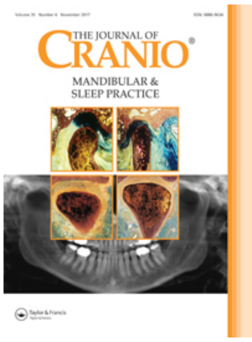

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EQUILIBRATION

Mandibular position influence on pilots' postural balance analyzed under dynamic conditions

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ABSTRACT

Objective: The aim of this study is to evaluate the influence of the mandibular position on the postural stability in a sample of civilian and military pilots.
Methods: Twenty military pilots (males, mean age 35.15 ± 3.14 years) and 17 civilian pilots (males, mean 34.91 ± 2.15 years) were enrolled in this study and underwent a Sensory Organization Test (SOT) using the EquiTest® (NeuroCom International Inc., Clackamas, OR, USA) computerized dynamic posturography. The composite parameter was recorded and analyzed.
Results: The equilibrium score (ES) recorded in centric occlusion is slightly higher than the ES recorded in mandibular rest position; civilian pilots showed ESs slightly higher than military pilots. The two-way ANOVA analysis shows these differences are not statistically significant.
Discussion: The findings of this study seem to suggest that the composite parameter of the SOT is not sensitive in analyzing the influence of the stomatognathic system on the postural balance of civilian and military pilots.

KEYWORDS
Postural balance; dental occlusion; sensory organization test; military personnel; bruxism; neck pain; TMJ; Air Force personnel

Introduction

The activity of military flight exposes the pilots to accelerative stresses. Pilots experience positive and negative G accelerations everyday when a plane engages in a steep climb or enters a high-speed turn, drops vertically towards the ground, when it encounters an air pocket and loses altitude, or when it encounters strong winds or air currents that produce a shearing action on the aircraft. The subjective effects associated with increasing G were described initially by Armstrong and Heim [1] and by Gauer [2], and have been portrayed more recently by Burton and Whinnery [3].

In modern high-performance tactical aircraft, such climbing and turning maneuvers often result in the sudden application of multiple G accelerations.

These accelerations and the stress of military flight cause pilots of high-performance fighters to frequently report work-related neck and back pain. Tired muscles are more vulnerable to acute injuries, and they are not able to support the spinal column as effectively as unexhausted muscles are. In fact, the cumulative number of flight hours has been identified as a significant determinant of acute in-flight musculoskeletal symptoms [4]. Sitting postures and ejection seat angles also need to be addressed when considering pilots' musculoskeletal loadings under hypergravitational forces.

Additionally, the stomatognathic apparatus is highly stressed by military flight, and Air Force pilots are also involved in dental and stomatognathic system problems. Two examples are barodontalgia, which affects 11% of military aircrews at a rate of 5 episodes/1000 flights [5], and another pathology, called "Dental Barotrauma," frequently reported during the WWII period, that deals with fracturing of restorations during high-altitude flying [6]. Air Force pilots also experience bruxism, an oral parafunction that can cause serious dental, periodontal, masticatory muscle, and temporomandibular joint problems [7,8]. In 2007, Lurie et al. performed research in which a significant percentage (69%) of Israeli Air Force pilots were affected by bruxism; the authors suggested the use of a protective treatment with occlusal bite for the teeth [9].

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Some studies demonstrated a significant connection, in terms of functional anatomy and pathophysiology, between the dysfunctions of the stomatognathic apparatus and the craniocervical structures [10–12].

A study done by Baldini et al. showed that a pilot's stomatognathic system is able to influence his postural system, especially in the cervical and lumbar regions. Using a dental splint, with the aim of protecting the pilot's stomatognathic system and balancing unstable occlusion, could help in the control of dental abrasion in balancing the postural system [13] and helping obtain a relaxation of Air Force pilots' masticatory muscles with consequent relaxation of their cervical area [14].

Thus, the craniocervical muscular condition, influenced by the mandibular position, could modify the postural system in pilots, changing the effects related to the physical stresses typical of flight accelerations.

Posture refers to the position of the human body and its orientation in space. Postural control represents a complex interplay between the sensory systems and the visual system. The suppression of one type of sensory information can be used to estimate its importance to postural control and indicate how the central nervous system adapts and reorganizes information provided by the remaining sensory information [15].

Posturography is an approach to the assessment of vestibular dysfunction that utilizes a force platform and provides various measures that reflect postural stability, such as the amount of body sway. There are essentially two types of clinical posturography: static platform posturography and dynamic platform posturography. Static platform posturography involves stance or tandem stance on a fixed platform with eyes open or closed [16,17]. Dynamic platform posturography includes test conditions in which the platform and visual environment are moved to reduce the subject's ability to use visual and somatosensory information for balance [18,19]. In addition, dynamic platform posturography incorporates sudden displacements of the platform to test the subject's response to balance perturbations [17,20].

Dynamic posturography (EquiTest®; NeuroCom International Inc., Clackamas, OR, USA) involves two tests of balance function: the sensory organization test (SOT) and a motor control test (MCT), that consists of sudden displacements of the platform to induce body sway [21].

A case-control study on 10 Air Force pilots and 30 healthy control subjects, utilizing a static force plate exam for evaluating their postural control [10], concluded that pilots have better postural control than normal individuals in all occlusal and visual combinations. In a study carried out by Sforza et al. on a group of astronauts [22], a statistically significant connection was reported among the modifications induced in the electromyographic values of the sternocleidomastoid muscle when a splint was inserted between the dental arches: the greater the muscular symmetry using the splint, the smaller the astronauts' areas of oscillation on the stabilometric platform. In fact, in literature, an occlusal splint can help in increasing masticatory muscle relaxation and symmetry in Air Force pilots [14]. A study made by Baldini et al. also demonstrated that mandibular position is able to influence the pilots' postural stability, analyzed using a static force platform [23].

A study done by Hosoda et al. [24] examined whether dental occlusion contributes to improvement of balance, analyzing the latency measurements of the MCT, representing the time from application of external disturbance to initiation of recovery action. In a sample of healthy subjects, they found that the time required for initiation of recovery in response to external disturbance in the standing position is shortened with jaw occlusion compared to no jaw occlusion.

Looking at previous studies [7,13,25], the mandibular position and the use of a protective dental splint are able to influence posture and the cervical muscular condition of military pilots. Thus, an occlusal therapy with occlusal splint could interfere with painful symptomatologies that are often experienced by pilots due to vibrations transmitted by the aircraft [7,13]. The influence on the postural balance in dynamic conditions was never analyzed in literature before. Therefore, it could be important to conduct an analysis of the stomatognathic apparatus influence on pilots' postural systems with the dynamic posturography.

The aim of this study is to evaluate the mandibular position influence on postural stability under dynamic test conditions in a sample of civilian and military pilots. In fact, owing to the different amplitude of the accelerations they are subjected to during flight and their different sitting angle and flight maneuvers, a different postural balance response between these two pilot categories could be hypothesized.

Thus, the null-hypothesis is that the postural balance is not influenced by the mandibular position and the pilot's category.

Materials and methods

Subjects

A total of 37 Italian male pilots aged from 27 to 40 years were enrolled in the study and analyzed at the Institute of Aerospace Medicine in Milan, Italy. The sample included 20 military pilots (males, mean age 35.15 ± 3.14 years) and 17 civilian pilots (males, mean age 34.91 ± 2.15 years).

Figure 1. EquiTest® system during a sensory organization test on a pilot.

They signed an informed consent form after being fully informed about the nature of the study. The study was conducted in accordance with the Helsinki Declaration and approved by the ethical committee of the Italian Air Force.

A clinical examination, oral examination, and anamnesis were carried out for each subject. All of the volunteers had to meet the following criteria: good general health according to a medical history, absence of trauma or surgery that could influence posture, absence of visual or vestibular problems, absence of any other disorder able to influence posture, absence of evident postural problems, fully dentate subjects without wisdom teeth (except for the presence/absence of the wisdom teeth), absence of cast restorations and extensive occlusal restoration, and absence of temporomandibular disorders (TMD). They were all physically well trained and unaware about the aim of the study.

Equipment and procedure

The subjects underwent a SOT using the EquiTest® (NeuroCom International Inc., Clackamas, OR, USA) computerized dynamic posturography; this system is characterized by a dynamic dual force plate with rotation and translation capabilities to measure the vertical forces exerted by the patient's feet, and a moveable visual surround (Figure 1).

The SOT evaluates postural stability with systematic changes in the type of visual and somatosensory information available to the patient to maintain stance. The amount of sway is estimated from maximum peak-to-peak displacement of the center of force during the test interval [26]. An equilibrium score represents the estimated peak-to-peak sway normalized to a theoretical maximum body sway [18].

During the SOT, subjects were required to stay barefoot on the platforms and remain as still and relaxed as possible, with their arms hanging free beside their trunk, and eyes looking forward; they also wore a security harness to prevent falls. Moreover, all subjects were asked to avoid alcohol, sports, and conservative therapies during the 24 h prior to the clinical recordings. The foot placement was standardized according to the height of the participant. During the test, pilots were exposed to six different combinations of visual and support surface conditions (eyes open or closed, support fixed or sway referenced, visual surround fixed or sway referenced).

The system detects the trajectory of the center of pressure of the subjects, calculating the equilibrium score (ES) in each condition. An ES of 100 represents an excellent balance control, whereas 0 represents the exceeding of the limits of stability of the subjects, resulting in a fall [27]. Then the composite parameter represents the summary of the equilibrium score recorded in each condition and was considered in this study.

Each session lasted 20 s, and the whole test was repeated in mandibular rest position and mandibular centric occlusion position. The mandibular rest position represents the habitual mandibular position of the subject, which is characterized by absence of teeth contact and a physiological equilibrium between gravity and an elevator muscles light tension. The mandibular centric occlusion represents the habitual dental occlusion of the subject in maximum intercuspal position obtained without clenching.

Statistical analysis

The composite ES parameters resulting from all the test conditions were summarized as means and SDs, with respect to mandibular position and pilot category. Because of the supposed moderate association between dependent variables, a two-way ANOVA analysis was performed in order to statistically evaluate the effective influence of each factor. A significance level of 0.05 was adopted.

Table 1. Mean and SD of the SOT composite parameter recorded in civilian and military pilots. Relative *p*-values after two-way ANOVA for category and mandibular position.

	Civilian		Military	
	Rest	Centric	Rest	Centric
Media	85.41	86.24	84.80	85.95
SD	2.74	3.96	4.64	4.56
	Two-way ANOVA			
	Category	M. position		
p-value	0.638	0.294		

Note: SD: Standard deviation; SOT: Sensory organization test.

Results

Table 1 displays mean and SD values for civilian and military pilots under mandibular rest position or centric occlusion.

The ES parameters recorded in centric occlusion are slightly higher than the ES recorded in mandibular rest position; civilian pilots showed ESs slightly higher than military pilots. The two-way ANOVA analysis shows these differences are not statistically significant with $p = 0.294$ for mandibular position and $p = 0.638$ for pilot category (civilian/military).

Discussion

Scientific literature lacks studies that analyze pilots' postural and stomatognathic systems using dynamic posturography that incorporates sudden displacement of the platform in order to test the pilots' response to balance perturbations. The SOT was widely used in literature in order to investigate the postural control of healthy or pathological subjects under platform and environment perturbations [19,27]. In this study, the SOT composite parameter was recorded in Air Force and civilian pilots who were tested with the mandible positioned in mandibular rest position and mandibular position of centric occlusion. In disagreement with Baldini et al. [23] and Hosoda et al. [24], the postural balance was not influenced by the occlusal condition. It is generally accepted that chronic stressful situations and mental states like anxiety or depression contribute to the development of occlusal parafunctions and temporomandibular disorders without being the only cause. Air Force pilots, due to the physical stresses to which they are subjected, often experience bruxism, an oral parafunction that can cause masticatory muscle pain; serious dental and periodontal problems; and TMD [7]. TMD and bruxism are characterized by hyperactivity of the masticatory muscles, and the dental occlusion is able to highly influence the Air Force pilots' muscular system, especially in the cervical area where the masticatory muscles tension can diffuse [14]. Thus, looking at the previous studies, different mandibular positions are associated with different muscle tensions and are able to influence posture in military pilots. The centric occlusion mandibular position adds tooth contact to the mandibular rest position, and thus, in this study, it could be expected that in subjects with a stressed stomatognathic apparatus as pilots are, the centric occlusion mandibular position could negatively influence posture, as observed by Baldini et al. in their study conducted using a force platform [13].

The absence of statistically significant differences in this study, in disagreement with previous ones, could be related to the use of different tests, instrumentations and parameters. In the Baldini et al. study [23], static posturography instrumentation was used, and the different results could be related to the use of dynamic posturography. But in the Hosoda et al. study [24], the same equipment (Equitest®) was used to conduct a different test, obtaining variations of their parameter related to dental occlusion. Considering these previous results, it could be assumed that the composite parameter of the SOT is not sensitive in analyzing the influence of the stomatognathic system on the postural balance.

The mean composite parameter for both civilian and military pilots was 85.6 ± 4.0, a little bit higher if compared with the same parameter on healthy subjects (83.4 ± 3.0) in the first session by Wrisley et al. [20], in agreement with previous studies that found pilots have a better postural control than normal individuals [10].

Further studies are needed to evaluate if other parameters of the EquiTest® could reveal an influence of the stomatognathic apparatus on pilots' postural balance.

Conclusions

Looking at the previous literature, the findings of this study seem to suggest that the composite parameter of the SOT is not sensitive in analyzing the influence of the stomatognathic system on the postural balance of civilian and military pilots. No significant differences in postural balance were found between these two groups. A detailed analysis using other parameters of the dynamic posturography should be done in order to enhance the knowledge in this field.

Disclosure statement

No potential conflict of interest was reported by the authors.

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