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ORIGINAL ARTICLE

The effect of supervised exercise on localized TMD pain and TMD pain associated with generalized pain

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ABSTRACT

Objectives: To evaluate the effect of a supervised exercise program in patients with localized/regional temporomandibular disorder (TMD) pain and with TMD associated with generalized pain.

Material and methods: Consecutively referred patients with localized/regional TMD pain ($n = 56$; 46 women and 10 men, mean age 44 years) and TMD associated with generalized pain ($n = 21$; 21 women, mean age 41 years) participated. Patients underwent a 10-session structured supervised exercise program over 10–20 weeks that included relaxation, and coordination and resistance training of the jaw and neck/shoulders. The outcomes were jaw pain intensity on the Numerical Rating Scale, endurance time for jaw opening and protrusion against resistance and chewing, and effect of pain on daily activities.

Results: After the exercise program, a reduction in jaw pain was reported by the local ($p = .001$) and general ($p = .011$) pain groups. There were no significant differences in jaw pain intensity between the groups, before ($p = .062$) or after treatment ($p = .121$). Endurance time increased for both groups for jaw opening/protrusion (both $p < .001$) and chewing (both $p = .002$). The effect of jaw pain on daily activities decreased after exercise compared to baseline for both the local ($p < .001$) and general ($p = .008$) pain groups.

Conclusions: Supervised exercise can reduce TMD pain and increase capacity in patients with TMD. The results suggest that activation of the jaw motor system with exercise has a positive effect in patients with localized/regional TMD pain and TMD associated with generalized pain.

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Exercise therapy; orofacial pain; resistance training; temporomandibular disorders

Introduction

Pain in the jaw-face region is a common condition in the general population [1,2] with significant impact on the quality of life [3]. Temporomandibular disorders (TMD), characterized by impaired function and pain related to the temporomandibular joint (TMJ) and/or masticatory muscles, is considered the most common cause of chronic orofacial pain [4].

The cause of TMD is conceptualized in a multifactorial and biopsychosocial model [5]. One hypothesis put forward to the onset and maintenance of TMD is the relationship between a load and the capacity of the tissues involved [6]. Biomechanical strain to the tissues can be caused by bruxism or other repetitive loading. In vulnerable individuals, these types of loadings may result in subsequent injury and develop into a condition with pain and dysfunction. In line with this hypothesis is an observed lower resistance to functional load in TMD patients compared to healthy controls [7]. A similar hypothesis for the development of osteoarthrosis of the TMJ has been proposed [8]. Several mechanisms are most likely involved in the spread and development of TMD pain, as well as in other pain conditions. Fibromyalgia (FM) is a condition characterized by widespread pain, low pressure pain thresholds, disturbed sleep and low resistance to load. Signs and symptoms of TMD are commonly observed in FM patients, and a large proportion of TMD pain patients fulfil criteria for FM [9]. In comparison to patients with local TMD pain, patients with TMD pain associated with widespread pain generally have a poorer prognosis and treatment outcome when treated with occlusal splints [10]. With regard to jaw exercises, it is not known if this treatment modality is efficient in patients with TMD pain related to widespread pain [11,12].

The jaw and neck regions have a close sensorimotor integration. Thus, a functional integration has been shown between the jaw and neck regions during normal jaw function in healthy individuals [13,14]. Jaw activities such as jaw opening–closing and chewing include movement of both the mandible and the head and activation of jaw and neck muscles in a task-dependent functional relationship [15]. Furthermore, it has been demonstrated in healthy individuals that this integrated function can be altered by mechanical restriction of head movements [16] as well as by experimentally induced masseter pain [17]. Furthermore, for patients with chronic pain in the jaw and neck regions, an association between pain and disturbed jaw motor function has been suggested [18]. Such findings include reduced amplitude for

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both lower jaw and head–neck movements, disturbed coordination of jaw and head–neck movements, and reduced endurance during chewing [19,20].

Patients with TMD pain report a higher prevalence of pain in the neck region [21,22] and vice versa [23]. In addition to this overlap between pain in the jaw–face and neck regions, a relationship has been demonstrated between orofacial pain and spinal pain [24]. This relationship was shown to be reciprocal in that pain in one region increases the risk of developing pain in the other region [25,26]. In addition to local and regional pain, a proportion of patients with TMD may also develop widespread generalized pain. This spread of pain has been suggested to be related to central sensitization. Some suggested factors associated with a higher risk to develop widespread pain are female gender, pain intensity and duration, catastrophizing and concomitant jaw and neck pain [27,28].

A systematic review of treatment modalities owing to TMD formed the basis for National guidelines for treatments in adults in Sweden. In addition to the scientific evidence of treatment, the review included health economical perspectives and a priority order. The outcome was in favor of behavior-directed treatment modalities, exercise programs and splint therapy. The review also disclosed many gaps of knowledge including exercise programs for TMD pain associated with widespread pain conditions.

The aim of the present study was to evaluate the effect of a structured supervised jaw–neck exercise program in patients with localized and regional TMD pain and TMD associated with generalized pain, respectively. Our hypothesis was that exercise improves jaw function and reduces pain in patients with localized TMD pain but not in patients with TMD associated with generalized pain.

Material and methods

Patients

Consecutive patients with local TMD pain ($n = 56$; 46 women and 10 men, mean age: 44 years, SD 15) and TMD associated with generalized pain ($n = 21$; 21 women, mean age: 41 years, SD 14) referred to the Department of Clinical Oral Physiology, Umeå, Sweden, participated in the study.

Patients were examined by questionnaire and a clinical examination. The clinical examination to determine if patients fulfilled inclusion criteria and group allocation (local or generalized pain) was carried out by TMD specialists at the Department of Clinical Oral Physiology. All examiners had been trained in the RDC/TMD but were not specifically calibrated for the present study.

Inclusion criteria for both groups were:

- Diagnosis of TMD myalgia (Group 1: muscle disorders) according to the RDC/TMD criteria, Axis I [29].
- Ability to understand oral and written Swedish.
- Age ≥16 years.

Patients were allocated to the generalized pain group if they both reported widespread pain and also registered

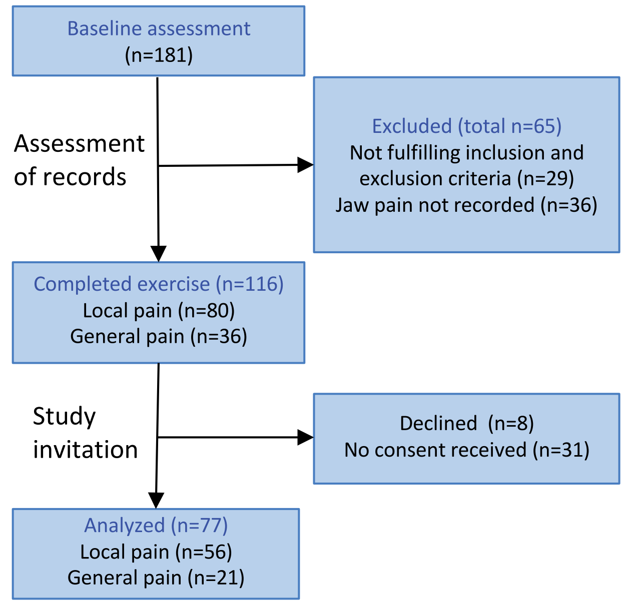

Figure 1. Flowchart of included and excluded patients.

significant palpation pain response (palpebral reflex or withdrawal) to shoulder, lower arm, thumb and calf muscles. The palpation is routine at the department and carried out as an additional procedure in addition to the RDC/TMD examination. Digital palpation was carried out with a pressure of ∼1.5 kg for 2 s. A positive response was registered when the palpation elicits a palpebral reflex in the eye or a protective response at all sites (thumb, underarm and calf muscles).

The local pain group included patients with regional pain in the neck/shoulder/spinal areas but absence of palpation pain response (palpebral reflex or withdrawal) to shoulder, lower arm, thumb and calf muscles. Exclusion criteria for both groups were diagnosis of rheumatic arthritis, neuropathic pain (including trigeminal neuralgia and atypical odontalgia), TMJ fractures, history of TMJ surgery or radiation therapy.

Out of 181 patients examined for eligibility in the study, 65 patients were excluded. The most common reason for exclusion ($n = 36$) was absence at baseline of registered jaw pain intensity level. The remaining 116 patients who participated in the supervised exercise program as part of their treatment were asked after the completion of the treatment for permission to use their clinical data as part of the present study. For all participants, the exercise program and capacity tests were supervised by one specifically trained dental nurse. Written information about the purpose of the study was sent by mail to all patients, together with a consent form. Eight patients declined participation, and a further 31 patients did not return the consent forms (Figure 1). Written consent was obtained from the remaining 77 patients; all individual data were coded before use in the data analyses. The general pain group ($n = 21$) included five patients who reported FM, seven patients with whiplash-associated disorder, three patients with FM and whiplash-associated disorder, and six patients with no additional diagnosis. The study was approved by the Regional Ethical Review Board in

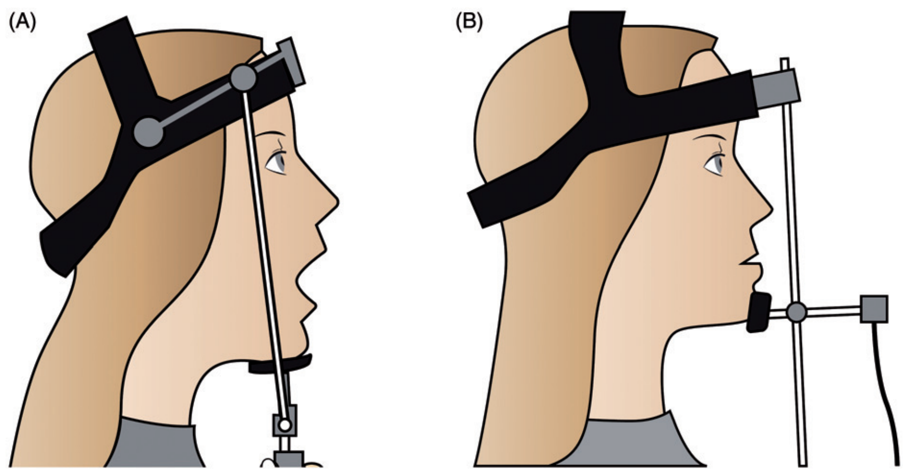

Figure 2. Schematic illustration of the custom-made adjustable helmet with a hydraulic system that provided resistance of 1.6 kg during jaw opening (A), and jaw protrusion (B). Details of this custom-made equipment have been described previously [7].

Umeå, Sweden and carried out in accordance with the Declaration of Helsinki.

Initial capacity test

The initial capacity test consisted of five endurance tests of jaw, neck and shoulder muscles. For all tests, the subjects were instructed to continue the exercise as long as possible but up to a maximum time limit of 5 min. The participants were free to stop at any time.

- Isometric shoulder test: Holding a 2 kg dumbbell in the right hand, with straight arm at a horizontal level.
- Isotonic shoulder test: Repeated lifting of a 2 kg dumbbell, at a pace of one lift per second, straight forward up to a horizontal level and back down with the left arm.
- Isotonic jaw opening with resistance: Repeated jaw opening–closing, at a pace of one cycle per second with the aid of a custom-made adjustable helmet with a hydraulic system that provided resistance of 1.6 kg during jaw opening (Figure 2(A)). Details of this custom-made equipment have been described previously [7].
- Isotonic jaw protrusion with resistance: Repeated jaw protrusion, at a pace of one cycle per second with the aid of a custom-made adjustable helmet with a hydraulic system that provided resistance of 1.6 kg during jaw protrusion (Figure 2(B)).
- Unilateral self-paced chewing test: Subjects received three pieces of chewing gum, 1 g each (V6), and they were allowed to chew the gum pieces for ~30 s to soften them. Subjects were then instructed to select one chewing side and to chew only on that side.

Individualized exercise program

The structured exercise program consisted of 10 supervised 1-h training sessions over a period of ~10–24 weeks (average 4.8 months; SD 2.2), according to the convenience of the patient. The intensity of the program was based on the initial capacity test, but it followed the same structure in all patients with coordination, endurance, and strengthening exercises for the jaw–neck–shoulder region. The program included small jaw opening–closing movements as a warm-up, jaw opening–closing movements coordinated with head–neck extension flexion, jaw stretching, neck coordination exercises, jaw opening and protrusion against resistance, chewing, shoulder lifts, and relaxation. The exercise program was individualized with different loads depending on the outcome of the initial capacity test, and the load was gradually increased over the sessions in the exercise program.

Exercise program (60 min in total)

- Warm-up
  - Heat from infrared lamp to the face (6 min)
  - Paced jaw 'jogging' (~100 beats/minute for 6 min)
- Strength/endurance
  - Suprahyoid muscles: jaw opening against resistance with the aid of a custom-made hydraulic system (Figure 2(A)) with adjustable load up to 1.6 kg (3 min).
  - Lateral pterygoid muscles: jaw protrusion against resistance with the aid of a custom-made hydraulic system (Figure 2(B)) with adjustable load up to 1.6 kg (3 min).
  - Shoulder exercises: Holding dumb bells (1–3 kg) in both hands and performing paced exercises—shoulder lifts with arms down, shoulder lifts with arms bent 90° (flies), lift straight up, straight arm lift at a horizontal level and straight side arm lift (16 min).
- Neck coordination
  - Tracking exercises to target patterns on the wall with laser pointer attached to head frame (14 min) (Figure 3).
- Relaxation
  - Resting in chair with headphones and relaxation audio (12 min).

Outcome measures

After the 10 exercise sessions, a new capacity test, identical to the initial capacity test, was carried out. The data from

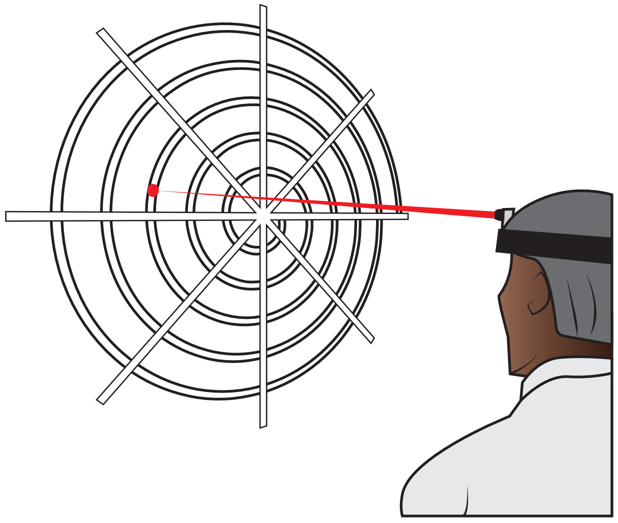

Figure 3. Schematic illustration of neck tracking exercises to target pattern on the wall with laser pointer attached to the head frame.

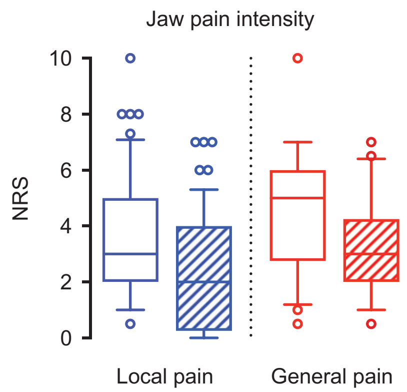

Figure 4. Jaw pain intensity (median, quartiles, 90%, 10% and outliers) rated on the NRS for the local ($n = 56$) and general ($n = 21$) pain groups before (unfilled boxes) and after (hatched boxes) exercise.

these two capacity tests provided the data analyzed in the present study.

At baseline and after the exercise program, a short questionnaire was filled out that included ratings of pain in the jaw, neck/shoulder and spinal regions once a week or more. The primary outcome was jaw pain intensity rated on the Numerical Rating Scale (NRS) with the endpoints 'no pain' (0), and 'worst possible pain imaginable' (10). Secondary outcomes from the capacity test were change in endurance times during jaw opening and protrusion against resistance, chewing, and shoulder lifts. The effect from jaw pain and dysfunction on the activities of daily living was assessed on a 7-point rating scale: 0 = No; 1 = Yes, but very little; 2 = Yes, to a certain degree; 3 = Yes, quite a bit; 4 = Yes, definitely; 5 = Yes, to a very high degree; 6 = Yes, totally handicapped due to the symptoms.

Statistics

Differences before and after exercise were tested with Wilcoxon matched pairs test and differences between the local and general pain groups with Mann–Whitney U-test. A level of <.05 was considered significant.

Results

Pain intensity

Both the local and general pain groups reported a reduction in jaw pain after the exercise program ($p = .001$ and $p = .011$, respectively). There were no significant differences in jaw pain intensity between the local and general pain group before (NRS 3.0 versus 5.0; $p = .062$) or after the exercise program (NRS 2.0 versus 3.0; $p = .121$). At the follow-up 12 patients in the local pain group reported no pain (NRS = 0) (Figure 4).

Endurance

After the exercise program was completed, a significant increase in the endurance time for both groups for jaw opening, jaw protrusion (both $p < .001$), and chewing (both $p = .002$) was observed. At baseline, the general pain patients had lower endurance than the local pain group for both jaw opening ($p < .001$), jaw protrusion ($p = .021$) and chewing ($p = .006$). After the exercise program, there was no difference between the local and general pain groups for jaw opening ($p = .24$), jaw protrusion ($p = .68$) or chewing ($p = .52$) (Figure 5).

Daily activities

The influence on daily activities from jaw pain and dysfunction decreased significantly after exercise compared to baseline for both the local ($p < .001$) and general ($p = .008$) pain groups. There were no differences between the general and local pain groups before ($p = .28$) or after ($p = .57$) exercise (Figure 6).

Discussion

The main finding of the present study was that a structured and supervised exercise program reduced jaw pain and increased capacity of jaw muscles to endure physical load in patients with localized and regional TMD pain as well as in patients with TMD pain in combination with generalized pain.

Physical exercise may have both local and general effects, such as improved mobility, increased blood flow, muscle strength and endurance, and reduced pain. Available evidence indicates that physical activity and exercise have few adverse effects, and that such interventions can reduce pain and improve physical function and thereby also improve a patient's quality of life [30]. Exercise has therefore been promoted as a promising treatment strategy for musculoskeletal conditions, including TMD, but the supporting evidence is ambiguous. Exercise therapy is, however, commonly used often as part of comprehensive treatment regimens for TMD. Jaw exercise programs are often combined with manual therapy or other therapies, which can make it difficult to evaluate the effect of the exercise treatment alone. In a recent systematic review, Armijo-Olivo et al. [11] suggested that a positive treatment outcome, with few adverse effects from postural

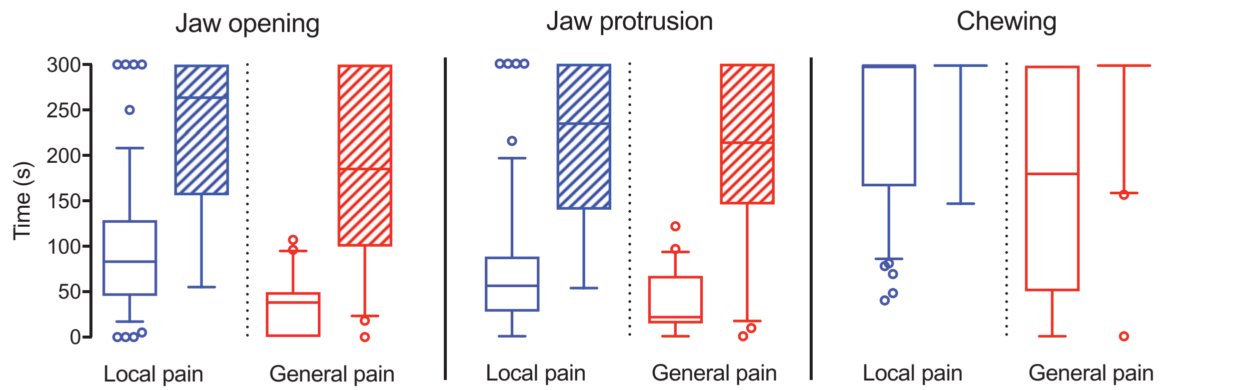

Figure 5. Endurance time (median, quartiles, 90%, 10% and outliers) for the local ($n = 56$) and general ($n = 21$) pain groups before (unfilled boxes) and after (hatched boxes) exercise for jaw opening, jaw protrusion and chewing. Data is missing for chewing after exercise for one individual in the general pain group.

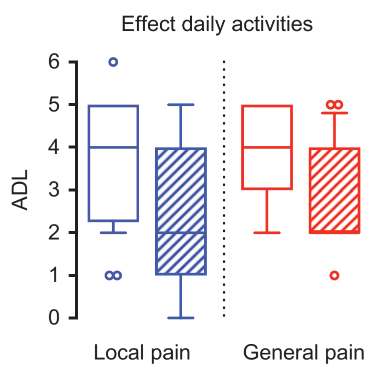

Figure 6. The effect from jaw pain and dysfunction (median, quartiles, 90%, 10% and outliers) on daily activities (ADL) for the local ($n = 56$) and general ($n = 21$) pain groups before (unfilled boxes) and after (hatched boxes) exercise.

exercise and jaw exercise was proposed, but also concluded that there is still great uncertainty about the effectiveness of exercise therapy for TMD. However, most of the included exercise programs were not supervised; therefore, it is also difficult to evaluate patient adherence to the programs.

Pain can be a cause of a disturbed neuromuscular control also for the jaw–neck motor system. We previously demonstrated an integration between the jaw and neck sensorimotor systems regarding normal function in healthy individuals [13], association between pain and disturbed jaw–neck function after whiplash trauma [18], as well as comorbidity and reciprocal influence between pain in the jaw and neck regions [25,26]. During jaw function, the neck muscles co-activate [15], and it is possible that impaired function of neck/shoulder muscles may lead to effects also on the masticatory system. The present exercise program was based on co-activation of jaw and neck muscles in order to improve co-ordination, strength and overall function. A well-coordinated jaw–neck muscle system can optimize the execution of jaw and neck movements in an efficient and energy-saving manner to avoid fatigue. This can be of special importance for individuals with impaired functional capacity with regard to force and endurance since a low capacity may increase the risk for developing pain and dysfunction [7]. Taken together, since there is a close sensorimotor relationship between the jaw and neck regions, it may be beneficial to include exercises also for the neck/shoulder region in exercise programs for patients with TMD.

One difference between localized TMD pain and TMD associated with generalized pain is that the prognosis for the outcome of any treatment option is more guarded for patients with widespread pain. Central sensitization is one of the mechanisms likely involved in the spread and maintenance of widespread pain [31]. Furthermore, there is support, both in experimental [32,33] and clinical [26] studies of spread and referral of muscle pain between the cervical and trigeminal regions. Patients with widespread pain typically display lower pressure pain thresholds, disturbed sleep and low resistance to load. Patients with TMD associated with generalized pain have a poorer outcome when treated with occlusal splints compared to local TMD pain patients [10]. Therefore, the results from the present study of significant improvement for both the local and general pain groups were promising and indicate that the jaw muscles have a readiness to respond to the physical demands.

Chronic pain is a major factor in personal suffering and societal costs and can lead to lower quality of life and work ability [34]. One reason for this is the psychosocial consequences that the widespread pain conditions may incur. Pain can, among other things, induce rumination, avoidance behavior and fear of movement [35]. Catastrophizing has been associated with both the risk of onset of TMD pain and progression of chronic TMD pain [36,37]. Furthermore, chronic pain often results in depression and anxiety, which can maintain and perpetuate pain and dysfunction [34,38]. Another possible contributing factor to perpetuation of pain and disability may be a lack of self-efficacy leading to avoidance of activities believed to inflict further harm. Such avoidance may in turn lead to disuse, loss of muscle coordination and development of faulty movement patterns, which will further reduce functional capacity. Reduced endurance to jaw motor tasks has been shown for patients with TMD compared to healthy subjects during chewing [20,39,40] as well as for specific jaw–neck exercises that involve demand and resistance [7]. Best practice to handle pain-related catastrophic worry has been identified as a field for future research. One related hypothesis is that exposing individuals to the factor that causes the fear avoidance, e.g. pain that is amplified during jaw movements, may increase the chances of recovery [35]. The use of exercise programs to treat patients with chronic pain has shown promising results [35], which is in accordance with the results from the present study. In clinical practice, the decision making process with regard to choice of treatment must include effectiveness, risk of side effects, patient values and costs. With regard to treatment strategies for patients with TMD, reversible treatment has been advocated, as opposed to irreversible treatment options. In this context, self-management, manual therapy, posture training and jaw exercises have been suggested since these treatment regimens have low costs and low risks of side effects. Jaw exercise therapy can either be done as part of a home-care program [12], or as in the present study in a clinical setting. The advantage with the clinical setting, although being more costly compared to home-exercises, is that the supervision of an exercise program may improve adherence to the program. Furthermore, the supervision can provide support and encourage activity in order to reduce fear of movement and avoidance behavior, which may in turn improve self-efficacy.

In the present study, the positive treatment effect may in part be explained by the emotional support and encouragement that a supervised exercise program can provide. Furthermore, the study did not include a true control group as both the local and general pain groups carried out the exercise program. Even so, our finding of a clear effect from the exercise program in both groups, indicate that exercise therapy can have a positive effect also in patients with TMD associated with generalized pain.

Conclusions

The results indicate that exercise can reduce pain and increase jaw muscles capacity in patients with TMD. Although the group with generalized pain had more pain and an overall lower endurance to functional load than the local/regional pain group before the exercise program, a significant improvement was found in both groups, and no significant difference in pain or capacity was found after treatment. These findings suggest that activation of the jaw motor system with exercise has a positive effect in patients with localized TMD pain as well as in TMD associated with generalized pain

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Disclosure statement

No potential conflict of interest was reported by the authors.

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