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The Effect of a Single Temporomandibular Joint Soft Tissue Therapy on Cervical Spine Mobility, Temporomandibular Joint Mobility, Foot Load Distribution, and Body Balance in Women with Myofascial Pain in the Temporomandibular Joint Area—A Randomized Controlled Trial

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Abstract: In contemporary times, a significant portion of the population experiences symptoms of temporomandibular joint (TMJ) dysfunction. The objective of this study was to evaluate the effects of a single-session TMJ soft tissue therapy on the TMJ and cervical spine mobility as well as on body balance and the foot load distribution. This study was a parallel-group, randomized, controlled trial with a 1:1 allocation ratio. Fifty women aged 20–30 years diagnosed with myofascial pain in the TMJ area were included in the study and divided into two groups. The experimental group received TMJ soft tissue therapy. The following research tools were used: a Hogetex electronic caliper, a CROM Deluxe, and a FreeMed Base pedobarographic platform. In the experimental group, an increase in mobility within all assessed jaw and cervical spine movements was observed. This change was statistically significant ($p < 0.05$) for lateral movement to the left, abduction, and protrusion of the jaw (an increase of 10.32%, 7.07%, and 20.92%, respectively) and for extension, lateral bending to the right and left, and rotation to the right and left, of the cervical spine (an increase of 7.05%, 7.89%, 10.44%, 4.65%, and 6.55%, respectively). In the control group, no significant differences were observed. No significant changes were observed in the load distribution and body balance assessment. A single session of TMJ soft tissue therapy increases jaw and cervical spine mobility but does not impact body balance or foot load distribution in static conditions in women diagnosed with myofascial pain in the TMJ area.

Keywords: temporomandibular joint; cervical spine mobility; foot load distribution; body balance

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1. Introduction

In contemporary times, a majority of the population experiences symptoms of temporomandibular joint (TMJ) dysfunction [1,2]. The causes of TMJ dysfunction include structural factors (e.g., muscular, skeletal, and neural), functional factors (e.g., lifestyle and body posture), psychological factors (e.g., stress), or any combination of these factors [3]. Epidemiological data on prevalence rates are highly variable [4]. Women are four times more likely to report temporomandibular joint dysfunctions, which, according to the authors, is due to hormonal factors and gender-specific biological characteristics [5]. TMJ dysfunctions often manifest as symptoms such as temporofacial pain, headaches, limited range of motion, a feeling of joint clicking, and acoustic symptoms such as joint clicking and crepitus. Prolonged excessive tension in the aforementioned structures can affect other sections of the spine, limbs, and even internal organs [6]. Changes in the TMJ cause adaptations throughout the musculoskeletal system, leading to postural changes, modifying the body's biomechanics, and disrupting overall body alignment [7].

The masticatory muscles, including not only the masseter muscle but also the temporalis and pterygoid muscles, play essential roles in jaw movement, stability, and the overall function of the temporomandibular joint. The masseter, temporalis, and pterygoid muscles are involved in various functional activities of the stomatognathic system, including chewing, swallowing, and speech. This range of functions requires coordination of the neuromuscular system with the appropriate activation of the tongue, facial, and pharyngeal muscles. In this regard, chewing is one of the most complex and coordinated functional movements, involving diverse jaw patterns [8,9]. Structurally, the jaw is connected to other body areas through the deep anterior fascial line. Myofascial lines are defined as direct connections between adjacent muscular structures within the fascial network. Tensions and overloads are transmitted along these lines. Due to its course, the deep anterior line connects two distant areas—the soles of the feet and the temporomandibular joints [10]. Studies indicate differences in foot load distribution between individuals with TMJ dysfunction and those without. Additionally, occlusal conditions of the masticatory system impact foot load distribution [11]. There is also an observed correlation between the stomatognathic system and body posture and postural stability [12].

Some scientific studies confirm clinical, anatomical, and functional links between the cranial area, TMJ, and cervical spine [13–15]. Nevertheless, the mechanism of this relationship remains unclear, and the correlation between TMJ disorders (TMD) and changes in head and neck posture remains controversial. Understanding the complex relationships between the stomatognathic system, cervical spine, pain, and dysfunction in other body areas is crucial for effectively treating patients at an early stage of painful symptoms and achieving faster and more effective therapeutic outcomes.

Current research suggests that cervical spine manual therapy can positively impact patients with TMJ disorder symptoms. This approach has demonstrated significant improvements in TMJ range of motion and a reduction in facial pain [16–18].

The authors indicate that the TMJ and cervical spine have interconnected relationships through neuroanatomical and neurophysiological structures, where issues in one area can influence symptoms in the other. Physical therapy applied to both areas over a three-month period has shown significant symptom reduction in both the TMJ and cervical regions. This finding supports an integrative treatment approach that addresses both the TMJ and cervical spine to enhance patient outcomes in cases of co-occurring dysfunction [19].

A review of the literature reveals that most existing studies focus primarily on the impact of TMJ therapy on the mobility of the TMJ itself. Some of these studies relate to the cervical spine. Few studies address the impact of TMJ therapy on body balance. There is a lack of comprehensive, multi-faceted studies on the muscles within the anterior myofascial chain. Considering the frequent occurrence of TMJ disorders, as well as the connection of the stomatognathic system with other parts of the body, there is a need to expand research in this area. The functional and structural connections between elements of the musculoskeletal system suggest that the applied local therapy may produce beneficial effects, not only in the temporomandibular joints but also in the cervical spine and in the feet. The objective of this study was to evaluate the effects of a single-session TMJ soft tissue therapy on the mobility of the cervical spine and temporomandibular joints in women aged 20–30 years diagnosed with myofascial pain in the TMJ area. Additionally, considering the connections within the anterior myofascial chain, the impact of the therapy on foot load distribution and body balance was assessed. We hypothesized that the applied single-session therapy, through the connections between the TMJ and distant parts of the body, would increase jaw and cervical spine mobility, as well as improve body balance and weight distribution on the feet. Consequently, the null hypothesis was: a single-session TMJ soft tissue therapy does not impact jaw and cervical spine mobility, nor does it influence body balance and foot load distribution in women diagnosed with myofascial pain in the TMJ area.

2. Materials and Methods

2.1. Participants

The study included 50 women aged 20–30 years (23.64 ± 2.05) diagnosed with myofascial pain in the TMJ area. The participants' body weights ranged from 43 to 76.5 kg (59.26 ± 7.88), and their heights ranged from 150 to 180 cm (166.18 ± 6.37). The inclusion criteria were as follows: consent to participate in the study, age 20–30 years, absence of pregnancy and miscarriages, nulliparity, and presence of the following symptoms within the temporomandibular joint area: pain modified with jaw movement, function or parafunction; pain in the jaw, temple, in the ear, or in front of ear; confirmation of pain location in the temporalis or masseter muscle during the examination; report of pain spreading beyond the site of palpation but within the boundary of the muscle; and report of familiar pain with palpation of the temporalis or masseter muscle. The diagnosis was confirmed by a maxillofacial surgeon in accordance with Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) [20].

Exclusion criteria were as follows: pregnancy; neurological, systemic, or mental disorders; recent orthopedic procedures; injuries within the last 6 months prior to the study; participation in TMJ therapy within the last 6 months; malocclusion; orthodontic treatment; and presence of implants. In studies on TMJ, it is recognized that patients with injuries occurring within six months prior to the study may present symptoms that could distort the interpretation of results. Therefore, excluding these patients is standard practice in clinical research [21].

Participants were recruited from 22 September to 27 October 2023 before the measurements started. All measurements were finished by 9 November 2023. The study flow diagram is presented in Figure 1.

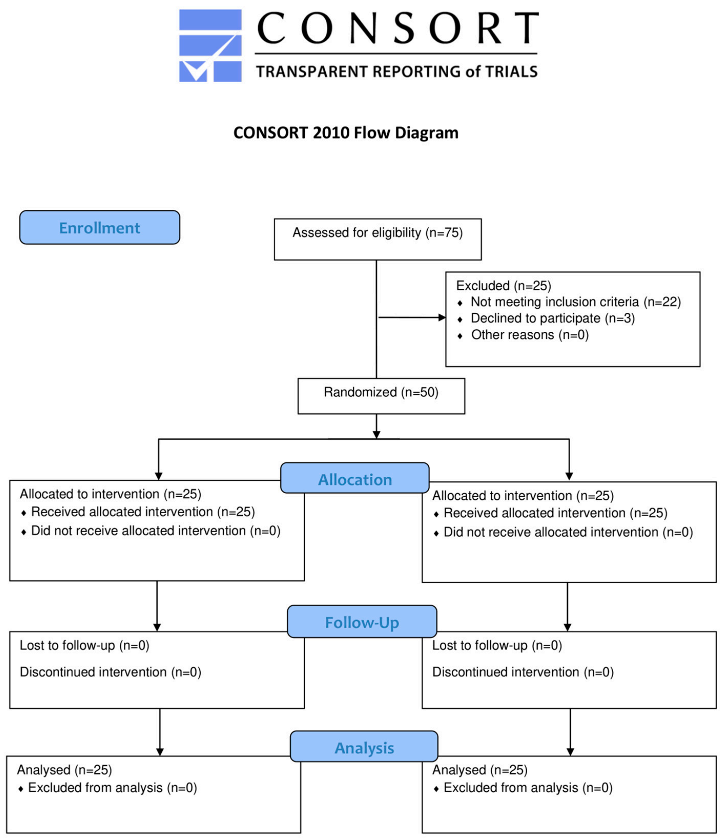

Figure 1. CONSORT flow diagram.

The study was conducted in the Functional Diagnostics Laboratory of the Central Scientific Research Laboratory at the University School of Physical Education in Kraków.

The study was conducted according to the guidelines of the Declaration of Helsinki. Ethical approval for the study was obtained from the Bioethics Committee, approval number KBKA/50/O/2023. The project was funded under the Ministry of Science and Higher Education program "Regional Initiative of Excellence" for the years 2019–2022, project number 022/RID/2018/19, with a total funding of 11,919,908 PLN. The study was registered on the Australian New Zealand Clinical Trials Registry platform (registration ID: ACTRN12623000766617). The study followed the CONSORT guideline for randomized controlled trials.

This study was a parallel-group, randomized controlled trial. The eligible participants were randomized in a 1:1 allocation ratio to either the intervention or the control group. Randomization was carried out using a computer-generated random number generator [22] by a member of the research team who did not participate in the patient recruitment process. The first group (n = 25) received a single 15 min session of TMJ soft tissue therapy. The second group (n = 25) served as the control group with no intervention. The researcher who performed the measurements was blinded to the participant group allocation. Before commencing the study, participants were informed about the purpose and procedure of the research and therapy, and they provided written consent to participate in the research project. Each participant completed a custom questionnaire before the study, including questions about age, place of residence, and education, as well as closed-ended questions regarding TMJ dysfunctions, dental malocclusions, orthodontic treatment, and the presence of implants. The questionnaire used allowed for the verification of factors that were established as exclusion criteria for the research project. A detailed characterization of the study group is provided in Table 1.

Table 1. Characteristics of the participants.

	Experimental Group (n = 25) Mean ± SD	**Control Group (n = 25) Mean ± SD**
Age [years]	23.84 ± 1.97	23.44 ± 2.14
High [cm]	166.16 ± 5.71	166.20 ± 7.09
Body mass [kg]	58.06 ± 6.78	60.46 ± 8.83
BMI [kg/m^2]	21.05 ± 2.46	21.90 ± 3.04

SD—standard deviation; cm—centimeters; kg—kilograms; BMI—body mass index; m—meters.

To assess the effects of the applied therapy, measurements were taken twice: before and immediately after the 15 min TMJ therapy session (in the first group), and measurements were taken twice with a 15 min break between measurements without any intervention (in the second group).

2.2. Research Tools

To evaluate the effectiveness of the applied therapy, appropriate measurements were conducted using research tools such as a Hogetex electronic caliper, a CROM Deluxe, and a FreeMed Base pedobarographic platform. Before each measurement, all devices were calibrated.

2.2.1. Hogetex Electronic Caliper

The Hogetex electronic caliper (Hogetex, Varsseveld, The Netherlands, 2021) was used to assess the mobility of the TMJ (Figure 2).

During the measurement, the patient was in a supine position, with the head positioned neutrally. The following active movements were measured:

- Jaw abduction: measured as the distance in millimeters between the edges of the upper and lower incisors during maximum mouth opening;
- Lateral movement to the right and left: distance in millimeters between the midline of the upper and lower dental arches during maximum lateral movements;

- Horizontal movement to the right and left: distance in millimeters between the midline of the upper and lower dental arches during maximum lateral movements;
- Protrusion: distance in millimeters between the midline of the upper and lower dental arches during maximum protrusion of the jaw [23].

Figure 2. The Hogetex electronic caliper.

2.2.2. Cervical Range-of-Motion Instrument (CROM) Deluxe

The CROM Deluxe (Fabrication Enterprises Inc., New York, NY, USA, 2009) was used to assess the mobility of the cervical spine (Figure 3).

Figure 3. Cervical Range-of-Motion instrument.

The patient was examined in a seated position, with the spine in a neutral position and feet flat on the floor (ankles aligned with the knees). The following active movements were evaluated: flexion, extension, right lateral flexion, left lateral flexion, right rotation, left rotation [24].

2.2.3. FreeMed Base Platform

The FreeMed Base platform was utilized for assessing balance and foot pressure distribution. It allows for the measurement of foot pressure distribution on the surface through built-in resistive sensors coated with 24-karat gold. The recording of pressure forces during foot contact with the surface occurs at a frequency of 250–400 Hz. Additionally, the platform enables posturographic examination, recording the magnitude of center-of-pressure sways. Measurement results are transmitted to the Free Step program. The study comprised two parts: (a) assessment of pressure distribution in static conditions; (b) posturographic examination in the following positions: bipedal standing position with eyes open (60 s), bipedal standing position with eyes closed (60 s), single-leg standing position (on left and right limbs) with eyes open (10 s), single-leg standing position (on left and right limbs) with eyes closed (60 s) [25] (Figures 4 and 5).

Figure 4. Posturographic examination in bipedal standing position.

Figure 5. Posturographic examination in single-leg standing position.

2.3. Intervention

The therapy comprised soft tissue mobilization techniques, both internally and externally, of the temporomandibular joints (TMJ). A qualified therapist conducted the soft tissue therapy, with a duration of 15 min for bilateral treatment. The patient was positioned lying on their back, upper limbs aligned along the torso, head in a neutral position, and a therapeutic roll placed under the knees. External work included the following steps:

(A) Temporalis muscle relaxation:

- Trigger point therapy on the temporalis muscle (technique duration: 1 min);
- Myofascial release along the path of the trigger point on the temporalis muscle (technique duration: 1 min);
- Positional relaxation of the temporalis muscle (technique duration: 30 s);
- Myofascial release of the temporalis muscle; work along the muscle from top to bottom (technique duration: 30 s).

(B) Masseter muscle relaxation: myofascial release along the path of the muscle from top to bottom (technique duration: 30 s).

Internal work included the following steps:

(A) Pterygoid muscle relaxation (technique duration: 1 min).
(B) Masseter muscle relaxation:

- Myofascial release along the path of the muscle fibers (technique duration: 1 min);
- Trigger point release in the attachment area (technique duration: 1 min).

The example techniques are presented in Figures 6–9.

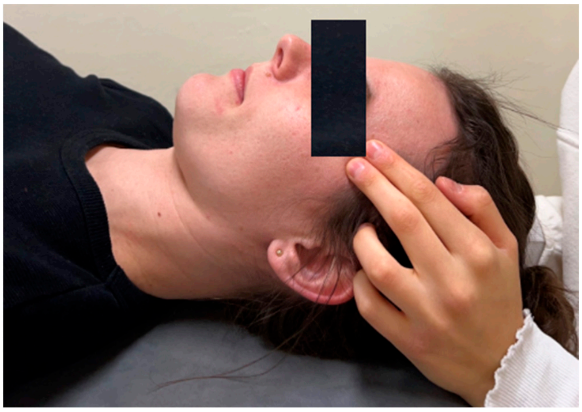

Figure 6. Temporalis muscle relaxation: trigger point therapy, external technique.

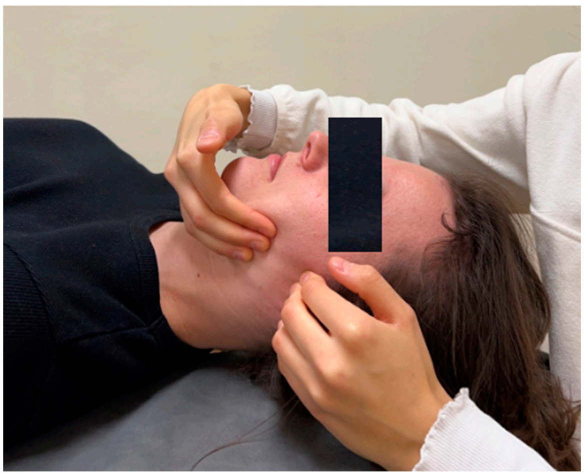

Figure 7. Masseter muscle relaxation: myofascial release, external technique.

Figure 8. Pterygoid muscle relaxation: internal technique.

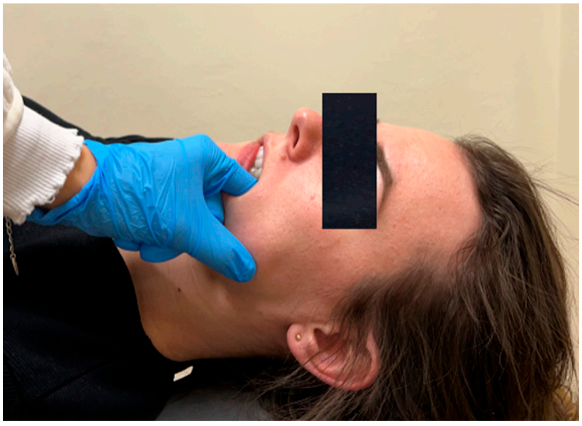

Figure 9. Masseter muscle relaxation: trigger point release in the attachment area, internal technique.

2.4. Statistical Analysis

The statistical analysis was conducted using STATISTICA 12.0 Pl (Statsoft Polska, Krakow, Poland). Results are given as mean values ± standard deviation (SD). Normality of variable distribution was checked using the Shapiro–Wilk test; a p-value > 0.05 was considered as normally distributed. To determine the significance of differences in the variables studied, a two-way analysis of variance (ANOVA) was performed with one main factor being between groups (experimental and control) and the other main factor being the repeated measure (time: before and after therapy in the experimental group and before and after a 15 min break in the control group). Post hoc analysis was performed using Tukey's post hoc test. The significance level was set at $\alpha = 0.05$. Effect size was calculated using Cohen's d and interpreted as trivial (<0.1), small (0.1–0.3), medium (0.3–0.5), and large (>0.5) [26]. We estimated the sample size with G*Power software (version 3.1, Duesseldorf, Germany). A power analysis for two-way ANOVA allowed us to determine that at least 17 participants from each group were required to obtain a power of 0.8 at a two-sided level of 0.05 with an effect size of d = 0.8. This analysis was based on data derived from previous literature on one of the primary outcome variables, such as jaw mobility [27].

3. Results

3.1. Temporomandibular Joint Mobility

In the first measurement, participants in the control group obtained higher values in every assessed movement compared to those in the experimental group. However, these differences were not statistically significant ($p > 0.05$). In the experimental group, after the application of a 15 min soft tissue therapy, an increase in mobility within all assessed jaw movements was observed. This change was statistically significant ($p < 0.05$) for lateral movement to the left, abduction, and protrusion of the jaw (an increase of 10.32%, 7.07%, and 20.92%, respectively). In the control group, no statistically significant differences were observed between measurements before and after the 15 min break. The results are presented in Table 2.

Table 2. Temporomandibular joint mobility.

	Measurement	Experimental Group (n = 25) Mean ± SD	*p*	ES [a]	Control Group (n = 25) Mean ± SD	*p*	ES [a]	*p* *	ES [b]
Lateral movement to the right (mm)	1 2	9.22 ± 4.19 9.76 ± 3.39	0.542	0.142	10.20 ± 3.30 9.57 ± 2.84	0.397	−0.205	0.754 0.997	0.260 −0.061
Lateral movement to the left (mm)	1 2	10.08 ± 4.74 11.12 ± 4.91	**0.048**	0.216	10.64 ± 4.16 10.25 ± 3.56	0.754	−0.101	0.969 0.895	0.126 −0.203
Jaw abduction (mm)	1 2	38.91 ± 6.81 41.66 ± 6.79	**0.018**	0.404	39.89 ± 7.33 39.83 ± 7.82	1.000	−0.008	0.963 0.806	0.139 −0.250
Protrusion (mm)	1 2	3.92 ± 2.86 4.74 ± 3.27	**<0.001**	0.267	4.29 ± 2.24 4.33 ± 2.18	0.989	0.018	0.962 0.952	0.144 −0.148

SD—standard deviation; mm—millimeters; *p*—between measurements; *p* *—between groups; ES [a]—effect size (Cohen's d) within each group; ES [b]—effect size (Cohen's d) between study groups.

3.2. Cervical Spine Mobility

After the application of a 15 min therapy in the experimental group, a greater range of motion in the cervical spine was noted in every plane. This change was statistically significant ($p < 0.05$) for extension, and lateral bending to the right and left, as well as rotation to the right and left (an increase of 7.05%, 7.89%, 10.44%, 4.65%, and 6.55%, respectively). In the control group, no statistically significant differences were observed. The results are presented in Table 3.

Table 3. Cervical spine mobility.

	Measurement	Experimental Group (n = 25) Mean ± SD	*p*	ES [a]	Control Group (n = 25) Mean ± SD	*p*	ES [a]	*p* *	ES [b]
Flexion (°)	1 2	52.80 ± 8.64 55.12 ± 10.23	0.155	0.245	56.52 ± 12.12 54.76 ± 11.97	0.375	−0.146	0.621 0.999	0.353 −0.032
Extension (°)	1 2	56.72 ± 13.44 60.72 ± 13.71	**0.002**	0.295	59.12 ± 12.45 58.68 ± 11.70	0.972	−0.036	0.911 0.943	0.185 −0.160
Sidebend to the right (°)	1 2	41.04 ± 6.71 44.28 ± 7.25	**0.001**	0.464	42.96 ± 7.44 42.28 ± 6.86	0.834	−0.095	0.773 0.750	0.271 −0.283
Sidebend to the left (°)	1 2	41.36 ± 7.06 45.68 ± 6.77	**<0.001**	0.625	43.12 ± 7.77 43.72 ± 8.08	0.909	0.076	0.837 0.788	0.237 −0.263
Rotation to the right (°)	1 2	68.80 ± 4.83 72.00 ± 5.07	**0.002**	0.646	69.00 ± 9.09 68.56 ± 8.52	0.952	−0.050	1.000 0.332	0.027 −0.491
Rotation to the left (°)	1 2	68.40 ± 6.48 72.88 ± 6.51	**<0.001**	0.690	69.40 ± 7.91 69.64 ± 6.81	0.990	0.033	0.957 0.361	0.138 −0.486

SD—standard deviation; *p*—between measurements; *p* *—between groups; ES [a]—effect size (Cohen's d) within each group; ES [b]—effect size (Cohen's d) between study groups.

3.3. Distribution of Foot Load in Static Conditions

In the experimental group, after the soft tissue therapy was applied, higher values of surface area and forefoot load were observed in both the left and right limbs; however, these changes were not statistically significant. In the control group, a decrease in surface area and an increase in forefoot load were noted in the second measurement, but these changes were also not statistically significant (Table 4).

Table 4. Static load distribution—forefoot.

	Measurement	Experimental Group (n = 25) Mean ± SD	*p*	ES [a]	Control Group (n = 25) Mean ± SD	*p*	ES [a]	*p* *	ES [b]
Surface L (cm^2)	1 2	44.96 ± 9.92 46.12 ± 12.16	0.896	0.105	44.40 ± 13.49 42.92 ± 9.44	0.807	−0.127	0.998 0.753	−0.047 −0.294
Load L (%)	1 2	40.16 ± 12.43 44.20 ± 15.71	0.261	0.285	40.64 ± 16.02 42.24 ± 13.36	0.883	0.108	0.999 0.963	0.033 −0.134
Surface R (cm^2)	1 2	43.32 ± 8.49 44.04 ± 11.15	0.936	0.073	42.24 ± 11.43 40.92 ± 9.22	0.706	−0.127	0.982 0.699	−0.107 −0.305
Load R (%)	1 2	43.00 ± 11.03 44.80 ± 13.58	0.696	0.146	39.84 ± 13.62 42.00 ± 12.44	0.561	0.166	0.816 0.864	−0.255 −0.215

SD—standard deviation; cm—centimeters; *p*—between measurements; *p* *—between groups; ES [a]—effect size (Cohen's d) within each group; ES [b]—effect size (Cohen's d) between study groups.

In the experimental group, after the soft tissue therapy was applied, a decrease in rearfoot load was observed in both the left and right limbs, as well as a decrease in the surface area of the left rearfoot. A higher value in the second measurement was obtained in the area of the surface of the right rearfoot. In the control group, a decrease in the values of all assessed variables in the area of the rearfoot was noted. However, the changes observed in both groups were not statistically significant. The data are presented in Table 5.

Table 5. Static load distribution—rearfoot.

	Measurement	Experimental Group (n = 25) Mean ± SD	*p*	ES [a]	Control Group (n = 25) Mean ± SD	*p*	ES [a]	*p* *	ES [b]
Surface L (cm^2)	1 2	36.92 ± 7.30 36.24 ± 8.19	0.834	−0.088	36.60 ± 7.78 34.52 ± 7.04	0.061	−0.280	0.999 0.854	−0.042 −0.225
Load L (%)	1 2	59.84 ± 12.43 55.80 ± 15.71	0.261	−0.285	59.36 ± 16.02 57.76 ± 13.36	0.883	−0.108	0.999 0.963	−0.033 0.134
Surface R (cm^2)	1 2	37.76 ± 4.99 38.12 ± 7.85	0.984	0.055	38.32 ± 7.79 35.96 ± 6.61	0.101	−0.327	0.992 0.688	0.086 −0.298
Load R (%)	1 2	57.00 ± 11.03 55.20 ± 13.58	0.696	−0.146	60.16 ± 13.62 58.00 ± 12.44	0.561	−0.166	0.816 0.864	0.255 0.215

SD—standard deviation; cm—centimeters; *p*—between measurements; *p* *—between groups; ES [a]—effect size (Cohen's d) within each group; ES [b]—effect size (Cohen's d) between study groups.

Analyzing the load on the entire foot in the experimental group, no statistically significant changes were observed after the soft tissue therapy was applied. In the control group, changes in the majority of the assessed variables were also not statistically significant, except for the plantar angle in the right foot, which significantly increased in the second measurement ($p < 0.05$). Detailed data are presented in Table 6.

Table 6. Static load distribution—together.

	Measurement	Experimental Group (n = 25) Mean ± SD	*p*	ES [a]	Control Group (n = 25) Mean ± SD	*p*	ES [a]	*p* *	ES [b]
Surface L (cm^2)	1 2	81.84 ± 14.73 82.36 ± 17.19	0.994	0.032	80.92 ± 17.85 77.48 ± 13.57	0.314	−0.219	0.997 0.701	−0.057 −0.315

Table 6. *Cont.*

	Measurement	Experimental Group (n = 25) Mean ± SD	p	ES [a]	Control Group (n = 25) Mean ± SD	p	ES [a]	p *	ES [b]
Load L (%)	1 2	50.72 ± 6.18 50.28 ± 5.51	0.969	−0.075	50.24 ± 4.38 51.36 ± 3.99	0.662	0.267	0.987 0.876	−0.090 0.225
Maximum load L (g/cm^2)	1 2	895.04 ± 151.20 887.96 ± 166.41	0.994	−0.045	994.16 ± 272.65 1020.28 ± 247.69	0.773	0.100	0.373 0.144	0.450 0.627
Average load L (g/cm^2)	1 2	363.84 ± 54.84 363.60 ± 71.51	1.000	−0.004	407.20 ± 110.55 425.16 ± 104.61	0.270	0.167	0.317 0.078	0.497 0.687
Plantar angle L (°)	1 2	6.76 ± 4.02 8.60 ± 5.47	0.245	0.383	7.68 ± 5.94 8.16 ± 4.26	0.960	0.093	0.915 0.989	0.181 −0.090
Plantar axis L (°)	1 2	3.60 ± 2.58 4.56 ± 2.45	0.170	0.382	4.24 ± 2.89 3.92 ± 2.23	0.898	−0.124	0.812 0.812	0.234 −0.273
Surface R (cm^2)	1 2	81.12 ± 12.10 82.28 ± 16.26	0.922	0.081	80.60 ± 16.58 76.96 ± 13.71	0.212	−0.239	0.999 0.584	−0.036 −0.354
Load R (%)	1 2	49.28 ± 6.18 49.72 ± 5.51	0.969	0.075	49.76 ± 4.38 48.64 ± 3.99	0.662	−0.267	0.987 0.876	0.090 −0.225
Maximum load R (g/cm^2)	1 2	849.64 ± 159.81 859.40 ± 167.27	0.979	0.060	984.16 ± 265.75 1006.00 ± 234.96	0.814	0.087	0.123 0.080	0.613 0.719
Average load R (g/cm^2)	1 2	355.00 ± 57.19 358.24 ± 65.79	0.986	0.053	402.80 ± 109.03 403.68 ± 88.58	1.000	0.009	0.184 0.222	0.549 0.582
Plantar angle R (°)	1 2	7.28 ± 2.98 7.08 ± 4.51	0.995	−0.052	6.88 ± 4.45 9.12 ± 3.98	**0.037**	0.531	0.985 0.285	−0.106 0.480
Plantar axis R (°)	1 2	5.28 ± 2.28 5.92 ± 3.01	0.550	0.240	7.00 ± 2.61 7.12 ± 2.15	0.995	0.050	0.086 0.345	0.702 0.459

SD—standard deviation; g—grams; cm—centimeters; *p*—between measurements; *p* *—between groups; ES [a]—effect size (Cohen's d) within each group; ES [b]—effect size (Cohen's d) between study groups.

3.4. Body Balance

In the assessment of body balance in the double-leg standing position with eyes open, no significant changes were observed in any of the groups during the second examination. With eyes closed, a significant increase in the area of the ellipse was noted ($p < 0.05$) in both groups. In the single-leg stance test on both the right and left limbs, in the second measurement, no significant changes were observed in any of the groups. However, a statistically significant difference between the groups was noted in the baseline assessment of the ellipse surface and delta X. Detailed data are presented in Tables 7–9.

Table 7. Body balance—both legs.

		Measurement	Experimental Group (n = 25) Mean ± SD	p	ES [a]	Control Group (n = 25) Mean ± SD	p	ES [a]	p *	ES [b]
Eyes open	Path length (mm)	1 2	497.67 ± 95.07 455.40 ± 104.07	0.365	0.424	515.29 ± 129.72 506.74 ± 134.93	0.987	−0.065	0.951 0.413	0.155 0.426
	Ellipse surface (mm^2)	1 2	49.19 ± 39.77 69.98 ± 70.71	0.691	0.362	61.30 ± 76.22 87.25 ± 84.40	0.521	0.323	0.928 0.818	0.199 0.222
	Delta X (mm)	1 2	6.36 ± 2.42 7.86 ± 4.86	0.461	0.391	6.96 ± 3.96 7.94 ± 3.91	0.764	0.249	0.950 1.000	0.183 0.018
	Delta Y (mm)	1 2	8.00 ± 3.42 10.51 ± 6.76	0.309	0.469	10.18 ± 5.43 12.53 ± 6.83	0.366	0.381	0.544 0.606	0.480 0.297
	Average speed (mm/s)	1 2	8.54 ± 1.64 7.96 ± 1.70	0.464	−0.347	8.88 ± 2.26 8.90 ± 2.23	1.000	0.009	0.933 0.344	0.172 0.474

Table 7. *Cont.*

		Measurement	Experimental Group (n = 25) Mean ± SD	*p*	ES [a]	Control Group (n = 25) Mean ± SD	*p*	ES [a]	*p* *	ES [b]
Eyes closed	Path length (mm)	1 2	523.89 ± 91.38 518.68 ± 118.60	0.996	−0.049	544.00 ± 120.44 554.86 ± 110.73	0.964	0.094	0.918 0.658	0.188 0.315
	Ellipse surface (mm^2)	1 2	58.87 ± 53.10 99.47 ± 103.25	**0.027**	0.495	55.28 ± 43.02 98.77 ± 68.45	**0.016**	0.761	0.998 1.000	−0.074 −0.008
	Delta X (mm)	1 2	7.57 ± 4.18 8.52 ± 4.97	0.663	0.207	7.85 ± 3.31 9.91 ± 4.18	0.059	0.546	0.996 0.657	0.074 0.303
	Delta Y (mm)	1 2	11.14 ± 6.26 14.53 ± 10.90	0.139	0.381	10.88 ± 5.23 14.62 ± 5.40	0.087	0.704	0.999 1.000	−0.045 0.010
	Average speed (mm/s)	1 2	8.85 ± 1.60 8.93 ± 1.82	0.995	0.047	9.25 ± 2.09 9.58 ± 1.76	0.743	0.171	0.865 0.592	0.215 0.363
Romberg Index	Path length (mm)	1 2	1.06 ± 0.11 1.16 ± 0.23	0.090	0.556	1.07 ± 0.13 1.12 ± 0.17	0.597	0.331	0.997 0.860	0.083 −0.198
	Ellipse surface (mm^2)	1 2	2.36 ± 3.38 2.27 ± 2.79	0.999	−0.029	1.80 ± 1.67 2.05 ± 2.05	0.969	0.134	0.869 0.989	−0.210 −0.090
	Average speed (mm/s)	1 2	1.04 ± 0. 11 1.14 ± 0.20	0.065	0.621	1.06 ± 0.13 1.10 ± 0.17	0.645	0.265	0.989 0.816	0.167 −0.215

SD—standard deviation; mm—millimeters; s—seconds; *p*—between measurements; *p* *—between groups; ES [a]—effect size (Cohen's d) within each group; ES [b]—effect size (Cohen's d) between study groups.

Table 8. Body balance—right leg.

		Measurement	Experimental Group (n = 25) Mean ± SD	*p*	ES [a]	Control Group (n = 25) Mean ± SD	*p*	ES [a]	*p* *	ES [b]
Eyes open	Path length (mm)	1 2	300.77 ± 63.20 280.38 ± 64.85	0.399	−0.318	307.26 ± 74.76 295.90 ± 79.02	0.815	−0.148	0.988 0.865	0.094 0.215
	Ellipse surface (mm^2)	1 2	214.37 ± 98.32 342.37 ± 275.97	0.222	0.618	421.92 ± 363.57 430.43 ± 249.17	1.000	0.027	**0.034** 0.643	0.779 0.335
	Delta X (mm)	1 2	12.27 ± 3.61 13.17 ± 4.01	0.893	0.236	16.43 ± 5.41 15.24 ± 3.74	0.790	−0.256	**0.005** 0.318	0.905 0.534
	Delta Y (mm)	1 2	18.31 ± 7.06 21.84 ± 8.92	0.400	0.439	22.89 ± 9.76 25.48 ± 10.84	0.654	0.251	0.305 0.508	0.538 0.367
	Average speed (mm/s)	1 2	17.32 ± 4.06 16.41 ± 3.67	0.832	−0.235	20.68 ± 5.73 19.19 ± 6.32	0.518	−0.247	0.097 0.219	0.677 0.538
Eyes closed	Path length (mm)	1 2	593.80 ± 138.31 541.65 ± 145.85	0.477	−0.367	608.10 ± 164.55 618.15 ± 191.88	0.992	0.056	0.989 0.343	0.094 0.449
	Ellipse surface (mm^2)	1 2	1767.12 ± 764.87 1838.80 ± 1222.81	0.998	0.070	1922.80 ± 874.18 2757.14 ± 2599.98	0.201	0.430	0.985 0.162	0.190 0.430
	Delta X (mm)	1 2	30.58 ± 5.78 29.42 ± 7.14	0.928	−0.179	32.40 ± 7.31 34.74 ± 11.92	0.615	0.237	0.868 0.119	0.276 0.541
	Delta Y (mm)	1 2	54.43 ± 16.51 54.82 ± 21.19	1.000	0.021	49.95 ± 12.52 60.64 ± 30.40	0.286	0.460	0.878 0.767	−0.306 0.222
	Average speed (mm/s)	1 2	46.69 ± 12.84 43.42 ± 14.24	0.758	−0.241	50.28 ± 15.15 52.59 ± 19.77	0.898	0.114	0.850 0.175	0.256 0.515
Romberg Index	Path length (mm)	1 2	2.02 ± 0.44 2.01 ± 0.61	1.000	−0.019	2.00 ± 0.43 2.14 ± 0.57	0.622	0.326	1.000 0.806	−0.046 0.246
	Ellipse surface (mm^2)	1 2	11.13 ± 13.15 8.05 ± 6.66	0.558	−0.296	6.85 ± 4.88 7.53 ± 5.55	0.991	0.130	0.263 0.996	−0.432 −0.085
	Average speed (mm/s)	1 2	2.78 ± 0.88 2.73 ± 0.90	0.991	−0.056	2.47 ± 0.65 2.84 ± 0.94	0.222	0.458	0.555 0.966	−0.401 0.120

SD—standard deviation; mm—millimeters; s—seconds; *p*—between measurements; *p* *—between groups; ES [a]—effect size (Cohen's d) within each group; ES [b]—effect size (Cohen's d) between study groups.

Table 9. Body balance—left leg.

		Measurement	Experimental Group (n = 25) Mean ± SD	*p*	ES [a]	Control Group (n = 25) Mean ± SD	*p*	ES [a]	*p* *	ES [b]
Eyes open	Path length (mm)	1 2	259.35 ± 64.94 238.58 ± 53.26	0.245	−0.350	265.73 ± 67.24 246.22 ± 50.72	0.296	−0.328	0.981 0.969	0.097 0.147
	Ellipse surface (mm^2)	1 2	247.13 ± 146.84 358.24 ± 275.66	0.168	0.503	302.11 ± 190.60 342.14 ± 235.99	0.874	0.187	0.809 0.994	0.323 −0.063
	Delta X (mm)	1 2	13.06 ± 4.77 14.26 ± 5.88	0.696	0.224	13.58 ± 2.76 14.70 ± 4.68	0.741	0.292	0.979 0.988	0.133 0.083
	Delta Y (mm)	1 2	19.46 ± 7.45 21.93 ± 7.89	0.685	0.322	19.99 ± 8.90 22.16 ± 9.09	0.764	0.241	0.996 1.000	0.065 0.027
	Average speed (mm/s)	1 2	19.09 ± 6.19 17.50 ± 4.50	0.337	−0.294	19.80 ± 5.45 18.66 ± 3.73	0.622	−0.244	0.960 0.849	0.122 0.281
Eyes closed	Path length (mm)	1 2	566.76 ± 129.07 520.66 ± 119.03	0.583	−0.371	615.00 ± 255.30 624.60 ± 223.68	0.993	0.040	0.809 0.227	0.238 0.580
	Ellipse surface (mm^2)	1 2	1589.52 ± 963.97 1785.00 ± 1255.38	0.998	0.175	2966.90 ± 5001.45 3191.66 ± 5780.00	0.997	0.042	0.598 0.582	0.382 0.336
	Delta X (mm)	1 2	28.58 ± 8.38 30.65 ± 8.48	0.983	0.246	35.67 ± 22.94 37.89 ± 36.22	0.980	0.073	0.674 0.659	0.411 0.275
	Delta Y (mm)	1 2	45.25 ± 13.81 47.35 ± 14.24	0.982	0.150	61.15 ± 27.85 60.77 ± 32.38	1.000	−0.013	0.087 0.190	0.723 0.537
	Average speed (mm/s)	1 2	43.60 ± 11.61 40.51 ± 11.82	0.808	−0.264	51.84 ± 25.58 51.99 ± 21.94	1.000	0.006	0.413 0.144	0.415 0.651
Romberg index	Path length (mm)	1 2	2.28 ± 0.61 2.30 ± 0.77	0.999	0.029	2.36 ± 0.83 2.56 ± 0.80	0.521	0.245	0.979 0.616	0.110 0.331
	Ellipse surface (mm^2)	1 2	7.79 ± 5.47 11.93 ± 28.46	0.891	0.202	12.77 ± 26.93 10.35 ± 12.21	0.975	−0.116	0.830 0.993	0.256 −0.072
	Average speed (mm/s)	1 2	2.56 ± 0.72 2.50 ± 1.15	0.997	−0.063	2.55 ± 1.17 2.81 ± 1.14	0.821	0.225	1.000 0.716	−0.010 0.271

SD—standard deviation; mm—millimeters; s—seconds; *p*—between measurements; *p* *—between groups; ES [a]—effect size (Cohen's d) within each group; ES [b]—effect size (Cohen's d) between study groups.

4. Discussion

The statistical analysis allowed for partial rejection of the null hypothesis regarding the lack of therapy's effect on the mobility of the jaw and cervical spine in the studied women. However, the results did not provide sufficient evidence to reject the hypothesis that therapy has no impact on body balance and foot load distribution.

The results obtained in our study showed an increase in the range of motion across all assessed movement patterns in the experimental group. These changes were statistically significant in most of the examined patterns, except for right lateral jaw movement and cervical spine flexion. In the control group, no statistically significant differences were observed. No significant changes in body balance assessment and load distribution were observed in either group. The main finding of this study is that a single-session temporomandibular joint soft tissue therapy may have a beneficial impact on the TMJ and cervical spine mobility in women with symptoms in the TMJ. Previous research has primarily focused on evaluating the impact of different kinds of therapy on local body areas. Few studies have assessed the impact of therapy on body balance. This study, for the first time, addressed the impact of TMJ soft tissue therapy in such a comprehensive manner, evaluating not only local joints but also the influence on distant body areas according to the concept of myofascial chains.

In our study, after TMJ soft tissue therapy an improvement in the range of motion of the jaw and the cervical spine in all planes was observed. In almost every evaluated movement, this change was statistically significant. Our findings align closely with those reported by Gomes et al. [27], who investigated the effectiveness of massage therapy versus occlusal splint therapy on mandibular range of motion (ROM) in patients with TMD. Both treatment approaches successfully enhanced the maximum active mouth opening and both right and left excursion. Similarly, Kalamir et al. [28] noted an improvement in mouth opening ROM after the applied intraoral myofascial therapy. DeVocht et al. [29] applied cross-friction massage and joint mobilization to eight patients with TMJ disorders. Manual therapy was performed three times a week for two weeks. After the study, the average mouth opening range improved by 9 mm.

Some studies have confirmed links between the cranial area, TMJ, and cervical spine. Czernielewska et al. [30] demonstrated a correlation between reduced TMJ mobility and limited mobility in the cervical spine segment in individuals with bruxism. Grondin et al. [31] showed that individuals with TMJ pain complaints have a reduced range of rotation in the cervical spine compared to healthy individuals. They also observed that individuals with TMJ pain complaints, who also complained of headaches, had restricted mobility in the cervical spine sagittal plane.

The results of Walczyńska-Dragon et al. [32] demonstrated a significant relationship between treating TMJ dysfunction and reducing neck pain, while simultaneously improving cervical spine mobility. A similar relationship was observed by Calixtre et al. [33] in a randomized study involving 61 women with TMJ complaints. The researchers assessed the effect of cervical spine mobilization and motor control and cervical spine stabilization exercises on reducing orofacial pain. A statistically significant reduction in TMJ pain complaints was observed in the group undergoing therapeutic intervention. Furthermore, Evcik and Aksoy [34] confirmed the hypothesis that changes in cervical spine posture affect the muscles of the stomatognathic system and lead to TMJ dysfunction.

Current research suggests that manual therapy targeting the cervical spine can positively affect women with TMJ symptoms, showing significant improvements in TMJ range of motion and reductions in orofacial pain. These findings highlight that interventions applied in one area—such as the cervical spine—can have beneficial effects in distant, related structures, such as the TMJ, underscoring the interconnectivity of musculoskeletal regions and the potential for comprehensive therapeutic approaches [18].

Crăciun et al. conducted a study aimed at evaluating the effectiveness of a physiotherapy program for TMJ dysfunctions and the relationship with the cervical spine. A three-month program of therapeutic exercises for jaw and neck muscles, combined with pharmacotherapy, was found to be more effective than pharmacotherapy alone. After therapy, both groups experienced reduced pain, but the combination approach achieved more significant improvements. The average percentage values of the Neck Disability Index and the Jaw Functional Limitation Scale 8 decreased significantly in both groups, but especially in the group that received physiotherapy [19].

Research by de Oliveira-Souza et al. indicates that neck motor control training is effective in improving orofacial pain in women with TMD. However, no significant effect on jaw mobility was observed. The authors suggest that the orofacial pain relief after neck-targeted exercises might have occurred due to the neuroanatomical connections between these areas. Specifically, stimulation of descending inhibitory pathways through the neck may reduce pain in the trigeminal nerve region. It is expected that therapies targeting both the neck and jaw areas may be more effective in improving the range of motion of the mandible and the function of the masticatory muscles [17].

Lee and Kim investigated the effectiveness of manual therapy and cervical spine stretching exercises for pain and disability in patients with myofascial TMD accompanied by headaches. It was concluded that the applied intervention could help resolve TMJ disorders accompanied by headaches through biomechanical changes in the cervical spine [16].

To the best of our knowledge, our study is the first in which the effect of a single-session TMJ soft tissue therapy on static load distribution was examined. However, no significant changes in the load distribution in static conditions were noted. Perhaps a single soft tissue therapy is not sufficient to produce an effect within this variable. Despite the lack of similar studies evaluating the effect of therapy on load distribution, several studies indicate the existence of a relationship between the TMJ and the foot. The study conducted by Souza et al. [35] using electromyography (EMG) showed that foot stimulation significantly increases tensions in the masticatory muscles and TMJ. Valentino et al. [36], in their electromyography-based research, observed a correlation between the muscles of the foot arches and the occlusal plane. Studies conducted by Cuccia and Caradonna [37] using a podobarographic platform reported a relationship between foot load distribution and jaw position.

Similarly, in the body balance test, no significant changes were observed in most of the variables assessed after the therapy. Only in the double-leg standing position with eyes closed was a significant increase in the area of the ellipse noted in both groups. A similar study was conducted by Hage et al. [38], who aimed to assess the effect of a single facial massage on the fluctuations of the center of pressure (CoP) in the anterior-posterior (AP) and medio-lateral (ML) directions in individuals with TMJ disorders (TMD). Balance assessment was performed with eyes open and closed before and after facial massage. Twenty individuals with diagnosed TMD were included in the study. The researchers did not observe significant differences in AP CoP velocity with eyes closed, but they did observe a significant difference in the mean velocity of AP CoP with eyes closed. In our study, we did not observe significant changes in this parameter.

Several limitations in this study should be noted. First, the jaw mobility assessment was conducted in a supine position, whereas in many studies it is performed in a sitting position. Both measurements (before and after therapy) were performed in the same position, allowing us to evaluate the impact of the therapy on jaw mobility. However, the results cannot be directly compared to those of other studies since the position may influence the outcome. The next limitation is the absence of a placebo therapy group, which may have substantially distorted the results. Moreover, applying the soft tissue techniques only once may have been too weak a stimulus to influence changes in foot load distribution. It would be valuable to assess the impact of long-term TMJ soft tissue therapy and increase the sample size of the experimental and control groups. Another limitation is the lack of reassessment of TMJ complaints after therapy. It would also be valuable to assess the effects of the therapy among individuals without TMJ symptoms, as well as among men.

Reviewing the literature, it is noted that the impact of TMJ therapy on the cervical spine has been previously addressed, while only a few studies have addressed the impact of TMJ therapy on the foot. There is a lack of comprehensive, multi-aspect studies of muscles within the anterior myofascial line and assessments of plantar pressure distribution and body balance. Previous researchers have focused on the impact of different types of therapy on improving mobility within the target joint, without examining associations with other body parts. Therefore, there is a need to expand research in this area. Functional and structural connections between elements of the musculoskeletal system suggest that the applied therapy may have beneficial effects, not only on the temporomandibular joints and cervical spine, but also on the feet. From a clinical perspective, our study's findings hold significant relevance. First, TMJ soft tissue therapy may be an effective treatment option for women with TMJ pain, providing substantial improvements in both jaw and cervical spine mobility. Second, these findings emphasize the need for an integrated approach to TMJ dysfunction therapy, where the effects on related structures, such as the cervical spine, are carefully considered. Future researchers interested in exploring the topic addressed in our study are recommended to increase the study sample size and apply longer duration soft tissue therapy to confirm obtained results and deepen our understanding of the mechanisms behind these observed effects. Additionally, it is recommended to assess the long-term effects of therapy as a continuation of research.

5. Conclusions

The results obtained in this study suggest that a single-session temporomandibular joint soft tissue therapy influences an increase in jaw mobility and cervical spine mobility in women diagnosed with myofascial pain in the TMJ area. However, it does not affect body balance and foot load distribution in static conditions. Further larger research in this area to corroborate these findings is recommended.

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