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Dental occlusion modifies gaze and posture stabilization in human subjects

Pierre Gangloff[a,b,c], Jean-Paul Louis[c], Philippe P. Perrin[a,b,d,*]

[a]Equilibration et Performance Motrice, Unité de Formation et de Recherche en Sciences et Techniques des Activités Physiques et Sportives (UFR STAPS), Université Henri Poincaré-Nancy 1, 30 rue du Jardin Botanique, 54600 Villers-lès-Nancy, France
[b]National Institute for Health and Medical Research (INSERM), U 420, Faculté de Médecine, Vandoeuvre-lès-Nancy, France
[c]Faculté de Chirurgie Dentaire, Université Henri Poincaré-Nancy 1, Nancy, France
[d]Laboratoire d'Exploration Fonctionnelle, Service ORL, Centre Hospitalier Universitaire de Nancy, Vandoeuvre-lès-Nancy, France

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Abstract

Repercussion of dental occlusion was tested upon postural and gaze stabilization, the latter with a visuo-motor task evaluated by shooting performances. Eighteen permit holders shooters and 18 controls were enrolled in this study. Postural control was evaluated in both groups according to four mandibular positions imposed by interocclusal splints: (i) intercuspal occlusion (IO), (ii) centric relation (CR), (iii) physiological side lateral occlusion and (iv) controlateral occlusion, in order to appreciate the impact of the splints upon orthostatism. Postural control and gaze stabilization quality decreased, from the best to the worst, with splints in CR, IO and lateral occlusion. In shooters, the improvement in postural control was parallel to superior shooting performance. A repercussion of dental occlusion upon proprioception and visual stabilization is suggested by these data. © 2000 Elsevier Science Ireland Ltd. All rights reserved.

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Dental occlusion studies reported in the past few years have allowed to postulate a possible relationship between dental occlusion and posture control [1,8,12]. Empirically, coaches advise high level sportsmen to wear occlusal splints during competitions in order to increase motor performances in such sports as baseball [9], football [15] and race-running [5].

When in the upright position, permanent oscillations are generated to maintain balance. Sensorial afferences are provided from proprioceptive, tactile, vestibular and visual receptors. Proprioception of the mandibular system, which arises from the masticatory muscular system and dento alveolar ligaments is secured by the trigeminal nerve (fifth cranial nerve) [14].

Alterations of the manducatory system, resulting from lesions in the masticatory muscles or dento alveolar ligaments, could induce a perturbation of the visual stabilization, and generate postural imbalances. This might prove especially damageable in activities requiring the best possible balance, such as professional shooters.

Complex nervous interactions regulate the function of oculo-cephalogyr synergetic centres. Such interactions can help in maintaining a proper masseter tone in order to keep the mandibular axis in the correct position [16]. Besides, Buisseret-Delmas et al. [3] and Pinganaud et al. [13] have demonstrated the existence of relationships between trigeminal and vestibular nuclei in the rat. As vestibular inputs represent an important afferent way for postural stabilization, position of the mandibular axis could impact on postural control.

Here we report a study devised to determine a possible repercussion of dental occlusion on postural control and gaze stabilization.

Thirty-six subjects were included in the study. All of them provided informed consent prior to the study. None of them had had, during the past 6 months, muscular, joint or bone lesions of the lower limbs, possibly interfering with postural control. Subjects with meniscus subluxation or luxation of the temporo mandibular joint were excluded from the study.

First, 18 subjects with irreproachable bucco dental hygiene were included as a control group for postural evaluation (P group) in various conditions of induced abnor-

* Corresponding author. Fax: +33-383-902-842.
E-mail address: philippe.perrin@staps.uhp-nancy.fr (P.P. Perrin).

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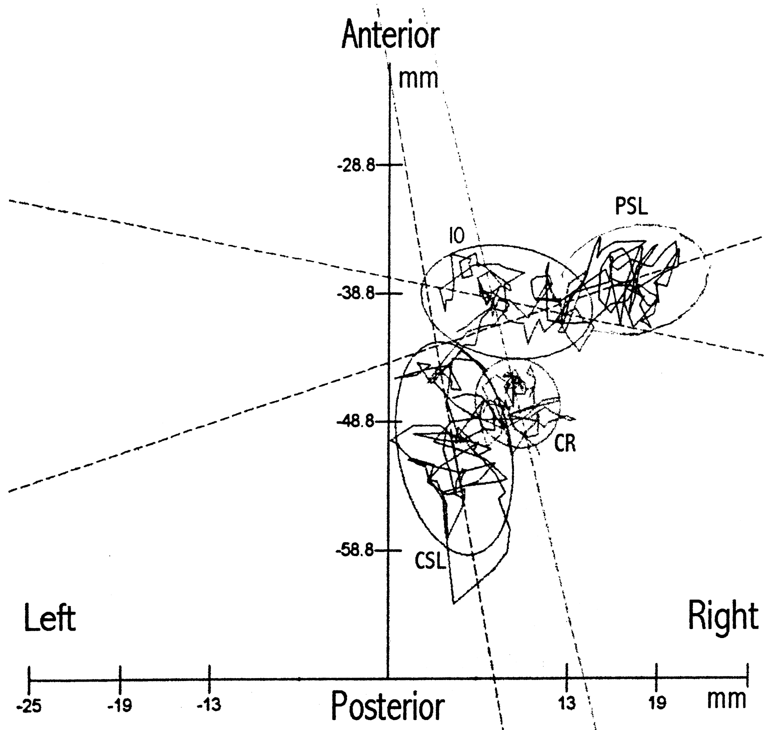

Fig. 1. Statokinesigrams. Typical curves obtained in four occlusal positions: centric relation (CR), intercuspal occlusion (IO), physiological side (PSL) and controlateral side lateralities (CSL) for the same subject.

mal dental occlusion. Then, 18 high level shooters were tested to appreciate gaze stabilization with the same type of dental occlusion disruption (GS group).

Spontaneous occlusion defaults in the frontal plane were evaluated for the 36 subjects in order to determine their chronic deviation side, which corresponds to the physiological side of this deviation.

To evaluate repercussions of dental occlusion experimental modifications, the mandibular position was jammed in four defined positions. Intercuspal occlusion (IO) was obtained by asking the subject to clench his/her teeth. This position is neutral but not symmetric, occlusion defaults being noted in majority of the general population. For the three other positions, specific artefacts were prepared for each subject using autopolymerizable resin wedges (GC, Tokyo, Japan) on articulators incisor shafts, frontal plane gaps being reproducible. Centric relation (CR) was attained by placing the mandibular condyles in a symmetric position in their respective glenoid cavity. This position is achieved using specific indented occlusion waxes by a bimanual manipulation of each subject's mandible and controlled with a second manipulation in order to verify occlusion similarity. This corresponds to a facial symmetric position, and achieves neuromuscular equilibrium. For laterality occlusion positions, a mandibular gap of 3 mm was set in the frontal plane on the right or the left. IO was considered to determine reference laterality. The first side of laterality was considered that corresponding to the side of gap between IO and CR. Subjects never were aware of the splint they were wearing.

Posturographic measurements (QFP Systèmes, Nice, France) were recorded in the same place and environmental conditions for all P group subjects. Centre of foot pressure (CFP) displacements were recorded during 20 s and represented by a statokinesigram (Fig. 1). For each occlusion position, one test was recorded in eyes open condition and then a second one in eyes closed condition.

Body oscillation was evaluated by computing the displacement of the CFP over time and by measuring the sway area contained in the confidence ellipse including 90% of the positions sampled. This procedure eliminates 10% of the extreme points in order to delete CFP values which could be induced by quasivoluntary movements not indicative of the amount of postural sway [10]. Oscillation surface is a statistic measurement of the dispersion of CFP and therefore a precise evaluation of how the postural system stabilizes the subject in relation to his environment [4]. Data were expressed as median, first quartile and third quartile values. The energy used by the subject to stand steady [7] was then appreciated by the coefficient X way area (XWA), which was calculated as follows: $XWA = ((4 - W)/(4 - A)) \times WA$.

In the GS group, four series of five shots (shooting distance: 10 m) were performed in each of the four predefinite mandibular positions. In accordance with their discipline, shooters used their own airgun or air rifle. After each round of shots, the score and accuracy were recorded.

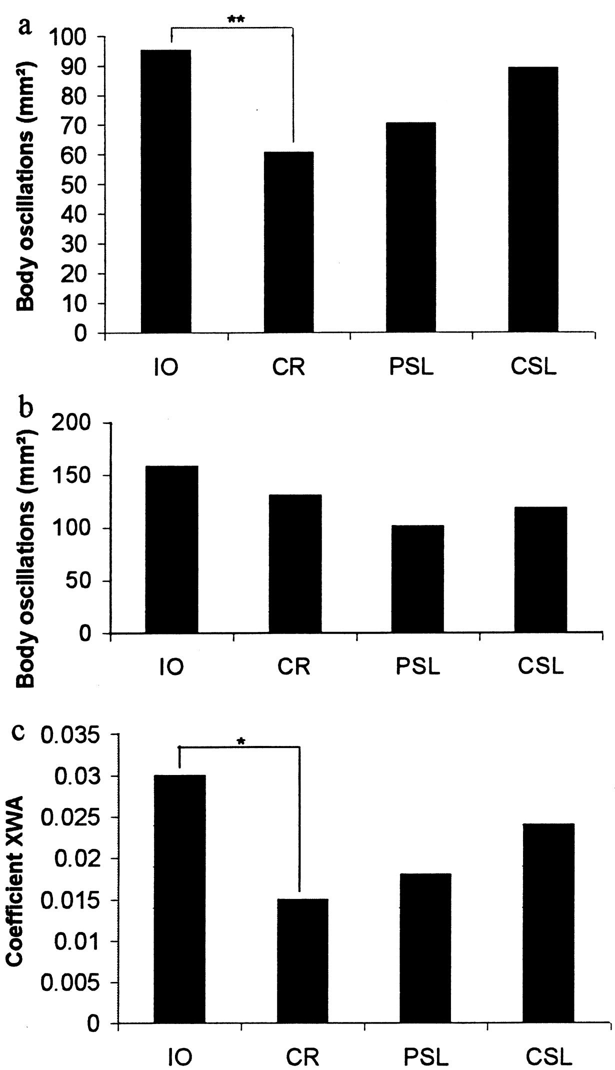

Fig. 2. Body oscillation surface in eyes open (a) and closed (b) conditions and XWA coefficient (eyes open condition) (c) during 20 s record according to dental occlusion position (median). IO, intercuspal occlusion. CR, centric relation. PSL, physiological side laterality occlusion. CSL, controlateral side laterality occlusion.

Centroid coordinates were used to calculate the bidimensional variable error (BVE), which represents a shooting dispersion surface evaluation [6].

For the P group, a non-parametric statistic test (*t* of Wilcoxon and Spearman) was used to compare the four series of measurements. For the GS group, Student's *t*-test allowed to compare the results.

For postural performances, the lowest surface covered by the CFP was noted in eyes open condition in CR (median: 60.8 mm^2. First quartile: 41.7 mm^2; third quartile: 106 mm^2 for the 20 s recording). Surface values were higher for the three other mandibular positions: 95.2 mm^2 (59.4–114) in IO, 70.6 mm^2 (54.8–149.3) in physiological side laterality (PSL) and 89.1 mm^2 (65.4–108.3) in controlateral side laterality (CSL). In eyes closed condition, the median was 130.05 mm^2 (79.6–198.1) in CR; 157.7 mm^2 (97.4–197.1) in IO; 100.3 mm^2 (85.4–148.8) in PSL and 117.8 mm^2 (82.8–209.6) in CSL (Fig. 2a,b).

The median XWA coefficient, in eyes open condition, was 0.015 (0.011–0.025) in CR; 0.018 (0.011–0.042) in PSL; 0.024 (0.013–0.037) in CSL and 0.030 mm^3 (0.015–0.038) in IO (Fig. 2c). A statistically significant difference was noted for the surface parameter in eyes open condition ($P < 0.01$) and for the XWA coefficient between CR and IO ($P < 0.05$).

In the GS group, the mean score was 40.3 points (±4.4) in IO; 43.3 points (±4.8) in CR; 41.1 points (±4.7) in PSL and 40.7 points (±4.8) in CSL (Fig. 3a). A statistically significant difference was noted between CR and IO ($P < 0.01$) and between CR and CSL ($P < 0.05$). The mean BVE was 1.82 (±0.94) in CR, 2.16 (±0.80) in IO, 2.18 (±1.09) in PSL and 2.31 points (±1.31) in CSL (Fig. 3b). A statistically significant difference was noted between CR and IO ($P < 0.05$).

The best results were always obtained in CR. Laterality occlusions induced a tendency towards lower body stabilization, and an increase of energy consumption for postural control. A better performance and a decrease of shooting dispersion surface was observed when GS subjects had occlusion set in PSL rather than in CSL.

A hierarchy can therefore be established for both groups,

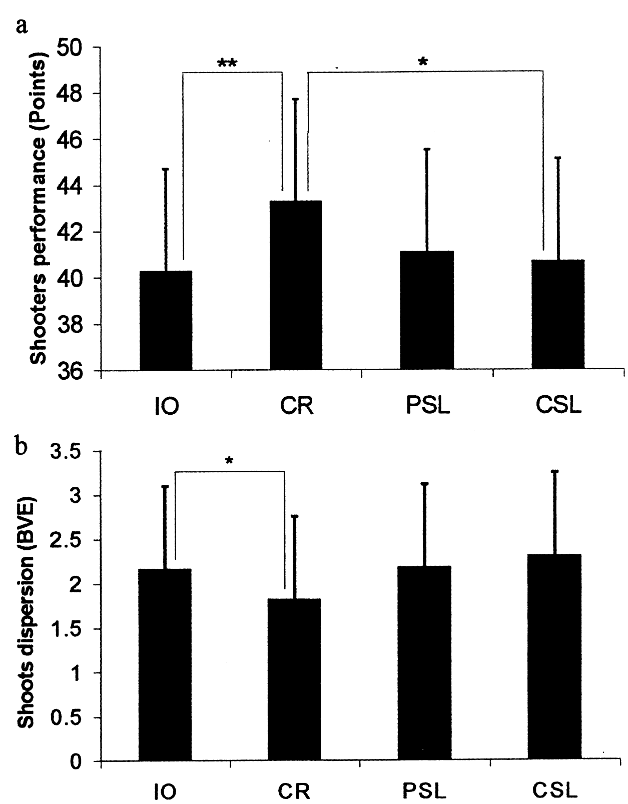

Fig. 3. Shooters performance (a) and shoots surface dispersion (BVE) (b) according to dental occlusion (mean). IO, intercuspal occlusion. CR, centric relation. PSL, physiological side laterality occlusion. CSL, controlateral side laterality occlusion.

from the best to the worst: CR, IO and laterality occlusion. No difference was noted between the two sides of laterality.

The data reported in this study demonstrate a clear relationship between dental occlusion and postural control. A better balance control and improved shooting performances were obtained when occlusion was artificially set on the CR, a position providing a facial symmetric position and neuromuscular equilibrium. The relationship observed here between this proprioceptive and motor output aiming to gaze stabilization by oculo-motricity and to posture stability by lower limbs extensor tone adaptation, suggests a role of trigeminal afferences in posture control. Occlusal perturbation modifies the myo-joint proprioception, one of the sensorial inputs crucial for balance control. Moreover, dento-muscular-joints afferences of the manducator system project on the accessory nerve (XI) nucleus in charge of sterno cleido mastoidal and trapeze muscles motricity. By intervening on the tonic motricity of the neck muscles, trigeminal afferencies are likely to infer on the fine regulation of orthostatic posture [11].

For shooters, the lower performance and increase of shooting dispersion surface when the mandible was in a unwedged position indicate that gaze stabilization is not optimal in this however natural circumstance. Meyer et al. [11] have shown relationships between dento-muscular-joints afferences and the cranial nerve nucleus, responsible for ocular motricity (oculo motor nerve: III; trochlear nerve: IV; abducens nerve: VI). This oculo trigeminal relation was demonstrated by Buisseret et al. [2], using peroxydase injection into oculo motor muscles as a marker which diffuses in the Gasser node, in the caudal sub nucleus of the trigeminal nerve and in the cervical brainstem (C1-C2). Furthermore, Buisseret-Delmas et al. [3] have shown that, in vestibular nuclei (VN), sensory information from facial receptors is added to that retrieved from proprioceptive afferences of the neck and body. The connections of the respective zones of the VN receiving trigeminal afferents suggest that sensory inputs from the face may influence vestibular control of eye and head movements. Pinganaud et al. [13] have shown that neurons in the caudal part of the trigeminal mesencephalic nucleus project mainly to the medial, inferior and lateral VN and moderately to the peripheral part of the superior vestibular nucleus. These authors have suggested that these anatomical relations are involved in mechanisms of eye-head coordination. For high level shooters, obtaining high level performances requires both the obtention of a perfect visuo-motor task for aiming and an optimal regulation of orthostatic postural tonic activity for body stability. The two complementary parts of our study tested both the proprioceptive input and gaze stabilization, and demonstrate repercussions of experimental dental occlusion modification on both parts of this possible sensori-motor chain.

The better results obtained when dental occlusion was set in CR could be explained by the optimal symmetry achieved in such conditions. Our data suggest that such divides as prepared here to set the mandible in CR could be proposed to high level sportsmen requiring optimal balance control in the practice of their sport. Better postural control performances in PSL than in CSL could be explained by a possible adaptation or habituation mechanism for their chronic mandibular unwedge.

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