Transcutaneous electrical nerve stimulation versus virtual reality on temporomandibular disorder following maxillofacial surgery

Estimulación eléctrica nerviosa transcutánea vs realidad virtual en trastorno temporomandibular tras cirugía maxilofacial

Authors

Mohamed Maher Elkeblawy [1]
Amany R Abdel Wahid [2]
Wafaa Atef Abd Allah [3]
Engi E.Sarhan [4, 5]
Amira H. Mohammed [6, 7]
Abeer M.Yousef [8, 9]

[1] National Center of Research, Egypt
[2, 8] Cairo University, Egypt
[3] Misr University for Science and Technology (MUST), Giza, Egypt
[4, 6, 9] Qassim University, Buraydah, Saudi Arabia
[5] Kafrelsheikh University, Egypt
[7] Delta University for Science and Technology, Gamasa, Egypt

Corresponding author:
Amira H. Mohammed
a.ebermbaly@qu.edu.sa

Received: 05-01-26
Accepted: 12-02-26

How to cite in APA

Elkeblawy, M. M., Wahid, A. R. A., Allah, W. A. A., Sarhan, E. E., Mohammed, A. H., & Yousef, A. M. (2026). Transcutaneous electrical nerve stimulation versus virtual reality on temporomandibular disorder following maxillofacial surgery. *Retos*, *76*, 923-930. https://doi.org/10.47197/retos.v77.118506

Abstract

Introduction**:** Temporomandibular disorder is very common postoperative complication following oral surgery. It is including several symptoms as pain, oedema, ROM restrictions and trismus.
Objective: The study compared the effect of TENS and virtual reality on temporomandibular disorder following maxillofacial surgery.
Methodology: Sixty patients (male and female) with ages ranged from 30-45 years with temporomandibular joint disorders post maxillofacial surgery randomized into two equivalent groups. Group A was given TENS in addition to traditional physiotherapy program which include (mobilizing exercises, ROM exercises, isometric contraction exercises, and massage) 3 times a week for four weeks, while Group B was given virtual reality plus the traditional physiotherapy program, 3 times a week for four weeks. Assessment of pain was done through a visual analogue scale (VAS) while maximum mouth opening (MMO) was determined in millimetres using a ruler at baseline and following the treatment program.
Results: The comparison between the two groups posttreatment exposed a significant improvement in both VAS and MMO for Group A while Group B showed significant improvements in (MMO) and non-significant pain reduction ($p < 0.001$).
Discussion: Findings from studies, including those by Carrougher, G., have provided valuable insights. J., et al., Esteban-Sopeña, J. et al., and Tejera, D. M. et al., conflicted with this study's conclusions.
Conclusions: Combining TENS therapy with and physical exercises alleviated temporomandibular pain after maxillofacial surgery, while integrating Virtual Reality with physical exercises showed greater improvements in maximum mouth opening.

Keywords

TENS; virtual reality (VR); manual therapy; maxillofacial oral surgery; temporomandibular joint disorders (TMJD).

Resumen

Introducción: el trastorno temporomandibular es una complicación postoperatoria frecuente tras la cirugía oral, caracterizada por dolor, edema, limitación del rango de movimiento y trismo.
Objetivo: el estudio comparó el efecto de la estimulación nerviosa eléctrica transcutánea y la realidad virtual sobre el trastorno temporomandibular después de la cirugía maxilofacial.
Metodología: participaron sesenta pacientes, hombres y mujeres, entre treinta y cuarenta y cinco años, con trastornos de la articulación temporomandibular tras cirugía maxilofacial. fueron asignados aleatoriamente a dos grupos equivalentes. el grupo a recibió estimulación nerviosa eléctrica transcutánea junto con un programa tradicional de fisioterapia (ejercicios de movilización, rango de movimiento, contracciones isométricas y masajes) tres veces por semana durante cuatro semanas. el grupo b recibió realidad virtual combinada con el mismo programa, con igual frecuencia y duración. el dolor se evaluó mediante escala visual analógica y la apertura bucal máxima se midió en milímetros al inicio y al finalizar el tratamiento.
Resultados: tras el tratamiento, el grupo a mostró mejoras significativas en dolor y apertura bucal máxima, mientras que el grupo b presentó mejoras significativas en la apertura bucal máxima y una reducción del dolor no significativa ($p < 0,001$).
Discusión: los hallazgos difirieron de otras investigaciones publicadas, que reportaron conclusiones distintas.
Conclusiones: la combinación de estimulación nerviosa eléctrica transcutánea con ejercicios físicos alivió el dolor temporomandibular tras cirugía maxilofacial, mientras que la integración de realidad virtual con ejercicios físicos produjo mayores mejoras en la apertura bucal máxima.

Palabras clave

Cirugía oral maxilofacial; estimulación nerviosa eléctrica transcutánea; realidad virtual; terapia manual; trastornos de la articulación temporomandibular.

Introduction

Maxillofacial surgeries often lead to varying degrees of postoperative inflammation and Temporomandibular joint disorders (TMDs) (Meneses-Santos et al., 2022). These conditions are a collection of conditions that result in pain, dysfunction in the jaw joints, discomfort, facial and oral swelling, trismus and limited mouth opening caused by muscle spasm. These disorders can significantly influence the quality of life associated with physical health (Adrian et al., 2020).

Extensive research has revealed a wide range of therapeutic options for temporomandibular disorders (TMD), including joint mobilization, friction massage, dry needling, patient education, occlusal splints, and targeted stretching and strengthening exercises. Additionally, treatment methods like ultrasound, laser therapy, TENS, interferential current, and acupuncture have been used to effectively control symptoms (Dickerson et al., 2017; Armijo-Olivoet al; 2016).

Virtual Reality (VR) offers interactive sessions that support the rehabilitation. It enhances patient engagement and enjoyment, reduces pain perception, and improves movement—factors that help overcome the common lack of motivation (Yang, 2009). This increased participation can lead to better rehabilitation outcomes and improved quality of recovery (Pedersen and Saltin, 2006). VR can be safe for non-pharmacological pain fading (Garrido-Ardila et al., 2022).

Manual therapy (MT) approaches, including muscle strengthening, flexibility training, and motor control exercises, can effectively alleviate pain and impairment in these individuals. Systematic reviews and meta-analyses on the best effectiveness and dose-response of exercise training in patients with temporomandibular joint disorders (TMJD) have shown little agreement.

Therapeutic exercises are intended to mobilize the TMJ and masticatory muscles. In summary, exercise therapy aims to alleviate muscle and joint pain and increase function in the muscles through focusing movement of certain body parts (Herrera-Valencia et al., 2020).

In addition to conventional manual treatment, such as active mobility exercises, isometric contraction exercises, and massage exercises, this study examined the effects of TENS and virtual reality on the temporomandibular joint following maxillofacial surgery.

Method

Study design

In 2025, a randomized controlled trial was conducted at Cairo University's college of physical therapy. Participants gave informed permission before they were enrolled, once the study had received the ethical clearance. The Cairo University Research Ethics Committee provided the ethical clearance, with number (P.T.REC/012/006160).

Sample size

G*POWER statistical software (version 3.1.9.2; Universitas Kiel, Germany) is used to calculate sample size. Each group must have 34 members in order to achieve a mean VAS difference of 2 points. α=0.05, power=90%, effect size=0.8, and allocation ratio N2/N1=1 was used in the computations.

Participants

Sixty individuals (female and male) with TMJ pain and ROM problems following maxillofacial surgery participated in this research; their ages ranged from 30 to 45 years. They were selected from government hospitals (El Kasr Al–Aini Hospital, and private dental center). Simple randomization method was done by assistant researcher who was blinded to study procedures.

Patients were randomly assigned to two equal groups: Group A (got TENS and manual treatment) and Group B (received VR and manual therapy). Group A: (TENS group): This group composed of 30 patients who had TMJ pain and ROM restriction after maxillofacial surgery, they received TENS post–surgical and manual therapy(Active mobility exercises and isometric contraction exercises, massage exercises)

, plus traditional medication for 4 weeks. Group B: (control group): This group consisted of 30 individuals who experienced TMJ pain and ROM restriction after maxillofacial surgery received Virtual Reality and manual therapy post-surgical (Active mobility exercises and isometric contraction exercises, massage exercises) plus traditional medication for 4 weeks. All patients were assessed by a maxillofacial surgeon before the start of the study.

The patients were chosen under the following criteria: Both genders participated in the study. Patients after Arthrocentesis. Age ranges between 30 – 45 years. All participants suffering from pain in the jaw and limited mouth opening, they didn't have periodontic disorders. All patients will have informed consent. The therapeutic intervention for all patients started day one post maxillofacial surgery. All patients were conscious. The current study excluded the patients with surgeries at the temporomandibular joint (arthroscopy, meniscectomy, etc.), and oral operations (such as third molar impaction surgery), and in subjects with any underlying systemic or neurological condition. Myofascial pain syndrome, mental illness, chronic infection, epilepsy or any psychological disorders patients were also excepted.

Outcome Measurement

A standard millimeter ruler was employed to assess the maximum mouth opening (MMO). This measurement was defined as the greatest vertical distance between the incisal margins of the maxillary and mandibular central incisors, ensuring a pain-free range of motion. The inter-incisal distance was measured in millimeters, with three consecutive readings taken, and the highest value was then recorded (Herrera-Valencia et al., 2020). Pain intensity was measured using a Visual Analog Scale (VAS) with a range of 0 to 10 cm, where 0 meant "no pain" and 10 indicated "the most severe pain ever experienced." Participants were told to indicate a point along the scale that best matched the discomfort they experienced when opening their mouth at the time of examination (Boonstra et al., 2014; Müller et al., 2013). All outcome measurements were collected by the same evaluator to ensure consistency at baseline and once more following a four-week intervention

Procedure

Following the collection of patient demographic details, a comprehensive medical and history was obtained. A routine examination was conducted, followed by a detailed assessment of the temporomandibular joint (TMJ) pain and pain free maximum mouth opening (MMO). Prior to initiating treatment, the procedures were explained to each participant. For four weeks, there were three therapy sessions each week as part of the research protocol.

Treatment procedures (Group A)

This group received the following interventions:

a. Transcutaneous Electrical Nerve Stimulation (TENS):

Low-voltage electrical currents are applied to the skin via the TENS device via surface electrodes, targeting underlying tissues. This stimulation helps alleviate pain by promoting muscle relaxation and reducing tension. TENS therapy is commonly employed for managing chronic orofacial pain and for relieving tension in the masticatory muscles (Kalaivanan et al, 2024).

Two electrode pads were used. One pad was placed diagonally from the cheek to the base of the neck, while the other was positioned surrounding the temporomandibular joint. TENS was used with 50 Hz frequency, and intensity was regulated according to patient tolerance without visible muscle contraction for 20 minutes.

b. Manual Therapy (MT):

Manual therapy was administered as part of a structured rehabilitation program. The intervention included mobilization exercises, range of motion exercises, isometric contractions, and massage techniques for 30 minutes.

- Mobilization exercises by the therapist to the ipsilateral temporomandibular joint (TMJ) using an oral appliance (tongue depressors) in form of TMJ Distraction, TMJ medial glide, and TMJ lateral glide.

- Range of Motion Exercises performed in form of repeated mouth opening and closing movements. Lateral excursions were completed by slowly shifting the lower mandible to the left and right. Passive jaw movements were facilitated by the patient using their own hands, wrapped in gauze, to gently separate the maxillary and mandibular jaws.
- Isometric contraction exercises introduced from the fifth post-surgical week
- Self-massage by patients performed self-massage of the masticatory muscles following each session.

Treatment procedures (Group B)

This group received the following interventions:

a. Virtual reality rehabilitation (VR):

During the intervention, patients wore virtual reality (VR) headsets displaying calming landscape scenes to facilitate pain distraction. There was an interpupillary distance (IPD) adjustment mechanism which allowed users to align the lenses with the spacing between their eyes for enhanced visual clarity. The headset included adjustable head straps and soft foam padding around the edges for comfort and stability. Concurrently, the therapist administered mobilization techniques targeting the temporomandibular (TM) joint using therapeutic video tasks. The headset provided a field of view (FOV) between 90° and 110°, delivering a moderately immersive experience. Select models also featured integrated headphones to enrich the auditory and interactive experience.

b. Manual Therapy (MT):

Manual therapy was administered to patients in Groups B the same manner as applied for group A.

Data analysis

An independent t-test was performed to compare the characteristics of the individuals in the various groups. To compare categories between groups, a chi-squared test was performed. The Shapiro-Wilk test was used to determine if the data was regularly distributed. The homogeneity of variances between groups was investigated using Levene's test. The researchers used a mixed-design MANOVA to determine how each group influenced the VAS and mouth opening. Following multiple comparisons, post-hoc tests were performed using Bonferroni correction. Statistical tests were performed at a significance level of $p < 0.05$. All statistical analyses in this investigation were carried out with SPSS 25 for Windows (IBM SPSS, Chicago, IL, USA).

Results

Subject demographic details

Table (1) shows the topic aspects of Group A and Group B. The groups did not differ substantially in terms of age or gender ($p > 0.05$).

Table 1. Participant's characteristics.

	Group A	Group B	MD	t- value	p-value
	Mean ± SD	Mean ± SD			
Age (years)	38.13 ± 3.99	38.56 ± 4.73	-0.43	-0.383	0.703
Sex, n (%)					
Females	14 (46.6%)	16 (53.4%)		$\chi2 = 0.267$	0.606
Males	16 (53.4%)	14 (46.6%)			

Standard deviation (SD), mean difference (MD), Chi squared value ($\chi2$), and level of significance (p-value).

Effect of treatment on VAS and Mouth opening

There was a significant interaction between treatment and time (F-value = 18.918, p-value = 0.001, partial Eta squared = 0.399). Time had a statistically significant primary effect (F-value = 1034.496, p-value

= 0.001, partial Eta squared = 0.973). The main effect of the therapy was statistically significant (F-value = 18.044, p-value = 0.001, partial Eta squared = 0.388).

Within group comparison

Following therapy, both groups' VAS and mouth opening significantly improved (p-value < 0.001). VAS and mouth opening changed by 74.12% and 58.47%, respectively, in group A and 77.74% and 79.58%, respectively, in group B.

Between groups comparison

There were no statistically significant changes (p-value > 0.05) in VAS or mouth opening between the pre-treatment groups. By comparing the two groups after treatment, it was shown that group B had significant increase in mouth opening (p-value < 0.001) than group A (Table 2).

Table 2. Mean VAS and mouth opening pre and post treatment of group A and B:

	Group A	Group B		
	Mean ±SD	Mean ±SD	MD (95% CI)	p value
VAS				
Pre treatment	7.33 ± 1.53	7.46 ± 1.67	-0.133 (-0.965: 0.698)	0.749
Post treatment	1.9 ± 0.84	1.66 ± 0.80	0.233(-0.192: 0.659)	0.277
MD (95% CI)	5.433 (4.775: 6.092)	5.8 (5.142: 6.458)		
% of change	74.12	77.74		
	p-value = 0.001	p-value = 0.001		
Mouth openning				
Pre treatment	20.23 ± 1.63	20.23 ± 1.63	0.0 (-0.844: 0.844)	1.00
Post treatment	32.06± 1.76	36.33± 2.48	-4.267 (-5.379: -3.155)	0.0001*
MD (95% CI)	-11.83 (12.808: -10.858)	-16.1 (-17.075: -15.125)		
% of change	58.47	79.58		
	p-value = 0.001	p-value = 0.001		

Standard deviation (SD), mean difference (MD), confidence interval (CI), and level of significance (p-value).

Discussion

Through the results of this study, there was improvement in pain and pain free ROM of mouth opening not only after application of TENS combined with manual therapy but also after application of VR combined with manual therapy in patients with temporomandibular disorders (TMD) post maxillofacial surgery. But the result indicated that TENS had the upper hand in pain reduction compared to VR even if this was non-significant reduction which meant that VR also contributed meaningfully to pain relief. On the other hand, comparing the pain free mouth opening ROM in both groups indicated that VR had a superior effect than TENS with significant difference between them.

On the other hand, VR showed a significantly greater improvement in pain-free mouth opening ROM compared to TENS. This implies that the immersive and distraction-based character of VR may play a more essential role in increasing functional mobility by lowering muscular tension and improving relaxation during therapy (Pizzoli et al., 2019).

The current study added that combining traditional techniques with innovative, noninvasive modalities can offer additional clinical advantages. The addition of interventions such as TENS or VR to manual therapy and exercise significantly enhanced treatment outcomes as confirmed by the result of this study. These adjunctive modalities provided therapeutic benefits that were not achieved through manual therapy and exercise alone, as evidenced by the findings of Armijo-Olivo, S. et al., study which mentioned that the efficacy of exercise and manual treatment alone for TMD is questionable (Armijo-Olivo et al., 2016).

The findings of this study are consistent with previous research. Kalaivanan et al. compared the effects of transcutaneous electrical nerve stimulation (TENS) and low-level laser therapy (LLLT) on temporomandibular joint (TMJ) disorders and confirmed that both modalities were effective in reducing pain, improving mouth opening, and alleviating muscular tenderness (Kalaivanan et., 2024). Moger et al. evaluated the effectiveness of TENS therapy in managing temporomandibular disorders and concluded that

TENS was highly effective for pain control (Moger et al., 2011). Gopi et al. examined the impact of TENS and systemic pharmacotherapies on TMJ problems. Based on their meta-analysis, they reported a significant reduction in pain following the use of TENS (Gopi et al., 2021).

Mennaallah et al. investigated the role of virtual reality (VR) in managing TMJ pain and dysfunction associated with cervicofacial burns. Their findings indicated that VR significantly improved chronic TMJ pain, maximum mouth opening (MMO), and overall quality of life (Mennaallah et al., 2025). Similarly, Carrougher et al. explored the effect of immersive VR on pain in adults with burn injuries and concluded that VR successfully reduced post-burn pain, offering a safe, non-pharmacological, and easy-to-apply supplementary analgesic therapy (Carrougher et al., 2009). Finally, Garrido-Ardila et al. conducted a systematic review of VR therapy outcomes in burn patients and reported consistent pain reduction across all cases, with improvements in range of motion in 33% of participants (Garrido-Ardila et al., 2022).

The results of certain studies differed from the findings of this research, including those by Carrougher et al., Esteban-Sopeña et al., and Tejera et al (Carrougher et al., 2009; Esteban-Sopeña et al., 2024; Tejera et al., 2020). Carrougher et al. reported that, in patients with burn injuries, range of motion (ROM) was not significantly improved after physical therapy combined with virtual reality (VR) compared to physical therapy alone. Although the VR group demonstrated a slightly greater ROM, the difference was not substantial.

Esteban-Sopeña et al. conducted a systematic review on the use of VR following total knee arthroplasty and concluded that VR had no meaningful effect on ROM compared to standard interventions. The authors noted that the evidence was based on studies with low methodological quality and recommended further high-quality research to confirm these findings. Similarly, Tejera et al. evaluated the impact of VR versus exercise therapy on pain severity, anxiety, and ROM in patients with non-specific chronic neck pain. Their results indicated no significant differences between the two modalities in any of these outcomes.

Under the result of this study, there is a recommendation to combine both VR and TENS alongside physical exercise in post-maxillofacial surgery rehabilitation protocols to achieve best result and more benefits to temporomandibular joint (TMJ) dysfunction. While TENS demonstrated superior efficacy in pain reduction, VR showed a significant greater impact on improving pain-free maximum mouth opening. Further study with bigger sample numbers and longer follow-up is needed to verify these findings and investigate the processes behind the differing effects of TENS and VR in TMD rehabilitation.

Conclusions

This study demonstrated that VR and TENS with manual therapy and physical exercises can significantly enhance rehabilitation outcomes following maxillofacial surgery. While TENS was more effective in reducing pain intensity, VR showed superior results in improving pain-free maximum mouth opening. These findings suggest that combining both VR and TENS may offer complementary benefits.

Acknowledgements

The authors express their profound thanks to the patients who took part in this study. The Authors would like to extend their gratitude to Basic Science Department, Faculty of Physical Therapy, Cairo University, Egypt, National Center of Research , Physical Therapy Surgery Department, Faculty of Physical Therapy, Cairo University(Egypt). Department of Physical Therapy for Diseases and Surgeries of the Musculoskeletal System, College of Physical Therapy - Misr university for Science and Technology(MUST),P.O.Box77,Giza (Egypt), Department of Physical Therapy for Neurology and its Surgery, Faculty of Physical Therapy, KafrElsheikh University, (Egypt), Department of Physical Therapy for Pediatrics, Faculty of Physical Therapy, Delta University for Science and Technology, Gamasa, (Egypt) and College of Applied Medical Sciences, Qassim University, Buraidah 51452, Saudi Arabia. without their con-tribution, this research would not have been possible.

Financing

The authors received no support for the study.

Conflicts of interest

No competing interests were declared by the authors.

References

Adrian, A. B., Terezinha, D., & Gisele, P. (2020). Temporomandibular disorders and their association with quality of life in adolescents and young adults: A systematic review. *Journal of Oral Rehabilitation*, *47*(3), 261–269.

Armijo-Olivo, S., Pitance, L., Singh, V., Neto, F., Thie, N., & Michelotti, A. (2016). Effectiveness of manual therapy and thera-peutic exercise for temporomandibular disorders: systematic review and meta-analysis. *Physical therapy*, *96*(1), 9-25.

Armijo-Olivo, S., Pitance, L., Singh, V., Neto, F., Thie, N., & Michelotti, A. (2016). Effectiveness of manual therapy and thera-peutic exercise for temporomandibular disorders: Systematic review and meta-analysis. *Physical Therapy*, *96*(1), 9–25. https://doi.org/10.2522/ptj.20140548

Boonstra, A. M., Schiphorst Preuper, H. R., Balk, G. A., & Stewart, R. E. (2014). Cut-off points for mild, moderate, and severe pain on the visual analogue scale for pain in patients with chronic musculoskeletal pain. *Pain*, *155*(12), 2545–2550.

Carrougher, G. J., Hoffman, H. G., Nakamura, D., Lezotte, D., Soltani, M., Leahy, L., Engrav, L. H., & Patterson, D. R. (2009). The effect of virtual reality on pain and range of motion in adults with burn injuries. *Journal of Burn Care & Research*, *30*(5), 785–791. https://doi.org/10.1097/BCR.0b013e3181b485d3

Dickerson, S. M., Weaver, J. M., Boyson, A. N., Thacker, J. A., Junak, A. A., Ritzline, P. D., & Donaldson, M. B. (2017). The effectiveness of exercise therapy for temporomandibular dysfunction: a systematic review and meta-analysis. *Clinical reha-bilitation*, *31*(8), 1039-1048.

Esteban-Sopeña, J., Beltran-Alacreu, H., Terradas-Monllor, M., Avendaño-Coy, J., & García-Magro, N. (2024). Effectiveness of virtual reality on postoperative pain, disability and range of movement after knee replacement: A systematic review and meta-analysis. *Life*, *14*(3), 289. https://doi.org/10.3390/life14030289

Garrido-Ardila, E. M., Santos-Domínguez, M., Rodríguez-Mansilla, J., Torres-Piles, S. T., Rodríguez-Domínguez, M. T., Gonzá-lez-Sánchez, B., & Jiménez-Palomares, M. (2022). A systematic review of the effectiveness of virtual reality-based interven-tions on pain and range of joint movement associated with burn injuries. *Journal of Personalized Medicine*, *12*(8), 1269. https://doi.org/10.3390/jpm12081269

Gopi, I., Maragathavalli, G., & Uma Maheshwari, T. (2021). Efficacy of transcutaneous electric nerve stimulation over sys-temic pharmacotherapy in the management of temporomandibular joint disorders – A systematic review and meta-analysis. *Journal of Indian Academy of Oral Medicine and Radiology*, *33*(3), 321–327. https://doi.org/10.4103/jiaomr.jiaomr_131_21

Herrera-Valencia, A., Ruiz-Muñoz, M., Martin-Martin, J., Cuesta-Vargas, A., & González-Sánchez, M. (2020). Efficacy of man-ual therapy in temporomandibular joint disorders and its medium- and long-term effects on pain and maximum mouth opening: A systematic review and meta-analysis. *Journal of Clinical Medicine*, *9*(11), 3404.

Kalaivanan, V., Muruppel, A., Deepthi, A., Ranjitha, E. G., Deepak, J., & Murugan, K. (2024). Comparing the efficacy of transcutaneous electric nerve stimulation (TENS) and low-level laser therapy (LLLT) in the management of temporoman-dibular joint disorders: A pilot study. *Journal of Indian Academy of Oral Medicine & Radiology*, *36*(4), 412–416.

Meneses-Santos, D., Costa, M. D. M. A., Inocêncio, G. S. G., Almeida, A. C., Vieira, W. A., Lima, I. F. P., & Paranhos, L. R. (2022). Effects of low-level laser therapy on reducing pain, edema, and trismus after oral surgery: A systematic review. *Lasers in Medical Science*, *37*(3), 1471–1485.

Mennaallah, M., Amal, M., Mahmoud, A., & Hussein, G. (2025). Virtual reality and pain of temporomandibular joint after cervicofacial burn: A randomized controlled trial. *International Journal of Environmental Sciences*, 3102–3110. https://doi.org/10.64252/md27x151

Moger, G., Shashikanth, M., Sunil, M., & Shambulingappa. (2011). Transcutaneous electrical nerve stimulation therapy in temporomandibular disorder: A clinical study. *Journal of Indian Academy of Oral Medicine and Radiology*, *23*(1), 46–50. https://doi.org/10.5005/jp-journals-10011-1090

Müller, L., van Waes, H., Langerweger, C., Molinari, L., & Saurenmann, R. K. (2013). Maximal mouth opening capacity: Per-centiles for healthy children 4–17 years of age. *Pediatric Rheumatology*, *11*(1), 17.

Pedersen, B. K., & Saltin, B. (2006). Evidence for prescribing exercise as therapy in chronic disease. *Scandinavian Journal of Medicine & Science in Sports*, *16*(Suppl 1), 3–63. https://doi.org/10.1111/j.1600-0838.2006.00520

Pizzoli, S. F. M., Mazzocco, K., Triberti, S., Monzani, D., Alcañiz Raya, M. L., & Pravettoni, G. (2019). User-centered virtual reality for promoting relaxation: An innovative approach. *Frontiers in Psychology*, *10*, 479. https://doi.org/10.3389/fpsyg.2019.00479

Tejera, D. M., Beltran-Alacreu, H., Cano-de-la-Cuerda, R., Leon Hernández, J. V., Martín-Pintado-Zugasti, A., Calvo-Lobo, C., Gil-Martínez, A., & Fernández-Carnero, J. (2020). Effects of virtual reality versus exercise on pain, functional, somatosenso-ry and psychosocial outcomes in patients with non-specific chronic neck pain: A randomized clinical trial. *International Jour-nal of Environmental Research and Public Health*, *17*(16), 5950. https://doi.org/10.3390/ijerph17165950

Yang, X. (2009). Virtual reality technology for pain management and rehabilitation. *Journal of Computer Science and Tech-nology*, *24*(1), 42–45.

Authors' and translators' details:

Mohamed Maher Elkeblawy	Katyary@yahoo.com	Author
Amany R Abdel Wahid	Amany.Wahid@gmail.com	Author
Wafaa Atef Abd Allah	wafaa.abdallah@must.edu.eg	Author
Amira H. Mohammed	a.ebermbaly@qu.edu.sa	Author
Engi E.Sarhan	en.sarhan@qu.edu.sa	Author
Abeer M.Yousef	abeer.mahmoud 28@yahoo.com	Author
Amira H. Mohammed	a.ebermbaly@qu.edu.sa	Translator