

Chapter 2 – REVIEW OF THE BELGIAN AND THE NETHERLANDS NATIONAL WORK PROGRAMME ON THE LONG TERM EFFECTS OF SUSTAINED HIGH G ON THE CERVICAL SPINE

FUNCTIONAL ASSESSMENTS OF THE CERVICAL SPINE IN F-16 PILOTS – AN OVERVIEW

by

Veerle De Loose PT

Frédéric Burnotte PT

Damien Van Tiggelen PT

Belgian Defence, Medical Component
Military Hospital of Base Queen Astrid
Bruynstraat 2, 1120 Brussels, Belgium

veerle.deloose@mil.be

frederic.burnotte@mil.be

damien.vantiggelen@mil.be

Marieke Van den Oord MSc

Ted Meeuwsen MSc

Pieter van Amerongen MD

Center for Man in Aviation
The Royal Netherlands Air Force
PO Box 22, Kampweg 3, 3769 ZG
Soesterberg, Netherlands

MHAH.vd.Oord@mindef.nl

T.meeuwsen@mindef.nl

p.v.amerongen.01@mindef.nl

2.1 INTRODUCTION

Neck pain in association with the dynamic work environment of the fighter pilot is a well-discussed issue. Spinal symptoms in these pilots were recognized as a serious aero medical problem. Often described contributing factors of neck pain in this population are head movements under high +Gz load, seat-back angle, forward bent posture, head worn equipment, the use of night vision goggles and numbers of flight hours [4, 5, 7]. This study was a collaboration of The Belgian Air Force and The Royal Netherlands Air Force; they both operate the F-16 Fighting Falcon. A battery of tests was developed for the functional assessment of the cervical spine, to provide a proper preventive training program for fighter pilots. This study was based on the injury prevention research by Van Mechelen et al. (Figure 2.1). According to the literature, lack of muscular force and endurance of the cervical spine could be one of the main risk factors causing neck pain [1, 2]. Although, other motor control impairments such as delayed reaction times, lack of range of motion, poor proprioception or muscular coordination and muscular imbalance could also play an important role in the occurrence of neck pain. Furthermore, psychosocial factors are also associated with neck pain. This report describes the methods used to identify the vulnerabilities within the functionality of the neck and presents the preliminary results.

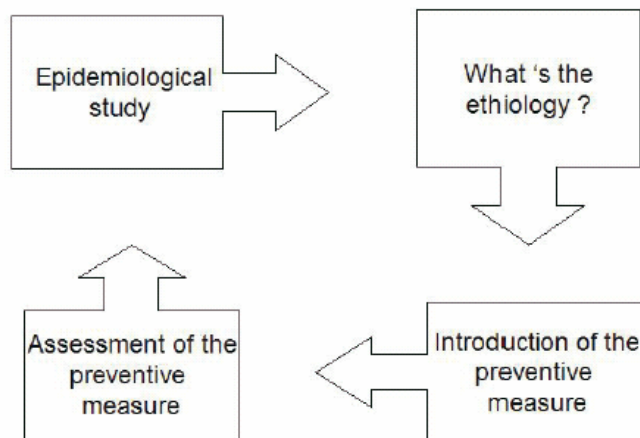


Figure 2.1: Four-Step Sequence of Injury Prevention Research.

2.2 METHODS

2.2.1 Subjects

Ninety male F-16 pilots (Table 2.1) of the Belgian Air Force and The Royal Netherlands Air Force participated voluntarily and gave informed consent. Anonymity was guaranteed by using a personal code; only the pilots owned the key to this code.

Table 2.1: Demographic Distribution of the F-16 Pilots

		Healthy pilots N=73		Neck pain pilots N=17	
		Average	C.I. (95%)	Average	C.I. (95%)
BMI		24.1	1.6	24.2	2.6
Years fighter pilot		9.5	5.4	9.7	5.2
		%		%	
Age	<30	47.1		41.1	
	30 – 39	47.1		56.2	
	40 – 49	5.9		2.7	
Flight	0 – 999	30.6		17.6	
hours	1000 – 1999	31.9		47.1	
	2000 – 2999	27.4		29.4	
	3000 – 4000	9.7		5.9	

The Belgian Defence and University of Ghent Ethical Research Committees approved the methods and measurements used. The tests were conducted in a random sequence. To avoid the influence of muscular fatigue on the other tests, muscular strength was always measured at the end of the evaluation. Besides the F-16 pilots, 22 male pilots in training of the Belgian Air Force participated. These pilots had less than 140 flight hours in low G aircrafts and experienced no neck pain.

2.2.2 Questionnaire

The questionnaire was divided into two parts: a general and a pilot specific part. The general part, based on the Dutch Musculoskeletal Questionnaire, was composed of questions concerning personal information, health, work situation, leisure activities, neck pain and the Neck Disability Index (NDI) [6, 8]. The NDI measured the self-rated disability during all day activities due to neck pain. The pilot specific part contained questions about flight experience, preventive measures and flight related causes of neck pain. Neck pain was defined as pain in the head and neck region, shades in a drawing of the head, neck and shoulder area [3].

2.2.3 Cervical Range of Motion

The cervical range of motion (CROM) was measured with the three-dimensional motion analyzer Zebris CMS20, WinSpine version 1.79 (Zebris Medizintechnik GmbH). The maximal CROM was measured for flexion – extension, right – left rotation and right – left lateroflexion. Each measurement consisted of three repetitions of each movement.

2.2.4 Proprioception

The proprioception was measured using the same equipment as the CROM, Windata version 2.20 (Zebris Medizintechnik GmbH). The starting position was the neutral position of his neck as defined by the pilot. The test consisted of two parts, first to return to their own neutral position after a sub maximum range cervical flexion-extension and right and left rotation, and second to return to a defined position (30° right or left rotation). For the first part the reposition error was calculated in the sagittal, frontal and horizontal planes, as a mean of 10 repetitions. For the second part the reposition error was calculated in the horizontal plane for right and left rotation, as a mean of 5 repetitions in each direction.

2.2.5 Reaction Time

A device called “Cervical Beamer” was developed to measure reaction time. The simple reaction time (i.e. 1 stimulus with 1 possible response) and the choice reaction time (i.e. 14 different stimuli with each 1 response) were measured. The reaction time was divided into decision time and movement time.

2.2.6 Muscular Strength of the Cervical Spine

The maximum isometric strength was measured with the David F-140 (David Back Clinic). The isometric strength tests were done in four directions: flexion, extension, right and left lateroflexion. Three maximum voluntary contractions were executed in each direction. The peak value (Nm) was registered; MVC was defined as the highest of the three peak values.

2.2.7 MRI

Candidates underwent MRI – evaluation of the cervical spine in supine position (Philips 0.5 T machine, no paramagnetic contrast material). Sagittal T1 and T2 weighted images were obtained and, in case of disc disorders, also axial T2 weighted images of the involved disc space. Discriminators of disorders were: degenerative changes in the intervertebral disc/discopathy in cervical spine, presence of osteophytes/osteophytic spurring, presence of osteophyte’s posterior in the spinal canal. Furthermore the cross-sectional area of the longus colli muscle, the longus capitis muscle, the sternocleidomastoid muscle, the rectus capitis posterior major muscle, trapezius muscle and the multifidus muscle was measured.

2.2.8 Statistics

Statistical analyses were performed with SPSS 12.0 software package (SPSS Inc., Chicago, IL) for windows. Differences between groups were calculated by cross-tabulations, a one-way-ANOVA, an independent sample's *t*-test or a Mann-Whitney *U* test (if normal data distribution was not obtained). Mean differences with 95% CI were given as descriptive statistics. In all tests, $p < 0.05$ was considered statistically significant. Pilots were divided in two groups: a neck pain group and a healthy group. Results of the healthy group were compared with the results of the pilots in training.

2.3 PRELIMINARY RESULTS

Year-prevalence of neck pain in F-16 pilots was 18.9%. High force demands, often sitting for a long time, often holding the neck in a forward bent posture and being physical tired at the end of the day; this were all physical work related factors which were significant pronounced in the neck pain group. Besides the physical factors the neck pain group reported significant more psychosocial factors as being mentally tired at the end of the day and being annoyed by others at the workplace. A sudden movement caused almost half of the pilot's neck pain and three fourths of the pilots with neck pain reported that their complaints were caused by the flight. Only a minority of the pilots who reported neck pain did consulted a physician.

Pilots experiencing neck pain had a less large range of motion in the sagittal and horizontal plan. No significant differences were observed between pilots with and without neck pain with regards to the reaction time, proprioception and maximal isometric strength.

Compared to the pilots in training the F-16 pilots of the healthy group had a significant better movement time and this in both cervical beamer tests. The MVC ratio flexion/extension was significant higher in the pilots in training. Though the flexion muscles were not significant lower in F-16 pilots neither were the extension muscles significant stronger than the pilots in training.

2.4 CONCLUSION

Prevalence was significant lower than a decade ago. The aetiology of neck pain is a complicated and a multifaceted problem. As in other populations, neck pain in F-16 pilots is a combination of different functional dysfunctions.

2.5 REFERENCES

- [1] Albano JJ, Stanford JB. Prevention of minor neck injuries in F-16 pilots. *Aviat Space Environ Med* 69: 1193-1199, 1998.
- [2] Äng B, Linder J, Harms-Ringdahl K. Neck strength and myoelectric fatigue in fighter and helicopter pilots with a history of neck pain. *Aviat Space Environ Med* 76: 375-380, 2005.
- [3] Cagnie B, Danneels L, Van Tiggelen D, De Loose V, Cambier D. Individual and work related risk factors for neck pain among office workers: a cross sectional study. *Eur Spine J* 16: 679-686, 2007.
- [4] Coakwell MR, Bloswick DS, Moser Jr R. High-risk head and neck movements at high G and interventions to reduce associated neck injury. *Aviat Space Environ Med* 75: 68-80, 2004.
- [5] Hamalainen O, Vanharanta H, Bloigu R. Determinants of +Gz-related neck pain: a preliminary survey. *Aviat Space Environ Med* 64: 651-652, 1993.

- [6] Hildebrandt VH, Bongers PM, van Dijk FJH, Kemper HCG, Dul J. Dutch musculoskeletal questionnaire: description and basic qualities. *Ergonomics* 44: 1038-1055, 2001.
- [7] Newman DG. +Gz-induced neck injuries in Royal Australian Air Force fighter pilots. *Aviat Space Environ Med* 68: 520-524, 1997.
- [8] Vernon H, Mior S. The neck disability index: a study of reliability and validity. *J Manipulative Physiol Ther* 14: 409-415, 1991.

2.6 FUTURE DIRECTION OF WORK PROGRAMME

- Analyzing MRI;
- Larger control group;
- Comparison fixed wing and helicopter crew;
- Assessment of deep neck flexors;
- Looking at movement strategies;
- Preventative programs based on individual values vs. normal values; and
- Collecting and analyzing values of prospective pilots.

