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Efficacy of Aerobic Exercise on Widespread Pain Sensitization in Patients with Temporomandibular Disorders: A Preliminary Randomized Controlled Study

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Abstract: Myogenic temporomandibular disorders (TMDs) are commonly associated with pain sensitization (PS), manifesting decreased local and distal pressure pain thresholds (PPTs). Aerobic exercise (AE) has shown hypoalgesic effects on PS. This study aimed to analyze the effects of AE in addition to physical therapy (PT) on widespread PS in myogenic TMDs. A randomized controlled trial was carried out, involving 20 subjects allocated to PT (n = 10) or PT + AE (n = 10). Both groups performed six sessions over four weeks, consisting of education, manual therapy, and therapeutic exercise. The PT + AE group also performed high-intensity intervallic AE on a stationary bike. Primary outcome: PPT in the Achilles tendon assessed with an algometer. Secondary outcome: Central Sensitization Inventory (CSI). Outcomes were recorded at baseline (T0), post-intervention (T1), and after 12 weeks (T2). Significant between-groups differences were found favoring PT + AE at T1 and T2 for the left Achilles PPT (T1 $p < 0.01$; d = 1.3; T2 $p < 0.001$; d = 2.5) and CSI (T1 $p < 0.001$; d = 2.3; T2 $p < 0.01$; d = 1.7), and at T2 for the right Achilles PPT ($p < 0.001$; d = 0.9). Thus, adding AE to PT improved widespread PS more than only PT in myogenic TMD.

Keywords: temporomandibular disorders; pain sensitization; aerobic exercise; physical therapy

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1. Introduction

Approximately 15% of the adult population will experience orofacial pain over the course of a year [1]. The prevalence of orofacial pain is greater in individuals between 20 and 40 years old, and it is more common in women [1]. Orofacial pain is usually associated with temporomandibular disorders (TMDs), which are the second most common musculoskeletal disorder causing pain and disability [2,3]. The classification of TMDs has been described by the Diagnostic Criteria for TMD (DC/TMD) Axis I [4], and states that patients can be divided into Group I (those with muscle disorders including myofascial pain with and without mouth opening limitations); Group II (those with disc displacement and with or without reduction and mouth opening limitations); Group III (those with arthralgia, arthritis, and arthrosis). Common signs and symptoms include a limited and/or abnormal range of motion, clicking, popping or crepitus in function with or without the locking of the jaw, temporomandibular joint pain, jaw opening pain, muscular orofacial pain, otalgia, tinnitus, or headache [5]. The most common TMD is of muscular origin and accounts for 42% of diagnosed TMD cases [1]. Myogenic TMD tends to become chronic, resulting in pain sensitization (PS) [6,7], which is defined by the International Association for the Study of Pain as an increased response from nociceptive neurons above the usual

pain threshold [8]. TMD patients may present overlapping symptoms with other chronic pain conditions, including headache, fibromyalgia, and neurological conditions, probably through the phenomenon of central sensitization (mainly allodynia and hyperalgesia) [9].

Widespread PS can involve both central and peripheral sensitization [8]. As central sensitization cannot be clinically assessed, it is difficult to confirm its presence and differentiate it from peripheral sensitization. Tools such as quantitative sensory testing (QST), the pressure pain threshold (PPT), temperature stimulus or temporal summation, and central sensitization index (CSI) have been used to assess central sensitization symptoms and hypothesize their involvement in chronic pain [10–12].

Patients with myogenic TMD tend to present a decreased PPT in local and remote areas without an alteration of temperature perception and a high CSI score [6]. The usual treatment for myogenic TMD consists of education, manual therapy, and the therapeutic exercise of the jaw and cervical areas [13,14]. Additionally, new treatment strategies such as radial extracorporeal shock wave therapy have been proposed [15]. These strategies have been shown to reduce the pain intensity, and improve function and the quality of life [13–15]. However, given the growing evidence of the presence of PS in remote areas in many of these subjects, local treatment may not be enough. Therefore, in addition to usual physical therapy (PT), the treatment for myogenic TMD should include care strategies for the treatment of widespread PS [16,17].

It has been shown that therapeutic exercises such as aerobic exercise (AE), strength, flexibility, and core or balance training programs have hypoalgesic effects as they reduce pain intensity [18,19]. Specifically, AE has been proposed as a therapeutic tool for the treatment of widespread PS, and myofascial pain could be modulated thanks to an increased blood supply in the trigger point areas. This increased blood supply allows for the reorganization of fibers, which causes a decrease in PS [10]. In the same way, in the short and long term, AE has been shown to increase the PPT, reduce pain perception, and improve the quality of life for patients with myofascial pain and chronic musculoskeletal pain due to its hypoalgesic effects [17,20]. Indeed, AE, especially when performed at a high intensity, can also trigger descending inhibition and have an effect on pain modulation by liberating endogenous opioids [21,22].

To the best of the authors' knowledge, there are no clinical trials that have studied the effect of the addition of AE to conventional PT treatment on individuals with myogenic TMD and widespread PS. Therefore, a preliminary randomized controlled trial was conducted to assess the effects post-intervention and at a 12 week follow-up of adding AE as a complement to PT on the PPT in the masseter, upper trapezius, and Achilles tendon; widespread PS symptoms; jaw opening; upper cervical range of motion (ROM); and anxiety and sleep quality of participants with myogenic TMD and widespread PS.

2. Materials and Methods

2.1. Study Design

A preliminary randomized controlled trial was conducted with a 1:1 allocation ratio, and aimed to estimate the effect sizes to determine the sample size needed for a larger-scaled randomized controlled trial. The study was carried out at the Biomechanics and Exercise Physiology Laboratory of the Universitat Internacional de Catalunya. The study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethical Research Committee of the Universitat Internacional de Catalunya (FIS/2022/007). The study was registered at clinicaltrials.gov (accessed on 1 July 2023) (number: NCT05540366). The study was reported following the CONSORT guidelines [23].

2.2. Participants

For this preliminary randomized controlled trial, a convenience sample of twenty participants with myogenic TMD and widespread PS was recruited from the University Dental Clinic of the Universitat Internacional de Catalunya.

The inclusion criteria were as follows: being older than 18 years of age; having a diagnosis of myogenic or mixed TMD according to the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) [4]; presenting a CSI score $\geq$ 30 [24]; and having a positive flexion-rotation test (FRT) (limited range of motion to 32° in one direction or a difference of more than 10° between both rotations) [25].

The exclusion criteria were as follows: a history of trauma; fracture in the temporomandibular joint or cervical spine within the last 3 months; previous surgery on the temporomandibular joint or cervical spine; active systemic, rheumatic, metabolic, neurological, psychiatric, pulmonary, or malignant neoplastic disease [15–17]; history of cardiovascular disease contraindicating moderate-intensity AE; wearing orthodontic braces, bruxism splints; substance addiction, alcoholism; pregnancy; having taken analgesic or muscle relaxant medication within 48 h before each data collection; and having received PT treatment for this condition within the last 3 months [26–28].

2.3. Randomization

One of the researchers randomized subjects into one of the two study groups using the program Random.org [29]. Subsequently, this researcher placed the assigned group for each participant into 20 sealed and numbered envelopes from 1 to 20, based on the prior randomization. These envelopes were handed over to researcher A, who verified the selection criteria, acquired the signature of the informed consent and gave the patients the sealed envelope if they were finally included in the study. After inclusion, researchers B and C recorded the outcome variables without knowing which group each subject belonged to. Finally, researcher D opened the sealed envelopes and was the only researcher who became aware of the group to which each participant was allocated. The same researcher applied the treatment techniques.

2.4. Outcomes

The primary outcome measure was the PPT measured in the Achilles tendon. The secondary outcomes were the masseter and upper trapezius PPT, widespread PS symptoms, orofacial pain intensity, jaw opening, upper cervical ROM and anxiety. All the outcomes were recorded at baseline (T0), two days post-intervention (T1), and at a 12-week follow-up (T2).

The PPT was measured using a pressure algometer applying a perpendicular pressure of 0.5 $kg/cm^2/s$. The PPT was assessed bilaterally in the Achilles tendon, masseter, and upper trapezius [30]. The recording was performed twice at each point. The intra-examiner reliability of this tool has proven to be good (r = 0.69–0.97) [31].

Symptoms related to widespread PS were registered with the Spanish version of the CSI. It consists of 25 items assessing the presence of symptoms related to central sensitization and previous disorders, with 5 severity responses ranging from 0 to 4. The total score ranges from 0 to 100 (0–29 = subclinical; 30–39 = mild; 40–49 = moderate; 50–59 = severe; 60–100 = extreme). The CSI demonstrated excellent test–retest reliability (r = 0.91) [32].

Orofacial pain intensity was recorded using the 100 mm visual analogue scale (VAS) at the time of assessment, and patients were asked about the worst pain experienced during the previous 24 h. Endpoints defined as 0 = no pain and 100 = worst imaginable pain. The subject marked the line to indicate their pain level. The VAS has demonstrated excellent test–retest reliability (ICC = 0.82) to assess pain intensity [33].

The maximum range of motion of the jaw opening was assessed by a millimeter ruler. Intra-examiner reliability had an ICC of 0.70–0.99, and inter-examiner reliability had an ICC of 0.90–1 [34].

The FRT was conducted to measure the mobility of the upper cervical spine (C1–C2). The intra-examiner reliability for the FRT had an ICC of 0.83–0.91, and the inter-examiner reliability had an ICC of 0.76–0.97. Three measurements were taken, and the mean of each was calculated [35].

The Hospital Anxiety and Depression Scale (HADS) was used to assess anxiety and depression. This scale has been validated in Spanish and consists of two subscales (depression and anxiety), each with 7 items. The score for each subscale can range from 0 to 21. Each item offers four response options, ranging from absence/minimal presence = 0 to maximum presence = 3, with higher scores indicating a greater likelihood of anxiety or depression. This scale has a Cronbach's alpha coefficient of 0.90 [36].

2.5. Intervention

The sample was divided into two groups: the physical therapy (PT) group and the physical therapy plus aerobic exercise (PT + AE) group. A physiotherapist with one year of experience performed the intervention, which consisted of six sessions over four weeks: two sessions per week for the first two weeks and one session per week for the following two weeks [37].

2.5.1. Physical Therapy Group

Each session for the control group lasted 30 min, and the treatment consisted of education, manual therapy, and therapeutic exercises.

Education: At the beginning of each session, a series of recommendations were provided to correct inappropriate behaviors such as parafunctions. This included explaining the correct resting position of the tongue and jaw, and proper breathing type to facilitate diaphragmatic function. Additionally, strategies to prevent the onset of symptoms such as avoiding hard foods, chewing gum, nail-biting, tongue or cheek biting, and teeth clenching were shared with the study participants [37].

Manual Therapy: Divided into four sections:

a. Distraction of the TMJ [38]: The technique was applied bilaterally at Grade II intensity (Kaltenborn-Evjenth Concept) for 90 s, divided into three 30 s intervals with 15 s of rest between them.
b. Mobilization of the Occipital–Atlas segment [39]: Dorsal sliding was performed at Grade III intensity (Kaltenborn–Evjenth Concept). The therapist stabilized the atlas with one hand and pushed the forehead with the shoulder. Four sustained mobilizations of 30 s each were performed with 15 s of rest between them.
c. Mobilization of the Atlas–Axis segment [39]: The traction of the atlas over the axis was performed at Grade III intensity (Kaltenborn–Evjenth Concept). The therapist stabilized the axis with one hand and performed the traction of the atlas with the other hand. Four sustained mobilizations of 30 s each were performed with 15 s of rest between them.
d. Manual Pressure [37,38]: Bilateral pressure was applied to the masseter, temporalis, sternocleidomastoid, and upper trapezius muscles. As a pressure guide, when participants experienced a pain level of 7/10 on the VAS, this pressure was maintained. When the pain decreased to 3/10, the pressure increased until the pain returned to 7/10. This process was repeated for each muscle for a maximum of 60 s or less if relaxation was previously observed.

Therapeutic Exercise: A total of 3 exercises were performed.

a. Opening and closing of the TMJ [37]: The controlled opening and closing exercises of the TMJ with the tongue in the resting position and in front of a mirror. Three sets of six repetitions were performed with 30 s of rest between each set.
b. Isometrics [37]: Isometric exercises were performed in the opening, protrusion, and lateral excursion of the TMJ from a position close to the jaw's resting position. The subject maintained an isometric contraction for 10 s for each movement, and the process was repeated 3 times.
c. Deep Cervical Muscle Training [40]: The deep cervical muscles were trained using Stabilizer^{TM} biofeedback, without contracting the superficial muscles (manual control of the sternocleidomastoid). The baseline pressure was 20 mmHg, and the patient

had to perform craniocervical flexion to increase the pressure to 22 mmHg and maintain this position for 10 s. Five different pressure levels were applied: 22, 24, 26, 28, and 30 mmHg, and in each position, two repetitions of 10s were performed.

2.5.2. The Physical Therapy Plus Aerobic Exercise Group

The intervention of this group consisted of adding AE to the prior intervention of PT explained before. The AE was performed for 30 min.

The AE was performed on a cycle ergometer. The session consisted of interval training [41], performed at a submaximal intensity [26]. To avoid altering the heart rate (HR) value when prescribing the AE, the room temperature was set at 21 °C with a maximum humidity of 50%, and participants were advised not to have a large meal before the session. The program was based on the studies by Molherino Alves et al. [26–28], which complied with the recommendations from a systematic review [10] regarding the required intensities to expect pain-related effects. The seat height was adjusted for each participant, and the training was divided as follows:

a. Warm-up: Participants cycled for 5 min at a heart rate reserve (HRR) of 50%.
b. Main work: For 24 min, participants performed an interval exercise divided into four intervals, with 4 min at 85% of the HRR and 2 min of recovery at 60% of the HRR in each cycle.
c. Active recovery: The last minute allowed participants to engage in active recovery at 50% of the HRR.

The HRR was calculated using the Karvonen formula used in similar studies [26–28]:

$$HRtarget = [HRR \times \% \text{ intensity}] + \text{Resting HR}, \text{ where } HRR = HRmax - HRrest, \text{ and } HRmax = 220\text{-age}.$$

AE intensity was measured according to HR by means of a Polar H10 chest sensor connected to the "Polar Beat" app. To achieve the required HR for each stage during the sessions, the exercise intensity was modified by the physiotherapist varying the resistance of the bike (watts), and/or the rhythm (pedaling per min). Patients were asked to feel comfortable with their rhythm, and to notify the physiotherapist if the power was too high and/or if it produced an important muscle fatigue.

2.6. Statistical Analysis

The statistical analysis was conducted using the SPSS 20.0 package (IBM, Armonk, NY, USA). The significance level was established at 0.05 and the confidence interval was set at 95%.

The analysis was conducted with a linear mixed model, and a repeated-measures ANOVA was used to analyze the differences in terms of time (baseline, post-intervention, and 12-week follow-up) and group (PT and PT + AE). The intention-to-treat principle was used for the statistical analysis [42]. The change scores for each outcome were calculated from baseline to post-intervention and three-month follow-up. For the present study, $p < 0.05$ was considered statistically significant. Cohen's d coefficient was used to carry out the between-group effect sizes analysis of the quantitative variables. An effect size > 0.8 was considered large; approximately 0.5, moderate; and <0.2, small.

2.7. Blinding

The outcome assessors were blinded to the allocation of each participant. However, due to the nature of the intervention, the participants and therapists could not be blinded [43].

3. Results

A total of 26 patients with TMD and muscle impairment were identified and evaluated to confirm the study's selection criteria. Ultimately, 20 patients who met all the criteria agreed to participate and completed the intervention (16 females and 4 males, 27.45 years of age ±10.1 years). Among the six subjects who did not enter the study, three did not have

a score ≥ 30 on the CSI, and three decided not to participate after the criteria were checked. All the participants were assessed at T1, and one subject allocated to the PT did not attend the T2 assessment (Figure 1). The baseline characteristics of the study participants are shown in Table 1. The means and standard deviations for all primary and secondary outcomes at baseline, T1 and T2 are presented in Supplementary Material Table S1.

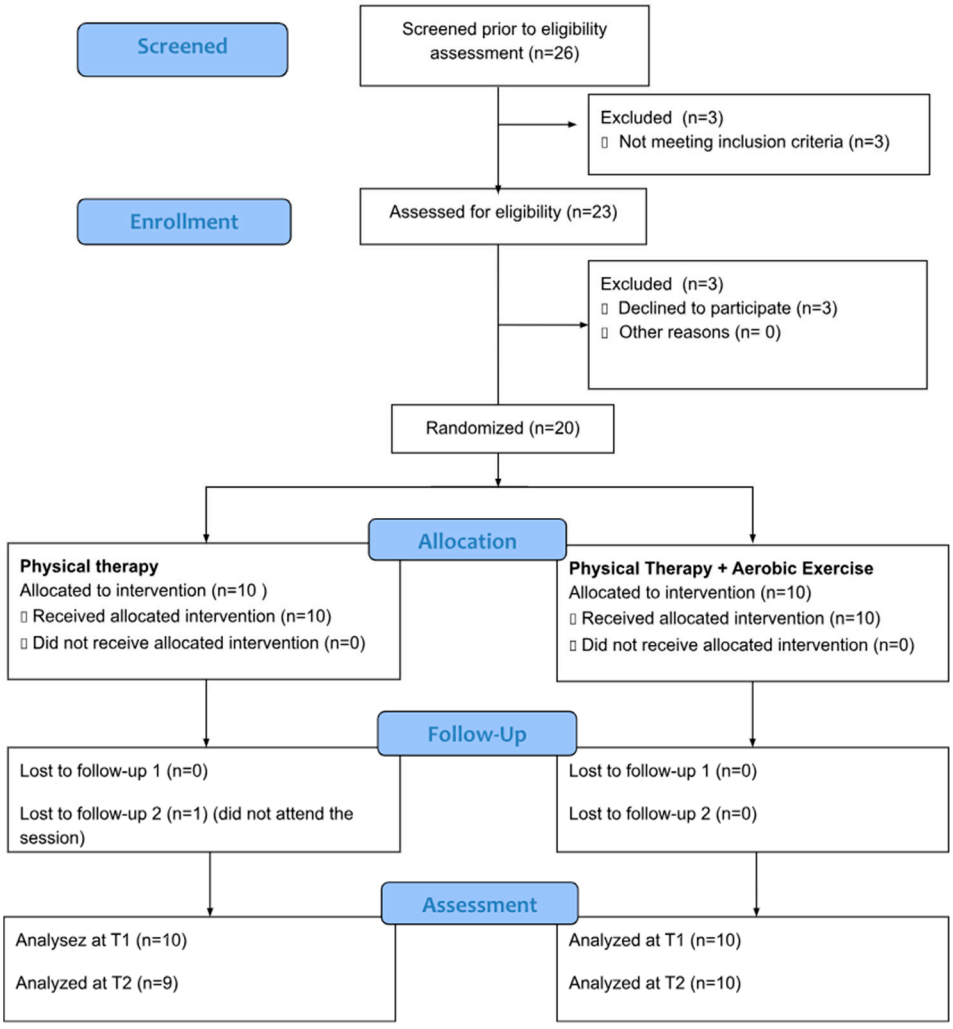

Figure 1. CONSORT flow diagram of the study.

Table 1. Sociodemographic characteristics of each group.

	PT (*n* = 10)	**PT + AE (*n* = 10)**
Sex (% women)	8 (80%)	8 (80%)
Age (years)	28.1 ± 10.0	26.8 ± 10.6
Height (cm)	163.9 ± 7.7	170.8 ± 7.3
Weight	59.9 ± 11.2	68.5 ± 15.6

AE: Aerobic exercise; PT: Physical Therapy; Data are presented as mean ± standard deviation.

The baseline, T1 change score, and T2 change score of the primary outcome are shown in Table 2, and the secondary outcomes are shown in Table 3. Statistically significant differences were observed for the PPT of the left Achilles at T1 and T2, for the PPT of the right Achilles in T2, and for the CSI at T1 and T2.

Table 2. Baseline, T1, and T2 results for the primary outcome.

Outcomes	PT (n = 10)	PT + AE (n = 10)	Between-Group Difference in Change Score	Effect Size
PPT Achilles (Left) (kg/cm^2)				
T0 Baseline	4.4 ± 1.3	3.8 ± 0.7		
T1–T0 change score	−0.1 ± 1.1	1.4 ± 1.2	−1.5 (−2.6, −0.4) ‡	1.3
T2–T0 change score	−0.3 ± 0.9	2.5 ± 1.3	−2.8 (−3.8, −1.6) *	2.5
PPT Achilles (Right) (kg/cm^2)				
T0 Baseline	4.6 ± 1.3	4.3 ± 0.8		
T1–T0 change score	0.0 ± 1.2	1.3 ± 1.6	−1.2 (−2.6, 0.1)	0.9
T2–T0 change score	−0.2 ± 1.0	1.9 ± 1.1	−2.1 (−3.1, −1.1) *	0.9

AE: Aerobic exercise; PPT: Pressure Pain Threshold; PT: Physical Therapy; Data are mean ± standard deviation. ‡: $p < 0.01$; *: $p < 0.001$.

Table 3. Baseline, T1, and T2 results for the secondary outcomes.

Outcomes	PT (n = 10)	PT + AE (n = 10)	Between-Group Difference in Change Score	Effect Size
PPT Masseter (Left) (kg/cm^2)				
T0 Baseline	1.4 ± 0.5	1.5 ± 0.6		
T1–T0 change score	0.0 ± 0.6	0.3 ± 0.4	−0.3 (−0.8, 0.1)	0.6
T2–T0 change score	0.2 ± 0.3	0.5 ± 0.4	−0.3 (−0.7, 0.0)	0.8
PPT Masseter (Right) (kg/cm^2)				
T0 Baseline	1.2 ± 0.5	1.3 ± 0.4		
T1–T0 change score	0.1 ± 0.3	0.3 ± 0.5	−0.2 (−0.8, 0.2)	0.5
T2–T0 change score	0.2 ± 0.3	0.7 ± 0.3	−0.5 (−0.8, −0.2) ‡	1.7
PPT Trapezius (Left) (kg/cm^2)				
T0 Baseline	2.1 ± 0.8	2.3 ± 0.9		
T1–T0 change score	0.1 ± 0.8	0.8 ± 0.8	−0.7 (−1.4, 0.1)	0.8
T2–T0 change score	0.7 ± 0.8	1.0 ± 0.9	−0.3 (−1.2, 0.4)	0.5
PPT Trapezius (Right) (kg/cm^2)				
T0 Baseline	2.1 ± 0.9	2.3 ± 0.6		
T1–T0 change score	0.5 ± 0.7	0.6 ± 0.6	−0.1 (−0.7, 0.5)	0.1
T2–T0 change score	0.6 ± 0.8	0.9 ± 1.0	−0.3 (−1.1, 0.6)	0.4
CSI				
T0 Baseline	37.0 ± 12.7	38.5 ± 5.6		
T1–T0 change score	−2.0 ± 4.3	−14.5 ± 6.5	12.5 (7.3, 17.6) *	2.3
T2–T0 change score	−4.5 ± 8.3	−16.9 ± 6.2	12.4 (5.3, 19.4) ‡	1.7
VAS 24 h (mm)				
T0 Baseline	38.0 ± 22.8	39.9 ± 19.4		
T1–T0 change score	−14.1 ± 12.1	−25.8 ± 19.3	11.7 (−6.8, 25.0)	0.7
T2–T0 change score	−22.4 ± 18.0	−24.2 ± 26.7	1.8 (−20.6, 24.1)	0.1
Jaw opening (mm)				
T0 Baseline	44.1 ± 8.9	40.8 ± 7.5		
T1–T0 change score	−1.9 ± 7.3	3.4 ± 5.5	−5.5 (−11.5, 0.3)	0.8
T2–T0 change score	−2.1 ± 7.5	3.3 ± 5.8	−5.4 (−11.9, 1.1)	0.8
FRT (Right) (°)				
T0 Baseline	27.0 ± 12.2	31.9 ± 10.2		
T1–T0 change score	9.0 ± 12.9	10.0 ± 14.1	−1.0 (−13.3, 11.5)	0.1
T2–T0 change score	2.1 ± 14.8	4.5 ± 15.6	−2.4 (−17.1, 12.5)	0.2
FRT (Left) (°)				
T0 Baseline	23.4 ± 9.1	31.0 ± 7.4		
T1–T0 change score	8.5 ± 9.3	9.7 ± 10.8	−1.2 (−2.1, 16.4)	0.1
T2–T0 change score	5.7 ± 13.0	6.4 ± 11.0	−0.7 (−12.4, 10.9)	0.1
HADS				
T0 Baseline	12.2 ± 3.0	12.5 ± 5.9		
T1–T0 change score	−1.2 ± 3.8	−4.0 ± 3.1	2.8 (−0.1, 6.3)	0.8
T2–T0 change score	−0.6 ± 5.9	−2.1 ± 4.3	1.5 (−3.4, 6.5)	0.3

AE: aerobic exercise; CSI: central sensitization index; FRT: flexion-rotation test; HADS: Hospital Anxiety and Depression Scale; PPT: pressure pain threshold; PT: physical therapy; VAS: visual analog scale; data are presented as mean ± standard deviation. ‡: $p < 0.01$; *: $p < 0.001$.

4. Discussion

The present study revealed that adding AE to PT improved the outcomes related to widespread PS in patients with myogenic TMD. The analysis showed differences between groups for the Achilles PPT and CSI in favor of the PT + AE group at T2.

In the PT + AE group, higher PPT values compared to the PT group were observed in the Achilles tendons of both legs, as well as a lower ICS. This difference could be attributed to having performed AE. The addition of AE to a PT treatment seemed to have additional benefits on myogenic TMD by improving their widespread PS. The effect sizes achieved between groups in the Achilles PPT, and on the CSIs at T1 (Left Achilles: d = 1.3; Right Achilles: d = 0.9; CSI: d = 2.3) and T2 (Left Achilles: d = 2.5; Right Achilles: d = 0.9; CSI: d = 1.7) suggested that AE had positive effects on widespread PS. AE at submaximal intensity had already shown hypoalgesic effects on other chronic musculoskeletal conditions with widespread PS [17]. It has been suggested that AE increases the blood supply and metabolic resources, allowing a mechanical reorganization of muscle fibers [16]. Additionally, when the AE is performed at submaximal intensities, lactate is secreted. This secretion appears to have an important role in chronic pain, as studies show alterations in the structural properties of the brain where the demand for lactate is greater [44–46]. Accordingly, global resistance training, as well as AE training, could compensate for this lack of lactate by stimulating its production [47,48].

The PPT was evaluated in areas close to the TMJ. Differences between groups were found only for the PPT of the right masseter at T2, with a significant difference between the groups in favor of the PT + AE ($p < 0.01$).

No significant differences were found between groups for the secondary outcomes. However, intragroup improvements were observed, although they were not analyzed as it was not the objective of the study. It is necessary to mention that the improvements observed in both groups in jaw opening and anxiety are smaller than those observed in previous studies [15]. This may be due to the small sample size of our study and the lack of experience of the physiotherapist responsible for the intervention. Despite the lack of significant differences between groups for these variables, the effect sizes showed that the PT + AE group had better improvements than the PT group. In fact, it has been shown that in patients with chronic non-specific neck pain, AE reduces neck pain and headaches [49,50]. Furthermore, in patients with mixed and myogenic TMD, AE improves headaches [26], pain perception [27,28], anxiety [28], oral health-related quality of life [26], and the activation and strength of masticatory muscles [27]. Finally, a systematic review and meta-analysis by Gordon et al. [51] showed that AE is effective for reducing anxiety. As previous studies have shown [52], there is a moderate to strong correlation between anxiety/depression and CSI. Therefore, the significant improvements in HADS and CSI scores in the AE group may demonstrate this relationship between both variables.

Therefore, AE could reduce widespread PS as well as myofascial pain. Given that myogenic TMD tends to become chronic and there is usually a PS in local and remote areas, AE could be a beneficial treatment.

The results presented should be interpreted with caution, as this study has some limitations. Firstly, there is no gold standard to assert the existence of central sensitization, thus we can only suspect its presence through assessments with CSI and sensorial quantitative tests [53]. Secondly, the data presented are from a preliminary study with a small sample size, therefore, we do not know if these results would be replicable in a larger sample with myogenic TMD. Furthermore, it is important to note that widespread PS is commonly present in patients with a tendency toward chronicity, so it will be essential to conduct a long-term follow-up. The single-blinding becomes another limitation, as it was difficult to blind the participants due to the intervention. However, one physiotherapist could perform the PT part and another physiotherapist could direct the AE to avoid a potential bias. Likewise, the formula used to determine the HRmax (=220-age) to standardize the HRtarget during the AE training was basic and did not take into account the physical capacity of each participant, which could make the work intensities not so accurate. Nonetheless, we

decided to use it as the intensity of AE training to reduce PS has been established to be between 40% and 85% of the HRR [17], allowing for a larger scope to achieve an hypoalgesic effect. Finally, the lack of experience of the physiotherapist may have had an impact on the improvement of some of the secondary outcomes. However, the same physiotherapist was in charge of the AE part, which provided significant differences in favor of the PT + AE group. Thus, novel physiotherapists should be considered for participation especially in guiding therapeutic exercise.

Future studies could consider exploring whether performing AE from the upper limb (rowing, swimming), which is biomechanically related to the orofacial region, has a similar effect to working from the lower limb (running, cycling). The effectiveness of a strength program on widespread PS also could be studied in this population. Future studies could also focus on interventions or patients with arthrogenic TMD, who, like myogenic TMD patients, may experience widespread PS.

5. Conclusions

The introduction of six sessions of AE to the physiotherapy treatment improved the PPT in the Achilles left tendon and the CSI post-treatment. These effects were sustained throughout the 12-week follow-up period, with a concurrent improvement observed in the PPT of the right Achilles tendon. The results of this preliminary study should be considered with caution given the small sample.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/app14051799/s1. The means and standard deviations for all primary and secondary outcomes at baseline, T1, and T2 are presented in Supplementary Material Table S1.

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