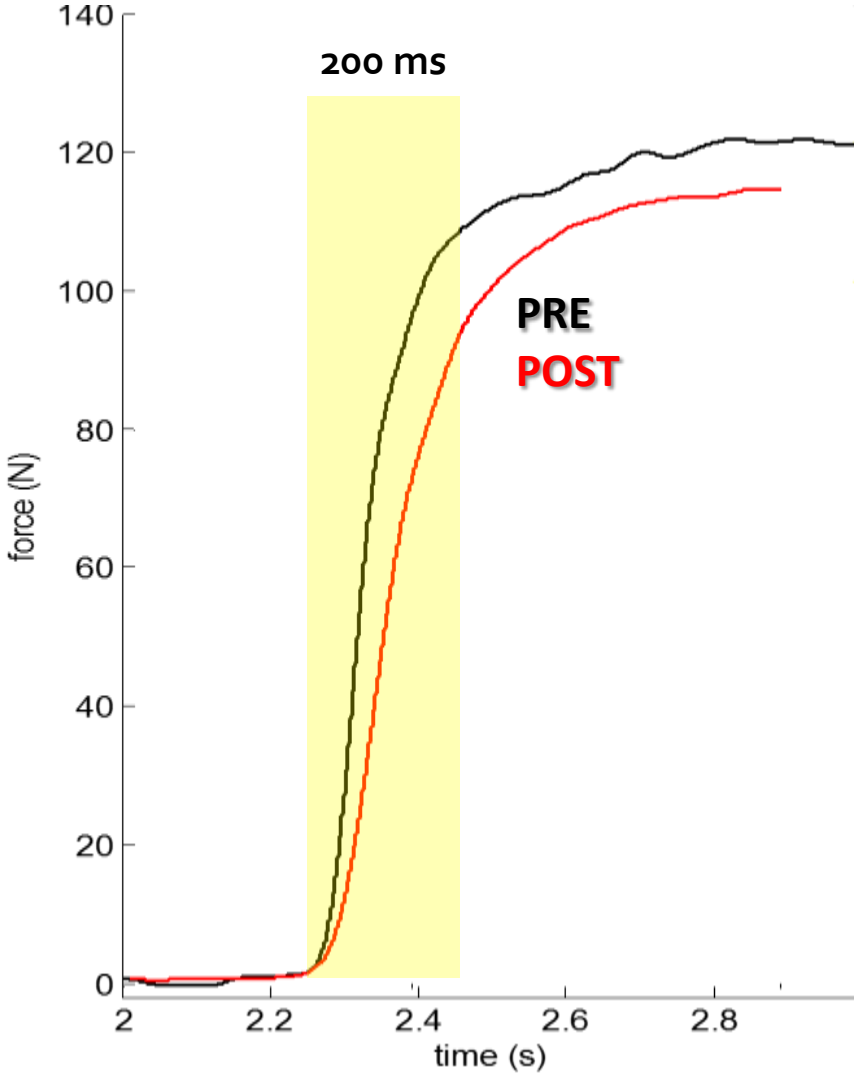


- Highly related to sport and daily-life movement
- RFD in the **first 100 ms of contraction**:
  - has little relationship with MVC (Andersen 2006)
  - highly dependent on muscle contractile properties

Rate of force development (RFD)

- «Push as **fast** and as **hard** as you can!!»
- RFD
  - 0-50 ms
  - 0-100 ms
  - 0-200 ms
  - Peak



Multichannel surface electromyography

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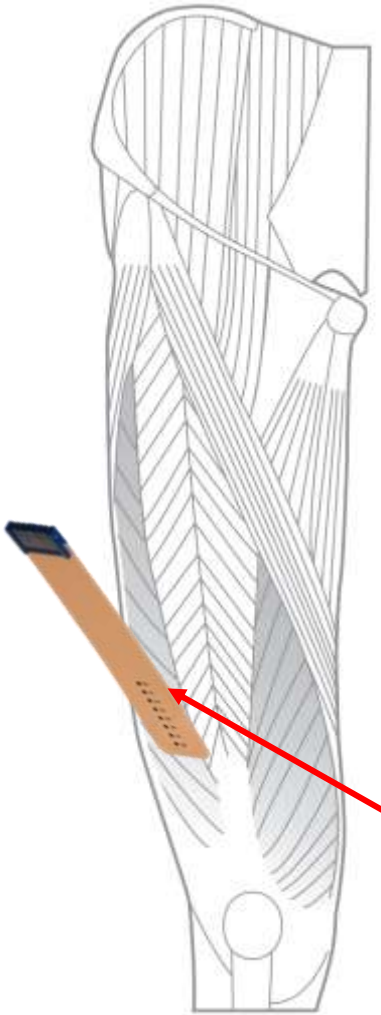
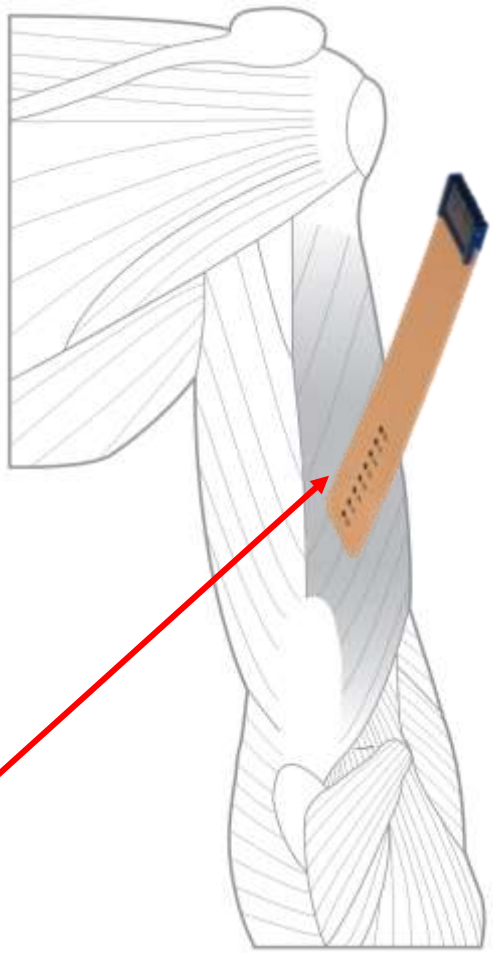
Vastus Lateralis

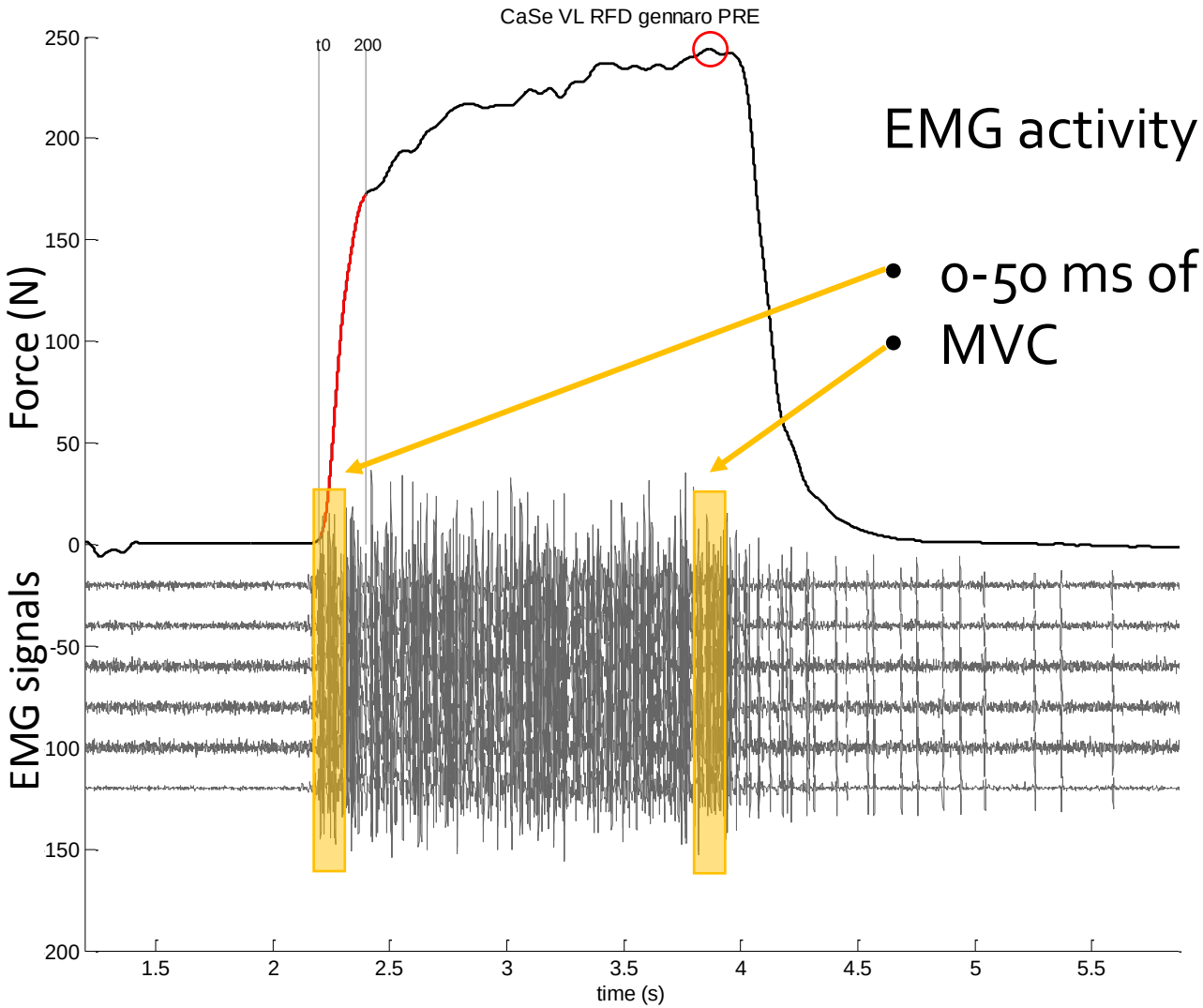


Lateral haed of triceps brachii



Recording electrode arrays

Amplitude of EMG signals



EMG activity during:

- 0-50 ms of RFD
- MVC

Muscle fiber conduction velocity

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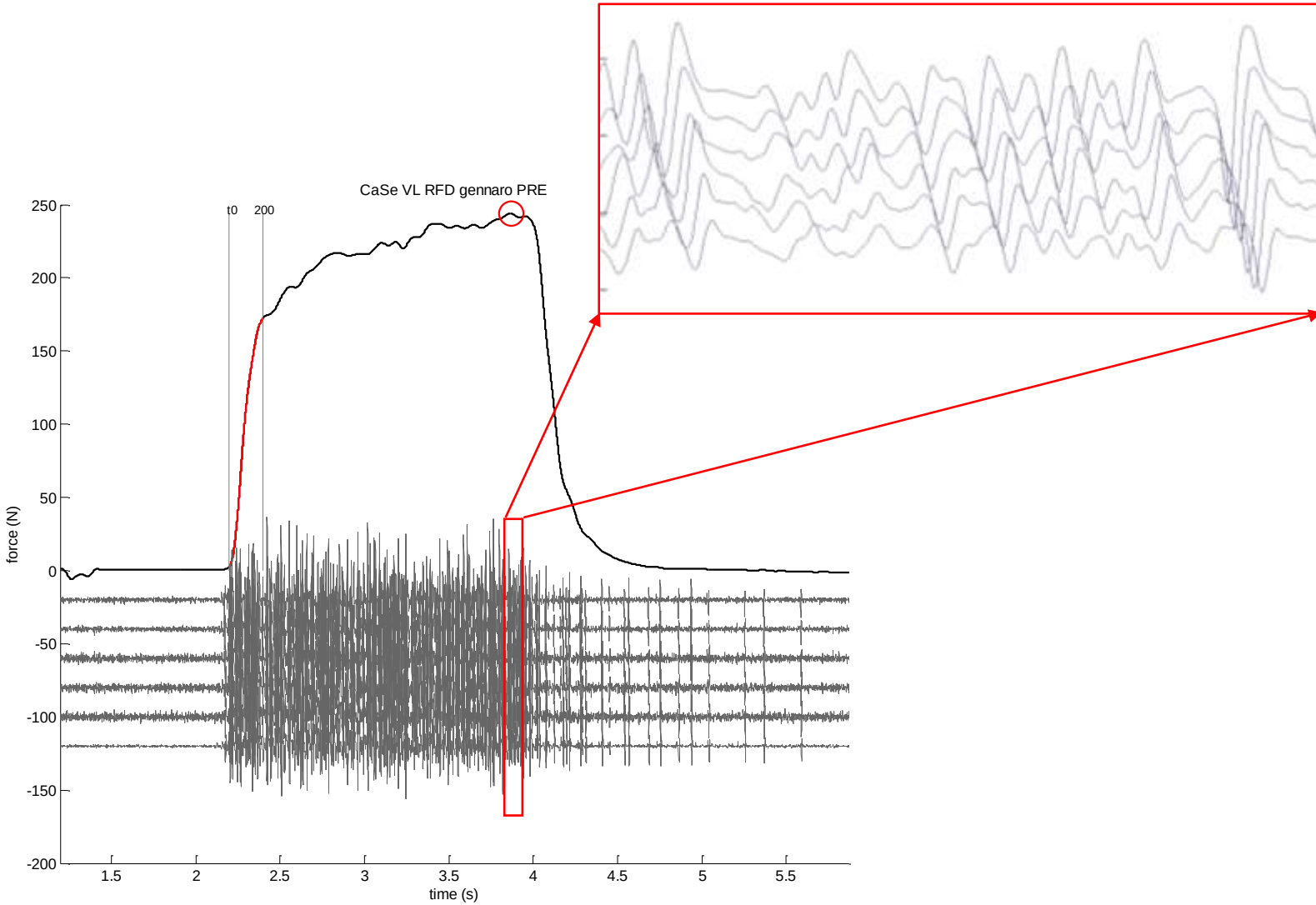
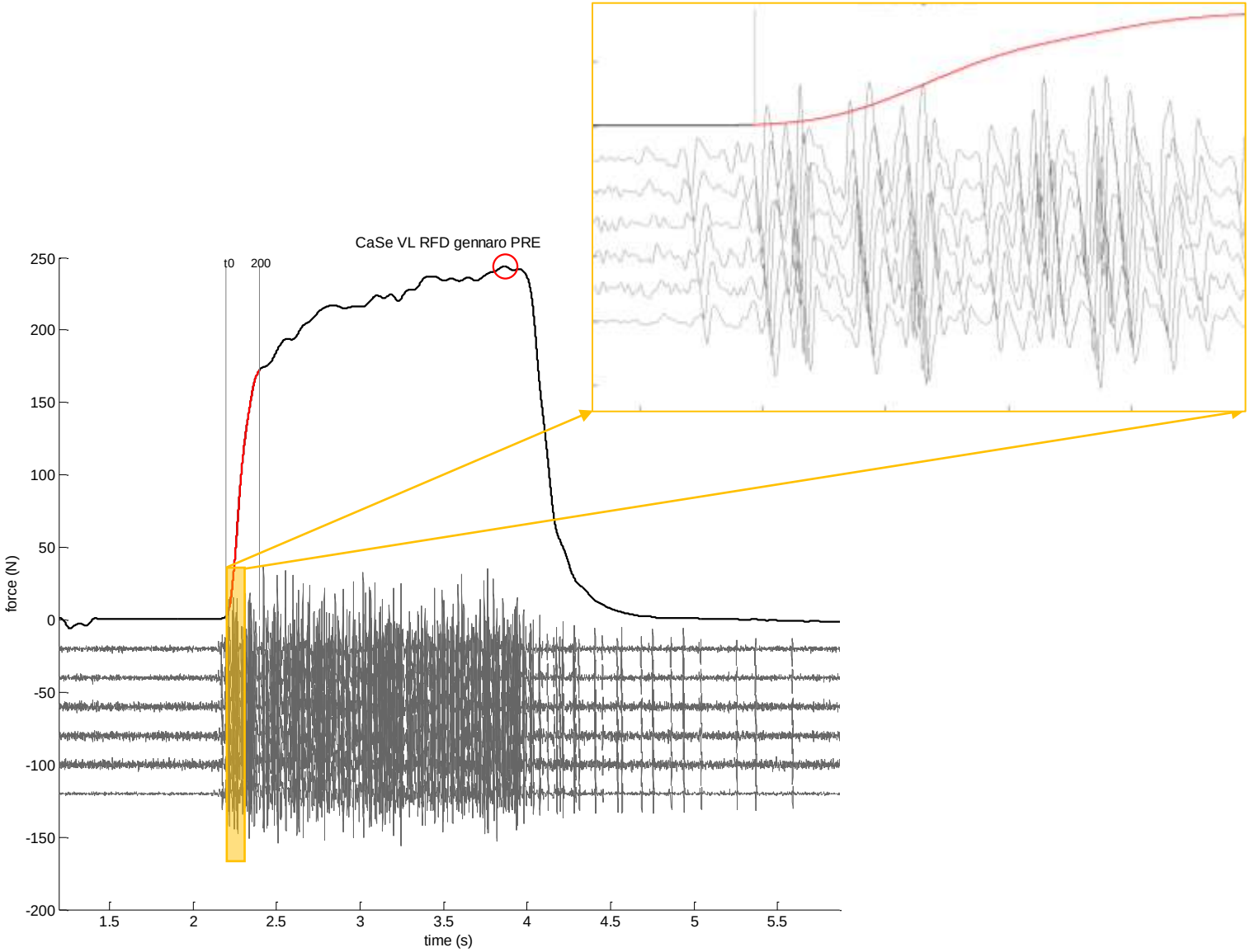
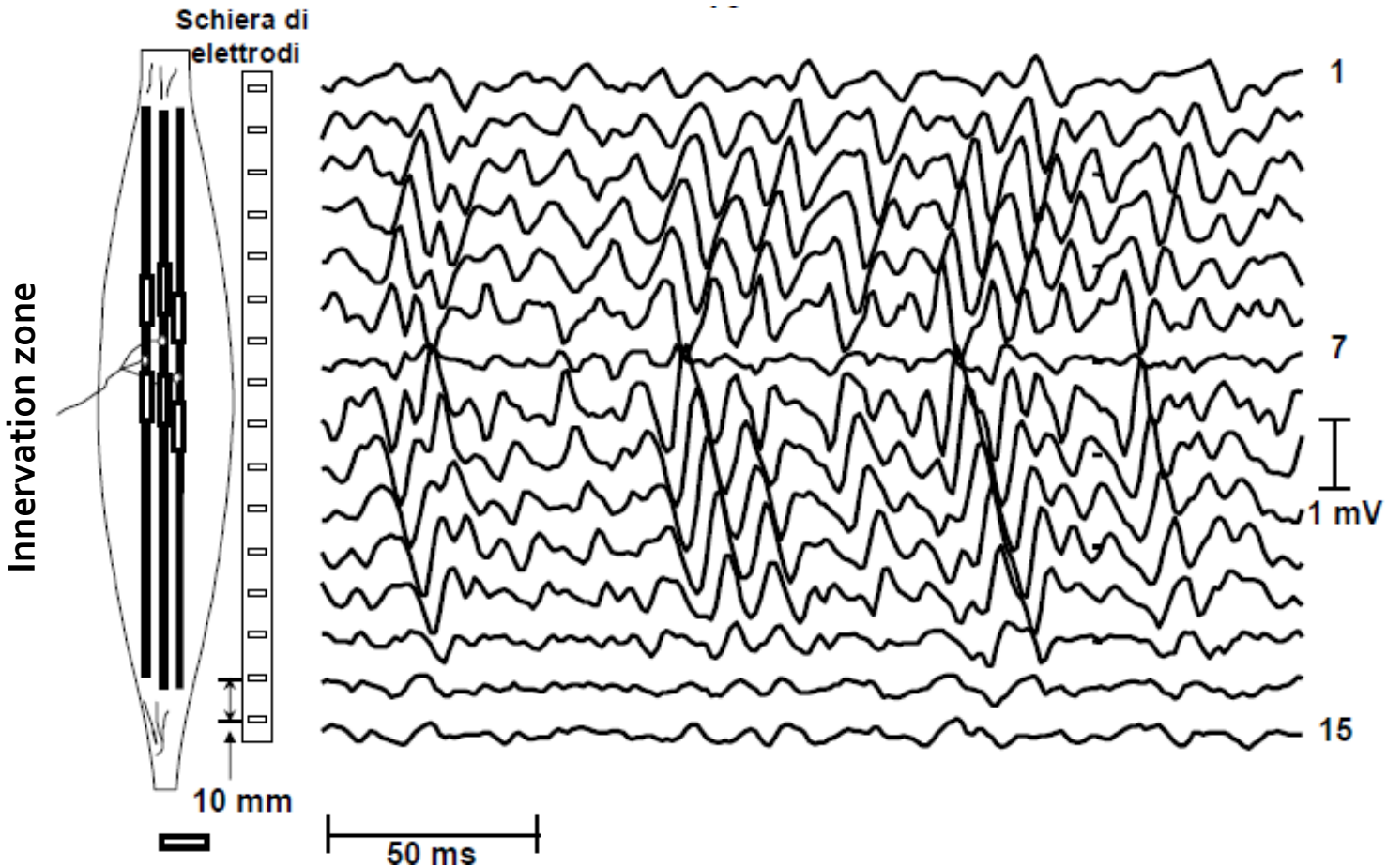


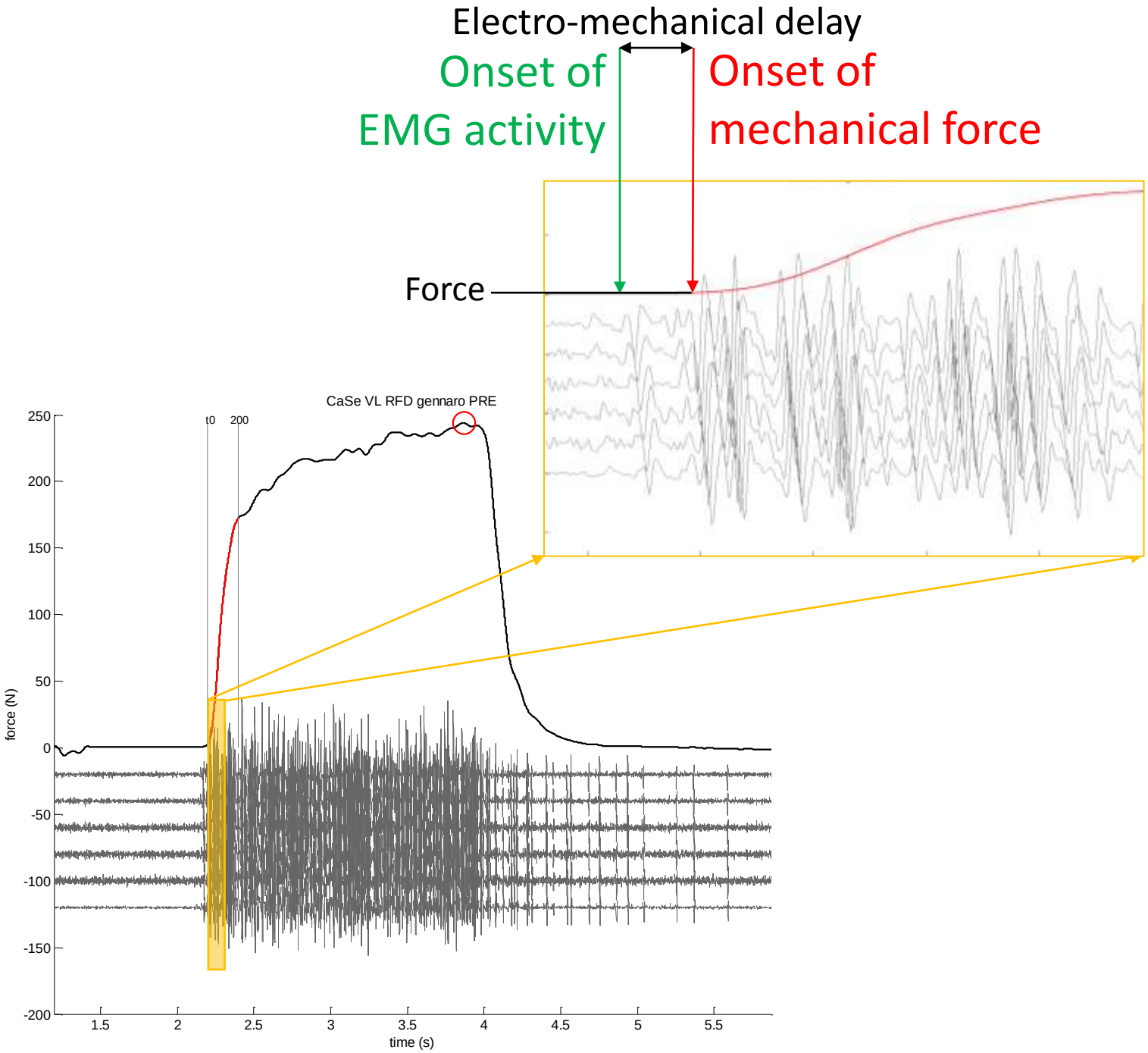
Muscle fiber conduction velocity



Muscle Fiber Conduction Velocity

It is related to the size of recruited muscle fibers




Electro-mechanical delay
Onset of EMG activity
Onset of mechanical force
Force
CaSe VL RFD gennaro PRE
t0
200
force (N)
time (s)
250
200
150
100
50
0
-50
-100
-150
-200
1.5
2
2.5
3
3.5
4
4.5
5
5.5

Superificial muscle stimulation

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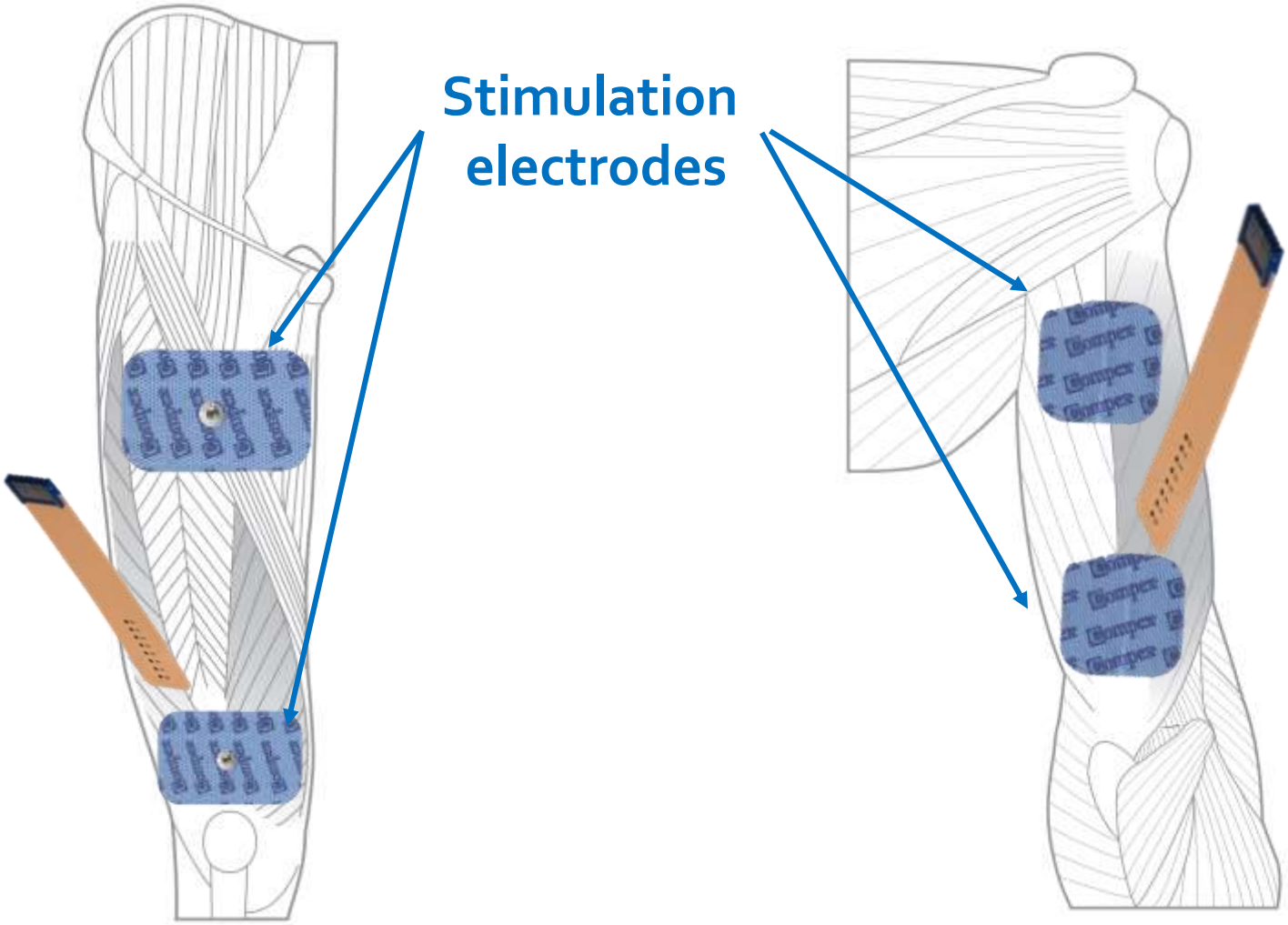
Knee extensors

Elbow extensors

Stimulation electrodes



Selecting the current stimulation intesity on the base of twitch amplitude

Twitch interpolation technique

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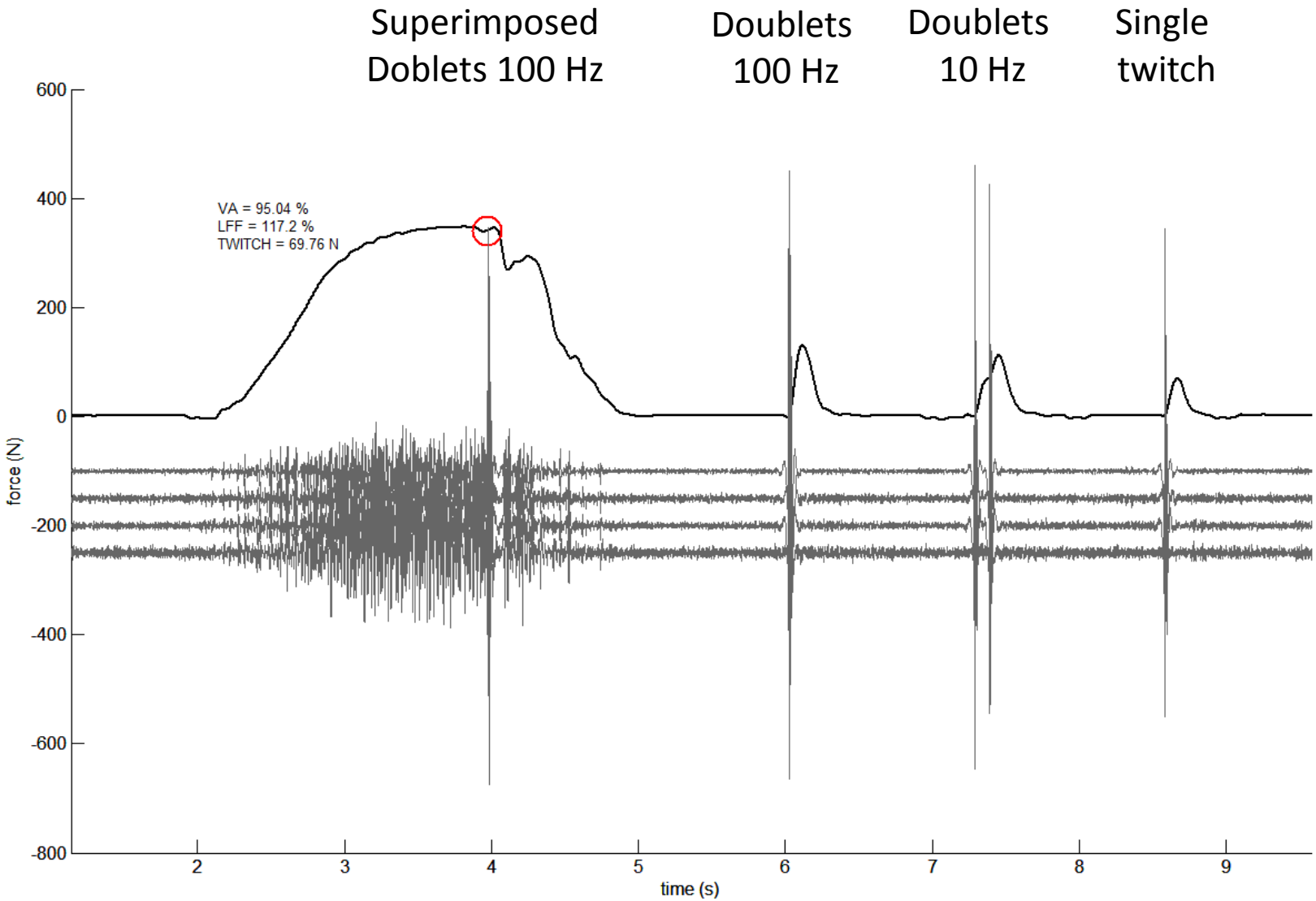
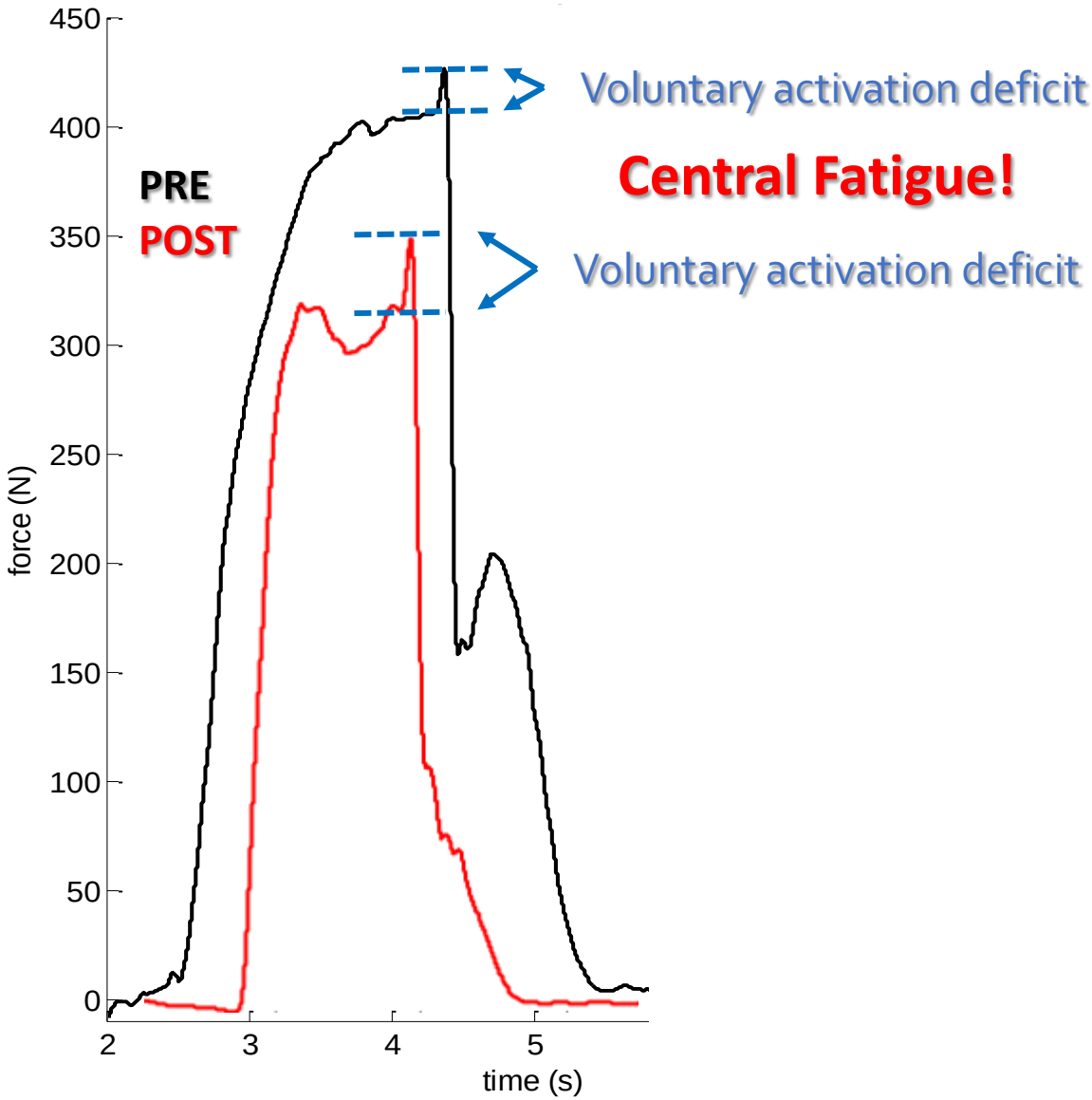

Superimposed Doblets 100 Hz
Doublets 100 Hz
Doublets 10 Hz
Single twitch
VA = 95.04 %
LFF = 117.2 %
TWITCH = 69.76 N
force (N)
600
400
200
0
-200
-400
-600
-800
2
3
4
5
6
7
8
9
time (s)

Twitch interpolation technique



Twitch interpolation technique

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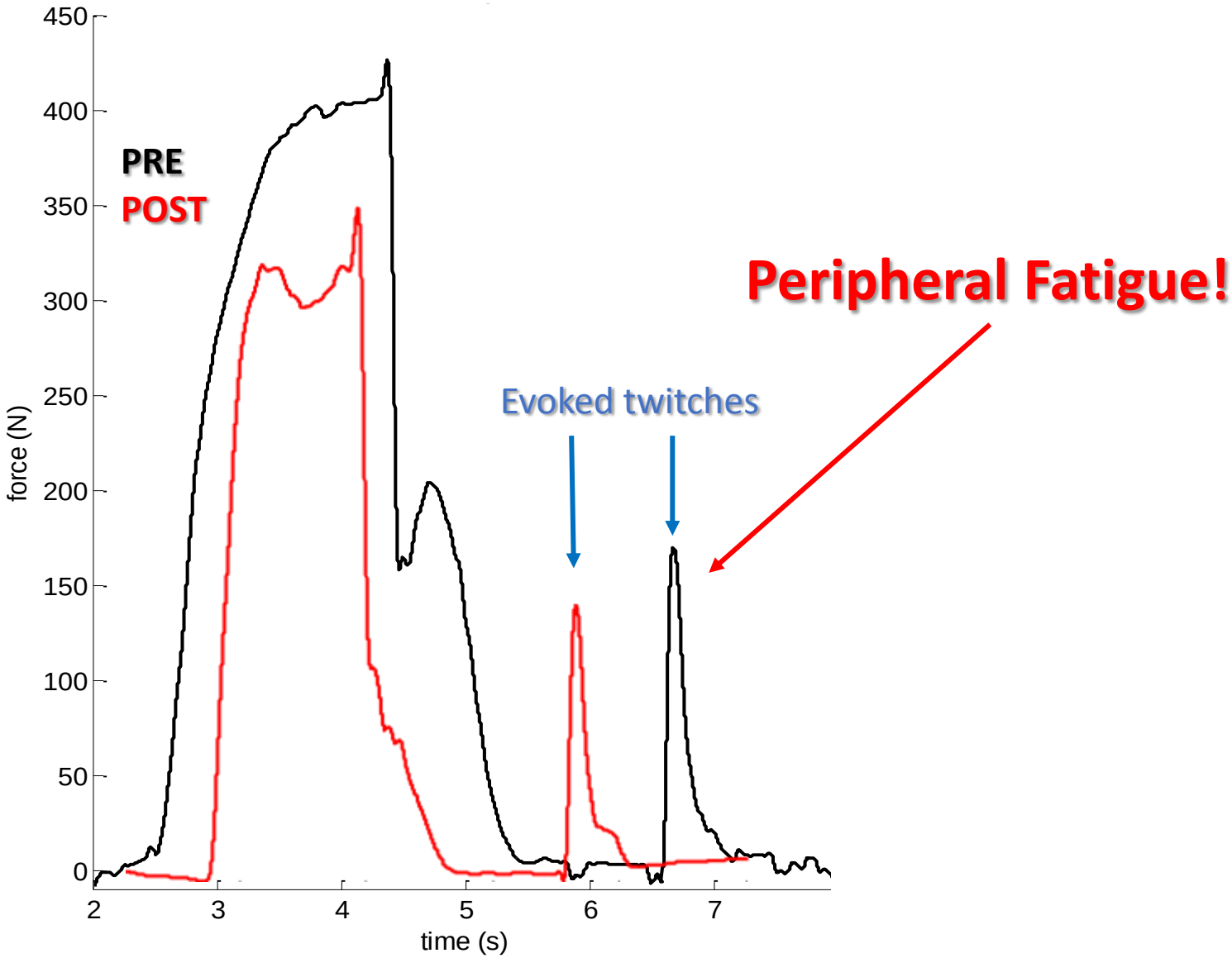
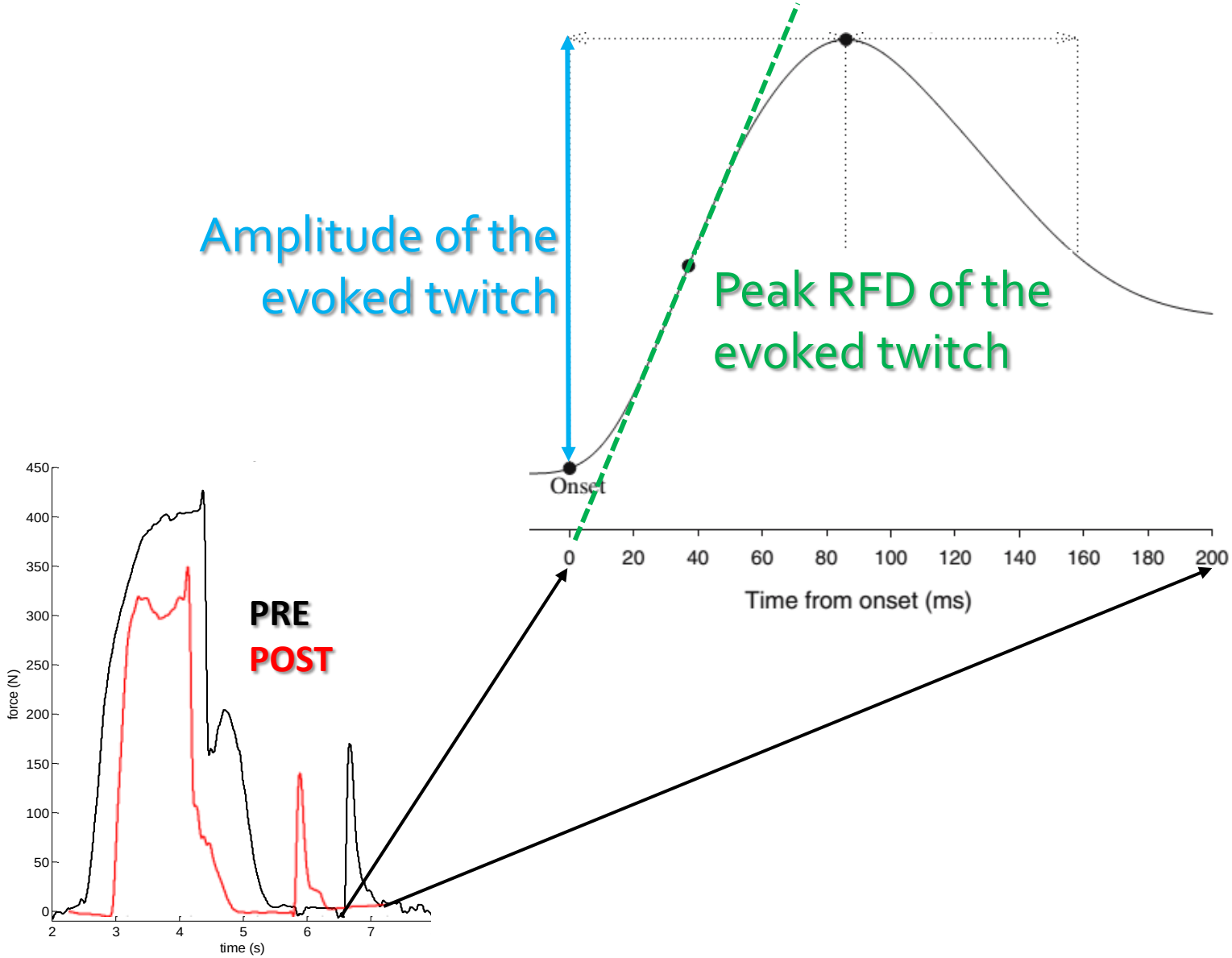


Evoked twitch



Generale and local fatigue perception

Borg scale CR-10

0	Assente	
0,3		
0,5	Estremamente lieve	Appena Percepibile
0,7		
1	Molto lieve	
1,5		
2	Lieve	Leggero
2,5		
3	Moderato	
4		
5	Forte	Intenso
6		
7	Molto forte	
8		
9		
10	Estremamente forte	"Massimo"
11		
↓		
•	Massimo in assoluto	Massimo Pensabile

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8		
9		
10	Estremamente forte	"Massimo"
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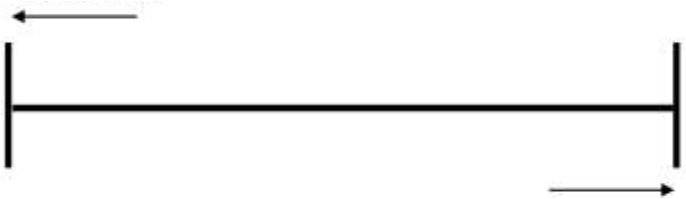
↯		
•	Massimo in assoluto	Massimo Pensabile

Visual Analogue Scales for upper and lower limbs



Internal and skin temperature

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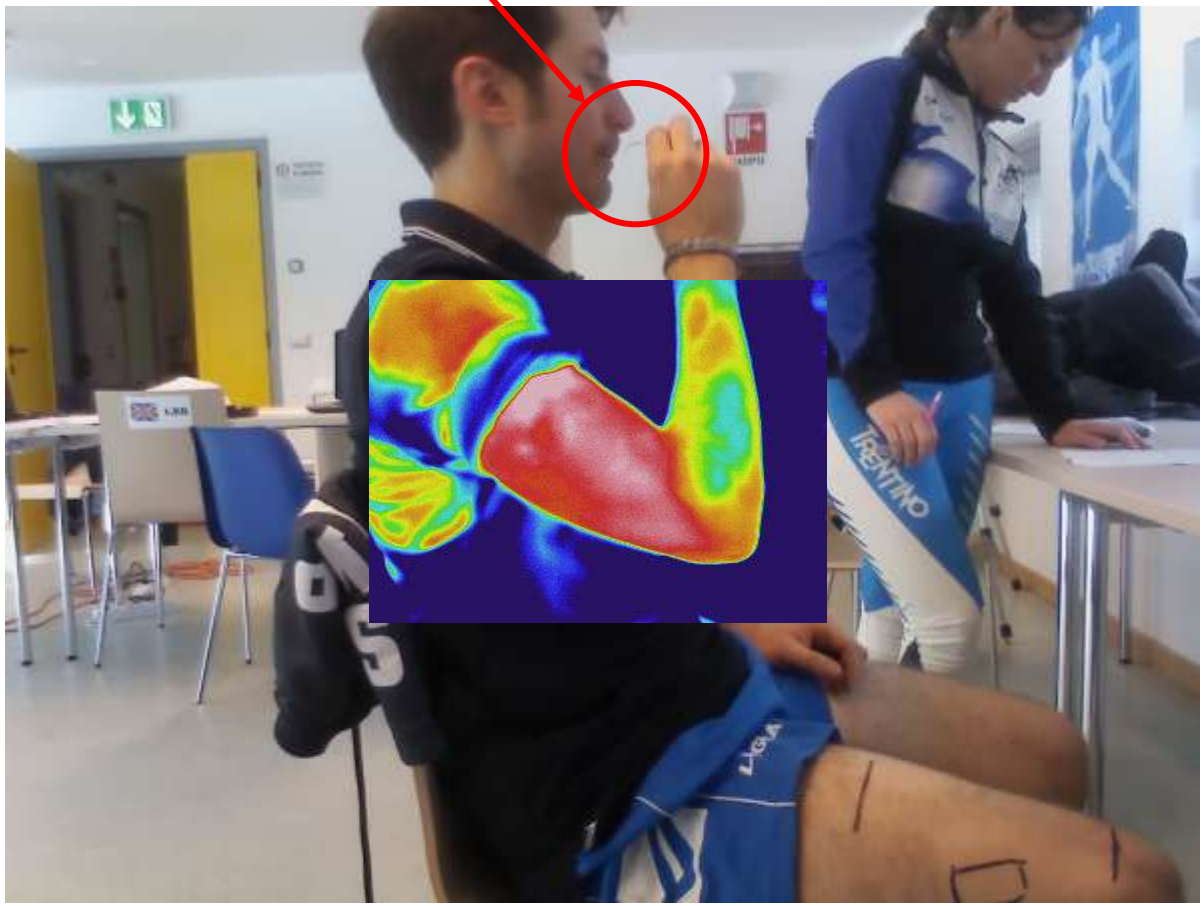
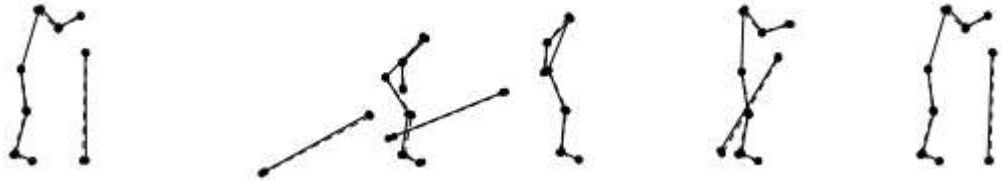


Techinques adopted during the race

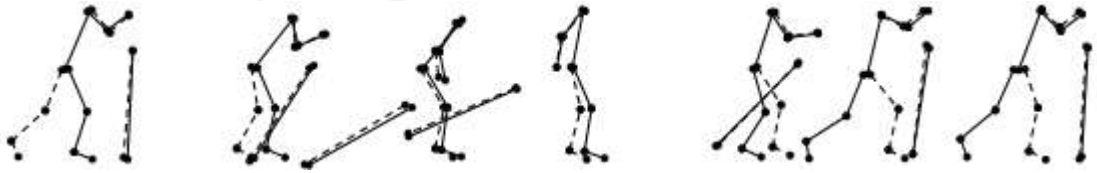
(estimated from a pattern recognition analysis based on an inertial platform mounted on the wrist)

Diagonal stride: 5±4% of time

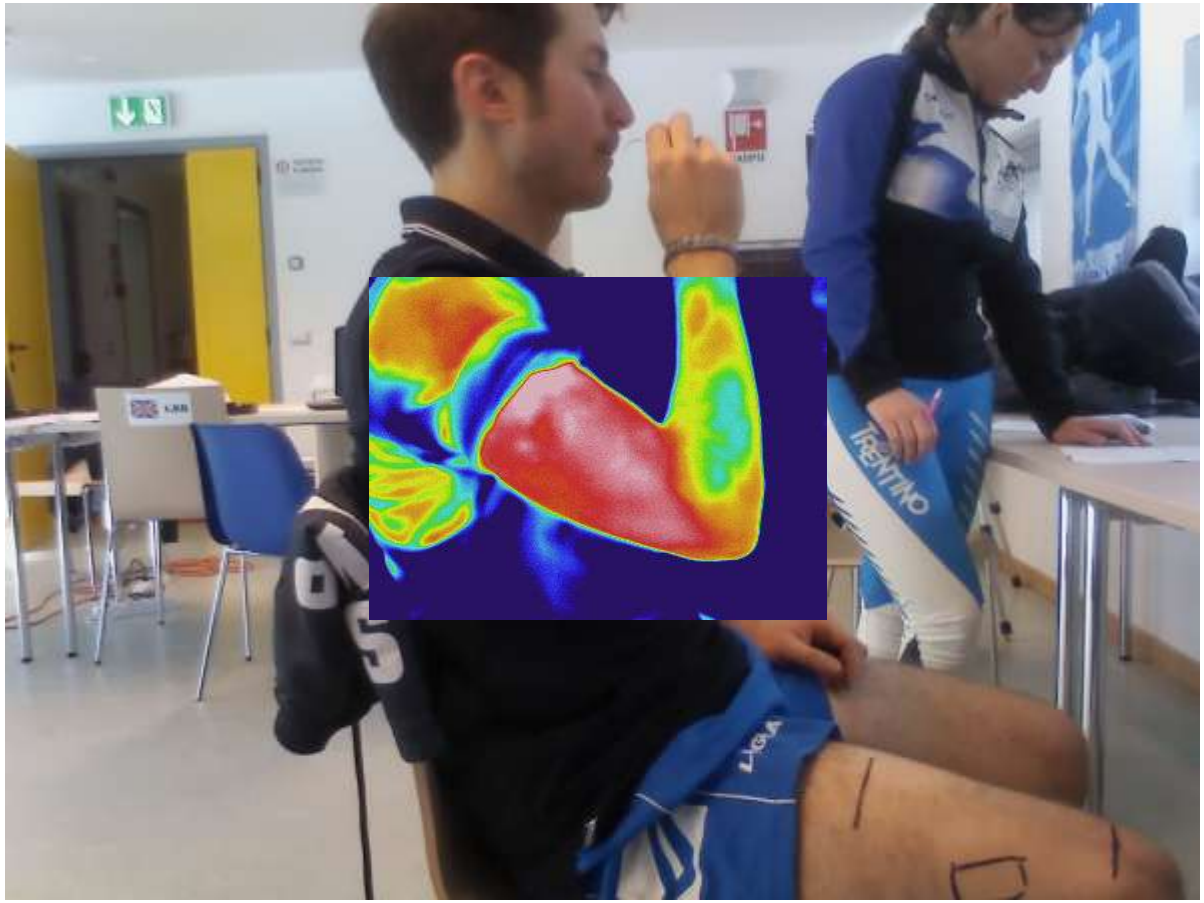
Double poling: 93±4% of time



Double poling with kick: 5±4% of time

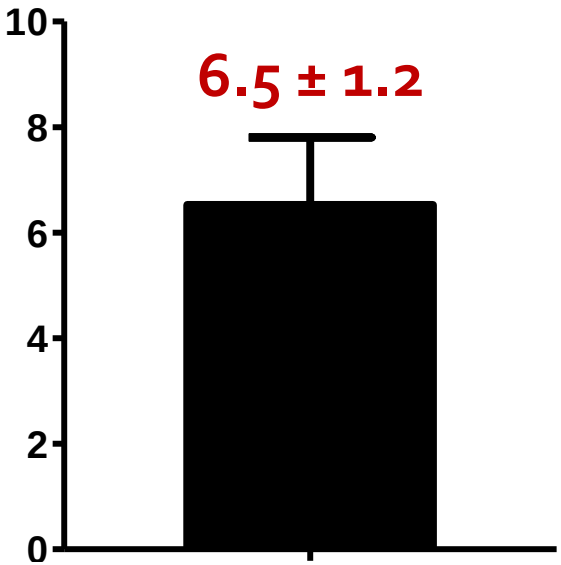


No difference in internal (about 36.5° C) and external temperature (about 28 °C) between PRE and POST

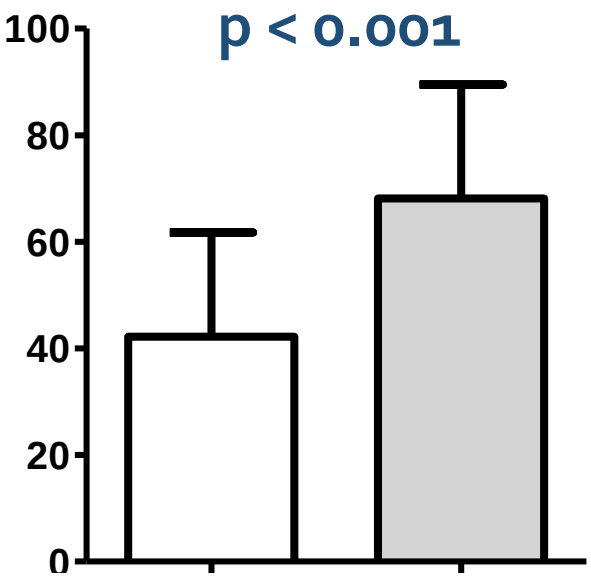


Fatigue perception: Greater in the UPPER LIMBS

General RPE



Visual analogue scales



Maximum voluntary contraction

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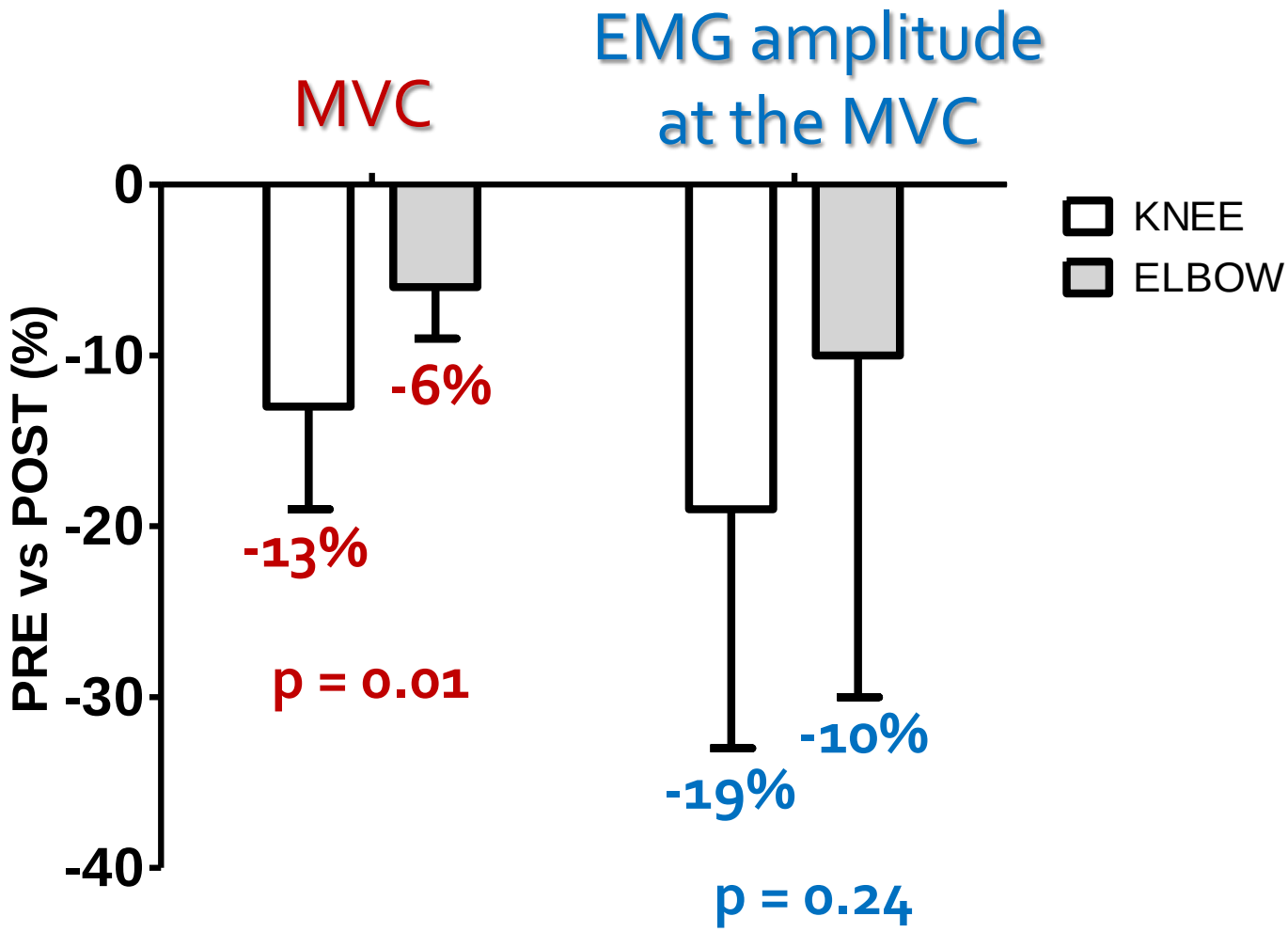

Rate of force development

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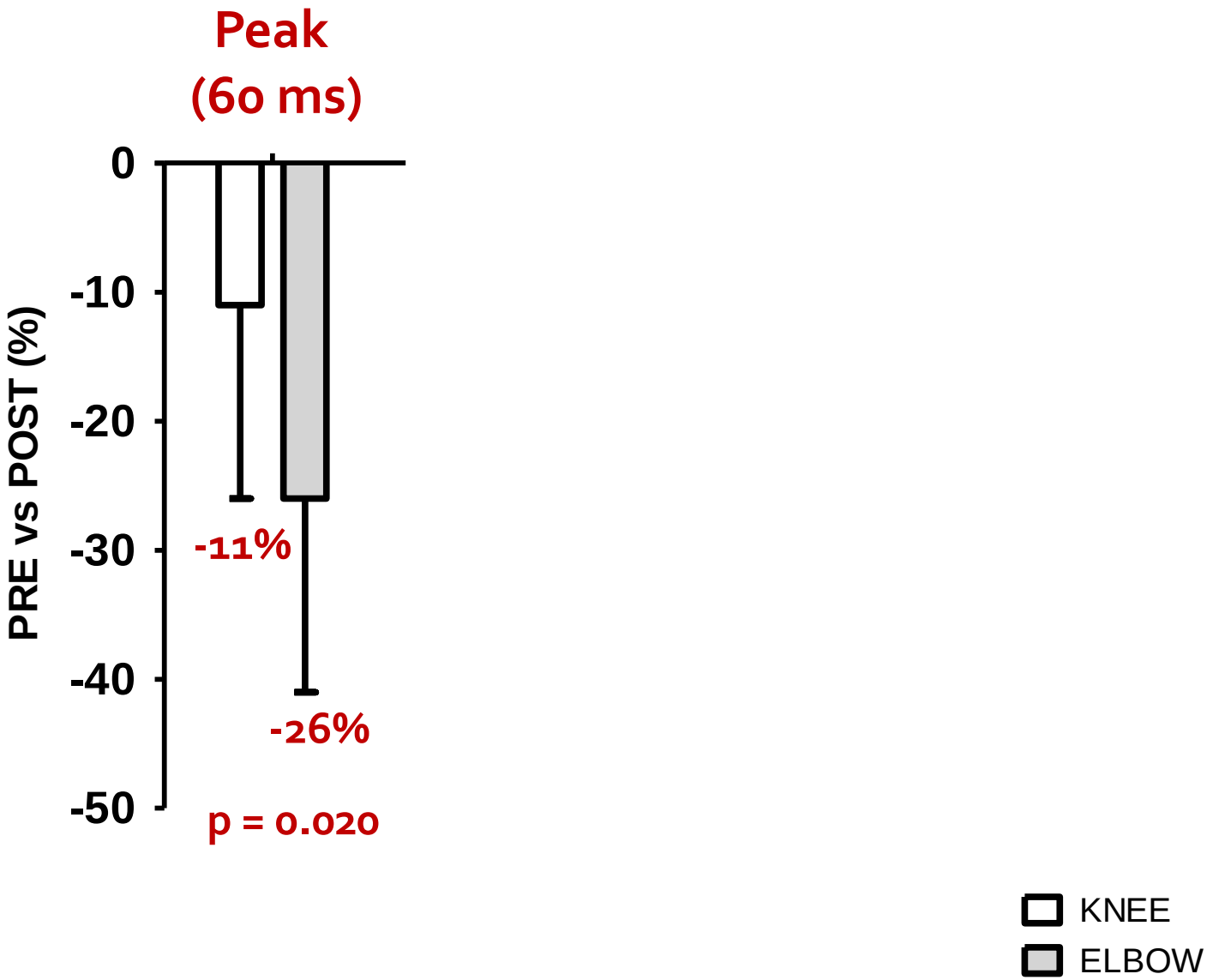

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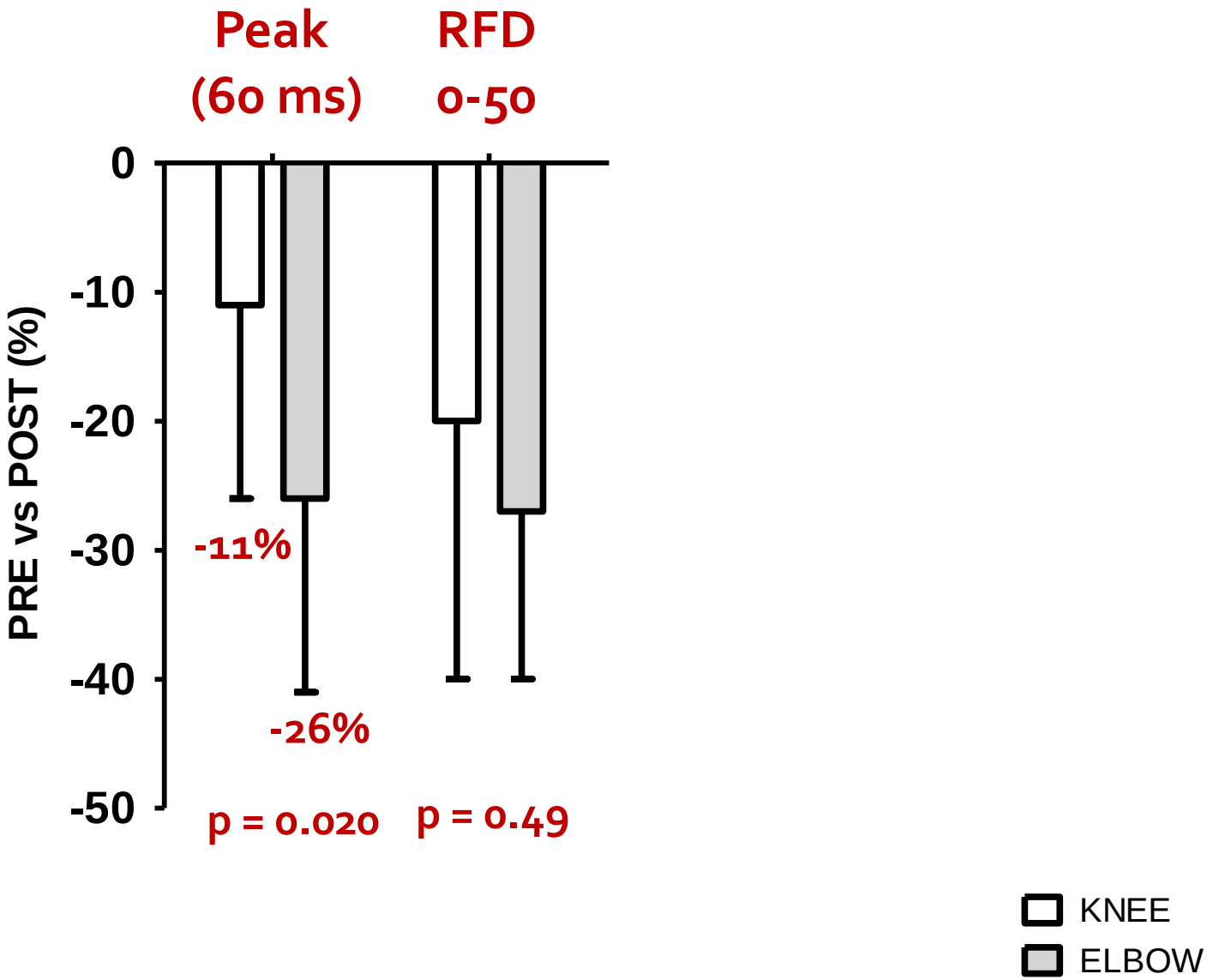

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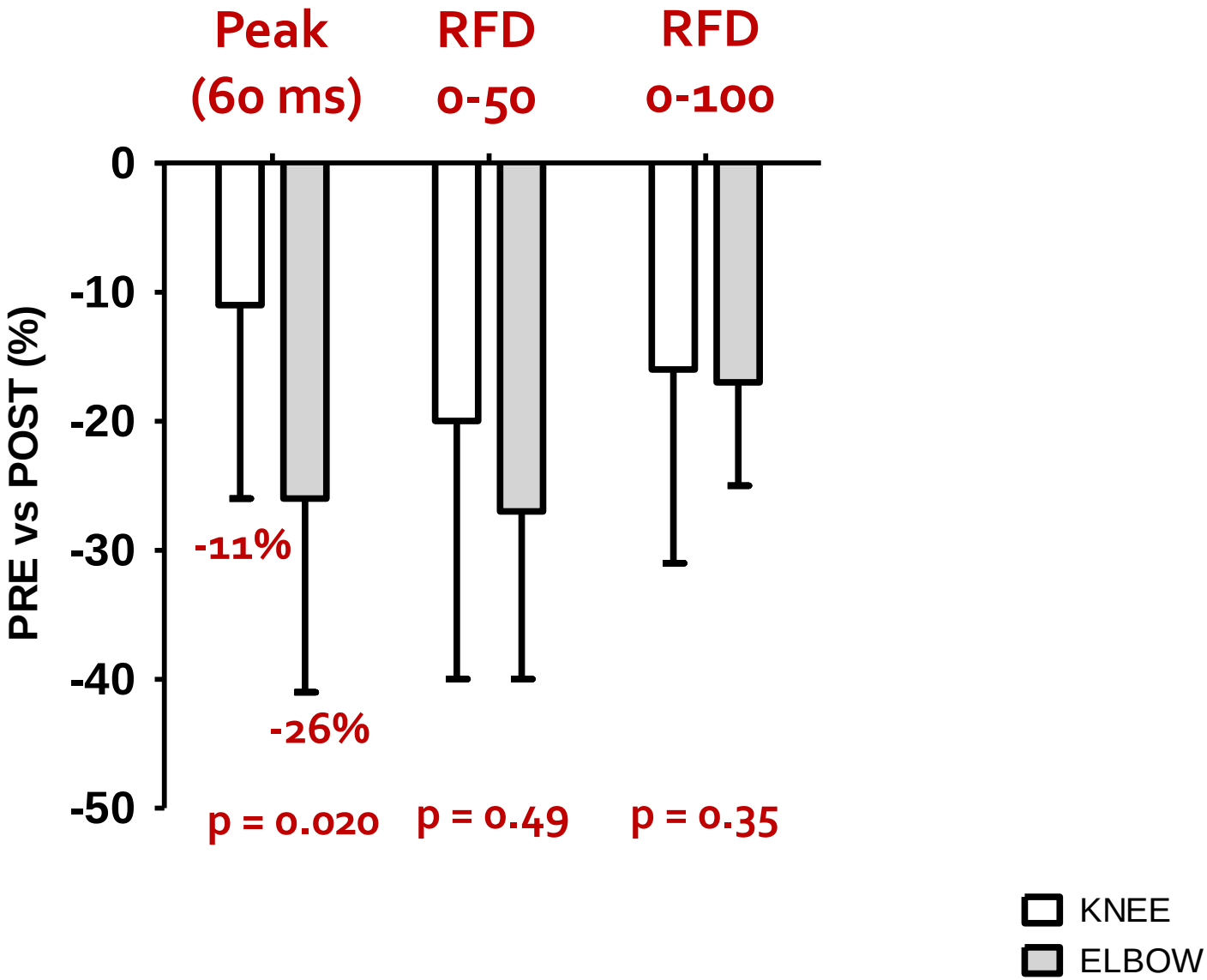

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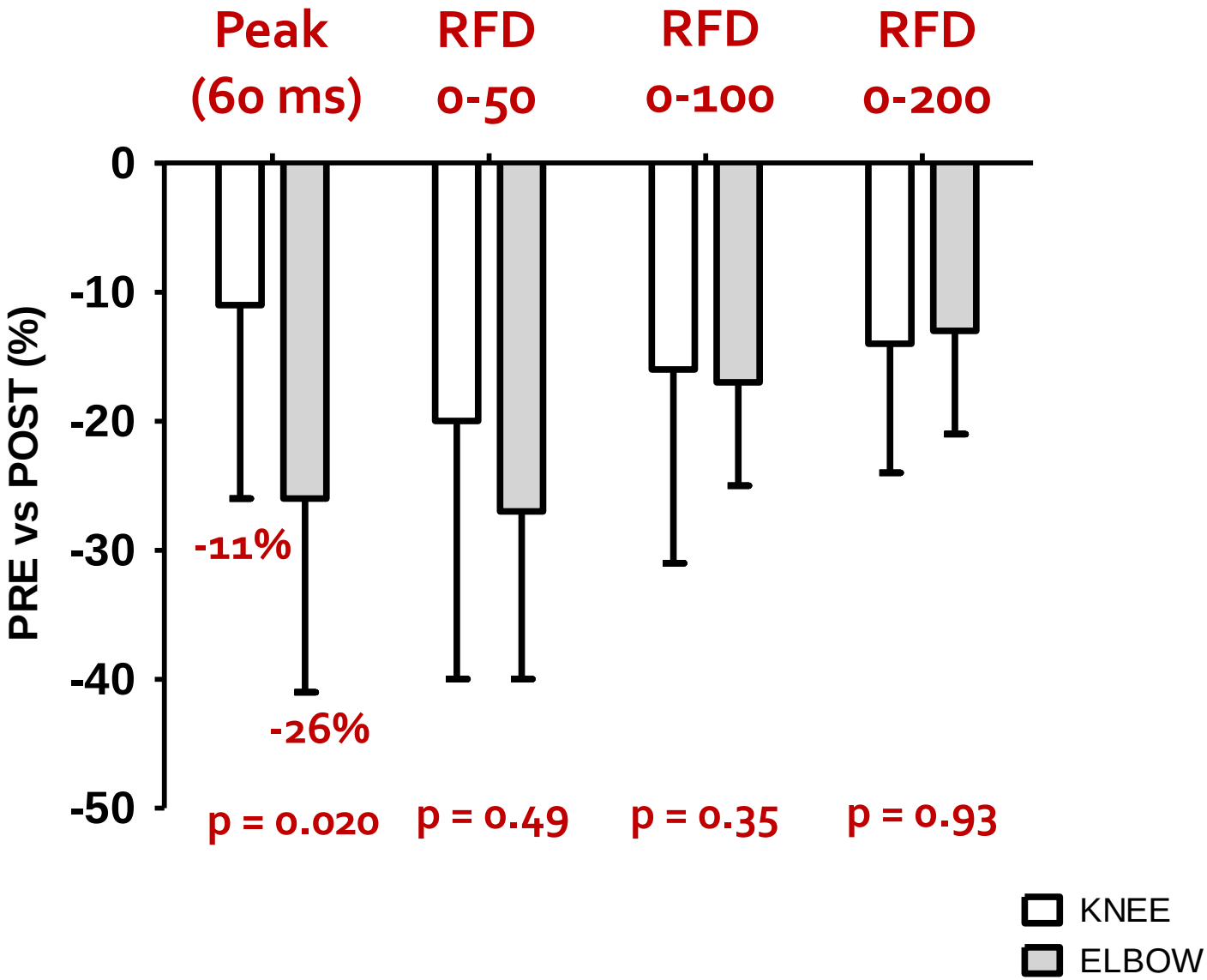

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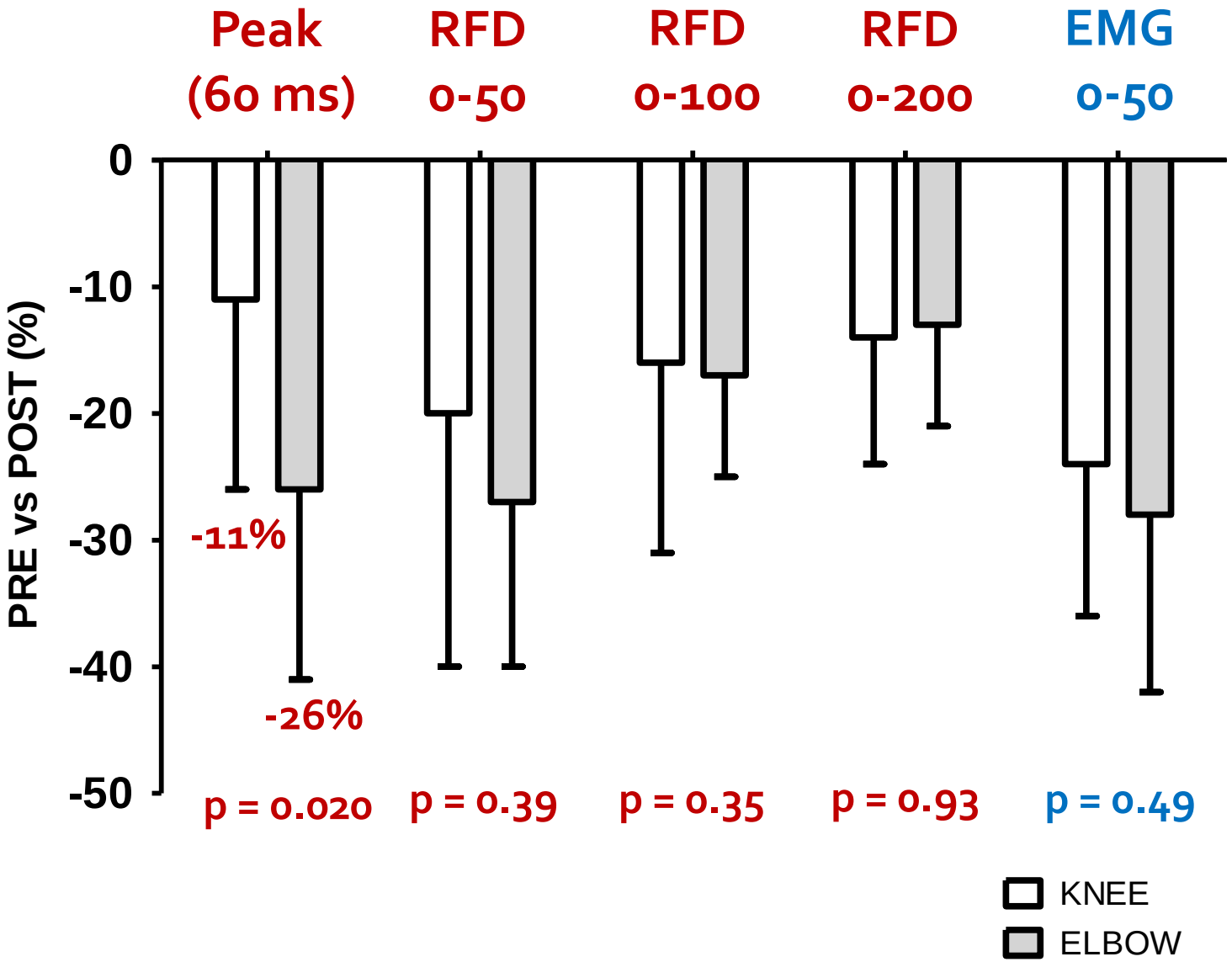

Central Fatigue

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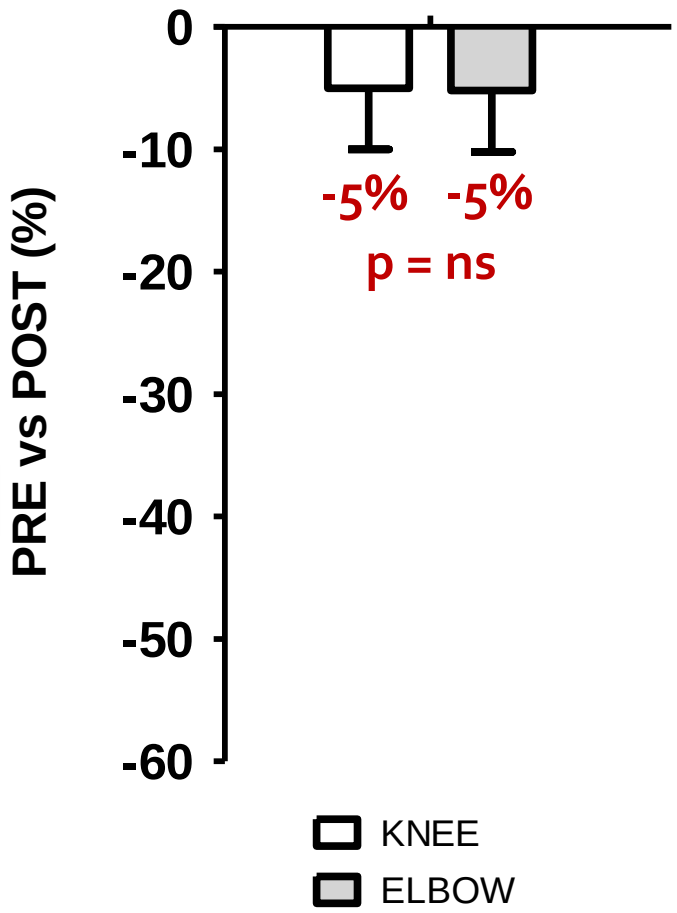
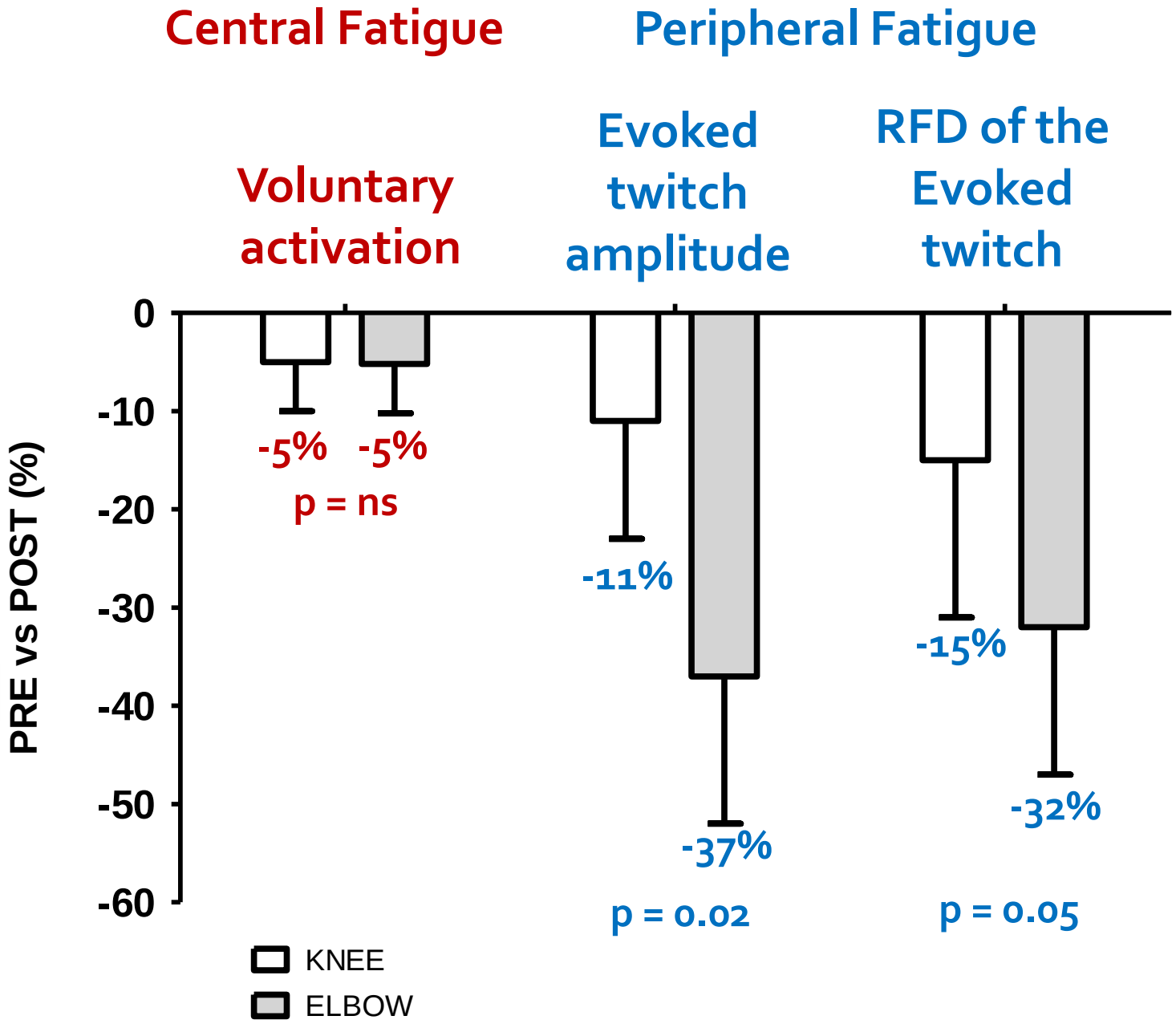
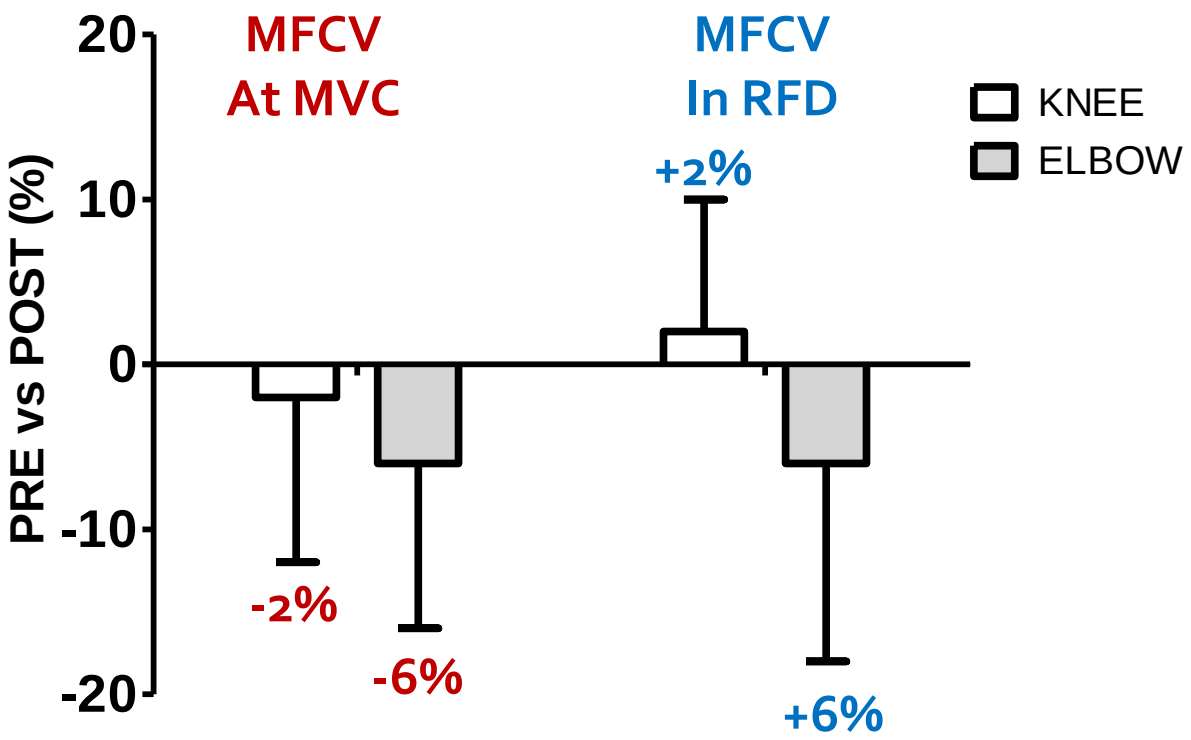
Voluntary activation




Central Fatigue
Peripheral Fatigue
Voluntary activation
Evoked twitch amplitude
RFD of the Evoked twitch
PRE vs POST (%)
0
-10
-20
-30
-40
-50
-60
-5%
-5%
p = ns
-11%
-37%
p = 0.02
-15%
-32%
p = 0.05
KNEE
ELBOW

Muscle Fiber Conduction Velocity: decreased only in ELBOW EXTENSORS



Differences between MVC and RFD

- Different recovery time between RFD and MVC (Molina 2012)
- **Muscle acidosis is expected to reduce the RFD, but not necessarily MVC**, because:
  - significantly reduces muscle fiber conduction velocity (Brody 1991)
  - Muscle fiber velocity of shortening (Knuth 2006)

Summary

	Knee extensors	Elbow extensors
MVC	-13%	-6%
Peak RFD	-10%	-26%
Central Fatigue	5%	5%
Peripheral Fatigue	10%	37%

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1. Importance to test elbow extensors in cross country studies → no single muscle study!

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1. Importance to test elbow extensors in cross country studies → no single muscle study!

2. RFD and MVC are not interchangeble

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1. Importance to test elbow extensors in cross country studies → no single muscle study!
2. RFD and MVC are not interchangeble
3. Only the early phase of RFD (≤ 100ms) was affected (only in elbow extensors)

Conclusions

1. Importance to test elbow extensors in cross country studies → no single muscle study!
2. RFD and MVC are not interchangeble
3. Only the early phase of RFD (≤ 100ms) was affected (only in elbow extensors)
4. Speculation: peripheral fatigue likely to influence most the RFD (in the elbow extensors) than MVC

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Thank you for your attention!

12/11/2015 – Rovereto

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