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The Journal of Craniomandibular & Sleep Practice



ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/ycra20

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To cite this article: Ezgi Hatice Abaci, Aysenur Tuncer & Abidin Hakan Tuncer (18 Apr 2025): Effectiveness of telerehabilitation-supported exercises in patients with temporomandibular disorders with probable sleep bruxism during the COVID-19 pandemic: A randomized controlled trial, CRANIO®, DOI: [10.1080/08869634.2025.2493365](https://doi.org/10.1080/08869634.2025.2493365)

To link to this article: <https://doi.org/10.1080/08869634.2025.2493365>



Published online: 18 Apr 2025.



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RESEARCH ARTICLE



Effectiveness of telerehabilitation-supported exercises in patients with temporomandibular disorders with probable sleep bruxism during the COVID-19 pandemic: A randomized controlled trial

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ABSTRACT

Objective: This study evaluated telerehabilitation-supported exercises' effects on pain, neck disability, anxiety, oral behaviors, and sleep quality in patients with Temporomandibular Disorders associated with probable sleep bruxism (TMDs-SB).

Methods: During the COVID-19 pandemic (March 2021–May 2022), 40 patients aged 18–65 with TMDs-SB were randomized to a telerehabilitation ($n = 20$) or home exercise ($n = 20$) groups. Both received education and exercises; the telerehabilitation group supervised 30-minute weekly WhatsApp video sessions for eight weeks. Outcomes were assessed at baseline and eight weeks.

Results: Both groups improved significantly in all outcomes from baseline to eight-week follow-up ($p < .05$). Telerehabilitation showed greater reductions in morning jaw pain ($p = .012$), neck disability ($p = .032$), trait anxiety ($p = .028$), and oral behaviors ($p = .001$) versus home exercises. Sleep quality improved similarly in both groups ($p = .154$).

Conclusions: Telerehabilitation effectively reduced TMDs-SB symptoms, offering a promising alternative to unsupervised exercises during the pandemic. Given this unique context, conducting studies outside the pandemic's conditions would enhance generalizability and clarify telerehabilitation's potential. Further studies are needed to confirm its efficacy beyond pandemic conditions.

KEYWORDS

Telerehabilitation; temporomandibular disorder; bruxism; exercise; COVID-19 pandemic

Introduction

Temporomandibular disorders (TMDs) are multifactorial biopsychosocial conditions affecting the masticatory muscles, temporomandibular joint, and related structures, with pain (e.g., myalgia, arthralgia, myofascial pain, and TMD-related headaches) being the most common symptom [1]. Their etiology spans traumatic, anatomical, pathophysiological, and psychosocial domains [2–4]. Psychosocial factors, such as stress-induced teeth clenching or grinding, are prominent, with depression and somatization prevalent in chronic cases [5], and jaw morphology variations potentially contributing [6]. Genetic predispositions also play a role, as identified in the OPPERA study [2], though anatomical influences remain under debate [3]. Globally, TMD prevalence is estimated at 31% in adults and 11% in children [7], while in Türkiye, 47.5% of students exhibit symptoms, with females more affected [8]. Sleep bruxism (SB), defined as masticatory muscle activity during sleep, distinct from movement or sleep disorders in healthy individuals [9,10], exacerbates TMD symptoms [11]. It is

associated with jaw dysfunction, neck disability, and poor sleep quality [11].

The COVID-19 pandemic significantly increased TMD and SB prevalence across adults and children, driven by heightened psychosocial stress and disrupted routines [12–18]. Studies report worsened psychological status, chronic facial pain, and oral parafunctional behaviors during this period [17], underscoring the need for accessible management strategies when traditional healthcare delivery was limited.

Telerehabilitation, a remote rehabilitation approach often delivered via video calls, emerged as a viable alternative during the pandemic, enhancing patient monitoring, education, and follow-up while reducing costs [19]. Systematic reviews affirm its efficacy in managing chronic musculoskeletal conditions (e.g., back pain, neck pain, osteoarthritis) and post-surgical rehabilitation (hip, knee, and shoulder arthroplasty) with outcomes comparable to conventional physiotherapy [20–22]. A recent review suggests that real-time telerehabilitation positively impacts attendance at treatment

appointments and adherence to exercise programs, resulting in similar satisfaction compared to conventional face-to-face physiotherapy [23].

Current TMD-SB treatment prioritizes non-invasive methods, such as exercises, over invasive interventions [24,25]. Early intervention and regular patient participation are crucial in preventing chronic pain. The pandemic highlighted barriers to in-person care, such as distance and restricted access, which can exacerbate chronic pain and psychosocial issues in TMD patients [12–14]. In recent years, there has been a growing demand for telerehabilitation services in managing TMDs. However, exercise programs for TMD patients are often unsupervised and infrequently studied [26–29], with no prior research specifically addressing telerehabilitation in TMDs-SB. Therefore, this study evaluated a supervised telerehabilitation exercise program versus an unsupervised home exercise program, assessing its effects on pain, neck dysfunction, anxiety, oral behaviors, and sleep quality in TMDs-SB patients. We hypothesized that real-time guidance would improve outcomes compared with unsupervised exercises, advancing TMD-SB management during and beyond the pandemic.

Materials and methods

Study design and participants

This randomized controlled trial was approved by the Hasan Kalyoncu University Faculty of Health Sciences Non-Interventional Research Ethics Committee (no: 2021/012) and registered with the WHO International Clinical Trials Registry Platform (NCT04884152). Conducted in Türkiye between March 2021 and May 2022 during the COVID-19 pandemic, the study evaluated patients at the Ankara University Faculty of Dentistry with institutional approval. All procedures adhered to the World Medical Association Declaration of Helsinki, and participants provided written and oral informed consent.

TMD diagnosis followed the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) Axis I protocol [30], performed by a dentist trained in this standard. Inclusion criteria were: (1) age 18–65; (2) TMD diagnosis per DC/TMD with probable sleep bruxism (SB) based on patient history and clinical evaluation [9]; (3) jaw, face, temporal, or ear pain for ≥ 3 months, with masticatory muscle pain on palpation; (4) Visual Analog Scale (VAS) pain score ≥ 3 ; (5) no medical treatment in the prior 3 months and none planned during the study; and (6) access to internet and WhatsApp. Probable sleep bruxism (SB) was diagnosed by the

dentist evaluating TMD, based on the patient's history and a clinical assessment. This included regular or frequent teeth-grinding sounds during sleep and at least one clinical sign (e.g., jaw muscle pain or fatigue upon waking, temporal headaches, masseter hypertrophy, abnormal tooth wear, or jaw locking) [9]. Exclusion criteria included disc displacement or joint degeneration, ongoing orthodontic/splint therapy, regular analgesic/anti-inflammatory use, systemic diseases, pregnancy/breastfeeding, history of TMJ/neck surgery or trauma (e.g., whiplash, condylar fracture), alcohol/substance abuse, TMJ treatment in the past 3 months, or inability to cooperate due to language barriers, cultural differences, or cognitive impairments. Eligible patients with TMD-related pain (e.g., myalgia, myofascial pain, TMD-related headache) were referred to a physiotherapist (E.H.A.) with 10 years of TMD expertise for treatment.

Sample size was calculated to detect a 0.24 effect size for key outcomes (pain, sleep quality, anxiety), derived from meta-analyses of exercise interventions in musculoskeletal disorders [20], using G*Power 3.1.9.6 with 90% power and 5% error level [31], requiring at least 40 participants (20 per group). Of 75 patients assessed, 15 did not meet inclusion criteria, and 10 declined participation. The remaining 50 were randomized using opaque, sequentially numbered envelopes generated by a computer-based system to ensure allocation concealment. The telerehabilitation group (experimental) received supervised exercises, while the home exercise group (control) performed unsupervised exercises. Five patients dropped out per group: in the telerehabilitation group, three withdrew after contracting COVID-19, and two discontinued due to internet connectivity. Similarly, five patients dropped out from the home exercise group. Two were unable to adhere to the program regularly, two requested withdrawal due to a lack of motivation, and one moved to another city and was unable to attend the final follow-up evaluation, resulting in exclusion from the study (see Figure 1 - Study Flowchart). Ultimately, 20 patients per group completed the 8-week intervention and were analyzed.

Measures and instruments

All measurements were conducted by physiotherapist E. H.A. at baseline and 8 weeks. Pain was assessed using the Visual Analog Scale (VAS), a 10 cm line with extremes of “no pain” (0) to “worst pain” (10) [32]. Patients reported six pain types: morning jaw pain, morning headache, chewing pain, daytime jaw pain, nighttime jaw pain, and neck pain. The Cronbach's alpha value was 0.82 [33]. The Minimal Detectable

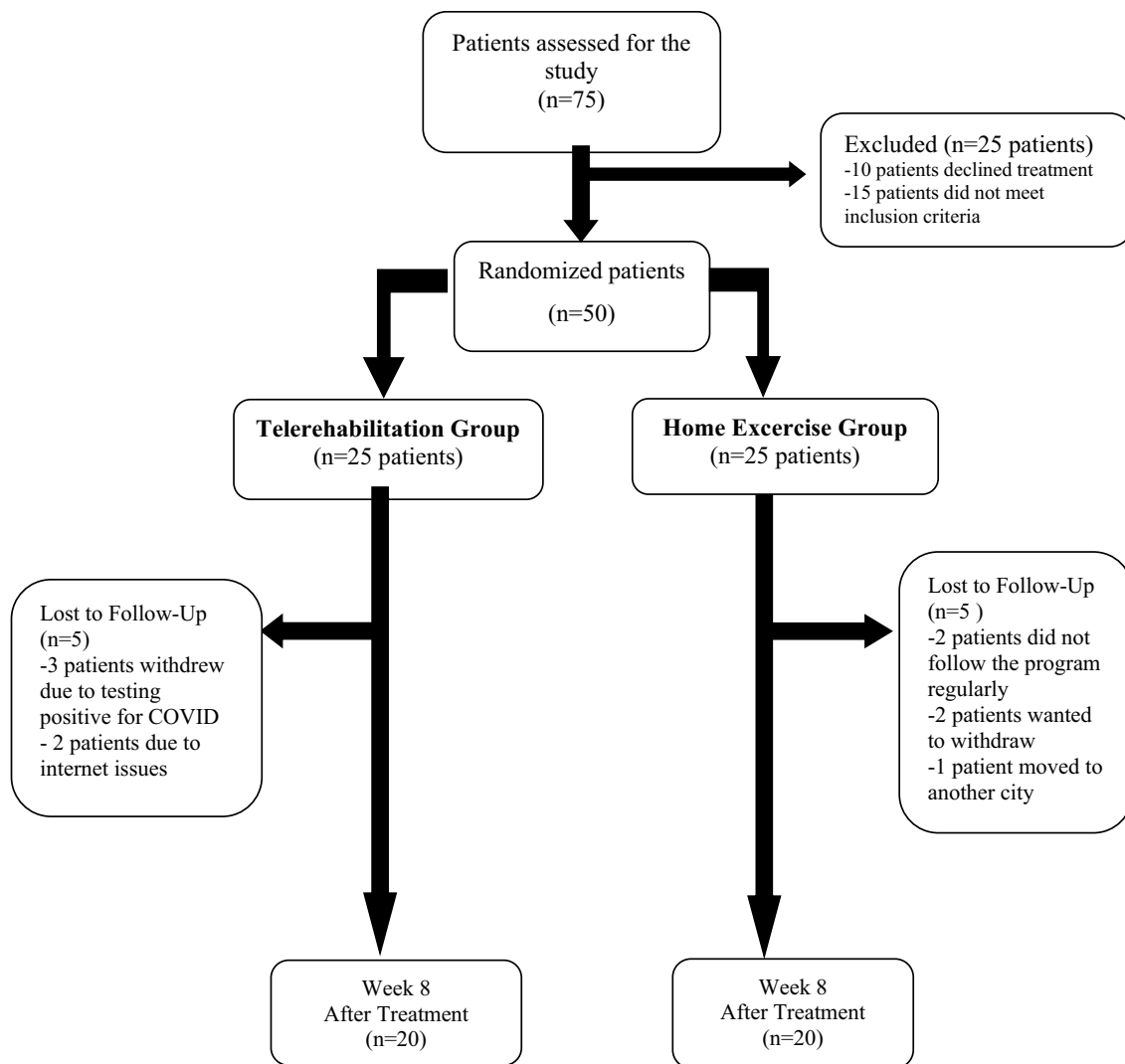


Figure 1. Study consort flowchart.

Change (MDC) = 0.08, and the Intraclass Correlation Coefficient (ICC) was 0.97 [34].

Maximum mouth opening (MMO) was measured in millimeters using a ruler for inter-incisal distance, with patients opening their mouths as wide as possible without pain [35]. Craniovertebral angle (CVA) assessed head posture with a goniometer, measuring the angle between the seventh cervical vertebra, tragus, and horizontal plane. A CVA of less than 48° was considered indicative of forward head posture [36]. The ICC ranged from 0.86 to 0.94 [37].

The frequency of oral behaviors was evaluated using the Oral Behavior Checklist (OBC), a 21-item questionnaire where patients rate the frequency of their complaints. Total scores range from 0 to 84, with higher scores indicating poorer oral habits [38]. Cronbach's α has been reported as 0.86, and the ICC = 0.91 [39]. Neck disability was measured using the Neck Disability Index (NDI), a 10-section scale comprising 10 sections with

a total score ranging from 0 to 50. Higher scores indicate greater disability [40]. Cronbach's α values range from 0.72–0.93; ICC = 0.68–0.93, and the MDC ranges from 5 to 10 points on a 50-point scale, suggesting that a change of 10% to 20% is necessary to exceed measurement error [41]. Anxiety was assessed with the State-Trait Anxiety Inventory (STAI), comprising State (S-Anxiety) and Trait (T-Anxiety) scales, each with 20 items rated on a 1–4 scale, covering worry, tension, anxiety, and nervousness. Total scores range from 20 to 80, with higher scores indicating greater anxiety [42]. Cronbach's α coefficients for both scales range from 0.86 to 0.95, and S-Anxiety ICC = 0.16–0.62; T-Anxiety ICC = 0.73–0.86 [43]. Sleep quality was evaluated using the Pittsburgh Sleep Quality Index (PSQI), with 24 items, 19 self-rated by the patient and 5 rated by a partner or roommate. Total scores range from 0 to 21, with higher scores indicating worse sleep quality. Sleep quality is classified as good (0–5 points) or poor

(6–21 points), with a score of ≥ 5 indicating poor sleep quality [44]. Cronbach's α values range from 0.70–0.83 [45], and ICC values range from 0.76–0.87 [46].

Procedures

Both groups received pre-treatment education on TMD, SB, and parafunctional behaviors from physiotherapist E.H.A., including instructions to avoid hard foods, unilateral chewing, and poor posture. Exercises were initially demonstrated face-to-face, and brochures were provided. The home exercise program group performed exercises three times weekly for eight weeks. Participants were contacted weekly by phone to assess adherence, with reminders provided to encourage consistency and feedback collected on motivation levels and challenges encountered. The telerehabilitation group, in addition to the home exercise program, received 30-minute one-on-one WhatsApp video sessions weekly. During these sessions, physiotherapist E.H.A. provided real-time monitoring and feedback, evaluated adherence, and supplemented the home exercise protocol.

Exercise program

The exercise regime, grounded in evidence-based TMD management [13], included:

- (1) *Tongue and Mandibular Resting Position*: The resting position of the tongue and mandible is crucial for maintaining orofacial function, preventing dental and musculoskeletal issues, and supporting airway health [47,48]. The ideal tongue resting position involves the tip gently touching the incisive papilla behind the upper front teeth (Fig. 2) with the dorsum against the hard palate, supporting maxillofacial development and stabilizing the dental arch. The mandible's resting position should maintain an interocclusal space of 1–3 mm between the upper and lower teeth, with lips gently closed without tension. This position minimizes strain on the TMJ and

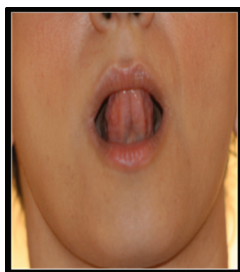


Figure 2. Tongue resting position.

associated muscles, reducing pain and dysfunction.

- (2) *Diaphragmatic Breathing Exercises*: Diaphragmatic breathing, also known as abdominal breathing (Fig. 3), enhances oxygenation, reduces muscle tension, promotes relaxation, and improves postural stability [49]. By activating the diaphragm, minimizing fatigue and shortness of breath. It also stimulates the vagus nerve, activating the parasympathetic nervous system and reducing sympathetic overactivity, aiding in the management of stress, anxiety, and autonomic dysfunction [50]. Diaphragmatic breathing alleviates bruxism by reducing masticatory muscle tension [51].
- (3) *Relaxation Exercises*: Chronic stress and excessive sympathetic activity are linked to hypertension, TMDs, bruxism, chronic pain, insomnia, and anxiety [14–16]. Relaxation exercises activate the parasympathetic nervous system, enhance neuromuscular relaxation, improve cognitive clarity, and support emotional regulation [52]. They are effective in managing TMD, headaches, neck pain, myofascial pain syndrome [53].
- (4) *Stretching Exercises*: Stretching exercises targeting the masticatory and cervical muscles (Fig. 4) maintain orofacial mobility, reduce musculoskeletal pain, and improve posture and function. Proper postural alignment supports respiratory efficiency by enhancing head, neck, and spinal alignment [54]. These exercises reduce myofascial trigger points contributing to pain and dysfunction, alleviating tightness and discomfort associated with TMD, bruxism, cervical tension, and postural syndromes [55].
- (5) *Head Posture Correction (Chin-tuck) and General Postural Exercises*: Forward Head Posture (FHP) increases the load on cervical vertebrae [56] and contributes to cervicogenic headaches, neck pain,



Figure 3. Diaphragmatic breathing exercises.

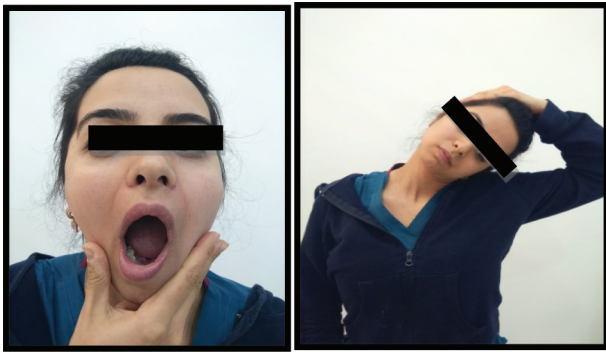


Figure 4. Stretching exercises for masticatory and cervical muscles.



Figure 5. Head posture correction (chin-tuck) exercise.

and TMD [57]. Head posture correction exercises, particularly the chin-tuck (Fig 5), address FHP, cervical strain, TMD, and musculoskeletal imbalances [58]. By promoting natural alignment of the head, neck, and spine, these exercises reduce muscle tension and establish muscular balance, effectively managing TMD.

Data analysis

Data analysis was performed using SPSS 26.0 (Statistical Package for Social Sciences, Chicago, IL, USA) program, with a 95% confidence level. Descriptive statistics, including the mean (M), standard deviation (SD), and medians, were calculated for the measurements. As each group contained fewer than 30 patients, non-parametric tests were employed. The Mann-Whitney U test was used for between-group comparisons, and the Wilcoxon signed-rank test was applied for within-group comparisons over time. For categorical variables, the Chi-square test was used to analyze relationships between groups. The Cochran Q test compared proportions across initial

and final assessments, and the McNemar test was used for within-group comparisons over time. The Bonferroni correction was applied to control Type I errors in multiple comparisons. Statistical significance was set at $p < .05$ [59]

Results

Baseline demographic and clinical characteristics of the 40 patients who completed the study are presented in Table 1. The sample was predominantly female (90%, $n = 36$), with a mean age of 25.85 ± 5.27 years in the home exercise group and 29.95 ± 9.34 years in the telerehabilitation group. No significant differences were found in age ($p = .179$), gender ($p = .605$), marital status ($p = .999$), education level ($p = .651$), or clinical characteristics (e.g., tinnitus, $p = .320$; neck pain, $p = .527$) between groups.

Pain outcomes, assessed via the VAS, are detailed in Table 2. After treatment, both groups showed significant reductions in all pain measures from baseline to 8 weeks ($p < .001$). The telerehabilitation group exhibited greater improvements in morning jaw pain ($p = .012$, $r = 0.396$, 95% CI: -3.6 to -0.6), morning headache ($p = .040$, $r = 0.325$, 95% CI: -2.9 to -0.1), and neck pain ($p = .001$, $r = 0.602$, 95% CI: -2.8 to -0.8) compared to the home exercise group. These reductions exceeded the VAS MDC of 0.08 [36], indicating clinically meaningful pain relief. No significant between-group differences emerged for chewing pain ($p = .063$) or daytime jaw pain ($p = .101$).

Maximum mouth opening and head posture outcomes are shown in Table 3. MMO (home exercise and telerehabilitation both $p = .000$) and CVA (home exercise $p = .002$, and telerehabilitation $p = .000$) improved significantly in both groups after treatment. The telerehabilitation group demonstrated larger gains in MMO ($p = .003$, $r = 0.476$, 95% CI: 2.1 to 6.3 mm) and CVA ($p = .001$, $r = 0.490$, 95% CI: 2.2 to 6.4°) compared to the home exercise group, reflecting enhanced jaw function and posture correction.

Table 4 presents neck disability, anxiety, oral behaviors, and sleep quality outcomes. Both groups improved significantly after treatment across all measures ($p < .05$). The telerehabilitation group outperformed the home exercise group in NDI ($p = .032$, $r = 0.339$, 95% CI: -5.6 to -0.3), STAI-T ($p = .028$, $r = 0.347$, 95% CI: -4.8 to -0.2), and OBC ($p = .001$, $r = 0.712$, 95% CI: -16.8 to -7.2), with changes exceeding the MDC 5–10 for NDI [43], and indicating substantial clinical improvement. No significant between-group differences were observed for STAI-S ($p = .290$) or PSQI ($p = .154$).

Table 1. Demographic information and clinical characteristics of patients.

| | | HE Group | TR Group | p |
|-----------------------------------------------|-------------------|-----------------------|-----------------------|--------------------|
| Age X±SD | | 25,85 ± 5,27 n (%) | 29,95 ± 9,34 n (%) | 0,179 ^a |
| Gender | Female | 19 (95) | 17 (85) | 0,605 ^b |
| | Male | 1 (5) | 3 (15) | |
| Marital Status | Married | 6 (30) | 7 (35) | 0,999 ^b |
| | Single | 14 (70) | 13 (65) | |
| Education Level | High School | 6 (30) | 5 (25) | 0,651 ^b |
| | Associate Degree | 3 (15) | 2 (10) | |
| | Bachelor's Degree | 9 (45) | 8 (40) | |
| | Master's Degree | 2 (10) | 5 (25) | |
| Clinical Characteristics History of Trauma | Positive | 0 (0) | 0 (0) | |
| | Negative | 20 (100) | 20 (100) | |
| Surgical History | Positive | 0 (0) | 0 (0) | |
| | Negative | 20 (100) | 20 (100) | |
| Allergy | Positive | 3 (15) | 8 (40) | 0,157 ^b |
| | Negative | 17 (85) | 12 (60) | |
| Unilateral Chewing | Right | 6 (30) | 6 (30) | 0,999 ^b |
| | Left | 1 (5) | 2 (10) | |
| | Bilateral | 13 (65) | 12 (60) | |
| Tinnitus | Positive | 9 (45) | 5 (25) | 0,320 ^b |
| | Negative | 11 (55) | 15 (75) | |
| Ear Pain | Positive | 8 (40) | 12 (60) | 0,343 ^b |
| | Negative | 12 (60) | 8 (40) | |
| Neck Pain | Positive | 12 (60) | 9 (45) | 0,527 ^b |
| | Negative | 8 (40) | 11 (55) | |
| Headache | Positive | 17 (85) | 19 (95) | 0,605 ^b |
| | Negative | 3 (15) | 1 (5) | |
| Dizziness | Positive | 6 (30) | 6 (30) | 0,999 ^b |
| | Negative | 14 (70) | 14 (70) | |
| Difficulty Swallowing | Positive | 2 (10) | 6 (30) | 0,235 ^b |
| | Negative | 18 (90) | 14 (70) | |

* $p < 0,05$; X: Mean; SD: Standard Deviation; HE: Home Exercise Group; TR: Telerehabilitation Group n: Number of People; ^ap: Mann Whitney test; ^bp: Chi-Square test.

Table 2. Comparison of patients' pain scores within and between groups.

| VAS (0–10 cm) | Groups | Before Treatment (X±SD) | After Treatment (X±SD) | p ^a | Effect Size (r) | p ^b | Effect Size (r) |
|-------------------------|--------|-------------------------|------------------------|----------------|---------------------|----------------|---------------------|
| Morning Jaw Pain | HE | 5.40 ± 2.01 | 3.00 ± 1.95 | 0.000* | 0.733–0.955 (0.887) | 0.355 | 0.086–0.706 (0.396) |
| | TR | 6.20 ± 1.94 | 1.60 ± 1.14 | 0.000* | 0.631–0.935 (0.839) | 0.012* | |
| Morning Headache | HE | 4.90 ± 2.67 | 2.60 ± 2.23 | 0.000* | 0.591–0.926 (0.819) | 0.723 | 0.015–0.635 (0.325) |
| | TR | 4.55 ± 2.67 | 1.15 ± 1.18 | 0.000* | 0.584–0.924 (0.815) | 0.040* | |
| Pain While Chewing | HE | 4.60 ± 2.87 | 2.45 ± 1.88 | 0.000* | 0.692–0.947 (0.869) | 0.368 | |
| | TR | 5.30 ± 2.30 | 1.35 ± 1.14 | 0.000* | 0.725–0.953 (0.880) | 0.063 | |
| Jaw Pain During the Day | HE | 4.15 ± 2.28 | 2.10 ± 1.65 | 0.000* | 0.673–0.943 (0.857) | 0.279 | |
| | TR | 5.00 ± 1.62 | 1.20 ± 0.77 | 0.000* | 0.671–0.942 (0.856) | 0.101 | |
| Neck Pain | HE | 6.25 ± 2.00 | 3.70 ± 1.49 | 0.000* | 0.725–0.953 (0.880) | 0.164 | 0.292–0.912 (0.602) |
| | TR | 5.45 ± 2.26 | 1.75 ± 1.29 | 0.000* | 0.677–0.944 (0.859) | 0.000* | |

* $p < .05$; VAS: Visual Analog Scale; HE: Home Exercise Group; TR: Telerehabilitation Group; cm: Centimeter; X: Mean; SD: Standard Deviation; ^aWilcoxon test; ^bMann-Whitney test; Effect size: 95% CI.

Table 3. Comparison of patients' maximum mouth opening and craniovertebral angle values within and between groups.

| Measure | Groups | Before Treatment (X±SD) | After Treatment (X±SD) | p ^a | Effect Size (r) | p ^b | Effect Size (r) |
|----------|--------|-------------------------|------------------------|----------------|---------------------|----------------|---------------------|
| MMO (mm) | HE | 36.00 ± 5.30 | 41.80 ± 4.60 | 0.000* | 0.695–0.948 (0.870) | 0.405 | 0.166–0.786 (0.476) |
| | TR | 37.60 ± 6.20 | 47.00 ± 5.10 | 0.000* | 0.369–0.871 (0.797) | 0.003* | |
| CVA (°) | HE | 45.80 ± 5.49 | 50.05 ± 2.80 | 0.002* | 0.718–0.952 (0.781) | 0.645 | 0.180–0.800 (0.490) |
| | TR | 44.25 ± 4.88 | 53.55 ± 4.55 | 0.000* | 0.631–0.935 (0.839) | 0.001* | |

* $p < .05$; X: Mean; SD: Standard Deviation; HE: Home Exercise Group; TR: Telerehabilitation Group; MMO:Maximum Mouth Opening; CVA: Craniovertebral Angle; ^aWilcoxon test; ^bMann-Whitney test; mm:Millimeter; Effect size: 95% CI.

Table 4. Comparison of patients' oral habits, neck disability, anxiety, and sleep quality values within and between groups.

| Measure | Groups | Before Treatment (X±SD) | After Treatment (X±SD) | p ^a | Effect Size | | Effect Size (r) |
|---------|--------|-------------------------|------------------------|----------------|---------------------|----------------|---------------------|
| | | | | | (r) | p ^b | |
| NDI | HE | 13.40 ± 7.29 | 8.35 ± 5.68 | 0.000* | 0.572–0.922 (0.810) | 0.587 | 0.030–0.649 (0.339) |
| | TR | 14.10 ± 5.52 | 4.95 ± 2.56 | 0.000* | 0.079–0.774 (0.504) | 0.032* | |
| STAI-S | HE | 41.55 ± 9.68 | 36.05 ± 6.27 | 0.024* | 0.174–0.810 (0.572) | 0.330 | |
| | TR | 39.20 ± 9.15 | 30.75 ± 7.60 | 0.000* | 0.642–0.937 (0.844) | 0.290 | |
| STAI-T | HE | 46.95 ± 10.86 | 43.00 ± 8.74 | 0.010* | 0.632–0.935 (0.840) | 0.050 | 0.037–0.657 (0.347) |
| | TR | 44.75 ± 9.22 | 38.35 ± 9.24 | 0.001* | 0.712–0.951 (0.878) | 0.028* | |
| OBC | HE | 38.50 ± 7.94 | 31.30 ± 6.60 | 0.000* | 0.584–0.925 (0.816) | 0.978 | 0.402–0.902 (0.712) |
| | TR | 38.60 ± 11.94 | 18.25 ± 6.39 | 0.000* | 0.487–0.902 (0.765) | 0.000* | |
| PSQI | HE | 9.45 ± 4.42 | 5.95 ± 3.68 | 0.000* | 0.710–0.951 (0.877) | 0.471 | |
| | TR | 8.90 ± 4.77 | 4.80 ± 2.84 | 0.000* | 0.717–0.952 (0.880) | 0.154 | |

*p < .05; X: Mean; SD: Standard Deviation; NDI: Neck Disability Index; STAI-S: State-Anxiety Inventory; STAI-T: Trait Anxiety Inventory; OBC: Oral Behavior Checklist; PSQI: Pittsburgh Sleep Quality Index; ^aWilcoxon test; ^bMann-Whitney test; Effect size: 95% CI.

Discussion

This study compared the effectiveness of telerehabilitation-supported supervised exercises versus unsupervised home exercise programs in patients with TMDs-SB, targeting pain, neck disability, anxiety, oral behaviors, and sleep quality. Conducted during the COVID-19 pandemic, it addressed a gap in the literature, as no prior studies have examined real-time telerehabilitation for TMDs-SB. Our findings confirmed the hypothesis: telerehabilitation yielded greater improvements across most outcomes, leveraging real-time supervision to enhance efficacy.

Pain and neck disability

Pain is a hallmark of TMDs, often linked to neck disability via biomechanical and neurophysiological connections between the cervical spine and temporomandibular region [1,60,61]. TMDs-SB patients are 3.47 times more likely to exhibit higher NDI scores than those without SB [61]. In our study, 60% of the home exercise group and 45% of the telerehabilitation group reported baseline neck pain, aligning with reports that 70% of TMD patients experience neck issues [62]. Both groups showed significant reductions in morning jaw pain, headache, and neck pain alongside improved neck disability and TMJ mobility. A CVA of less than 48° was considered indicative of forward head posture. Post-treatment CVA in both groups surpassed the forward head posture threshold [38], suggesting a clinically significant shift. The telerehabilitation group's superior outcomes likely stem from real-time feedback enhancing exercise precision and adherence [20,23], correcting posture and reducing parafunctional loading. These results highlight telerehabilitation's potential as an effective alternative when in-person care is limited, consistent with its established role in musculoskeletal disorders.

Anxiety and oral behaviors

The COVID-19 pandemic exacerbated anxiety and oral parafunctional behaviors in TMD patients [15–18], with our sample showing high baseline STAI-Trait and OBC scores. Pfefferbaum and North noted that unprecedented stressors such as quarantine and disrupted daily routines, intensified the pandemic's mental health impact, particularly elevating anxiety [63]. Although no studies directly address anxiety-targeted exercise interventions in TMD patients during the pandemic, existing research highlights the potential of exercises like yoga to reduce anxiety [64]. During the pandemic, direct evidence of the effects of exercise interventions on oral parafunctional habits in TMD patients remained limited. However, studies underscore pandemic-related stress's significant impact on oral habits and TMD symptoms. A cohort study by Asquini et al. [17] on COVID-19-related stress in TMD patients revealed worsening psychological status, increased central sensitization, and heightened chronic facial pain intensity in chronic TMD cases. These findings suggest stress significantly exacerbates TMD symptoms and related parafunctional habits. These findings suggest that exercise-based interventions may effectively manage anxiety in TMD patients, particularly during challenging periods like the pandemic. Following an eight-week treatment program, both groups reduced anxiety and oral behaviors, with telerehabilitation showing greater gains. This aligns with exercise-based anxiety reduction [64] and our prior pediatric study linking oral habits to bruxism [13]. Real-time supervision likely amplified patient awareness and adherence, addressing stress-related behaviors more effectively than unsupervised exercises [23]. By the study's end, pain level reductions, alongside anxiety and OBC score improvements, highlight a strong interrelationship among these variables. These findings emphasize the value of integrating holistic approaches, such as stress management and exercise, into TMD patient treatment. Given sleep bruxism's

dynamic nature and complex ties to health variables, high-quality, evidence-based future studies are essential to deepen understanding and evaluation.

Sleep quality

Poor sleep quality is prevalent in TMDs-SB [65], worsened by the pandemic [16–18]. Regular exercise has been shown to boost psychological well-being and motivation [50,64]. Exercise programs enhanced sleep quality by educating patients about their condition and symptoms, also reducing headaches and neck pain in roughly 50% of patients [66]. In our study, patients exhibited poor sleep quality before treatment, as evidenced by PSQI scores (≥ 5) [44]. Although direct studies on exercise interventions' effects on sleep quality in TMD-SB patients during the pandemic are scarce, broader research suggests that exercise can enhance sleep quality. Here, education and exercise interventions improved sleep quality in both groups; however, only the telerehabilitation group's post-treatment PSQI scores dropped below the poor sleep threshold (< 5), reflecting a clinically significant improvement [44]. These findings affirm exercise's positive impact on sleep quality and indicate that telerehabilitation offered additional benefits, proving more effective in enhancing sleep quality.

Telerehabilitation

Telerehabilitation refers to the delivery of rehabilitation services remotely, utilizing technologies such as real-time video conferencing, pre-recorded videos, telephone calls, or virtual reality systems [19]. Turolla et al. [67] emphasized the benefits of telerehabilitation during the COVID-19 pandemic for musculoskeletal rehabilitation, highlighting its role as a viable alternative when face-to-face care was restricted. This approach encompasses two primary methods: asynchronous telerehabilitation, which involves the delayed analysis of digital images or data, and synchronous telerehabilitation, which facilitates real-time interaction and immediate feedback between therapist and patient [27]. In this study, we implemented synchronous telerehabilitation to provide interactive, real-time treatment sessions via WhatsApp video calls. This real-time interaction differs markedly from asynchronous methods, which lack the dynamic engagement essential for ensuring exercise accuracy and maintaining patient morale. Our method enabled direct supervision of exercises, allowing immediate corrections to technique, posture, and adherence. However, a significant challenge emerged due to unreliable internet connectivity, particularly for patients in rural areas, which disrupted session

continuity and contributed to patient dropout in the telerehabilitation group. The OPPERA cohort study underscored the difficulty of patient retention in chronic TMD pain management, reporting a 24% full recovery rate over five years but a 78% dropout rate [65]. In our study, conducted during the COVID-19 pandemic, both groups experienced a 20% dropout rate, with motivational issues affecting the home exercise group and internet connectivity problems impacting the telerehabilitation group. Future studies should explore strategies to improve compliance in home-based programs – such as motivational interviewing or hybrid models – and address telerehabilitation's reliance on stable internet by recruiting larger initial samples to account for potential dropouts.

Recent research and clinical guidelines highlight the critical role of physiotherapist feedback in telerehabilitation's effectiveness [68,69]. Real-time video sessions provide immediate guidance on exercise execution, posture correction, and movement quality. This feedback loop significantly enhances patient understanding and compliance, both of which are vital for rehabilitation progress. A review by Sia et al. [68] notes physiotherapists' positive views of telerehabilitation, emphasizing its improvements in accessibility, cost-effectiveness, privacy, and patient confidence in self-management. However, some studies suggest that technological barriers, such as inconsistent internet access, can weaken the patient-therapist relationship or diminish interaction quality, while others report enhanced engagement compared to traditional methods. These conflicting findings indicate that, while telerehabilitation offers substantial promise, it cannot fully replace face-to-face care, particularly for complex cases requiring hands-on physical assessment.

In recent years, ecological momentary assessment (EMA) and intervention approaches have gained significant importance in the evaluation and management of awake bruxism. These methods help patients increase their awareness of jaw muscle activity during daily life and enable better control, thereby contributing to the management of TMD-related pain [70,71]. Although our study focused on sleep bruxism, integrating EMA-based strategies into telerehabilitation or home-based protocols may serve as a complementary approach to enhance the effectiveness of treatment for patients with TMDs-SB.

Effective management of TMDs-SB requires interventions that address the condition's multidimensional nature, including specific sources of pain and contributing psychosocial factors [65]. In our study, we adopted a comprehensive approach by combining patient education with therapeutic exercises. In contrast to earlier TMD studies that lacked real-time supervision

[26–29], our supervised telerehabilitation model demonstrated superior outcomes in pain intensity, neck disability, anxiety levels, and oral behaviors compared to unsupervised home exercise programs. This superiority suggests that synchronous telerehabilitation effectively targets the biopsychosocial dimensions of TMDs-SB, particularly amidst the heightened stress of the pandemic. The pandemic context further underscores telerehabilitation's value, as increased stress and isolation likely exacerbated TMDs-SB symptoms, rendering remote accessibility a critical advantage during this period. Considering these insights, telerehabilitation emerges as a compelling alternative for early intervention, patient education, regular follow-up, and sustained treatment continuity. It serves as a practical solution when physical access is limited, such as during the COVID-19 pandemic. We contend that telerehabilitation complements, rather than replaces, traditional care, given its capacity to overcome accessibility barriers while falling short of fully replicating in-person diagnostic capabilities.

Limitations

This study has several limitations that warrant consideration. First, the small sample size and the unique pandemic context, characterized by a 20% dropout rate, limit the generalizability of our findings beyond this period. Second, the telerehabilitation group's reliance on technology – requiring internet access and WhatsApp – excluded patients from rural or low-resource settings, with connectivity issues contributing to dropouts. Third, our assessment of probable sleep bruxism relied on self-reports and clinical signs rather than objective measures like polysomnography or the Standardized Tool for the Assessment of Bruxism (STAB) [72], reducing diagnostic precision. Fourth, the lack of a face-to-face control group precluded direct comparisons with traditional care, a key benchmark for evaluating telerehabilitation's efficacy. Fifth, adherence was monitored through self-reports, and patient satisfaction was assessed via verbal feedback rather than standardized scales, weakening the reliability of these measures. Finally, excluding patients with disc displacement or joint degeneration narrowed the scope of TMDs-SB cases examined, potentially limiting broader applicability. To address these issues, future research should utilize larger, more diverse samples; employ objective or multidimensional tools to assess bruxism; measure adherence and satisfaction with standardized instruments; include patients with disc displacement or joint degeneration; and incorporate face-to-face control groups. Conducting studies outside the pandemic's unique conditions would improve

generalizability and clarify telerehabilitation's potential, while systematic adherence monitoring could enhance outcome reliability.

Conclusion

This study demonstrates that telerehabilitation-supported exercises outperform unsupervised home exercises in reducing pain, neck disability, anxiety, and oral behaviors in TMDs-SB patients during the COVID-19 pandemic. Real-time supervision via WhatsApp enhanced outcomes, offering a feasible, effective complement to traditional care when in-person access is restricted. While both interventions improved sleep quality, telerehabilitation's broader impact highlights its potential in managing TMDs-SB's biopsychosocial dimensions. Given the pandemic's unique stressors, further research is needed to confirm these findings in non-crisis settings, refine technological barriers, and integrate objective measures for broader applicability.

Acknowledgments

The authors would like to thank their patients who participated in the study.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

The author(s) reported there is no funding associated with the work featured in this article.

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Informed consent

A written informed consent form was obtained from all participants.

Contributors

All listed authors made valuable contributions to the development of this manuscript. Conception and Design: AT, EHA; Collection and assembly of data: EHA; Analysis and interpretation of the data: EHA, AT, AHT; Drafting of the article: AT, EHA, Critical revision of the article for important intellectual content and final edition of the manuscript: AT, AHT.

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