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.

• 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
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)
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.

Maximal Voluntary Contraction (MVC). 3 times

2 minutes of rest

Isometric contraction at 40% (C40) of the maximum of the MVC value.

2 minutes of rest

Isometric contraction at 60% (C60) of the maximum of the MVC value.

Both before and after training

For the right and left SCM, UT and MT muscles
Experimental procedure 2: Fatigue condition. Soon after flight.

- Isometric contraction at 40% (C40) of the maximum of the MVC value.
  - 2 minutes of rest
- Isometric contraction at 60% (C60) of the maximum of the MVC value.

Both before and after training

For the right and left SCM, UT and MT muscles
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
CV AND MDF RECOVERING THEIR NORMAL VALUES

PROGRESSIVELY LARGER FIBRES HAVING HIGHER CV

LARGER MU DROP OUT AND CV DECREASES

PROGRESSIVE CV REDUCTION
RESULTS
C40 - Right side

C40 - Left side

C60 - Right side

C60 - Left side

27/03/2018
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.