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Temporomandibular Disorders Do Not Correlate with Detectable Alterations in Body Posture

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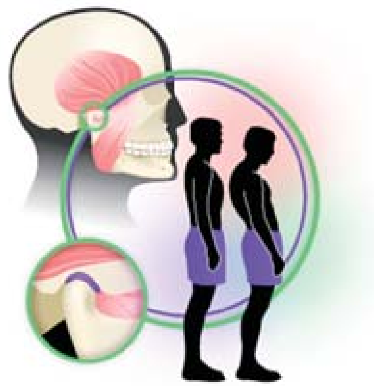

Abstract

Aim: This study aimed to determine if temporomandibular disorders (TMD) correlate with alterations in body posture detectable through posturography.

Methods and Materials: Thirty-five asymptomatic subjects and 35 TMD patients (34 males and 36 females; mean age, 27.7±8.6 years) constituted the matched control and TMD groups, respectively. Posturography was performed under four different experimental conditions: (a) eyes open with mandibular rest position (Eyes Open RP); (b) eyes open with dental occlusion (Eyes Open DO); (c) eyes closed with mandibular rest position (Eyes Closed RP); and (d) eyes closed with dental occlusion (Eyes Closed DO). The X, Y, and absolute centre of pressure displacements from the projection of a theoretical barycentre and the sway area, sway length, and sway velocity were recorded as static and dynamic posturographic parameters, respectively.

Results: Generally, no differences were found in any of these parameters between the groups and between the RP and DO within either Eyes Open/Closed conditions. The only differences were found under Eyes Closed as compared to Eyes Open, irrespective of the RP/DO conditions for dynamic and not for static posturographic parameters.

Conclusion: This study failed to show detectable alterations in body posture in TMD patients.

Keywords: Temporomandibular disorders, TMD, musculoskeletal equilibrium/physiology, physiological adaptation, mandible physiology, biomechanics

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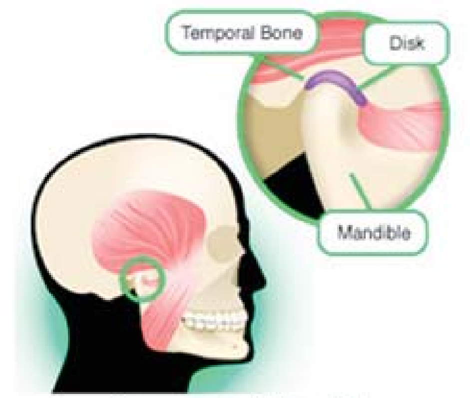
Introduction

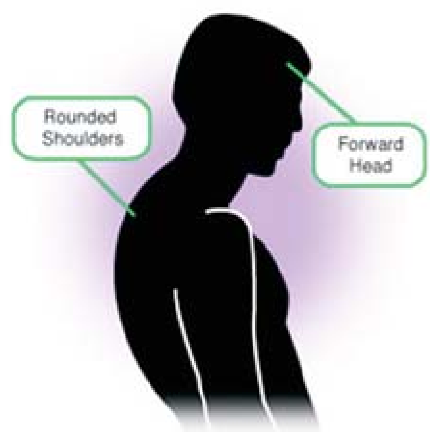
A balanced tension between the anterior and posterior craniocervical bones and myofascial structures is responsive in the maintenance of the erect positioning of the head. Dental occlusion is also an important element in the bone relationships of the anterior area; with this consideration in mind an influence of the stomatognathic system on head and cervical spine posture has been reported.[1] Moreover, temporomandibular disorders (TMDs) have been shown to be associated with forward head positioning[2,3] and rounded shoulders,[3] while occlusal alteration has been associated with imbalance of the cervical spine.[4] All of these results are supported by recent neuroanatomical investigations demonstrating a projection of the trigeminal neurons to the vestibular nuclei[5] and trigeminocerebellar links.[6] However, the functions of this still needs to be fully explained.

Assessing postural coordination by measuring the sway of the human body in an upright posture has become popular both in clinical care and in clinical research.[7] This is achieved by monitoring the displacement of the body centre of pressure (COP) and other postural parameters using a vertical force platform (posturography). In particular, this approach is now widely used in the diagnosis and rehabilitation of patients with vestibular and other neurological disorders.[8]

In recent years studies have been performed to determine whether a correlation between the stomatognathic system and body posture is detectable through posturography in asymptomatic subjects[9-13] and TMD patients.[9] However, inconclusive results have been reported. Some of these investigations have described detectable correlations between body posture and gaze stabilization,[10] diminished trigeminal afferences through unilateral anaesthesia,[11] and dental occlusion.[12] In contrast, Perinetti[13] failed to find any clinically detectable correlation between body posture (recorded through four posturographic parameters) and dental occlusion in asymptomatic subjects who were monitored under opposing visual (eyes open/closed) and dental occlusion (mandibular rest/intercuspidation positions) conditions. Similarly, Ferrario et al.[9] reported no significant differences in terms of COP variations with respect to dental occlusion, malocclusion, or TMDs through posturography. However, while these previous studies evaluated limited numbers of posturographic parameters (either static or dynamic) and experimental conditions,[9–12] the use of multiple parameters to better describe body posture may prove to be of more value.



Temporomandibular Joint



Of note, Munhoz et al.[14] very recently described no correlation between internal temporomandibular joint (TMJ) derangement and global body posture, according to an analysis of a set of body posture photographs. However, this method is limited by the "static nature" of the data collected and does not take into account all of the components of body sway nor allow a recording of any of the dynamic aspects of posture. Indeed, body posture has both static and dynamic components that might behave differently.[15] Moreover, it is possible an instantaneous recording, rather than a time recording (i.e., one minute long), might be insufficient to detect postural differences.

The present controlled study was, thus, aimed at providing more conclusive results towards determining if TMDs do correlate with static and dynamic body posture alterations to a detectable level through posturography and at ultimately determining whether posturography can be used as a diagnostic tool in dentistry. This was achieved by a comparison of body posture in asymptomatic subjects and TMD patients. The data was recorded as different parameters at different mandibular positions without and with deprivation of visual input.

Methods and Materials

Study Population

Seventy subjects (34 males and 36 females) were enrolled in the study after conveying written informed consent. They were diagnosed as either asymptomatic subjects or TMD patients and made up the control and TMD groups of equal size. All of the subjects had to comply with the following inclusion criteria:

- Good general health according to their medical history and the clinical judgment of the researcher.
- A negative history of vertigo through central nervous disease.
- Negative findings of symptoms caused by any previous trauma or surgery.
- An absence of any abnormalities after a neurological investigation, including assessment of vision and vestibular and lower leg sensory functions.
- A negative history of macro trauma in the head region or in the vertex.
- The absence of any particular episode of psychosocial and psychological stress in the previous month.

The subjects included in the control group (19 males and 16 females; mean age 26.2±6.8 years) also had to comply with the following criteria:

- The presence of a natural dentition and a bilateral molar support with ±2 mm molar and canine Angle I relationship.[16]
- Free of any cross-, open-, or depth-bite.
- Free of cast restorations and extensive occlusal restoration.
- Free of any TMD as diagnosed below.

The subjects included in the TMD group (15 males and 20 females; mean age 29.2±10.0 years) were diagnosed as TMD patients. A combination including the following two signs of TMD had to be present:

1. TMJ sounds during mandibular movement.
2. Limited mandibular range of vertical and mandibular opening.

These were present in combination with any of the following:

- Localized pain in the TMJ or ear.
- Pain on mandibular movement.
- Headaches aggravated by mandible movement.
- A history of TMJ locking.
- The presence of chronic muscle pain, either according to their signs and symptoms history or as elicited during palpation of the muscles of the trunk, neck, and stomatognathic area.

In particular, pain *per se* was not considered as an inclusion criterion and patients relating only this symptom were excluded from the study.

Posturographic Recordings

Posturographic recordings were performed by using a vertical force platform along with its dedicated software (Lizard s.r.l., Como, Italy) with subjects placed in a quiet stance. (Figure 1).

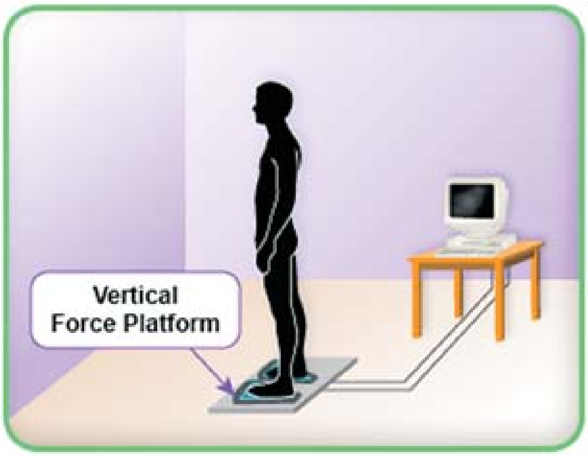


Figure 1. A. Vertical force platform. **B.** Experimental Setup.

In particular, this platform is characterized by load cells with an internal circuit that changes electrical resistance upon the application of a force. The subjects were required to remain as stable as possible but relaxed with their arms hanging free beside their trunk and facing the wall (150 cm away). Moreover, all subjects were asked to avoid alcohol and heavy exercise during the 24 hours preceding the clinical recordings.

Four different conditions were used during static posturography as follows:

1. Eyes open with mandibular rest position (Eyes Open RP).
2. Eyes open with dental occlusion (Eyes Open DO).

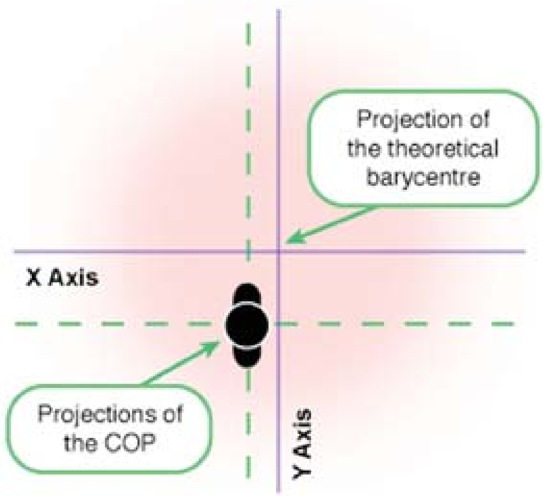


Figure 2. Representation of the statokinesigram.

3. Eyes closed with mandibular rest position (Eyes closed RP).
4. Eyes closed with dental occlusion (Eyes Closed DO).

The RP was defined as the habitual postural position of the mandible when at rest,[17] while DO (without clenching) was performed with two cotton rolls mildly crushed between the dental arches.[9] For each condition, the successive projection of the COP were recorded at 10 Hz on a statokinesigram (Lizard, Figure 2) and its mean displacements from the projection of the theoretical barycentre (in mm) along both the lateral (X) and antero-posterior (Y) axes and were used as spatial (static) posturographic parameters.

The theoretical barycentre is considered as the point where its projection on the ground falls in the middle of the connecting segment between the barycentre of the right and left limbs (Figure 2). The absolute mean displacement of the COP projection from the projected theoretical barycentre was also calculated as follows: $[(X^2 + Y^2)^{1/2}]$. In particular, only the COP projections within the ellipse of 90% of the projected points were considered in the final estimation of the outcomes. Moreover, the projected sway area (in mm^2), the sway length (in mm), and the sway velocity (in mm/s) were recorded as dynamic posturographic parameters.

Data Analysis

Statistical Package for Social Sciences software (SPSS® Inc., Chicago, Illinois, USA) was used to perform the data analysis. Each data set was tested for normality using the Shapiro-Wilk's test and by Q-Q normality plots; equality of variance was also tested by means of the Levene's test and Q-Q normality plots of the residuals. Through this analysis, non-parametric methods were used in hypothesis testing. A chi-squared test and a Mann-Whitney test were used to assess the equality of groups by gender and age, respectively. For each posturographic parameter recorded (X, Y, and absolute COP displacements, sway area, sway length, and sway velocity), the Mann-Whitney test was also used to assess the significance of the differences between the groups within each experimental condition. In the same way, for each posturographic parameter, a Friedman test was used to assess the significances of the differences among the experimental conditions within each group. Subsequently, and when appropriate, pairwise comparisons, between the experimental conditions within each group, were performed by a Bonferroni-corrected Wilcoxon rank sum test. A p value less than 0.05 was accepted for rejection of the null hypothesis.

Results

Experimental groups were balanced by gender (p >0.4) and age (p >0.1). None of the posturographic parameters showed any significant differences between the groups within any of the experimental conditions with the exception of the X COP displacement which was significantly greater in the TMD group as compared to the control group under the Eyes Closed DO condition (Tables 1 and 2).

For the intra-group comparisons, the same results were generally seen for both of the groups. The static posturographic parameters X, Y, and absolute COP displacements yielded no statistically significant differences among the experimental conditions within each group except the Y COP displacement for the control group. Indeed, a statistically significant difference was found between the Eyes Closed RP condition as compared to the Eyes Open RP condition (-6.4 mm and -3.9 mm, respectively) as shown in Table 1. On the contrary, the dynamic posturographic parameters, sway area, sway length, and sway velocity, showed statistically significant differences among the experimental conditions within each group. In particular, the pairwise comparisons showed greater values for

Table 1. Static posturographic parameters among the different experimental conditions in each group (n = 35).

Variable	Experimental condition	Control Group				TMD Group			
		Mean±SD	Median	Minimum	Maximum	Mean±SD	Median	Minimum	Maximum
X COP Displacement (mm)	Eyes Open RP	0.8±4.0	2.0	-10.6	8.9	1.7±8.0	1.2	-26.7	16.2
	Eyes Open DO	0.5±5.5	1.3	-19.1	9.4	2.4±6.1	2.7	-10.4	17.7
	Eyes Closed RP	-0.3±5.6	-0.7	-22.4	11.6	1.7±7.2	1.7	-22.6	12.6
	Eyes Closed DO	-0.3±6.4	-0.2	-23.0	14.6	3.9±6.8, c	1.8	-5.7	15.8
	Diff.	p>0.5; NS				p>0.5; NS			
Y COP Displacement (mm)	Eyes Open RP	-3.9±16.5	-6.6	-35.2	26.6	-10.8±15.9	-11.4	-47.8	14.0
	Eyes Open DO	-3.7±17.5	-5.5	-43.3	29.3	-9.2±13.1	-10.4	-59.3	13.5
	Eyes Closed RP	-6.4±15.9*	-7.6	-44.3	18.5	-10.4±17.2	-7.7	-53.4	13.4
	Eyes Closed DO	-5.1±16.2	-5.2	-46.7	16.8	-10.4±17.8	-6.5	-59.9	11.1
	Diff.	p<0.01; S				p>0.5; NS			
Absolute COP Displacement (mm)	Eyes Open RP	14.9±8.7	13.8	1.7	35.3	17.2±11.6	15.8	3.4	47.8
	Eyes Open DO	15.1±10.7	12.5	1.7	43.3	14.3±9.6	10.7	4.4	59.9
	Eyes Closed RP	15.2±9.5	13.9	3.3	44.3	17.2±12.6	12.9	2.6	54.1
	Eyes Closed DO	14.3±10.9	11.0	2.6	46.7	17.4±13.4	13.5	3.7	60.6
	Diff.	p>0.5; NS				p >0.5; NS			

Diff., difference among the experimental conditions; **c,** different from the corresponding value of the control group; ***,** different from Eyes Open RP; **§,** different from Eyes Open DO. **NS,** No statistically significant difference; **S,** Statistically significant difference.

Table 2. Dynamic posturographic parameters among the different experimental conditions in each group (n = 35).

Variable	Experimental condition	Control Group				TMD Group			
		Mean±SD	Median	Minimum	Maximum	Mean±SD	Median	Minimum	Maximum
Sway Area (mm^2)	Eyes Open RP	73.0±36.5	65.3	26.2	154.1	102.5±139.9	56.6	24.5	633.2
	Eyes Open DO	98.0±67.8*	81.7	25.0	234.4	68.5±46.4	64.0	26.2	229.7
	Eyes Closed RP	138.1±86.9*	142.6	26.0	465.8	178.6±278.8*	68.7	22.1	1251.8
	Eyes Closed DO	138.1±102.6§	121.4	24.9	529.9	178.7±253.8§	83.5	24.9	1127.5
	Diff.	p<0.01; S				p<0.01; S			
Sway Length (mm)	Eyes Open RP	242.8±58.4	247.7	157.3	330.7	256.4±117.6	202.6	134.5	644.7
	Eyes Open DO	264.4±85.7*	251.6	139.3	436.2	236.5±63.4	232.5	141.4	436.2
	Eyes Closed RP	331.9±99.2*	341.9	153.0	529.0	351.1±186.0*	296.4	132.7	967.2
	Eyes Closed DO	330.9±104.7§	327.8	162.3	507.6	347.1±177.9§	285.5	162.3	918.8
	Diff.	p<0.01; S				p<0.01; S			
Sway Velocity (mm/s)	Eyes Open RP	6.9±1.8	6.5	4.1	10.5	7.3±3.4	6.1	4.1	18.5
	Eyes Open DO	7.7±2.6*	6.8	4.1	13.3	6.7±1.8	6.5	4.1	12.8
	Eyes Closed RP	9.4±2.9*	10.0	4.3	17.8	9.9±5.3*	8.1	4.3	27.6
	Eyes Closed DO	9.4±3.0§	9.0	4.3	16.5	9.9±5.3§	8.2	4.3	27.7
	Diff.	p<0.01; S				p<0.01; S			

Diff., difference among the experimental conditions; **c,** different from the corresponding value of the control group; *, different from Eyes Open RP; **§,** different from Eyes Open DO. **NS,** No statistically significant difference; **S,** Statistically significant difference.

the Eyes Closed as compared to the Eyes Open conditions within each of the RP/DO conditions. Moreover, in the control group only, statistically significant greater values were found for the Eyes Open DO condition as compared to the Eyes Open RP condition for all of the dynamic posturographic parameters (although the corresponding median values were rather similar as shown in Table 2).

Discussion

This cross-sectional study has investigated whether detectable alterations in body posture occur between asymptomatic subjects and TMD patients and would ultimately determine if posturography could be used as a new diagnostic tool in dentistry. Indeed, if a detectable correlation does exist between TMD and body posture then the monitoring of the latter would be indicated in such patients. The use of posturography as an objective and non-invasive diagnostic tool would be invaluable considering the high prevalence of TMDs in the community and their wide spectrum of symptoms and signs.[18,19] However, with the recording of six posturographic parameters that describe both static and dynamic postural components, the present investigation failed to find detectable correlations between TMDs and body posture.

Because different posturographic parameters describe different aspects and properties of posture it is reasonable to use multiple parameters to properly describe it. The mean X, Y, and absolute COP displacements describe the real position of the COP from the theoretical optimum, thus, stressing the static components of body posture.[20] In contrast, sway area, sway length, and sway velocity are all related to dynamic changes in COP and describe the dynamic components of body posture.[20,21]

The present investigation has the advantage of considering six posturographic parameters describing both static and dynamic components of body posture, while previous studies have been limited in the number of parameters examined.[9-12,14] In this context it is interesting to note the present investigation shows a different behavior for the static posturographic parameters as compared to the dynamic variables (Tables 1 and 2). This finding provides further insight by discriminating between static and dynamic posturographic parameters on the basis of their sensitiveness to visual deprivation and is in agreement with the recent reported of Perinetti,[13] although in that study the dental intercuspidation was performed without cotton rolls.

To describe the postural control in these control and TMD subjects, both RP and DO conditions were also tested with deprivation of any interference from visual sensory function.[22] Moreover, the DO conditions were recorded using cotton rolls between the dental arches, to distribute the occlusal load over several teeth and to minimize the impact of incongruous occlusal contact.[9]

Cotton Rolls used for DO Conditions

The X, Y, and absolute COP displacements in the TMD group were generally similar to those in the control group under all of the experimental conditions. The only exception was the X COP displacement under the Eyes Closed DO condition which showed a statistically significant difference between the groups (Table 1). This is in line with the results from Ferrario et al.[9] (although they used a slightly different COP spatial monitoring), and supports the hypothesis TMDs do not affect, or affect at a sub-detectable level, spatial posturographic parameters. These results are also in accordance with those recently reported by Munhoz et al.[14] as described in the Introduction section of this article. It is possible older subjects may show a significant difference since the degree of postural control has been shown to be inversely proportional to age even in healthy subjects.[23] Of interest, generally no differences in any X, Y, and absolute COP displacements were found among the experimental conditions within each group. However, Y COP displacement differences within the control group yielded statistically significant differences, Eyes Closed RP vs. Eyes Open RP (Table 1). This demonstrates spatial posturographic parameters are unaffected by proprioception from the stomatognathic system or by deletion of the visual input at least in subjects with no neurological disorders in the age range considered in the present investigation. Specifically, for the asymptomatic subjects, these results are in contrast with those previously reported by Bracco et al.,[12] and they are in agreement with those from Perinetti.[13] Of interest, Bracco et al.[12] described a change in the COP coordinates among different mandible positions (all with the eyes closed). However, it should be noted, while statistically significant, these differences were small and were probably not clinically meaningful considering the high standard deviations recorded.

The other posturographic parameters, sway area, sway length, and sway velocity, showed similar behaviors. The mean values of each of the parameters under each experimental condition were similar in the control and TMD groups with no statistically significant differences between them. In contrast, significantly greater mean values for sway area, sway length, and sway velocity were always found in the Eyes Closed as compared to the Eyes Open conditions, in line with a report by Edwards,[24] irrespective of the RP/DO conditions. Moreover, in the control group only, significantly greater values were also found in the Eyes Open DO, as compared to Eyes Open RP (Table 2). This is interestingly in line with a previous report by Gangloff et al,[10] who reported there was an increase in the sway area of about 20% under the Eyes Open DO condition over the Eyes open RP. Given the relatively high intra-subject variability always found in posturography,[21] and the similar median values recorded in the present study, a need for caution in the interpretation of these data is warranted. As reported above, this appears to be a case in which differences, although statistically significant, are probably not clinically meaningful.

This study, thus, failed to show a detectable alteration in body posture in TDM patients as compared to asymptomatic subjects, at least in the age range of the population included in the present study. This failure could be caused by several sensory afferences to the complex neuromuscular system responsive for body posture (i.e., pressoceptor input from the feet[23]) masking a real effect due to TMD. Postural control requires the integration of a complex of sensory pathways (vision, proprioception, and the vestibular system) with internal feed-back pathways[25] which can produce a total or partial compensation for any imbalance produced by TMDs. Moreover, the large intra- and inter-subject variability found in posturography (see ranges in Tables 1 and 2) tends to restrict its application. However, further differentiation between asymptomatic subjects and TMD patients might be derived from more complex types of posturographic recordings in which the postural control is challenged somehow, i.e., by vibratory stimulation to the calf muscles.[15,26]

Conclusion

In conclusion, the present study used posturography to assess differences between TMD patients and asymptomatic subjects in a cross-sectional way and it has provided further insights. Although correlations between TMDs and body posture have been described, the present results might fit the hypothesis they are limited to the cranio-cervical tract of the column and are not able to affect the whole body posture as recorded through posturography. Of note, these results are also in line with a recent investigation showing no correlation between painful craniomandibular disorders, with or without a painful cervical spine disorder, and head posture.[27] However, a recent systematic review[28] on the association between head and cervical posture and TMDs suggested caution in the interpretation of all of the available findings due to methodological limitations of the studies performed to date. Therefore, even if the use of posturography in diagnosis and treatment of TMD patients is not indicated here future investigations performed with different types of posturographic recordings that can evaluate the existence of detectable postural responses to TMD treatment are warranted.

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