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Postural Stability in Pilots Under Vestibular Stress – A Comparative Look at Pilot Candidates Versus Experienced Jet-Aircrews

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Introduction: All Air Forces battle the lack of sufficient recruitment of pilot and aircrew candidates. One way to solve the problem is to look into extending the flying career of an individual. German regulations require jet aircrew members - except those in commanders' positions - to stop flying at the age of 41 and leave the Bundeswehr to pursue a civilian career. This means the loss of experienced aircrews not because of medical problems but because of legal requirements. This age restriction of 41 might not be justified any more from a medical point of view. Aeromedical specialists all around the world are looking into the issue of aircrew aging.

Orientation in space and postural control are very important for any aircrew. In this study we compared the postural control of experienced pilots versus pilot candidates. We tried to determine possible differences between the age groups to get an indication of the ability to control one's position in space after a strong vestibular stimulus. As a working hypothesis, we assumed that there would be no significant differences between the two groups of test persons.

Methods: In Div. III of the German Air Force Institute of Aviation Medicine we looked into the postural stability of pilot candidates versus experienced jet pilots after subjecting them to a strong vestibular stress induced by the Flight Orientation Trainer (FOT). The FOT was installed in Fürstenfeldbruck in 1994. Its fully cardanic gondola with its cockpit is mounted on a 30 ft planetary arm.

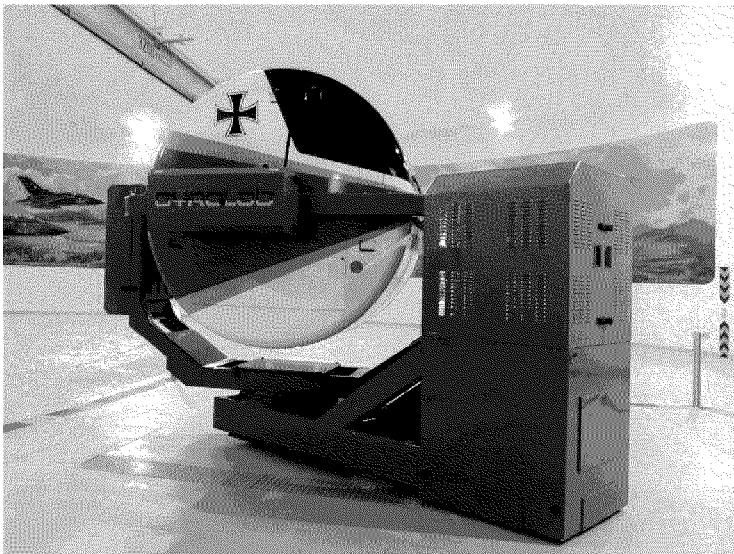
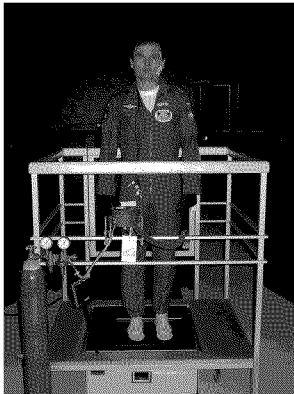


Figure 1: The Flight Orientation Trainer

The Flight Orientation Trainer with its ability to rotate freely in space around all three axes can stimulate the vestibular and otolith organs. Especially coriolis effects can be generated by rapidly changing the rotational plane.

The test persons were rotated about their yaw axis at 120°/sec or 20 RPM and at the same time on the planetary arm of the FOT at 150°/sec or 15 RPM. Each trial lasted exactly 180 sec and ended abruptly with a simultaneous deceleration in both axes, inducing a strong coriolis effect. The time of continuous motion lasted approximately 150 sec.

Before entering and after exiting the FOT the test persons were guided to the posturography. The distance from the FOT to the posturography was 25 meters. The time between the end of the FOT run and the start of the posturographic measurement was approximately 90 seconds.



The posturography made by the Thoennies company measured body sway in anterior/posterior and lateral direction as well as the area covered. For that purpose the test persons had to stand still in a relaxed posture on the platform. For all measurements the test persons had to remove their shoes. Postural control and stability was measured over a period of 120 sec comprising 6 measurement periods of 20 sec each. Measurements were performed with eyes open, respectively with eyes closed. During the 'eyes open' data recording the test persons could see a fixing cross at 3m distance at eye level. Piezoreceptors in the measuring platform sensed the shift of body weight and sent these electronic signals to a computer. The data were computed and displayed in numeric tables and viewgraphs for distance and area covered.

Figure 2: Posturography

Before and after the test runs the test persons were also questioned about their well-being, and basic physiological parameters were measured (heart rate, blood pressure).

Personnel that took part in the study included 21 male test persons: 10 experienced jet aircrew members between 39 and 50 years old with an average age of 43.5 years (43.5 ± 4.0) and 11 pilot candidates between 20 and 25 years with an average age of 21.7 years (21.7 ± 1.4). The experienced pilots participated during their tri-annual flight physical at the GAF Institute of Aviation Medicine. The pilot candidates had passed all initial aeromedical and psychological testing and were waiting to start their flight training. Informed consent was obtained from all test persons.

Statistical calculations of the p-values were done by means of the Student T-Test.

Results: It is known that – regardless of age groups – there is a significant difference in the values for posturographic measurements with eyes open or eyes closed. In the tables below, the x-axis depicts the registration phases 1, 2 and 3 for eyes open or eyes closed measurements before and after the FOT run. The y-axis shows the area covered in cm²/sec for the respective measurements. The rhombic marks indicate the values before ("PRAE"), the square marks indicate the values after ("POST") the FOT runs. Age group <30 years represents the pilot candidates, age group 30<50 years represents the experienced pilot group.

None of the test persons fell out of the "clinical envelope" of the normal posturographic range. None of the test persons suffered from motion sickness during or after the test.

In Table 2 the values for the pilot candidates with eyes open are depicted. It shows that the area covered after the FOT run is greater than before. It also shows that the values decrease as time passes after the vestibular stress.

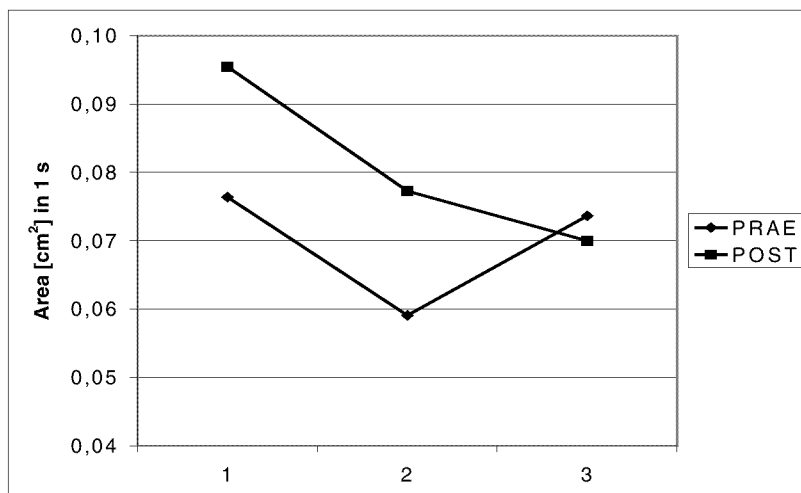


Table 2: <30 Years, eyes open (means, n=11)

Table 3 shows the values for the area covered for the measurements with the eyes closed for the pilot candidate group. Values taken after the FOT run are initially much higher than before the run and as compared to the measurements taken with eyes open. As time passes after the stimulus they nearly reach the same values after approximately 210 sec.

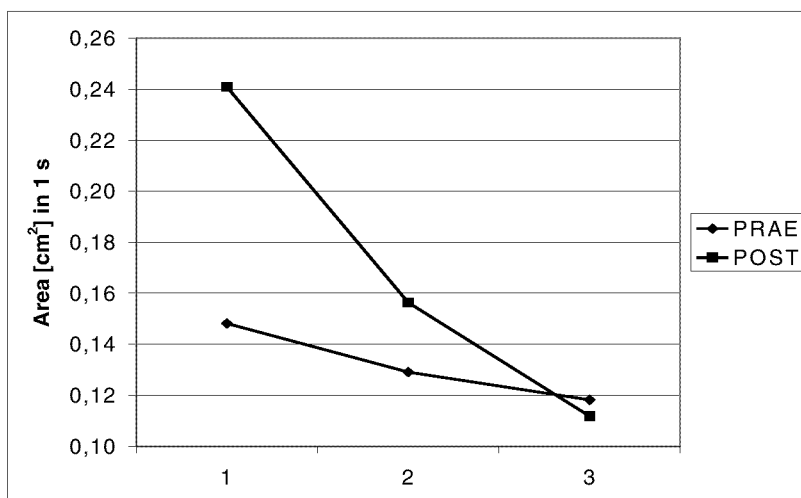


Table 3: <30 years, eyes closed (means, n=11)

For the 30<50 years age group, Table 4 depicts the values for the measurements with eyes open before and after the FOT runs. The values between before and after the FOT run show a different level. The value for the second measurement is in both cases higher than that of the first measurement. Whereas the value of measurement 3 "prae" remains higher than measurement 1, the value of measurement 3 "post" is decreased in relation to measurement 1.

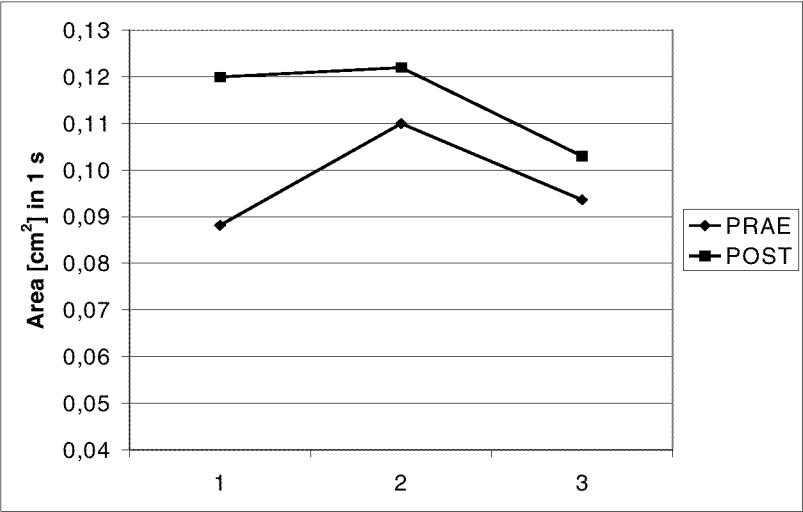


Table 4: 30<50 years, eyes open (means, n=10)

In Table 5 the values for the experienced pilot group with eyes closed are shown. The values of all measurements before and after the FOT run remain at different levels during all registration phases. Although the value levels are clearly separated, a statistically significant difference could not be found.

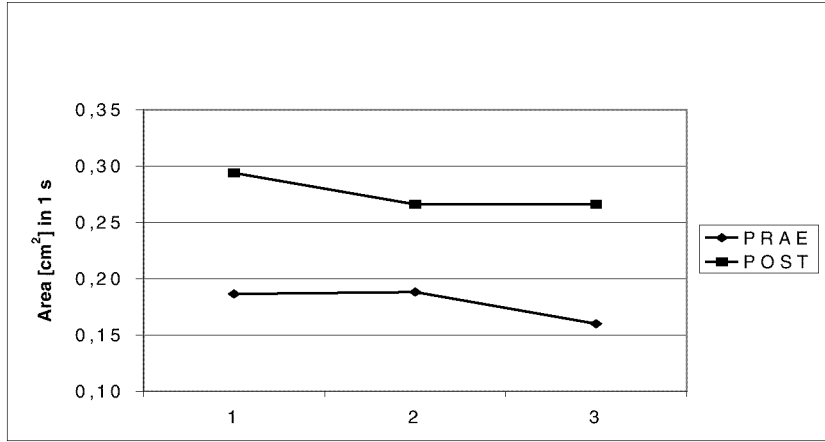


Table 5: 30<50 years, eyes closed (means, n=10)

Table 6 shows the comparison between the two groups of test persons. Only the values for the area covered after the vestibular stress by the FOT run show significant differences for the age groups.

	Time	Eyes	Difference	P-Values
Dist.	PRAE	closed	0,0042	0,9736
		open	0,12	0,91
	POST	closed	0,0815	0,6151
		open	0,0498	0,4679
Area	PRAE	closed	0,09	0,1565
		open	0,0276	0,0979
	POST	closed	0,15	0,0435
		open	0,0341	0,0209

Table 6: Comparison of age groups (<30 years and 30<50 years); P-Values for differences of the mean

Discussion: The purpose of this study was to get an indication if there might be differences in age and experience groups with regard to the compensation of vestibular stress.

In our working hypothesis we assumed that there would be no significant differences between the two groups of test persons.

Generally, the pilot candidates seemed to be less affected by the vestibular stimulation. They recovered to baseline faster than the experienced pilots. The absolute values were lower for the pilot candidate group before and after the FOT run. Only the "area" measurement was significantly different in both groups but generally the results show a tendency towards a longer recovery period for the experienced pilot group. Unfortunately, the number of test persons is small because experienced jet aircrews are hard to include in a study that is performed in addition to their regular flight physical.

An additional problem was the distance between the FOT and the posturography. It was 25m. In the approximately 90 sec between the end of the vestibular stress induced by the FOT and the starting point of the first measurement, a lot of the effect is lost and a stabilization of the vestibular regulation has already taken place. This could clearly be seen because many test persons of both groups could not walk a straight line without help directly after exiting the FOT. Unfortunately, this effect was nearly washed out before the first measurement was taken.

Although the vestibular stimulation lasted for 180 seconds, all test persons described the sudden deceleration from a continuous motion as the strongest stimulus. A test profile that provides more short-term accelerations and decelerations would increase the coriolis-like vestibular stress, which could be more effective than just the continuous motion around more than one axis.

Conclusions: The results indicate that vestibular stress might affect older aircrew members more than pilot candidates. The significant differences in the area measurements after the 'vestibular stress and eyes closed' have to be verified with a larger sample size.

It appears that motions inducing a coriolis effect are more effective in inducing vestibular stress. For that purpose the FOT profile should be redesigned to produce these effects.

To more directly register the effect of the vestibular stimulation, time and distance between FOT and posturographic measurement have to be shortened.

At this point our results do not indicate that the vestibular regulation in the older test group might be insufficient for these pilots to continue to fly jet aircraft.