Effect of pedaling cadence on physiological responses and neuromuscular fatigue during a single interval-training session

Sébastien DUC, Jeremie ALLINGER, Stéphane VERRIER

Laboratory of Performance, Health, Metrology and Society, University of Reims Champagne Ardennes, Reims, France

- NMF corresponds to a failure to maintain or develop an expected force or PO

(Millet et al. 2004)

peripheral fatigue (muscular)

central fatigue (neural)

↘ contractile properties of muscle fibbers

↘ twitch response

↘ central drive

↘ voluntary activation

↘ MVC force

- CAD influences cardiovascular responses (VO_2, HR) and MU recruitment during prolonged intense cycling exercise (e.g. 30 min @ 80% PPO) **but no central and peripheral NMF**

(Ahlquist et al., 1992; Lepers et al., 2001 ; Sarre et al., 2008; Theurel et al., 2008)

Effect of CAD during a intermittent prolonged intense cycling exercice (e.g. IT session) has never been studied

To compare the physiological responses and NMF during a single IT session performed with 3 different CAD (low – medium – high)

Hypothesis :

1) **High CAD induces higher physiological stress (HR) while low CAD results in higher muscular recruitment**
2) **Peripheral fatigue is higher with low CAD compare to high CAD but central fatigue does not differ**

9 trained male cyclists and triathletes

Caracteristics of participants	
Age (yrs)	23.3 ± 6.3
Heigh (m)	1.81 ± 0.04
Body mass (Kg)	69.1 ± 5.3
PPO (W) PPO (W/kg)	363 ± 35 5.28 ± 0.56
HR peak (bpm)	189 ± 9
Training volume (h/wk)	9.8 ± 1.8

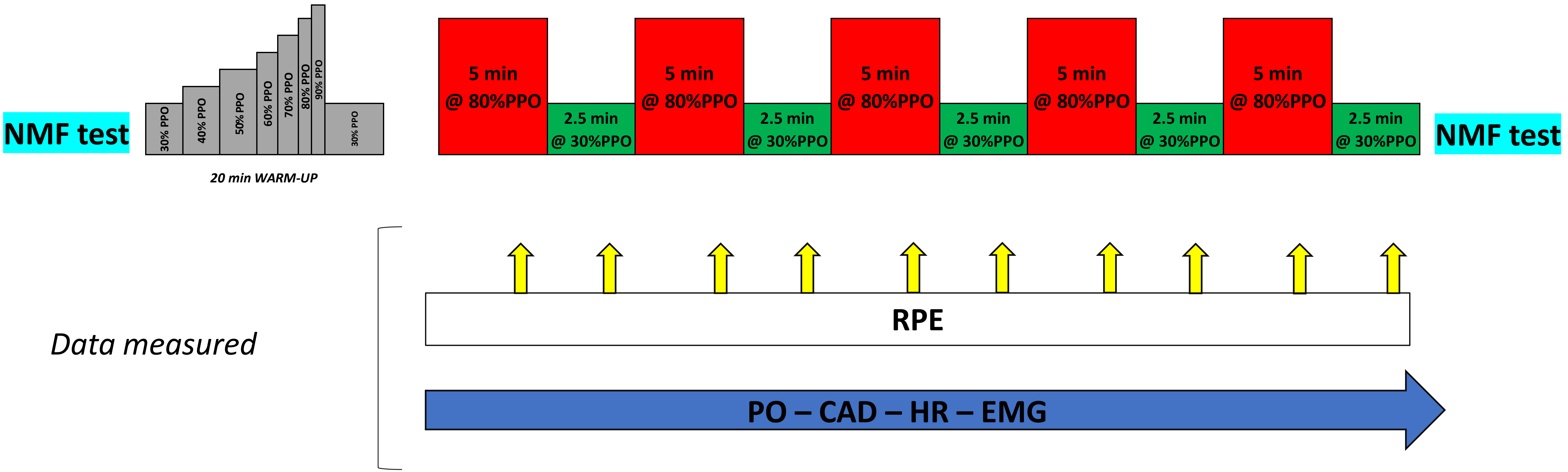
Hammer H3 direct-drive trainer
Reliable and reproductible

Lillo Bevia et al. 2018
Duc et al. 2019

3 IT sessions separated by at least 2 days

60 – 90 – 110 rpm in a randomized order

80% PPO	30%PPO
=	=
291 ± 29 W	107 ± 10 W
4.19 ± 0.45 W/kg	1.5 ± 0.2 W/kg

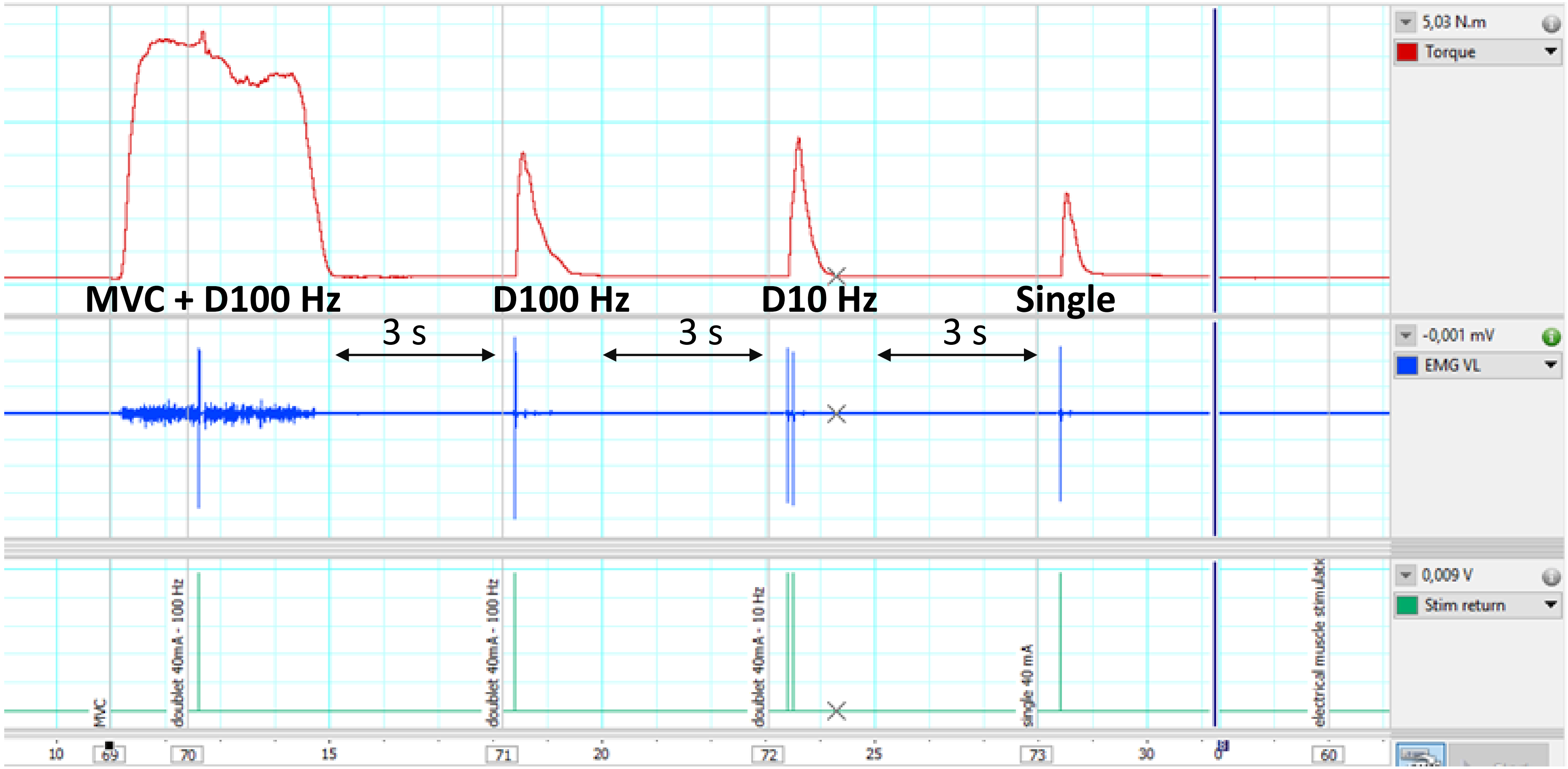


Neuromuscular fatigue (NMF) test

- ✓ Electrical stimulation with optimal intensity
- ✓ 3 repetitions of below sequence (1 min rest)

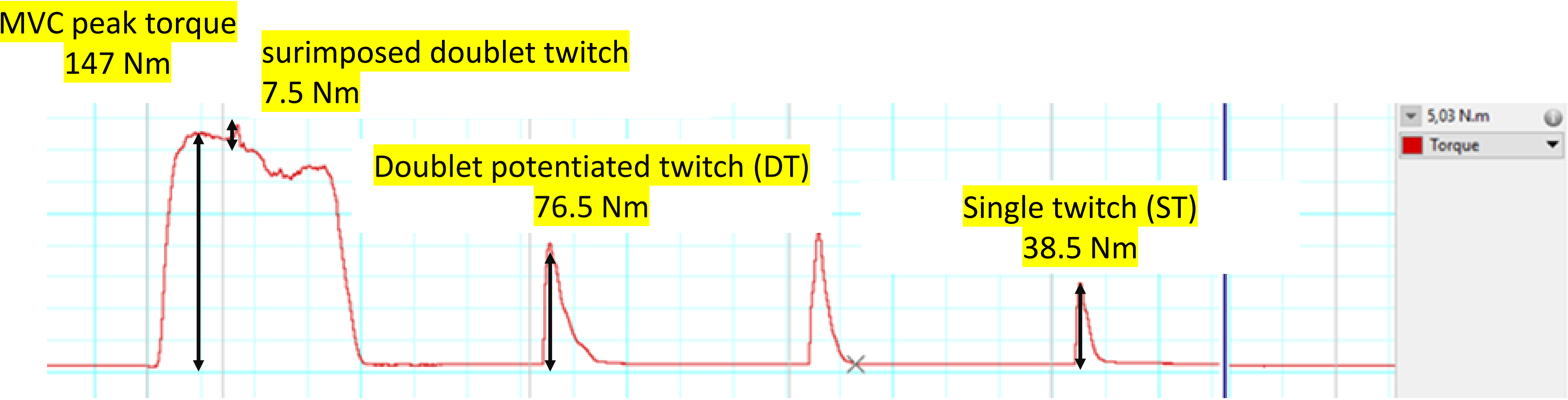
Contrex-2 isokinetic ergometer

Digitimer stimulator




APS
Reims
PHYSIOMED
PHYSIOMED

Neuromuscular fatigue (NMF) data analysis

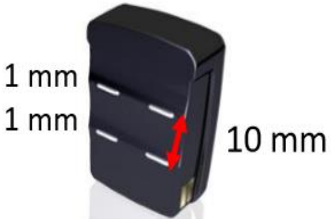


$$\textbf{\% VAL} = \left(1 - \frac{\textit{surimposed twitch amplitude}}{\textit{DT amplitude}}\right) \times 100 = \left(1 - \frac{7{,}5}{76{,}5}\right) \times 100 = 90\ \%$$

Data collection

- PO, CAD, HR (every 1 s)
- RPE 6-20 Borg's scale
- EMG activity at 2000 Hz

Wireless Trigno Sensor
(Delsys**)**



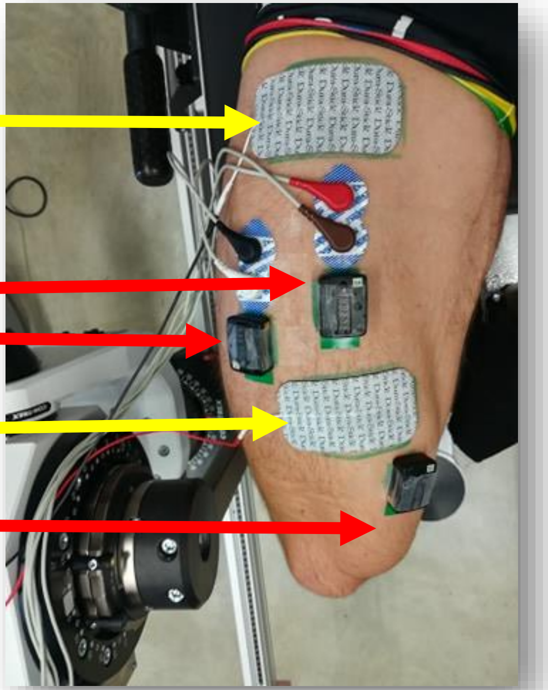
Electrode stimulation (anode)

Rectus Femoris (RF)

Vastus Lateralis (VL)

Electrode stimulation (cathode)

Vastus Medialis (VM)



Biceps Femoris (BF)

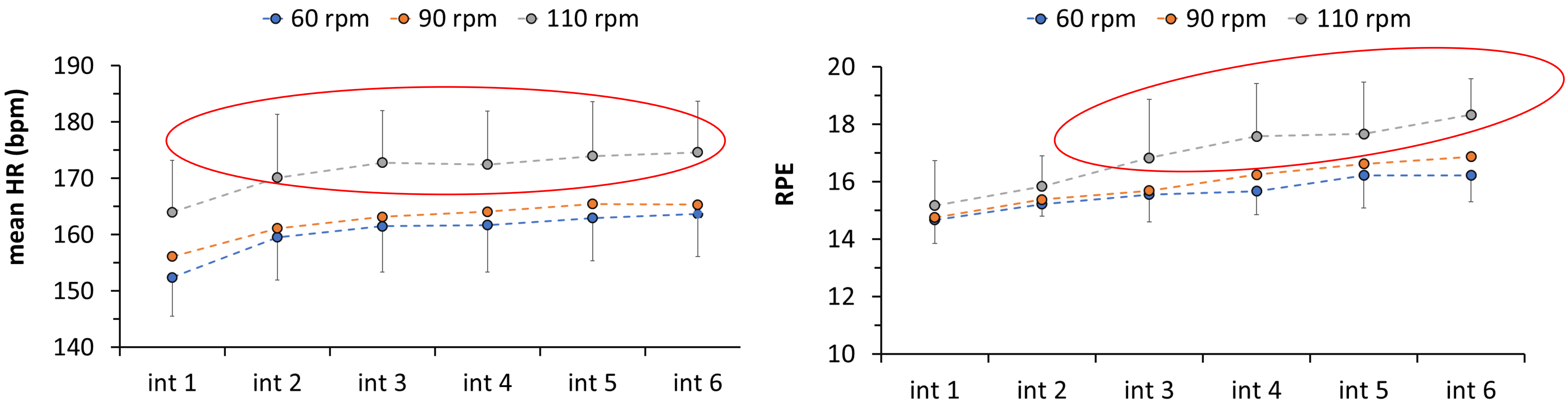
Data analysis

- Mean value of PO, CAD, HR and EMG computed over each interval of 5 min
- EMG normalised to mean RMS measured at 90% PPO (during warm-up)

Statistics

- ANOVA repeated measures tests compare physiological and EMG variables between 3 CAD
- Student`s paired t-tests to compare NMF variables before and after IT
- $p < 0.05$

Physiological responses during the IT sessions



Using high CAD involves higher HR and RPE (in accordance with Lepers et al. 2001)

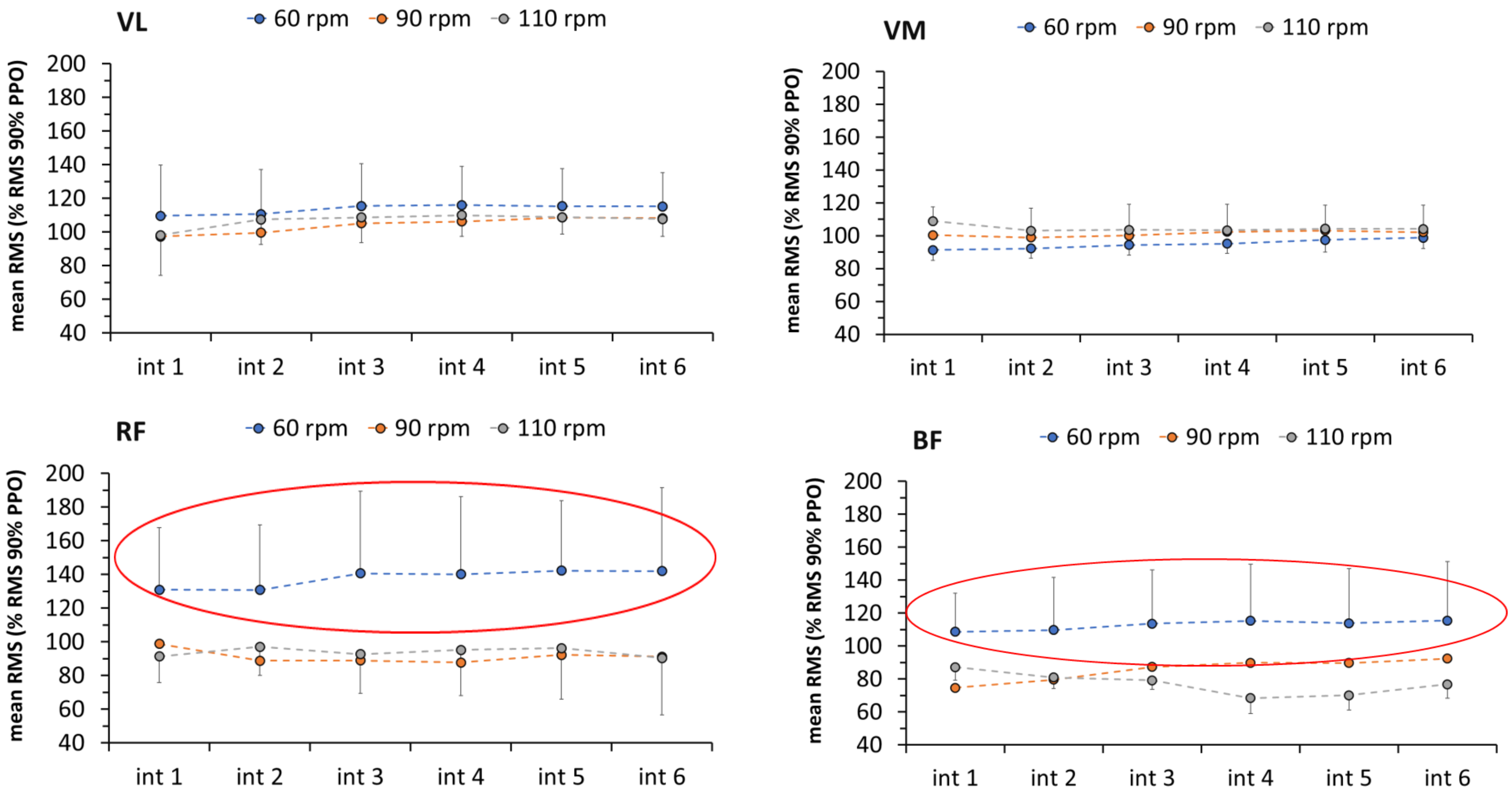
↗ cardiovascular stress

Physiological responses during the IT sessions

HIIT session	60 rpm	90 rpm	110 rpm
Work intervals			
CAD (rpm)	58 ± 3	90 ± 3	108 ± 7
Mean HR (bpm)	160 ± 8	163 ± 10	171 ± 9*
Mean HR (% HR max)	85 ± 3	86 ± 5	90 ± 2*
Peak HR (bpm)	174 ± 7	173 ± 9	182 ± 11
Peak HR (% HR max)	92 ± 3	92 ± 4	96 ± 3
Mean RPE	15.6 ± 0.7	15.9 ± 0.7	16.9 ± 1.5
Recovery periods			
Mean HR (bpm)	141 ± 9	137 ± 11	149 ± 12*
Mean HR (% HR max)	74 ± 4	73 ± 5	79 ± 5*
Mean RPE	9.3 ± 1.6	9.8 ± 1.8	10.3 ± 2.4

** Significant difference compared to 60 rpm*

EMG responses during the HIIT sessions



Using low CAD results in higher flexor muscles activity
…to pull more on the pedal ?

UNIVERSITÉ DE REIMS CHAMPAGNE-ARDENNE
STAPS Reims
PSMS Performance Santé Métrologie Société

EMG responses during the HIIT sessions

HIIT session	60 rpm	90 rpm	110 rpm
Mean normalized RMS (% RMS of 90% PPO)			
VL	114 ± 24	104 ± 9	107 ± 13
VM	95 ± 6	101 ± 8*	105 ± 14*
RF	138 ± 43	91 ± 16*	94 ± 5*
BF	113 ± 32	86 ± 23*	77 ± 18*

** Significant difference compared to 60 rpm*

Using low CAD results in higher recruitment of the flexors muscle <u>while</u> high CAD slightly increased VM activity

MVC : maximal voluntary contraction
VA : voluntary activation level
DT : Doublet Twitch amplitude
ST : Single Twitch amplitude

NMF test variables

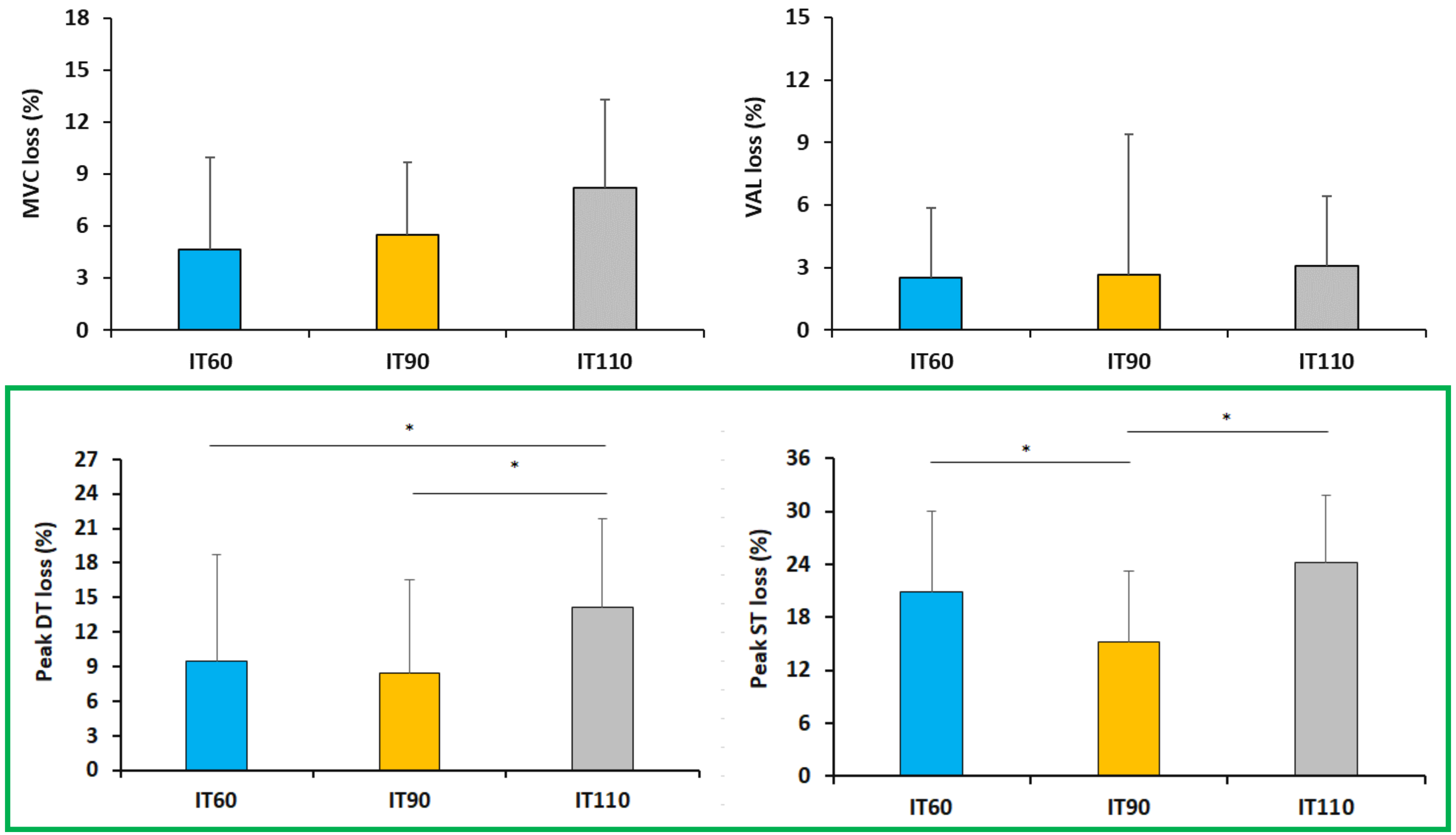
HIIT session	60 rpm		90 rpm		110 rpm	
NMF test	Before	After	Before	After	Before	After
MVC (Nm)	213 ± 48	↘ 203 ± 46#	205 ± 45	↘ 194 ± 43#	219 ± 53	↘ 200 ± 46#
Central fatigue VAL (%)	93 ± 4	91 ± 5	93 ± 3	90 ± 4	95 ± 3	92 ± 3
Peripheral fatigue DT (Nm)	76 ± 15	↘ 69 ± 11#	68 ± 8	↘ 62 ± 7#	79 ± 17	↘ 67 ± 14#
Peripheral fatigue ST (Nm)	53 ± 8	↘ 41 ± 3#	48 ± 7	↘ 40 ± 6#	54 ± 8	↘ 41 ± 6#

 # Significant difference compared to Before

↘ MVC is due to peripheral fatigue <u>but</u> no central fatigue

(≠ Lepers et al. 2001) →≠ quadriceps ES vs motor nerf ES

NMF test variables



Peripheral fatigue is greater with the use of low or high CAD

… slow and fast fibers are more fatigued? (≠ Lepers et al. 2001)

- ✓ **Using high CAD during a IT session (6 x 5 min @80% PPO) induces higher cardiovascular stress while low CAD increases flexor activity**
- ✓ **Both CAD involve higher peripheral fatigue (compared to 90 rpm)**
- ✓ **Intermittent intense cycling exercise seems do not induce central fatigue**

Practical application

- Performing IT with extreme CAD to increase training load

Perspectives

- Assessment of NMF of hamstrings