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Subjects with temporomandibular joint disc displacement do not feature any peculiar changes in body posture

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SUMMARY **The presence of body posture changes among patients with temporomandibular disorders (TMD) has been a controversial topic in dentistry. Based on that, the aim of this study was to assess postural features of pain-free subjects with internal derangement of the temporomandibular joint (TMJ), viz. disc displacement, when compared to subjects with normal disc position. A total of 21 subjects with unilateral, pain-free TMJ disc displacement (DD) and 21 subjects without any TMD signs of symptoms were assessed for body posture changes by means of posturographic evaluation of several body segments and postural balance reactions through the centre of mass during jaw movements using a balance platform. Posturographic measurements showed the absence of any significant differences between the two groups in any of the outcome parameters. Similarly, all balance platform responses to mandibular movements were not different between groups. There are no significant differences in body posture between subjects with and without unilateral disc displacement in the temporomandibular joint. Such observations, indicating a well-preserved postural balance in the presence of TMJ internal derangement, put into serious question the potential influence of TMJ disorders on whole body posture and viceversa.**

KEYWORDS: **temporomandibular joint, internal derangement, body posture**

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Introduction

Body posture is defined as the result of the relationship between near segments of the body as well as the interconnections between all segments composing the human body (1). From a theoretical viewpoint, the ideal posture is the condition in which all structures combine their work to maintain static and dynamic balance with maximum efficiency and minimal overload and energy expense. On the contrary, poor posture is seen as a faulty relationship between the different body segments, requesting an increased demand for adaptation to the support structures and a decreased equilibrium efficiency (2).

The posture of each individual is determined by muscle chains, fascias, ligaments and bone structures, mutually influencing each other, and covering the whole body. It includes integration at the level of the central nervous system of vestibular, visual and proprioceptive inputs. The resulting body posture depends on the efficient weight distribution on the supporting basis, highly determined by the body segment characteristics (length and weight), which is usually referred to as 'postural balance' (3).

Temporomandibular disorders (TMD) are a heterogeneous group of conditions affecting the temporomandibular joint (TMJ), the jaw muscles or both (4). They recognise a multifactorial aetiology, with a number of risk and associated factors that should be accounted for during the diagnostic process (5, 6). Some authors hypothesised the presence of postural abnormalities or peculiar postural features in patients

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with TMD, with claims that changes in the head or mandible posture may be associated with pain in the head and/or in the cervical region (7, 8). However, available reviews suggest that there is an absence of evidence that posturography may actually be a valuable additional tool in the field of dentistry and oro-facial pain/TMD practice (9–11), based on the poor reliability of posturographic findings (12) and the absence of discriminatory power of head and cervical posture's analysis to identify TMD subjects (13, 14).

A major limitation of the available literature on the TMD–body posture relationship is that it focused on subjects with TMD pain. Such approach is likely not the most appropriate strategy to assess the phenomenon, because the presence of pain may provoke a demand for postural adaptation, viz. postural changes potentially being the effects and not the cause of the symptoms (10). In other words, studying the physiology of body posture in individuals with non-painful mechanical disorders of the TMJ, such as internal derangements, seems a more logical approach to collect data on the topic.

Based on this premise, the aim of this study was to assess postural features of pain-free subjects with internal derangement of the TMJ, viz. disc displacement, and to compare them with subjects with normal disc position. To this aim, several body segments have been evaluated with a battery of static and dynamic posturography assessments.

Materials and methods

Study sample and design

Participants were recruited by convenience according to a case–control design within two institutions of higher education and a temporomandibular rehabilitation clinic. All subjects underwent a TMD assessment according to the RDC/TMD protocols (15), with focus on the axis I clinical diagnosis of disc displacement with reduction. Two demographically matched groups of pain-free individuals, aged between 18 and 40 years, were recruited. Subjects of the disc displacement group presented unilateral joint sounds during jaw movements reproducible in two of three repeated trials and had a magnetic-resonance confirmation of disc displacement. Subjects of the control group did not have any joint sounds during jaw movements.

Potential participants were excluded if they had audible crepitus noises related to degenerative diseases such as osteoarthritis or osteoarthrosis, systemic diseases such as rheumatoid arthritis, systemic lupus erythematosus or collagen disease, a history of trauma to the neck and/or in facial region, a history of changes in the balance (frequent falls) or pain symptoms influenced by orthostatic position, or a history of orthopaedic or dental surgery with impact on the mobility of the TMJ.

A priori power analysis to determine the needed sample size was performed. In the absence of literature data on the argument, the difference to detect for a clinically relevant statistical significance was arbitrarily set that at least a one-third effect size, viz. between-group difference, because differences of lower magnitude were unlikely to have any clinical meanings. To calculate the needed sample size, head posture inclination was assumed as the main outcome parameter, and it was measured in ten asymptomatic, TMD-free, subjects before the start of the study. An average value of 40 ± 5 degrees with the measurement strategy described below was observed, and it was assumed as the expected value for sample size calculation. Then, based on the suggested strategies to perform *a priori* sample size calculation (16), the need for 21 subjects per group was determined to achieve an 80% statistical to detect a 33% between-group difference with an alpha error probability of 5%.

Thus, volunteers were consecutively recruited until two groups of 21 subjects each were gathered. The control group included 15 females and six males, with a mean age of 21·2 ± 3·7 years, a mean height of 169·3 ± 7·7 centimetres (cm) and a mean weight of 73·7 ± 14·8 kilograms (kg). The disc displacement group included 17 females and four males, with a mean age of 22·2 ± 3·9 years, a mean height of 169·7 ± 7·8 cm and a mean weight of 70·2 ± 14·6 kg.

The study protocol was approved by the University of Coimbra's IRB, and all participants gave their consensus to take part to the study.

Instruments and protocol

Body posture segments. For the body posture segment analysis, a reference in galvanised steel with a board of plywood in between was constructed, previously prepared with a grid chart for postural evaluation, scaled in centimetres. Passive markers were placed on the grid chart, translating specific measures to minimise the measurement errors in the analysis.

Reflective spherical passive markers were placed for postural analysis, on the tragus (bilaterally), on the mid-point between the angle of the mandible and the mandibular condyle (bilaterally), on the spinous process of the seventh cervical vertebra, on the acromion (bilaterally), on the anterosuperior iliac spine (bilaterally), on the posterosuperior iliac spine (bilaterally), on the greater trochanter (bilaterally), on the lateral femoral condyle in its lateral region (bilaterally), on the anterior tibial tuberosity (bilaterally) and on the lateral malleolus (bilaterally). Photographic records were made in anterior, posterior, lateral left and lateral right views, for later postural analysis in Kinovea© software version 0.8.15 (Open source project). Participants were instructed to stand on the ground in a relaxed position with the feet in line with the distance between the shoulders and a 30° rotation towards outside. The visus was standardised by keeping eyes fixed to the same point on the horizon with the lower jaw parallel to the floor. During all procedures, the patients were instructed to keep the mandible in rest position, with the jaw muscles relaxed and the teeth slightly apart.

Anterior and posterior views were used to check for an elevated segment of bilateral structures, tragus, acromions, anterosuperior iliac spines, posterosuperior iliac spines, greater trochanters, external femoral condyles, tibial tuberosities and external malleolus. The reference position, considered normal for these bilateral structures, was 180°, indicating the alignment in the frontal plane. The reference for evaluation was placed in the centre of the right passive marker of the tragus, completing an angle of 90° at the time of the placement. The vertical arm was adjusted to make an angle of 180°, and after this configuration, it was considered the fixed arm. The movable arm was placed on the centre of the passive marker in the contralateral structure (left tragus), and its value was recorded. This process was repeated bilaterally for all the structures.

The anteriorisation or post-eriorisation of the head was evaluated in right lateral view, placing the reference on the centre of the C7 passive marker and forming a 90° angle. The horizontal arm was considered the fixed arm, the moving arm was placed on the centre of the right tragus passive marker, and the value obtained by this angle was registered. The cervical flexion or extension was also evaluated in right lateral view placing the reference on the centre of the tragus passive marker forming an angle of 90°. The vertical arm was adjusted to make an angle of 180°, and after this arm configuration, it was considered the fixed arm. The moving arm was aligned with the centre of the eye socket, and the obtained value was recorded. All 90° and 180° angles were adjusted with goniometer.

The length of each segment evaluated in right lateral view was compared with the same segment's length in left lateral view. The reference length of passive markers on the board was 50 cm. A line was drawn between two passive markers of the evaluated segments and compared with the contra lateral segments.

The description of each parameter that has been assessed and the corresponding code used in the results table are presented in Table 1.

Postural balance reactions. Data from subjects' balance were collected with the Basic Balance Master® platform[a] which is a force plate linked to a computer with the software provided by the manufacturer.

All subjects underwent three tests, consisting of three 30-second trials to record, respectively, the initial alignment of the centre of gravity (COG), the oscillation speed of the COG and the path of the COG. In the first test, three trials of mouth opening–closing movement were performed, in the second test, three trials of right lateral excursion and return to the midline, while in the third test, three trials of left lateral excursion and return to the midline. Data were collected at 100 Hz.

Oscillation speed of the COG (degrees/second) (°/s) and the mean of displacement of the COG (degrees) (°), during all the test movements, were analysed. The sway velocity of COG was obtained from the Neurocom software (Neurocom SA, Athens, Greece) and post-processed in Microsoft Excel (Microsoft Corporation, Redmond, WA, USA). The average path of the COG was obtained by performing the average of '*x*' and '*y*' values. The first value of each repetition, which represents the position 0 of the COG, was removed from the average. The values obtained by this process gave information on the average path of the COG during mandibular motion in the axis '*x*'

[a]NeuroCom® International Inc., Clackamas, OR, USA

Table 1. Code and description of each parameter that has been assessed for postural evaluation

Code	Evaluation	Plan	Description
Parameter 1	Anteriorisation of the head*	Sagittal	Tragus – C7; C7 – Horizontal plan (lower α, more anteriorisation)
Parameter 2	Flexion/Extension of the head*	Sagittal	Tragus – Eye socket (Normal 180°)
Parameter 3	Bilateral Distances (muscle shortening)	Sagittal	C7 – Right tragus
Parameter 4	right vs. left	Sagittal	C7 – Left tragus
Parameter 5	Inclinations of the head*,†	Coronal Anterior	Right tragus – Left tragus
Parameter 6	Bilateral Distances (muscle shortening)	Sagittal	Right acromion – Right tragus
Parameter 7	right vs. left	Sagittal	Left acromion – Left tragus
Parameter 8	Asymmetrical Elevations†	Coronal Anterior	Acromions – Horizontal plan
Parameter 9		Coronal Anterior	Anterosuperior Iliac spines – Horizontal plan
Parameter 10		Coronal Anterior	Great Trochanters – Horizontal plan
Parameter 11		Coronal Anterior	Lateral femoral condyles – Horizontal plan
Parameter 12		Coronal Anterior	Tibial tuberosities – Horizontal plan
Parameter 13		Coronal Posterior	Posterosuperior Iliac spines – Horizontal plan
Parameter 14		Coronal Posterior	Lateral malleolus – Horizontal plan
Parameter 15	Dysmetrias	Sagittal	Right Great Trochanter – Right Lateral femoral condyle
Parameter 16		Sagittal	Right Lateral femoral condyle – Right Lateral malleolus
Parameter 17		Sagittal	Left Great Trochanter – Left Lateral femoral condyle
Parameter 18		Sagittal	Left Lateral femoral condyle – Left Lateral malleolus
Parameter 19	Bilateral Distances (muscle shortening)	Sagittal	C7 – Right acromion
Parameter 20	right vs. left	Sagittal	Right great trochanter – Right anterosuperior iliac spine
Parameter 21		Sagittal	C7 – Left acromion
Parameter 22		Sagittal	Left great trochanter – Left anterosuperior iliac spine
Parameter 23		Sagittal	Right anterosuperior iliac spine – Right Lateral malleolus
Parameter 24		Sagittal	Left anterosuperior iliac spine – Left Lateral malleolus

*According to the altered protocol proposed by Raine and Twomey, 1994.
†The correct alignment (180°) is represented as 0. The elevated segment is represented as (+) signal if it is elevated to the right side, and (−) signal if it is elevated to the left side.

[shift to the left(−)/right(+)] and the axis '*y*' [shift to anterior(+)/posterior(−)].

Statistical tests

A descriptive analysis of the study variables was first reported. Then, an analysis of repeatability of measurements (ANOVA univariate) was performed.

Student's *t*-test was performed to compare the average values between the two groups. Bonferroni's correction for multiple comparisons was applied, and level of statistical significance was thus set at $P < 0{\cdot}002$ (0·05/24). The software SPSS, version 21.0 (IBM, Milan, Italy), was used to perform all statistical analyses.

Results

There are no significant differences between the two groups in any of the body posture segment outcome parameters (Table 2).

Similarly, all postural balance reactions to mandibular movements showed no significant differences between groups.

The COG sway velocity during jaw movements was slightly higher in subjects with DD, but the difference between groups was not significant. The COG mean path during jaw movement was not significantly different between groups (Table 3).

Discussion

This investigation was performed to get a deeper insight into the physiology of body posture in subjects with biomechanical, pain-free disorders of the TMJ, so as to add data to the scarce amount of literature on the issue.

Findings clearly show that the presence of disc displacement of the TMJ is not associated with any peculiar features of static posture or patterns of postural balance during mandibular movements.

Table 2. Body posture results comparison between groups

Posture segments	Group	*N*	Minimum	Maximum	Mean (±SD)	Sig. (*P* value)
Parameter 1 (°)	No DD	21	31·0	51·0	40·5 (±6·0)	0·077
	DD	21	36·0	53·0	43·6 (±4·8)	
Parameter 2 (°)	No DD	21	150·0	180·0	162·9 (±8·0)	0·851
	DD	21	156·0	172·0	163·3 (±4·5)	
Parameter 3 (cm)	No DD	21	13·7	21·5	16·7 (±1·8)	0·545
	DD	21	14·5	19·9	17·0 (±1·5)	
Parameter 4 (cm)	No DD	21	14·5	23·7	17·0 (±2·1)	0·431
	DD	21	15·4	19·4	17·4 (±1·3)	
Parameter 5 (°)	No DD	21	−5·0	3·0	−1·5 (±2·2)	0·122
	DD	21	−5·0	13·0	0·0 (±3·7)	
Parameter 6 (cm)	No DD	21	12·6	20·8	18·0 (±2·1)	0·369
	DD	21	14·3	21·5	17·5 (±1·9)	
Parameter 7 (cm)	No DD	21	14·5	19·8	17·4 (±1·5)	0·517
	DD	21	12·8	20·0	17·1 (±1·8)	
Parameter 8 (°)	No DD	21	−5·0	2·0	−1·8 (±1·8)	0·277
	DD	21	−5·0	3·0	−1·1 (±2·1)	
Parameter 9 (°)	No DD	21	−4·0	2·0	−0·2 (±1·7)	0·830
	DD	21	−5·0	6·0	−0·1 (±2·5)	
Parameter 10 (°)	No DD	21	−5·0	4·0	−0·8 (±2·5)	0·408
	DD	21	−5·0	4·0	−0·1 (±2·3)	
Parameter 11 (°)	No DD	21	−2·0	5·0	0·9 (±1·8)	0·740
	DD	21	−4·0	6·0	1·1 (±2·7)	
Parameter 12 (°)	No DD	21	−9·0	4·0	−0·6 (±3·4)	0·553
	DD	21	−6·0	3·0	0·0 (±2·1)	
Parameter 13 (°)	No DD	21	−10·0	4·0	−0·8 (±3·1)	0·872
	DD	21	−4·0	4·0	−0·6 (±2·6)	
Parameter 14 (°)	No DD	21	−5·0	0·0	−2·3 (±1·5)	0·004
	DD	21	−3·0	5·0	−0·6 (±1·8)	
Parameter 15 (cm)	No DD	21	33·6	48·2	40·5 (±4·9)	0·802
	DD	21	32·8	48·9	40·8 (±4·0)	
Parameter 16 (cm)	No DD	21	39·7	48·8	45·1 (±2·7)	0·801
	DD	21	41·7	50·6	45·3 (±2·8)	
Parameter 17 (cm)	No DD	21	35·1	48·9	41·9 (±4·2)	0·987
	DD	21	35·6	51·3	41·9 (±4·0)	
Parameter 18 (cm)	No DD	21	38·3	51·5	44·9 (±2·9)	0·379
	DD	21	39·4	53·0	45·9 (±4·1)	
Parameter 19 (cm)	No DD	21	6·4	14·7	11·0 (±2·3)	0·064
	DD	21	4·5	16·5	9·3 (±3·3)	
Parameter 20 (cm)	No DD	21	13·0	20·3	16·2 (±2·3)	0·911
	DD	21	12·8	22·2	16·2 (±2·1)	
Parameter 21 (cm)	No DD	21	7·7	15·2	10·5 (±2·0)	0·225
	DD	21	4·6	13·9	9·7 (±2·4)	
Parameter 22 (cm)	No DD	21	11·5	20·5	15·1 (±2·2)	0·190
	DD	21	11·0	21·0	16·2 (±2·8)	
Parameter 23 (cm)	No DD	21	87·0	112·4	99·8 (±6·5)	0·630
	DD	21	89·0	113·3	100·7 (±5·9)	
Parameter 24 (cm)	No DD	21	87·4	114·5	100·6 (±6·8)	0·370
	DD	21	89·9	116·3	102·6 (±7·4)	

DD, disc displacement.

As for body posture segments, both groups showed a forward inclination of the head and an extension of the cervical spine. These findings may be due to habitual daily postures and the subsequent need to gain a broader view by means of a compensatory cervical extension. Interestingly, the fact that both DD and non-DD subjects showed this postural feature may suggest that it can be considered a widely diffused, non-pathologic adaptation.

Table 3. Balance platform results comparison between groups

	Balance response	Group	*N**	Minimum	Maximum	Mean (±SD)	Sig. (*P* value)
COG Sway Velocity (°/sec.)	No Movement	No DD	15	0·1	0·5	0·2 (±0·1)	0·080
		DD	20	0·1	1·2	0·4 (±0·3)	
	Opening–Closing	No DD	63	0·1	1·6	0·3 (±0·2)	0·372
		DD	63	0·1	1·4	0·4 (±0·3)	
	Right Exc.–Rest Pos.	No DD	63	0·1	1·1	0·3 (±0·2)	0·077
		DD	63	0·1	2·3	0·5 (±0·4)	
	Left Exc.–Rest Pos.	No DD	63	0·0	1·5	0·4 (±0·3)	0·567
		DD	63	0·1	1·9	0·5 (±0·4)	
COG Mean Path (°)	No Movement X	No DD	15	0·0	0·1	0·0 (±0·0)	0·117
		DD	20	−0·1	0·1	0·0 (±0·1)	
	No Movement Y	No DD	15	−0·4	0·2	0·0 (±0·1)	0·190
		DD	20	−0·2	0·7	0·1 (±0·2)	
	Opening–Closing X	No DD	63	−0·1	0·9	0·0 (±0·1)	0·864
		DD	63	−0·3	0·3	0·0 (±0·1)	
	Opening–Closing Y	No DD	63	−0·2	0·3	0·0 (±0·1)	0·200
		DD	63	−0·5	0·6	0·0 (±0·1)	
	Right Exc.–Rest Pos. X	No DD	63	−1·3	0·2	0·0 (±0·2)	0·959
		DD	63	−0·2	0·1	0·0 (±0·1)	
	Right Exc.–Rest Pos. Y	No DD	63	−0·6	0·7	0·0 (±0·2)	0·447
		DD	63	−0·2	0·4	0·0 (±0·1)	
	Left Exc.–Rest Pos. X	No DD	63	−0·2	0·2	0·0 (±0·9)	0·147
		DD	63	−0·2	0·1	0·0 (±0·1)	
	Left Exc.–Rest Pos. Y	No DD	63	−0·5	0·5	0·0 (±0·2)	0·808
		DD	63	−0·4	0·7	0·0 (±0·2)	

COG, centre of gravity; DD, disc displacement.
*Valid/completed repetitions in the three attempts.

Also, both groups showed a correct tragus alignment, with the DD subjects not having any lateral inclination of the head and the non-DD group showing a non-relevant inclination of the head (on average, 1·5° to the right side).

In summary, the postural features described in this investigation are not related to any significant body posture abnormalities in any groups. On this purpose, it should be even noticed that, even if not significantly different with respect to the DD group, signs of potential body 'misalignment' are more present in the non-DD group. In short, this means that there exists a very wide variation in the physiological posture parameters, possibly due to functional adaptations. Consequently, it is very unlikely that the study of body posture may be of some help to discriminate between subjects with and without TMJ disorders, and further studies attempting to definitively establish the amount of variation in physiological posture values are strongly recommended before including pain subjects within any study protocol.

This study is in accordance with the literature as far as the relationship between TMD and forward head posture is concerned (1, 7, 17–21). In addition, current investigation's findings that such a forward head posture is also featured by subjects without disc displacement confirm results from studies that seriously questioned the validity of this parameter as a screening tool for TMD (13).

The absence of significant body posture changes in subjects with disc displacement is also in line with mainstream suggestions on the topic (9, 10, 12, 22).

Other purported body posture abnormalities that were suggested to be present in patients with TMD, such as unlevelled shoulders (23–25), rotation and/or inclination of the head (26), postural deviations in the pelvis and hip joint (27), were not found in this investigation.

As for postural balance reactions, the very low values and the non-significant between-group differences as far as the COG sway velocity and the COG path during jaw movements are concerned suggest that balance and posture control mechanisms are well preserved in the presence of unilateral internal derangement of the TMJ. This kind of balance platform findings are in close relationship with the above-described findings on body posture, because in the absence of uncoordinated actions of external and internal forces able to move the centre of mass, there is a consequent absence of imbalance to the musculoskeletal system.

These results on the body posture–TMD relationship should be confirmed with studies performed with dynamic involvement of the body segments (like in gait), even if based on the available literature, it is unlikely that findings may change relevantly (9, 10, 12, 28).

As a suggestion for the future, it is also recommendable that the body posture–TMD relationship should be appraised by taking into account several factors that have not been addressed so far in the literature, such as the influence of facial and body morphology. In particular, the presence of certain facial morphologies (i.e. skeletal type II, hyperdivergent growth patterns) has been recently addressed as a predisposing factor for TMJ internal derangement (29). Thus, the study of possible different features of postural parameters in subjects with different facial morphology, especially as far as the sagittal plane is concerned (e.g. hyperdivergent versus normo/ipodivergent jaw growth pattern), may emerge as a prerequisite for the assessment of the relationship of body posture with TMJ disorders. Furthermore, as a possible minor limitation of this study, it should be remarked that the healthy group did not undergo MRI assessment of the disc status, so not fully excluding the possible presence of asymptomatic internal derangements. Thus, future studies assessing the actual TMJ status of both groups may be encouraged, possibly with the use of dedicated imaging techniques aiming to assess morphology (i.e. computerised tomography) in addition to the disc–condyle relationship assessed in this investigation. Such an approach may help increasing knowledge on the physiology of the body posture–TMJ relationship, as assuming a clinical usefulness of posturography in dentistry and TMD/orofacial pain patients seems to be a too long jump forward, being based on purported signs of abnormality that are actually emerging as part of normal variations.

Conclusions

In conclusion, there were no significant differences in body posture between subjects with and without unilateral disc displacement in the temporomandibular joint. Such observations, indicating a well-preserved postural balance in the presence of TMJ internal derangement, put into serious question the potential influence of TMJ disorders on whole body posture, and viceversa. It is recommended that better studies on the physiology of the TMJ–body posture relationship and the establishment of parameters of normal variation are performed before jumping to any possible conclusions about the potential clinical usefulness of posturography in the field of temporomandibular disorders and oro-facial pain.

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