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NECK AND SHOULDER MUSCLE FATIGUE IN PILOTS FLYING ON EUROFIGHTER AIRCRAFT

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INTRODUCTION

HEALTH - CONCENTRATION - SAFETY

«Neck muscle fatigue is a risk factor for muscle injury and may interfere with muscle coordination»

High Performance Flying Acceleration Environment

- High performance flying environment involves high intensity forces (occasionally greater than 9 Gz)
- Forces above 4 Gz have been associated with the potential for neck injury. Most surveys have reported symptom onset in the 4 to 9 Gz range.
- These exposures represent the well known work-related musculoskeletal disorder (WMSD) risk factors of high force and high repetition.

Sagittal Plane model

- The forces acting on the C-spine in high performance flying can be broken down into **compressive**, **tensile**, and **shear** components.
- **Shear** forces are increased as aircraft accelerations occur simultaneously in more than one axis.

Positive Gz forces

- Forces acting along the z axis are of most importance with respect to adverse effects on the cervical spine. Positive Gz forces cause spinal compression. This compression is also manifested as varying shear components at each level of the C-spine, largely due to the orientation of the facet joint articulations.

sEMG in jet pilots

Oksa, 1996; Green, 2004; Linder, 2005; Lecompte, 2008

- Oksa found mean muscle strain exceeding ergonomic recommendation for static work (Jonsson, 1982) in left sternocleidomastoid.
- Lecompte compared neck strength and sternocleidomastoid and erector spinae sEMG activity during maximal isometric contractions in a sitting position in the sagittal and coronal planes in asymptomatic fighter pilots (AP) vs. symptomatic fighter pilots (SP). His results suggest altered muscle function in SP compared with AP in the coronal but not in the sagittal plane.

Neck strength and myoelectric fatigue in fighter and helicopter pilots with a history of neck pain. Aviat Space Environ Med 2005; 76:375–380

- Äng, Linder and Harms-Ringdahl investigated **neck muscle fatigue** by means of the decline of the sEMG **median frequency** power spectra in fighter and helicopter pilots with neck pain. Furthermore they noticed that fighter pilots had significantly lower extensor **MVC** than controls

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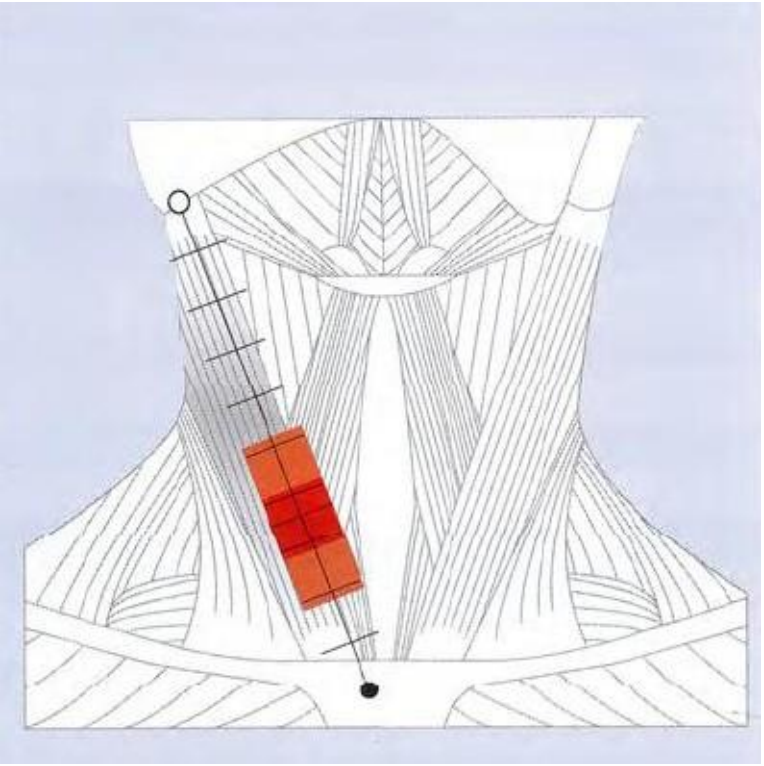
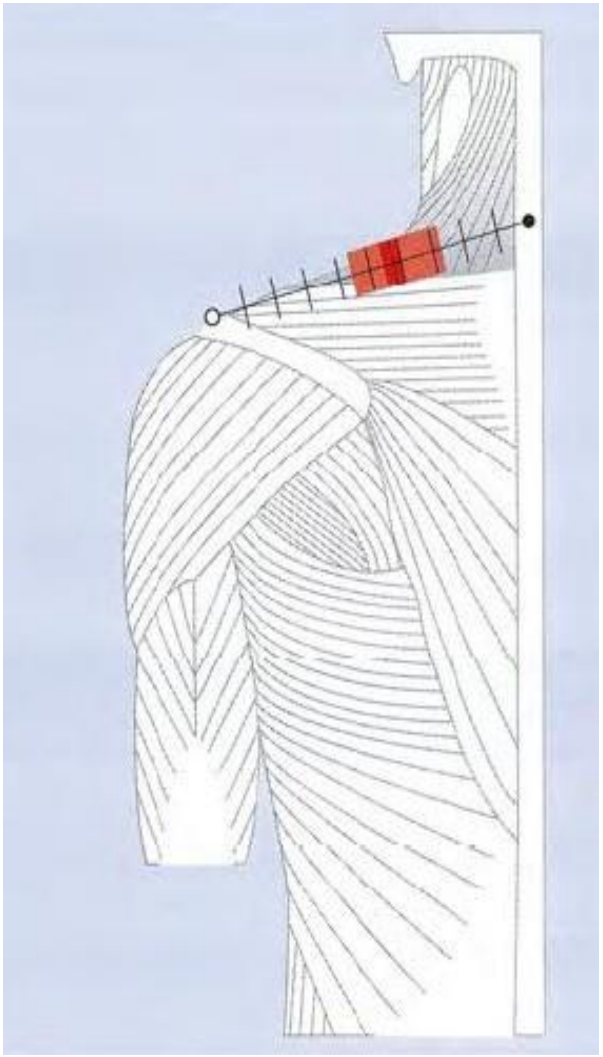
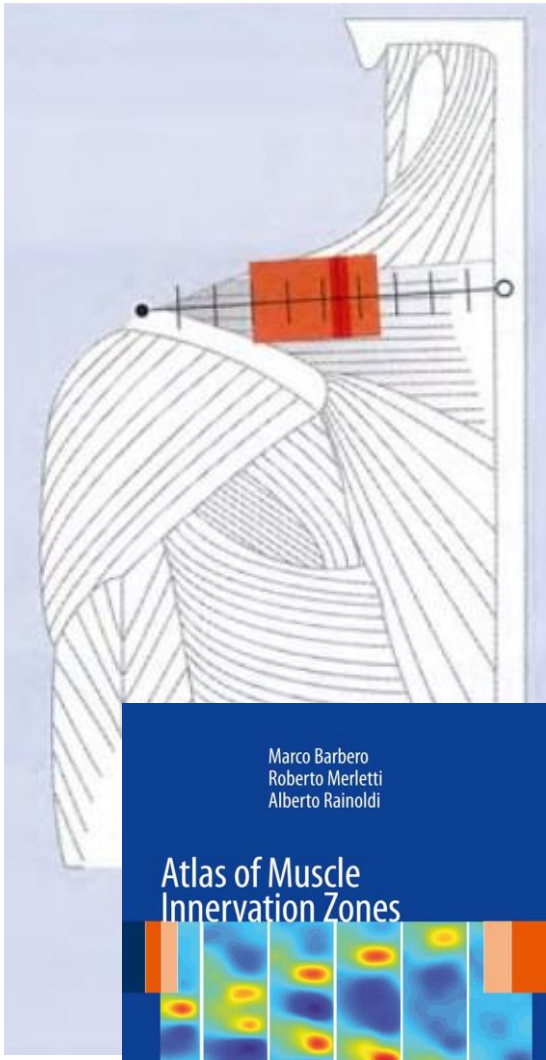
METHODS

sEMG recording technique

- 16-channel Wi-Fi transmission surface electromyography (FreeEMG300 System, BTS)
- electrodes were placed along the direction of the muscle fibers of the right and left sternocleidomastoid (SCM), upper trapezius and middle trapezius (UT and MT)



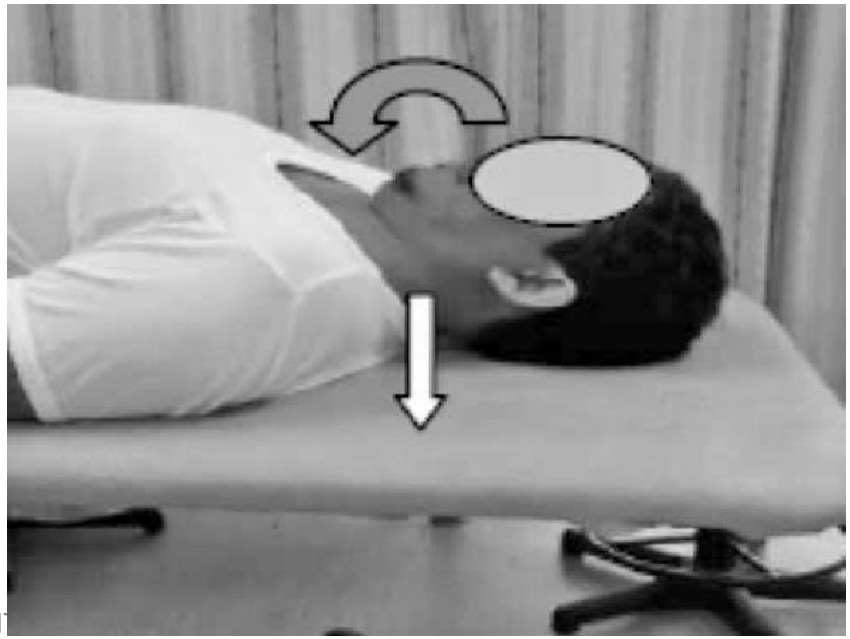




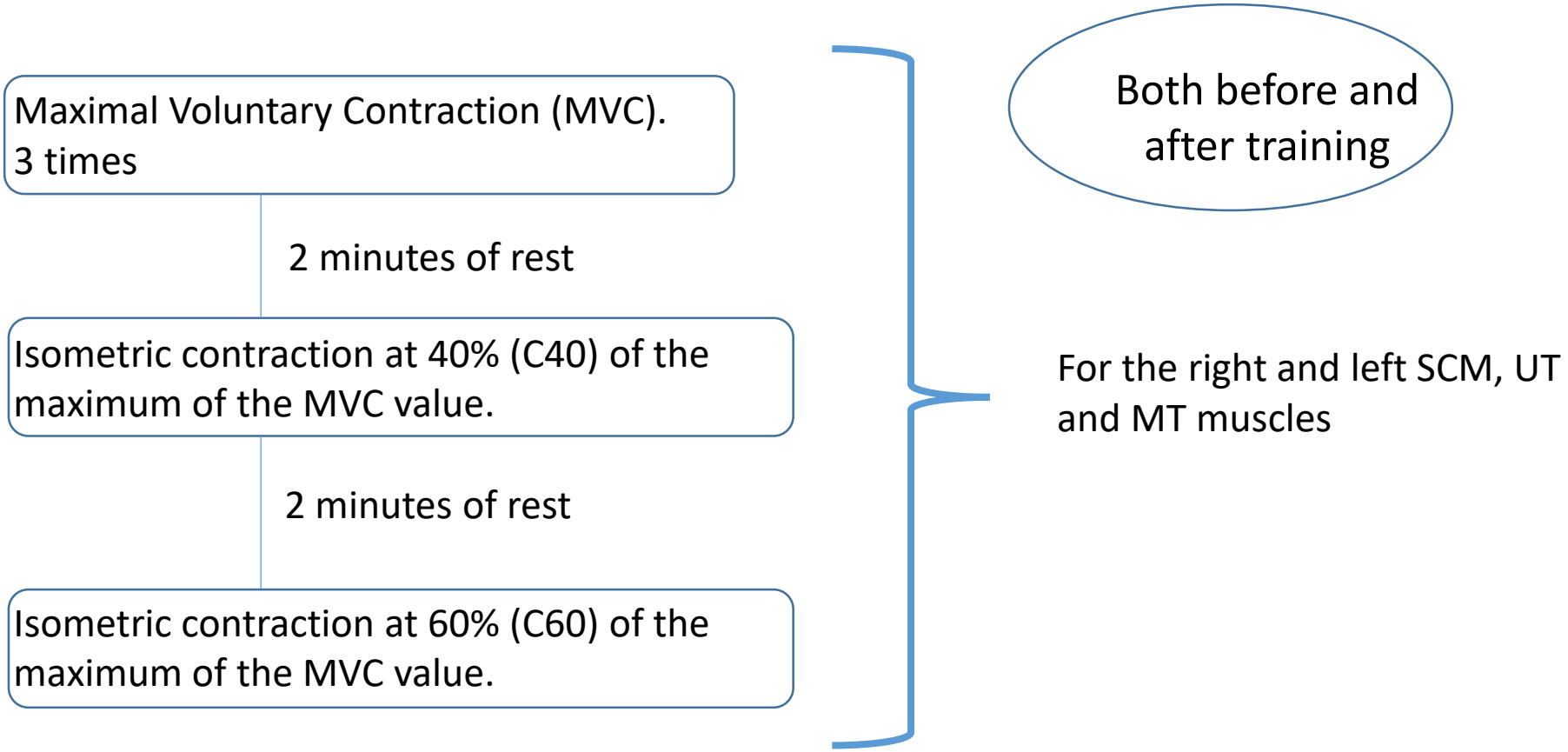
Marco Barbero
Roberto Merletti
Alberto Rainoldi
Atlas of Muscle Innervation Zones
Understanding Surface Electromyography and Its Applications
Foreword by Gwendolen Jull
Springer
EXTRA MATERIALS

Subjects

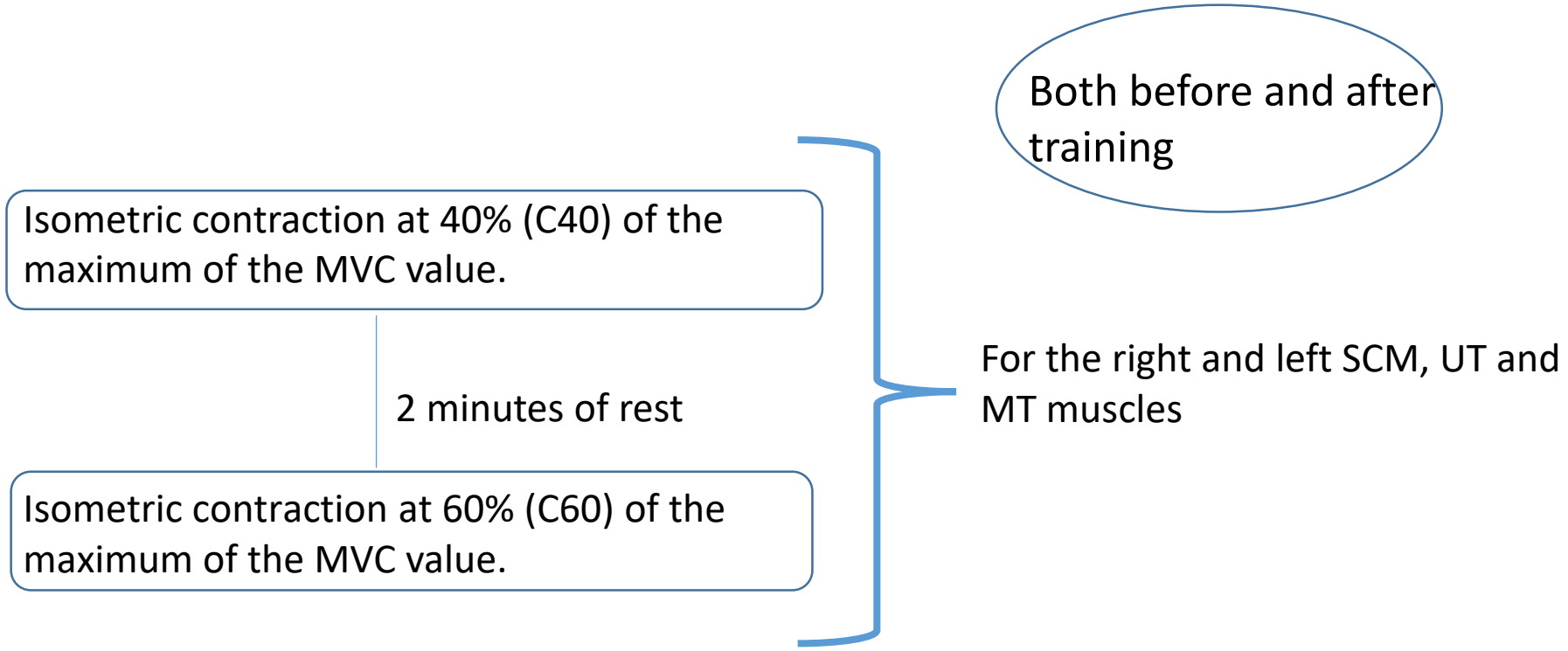
- Two male left-handed pilots:
- Height*: 1.795±0.007 m
- Weight*: 71.40±1.27 kg
- BMI*: 22.16±0.22 kg/m2
- Measures were performed before and after a neck and shoulder specific *training*;
- *Muscles training consisted in 6-weeks of specific exercises, twice a week for 30 minutes.*



Experimental procedure 1: Baseline: at rest, before flight.

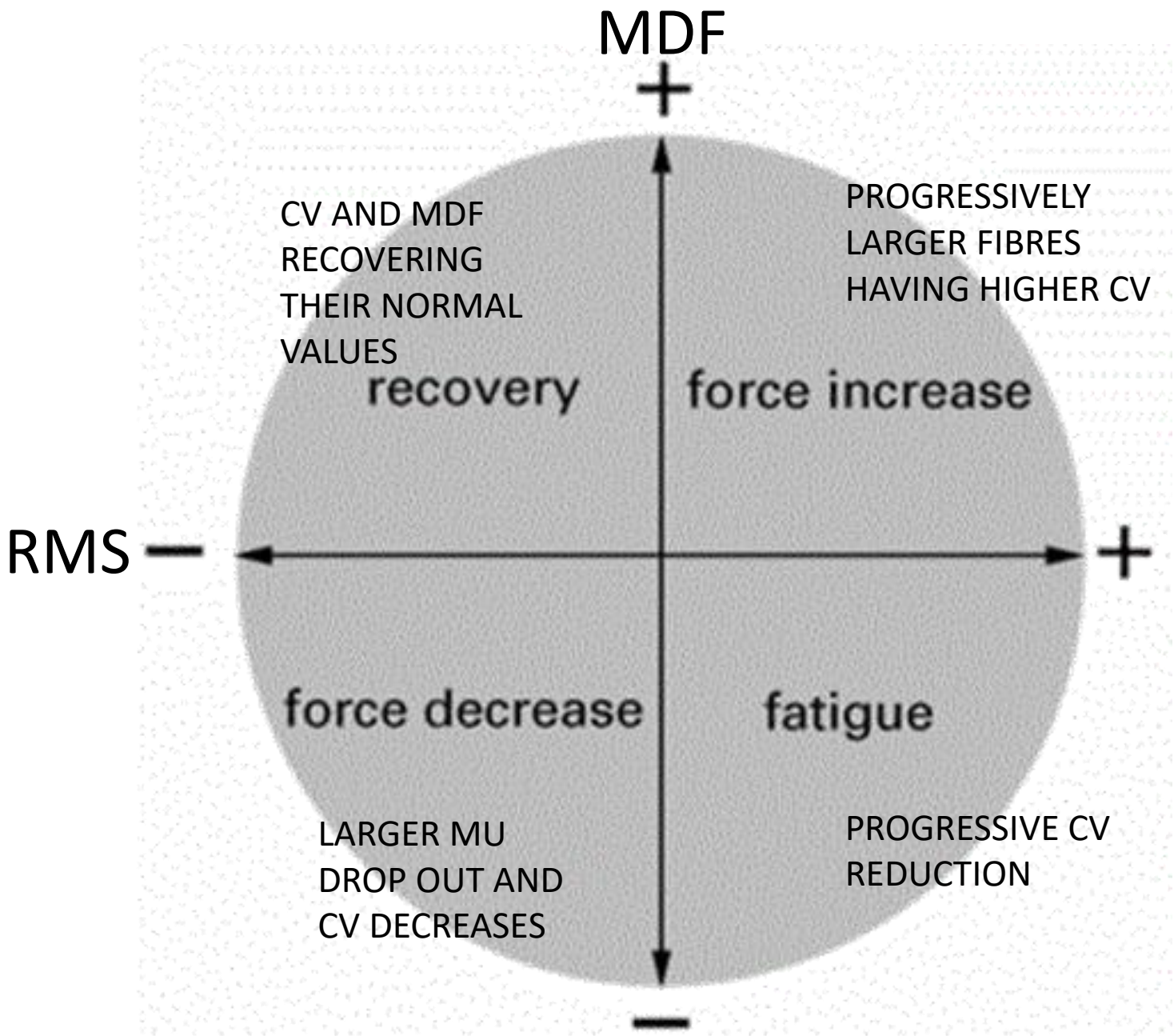


Experimental procedure 2: Fatigue condition. Soon after flight.



Data Analysis

- Software: Smart Analyzer, BTS, Italy;
- Root Mean Square (RMS);
- Median Frequency (MDF)
- The Joint Analysis of the Spectrum and Amplitude (JASA) Luttmann 2000


MDF
+
CV AND MDF
RECOVERING
THEIR NORMAL
VALUES
PROGRESSIVELY
LARGER FIBRES
HAVING HIGHER CV
recovery
force increase
RMS
−
+
force decrease
fatigue
LARGER MU
DROP OUT AND
CV DECREASES
PROGRESSIVE CV
REDUCTION
−

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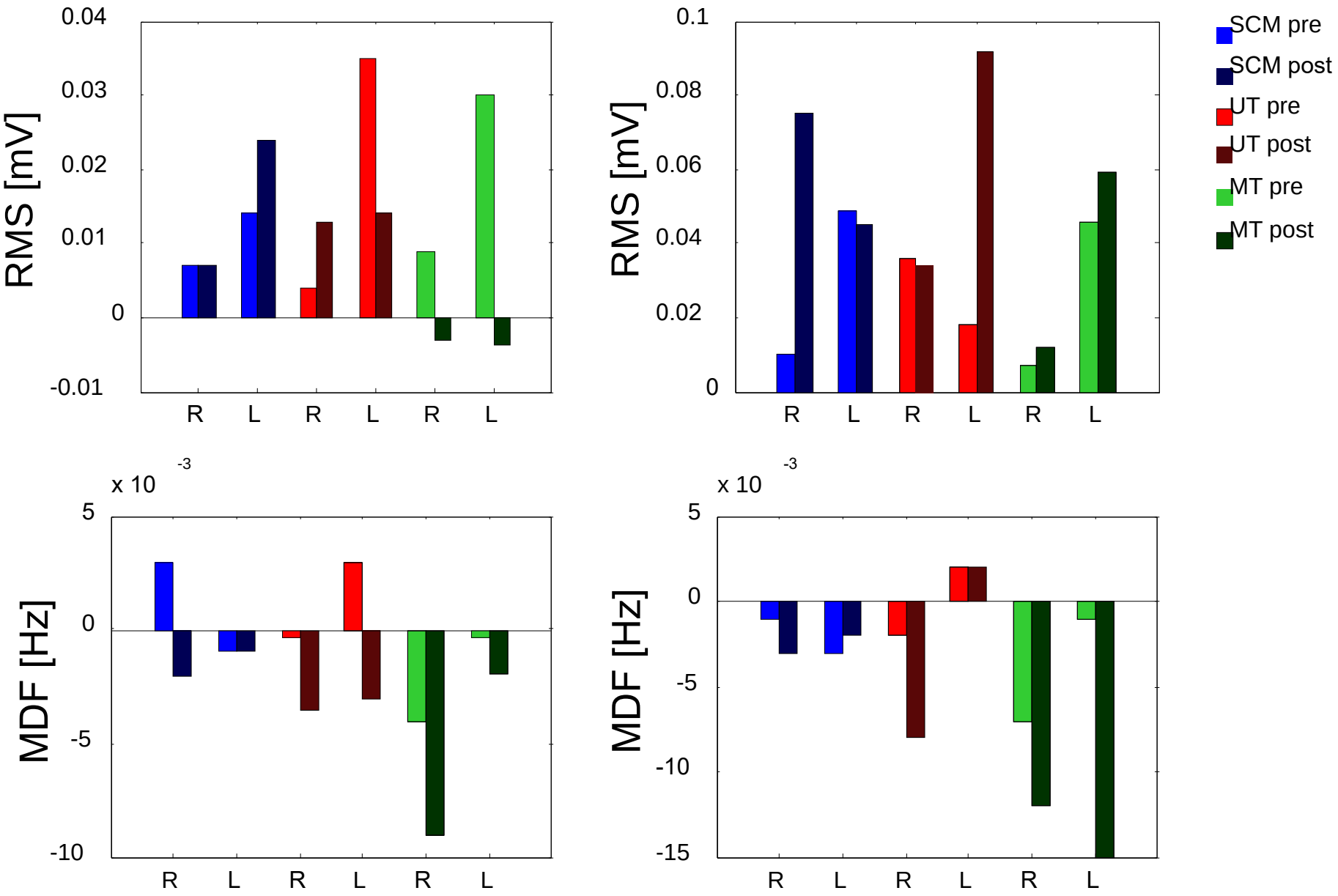
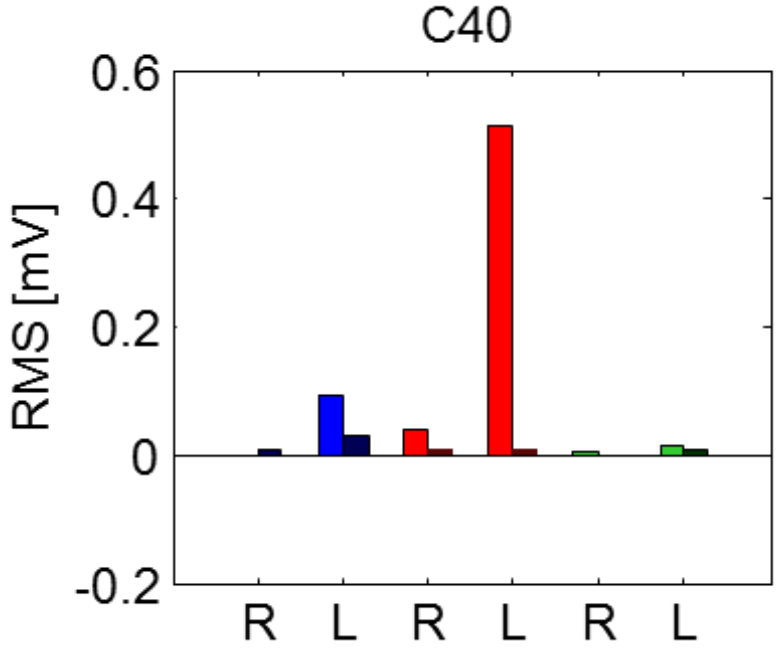
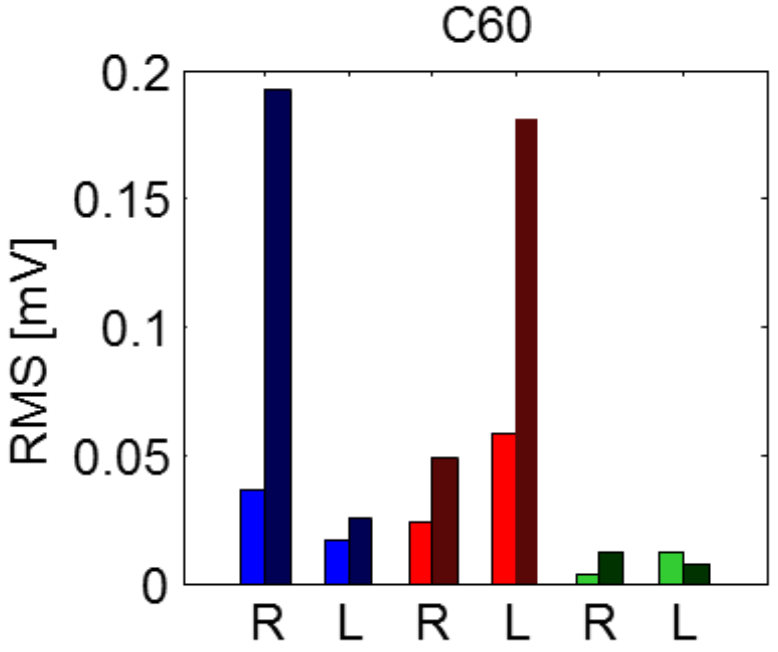
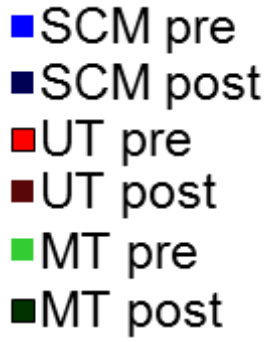
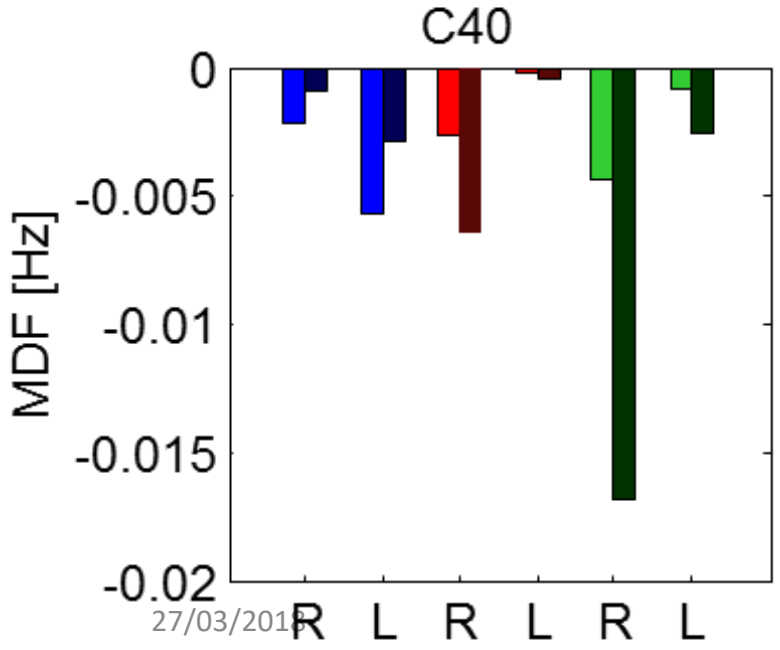
RESULTS

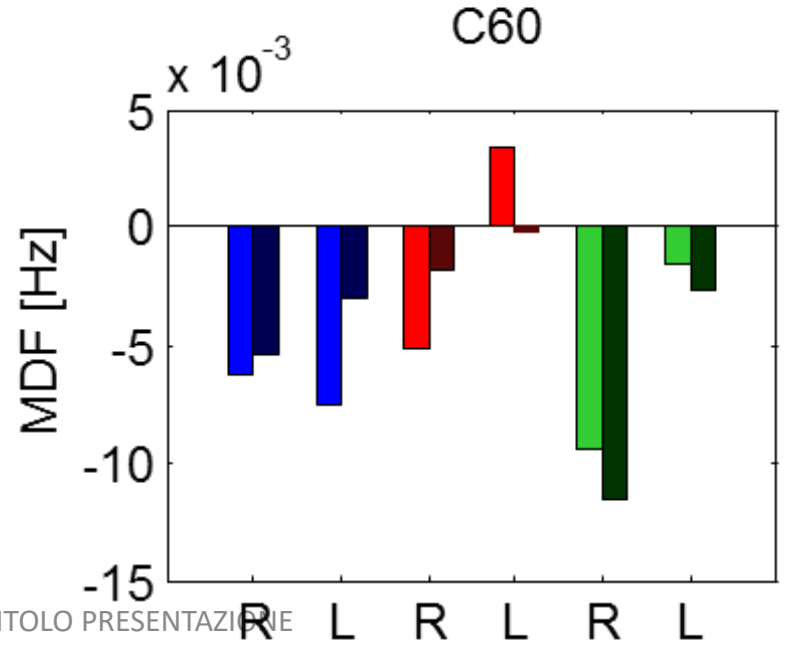

C40
C60
RMS [mV]
0.04
0.03
0.02
0.01
0
-0.01
0.1
0.08
0.06
0.04
0.02
0
R
L
SCM pre
SCM post
UT pre
UT post
MT pre
MT post
x 10
-3
MDF [Hz]
5
0
-5
-10
-15

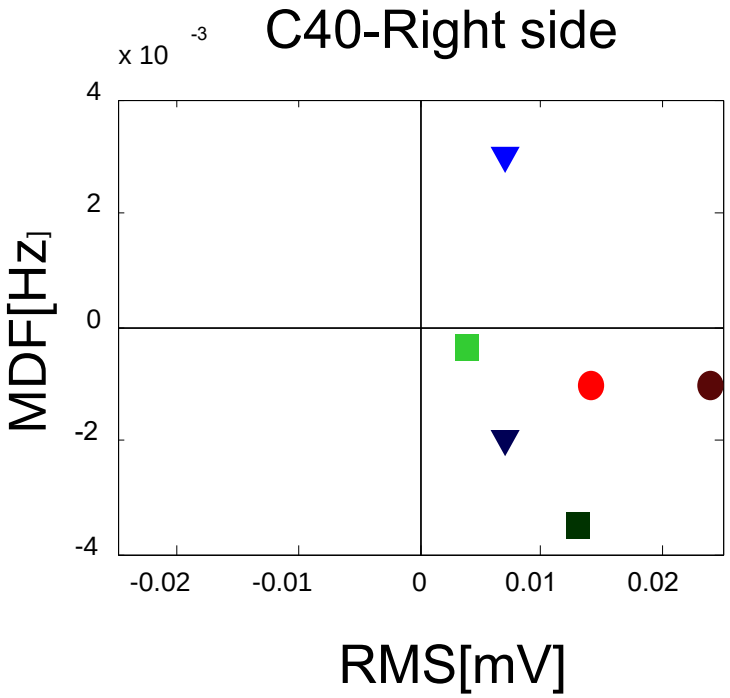

C40
RMS [mV]
0.6
0.4
0.2
0
-0.2
R L R L R L

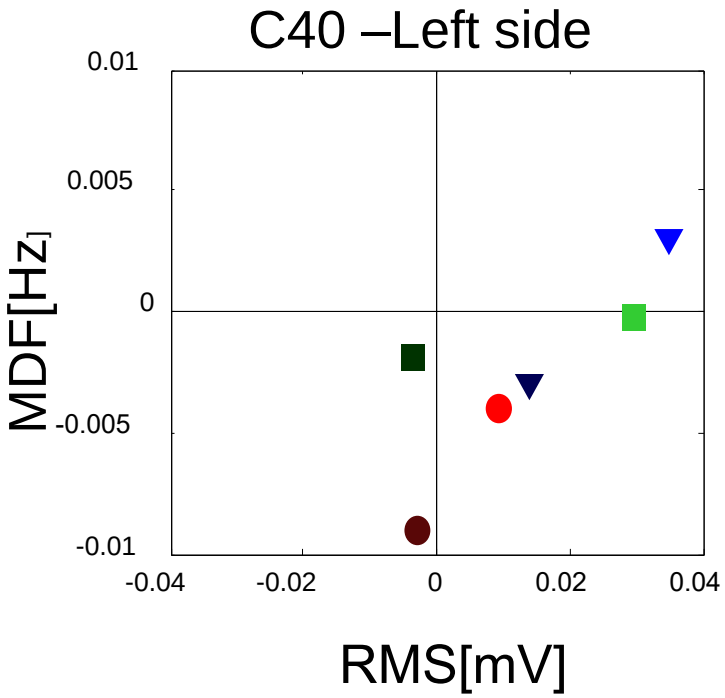

C60
RMS [mV]
0.2
0.15
0.1
0.05
0
R L R L R L

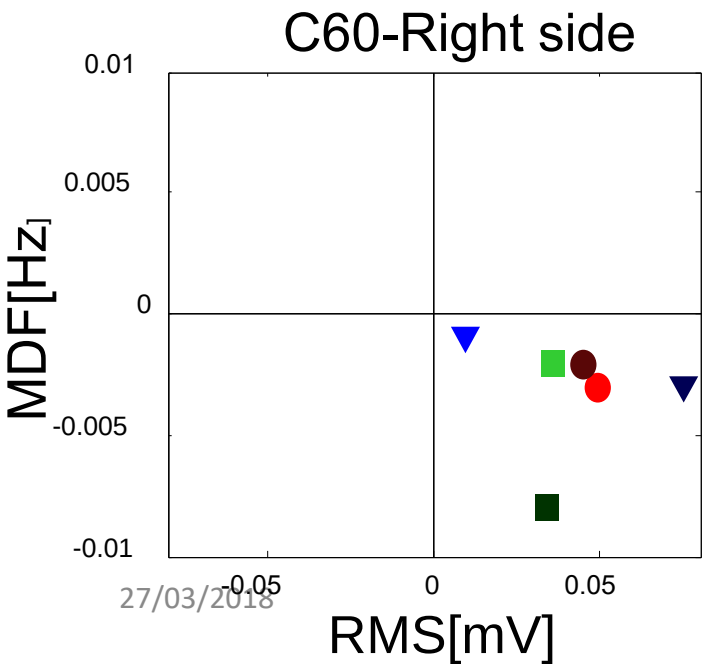

SCM pre
SCM post
UT pre
UT post
MT pre
MT post

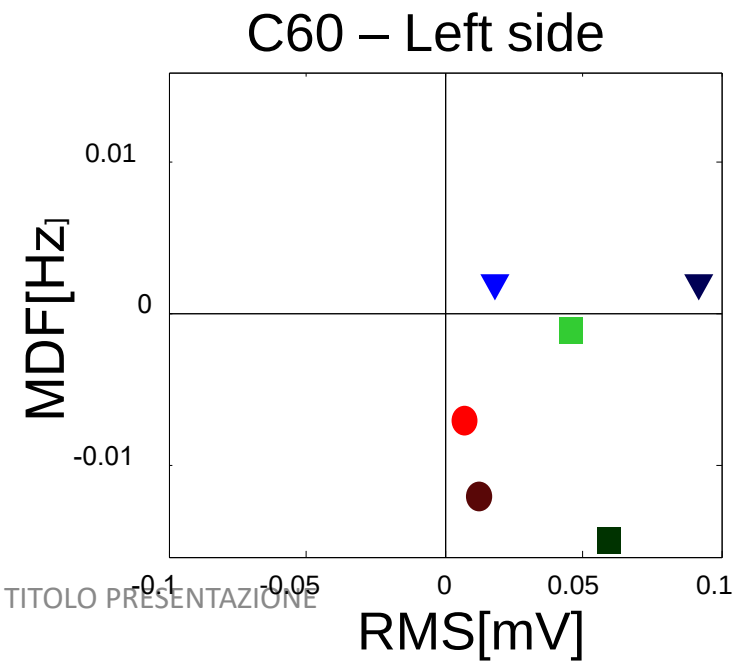

C40
MDF [Hz]
0
-0.005
-0.01
-0.015
-0.02
R L R L R L


C60
x 10^-3
MDF [Hz]
5
0
-5
-10
-15
R L R L R L

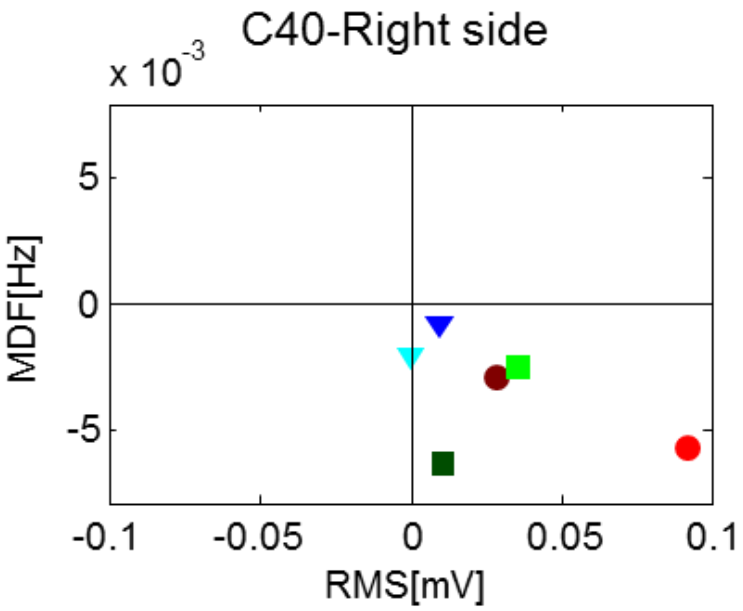

C40-Right side
x 10 -3
4
2
0
-2
-4
-0.02
-0.01
0
0.01
0.02
MDF[Hz]
RMS[mV]

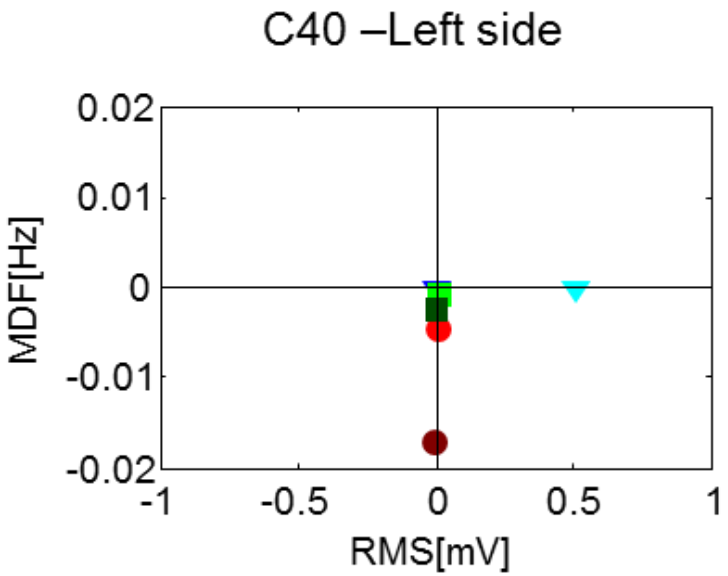

C40 –Left side
0.01
0.005
0
-0.005
-0.01
-0.04
-0.02
0
0.02
0.04
MDF[Hz]
RMS[mV]


C60-Right side
0.01
0.005
0
-0.005
-0.01
-0.05
0
0.05
MDF[Hz]
RMS[mV]

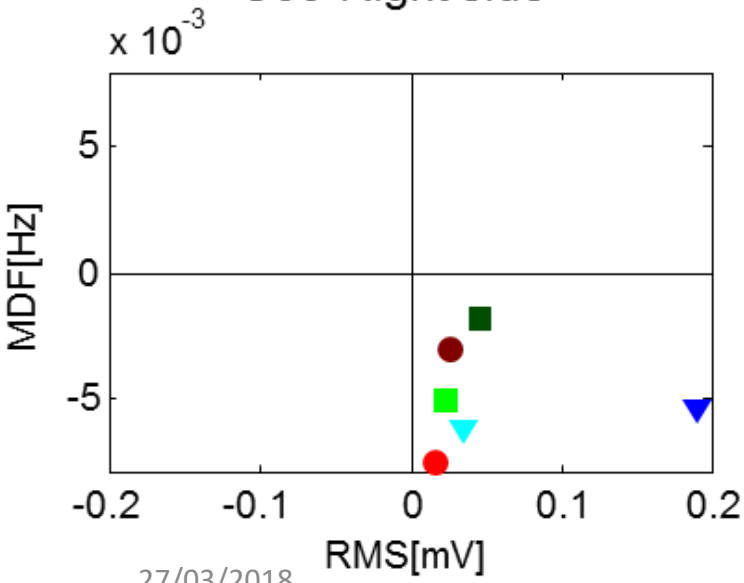

C60 – Left side
0.01
0
-0.01
-0.1
-0.05
0
0.05
0.1
MDF[Hz]
RMS[mV]

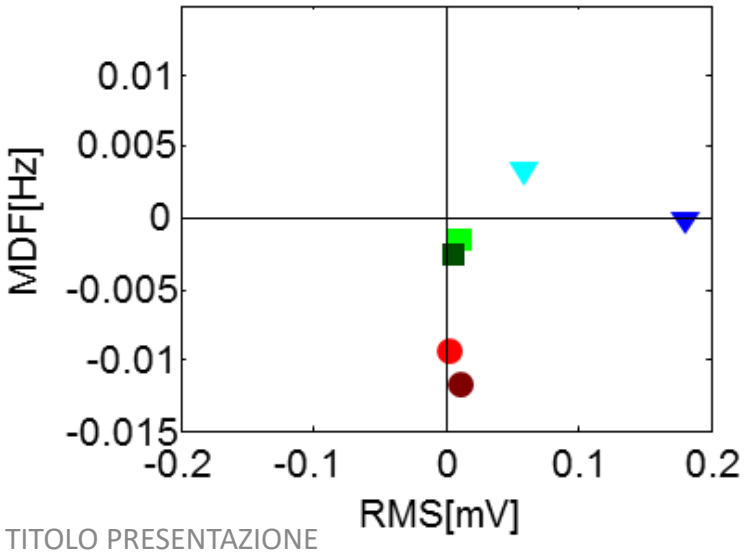

SCM pre
SCM post
UT pre
UT post
MT pre
MT post





SCM pre
SCM post
UT pre
UT post
MT pre
MT post





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CONCLUSIONS

Conclusions 1/2

- This study showed that it is possible to obtain information about pilots neck stress through sEMG fatigue parameters;
- the fatigue assessment could be a practical tool to provide an insight for helmet and seat design improvements;

Conclusions 2/2

- the results of this study strengthen the suggestion to incorporate neck and shoulder specific training in the list of operational duties;
- future examinations are needed to expand the analyzed sample to validate a protective neck training protocol or to validate ergonomic changes to the cockpit and the helmet.

GRAZIE PER L'ATTENZIONE