Are motor-related electro-cortical markers modulated by an acute endurance exercise?

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INTRODUCTION

Self-initiated voluntary movements are preceded by a low frequency (<5Hz) brain activity that occurs about 1.5 seconds before the onset of movement. This Movement-Related Cortical Potential (MRCP), also known as Readiness Potential (RP), reflects the neural process involved in preparing and executing the motor command (Deecke, 1996; Shibasaki and Hallet, 2006).

After repetitive simple-task contractions, some authors have observed an increase in MRCP amplitude negativity (Johnston and Slobounov, 2001, Shillings et al. 2006). However, motor cortex excitability could be influenced differently between sustained single-joint contractions and locomotor exercises (Sidhu et al. 2012).

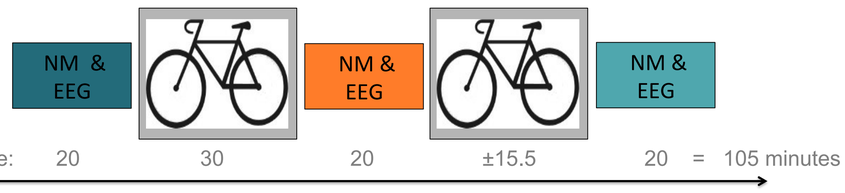
Thus, we aim to investigate the effect of a whole-body exercise on pre-motor potential associated with fatigue-related neuromuscular measures.

PURPOSE

To investigate the effect of an endurance exercise, leading to global physical fatigue, on MRCP modulations.

METHOD

Sixteen well-trained athletes (29±7 years; 63.8±5.8 VO_2max; 385±47 maximal aerobic power) performed a submaximal cycling exercise during 30 minutes, followed by a 10 kilometer time trial. Neuromuscular and EEG data were collected before, between, and after exercise.



Neuromuscular data (NM)

Subjects performed 2 maximal isometric contractions of the knee extensor, surimposed by a 100Hz paired stimuli during the plateau and at rest (interpolated twtich technique).

NM components

Force:	Maximal voluntary force
VAL:	Voluntary activation level
P100Hz:	Paired stimuli force at 100Hz

EEG data

Surface EEG (64-e) was recorded during 60 self-paced leg extensions at 15% of the maximal force. MRCP was segmented and averaged into non-overlapping epochs from 2500 ms before and 500 ms after movement onset.

MRCP components

Early RP:	From -1500 to -1000 ms
Late RP:	From -1000 to -500 ms
NS:	From -500 to movement onset (negative slope)
MP:	Motor potential (=peak amplitude)

RESULTS

1. NEUROMUSCULAR

Compared to pre-exercise, the exercise induced significant (*p<0.5) **physical fatigue, resulting in a reduction in the maximal voluntary force** (Figure 1)**.** This global fatigue is associated with a **reduction in the paired stimuli force** (Figure 2)**,** and to a lesser extend to a **reduction in the voluntary activation level** (Figure 3)**.**

Fig. 1

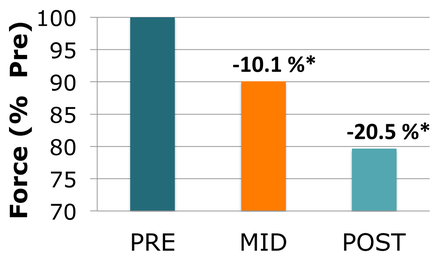


Fig. 2

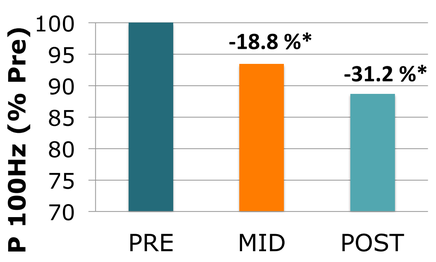
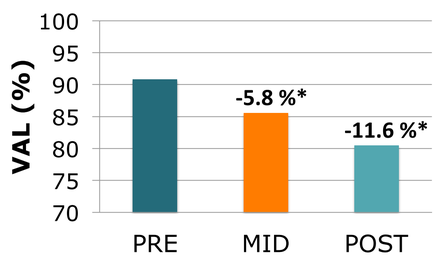
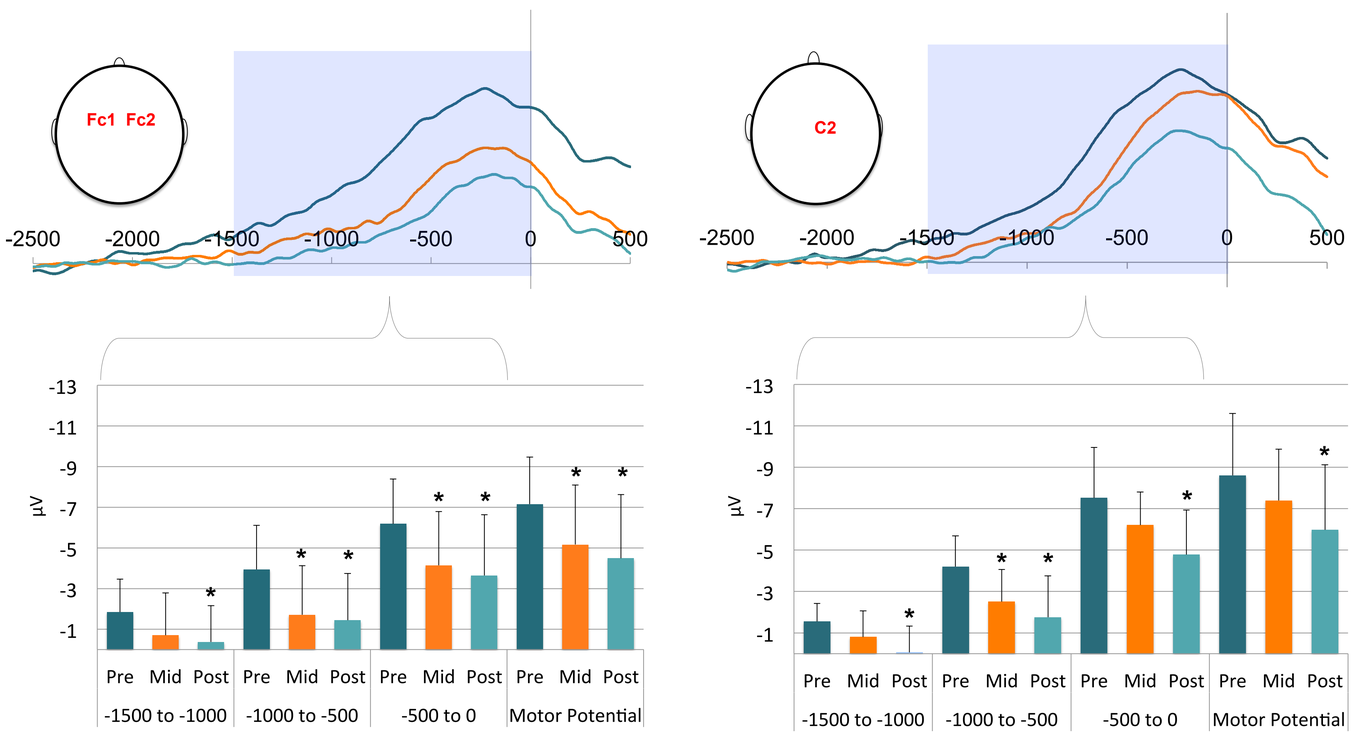


Fig. 3



2. EEG

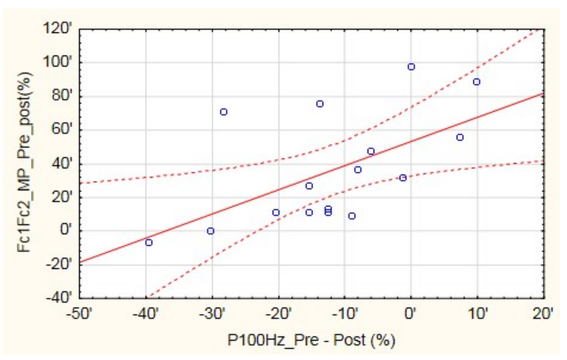
Compared to pre-exercise, MRCP components decreased significantly (*p<0.5) above the supplementary motor area (mean Fc1-Fc2) and the contralateral motor cortex (C2).



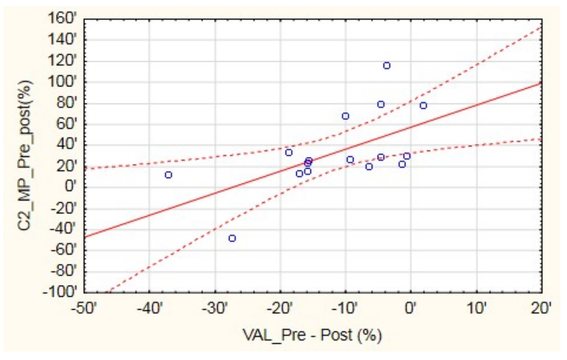
3. CORRELATIONS

Correlations are based on the differences between Pre and Post conditions. Representative MRCP components recorded on Fc1-Fc2 and C2 eletrodes were correlated with P100Hz and VAL respectively.

Mean Fc1-Fc2	Δ P100Hz
Δ Early RP	n.s.
Δ NS	R = 0.61 / p = 0.01
Δ MP	R = 0.61 / p = 0.01



C2	Δ VAL
Δ Early RP	R = 0.57 / p = 0.02
Δ NS	R = 0.72 / p = 0.02
Δ MP	R = 0.64 / p = 0.01



CONCLUSION

We confirm that cycling exercise reduced the maximal force of the knee extensor, as already observed by other authors (Millet and Lepers, 2004). This fatigue can be attributed to peripheral alterations as seen through the reduction in the paired stimuli force, and to central fatigue as shown by the inability to produce the same voluntary activation level after exercise.

New findings

Endurance exercise induced a reduction in the MRCP amplitude. This observation did not confirm previous results on single-task contractions. We suggest that the electro-cortical process involved in motor preparation is modulated differently according to the task and not only by fatigue *per se*. Intra-cortical inhibition and/or modulations in type III/IV afferent fibers could explain this difference.

The correlations between MRCPs above the SMA and the motor cortex suggest that MRCP could be considered as a marker of central fatigue after cycling exercise.

PERSPECTIVES

Our results should be confirmed using other global exercises (i.e. running, walking) to better understand the effect of task-specificity on MRCPs.

Given that fatigue is influenced differently by exercise intensity, it would be interesting to compare MRCP across varying intensities.

The interpretation of MRCP modulations by exercise requires the combination of other investigation approaches, like transcranial magnetic stimulation or metabolic measurements (i.e. tryptophan), for example.

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Deecke L., Cognitive Brain Research 3, 59-64, 1996 / Schillings M.L., Kalkman J.S.., Van der Werf S.P., Bleijemberg G., Van Englen B.G.M., Zwarts M.J., Eur. J. Appl Physiol 97, 521-526, 2006 / Sidhu S.K., Cresswell A.G., Carroll T.J., J. Appl Physiol 113, 401-409, 2012 / Millet G., Lepers R., Sports Med 34 (2), 105-116, 2004.