Journal of Advances in Medicine and Medical Research

Volume 36, Issue 7, Page 417-429, 2024; Article no.JAMMR.119402
ISSN: 2456-8899, NLM ID: 101711724
(Past name: British Journal of Medicine and Medical Research, Past ISSN: 2231-0614, NLM ID: 101570965)

Protocol for a Randomized Clinical Trial of Oculomotor Exercises Added to Treatment for Temporomandibular Disorders

Leticia Neves Mode [a], Cindy Mozer Nakamura [a], Taisi Antunes Da Cunha [a], Fernanda Cardoso Nakamoto [a], Margarete Nobilo Leonardis [a], Cid André Fidelis De Paula Gomes [a], Fabiano Politti [a] and Daniela Aparecida Biasotto-Gonzalez [a*]

[a] Universidade Nove de Julho, São Paulo, Brazil.

Authors' contributions

This work was carried out in collaboration among all authors. Author LNM contributed to the concepts, design definition of intellectual content, literature search, data acquisition, manuscript preparation, manuscript review, and final approval. Authors CMN and TADC contributed to the literature search, data acquisition, and manuscript review. Author FP contributed to the statistical analysis. Author FCN contributed to the analysis of this study. Author MNL contributed to the manuscript review. Author CAFDPG contributed to the concepts, design definition of intellectual content, and final approval. Author DABG contributed to concepts, design definition of intellectual content, literature search, data acquisition, statistical analysis, manuscript preparation, manuscript review, and final approval. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/jammr/2024/v36i75518

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/119402

Study Protocol

Received: 25/03/2024
Accepted: 19/06/2024
Published: 16/07/2024

**Corresponding author: E-mail: biasottogonzalez@gmail.com;*

Cite as: *Mode, Leticia Neves, Cindy Mozer Nakamura, Taisi Antunes Da Cunha, Fernanda Cardoso Nakamoto, Margarete Nobilo Leonardis, Cid André Fidelis De Paula Gomes, Fabiano Politti, and Daniela Aparecida Biasotto-Gonzalez. 2024. "Protocol for a Randomized Clinical Trial of Oculomotor Exercises Added to Treatment for Temporomandibular Disorders". Journal of Advances in Medicine and Medical Research 36 (7):417-29. https://doi.org/10.9734/jammr/2024/v36i75518.*

ABSTRACT

Objective: To evaluate the effect of adding oculomotor exercises to the treatment of Temporomandibular Disorder (TMD) on pain intensity, range of mandibular movement, TMD severity, and ocular convergence insufficiency (CI), immediately, 3 months, and 6 months after treatment**.**
Study Design: Controlled and randomized clinical trial included blinded evaluators and participants.
Methodology: Individuals aged 18–45 years diagnosed with TMD and convergence insufficiency.
Intervention: Two groups: the experimental group (EG) and the control group (CG) groups will receive 12 treatment sessions. Main outcome measures: pain intensity, range of mandibular movement, convergence insufficiency, and severity of TMD during follow-up immediately after treatment, 3 and 6 months.
Analysis: The statistical analysis will use linear mixed models based on the intention to treat. The significance level will be set at 5%.
Results: This is a preliminary protocol; results will be available once the study is completed. It is expected relevant patient clinical improvement results.
Conclusion: It will be possible to determine the effects of adding oculomotor exercises in the treatment of TMD.
Implications for Practice: If successful, the protocol could be integrated into clinical practice as an adjunct to conventional therapy for TMD, expanding the therapeutic options available to healthcare professionals and patients.

Keywords: Temporomandibular disorder; clinical trials; physical therapy; convergence insufficiency; oculomotor therapy.

1. INTRODUCTION

Convergence insufficiency (CI) is a prevalent binocular vision disorder in which the eyes do not focus on a nearby object [1,2]. This dysfunction can cause symptoms such as headache, discomfort, drowsiness, diplopia, eye fatigue, blurred vision, difficulty in concentrating, tearing, orbital discomfort, among others [3,4,5,6]. The prevalence of this condition varies from 1.75% to 33.0%, with an average of 5% [7,8,9].

Studies have identified different therapeutic approaches for ocular convergence insufficiency and have sought to clarify the effectiveness of these treatment approaches based on the signs and symptoms present [3,10]. Therapeutic modalities include Brock's cord, Barriles card, and eccentric circles [11,12]. However, there is no consensus on the ideal intervention for adults [11].

Anatomical and physiological evidence indicates connections between the oculomotor and stomatognathic systems [13,14,15,16,17]. The visual and masticatory systems are integrated by the trigeminal system, as the afferent pathways of the trigeminal nerve linked to the masticatory muscles and extraocular muscles are located in the mesencephalic and cuneate nuclei of the brain stem, where they make connections [16,17,18].

The literature points to associations between convergence insufficiency (CI) and Temporomandibular Disorder (TMD) in the outcomes of pain and severity of TMD [13]. Monaco et al. [14] found correlations between abnormalities in ocular convergence in adults with TMD and concomitant symptoms, such as restrictions in maximum mouth opening and myofascial pain.

It is important to highlight that TMD has a multifactorial etiology and is the main musculoskeletal cause of non-odontogenic orofacial pain [19,20,21], with an estimated prevalence of 31% in adults and around 11% in young children [22,23], and is more prevalent in women [24,25].

The most common manifestation of TMD is myofascial pain in the masticatory muscles [26], which can coexist with other conditions, such as headache, chronic fatigue, sleep disorders, and sensory disorders [24,27,28].

Conservative and non-invasive therapeutic approaches have been prioritized for the management of TMD [29]. One of the most

recommended therapeutic modalities is physiotherapy, especially manual therapy, which directly affects the muscular system to reduce excessive tension and pain [30].

Considering the proposed interrelationship between the oculomotor system and TMD, this study aimed to evaluate the effects of oculomotor therapy on the outcomes of perceived pain intensity, ocular convergence insufficiency, and range of mandibular movement. Considering the proposed interrelationship between the oculomotor system and TMD, this study will aim to evaluate the effects of oculomotor therapy on the outcomes of perceived pain intensity, ocular convergence insufficiency, range of mandibular movement, and severity of TMD.

The aim of the present study will be to identify whether the addition of oculomotor treatment in patients with TMD interferes with the intensity of perceived pain, insufficiency of ocular convergence, range of mandibular movement, and severity of TMD.

2. METHODOLOGY

Design: This study is a randomized, double-blind clinical trial, following the recommendations of the Consolidated Standards of Reporting Trials (CONSORT), as shown in Fig. 1 [31]. This protocol follows the Standard Protocol Items: Recommendations for Interventional Trials (SPIRIT) [32].

Participants: The screening of individuals will be conducted using posters installed in corridors and at the reception of the university's school clinic, as well as publicity via social networks. The screening will continue until the target population is reached. The study participants will not participate in the design or objectives of this research.

Eligibility Criteria: Individuals aged between 18 and 45 years will be included; pain intensity greater than or equal to 3 in the Temporomandibular Joint (TMJ) or masticatory muscles; diagnosis of myogenic TMD; Moderate or severe TMD; and insufficiency of convergence. Individuals with persistent strabismus will be excluded; previous surgeries for strabismus; trauma or surgery in the cervical/craniofacial region; injuries to ocular innervation; neurological pathologies; systemic diseases; diagnosis of fibromyalgia; treatment for TMD in the last 3 months; recent oculomotor therapies for convergence insufficiency; continuous occlusal treatment; use of medications that affect accommodation or vergence; conditions that compromise ocular accommodation and motility, such as multiple sclerosis, diabetes, Graves' disease, myasthenia gravis; and confirmed pregnancy.

Randomization and blinding: A physical therapist will screen the participants to determine their eligibility. Participants will be stratified according to gender, severity, and pain into two groups: The experimental group (EG) and the Control group (CG), using the randomization.com program. A second researcher will be responsible for evaluating eligible participants. Participants will remain blinded to the treatment modality prescribed. A third researcher will be responsible for the treatment and will not know the evaluations. Unmasking will only be available to the researcher conducting the assessments after the last session.

The researcher responsible for evaluating the results will remain blind to the type of treatment assigned, aiming to minimize any detection bias inherent to the study. Likewise, the statistician responsible for analyzing the data will be unaware of the specificity of group allocation, ensuring an objective interpretation devoid of predispositions.

Intervention: EG will undergo the clinical protocol for TMD added to the oculomotor intervention. The CG will receive the clinical protocol for TMD. Both groups will receive individual care provided by a trained physiotherapist with 10 years of experience. The duration of the therapeutic protocol for both groups will be 12 sessions of 50 min per week. The number of sessions may be at least 6, if the participant presents no pain, as assessed by the Numerical Pain Scale (NPS). After each session, the Patient Global Impression Instrument [PGIS] will be applied to capture the subject's global perception of the therapy [33,34]. A reassessment will be performed after the 12th session, as well as after 3 and 6 months, by the same evaluator responsible for the initial measurement, considering the same clinical parameters obtained in the initial assessment. It is worth noting that patients will be instructed, from the moment they accept to participate, not to miss and be aware of the importance of their adherence to benefit science and future therapeutic protocols for TMD. If a group has a better result, patients in the opposite group will

receive the best treatment after the study is completed.

Treatment protocol for TMD: The proposed treatment is in accordance with the current guidelines for TMD [35]. Standardized techniques will be used, such as intra- and extraoral massages [36,37]; myofascial release of the masseter, temporalis, and sternocleidomastoid muscles [30]; release of cervical soft tissues [38]; cervical pumpage [39]; suboccipital inhibition and passive anteroposterior mobilization of the upper cervical [40,41] [Fig. 2]; cervical exercises [38] [Fig. 3]; and exercises targeting the TMJ, including the opening exercise with the tongue on the palate and proprioceptive exercises [38,42,43] [Fig. 4].

Oculomotor therapeutic protocol: Oculomotor intervention will be guided and adapted on the basis of the CITT protocol to treat convergence insufficiency [6]. The modalities will be introduced progressively, from the least to the most complex degree, covering techniques such as Brock's Cord, Barrilles Chart, Lifeguard Chart, Eccentric Circles, and Eye Relaxation [Fig. 5].

It is worth noting that in both therapeutic protocols, if the patient needs to be interrupted for any reason, it will be interrupted.

Primary outcome measures: Diagnostic Criteria for Temporomandibular Disorders (DC/TMD): A biaxial instrument for diagnosing TMD. Axis I comprises demographic data, two questionnaires, and clinical examination. Axis II consists of pain drawing and eight other questionnaires. The diagnostic decision diagram offers nine diagnostic possibilities, with more than one diagnosis possible for each joint [44]. Axis 1 physical examination will be conducted by a single examiner [physiotherapist] previously trained with 6 years of experience.

Numerical Pain Scale (NPS): This is an easy-to-apply scale, where the individuals will be asked to respond, in a numerical sequence from 0 (no pain) to 10 (worst pain), how intense their pain is [45].

Convergence Test (CT): This instrument will be used to diagnose CI and evaluate the balance of the extrinsic ocular muscles. The operator will move a digital caliper (150mm/6"), from Starrett ® Ind. e Com. LTDA, toward the nose at eye level (Fig. 6), allowing the estimation of the distance by which the two eyes diverge; less than 4.0 cm will be considered normal, 4.1–6.9 cm will be considered sufficient, and greater than or equal to 7 will be considered insufficient [46].

Convergence Insufficiency Symptom Questionnaire (CISS): Developed by the Convergence Insufficiency Treatment Trial, the CISS is a validated and reliable instrument composed of 15 items, which quantifies the frequency and type of symptoms related to convergence insufficiency or other binocular or accommodative disorders. It is classified from 0 to 10 points: normal binocular vision; 11 to 36 points: suspected CI, and 37 to 60 points: CI [47].

Secondary outcome measures:

Mandibular Function Impairment Questionnaire (MFIQ): This is a validated tool for the Portuguese language and is reliable for evaluating mandibular function in individuals with TMD [48]. It has two domains: functional capacity and nutrition. The higher the score, the greater the functional limitation.

Fonseca Anamnestic Index (FAI): This instrument classifies TMD according to severity [37]. The sum of the points is classified as no TMD (0-15 points), mild TMD (20-40 points), moderate TMD [45-65 points], and severe TMD [70-100 points] [49].

Sample size: The sample size was calculated from a pilot study with eight individuals with TMD and CI, aged between 18 and 45 years, considering the mean and standard deviation of the pre- and post-intervention conditions for each clinical outcome [primary]. For the calculation, the values $\alpha = 0.05$ [5% chance of type I error] and $1-\beta = 0.95$ [% of sample power] were considered. The number of individuals was estimated for each outcome studied to compose the sample. The possibility of a sample loss of 20% was also considered and added to the estimated calculation (Table 1). Calculations were performed using G*Power software [50].

Statistical analysis: The normality of data related to outcome measures will be verified using the Shapiro-Wilk test. Participant characteristics will be verified using descriptive statistics (test *t* independent), and possible differences between groups will be tested using linear mixed models, considering the moments before, after 12 treatment sessions, after 3

months of treatment, and after 6 months of treatment. The differences between the groups [treatment effects] and their respective confidence intervals (95%CI) will be calculated through the construction of linear mixed models [51] using interaction terms of treatment groups versus time, with all models adjusted to initial estimates. If the data do not present a normal distribution, Friedman's ANOVA with Dunn's post hoc test will be used. The statistical significance considered will be $p<0.05$.

Cohen *d* and the partial eta squared ($_p{}^2$) will be used to calculate the effect size of the results [52], and the interpretation will be based on the values established by Cohen: low effect (*d* =0.2 and $_p{}^2 = 0.01$); moderate effect (approximately *d* =0.5 and $_{p2} = {}^{0.06}$); and large effect (from: *d* =0.8 and $_p{}^2 = 0.14$).

For data analysis, a value of $p < 0.05$ will be considered. These analyses will be performed using SPSS 20.0 software [SPSS Inc., Chicago, USA].

Table 1. Sample for each clinical outcome, with a 20% increase

	Sample	20%
Primary Outcome		
Pain Intensity	09	11
Ocular Convergence	25	30
Symptoms of Ocular Convergence	42	50

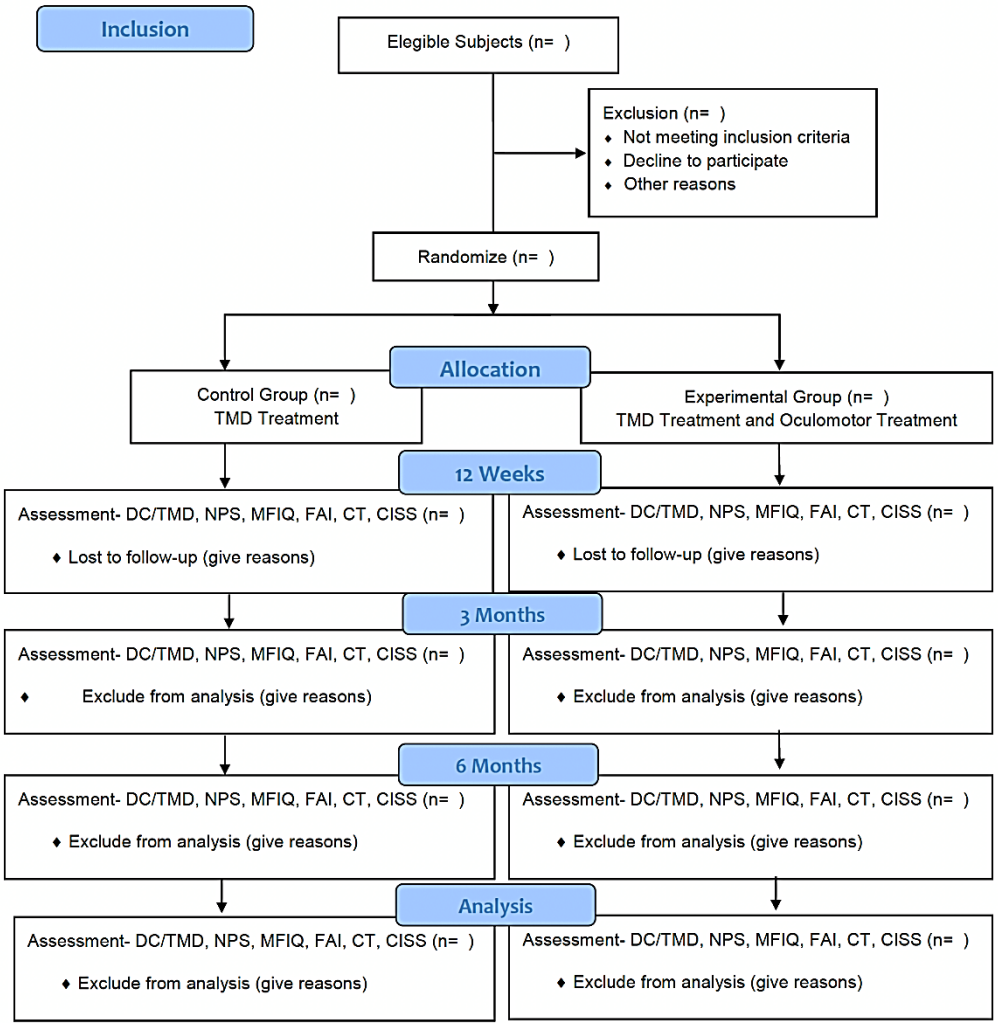

Fig. 1. Study design flowchart according to CONSORT
(NPS: Numerical Pain Scale; FAI: Fonseca Anamnestic Index; CT: Convergence test)

Fig. 2. [a] Extraoral massage on the masticatory muscles; [b] Intraoral massage on the masticatory muscles; [c] Myofascial Release Massage: [c1] Masseter; [c2] Sternocleidomastoid; [c 3] Temporalis; [d1] Cervical Pompage; [d1] Suboccipital Inhibition; [d2] Passive Anteroposterior Mobilization of the Upper Cervical

Fig. 3. Cervical Exercises: [a] Flexion; [b] Extension; [c] Left Rotation; [d] Right Rotation; [e] Left lateral inclination; [f] Right lateral inclination

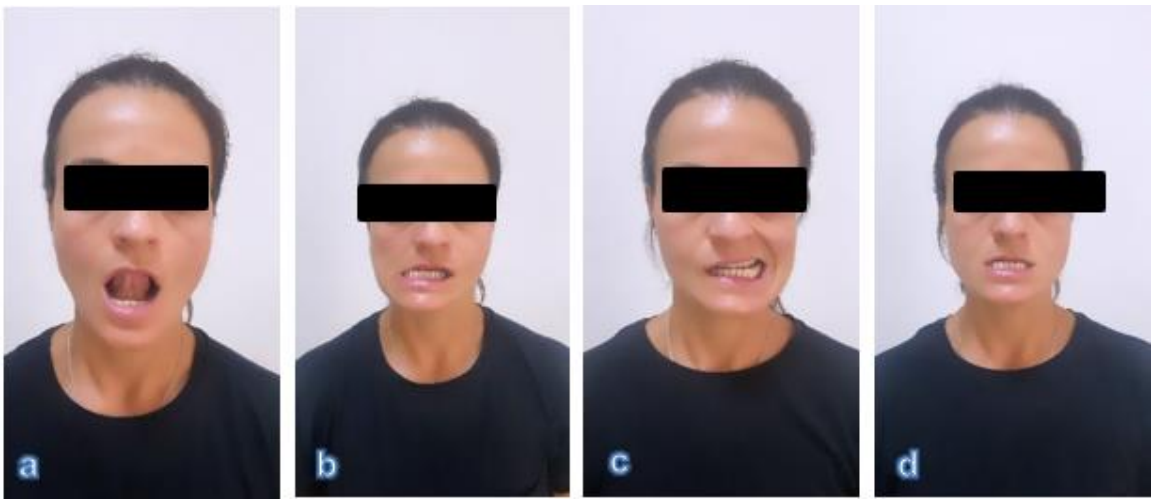

Fig. 4. Exercises for the TMJ: [a] Opening the mouth with the tongue on the palate; [b] Right Lateralization; [c] Left Lateralization; [d] Protrusion

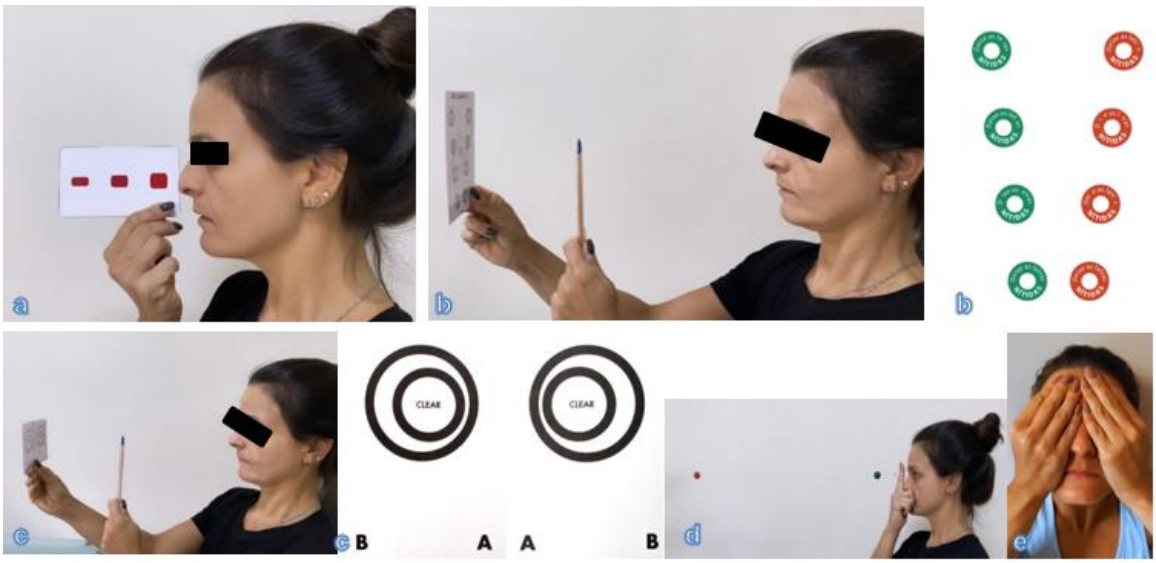

Fig. 5. [a] Barrile Chart; [b] Life Saving Letter; [c] Eccentric Circles; [d] Brock cord [e] Eye relaxation

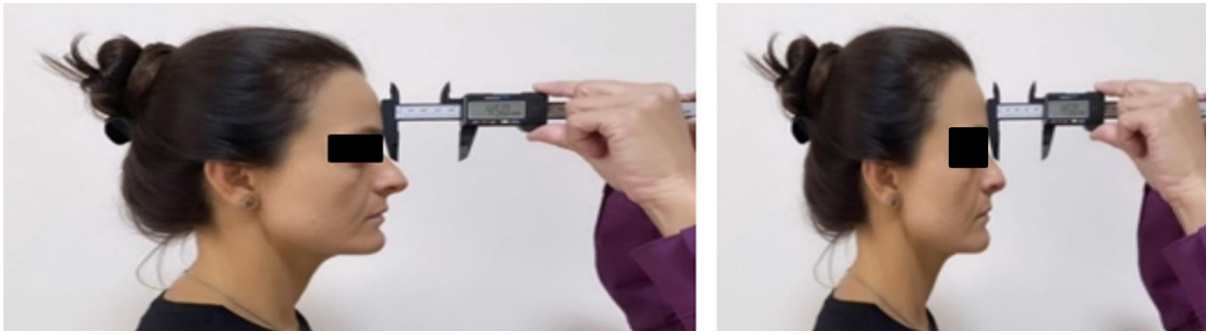

Fig. 6. Convergence test

3. RESULTS

The protocol of the present study is innovative because in a pilot study conducted in our laboratory, before the development of this protocol, we observed that patients who received treatment for TMD with the addition of oculomotor therapy benefited with results for the outcome pain, range of motion, and ocular convergence. To determine the success of the intervention protocol, a minimum clinically important difference (MCID) will be considered, i.e., a 30% decrease in pain intensity and an increase in range of motion between 3 and 9 mm [53]. In addition, there will be a change in the severity of TMD. For the convergence test, values smaller than 4.0 cm will be considered normal, and 4.1–6.9 cm will be considered sufficient convergence [46].

4. DISCUSSION

The study protocol will be the first randomized, blind, and controlled clinical trial that describes a methodology to evaluate the additional effect of an oculomotor rehabilitation protocol on the treatment for TMD, which aims to evaluate the intensity of perceived pain, range of mandibular movement, ocular convergence insufficiency, and severity of TMD in individuals with TMD.

This study highlights the importance of therapeutic exercises and manual therapy, supported by existing evidence [36,35], to promote strength, coordination, mobility, and pain relief in the management of TMD. Furthermore, to the best of our knowledge, no previous study has investigated the additional effect of an oculomotor rehabilitation protocol on a rehabilitation program for TMD. We believe that this study will help to better understand whether eye exercises contribute to the chosen outcomes when compared before, after 12 sessions, and at follow-up.

In the clinical practice of physiotherapy, it is common to include global mandibular exercises and manual therapy for treating patients with TMD. However, the literature is inconsistent regarding the best therapeutic practices for CI in adults. A systematic review with meta-analysis showed the use of different therapeutic strategies to improve ocular convergence and its symptoms. The resources used were compared with those of other therapies and placebo.

This study suggests that accommodative vergence therapy with home reinforcement can significantly increase the chances of therapeutic success compared with placebo therapy [54].

However, the body of therapeutic evidence becomes limited when we combine CI in patients with TMD. To date, no studies have shown the effect of oculomotor interventions in improving the symptoms of this dysfunction and CI in this population. There is a possibility of a connection between the oculomotor system and the stomatognathic system [13,14,15,16,17], as well as significant relationships between CI and TMD [13,14], this protocol can add evidence to clinical practice. However, as TMD is multifactorial, the need for multimodal approaches to managing symptoms has been shown to be effective in reducing pain intensity and improving muscle function [55], justifying the use of oculomotor therapy added to other interventions already used to treat TMD in this protocol.

The lack of standardization in interventions for this population makes it important to develop targeted studies to identify effective therapeutic approaches [55,23,55]. In summary, this study seeks to fill gaps in the scientific literature by providing useful findings to optimize the treatment of individuals with TMD and CI through a multimodal approach, which can help physiotherapists and patients select the most appropriate treatments for convergence insufficiency in patients who present with this dysfunction and TMD [52,56-59].

5. CONCLUSION

This study will evaluate whether the addition of oculomotor exercises decreases perceived pain intensity and improves mandibular range of motion and ocular convergence and its symptoms (headache, discomfort, drowsiness and diplopia, eye fatigue, blurred vision, difficulty concentrating, tearing, orbital discomfort, among others) in patients with TMD who have CI. This protocol seeks to determine whether the addition of oculomotor exercises can guarantee the success of rehabilitation and thus be included in therapeutic planning for patients with TMD.

6. LIMITATIONS

The strengths of this study include the combination of exercises that are easy to perform for eligible patients. However, this study may present some limitations such as possible loss of participants during the study and follow-up, in addition to possible biases or challenges in blinding.

7. FUTURE RESEARCH

This protocol may contribute to new research possibilities, including oculomotor exercises combined with other therapeutic techniques and isolation in patients with TMD and headaches. Opening a new field of investigation. The approach can also be integrated into clinical practice as a complement to conventional TMD therapy, expanding the therapeutic options available to healthcare professionals and patients.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

CONSENT AND ETHICAL APPROVAL

This protocol follows specific research guidelines for human subjects and was approved by the University's Research Ethics Committee (CAAE: 56799322.9.0000.5511; document number: 5.453.957). Individuals who agree to participate in the research will sign the written Consent Form. The protocol was registered at ClinicalTrials.gov (NCT05761106). This study will be carried out at the University's Musculoskeletal Research Center (NUPEM).

ACKNOWLEDGEMENTS

The authors would like to thank the Universidade Nove de Julho, represented by the Rector Prof. José Eduardo Storopoli, the Director João Carlos Ferrari of Rehabilitation Sciences, and all those who will participate in the study. This work will be partially funded by the Coordination for the Improvement of Higher Education Personnel (CAPES), financial code 001. This funding source had no role in the design of this study and will have no role during its execution, analysis, interpretation of data or decision to present results.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Widmer DE, Oechslin TS, Limbachia C, Kulp MT, Toole AJ, Kashou NH, et al. Post-therapy functional magnetic resonance imaging in adults with symptomatic convergence insufficiency. Optom Vis Sci. 2018, Jun; 95(6):505-514. DOI: 10.1097/OPX.0000000000001221. PMID: 29787484.
2. Scheiman M, Wick B. Clinical Management of Binocular Vision: Heterophoric, Accommodative, and Eye Movement Disorders. 3rd ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2008.
3. Alvarez TL, Vicci VR, Alkan Y, Kim EH, Gohel S, Barrett AM, et al. Vision therapy in adults with convergence insufficiency: Clinical and functional magnetic resonance imaging measures. Optom Vis Sci. 2010, Dec;87(12):E985-1002. PMID: 21057347; PMCID: PMC3134155. DOI : 10.1097/OPX.0b013e3181fef1aa.
4. Pickwell LD, Hampshire R. The significance of inadequate convergence. Ophthalmic Physiol Opt. 1981;1(1):13-8. PMID: 7339524.
5. Daum KM. Convergence insufficiency. Am J Optom Physiol Opt. 1984, Jan;61(1):16-22. DOI:10.1097/00006324-198401000-00003. PMID: 6702996.
6. Bade A, Boas M, Gallaway M, Mitchell GL, Scheiman M, Kulp MT, Cotter SA, Rouse M, CITT Study Group. Relationship between clinical signs and symptoms of convergence insufficiency. Optom Vis Sci. 2013, Sep;90(9):988-95. DOI: 10.1097/OPX.0000000000000012. PMID: 23958713; PMCID: PMC3929100.
7. Aletaha M, Daneshvar F, Mosallaei M, Bagheri A, Khalili MR. Comparison of three vision therapy approaches for convergence insufficiency. J Ophthalmic Vis Res. 2018, Jul-Sep;13(3):307-314. DOI: 10.4103/jovr.jovr_99_17. PMID: 30090188; PMCID: PMC6058546.
8. Porcar E, Martinez-Palomera A. Prevalence of general binocular dysfunctions in a population of university students. Optom Vis Sci. 1997, Feb;74(2): 111-3. DOI: 10.1097/00006324-199702000-00023. PMID: 9097328.
9. Cooper J, Jamal N. Convergence insufficiency-A major review. Optometry. 2012, Apr 30;83(4):137-58. PMID: 23231437.
10. Bastos A. Assessment and types of intervention in Convergence Insufficiency: A systematic review; 2018.

11. Scheiman M, Mitchell GL, Cotter S, Kulp MT, Cooper J, Rouse M. A randomized clinical trial of vision therapy/orthoptics versus pencil pushups for the treatment of convergence insufficiency in young adults. Optom Vis Sci. 2005, Jul;82(7):583-95. DOI:10.1097/01.opx.0000171331.36871.2f PMID: 16044063.
12. Convergence Insufficiency Treatment Trial (CITT) Study Group. The convergence insufficiency treatment trial: design, methods, and baseline data. Ophthalmic Epidemiol. 2008, Jan-Feb; 15(1):24-36. PMID: 18300086; PMCID: PMC2782898. DOI :10.1080/09286580701772037.
13. Dos Santos DM, Politti F, de Azevedo LMA, de Cassia das Neves Martins R, Ricci FC, Masuda KSY, et al. Association between convergence insufficiency and temporomandibular disorder cross-Sectional study. Clin Oral Investig. 2021, Mar;25(3):851-858. DOI : 10.1007/s00784-020-03372-8. Epub 2020 Jun 4. PMID: 32500402.
14. Monaco A, Streni O, Marci MC, Sabetti L, Giannoni M. Convergence defects in patients with temporomandibular disorders. Skull. 2003, Jul; 21(3):190-5. PMID: 12889675. DOI: 10.1080/08869634.2003.11746250.
15. Monaco A, Streni O, Marci MC, Sabetti L, Marzo G, Giannoni M. Relationship between mandibular deviation and ocular convergence. J Clin Pediatr Dent. 2004, Winter;28(2):135-8. DOI: 10.17796/jcpd.28. 2.mj 7311l03m257134. PMID: 14969372.
16. Wang N, May PJ. Peripheral muscle targets and central projections of the mesencephalic trigeminal nucleus in macaque monkeys. Anat Rec (Hoboken). 2008, Aug;291(8):974-87. DOI : 10.1002/ar.20712. PMID: 18461596; PMCID: PMC2859174.
17. Nyberg G, Blomqvist A. The central projection of muscle afferent fibers to the lower medulla and upper spinal cord: An anatomical study in the cat with the transganglionic transport method. J Comp Neurol. 1984, Nov 20;230(1):99-109. DOI : 10.1002/cne.902300109. PMID: 6096417.
18. Morquette P, Lavoie R, Fhima MD, Lamoureux X, Verdier D, Kolta A. Generation of the masticatory central pattern and its modulation by sensory feedback. Program Neurobiol. 2012, Mar;96(3):340-55. It hurts 10.1016/j.pneurobio.2012.01.011. Epub 2012 Feb 9. PMID: 22342735.
19. Herrera-Valencia A, Ruiz-Muñoz M, Martin-Martin J, Cuesta-Vargas A, González-Sánchez M. Efficacy of manual therapy in temporomandibular joint disorders and its medium- and long-term effects on pain and maximum mouth opening: A systematic review and meta-analysis. J Clin Med. 2020, Oct 23;9(11): 3404. DOI: 10.3390/jcm9113404. PMID: 33114236; PMCID: PMC7690916.
20. Kalladka M, Young A, Khan J. Myofascial pain in temporomandibular disorders: Updates on etiopathogenesis and management. J Bodyw Mov Ther. 2021, Oct; 28:104-113. DOI: 10.1016/j.jbmt.2021.07.015. Epub 2021 Aug 8. PMID: 34776126.
21. Armijo-Olivo S, Pitance L, Singh V, Neto F, Thie N, Michelotti A. Effectiveness of manual therapy and therapeutic exercise for temporomandibular disorders: Systematic review and meta-analysis. Phys Ther. 2016, Jan;96(1):9-25. Epub 2015 Aug 20. PMID: 26294683; PMCID: PMC4706597. DOI : 10.2522/ptj.20140548.
22. Okeson JP. Management of Temporomandibular Disorders and Occlusion, Missouri Elsevier Mosby, St. Louis, MI, USA, 7th; edition; 2012.
23. Valesan LF, Da-Cas CD, Defendants JC, Denardin ACS, Garanhani RR, Bonotto D, Januzzi E, de Souza BDM. Prevalence of temporomandibular joint disorders: A systematic review and meta-analysis. Clin Oral Investig. 2021, Feb; 25(2): 441-453. Epub 2021 Jan 6. PMID: 33409693. DOI : 10.1007/s00784-020-03710-w.
24. Gonçalves DA, Dal Fabbro AL, Campos JA, Bigal ME, Speciali JG. Symptoms of temporomandibular disorders in the population: an epidemiological study. J Orofac Pain. 2010 Summer;24(3):270-8. PMID: 20664828.
25. Fernández-de-las-Penas C, Svensson P. Myofascial temporomandibular disorder. Curr Rheumatol Rev. 2016;12(1):40-54. PMID: 26717949. DOI:10.2174/1573397112666151231110947.
26. Manfredini D, Guarda-Nardini L, Winocur E, Piccotti F, Ahlberg J, Lobbezoo F.

Research diagnostic criteria for temporomandibular disorders: A systematic review of axis I epidemiological findings. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2011, Oct;112(4):453-62. Epub 2011 Aug 11. PMID: 21835653.
DOI: 10.1016/j.tripleo.2011.04.021.

27. Dahan H, Shir Y, Velly A, Allison P. Specific and number of comorbidities are associated with increased levels of temporomandibular pain intensity and duration. J Headache Pain. 2015;16:528. Epub 2015 May 20. PMID: 26002637; PMCID: PMC4441879.
DOI: 10.1186/s10194-015-0528-2.
28. Rener -Sitar K, John MT, Bandyopadhyay D, Howell MJ, Schiffman EL. Exploration of dimensionality and psychometric properties of the Pittsburgh Sleep Quality Index in cases with temporomandibular disorders. Health Qual Life Outcomes. 2014, Jan 21;12:10 .
DOI: 10.1186/1477-7525-12-10. PMID: 24443942; PMCID: PMC3902412.
29. Ferrillo M, Ammendolia A, Paduano S, et al. Efficacy of rehabilitation on reducing pain in muscle-related temporomandibular disorders: A systematic review and meta-analysis of randomized controlled trials. J Back Musculoskelet Rehabil. 2022; 35(5):921-936.
DOI:10.3233/BMR-210236. PMID: 35213347.
30. Urbański P, Trybulec B, Pihut M. The Application of manual techniques in masticatory muscles relaxation as adjunctive therapy in the treatment of temporomandibular joint disorders. Int J Environ Res Public Health. 2021, Dec 8; 18(24):12970. PMID: 34948580; PMCID: PMC8700844.
DOI: 10.3390/ijerph182412970.
31. Butcher NJ, Monsour A, Mew EJ, Chan AW, Moher D, Mayo-Wilson E, Terwee CB, Chee-A-Tow A, Baba A, Gavin F, Grimshaw JM, Kelly LE, Saeed L, Thabane L, Askie L, Smith M, Farid-Kapadia M, Williamson PR, Szatmari P, Tugwell P, Golub RM, Monga S, Vohra S, Marlin S, Ungar WJ, Offringa M. Guidelines for Reporting Outcomes in Trial Reports: The CONSORT- Outcomes 2022 Extension. JAMA. 2022, Dec 13;328(22):2252-2264.
DOI: 10.1001/jama.2022.21022. PMID: 36511921.
32. Chan AW, Tetzlaff JM, Altman DG, Laupacis A, Gøtzsche PC, Krleža-Jerić K, Hróbjartsson A, Mann H, Dickersin K, Berlin JA, Doré CJ, Parulekar WR, Summerskill WS, Groves T, Schulz KF, Sox HC, Rockhold FW, Rennie D, Moher D. SPIRIT 2013 statement: defining standard protocol items for clinical trials. Ann Intern Med. 2013, Feb 5; 158(3):200-7. PMID: 23295957;
PMCID: PMC5114123.
DOI: 10.7326/0003-4819-158-3-201302050-00583.
33. Hurst H, Bolton J. Assessing the clinical significance of change scores recorded on subjective outcome measures. J Manipulative Physiol Ther. 2004, Jan; 27(1):26-35.
DOI: 10.1016/j.jmpt.2003.11.003.
PMID: 14739871.
34. Domingues L, Cruz E. Cultural adaptation and contribution to the validation of the patient global impression scale of change. Escola Sup de Saúde do Inst Politécnico de Setúbal. 2011;2(1):31-37.
35. Busse JW, Casassus R, Carrasco-Labra A, Durham J, Mock D, Zakrzewska JM, Palmer C, Samer CF, Coen M, Guevremont B, Hoppe T, Guyatt GH, Crandon HN, Yao L, Sadeghirad B, Vandvik PO, Siemieniuk RAC, Lytvyn L, Hunskaar BS, Agoritsas T. Management of chronic pain associated with temporomandibular disorders: A clinical practice guideline. BMJ. 2023, Dec 15;383: e076227. PMID: 38101929.
DOI : 10.1136/bmj-2023-076227.
36. de Melo LA, Bezerra de Medeiros AK, Campos MFTP, Bastos Machado de Resende CM, Barbosa GAS, de Almeida EO. Manual therapy in the treatment of myofascial pain related to temporomandibular disorders: A systematic review. J Oral Facial Pain Headache. 2020, Spring. 34(2):141-148. PMID: 32255579.
DOI : 10.11607/ofph.2530.
37. Miernik M, Wieckiewicz M, Paradowska A, Wieckiewicz W. Massage therapy in myofascial TMD pain management. Adv Clin Exp Med. 2012, Sep-Oct;21(5):681-5. PMID: 23356206.
38. Ghodrati M, Mosallanezhad Z, Shati M. Adding Temporomandibular joint treatments to routine physiotherapy for patients with non-specific chronic neck pain: A randomized clinical study. J Bodyw Mov Ther. 2020, Apr; 24(2):

202-212. Epub 2019 Nov 22. PMID: 32507146.
DOI : 10.1016/j.jbmt.2019.11.004.

39. Silva M, Bustamante B. Physiotherapeutic approaches in cervicocraniomandibular disorders. Publishing Company Total; 2022.
40. Calixtre LB, Oliveira AB, de Sena Rosa LR, Armijo-Olivo S, Visscher CM, Alburquerque-Sendín F. Effectiveness of mobilization of the upper cervical region and craniocervical flexor training on orofacial pain, mandibular function and headache in women with TMD. A randomized, Controlled Trial. J Oral Rehabil. 2019, Feb; 46(2):109-119.
DOI: 10.1111/joor.12733. Epub 2018 Oct 26. PMID: 30307636.
41. Maitland G, Hengeveld E, et al. Maitland's Vertebral Manipulation. 7th Edition; 2005.
42. Shaffer SM, Brismée JM, Sizer PS, Courtney CA. Temporomandibular disorders. Part 2: conservative management. J Man Manip The R. 2014, Feb; 22(1):13-23. PMID: 24976744; PMCID: PMC4062348.
DOI : 10.1179/2042618613Y.0000000061.
43. Lindfors E, Arima T, Baad -Hansen L. Jaw exercises in the treatment of temporomandibular disorders-An international modified delphi study. J Oral Facial Pain Headache. 2019, Fall; 33(4):389–398. Epub 2019 Jun 24. PMID: 31247061.
DOI : 10.11607/ofph.2359.
44. Ahmad M, Hollender L, Anderson Q, Kartha K, Ohrbach R, Truelove EL, John MT, Schiffman EL. Research diagnostic criteria for temporomandibular disorders (RDC/TMD): Development of image analysis criteria and examiner reliability for image analysis. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009, Jun; 107(6):844-60. PMID: 19464658; PMCID: PMC3139469.
DOI 10.1016/j.tripleo.2009.02.023.
45. Ferreira-Valente MA, Pais-Ribeiro JL, Jensen MP. Validity of four pain intensity rating scales. Pain. 2011, Oct;152(10):2399-2404.
PMID: 21856077.
DOI : 10.1016/j.pain.2011.07.005.
46. Cuccia AM, Caradonna C. Binocular motility system and temporomandibular joint internal derangement: A study in adults. Am J Orthod Dentofacial Orthop. 2008, May;133(5):640.e 15-20.
DOI: 10.1016/j.ajodo.2007.10.034. PMID: 18456134.
47. Tavares C, Nunes AM, Nunes AJ, Pato MV, Monteiro PM. Translation and validation of Convergence Insufficiency Symptom Survey (CISS) to Portuguese - psychometric results. Arq Bras Oftalmol. 2014, Jan-Feb;77(1):21-4.
PMID: 25076368.
DOI: 10.5935/0004-2749.20140007.
48. Campos JA, Carrascosa AC, Maroco J. Validity and reliability of the Portuguese version of mandibular function impairment questionnaire. J Oral Rehabil. 2012, May; 39(5):377-83. Epub 2012 Jan 17. PMID: 22251134.
DOI: 10.1111/j.1365-2842.2011. 02276.x.
Pereira LJ, Steenks MH, de Wijer A, Speksnijder CM, van der Bilt A. Masticatory function in subacute TMD patients before and after treatment. J Oral Rehabil. 2009, Jun; 36(6):391-402. Epub 2009 Feb 6. PMID: 19210681
DOI: 10.1111/j.1365-2842.2008. 01920.x.
49. Bevilaqua-Grossi D, Chaves TC, de Oliveira AS, Monteiro-Pedro V. Anamnestic index severity and signs and symptoms of TMD. Skull. 2006, Apr;24(2):112-8. PMID: 16711273. 2006.
DOI: 10.1179/crn.2006.018.
50. Faul F, Erdfelder E, Lang AG, Buchner A. G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav Res Methods. 2007, May;39(2):175-91.
DOI:10.3758/bf03193146. PMID: 17695343.
51. Twisk, Jos WR applied longitudinal data analysis for epidemiology: A practical guide. Cambridge, USA: Cambridge University Press; 2003.
52. Cohen J. Statistical Power Analysis for the Behavioral Sciences, 2 edition. Routledge, Hillsdale, NJ; 1998.
53. Calixtre LB, Oliveira AB, Alburquerque-Sendín F, Armijo-Olivo S. What is the minimal important difference of pain intensity, mandibular function, and headache impact in patients with temporomandibular disorders? Clinical significance analysis of a randomized controlled trial. Musculoskelet Sci Pract. 2020, Apr;46:102108. Epub 2020 Jan 11. PMID: 31999615.
DOI : 10.1016/j.msksp.2020.102108.
54. Scheiman M, Kulp MT, Cotter SA, Lawrenson JG, Wang L, Li T. Interventions

for convergence insufficiency: A network meta-analysis. Cochrane Database Syst Rev. 2020, Dec 2;12(12):CD006768. PMID: 33263359;
PMCID: PMC8092638.
DOI: 10.1002/14651858.CD006768.pub3.

55. López-de- Uralde -Villanueva I, Beltran-Alacreu H, Fernández- Carnero J, La Touche R. Pain management using a multimodal physiotherapy program including a biobehavioral approach for chronic nonspecific neck pain: A randomized controlled trial. Physiother Theory Practice. 2020;36:45 –62.
Available:https://doi.org/10.1080/09593985.2018.1480678

56. Melis M, Di Giosia M, Zawawi KH. Oral myofunctional therapy for the treatment of temporomandibular disorders: A systematic review. Skull. 2022, Jan;40(1): 41-47.
DOI: 10.1080/08869634.2019.1668996. Epub 2019 Sep 17.
PMID: 31530110.

57. Park JW, Clark GT, Kim YK, Chung JW. Analysis of thermal pain sensitivity and psychological profiles in different subgroups of TMD patients. Int J Oral Maxillofac Surg. 2010, Oct;39(10):968-74. Epub 2010 Jul 6. PMID: 20609564.
DOI : 10.1016/j.ijom.2010.06.003.

58. Oliveira SS, Pannuti CM, Paranhos KS, Tanganeli JP, Laganá DC, Sesma N, Duarte M, Frigerio ML, Cho SC. Effect of occlusal splint and therapeutic exercises on postural balance of patients with signs and symptoms of temporomandibular disorder. Clinical and Experimental Dental Research. 2019, Apr;5(2):109-15.

59. Raja GP, Bhat NS, Fernández-de-las-Peñas C, Gangavelli R, Davis F, Shankar R, Prabhu A. Effectiveness of deep cervical fascial manipulation and yoga postures on pain, function, and oculomotor control in patients with mechanical neck pain: Study protocol of a pragmatic, parallel-group, randomized, controlled trial. Trials. 2021, Aug 28;22(1):574.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/119402