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Research Article

Effects of pilates method on the posture, postural habits, and neck and back pain of women with temporomandibular dysfunction: A randomized clinical trial

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Abstract

Background: Associations between changes in body posture for people with Temporomandibular Dysfunction (TMD) have been discussed in the literature. Although the Pilates method is an alternative for treating postural changes, there is a lack of studies evaluating its effects on individuals with TMD. The purpose of the study is to investigate the effects of an exercise program based on the Pilates method on static posture, postural habits, and neck and low back pain in young women with TMD. 40 women between 18 and 35 years old with TMD were randomized into either a Control Group (CG), who received conventional treatment with myorelaxant plates, or an Intervention Group (IG), who received conventional treatment but were also submitted to an exercise program based on the Pilates method for 15 weeks, totaling 30 sessions. All subjects underwent the following: (1) assessment of neck and back pain and postural habits, (2) evaluation of posture by means of computerized photogrammetry, and (3) evaluation of TMD severity. The assessment was conducted prior to and following the intervention.

Results: There was a significant difference between the groups [F(1,37)=4.702; p=0.037; $\eta^2=0.096$], between the evaluative times [F(1,37)=8.951; p=0.005; $\eta^2=0.023$], and an interaction effect [F(1,37)=13.969; p=0.001; $\eta^2_p=0.274$] for the TMD severity variable.

Conclusion: Regarding the exercise program based on the Pilates method, no effect was observed on neck and back pain, posture, and posture habits in young women with TMD. However, there was a decrease in the graduation of TMD severity after the intervention period only for the intervention group.

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Abbreviations

TMD: Temporomandibular Dysfunction; RDC/TMD: Research Diagnostic Criteria for Temporomandibular Disorders; CG: Control group; IG: Intervention group; TO: Beginning of the study; T15: End of the intervention period; BackPEI-A: Back Pain and Body Posture Evaluation Instrument for Adults; VAS: Visual Analogue Scale; DIPA©: Digital Image-based Postural Assessment; TR: Tragus; AC: Acromion; SLA: Scapula lower angle; CO: Occipital protuberance; C1: Spinous processes of the first cervical vertebra; C2: Spinous processes of the second cervical vertebra; C4: Spinous processes of the fourth cervical vertebra; C6: Spinous processes of the sixth cervical vertebra; C7: Spinous processes of the seventh cervical vertebra; T1: Spinous processes of the first thoracic vertebra; T2: Spinous processes of the second thoracic vertebra; T4: Spinous processes of the fourth thoracic vertebra; T6: Spinous processes of the sixth thoracic vertebra; T8: Spinous processes of the eighth thoracic vertebra; T10: Spinous processes of the tenth thoracic vertebra; T12: Spinous processes of the twelfth thoracic vertebra; L2: Spinous processes of the second lumbar vertebra; L4: Spinous processes of the fourth lumbar vertebra; S2: pinous processes of the second sacral vertebra; PSIS: Posterior superior iliac spine; ASIS: Anterior Superior Iliac Sine; MFIQ: andibular Function Impairment Questionnaire; SPSS: Statistical Package for Social Sciences; η^2: Eta square; η^2_p: Partial eta square.

Introduction

The prevalence of postural changes has increased in recent years together with related problems, such as back and neck pain [1,2]. Spinal pain has significant social, economic, and health impacts, and it may cause decreased productivity at work [3]. Individuals who experience back pain have about 60% more health care expenses than do pain-free individuals [3].

Associations between changes in body posture for people with TMD have been discussed in the literature [4-10], in terms of a relationship between the muscles of the head and the cervical region and the muscles involved in the stomatognathic system [5]. The shortening of a muscle causes a dislocation of the bone structures in which this muscle is inserted, all other muscles that are inserted in these bone structures will also be altered and so on [11]. A systematic review showed strong evidence of craniocervical postural changes in myogenous TMD, moderate evidence of cervical postural misalignment in arthrogenous TMD, and no evidence of craniocervical postural misalignment in mixed TMD patients or of global body postural misalignment in patients with TMD [12]. It is important to note the poor methodological quality of the studies, particularly those concerning global postural misalignment in TMD patients, highlighted by the authors of this systematic review [12]. However, several studies have shown deviation in a joint subunit may lead to compensations in other joints [9,11,13,14]. Therefore, it is plausible to suggest that postural alterations throughout the body, and not only those directly involving the head and the cervical spine, could be related with TMD.

To reduce the adverse effects of poor posture, such as pain complaints, we believe that training programs that promote behavioral changes in relation to habits and health should be valued. The Pilates method-involving physical, mental, and emotional conditioning-has gained a large number of fans around the world [15]. The Pilates training is intended to improve general body flexibility and health by emphasizing stability to the center of the body (i.e. the core), posture, and coordination of breathing with movement [16], However, the scientific validity of these claims remains untested. Despite that, based on our empiric practice, we believe the Pilates training could be considered an appropriate form of treatment for postural changes, promoting behavior adaptations. Although there are several reports of treatments using exercises, based on Pilates method, for patients with pain, mainly in the spine [17-20], to the best of our knowledge, no studies have related Pilates exercises with TMD patients.

Hence, the aim of the present study was to investigate the effects that a Pilates-based exercise program has on static posture, postural habits, and neck and back pain in young women with TMD. Thus, considering the interrelationship between posture and TMD [12], as well as the benefits of the Pilates method in body posture [21] and pain [22-24], we hypothesize that a Pilates-based exercise program could be used to improve the global postural alignment, life habits and reduce pain in patients suffering from TMD.

Methods

The present study is a randomized clinical trial with blinded evaluators. It was approved by the ethics committee of the university where it was conducted (No. 817321) and registered in the Clinical Trials (NCT 02292355). The complete study protocol was published in the *Journal of Bodywork and Movement Therapies* [25], The present study is restricted to the postural outcome and his associated factors, such as postural habits and back pain. Pain in the tmporomandibular joint and activity of masticatory muscles, have been dealt with elsewhere. The total study period was from January to December 2016.

Request for participants was published in major newspapers and through social media. All respondents were informed of all the study procedures, and those that were interested, received a brief introduction about the selection process. All participants signed the informed consent form, which was prepared in compliance with Resolution 466/2012 of the Brazilian Health Council. Considering that, TMD occurs in both sexes and in all age groups, affecting about 7 to 15% of the population, but its highest incidence is in women of working age [26] and considering the majority of Pilates clients are middle-aged women who did not regularly participate in other exercise activities [27], the inclusion criteria were being a female between 18 and 35 years old and receiving the diagnosis of TMD through the RDC/TMD, which is considered an excellent tool for the evaluation of TMD [28]. The exclusion criteria were body mass index greater than 35 kg/m²; diagnosis of other disorders of the stomatognathic system; a history of any surgical procedure on the face, teeth, and spine in the past six months; severe pathologies of the spine (fractures, inflammatory diseases, or tumors); intellectual disability or

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inability to give consistent information; ongoing treatment for TMD, whether physical, medical, or dental therapy throughout the study period; practicing Pilates in the past six months; pregnancy; the use of a dental prosthesis or appliance; a history of trauma to the face and/or temporomandibular joint in the past six months; temporomandibular joint dislocation in the past six months; dental flaws between canines and molars; cross bite, overbite or open bite; undershot or overshot jaw; vestibular disorders that may interfere with the balance; and the use of continuous medication for pain or inflammation.

Sample size

The sample size was estimated in G*Power 3.1 software, based on family F-tests, for ANOVA of repeated measures between factors, with two groups and two measures (before and after intervention). A moderate effect size (0.4), an α= 0.05, and a power of 80% were considered, and a correlation between the factors of 0.5 was assumed. The result indicates the need for 20 subjects in each group.

Randomization

The randomization of the sample in the CG and the IG was done according to the sequence of codes generated randomly by CLINSTAT software [29], This sequence of codes, randomly generated from the block sizes (1 to 5), was prepared by an independent researcher who was unaware of the numeric codes for the two groups. The number sequence was kept in opaque envelopes, numbered sequentially from 1 to 40, according to the sample size calculation and following the order generated by the software. The sequence was disclosed only before the start of the intervention program for the physiotherapist responsible for the Pilates sessions to ensure the concealment of the allocation sequence and to keep participants blinded to the type of intervention.

Interventions

All study participants made use of myorelaxant plates for 15 weeks while they were sleeping, which were made from the dental arches of each participant individually by two dentists with more than 20 years of experience. The following steps were used to elaborate the plates: selection of trays, moulding maxillary and mandibular with alginate using the selected tray, casting of plaster in the tray, preparation of the acrylic plate on the plaster cast and adjustments with carbon film for each participant. The use of plates to treat TMD is a conservative and provides symptom relief. Evidence suggests plates are more efficient in the treatment of myogenous TMD, but may also be useful in cases of arthrogenous TMD when the patient has been suitably selected [30].

The IG made use of the plate concomitantly with a Pilates-based exercise program for 15 weeks. The program consisted of 30 sessions held twice per week with two-day intervals for a duration of 50 minutes per session. Sessions were held within the university in the period between August and November 2017. The sessions were taught by a physiotherapist trained in Pilates and with four years of experience, attending up to four individuals per session. The exercises and their progressions were systematized according to a single protocol (Figure 1), as suggested by Siler [30].

In sessions 1 to 5 the participants were initiated to control breathing and core stabilization (Pilates familiarization), as well as basic-level upper-limb and wall exercises were carried out. In sessions 6 to 10, basic-level exercises were added, and from the 11^{th} session, intermediate-level exercises were included. At the 16^{th} session, other intermediate exercises were introduced, and from session 21 onward, intermediate-level upper-limb exercises were also included. Progress within this protocol, as well as the number of repetitions, were defined according to the capacity of the members of each group. In cases where the participants presented limitations or needed extra help to advance in the protocol, preparatory, adapted and/or dismembered exercises were included in any session at the discretion of the instructor.

Participants were asked to maintain their initial level of physical activity throughout the intervention, and a weekly notice was sent to both the CG and the IG via mobile phone, reminding them of the need to use the plate while sleeping.

Outcomes

All participants were evaluated at the T0 and at the T15 after confirming the eligibility criteria, which was performed by a physical therapist and two blinded dentists using the RDC/TMD and clinical dental examinations. The evaluation procedures were conducted for neck and back pain, static posture, posture habits, and TMD severity. All evaluations were performed by the same evaluator, a physiotherapist who was blinded in relation to the allocation of participants in groups, and with 3 years of experience in postural evaluation. The order of the evaluation was also randomized.

Postural habits and neck and back pain were evaluated through the BackPEI-A [31]. In order to evaluate posture habits, questions about the following were asked: posture when sitting to write at the table, posture when sitting to talk with friends, posture when sitting to use the computer, posture when picking up an object from the ground, and position while sleeping. To assess the intensity of neck and back pain, questions involving the VAS were used. Only participants who have had back or neck pain answered these questions.

Static posture was evaluated via computerized photogrammetry using the DIPA© software. For this, the anatomical points of interest were initially palpated and identified with markers, as suggested by the protocol [32]. The points were: right and left TR; right and left AC; right and left SLA; C0; C1; C2; C4; C6; C7; T1; T2; T4; T6; T8; T10; T12; L2; L4; S2; right and left PSIS; and right ASIS.

Then, the participants were positioned standing for the photographic record in the right sagittal and frontal planes. The photographs were analyzed using the DIPA© software by scanning the markers.

- The variables quantified in the right sagittal plane wereHead position: Smaller angle formed between a

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Exercises	Repetitions	Sessions	Goal
The hundred	100	1-30	Heating, breathing control and strengthening of abdominal muscles
Roll up	3-5	1-30	Mobilization of spine, strengthening of abdominal muscles and stretching paravertebral muscles
Single leg circles	3-5 in each direction, with each leg	1-30	Strengthening of abdominal muscles, coordination and dissociation of pelvic girdle
Rolling like a ball	3-5	1-30	Stability of spine and mobility in flexion
Single leg stretch	3-5	1-30	Strengthening of abdominal muscles, coordination, alignment and dissociation of pelvic girdle
Double leg stretch	3-5	1-30	Strengthening of abdominal muscles, coordination and alignment
Single straight leg stretch	3-5	11-30	Strengthening of abdominal muscles, coordination, stretching of posterior chain muscles and dissociation of pelvic girdle
Double straight leg stretch	3-5	11-30	Strengthening of abdominal muscles and stabilization of pelvis
Crisscross	3-5	16-30	Strengthening of oblique muscles, alignment and stabilization of trunk
Spine stretch forward	3-5	1-30	Alignment, stretching paravertebral and posterior chain muscles
Open leg rocker	3-5	16-30	Mobility in flexion, stabilization of trunk and balance
Corkscrew	3 a 5	16-30	Strengthening of oblique muscles and stabilization of trunk
Saw	3-5	11-30	Mobility in flexion, stretching of posterior chain muscles and alignment
Single leg kicks	3-5	1-30	Strengthening of hamstrings, gluteus and spinal extensors muscles and dissociation of shoulder girdle
Swan dive	3-5	1-30	Mobility in extension
Double leg kicks	3-5	21-30	Mobility in extension, strengthening of spinal extensors muscles and alignment
Neck pull	3-5	16-30	Strengthening of abdominal muscles, mobility of trunk, alignment and stretching of posterior chain muscles
Side kicks/front back	3-5	11-30	Stabilization of trunk and strengthening of hip abductors and flexors muscles
Side kicks/up down	3-5	6-30	Stabilization of trunk and strengthening of hip abductors and flexors muscles
Side kicks/small circles	3-5	6-30	Stabilization of trunk and strengthening of hip abductors and flexors muscles
Side kicks/inner-thigh lift	3-5	16-30	Stabilization of trunk and strengthening of hip adductors muscles
Side kicks/heel beats	5	21-30	Stabilization of trunk, mobility in extension and strengthening of spinal extensors muscles
Teaser	3-5	6-30	Strengthening of abdominal muscles and stabilization of trunk
The seal	3-5	21-30	Mobility and stabilization of trunk
Zip up	3-5	1-30	Postural alignment and strengthening of elbow flexors muscles
Chest expansion	3-5	1-30	Postural alignment, stretching of pectoral muscle and strengthening of elbow extensors muscles
Shaving the head	3-5	1-30	Postural alignment and strengthening of elbow extensors muscles
Arm circles	3-5	1-30	Postural alignment, coordination and mobility of shoulder
Biceps curl I	3-5	1-30	Postural alignment and strengthening of elbow flexors muscles
Biceps curl II	5	1-30	Postural alignment and strengthening of elbow flexors muscles
Triceps extension	3-5	21-30	Stability of trunk and strengthening of elbow extensors muscles
The bug	3-5	21-30	Stability of trunk and strengthening of elbow extensors muscles
Circles on the wall	5 in each direction	1-30	Mobilization of shoulder
Sliding down the wall	3-5	1-30	Strengthening of quadriceps muscles
Rolling down the wall	5 in each direction	1-30	Stretching of posterior muscles, articular detachment of shoulder and relaxation

Figure 1: Exercises used in progression of Pilates sessions.

line drawn between right TR and C7 and a horizontal line starting from C7;

- Cervical curvature: Smaller angle formed between two tangent lines, one passing through C1 and one through C7 from a third order polynomial passing through C0, C1, C2, C4, C6, C7, T1, and T2;
- Thoracic curvature: Smaller angle formed between two tangent lines, one passing through T2 and one through T12 from a third order polynomial passing through C7, T2, T4, T6, T8, T10, T12, and L2;
- Lumbar curvature: Smaller angle formed between two tangent lines, one passing through L2 and one through S2 from a third order polynomial passing through T12, L2, L4, and S2;
- Position of the pelvis: Smaller angle formed between a line drawn between right PSIS and ASIS and a horizontal line starting from ASIS.

The variables quantified in the frontal plane were:

- Head tilt: Smaller angle formed between a line drawn

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between right and left TR and a horizontal line;

- Horizontal alignment of the shoulder, scapulae, and pelvis: Difference expressed in centimeters (and normalized by individual stature) between right and left AC heights for shoulder alignment, between right and left SLA heights for alignment of scapulae, and between right and left PSIS heights for the alignment of the pelvis.

The severity of TMD was assessed using the MFIQ, which presents 17 questions with a choice of five answers with values ranging from zero to four. From the sum of the scores, it is possible to calculate the mandibular functional impairment index; from this calculation, it is possible to obtain the degree of functional impairment (between 0 and 5) and, finally, the degree of TMD severity. With the intention of describing the sample, participants are classified as having a TMD severity that is low (when the degree of functional impairment is 0 or 1), moderate (2 or 3), or severe (4 or 5) [28]. For statistical analysis, the mandibular functional impairment index was used.

Statistical methods

Statistical analysis was performed in the SPSS version 20.0, and the level of significance was α= 0.05. The normality of the data was confirmed using the Shapiro-Wilk test. Descriptive statistics were used with frequency tables and measures of central tendency (mean) and dispersion (standard deviation). To check the homogeneity of the groups regarding age, body mass, and height, the independent t-test and the Mann-Whitney U-test were used respectively for the parametric and non-parametric variables.

For the variables of pain, TMD severity, and posture, Factor Mixed Design of ANOVA with two factors was used. The independent factor was the group (CG and IG), and the factor of repeated measures was the evaluative moment (T0 and T15). To estimate the effect size, η^2 (eta square) for the main factors, and η^2_p (partial eta square) for the interactions between the group and evaluative moment were calculated. For postural habits, the Mann-Whitney and Wilcoxon tests were applied, with the effect size calculated using the equation $r = z/\sqrt{N}$. Effect sizes were classified as [33]: small (0.02), medium (0.13), and large effects (0.26) for η^2; small (0.01), medium (0.06), and large effects (0.14) for η^2_p; and small (0.10), medium (0.30), and large effects (0.50) for r.

Data from all participants were assessed with intention-to-treat analysis. In cases of treatment discontinuation, participants were invited to return to the assessment at the end of the intervention period. For participants who refused to return to the evaluation, the T0 data were repeated and composed the T15 data of these participants.

Results

Ninety-seven women with TMD were selected, and of those, only 40 met the eligibility criteria. Figure 2 shows the study flow diagram. There was an exclusion of one participant from the CG and 11 dropouts during the intervention period (six from the IG and five from the CG). The T0 data were

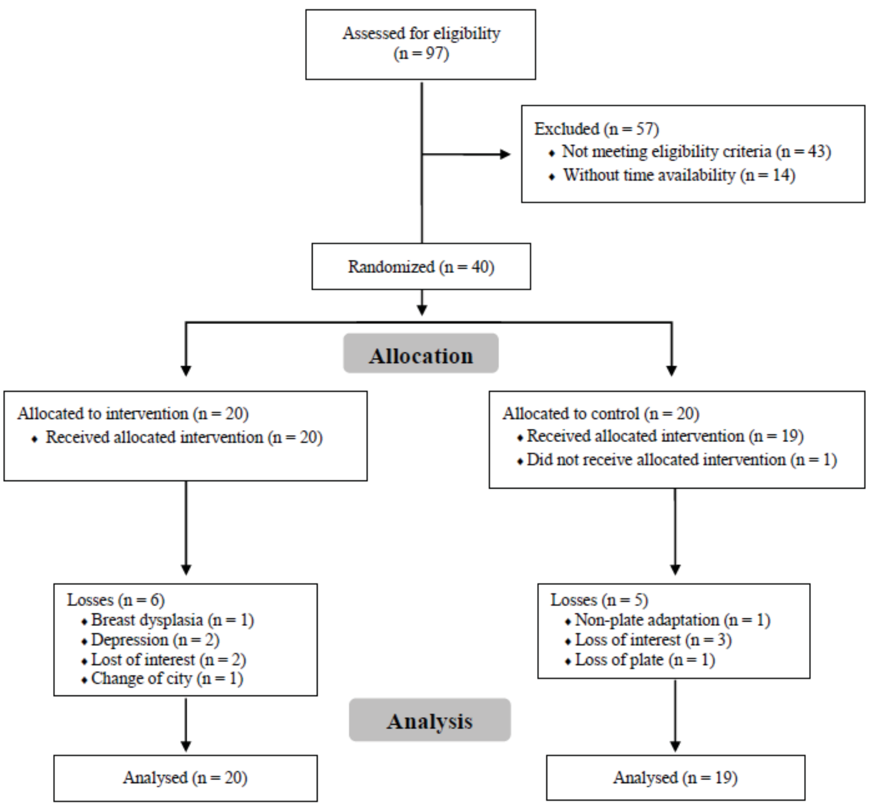

Figure 2: Flow diagram of study design.

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repeated and composed the T15 data of the 11 participants who discontinued participation throughout the intervention period according to the intention-to-treat analysis. Thus, the data of 20 IG participants and 19 CG participants were analyzed. Table 1 shows that the groups were similar in age, body mass, and height. The average participation in the Pilates sessions by the IG was 19.4±8.0 sessions, and the average use length of the myorelaxant plate of both groups was 11.1±6.5 weeks.

Regarding the neck and back pain there was no significant difference in the comparison between the groups and between T0 and T15 (Table 2).

Regarding the TMD severity, which was evaluated through the MFIQ, there was a significant difference between the groups [F = 4.702, p= 0.037, η^2= 0.096] and between T0 and T15 [F= 8.951, p= 0.005, η^2= 0.023]. There was also an interaction effect between the Pilates-based exercise program and the evaluative moment (T0 and T15) [F= 13.969, p= 0.001], with a large effect size (η^2_p= 0.274) (Table 2) indicating a reduction (in average 1.0 points) in the degree of mandibular functional impairment only for the IG, changing the TMD classification from moderate to low degree of severity.

In relation to the static posture (Table 2) and postural habits (Table 3), only the variables of head position, cervical curvature and thoracic curvature presented a significant difference in the comparison between the evaluative moments (T0 and T15). The head position increased 0.8° in average [F= 4.309, p = 0.045, η^2= 0.009]; the cervical curvature increased 2.0° in average [F= 4.215, p= 0.047, η^2= 0.016]; and thoracic curvature reduced 3.2° in average [F= 9.560, p= 0.004, η^2= 0.047]. However, there was no significant difference in the comparison between groups and no interaction effect between the practice of the Pilates-based exercise program and the evaluative moments for these variables, indicating that differences occurred for both CG and IG.

Discussion

Several studies have been conducted to determine the efficacy of physical therapy in patients with TMD, including joint mobilization, manual therapy, coordination exercises, strengthening exercises, stretching, patient education, and the combination of these techniques [34,35], These studies have in common the fact that all of these interventions were applied in the region of the head and neck, where patients' symptoms manifested. The present study proposed a more global treatment alternative for TMD, aiming to reach a factor of important relation with the pathology, which are postural changes. Pilates is a well-known and practiced exercise method that has the postural alignment of the whole body as one of its main objectives [36].

Regarding the severity of TMD, the sample consisted of women with predominantly low to moderate severity and therefore required relatively little improvement. Nevertheless, our results showed a large effect (η^2_p= 0.274) of the Pilates-based exercise program, corresponding to a 20% improvement, concomitant to the use of myorelaxant plates, in reducing the severity of TMD in young women. These findings corroborate with Wright, Domenech, and Fischer [37], who evaluated the efficacy of posture training, from isometric exercises of deep cervical flexors, stretching of pectoral muscles, abdominal exercises, and active exercises of trunk extensors and shoulder girdle muscles, in 60 patients with TMD. The authors found a decrease in the severity of the symptoms (p<0.001), in addition to an increase in the opening of the mouth without pain (p<0.05) and in the muscle pain threshold (p<0.05), in the group that received posture training and self-management instructions compared to another group that received only self-management instructions. Other studies using myorelaxant plates and physioterapy [38] and physiotherapy and counseling [39], have also been showed to reduce the severity of TMD by around 10%, which highlights the clinical importance of our results.

Regarding pain, current literature shows evidence that Pilates is an effective tool in the reduction of back [22,23] and neck pain [24]. However, our study found no change in the intensity of neck and back pain. These results may be related to poor treatment adherence in the sample. The mean participation in the Pilates sessions by the IG was 19.4±8.0, showing that there was a great variability in adherence to the treatment within the group. Considering the initial proposal

Table 1: Characterization of the sample and comparison of pre-intervention evaluation data from both groups.

	CG (n=19)	IG (n=20)	Mean difference tests
Age in years [mean (SD)]	28.5 (6.2)	29.3 (5.9)	U=171; z=-0.536; p=0.592ᵃ
Body mass in kg [mean (SD)]	64.1 (11.7)	65.2 (4.1)	U=129.5; z=-1.703; p=0.089ᵃ
Height in cm [mean (SD)]	162.9 (8.3)	164.8 (7.0)	*t*(37)=0.941; p=0.353ᵇ
Presence of neck pain (%)	(95)	(90)	U=170; z=-0.078; p=0.938ᵃ
Intensity of neck pain in cm [mean (SD)]	5.6 (2.2)	6.0 (2.5)	t(32)=-0.442; p=0.662ᵇ
Presence of back pain (%)	(95)	(90)	U=170.5; z=-0.039; p=0.969ᵃ
Intensity of back pain in cm [mean (SD)]	5.0 (2.1)	4.9 (1.9)	t(32)=0.157; p=0.876ᵇ
Degree of severity (%)			
Low	42.1	55	
Moderate	47.4	30	U=173; *z*=-0.526; p=0.599ᵃ
Severe	10.5	15	
Characteristics of the dysfunction (%)			
Mixed	55	75	
Muscular	20	10	U=161; *z*=-1.248; p=0.212ᵃ
Articulate	25	15	

Legend: Intervention group (IG); Control group (CG); Mann-Whitney U-test (a); Independent t-test (b); Standard deviation (SD).

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Table 2: Clinical data of variables evaluated in pre-intervention (T0) and post-intervention (T15) evaluation and respective ANOVA results and effect size.

Variables		CG		IG		Groups	Time	Groups*Time
		Mean (SD)	CI 95%	Mean (SD)	CI 95%			
NP (cm)	T0	5.6 (3.1)	4.25 - 6.87	5.3 (2.5)	3.94 - 6.64	F(1.35)=0.222	F(1.35)=0.028	F(1.35)=0.285
	T15	5.7 (3.3)	4.26 - 7.08	5.1 (2.7)	3.63 - 6.53	p=0.641; η^2=0.006	p=0.868; η^2=0.000	p=0.597; η^2_p=0.008
BP (cm)	T0	4.7 (2.3)	3.54 - 5.79	4.5 (2.5)	3.38 - 5.63	F(1.36)=0.310	F(1.36)=1.301	F(1.36)=1.011
	T15	4.6 (2.2)	3.63 - 5.63	4.0 (2.1)	3.01 - 5.01	p=0.581; η^2=0.008	p=0.261; η^2=0.004	p=0.321; η^2_p=0.027
TMD severity	T0	2.1 (1.4)	1.44 - 2.77	1.8 (1.5)	1.10 - 2.40	F(1.37)=4.702	F(1.37)=8.951	F(1.37)=13.969
	T15	2.2 (1.4)	1.63 - 2.79	0.8 (1.1)	0.23 - 1.37	p=0.037*; η^2=0.096	p=0.005*; η^2=0.023	p=0.001*; η^2_p=0.274
HP (°)	T0	53.4 (4.4)	51.15 - 55.58	53.3 (5.1)	51.14 - 55.46	F(1.37)=0.055	F(1.37)=4.309	F(1.37)=0.995
	T15	53.8 (4.1)	51.89 - 55.69	54.5 (4.1)	52.65 - 56.35	p=0.816; η^2=0.001	p=0.045*; η^2=0.009	p=0.325; η^2_p=0.026
HT (cm)	T0	0.4 (1.6)	-0.50 - 1.23	0.8 (2.1)	-0.03 - 1.66	F(1.37)=0.263	F(1.37)=0.709	F(1.37)=0.374
	T15	0.8 (1.7)	-0.14 - 1.69	0.9 (2.2)	-0.01 - 1.77	p=0.611; η^2=0.006	p=0.405; η^2=0.004	p=0.544; η^2_p=0.010
CC (°)	T0	46.2 (8.3)	42.68 - 49.75	45.8 (6.9)	42.31 - 49.20	F(1.37)=0.206	F(1.37)=4.215	F(1.37)=0.383
	T15	44.8 (9.1)	41.12 - 48.57	43.2 (6.9)	39.57 - 46.83	p=0.652; η^2=0.005	p=0.047*; η^2=0.016	p=0.540; η^2_p=0.010
TC (°)	T0	46.3 (6.4)	43.27 - 49.36	45.7 (6.7)	42.68 - 48.62	F(1.37)=0.003	F(1.37)=9.560	F(1.37)=0.277
	T15	42.6 (7.4)	38.86 - 46.30	43.0 (8.5)	39.38 - 46.62	p=0.954; η^2=0.000	p=0.004*; η^2=0.047	p=0.602; η^2_p=0.007
LC (°)	T0	45.9 (5.4)	43.33 - 48.46	44.9 (5.6)	42.35 - 47.35	F(1.37)=0.065	F(1.37)=0.106	F(1.37)=7.516
	T15	45.1 (5.5)	42.40 - 47.71	45.3 (6.0)	42.66 - 47.84	p=0.801; η^2=0.001	p=0.747; η^2=0.000	p=0.367; η^2_p=0.022
HAS (cm)	T0	0.0 (1.1)	-0.39 - 0.48	0.0 (0.7)	-0.42 - 0.43	F(1.37)=0.044	F(1.37)=3.177	F(1.37)=0.094
	T15	0.2 (1.1)	-0.24 - 0.644	0.1 (0.8)	-0.31 - 0.55	p=0.835; η^2=0.001	p=0.083; η^2=0.005	p=0.761; η^2_p=0.003
HASC (cm)	T0	0.0 (0.9)	-0.51 - 0.45	-0.3 (1.1)	-0.75 - 0.18	F(1.37)=0.975	F(1.37)=0.004	F(1.37)=0.004
	T15	0.0 (0.7)	-0.39 - 0.34	-0.3 (0.9)	-0.66 - 0.06	p=0.330; η^2=0.022	p=0.949; η^2=0.000	p=0.949; η^2_p=0.000
HAP (cm)	T0	0.1 (0.3)	-0.12 - 0.29	-0.2 (0.5)	-0.38 - 0.03	F(1.37)=1.789	F(1.37)=2.986	F(1.37)=1.799
	T15	0.1 (0.4)	-0.08 - 0.31	0.0 (0.5)	-0.14 - 0.24	p=0.189; η^2=0.033	p=0.092; η^2=0.021	p=0.188; η^2_p=0.046
PP (°)	T0	13.6 (4.4)	11.52 - 15.67	11.2 (4.6)	9.18 - 13.23	F(1.37)=2.296	F(1.37)=0.979	F(1.37)=0.799
	T15	13.6 (4.6)	11.69 - 15.59	12.0 (3.8)	10.13 - 13.94	p=0.138; η^2=0.053	p=0.329; η^2=0.003	p=0.377; η^2_p=0.021

Legend: Significative difference (*); Intervention group (IG); Control group (CG); Confidence interval (CI); Standard deviation (SD); Sagittal plan (S); Frontal plan (F); Mean difference (MD); Pre-intervention evaluation (T0); Pos-intervention evaluation (T15); Eta square (η^2); Partial eta square (η^2_p); Neck pain (NP); Back pain (BP); Head position (HP); Head tilt (HT); Cervical curvature (CC); Thoracic curvature (TC); Lumbar curvature (LC); Horizontal alignment of the shoulder (HAS); Horizontal alignment of the scapulae (HASC); Horizontal alignment of the pelvis (HAP); Position of the pelvis (PP).

Table 3: Frequency of appropriate posture habits for groups (GC and GI) and comparison between the evaluative moments (T0 and T15) and between groups.

Measured variables		Right answer		Time	Group
		T0	T15		
Sitting to write (%)	CG	5.3	10.5	z=-1.342; p=0.180; r=-0.30[a]	z=-0.696; p=0.487; r=-0.15[b]
	IG	20.0	15.0	z=-0.447; p=0.655; r=-0.10[a]	
Sitting to talk (%)	CG	21.1	15.8	z=-0.317; p=0.751; r=-0.07[a]	z=-0.963; p=0.336; r=-0.22[b]
	IG	15.0	25.0	z=-1.667; p=0.096; r=-0.38[a]	
Sitting to use computer (%)	CG	5.3	15.8	z=-0.276; p=0.783; r=-0.06[a]	z=-0.516; p=0.606; r=-0.11[b]
	IG	20.0	30.0	z=0.000; p=1.000; r=0.00[a]	
Picking up an object from the ground (%)	CG	21.1	31.6	z=-1.186; p=0.236; r=-0.27[a]	z=-0.137; p=0.891; r=-0.03[b]
	IG	35.0	35.0	z=-0.711; p=0.477; r=-0.16[a]	
Sleeping (%)	CG	78.9	84.2	z=-0.447; p=0.655; r=-0.10[a]	z=-0.337; p=0.736; r=-0.07[b]
	IG	70.0	60.0	z=-1.414, p=0.157; r=-0.32[a]	

Legend: Intervention group (IG); Control group (CG); Pre-intervention evaluation (T0); Pos-intervention evaluation (T15); Wilcoxon test ([a]); Mann-Whitney U-test([b]); Effect size (r).

of 30 sessions, none of the IG participants completed the intervention protocol. In addition, the mean number of weeks of use of the myorelaxant plate in both groups was also small (11.1±6.5 weeks), even with a weekly warning sent to participants via mobile phone to remind them of the need to use the plate while sleeping. It should be noted that this lack of adherence, in a way, represents what happens in clinical practice when the patient does not attend all the sessions, whether for personal, climatic, or other reasons, as well as not always making use of the plate or similar devices.

Another variable that may have influenced the results and is also considered a limitation of our study was the absence of a control for the physical activity level of participants. Despite instructions offered to the participants to not start or stop any physical activity during the study period, no follow-up was done.

The lack of adherence to treatment could also explain the results found in relation to the variables of static posture and postural habits evaluated in this study. There was a significant difference only in the comparison between the evaluative moments (T0 and T15) for the variables of head position, cervical curvature, and thoracic curvature. However, there was no difference in the comparison between the groups, showing that both the IG and CG presented changes in these variables and, therefore, these changes cannot be considered an effect of the Pilates-based exercise program, but they may be an effect of the use of the plate. The exercises for the IG should also be considered. The Pilates Method includes a vast array of exercises [30] and the choice of the exercises may have influenced our results. Therefore, further studies should seek to identify the Pilates exercises that influence the alterations in body posture of the participants.

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In the systematic review conducted by Schmit, et al. [21], which aimed to establish the level of evidence from randomized and non-randomized clinical trials that assessed the influence of the Pilates method on postural alignment of women, the findings showed: (1) adjustments in the shoulders and pelvis of adult women after 24 Pilates sessions; (2) improvements to head alignment of adult women after 48 sessions; and (3) decrease in thoracic kyphosis and cervicothoracic distance in a sample of elderly women after 60 Pilates sessions. However, the studies included in this review were conducted on healthy subjects in different age groups. Due to methodological differences between the studies and the variability of the findings, the authors concluded that there is no scientific evidence confirming the effects of the Pilates method in the postural alignment of healthy women. These results, associated with our findings, highlight the need for conducting further studies that evaluate the effect of the Pilates method on body posture, both in healthy individuals and in patients with TMD. However, it is worth noting that in general, the number of sessions used in other studies was higher than the 30 sessions used in this study, a factor that may explain the studies' different results.

A study by Komiyama, et al. [40], applied a cognitive-behavioral treatment with and without posture correction instructions during activities of daily living in patients with TMD who presented limitations of mouth opening due to pain. The results of this study suggest that posture correction instructions for sitting and standing, while sleeping, eating, walking, and doing other daily activities may have a positive effect on myofascial pain relief for these patients ($p<0.05$). Once the Pilates method is considered a method of physical, mental, and emotional conditioning, we seek in our study to include the assessment of postural habits in order to provide preliminary evidence. However, no effect of Pilates sessions on IG posture habits was observed. Some factors could explain this result, such as the low adherence of the sample to the treatment, and the fact that no guidance was given to the IG about the importance of adopting good posture habits and correct posture for carrying out daily activities, as was performed in the study by Komiyoma, et al. [40].

Besides the absence of a control for the physical activity level of participants, we can indicate other limitations of the present study, such as: The lack of a sample inclusion criteria involving neck and back pain; the lack of precise control in relation to the use of the myorelaxant plates by the participants, despite the weekly reminder sent via mobile phone; and the generic nature of the Pilates exercise program which did not focus on postural alterations. While the high dropout rate in our sample may be considered a limitation, we used "intention to treatment" statistics to deal with this problem, similarly to recent studies that have also reported high dropout rate [41,42].

Given the above, we have concluded that a Pilates-based exercise program for neck and back pain, static body posture, and postural habits had no observable effect on young women with TMD. However, there was a decrease in the severity of TMD after the intervention period only for the IG, showing that Pilates can be used as a tool in the treatment of TMD, concomitant with the use of a myorelaxant plate, in order to reduce the severity of the disease in young women.

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