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Original Research Article

Association Between Bilateral Posterior Occlusal Contact Symmetry and Static Postural Stability in Healthy Adults: A Cross-Sectional Baropodometric Study

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Abstract

Statement of problem: Evidence concerning the relationship between dental occlusion and postural stability is conflicting, and functional occlusal-contact symmetry has been investigated less frequently than morphologic classifications.

Purpose: The purpose of this cross-sectional study was to determine whether the change in static postural sway from mandibular rest to maximum intercuspation differed between adults with greater and lower bilateral posterior occlusal-contact symmetry under eyes-open and eyes-closed conditions.

Material and methods: Thirty healthy adults (17 women and 13 men; mean age, 35±10 years) underwent an occlusal assessment and static baropodometric evaluation. Participants were classified as having greater symmetry (Group 1: 2 to 4 simultaneous bilateral posterior contact pairs; n=15) or lower symmetry (Group 2: 0 or 1 bilateral contact pair; n=15). Total postural sway area was recorded during mandibular rest and maximum intercuspation with the eyes open and closed. Separate 2-way mixed-model ANOVAs were performed for each visual condition, with occlusal-contact group as the between-participant factor and mandibular position as the within-participant factor. The group-by-position interaction was the primary effect.

Results: The group-by-mandibular-position interaction was not significant with the eyes open ($F(1,28)=2.55$, $P=.122$, partial $\eta^2=.083$). With the eyes closed, the interaction was significant ($F(1,28)=19.18$, $P<.001$, partial $\eta^2=.407$). From rest to maximum intercuspation, the greater-symmetry group showed a mean reduction in sway area of 40.76 cm^2, whereas the lower-symmetry group showed a mean increase of 34.93 cm^2. The between-group difference in change was 75.70 cm^2 (95% confidence interval, 40.29 to 111.10 cm^2; $P<.001$).

Conclusions: Under eyes-closed conditions, the effect of mandibular position on static postural sway differed according to bilateral posterior occlusal-contact symmetry. No corresponding interaction was identified with the eyes open. These findings indicate an association under reduced visual input but do not establish causality or a therapeutic effect of occlusal intervention.

CLINICAL IMPLICATIONS

The relationship between dental occlusion and whole-body posture remains controversial, with heterogeneous findings across study designs and outcome measures. [4-6,25,31,35] In this sample, the change in postural sway from mandibular rest to maximum intercuspation differed according to bilateral posterior occlusal-contact symmetry only when visual input was absent. Stable bilateral posterior contacts remain an appropriate conventional objective of prosthodontic rehabilitation; however, these findings do not support occlusal intervention as a treatment for postural disorders.

INTRODUCTION

The maintenance of upright posture depends on continuous integration of visual, vestibular, and somatosensory information by the central nervous system. [1,2] The stomatognathic system contributes somatosensory input through periodontal mechanoreceptors, temporomandibular-joint receptors, and muscle spindles within the masticatory system. [3,15,20,21] Trigeminal afferents communicate with brainstem, vestibular, cerebellar, and cervical motor networks, providing a biologically plausible pathway through which changes in orofacial sensory input could modulate postural regulation. [15,19,20]

Despite this biological plausibility, investigations of dental occlusion and posture have produced inconsistent findings. [4-10,25-27,31-33,35]

Methodological heterogeneity is substantial and includes differences in participant selection, postural tasks, acquisition duration, visual conditions, mandibular

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positions, and the criteria used to classify occlusion. [4-6,25,27] Many studies have emphasized Angle classification, temporomandibular disorders, or experimentally altered mandibular positions rather than the functional symmetry of simultaneous posterior contacts. [5,6,25,34]

The sensory-reweighting model proposes that the central nervous system dynamically changes the relative contribution of sensory inputs according to their availability and reliability. [16-18] When visual input is removed, greater reliance is placed on vestibular and somatosensory information. [17,18] Consequently, any contribution from occlusal proprioception may become more apparent under eyes-closed or otherwise challenging postural conditions. [8,27,28]

Electromyographic investigations have demonstrated functional coupling between masticatory activity and cervical or more distant postural muscles. [10,22,23] Other studies have reported changes in postural measures after modification of mandibular position, posterior contact area, or occlusal balance. [8-14,24,29,30] However, comparatively few investigations have classified healthy adults according to the symmetry of naturally occurring simultaneous posterior contacts and examined the within-participant change between mandibular rest and maximum intercuspation. [24,27]

Therefore, the purpose of this cross-sectional study was to determine whether the change in static postural sway from mandibular rest to maximum intercuspation differed between adults with greater and lower bilateral posterior occlusal-contact symmetry under eyes-open and eyes-closed conditions. The null hypothesis was that the rest-to-maximum-intercuspation change in total sway area would not differ between occlusal-contact groups under either visual condition.

MATERIAL AND METHODS

This cross-sectional observational study was conducted in accordance with the Declaration of Helsinki and was approved by the Research Ethics Committee of the Clementino Fraga Filho University Hospital (HUCFF; Protocol No. 089/09) on September 3, 2009. Thirty volunteers aged 18 to 60 years were recruited through notices placed in the otorhinolaryngology outpatient department and the integrated dental clinic. The sample comprised 17 women and 13 men (mean age, 35±10 years). Group 1 included 9 women and 6 men, and Group 2 included 8 women and 7 men. Participants were required to have a complete dentition through the second molars, although isolated individual crowns were permitted, and to be able to stand unsupported and follow the study instructions. Exclusion criteria were removable partial or complete dentures, fixed bridges or extensive prosthetic restorations, active orthodontic treatment, diabetes mellitus, neurologic disease, limiting or deforming musculoskeletal disease, a history of otologic, orthopedic, or neurosurgical procedures, dizziness or imbalance, inability to maintain an unsupported standing position, and use of benzodiazepine or anticonvulsant medication.

Occlusal Assessment

A single calibrated examiner evaluated posterior occlusal contacts in maximum intercuspation using 12-µm Arti-Fol® articulating film (Bausch). Participants were seated with lumbar support, their feet on the floor, and their knees flexed to approximately 90 degrees. They were instructed to close slowly and progressively into maximum intercuspation. Simultaneous contacts were assessed separately for homologous pairs of first premolars, second premolars, first molars, and second molars. A contact pair was classified as bilateral when homologous right and left posterior tooth pairs contacted simultaneously. Participants were allocated to Group 1 (greater symmetry: 2 to 4 bilateral contact pairs) or Group 2 (lower symmetry: 0 or 1 bilateral contact pair).

Postural Analysis

Static postural sway was recorded using a DIASU computerized baropodometric platform equipped with 12 800 pressure-sensitive electrodes over an 80×40-cm surface and a standardized foot-positioning guide. The platform was positioned 2 m from a wall in a quiet, private room. Participants stood barefoot in light clothing, with the arms relaxed, the feet slightly separated, and the feet oriented at approximately 30 degrees according to the positioning guide. Each recording lasted 30 seconds. Four conditions were evaluated:

1. Mandibular rest with the eyes open (EO/Rest)
2. Mandibular rest with the eyes closed (EC/Rest)
3. Maximum intercuspation with the eyes open (EO/MIH)
4. Maximum intercuspation with the eyes closed (EC/MIH)

The primary outcome was the total postural sway area recorded by the baropodometric platform and expressed in cm². For descriptive change analyses, the MIH value was subtracted from the mandibular-rest value. Positive values therefore indicated reduced sway during MIH, whereas negative values indicated increased sway during MIH.

Statistical Analysis

The raw data were reanalyzed for the present report using Python 3.13 (Python Software Foundation), SciPy 1.17, and statsmodels 0.14.6. Separate 2-way mixed-model ANOVAs were performed for the eyes-open and eyes-closed conditions. Occlusal-contact group (greater or lower symmetry) was the between-participant factor, and mandibular position (rest or MIH) was the within-participant factor. The group-by-mandibular-position interaction was the primary effect of interest. Partial η^2 was reported as the effect-size estimate. Because 2 primary interaction tests were performed, statistical significance for these tests was set at $\alpha=.025$. Within-group paired t tests and 95% confidence intervals were reported as secondary descriptive analyses. Because the eyes-closed change scores were non-normally distributed, Mann-Whitney U and Wilcoxon signed-rank tests were performed as sensitivity analyses.

RESULTS

All 30 participants completed the protocol. The greater-symmetry group comprised 9 women and 6 men, and the lower-symmetry group comprised 8 women and 7 men. Angle and bilateral posterior-contact distributions are presented in **Table 1**. Angle Class I was observed in 11 participants in Group 1 and 5 in Group 2; Class II in 3 and 8 participants, respectively; and Class III in 1 and 2 participants, respectively.

Table 1. Occlusal characteristics of participants according to bilateral posterior contact symmetry.

Characteristic	Symmetric group (n=15)	Asymmetric group (n=15)	Total (N=30)
Angle classification			
Class I	11 (73.3)	5 (33.3)	16 (53.3)
Class II	3 (20.0)	8 (53.3)	11 (36.7)
Class III	1 (6.7)	2 (13.3)	3 (10.0)
Number of bilateral posterior contact pairs			
0	0	7 (46.7)	7 (23.3)
1	0	8 (53.3)	8 (26.7)
2	8 (53.3)	0	8 (26.7)
3	3 (20.0)	0	3 (10.0)
4	4 (26.7)	0	4 (13.3)

Data are n (%). Percentages in the group columns are based on n=15; percentages in the total column are based on N=30.

Descriptive sway-area values are presented in **Table 2**, and the mixed-model ANOVA results are presented in **Table 3**. Under eyes-open conditions, neither the main effect of occlusal-contact group ($F(1,28)=2.25$, $P=.145$, partial $\eta^2=.074$) nor the main effect of mandibular position ($F(1,28)=3.40$, $P=.076$, partial $\eta^2=.108$) was significant. The group-by-mandibular-position interaction was also not significant ($F(1,28)=2.55$, $P=.122$, partial $\eta^2=.083$). The mean rest-to-MIH reduction was 15.58 cm² in Group 1 and 1.13 cm² in Group 2.

Table 2. Total postural sway area according to visual condition, occlusal-contact group, and mandibular position.

Visual condition	Occlusal-contact group	Rest, mean ±SD (cm²)	MIH, mean ±SD (cm²)	Change (rest - MIH), mean ±SD (cm²)	95% CI for change	P value*
Eyes open	Symmetric	41.83 ±34.69	26.25 ±35.90	15.58 ±29.66	-0.84 to 32.00	.061
Eyes open	Asymmetric	20.23 ±25.80	19.10 ±14.76	1.13 ±18.72	-9.24 to 11.49	.819
Eyes closed	Symmetric	63.92 ±67.84	23.16 ±29.77	40.76 ±43.02	16.94 to 64.59	.003
Eyes closed	Asymmetric	22.69 ±19.84	57.62 ±64.28	-34.93 ±51.29	-63.34 to -6.53	.019

MIH, maximum intercuspation; CI, confidence interval. Positive change values indicate reduced sway during MIH, whereas negative values indicate increased sway. Within-group paired t test comparing rest and MIH.

Under eyes-closed conditions, the main effects of group ($F(1,28)=0.04$, $P=.835$, partial $\eta^2=.002$) and mandibular position ($F(1,28)=0.11$, $P=.739$, partial $\eta^2=.004$) were not significant; however, the group-by-mandibular-position interaction was significant ($F(1,28)=19.18$, $P<.001$, partial $\eta^2=.407$). Group 1 showed a mean reduction in sway area of 40.76 cm² from rest to MIH (95% confidence interval [CI], 16.94 to 64.59 cm²; $P=.003$), whereas Group 2 showed a mean increase of 34.93 cm² (95% CI, 6.53 to 63.34 cm²; $P=.019$). The between-group difference in change was 75.70 cm² (95% CI, 40.29 to 111.10 cm²; $P<.001$; Hedges $g=1.56$). Individual change scores and group means with 95% CIs are shown in **Figure 1**. Sensitivity analyses supported the primary finding: the between-group difference in eyes-closed change scores remained significant with the Mann-Whitney U test ($P<.001$), whereas the eyes-open comparison was not significant ($P=.089$).

Table 3. Two-way mixed-model ANOVA results for total postural sway area.

Visual condition	Effect	F	df	P value	Partial η²
Eyes open	Occlusal-contact group	2.25	1, 28	.145	.074
Eyes open	Mandibular position	3.40	1, 28	.076	.108
Eyes open	Group × mandibular position	2.55	1, 28	.122	.083
Eyes closed	Occlusal-contact group	0.04	1, 28	.835	.002
Eyes closed	Mandibular position	0.11	1, 28	.739	.004
Eyes closed	Group × mandibular position	19.18	1, 28	<.001	.407

Separate analyses were performed for the eyes-open and eyes-closed conditions. Occlusal-contact group was the between-subject factor, and mandibular position (rest or maximum intercuspation) was the within-subject factor. The group × mandibular-position interaction was the primary effect of interest. ANOVA, analysis of variance.

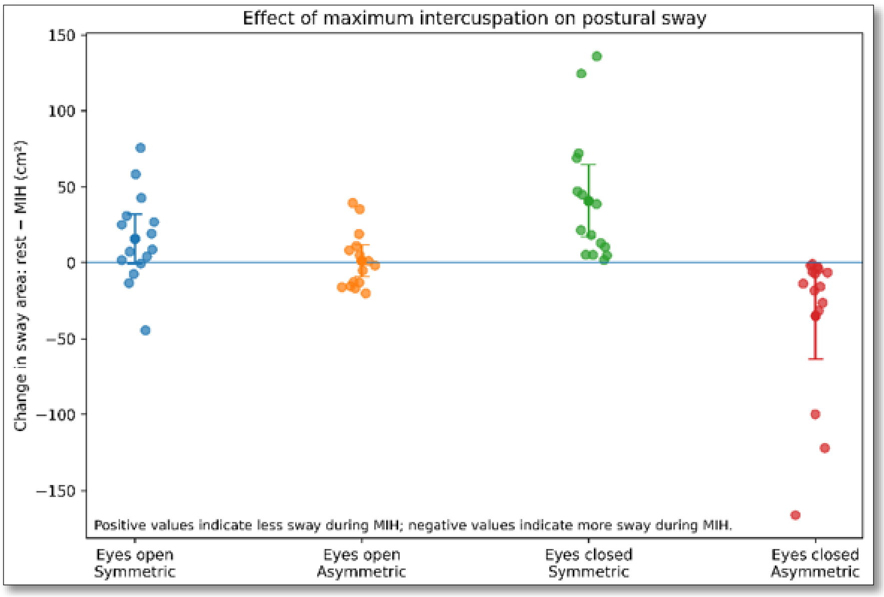

Figure 1. Effect of maximum intercuspation on static postural sway according to bilateral posterior occlusal-contact symmetry and visual condition. Individual points represent participant-level changes in total sway area calculated as mandibular rest minus maximum intercuspation (MIH). Positive values indicate reduced sway during MIH, and negative values indicate increased sway. Larger markers and error bars represent group means and 95% confidence intervals. The symmetric group had 2 to 4 bilateral posterior contact pairs, and the asymmetric group had 0 or 1 bilateral contact pair.

DISCUSSION

The null hypothesis was rejected for the eyes-closed condition but not for the eyes-open condition. The principal finding was a group-by-mandibular-position interaction rather than a general main effect of occlusal-contact group. When vision was absent, participants with greater bilateral posterior contact symmetry generally showed reduced sway during maximum intercuspation, whereas those with lower symmetry showed increased sway. With the eyes open, the rest-to-MIH change did not differ significantly between groups.

A cautious physiological interpretation is that visual input may compensate for, or reduce the relative weighting of, stomatognathic somatosensory information during quiet standing. When visual information is removed, trigeminal, vestibular, and other somatosensory inputs may assume greater relative importance.15-21,27 Symmetric posterior contacts could provide more balanced periodontal and masticatory afferent input than markedly asymmetric contacts; however, neural activity, vestibular function, and cervical or postural muscle activity were not measured in this study. **Figure 2** therefore presents a conceptual explanatory model rather than a mechanism demonstrated by the data. [3,19,20,31]

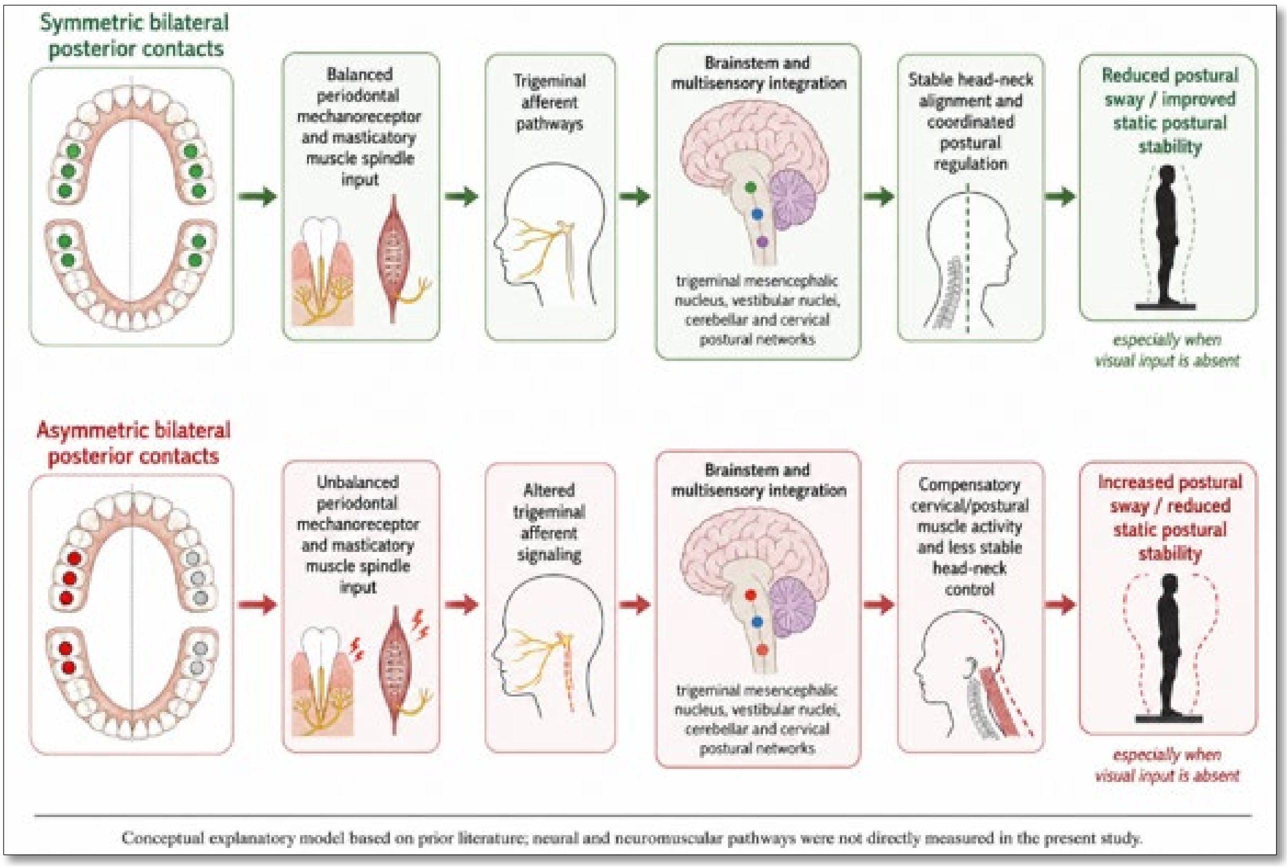

Figure 2. Proposed physiological model linking bilateral posterior occlusal-contact symmetry with postural control. The upper pathway illustrates the hypothesized effect of balanced posterior contacts on periodontal and masticatory afferent input, multisensory integration, and postural regulation. The lower pathway illustrates the corresponding hypothesis for asymmetric contacts. These neural and neuromuscular pathways are conceptual explanations based on previous literature and were not directly evaluated in the present study.

The present findings are compatible with reports that mandibular position, posterior contact area, or experimentally improved occlusal balance can alter postural measures, particularly under more demanding sensory or motor conditions. [8-14,24,27,29,30] They also differ from studies that found no clinically meaningful relationship between occlusion and posture or only small, inconsistent associations. [4-7,25,26,32,33,35] These differences reinforce the importance of the selected occlusal variable. Angle classification describes anteroposterior dental relationships but does not directly quantify the timing and bilateral symmetry of posterior contacts. The present study specifically examined a functional contact criterion, although the imbalance in Angle classifications between groups remains a potential confounder.

From a prosthodontic perspective, stable and bilaterally distributed posterior contacts are already conventional functional objectives. The current results suggest that such symmetry may also be associated with the postural response to maximum intercuspation when visual input is absent. Nevertheless, the study does not demonstrate that occlusal adjustment improves postural health, prevents falls, or treats a postural disorder. Occlusal intervention should not be prescribed for postural complaints on the basis of these findings, particularly because postural control is multifactorial and the broader literature remains inconsistent. [4,5,25,31,35]

Several limitations should be considered. The cross-sectional design precludes causal inference, and the sample was small and limited to healthy adults. Only one 30-second recording was available for each condition, and the sequence of the four conditions was not documented as randomized. Occlusal symmetry was classified clinically with articulating film rather than quantified digitally, and no electromyographic, vestibular, or cervical kinematic measurements were obtained. Age was available only for the total sample, and the different Angle-class distributions between groups may have confounded the association. The sway data included high values and non-normal eyes-closed change distributions, although nonparametric sensitivity analyses supported the principal interaction. Finally, the complete separation in the direction of eyes-closed change within this sample should be replicated in larger, prospectively designed cohorts.

CONCLUSIONS

Within the limitations of this cross-sectional study, the following conclusions were drawn:

1. Under eyes-closed conditions, the change in total postural sway area from mandibular rest to maximum intercuspation differed significantly according to bilateral posterior occlusal-contact symmetry.

2. Participants with greater contact symmetry showed reduced sway during maximum intercuspation, whereas participants with lower symmetry showed increased sway; no significant group-by-position interaction was observed with the eyes open.

3. The findings identify an association under reduced visual input but do not establish a causal mechanism or support occlusal intervention as treatment for postural disorders.

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