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STUDY ON THE COMBINED USE OF HIGH-ENERGY LASER AND MANUAL THERAPY IN PATIENTS WITH FUNCTIONAL THORACIC SPINE DISORDERS

ABSTRACT

of
Doctoral Dissertation for the Award

of Scientific and Educational Degree "Doctor"

Research Supervisor:
Associate Professor Dr. Iliya Todorov, MD

Varna, 2024

The dissertation contains 143 pages and is illustrated with 24 tables, 42 figures and 16 applications are included. The bibliographic list consists of 166 references, of which 18 are in Cyrillic and 148 in Latin.

Note: The numbering of the tables and figures in the abstract does not correspond to those in the dissertation.

The study was carried out in the Clinic of Physical and Rehabilitation Medicine of the University Hospital "St. Marina" - Varna.

The dissertation was approved and directed for defense at a meeting of the "Department of Physiotherapy, Rehabilitation and Talassotherapy" at Medical University "Prof. dr. Paraskev Stoyanov" - Varna.

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ABBREVIATIONS

VAS – Visual analogue scale

MLS - Multiwave Locked System

FRI - Function Rating Index

INTRODUCTION

Spinal pathologies are an increasingly relevant problem of modern medicine. They represent a diagnostic and therapeutic challenge for medical professionals requiring a multidisciplinary approach. A number of studies have shown that musculoskeletal disorders related to the spine are a common cause of acute and chronic pain in the general population. (Kemerov S. et al., 2008; Johannes CB. et al., 2010; Wong WS. Et al., 2011). They worsen patients' quality of life and are a major financial cost to the health system.

Functional disorders in the thoracic spine are a common cause of pain and limited range of motion along the spinal column. They are conditions of irreversibly impaired function in the joint without the presence of structural changes in the joint mechanism. Their significance and prevalence dominate over structural pathologies and degenerative changes, especially in young and active age (Wood KB. et al., 1995; Gongalsky V., 2014; Heneghan NR. et al., 2019). In the adult working population, the incidence of somatic dysfunction in the thoracic region is estimated to be 30%, which is comparable to those in the cervical and lumbar regions. Their prevalence is higher in occupations associated with physical labor, medical and office workers, and those associated with improper and static spinal position (Briggs AM. et al., 2009).

This pathology presents a diagnostic challenge due to the technical difficulties associated with analyzing movements in this area, as well as the complexity of the thoracic segment and the presence of a large number of structures that can generate pain. This often leads to misdiagnosis, improper treatment and chronicification of the condition.

All these data indicate the need for in-depth research and development of effective protocols for diagnosis, treatment and prevention of functional disorders in the thoracic spine.

OBJECTIVE

The aim of the present study is to investigate the effect of combined application of high-energy MLS laser and manual therapy in patients with functional thoracic spine disorders.

TASKS

1. To use the author's methodology for the treatment of patients with functional spine disorders in the thoracic region, with a combination of manual manipulations and high-energy MLS laser.
2. To study the immediate and long-term therapeutical effects of manual therapy as monotherapy and its combined application with the high-energy MLS laser, in patients with functional thoracic spine.
3. To conduct a comparative analysis and evaluation of the treatment effect between the two therapeutic protocols used, in terms of the eight measurement indicators.
4. To determine whether the course of laser therapy eliminates the need of second course of manual manipulation.
5. To study the presence or absence of adverse effects of the applied therapeutic protocols.

HYPOTHESES

1. We assume that the combined application of manual therapy and high-energy MLS laser in patients with functional thoracic spine disorders will lead to an improvement in the results of the measured indicators at the end of the therapeutic course and on the 45th day of starting the treatment.
2. We assume that the application of manual therapy as a monotherapy in patients with functional thoracic spine disorders will lead to an improvement in the results of the measured indicators at the end of the therapeutic course and on the 45th day of starting the treatment.
3. We assume that patients treated with the combined application of manual therapy and high-energy MLS laser will have a better clinical and functional recovery compared to patients treated with manual therapy alone, at the end of the therapeutic course and on the 45th day of starting the treatment.

MATERIALS AND METHODS

For the purpose of this study, a total of 82 patients aged between18 to 50 years with functional disorders of the thoracic spine were included.

1. Design of the study

- This is a prospective, randomized, parallel study conducted at the Clinic of Physical and Rehabilitation Medicine of St. Marina" - Varna and Rehabilitation Department, located in the hotel "Estreya Residence" in St. St. Constantine and Helena."
- The study was conducted in compliance with all the principles set out in the Declaration of Helsinki on Ethical Principles in medical research on human subjects. Permission has been obtained from Commission for Scientific Research Ethics, appointed at MU-Varna by Protocol No 97/22.10.2020.
- The survey period is: from 22.10.2020 until 05.05.2023.
- According to the study design, the patients were divided into two groups: group A (applied manual therapy) and group B (applied manual therapy and high-energy MLS laser).
- The inclusion of patients in the both groups was in the order of examination appearance, and the selection step was through one, i.e., every second patient who looked for treatment fell into the group B.
- An equal number of 41 patients fell into each of the study groups.

1.1. Inclusion criteria:

- Age from 18 to 50 years old;
- Patients with clinical manifestations of non-specific thoracic spine pain and restricted back movement with duration of symptoms no more than 45 days';
- Patients responding to the manual diagnostic criteria for functional thoracic spine disorders;
- Skin type from I to IV according to the Fitzpatrick scale;
- Declaration of Informed Consent.

1.2. Exclusion criteria:

- Age below 18 or above 50 years old;
- Presence of significant structural vertebral pathology (spinal stenosis, listhesis, pathological fracture of the vertebral bodies, advanced chronic degenerative diseases affecting the spine);
- Patients with rheumatological diseases affecting the spine (ankylosing spondylitis, reactive arthritis, etc.)
- Systemic neoplastic, infectious and autoimmune diseases;
- Association of pain with recent back injury;
- Pregnancy;
- Osteoporosis;
- Patients on NSAID or corticosteroid drug therapy at the time of study entry;
- Patients treated with physiotherapy treatment after the onset of complaints;
- Skin type - V and VI on the Fitzpatrick scale (Fitzpatrick, 1988);
- Refusal to sign the informed consent form;

2. Methods for following up on the indicators

The following indicators were used to objectify the results:

- Ott sign - to examine range of motion in the thoracic spine for flexion and extension, measured in centimeters.
- Anglemetry - to examine range of motion for rotation in the thoracic spine in both directions with an inclinometer, measured in degrees. The Lumbar-Locked Rotation Test is used.
- Assessment of spontaneous and palpatory pain according to VAS (visual analog scale).
- Patients complete the McGill Short Form Pain Questionnaire (SF-MPQ) to report pain quality and intensity.
- Patients complete the Functional Rating Index - a self-reporting instrument that express graduating degrees of disability.

All patients were described in detail according to gender, age, profession, physical activity and results from the physical examination (Ott sign, rotation anglemetry, VAS, McGill Short Form and Functional Rating Index). The condition was followed up at three different moments: at

the baseline level, before the start of treatment (T0), after the completion of the therapeutic course (T1), and on the 45th day from the baseline (T2).

3. Therapeutic approach in patients of both groups

3.1.Therapeutic approach in group A

The therapeutic method for group A consists of two manual therapy procedures, which were taken on the 1st day after the examination and on the 15th day from the start of treatment. The applied therapeutic course of manual therapy includes manipulation for the thoracic vertebrae and for the ribs, after determining the level of functional blockage. Manual manipulation for thoracic vertebrae was accomplished by pistol grip technique. Through it, manipulation of the thoracic spine intervertebral and costovertebral joints is performed. For rib manipulation, a cruciate technique was used to impact the costotransverse joint.

3.2.Therapeutic approach in group B

The therapeutic method for group B consists of manual therapy procedures once, on the first day of the study initiation, followed by MLS laser therapy treatment. The therapeutic course of MLS laser consists of a total of 6 procedures spread over two consecutive work weeks.
The therapeutic course with high-energy laser therapy was performed with the robotic device for MLS laser therapy - M6, developed by the Italian company "ASA", Italy. The unit features a robotic multi-diode head (up to 3.3W) performing automatic scanning and a manual applicator (up to 1.1W) used for manual spot processing or scanning. The protocol for conducting MLS laser procedures includes:

- Dynamic scanning phase with MLS fixed, robotic multi-modality device in the thoracic spine at a distance of 20 cm. from the skin, with parameters: area 375 cm^2, FPW operation mode, frequency 300Hz, duration 20 minutes, 50% Int., total energy 1148.8 J, energy density - 3.06 J/cm^2.
- Painful points treatment phase with MLS single diode hand applicator (contact methodology) with parameters for each point treatment: FPW mode, 100 Hz, duration 20 seconds, 25% Int., energy density - 0.90 J/cm^2.

4. Statistical methods

4.1. Descriptive methods

- Alternative analysis presents the structural distribution of the qualitative variable values.
- Analysis of Variance - mean values (Mean), Minimum, Maximum, standard error of the mean (Sdt. Error Mean), and standard deviation (Std. Deviation) of each of the indicators (variables) are presented.

• Graphical methods for comparison and visualization of the statistical data.

Methods for statistical evaluation:
95% confidence intervals for mean values and relative shares were determined.

4.2. Methods of hypothesis testing

- Parametric methods - Student's Paired Samples t-test and Independent Samples t-test;
- The significance level of the null hypothesis was chosen as p=0.05.

The data from the study was organized and analyze by IBM SPSS Statistics for MAC v. 29.0.1.0(171). For the graphical representation of the results the program Microsoft Excel for Mac Version 16.69.1, 2019 is used.

RESULTS

1. Demographic characteristics

For the purpose of this dissertation, 82 individuals with functional disorders in the thoracic spine were studied. The mean age of study participants was 34.36 ± 8.77 years. The prevalence of functional disorders in the thoracic motor segments according to age was as follows: 34% in the age range 18-29 years, 42% in the age range 30-39 years, and 24% in the age range 40-50 years (Figure 1).

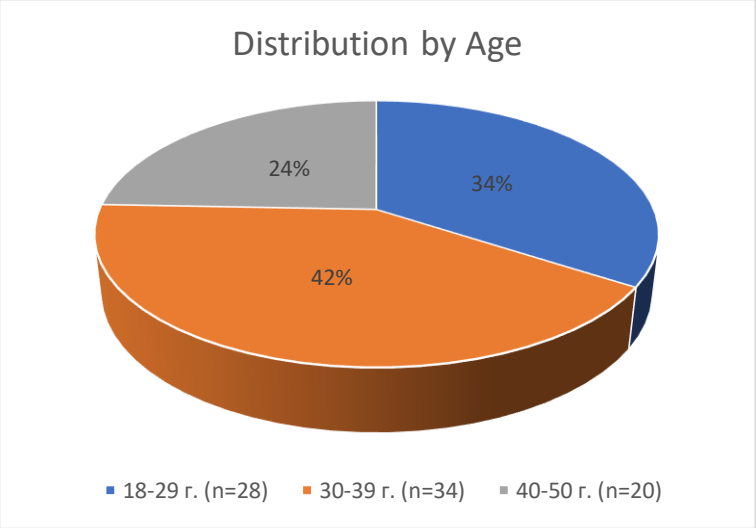


Fig. 1. *Distribution of the examined patients according age*

Participants in the study were 46 females and 36 males indicating that the gender distribution has a slight female gender preponderance, accounting for 56% of the total number of participants compared to 44% males (Figure 2).

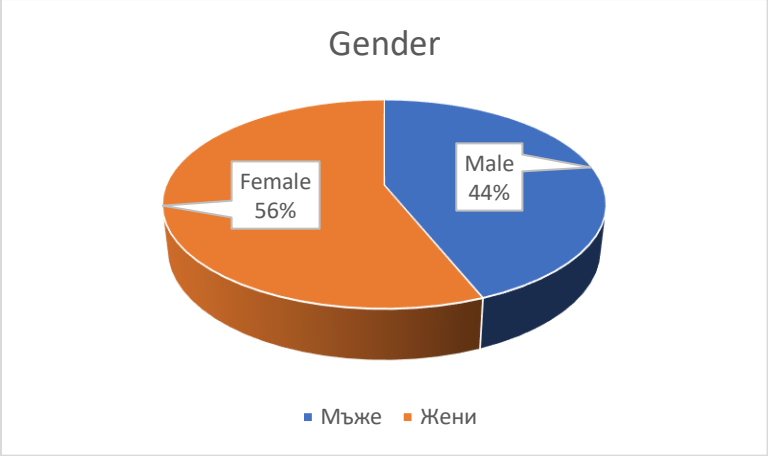


Fig. 2. *Distribution by gender*

Functional blockages of 203 thoracic motor segments were detected after manual diagnostic examination of all patients. Evaluation of the distribution of functional disorders according to the level of the blocked motor segment showed that they were most frequent in the middle thoracic region (T5-T8) - 52%. For the upper thoracic spine(T1-T4) and lower thoracic (T9-T12) region, the prevalence rates were 32% and 16%, respectively (Figure 3).

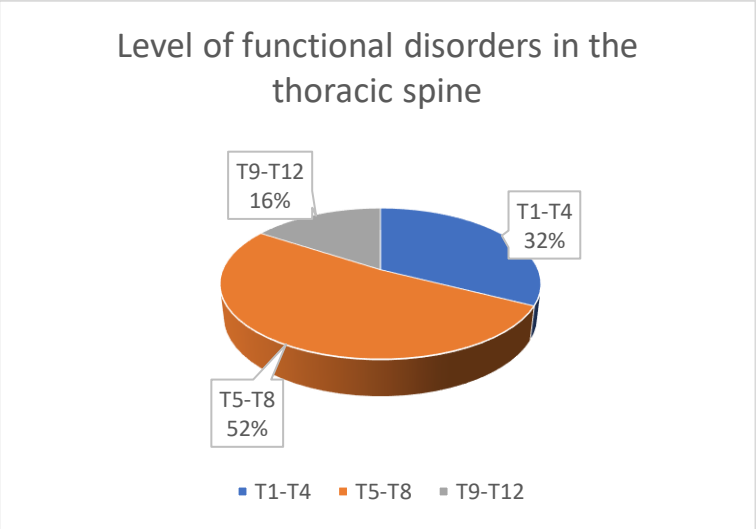


Fig. 3. *Distribution of functional disorders according to the level of the blocked motor segment in the thoracic spine*

After the diagnostic examination, it was found that 65.9% of the participants, in addition to functional disorders for the intervertebral joints in the thoracic spine, had also somatic dysfunction for the costovertebral and costotransversal joints (Figure 4).

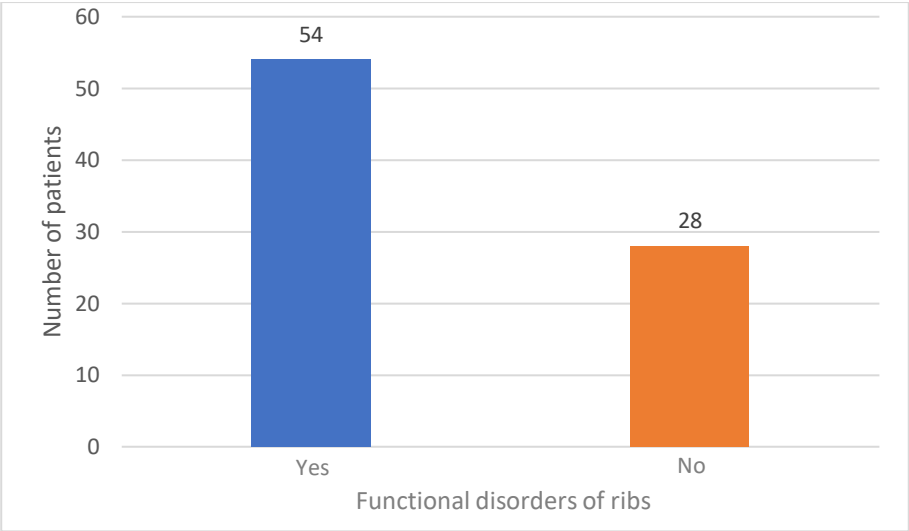


Fig.4. *Distribution of patients according to the presence of functional rib disorders*

In terms of employment, it was found that the majority of the study participants performed work activities associated with physical strain in the thoracic region, with frequent repetitive movements of the same type for the spine. The highest proportion of 46% are people engaged in occupations related to static body position from a sitting or standing position - office workers, computer specialists, teachers, doctors, etc. Around 26% practice occupations involving heavy physical labor - construction workers, warehouse workers, dockers, factory workers, drivers and others. Students accounted for 21% of participants, and 7% were professional athletes (Figure 5).

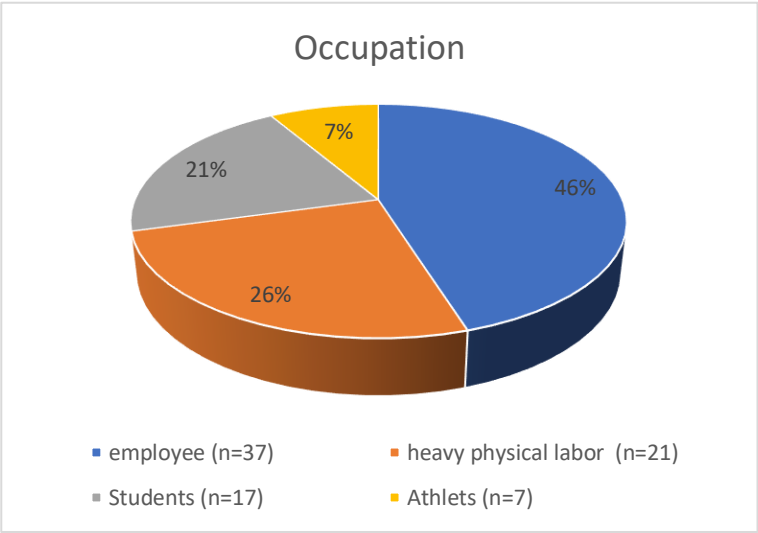


Fig. 5. *Distribution of patients according to occupation*

The distribution in terms of physical activity of the patients showed that 35.4% of the treated subjects had low, 40.2% medium and 24.4% high physical activity (Figure 6).

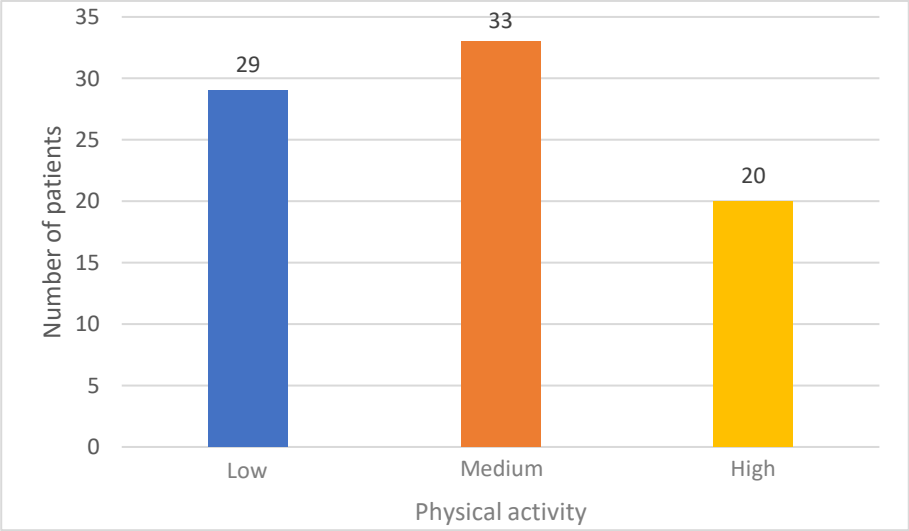


Fig. 6. *Distribution of patients according to their physical activity*

The mean age of patients in group A is 35.09 ± 8.26 years and in group B is 33.63 ± 9.29 years. In both groups, persons in the age range between 30 and 39 years outnumber the others. The gender distribution in the two groups shows a female predominance. In Group A, 46% (n = 19) are men compared with 54% (n = 22) women, while in Group B, 41% (n = 17) are men and 59% (n = 24) women (Figure 7).

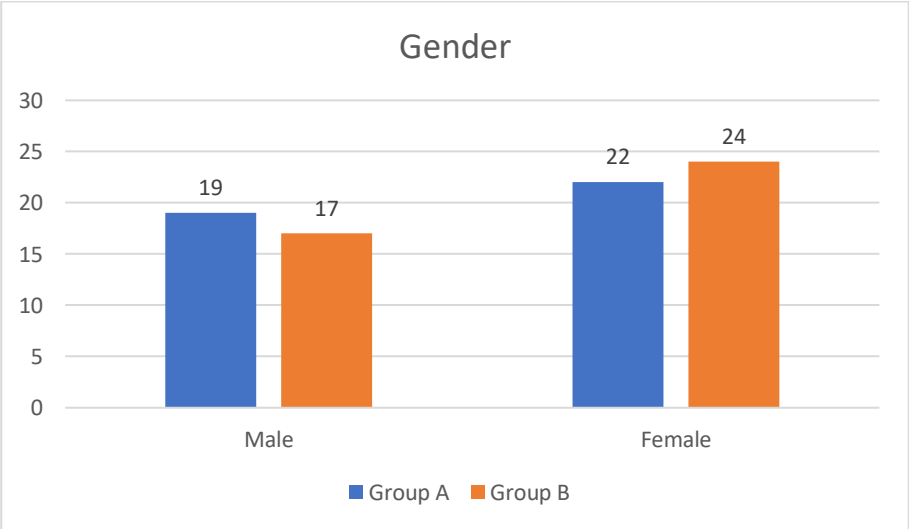


Fig. 7. *Gender distribution in group A and group B*

According to physical activity, the distribution in the two groups showed a predominance of patients with low and medium physical activity. In group A, 32% had low, 46% medium and

22% high physical activity. In group B the distribution is 39%, 34% and 27% had low, medium and high physical activity, respectively (Figure 8).

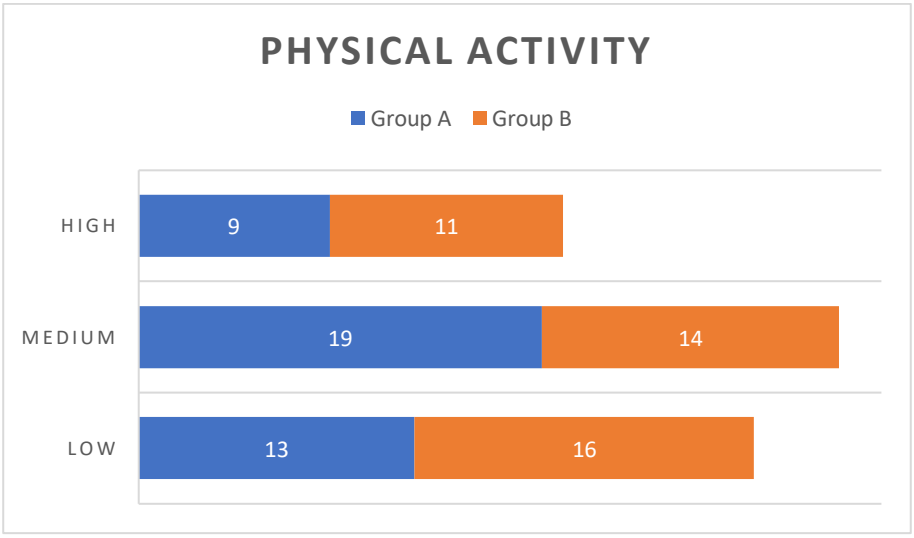


Fig. 8. *Distribution according to physical activity in group A and in group B*

2. Analysis of baseline values of the measurement indicators tracking the effectiveness of the treatment in both groups

After the initial examination, baseline data for all patients were recorded for the Ott flexion test measured in centimeters (Figure 9). The mean baseline value for all study participants is 2.7 ± 1.06. In group A, the mean baseline value for Ott's flexion test in centimeters is 2.72 ± 1.02, and in group B 2.68 ± 1.11

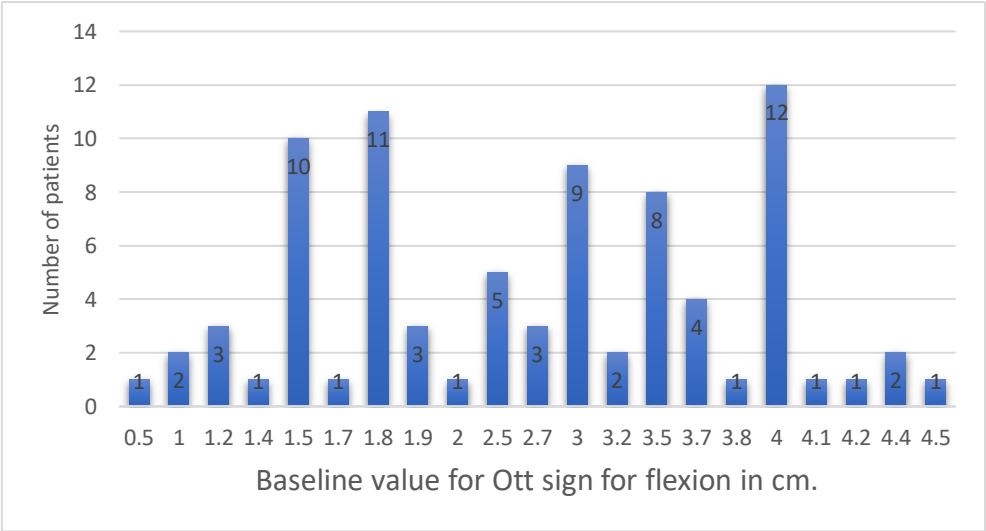


Fig. 9. *Distribution of the number of patients according to baseline values for the Ott flexion test in centimeters*

Baseline values were obtained for all patients for the Ott test for extension measured in centimeters (Figure 10). The mean value for the trait tracked for all subjects tested is 1.32 ± 0.57.

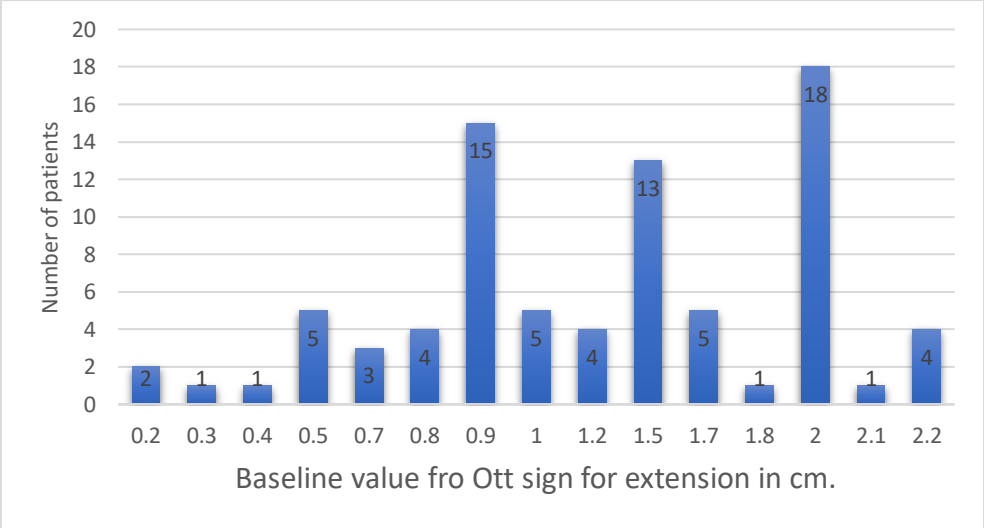


Fig. 10. *Distribution of the number of patients according to baseline values for the Ott extension test in centimeters*

In group A, the mean value for Ott's extension test in centimeters at baseline is 1.34 ± 0.56, and in group B, 1.30 ± 0.58.

Baseline values were obtained for rotation in the thoracic spine in both directions measured in degrees (Figure 11 and 12). The mean baseline value across all study participants for right rotation is 44.46 ± 6.46 and for left rotation is 47.71 ± 5.85.

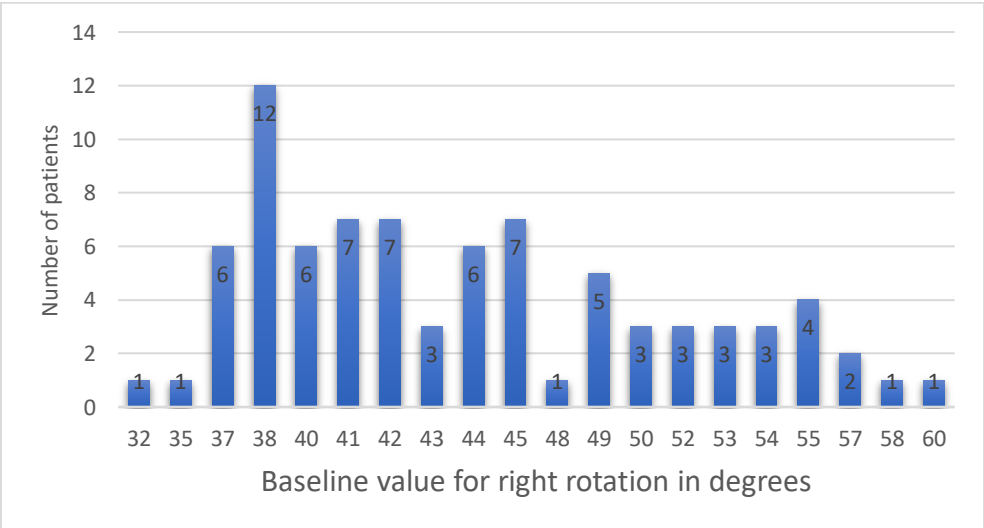


Fig. 11. *Distribution of the number of patients according to baseline values for right rotation in degrees*

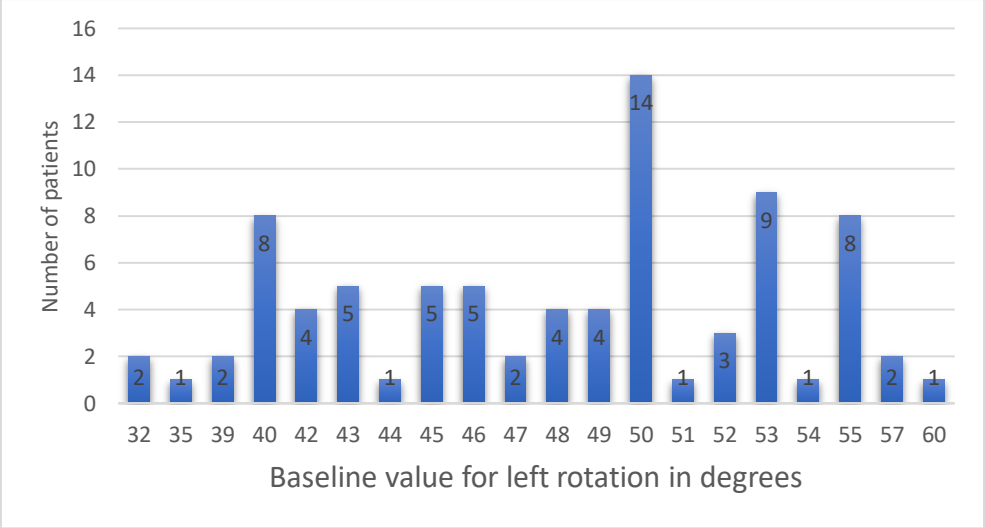


Fig. 12. *Distribution of the number of patients according to baseline values for left rotation in degrees*

For group A, the mean baseline value for rotation in both directions measured in degrees is 43.29 ± 6.03 for right rotation and 48.63 ± 5.06 for left rotation. In group B, the respective baseline means are 45.63 ± 6.74 for right rotation and 46.80 ± 6.48 for left rotation in the thoracic spine.

Baseline values were obtained for all patients for spontaneous pain as measured by the visual analog scale VAS (Figure 13). The mean spontaneous pain score according to VAS for all subjects tested is 3.36 ± 1.07.

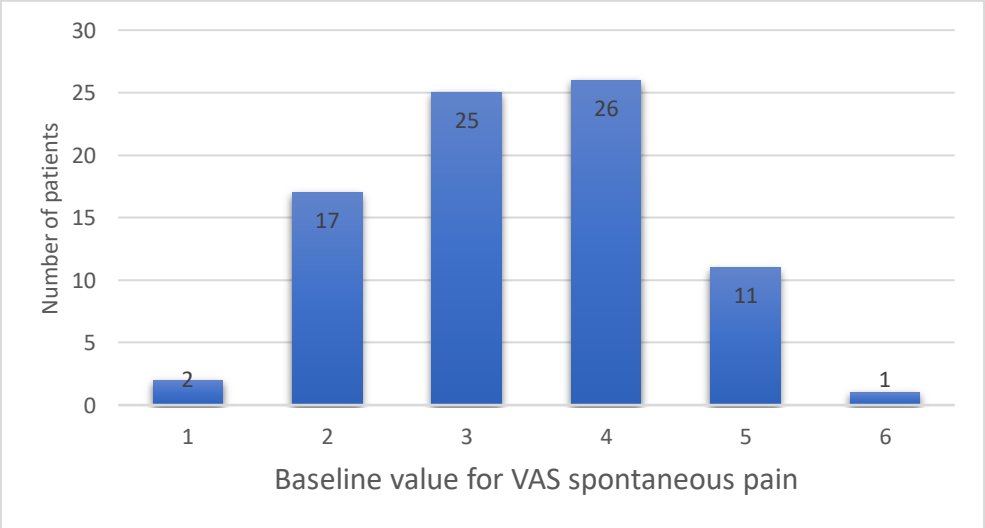
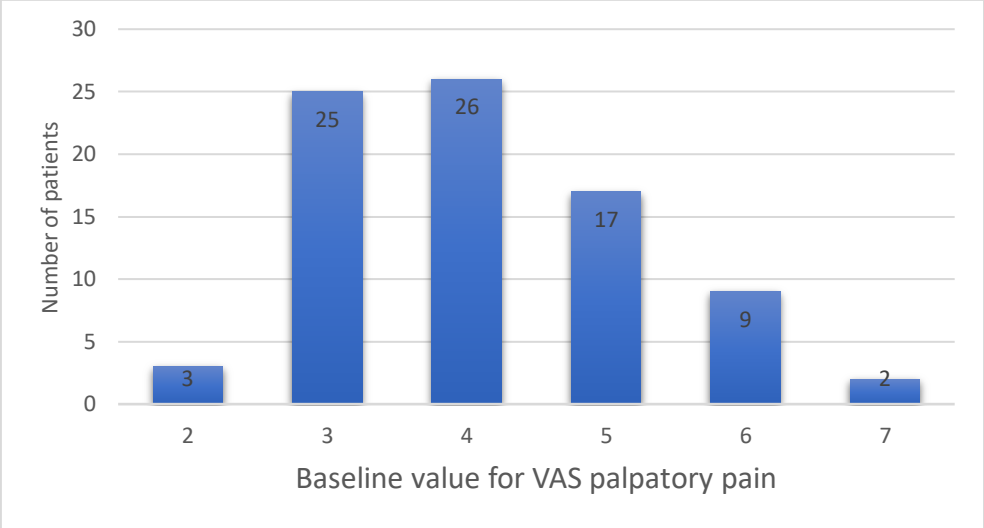


Fig. 13. *Distribution of the number of patients according to baseline values for VAS spontaneous pain*

For group A, the mean value for VAS spontaneous pain at baseline level is 3.19 ± 0.98, whereas for group B it is 3.53 ± 1.14.

Baseline values were obtained for all patients for palpatory pain according VAS (Figure 14). The mean VAS palpatory pain score for all subjects is 4.12 ± 1.14. For group A, the mean value for VAS palpatory pain at baseline is 4.00 ± 1.16, whereas for group B it is 4.24 ± 1.13.



Фиг. 14. *Distribution of the number of patients according to baseline values for VAS palpatory pain*

Baseline values were obtained for all patients for the short form of the McGill questionnaire (Figure 15). The mean for the McGill questionnaire for all individuals tested is 12.58 ± 4.55.

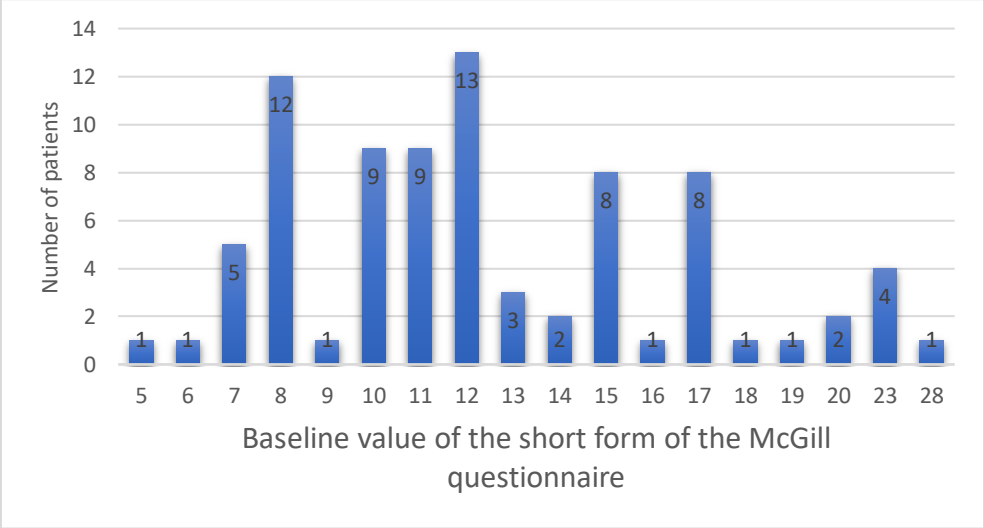


Fig. 15. *Distribution of the number of patients according to baseline values from the short form of the McGill pain questionnaire*

For Group A patients, the mean for the McGill short form questionnaire at baseline is 12.29 ± 4.27, while for Group B it is 12.87 ± 4.85.

Baseline values were obtained for all patients for the Functional Rating Index (Figure 16). The mean FRI for all patients is13.30 ± 3.44. For group A, the mean FRI output is 12.92 ± 3.06, whereas for group B it is 13.68 ± 3.78.

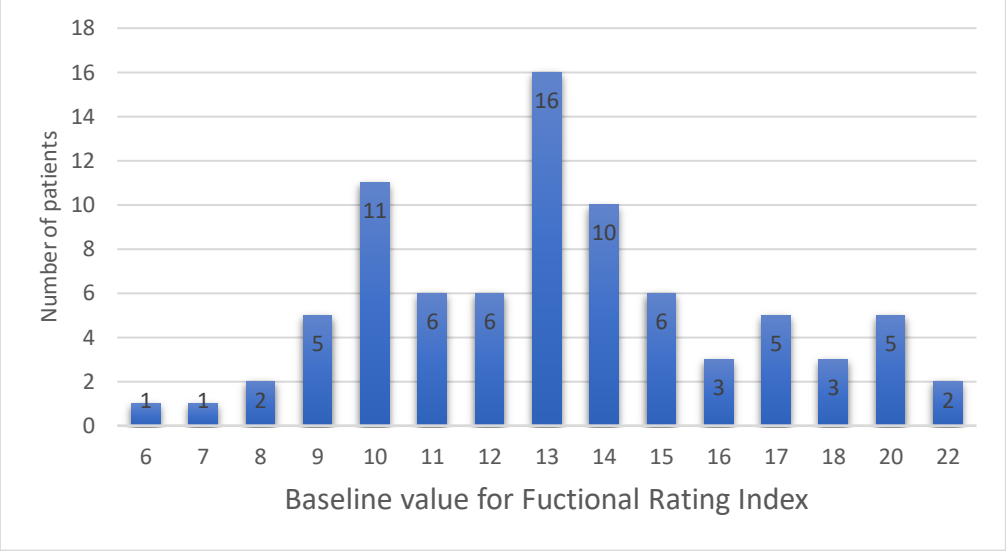


Fig. 16. *Distribution of the number of patients according to baseline values from the Functional Rating Index*

Statistical testing using Student's t-test to compare the difference in means for the main observed characteristics in the two groups showed that for all indicators we had no statistically significant difference ($p>0.05$). There is no difference in the demographic indicators, the assessment for pain and the functional status of the thoracic spine between the patients studied in the two groups, leading to their mutual homogeneity. This is an important condition for the reliability of the results from the comparative analysis which is an objective of the present study (Table 1).

***Table 1**. Comparative analysis between patients in group A and group B in terms of basic demographic characteristics and baseline values of the pursued characteristics*

	Група А	**Група Б**	**p**
Age (Mean±SD)	35.09 ± 8.26	33.63 ± 9.29	0.4542
Gender (males, %/n)	46% (n=19)	44% (n=17)	0.9055
Physical activity (low, %/n)	32% (n=13)	39% (n=16)	0.7009
Ott sign for flexion (Mean±SD)	2.72 ± 1.02	2.68 ± 1.11	0.8655
Ott sign for extension (Mean±SD)	1.34 ± 0.56	1.30 ± 0.58	0.7516
Test for right rotation (Mean±SD)	43.29 ± 6,03	45.63 ± 6.74	0.1015
Test for left rotation (Mean±SD)	48.63 ± 5.06	46.80 ± 6.48	0.1580
VAS spontaneous pain (Mean±SD)	3.19 ± 0.98	3.53 ± 1.14	0.1515
VAS palpatory pain (Mean±SD)	4.00 ± 1,16	4.24 ± 1.13	0.3455
Short form of the McGill (Mean±SD)	12.29 ± 4,27	12.87 ± 4.85	0.5671
Functional Rating Index (Mean±SD)	12.92 ± 3,06	13.68 ± 3.78	0.3264

3. Evaluation of the clinical effectiveness of the two treatment methods according to the monitored indicators, in three time periods

This analysis was ascertained by comparing the mean values for the eight measured indicators (Ott flexion-extension test, rotation test, VAS spontaneous and VAS palpatory pain, McGill questionnaire and FRI) at the three time points considered (at baseline (T0), after completion of treatment (T1), and at day 45 of study entry (T2)).

After the initial examination (T0), the following baseline Ott flexion test values in centimeters are recorded for the subjects in group A: mean - 2.72, minimum - 1, maximum - 4.2. On the 15th day after the end of the therapeutic course (T1) for the same indicator are: mean - 3.19, minimum - 1.8, maximum - 4.5. The data recorded on the 45th day after treatment initiation (T2) for Ott's flexion test are, respectively: mean - 3.29, minimum - 2, maximum - 4.5 (Figure 17)

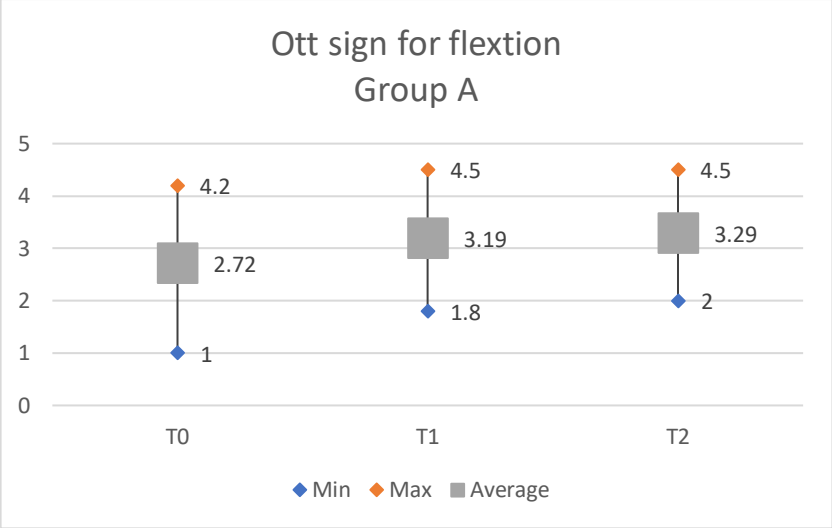


Fig. 17. *Mean, minimum, and maximum value for Ott flexion test in centimeters measured at the three follow-up time points for group A subjects*

Data from the intragroup statistical analysis for linked samples for Ott's test for flexion for individuals in group A showed a statistically significant difference ($p < 0.05$) in means calculated according to the three time periods (Table 2). The difference found represents a statistically significant increase in mean values at the end of treatment compared to the beginning of the study (T1-T0). This tendency for statistically significant improvement is also preserved when we analyze the results on the 45th day from the beginning of the study, both regarding the end of treatment (T2-T1) and the baseline condition (T2-T0).

Table 2. *Intragroup statistical analysis between Ott flexion test values for the three follow-up time intervals, in group A patients*

Ott sign for flexion in cm	**Mean**	**Std. Deviation**	**Std. Error Mean**	**t**	**df**	**95% Confidence Interval of Difference Lower**	**Upper**	**One-Sided P -value**	**Two-Sided P-value**
T1–T0	0.468	0.505	0.079	5.933	40	0.308	0.627	<0.001	<0.001
T2–T1	0.102	0.229	0.035	2.856	40	0.299	0.174	0.003	0.007
T2–T0	0.570	0.655	0.102	5.579	40	0,364	0.777	<0.001	<0.001

The following baseline values for the Ott test, measured in centimeters, are reported for patients in group B: mean - 2.68, minimum - 0.5, maximum - 4.5. On the 15th day, immediately after completion of therapy (T1) for the same sign are: average - 3.2, minimum - 1.8, maximum - 4.5. The data recorded on day 45 after the start of the study (T2) for the Ott flexion test are: mean, 3.27; minimum, 2; maximum, 4.5 (Figure 18).

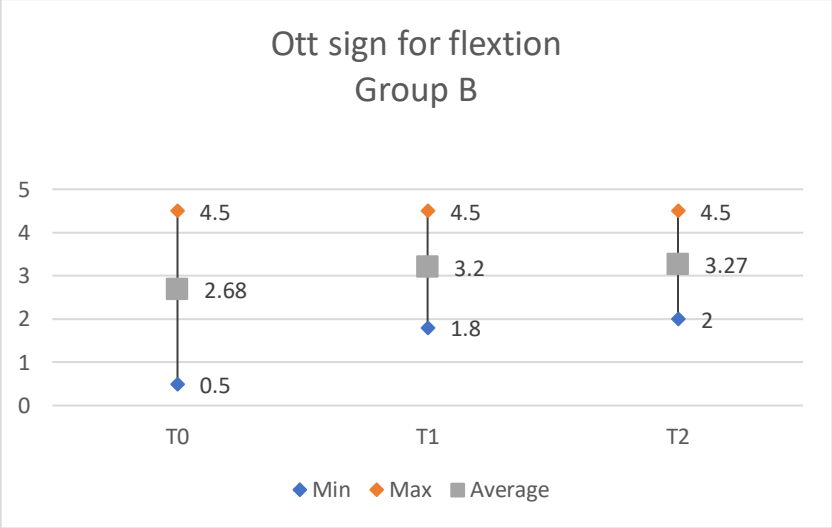


Fig. 18. *Mean, minimum, and maximum value for Ott flexion test in centimeters measured at the three follow-up time points for group B patients*

The data from the intragroup analysis regarding Ott's flexion test for the subjects in group B, showed a statistically significant difference ($p < 0.05$) when comparing the means of the three time periods (Table 3). The difference found represents a statistically significant increase in mean values at the end of treatment compared to the beginning of the study (T1-T0). This tendency for statistically significant improvement is also preserved when we analyze the results on the 45th day from the beginning of the study, both regarding the end of treatment (T2-T1) and the baseline condition (T2-T0).

Table 3. *Intragroup statistical analysis between Ott flexion test values for the three follow-up time intervals, in group B patients*

Ott sign for flexion in cm	Mean	Std. Deviation	Std. Error Mean	t	df	95% Confidence Interval of Difference Lower	Upper	One-Sided P -value	Two-Sided P-value
T1–T0	0.522	0.555	0.086	6.020	40	0.346	0.697	<0.001	<0.001
T2–T1	0.063	0.144	0.022	2.810	40	0.0178	0.109	0.004	0.008
T2–T0	0.585	0.624	0.097	6.004	40	0,388	0.782	<0.001	<0.001

After the initial examination (T0), the following baseline values for Ott's extension test in centimeters are recorded for the subjects in group A: mean - 1.34, minimum - 0.3, maximum - 2.2. After treatment (T1) for the same trait are: mean - 1.58, minimum - 0.9, maximum - 2.2. The data recorded on day 45 after initiation of therapy (T2) for Ott's test of extension are, respectively: mean, 1.65; minimum, 1; maximum, 2.3 (Figure 19).

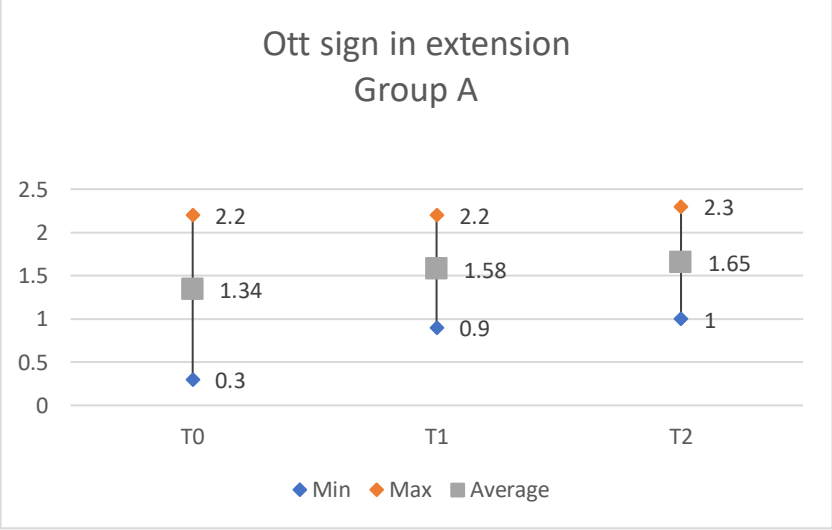


Fig. 19. *Mean, minimum, and maximum value for Ott extension test in centimeters measured at the three follow-up time points for group A patients*

The intragroup analysis of the data in terms of Ott's test of extension for the subjects in Group A are presented in Table 4. Their analysis showed a statistically significant difference ($p < 0.05$) when comparing the mean levels for the three time intervals monitored.

Table 4. *Intragroup statistical analysis between Ott extension test values for the three follow-up time intervals, in group A patients*

Ott sign for extension in cm	Mean	Std. Deviation	Std. Error Mean	t	df	95% Confidence Interval of Difference Lower	Upper	One-Sided P -value	Two-Sided P-value
T1–T0	0.236	0.273	0.042	5.536	40	0.1502	0.323	<0.001	<0.001
T2–T1	0.073	0.141	0.022	3.312	40	0.0285	0.117	<0.001	0.002
T2–T0	0.309	0.363	0.056	5.461	40	0,1951	0.424	<0.001	<0.001

For group B patients, the reported baseline values (T0) for Ott's test of extension in centimeters are: mean - 1.3, minimum - 0.2, maximum - 2.2. On the 15th day (T1) the data for the same trait are: mean - 1.58, minimum - 0.8, maximum - 2.2. The data recorded on day 45 after treatment initiation (T2) for Ott's test of extension are, respectively: mean, minimum, 1.62; maximum, 2.5 (Figure 20).

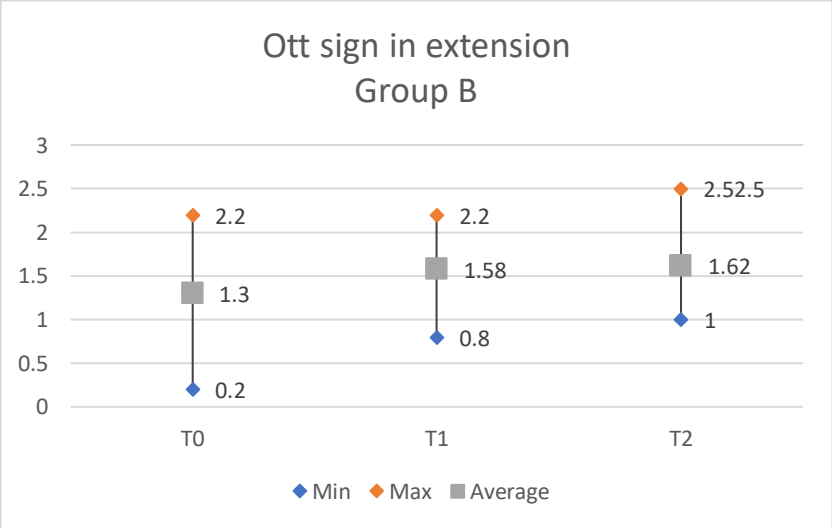


Fig. 20. *Mean, minimum, and maximum value for Ott extension test in centimeters measured at the three follow-up time points for group B subjects*

Intragroup statistical analysis with respect to Ott's test of extension for the subjects in Group B showed a statistically significant difference ($p < 0.05$) when comparing the mean values for the three follow-up time intervals (Table 5). The difference found represents a

statistically significant increase in mean values at the end of treatment compared to the beginning of the study (T1-T0). This tendency for statistically significant improvement is also preserved when we analyze the results on the 45th day from the beginning of the study, both regarding the end of treatment (T2-T1) and the baseline condition (T2-T0).

Table 5. *Intragroup statistical analysis between Ott extension test values for the three follow-up time intervals, in group B patients*

Ott sign for extension in cm	Mean	Std. Deviation	Std. Error Mean	t	df	95% Confidence Interval of Difference Lower	Upper	One-Sided P -value	Two-Sided P-value
T1–T0	0.280	0.350	0.054	5.129	40	0.1700	0.391	<0.001	<0.001
T2–T1	0.041	0.094	0.014	2.800	40	0.0115	0.071	0.004	0.008
T2–T0	0.322	0.382	0.059	5.390	40	0,2012	0.442	<0.001	<0.001

For the tested patients of group A, the results (mean, minimum and maximum) of the functional test for rotational movements in a thoracic spine region in both directions measured in degrees, are presented in Figure 21 and Figure 22.

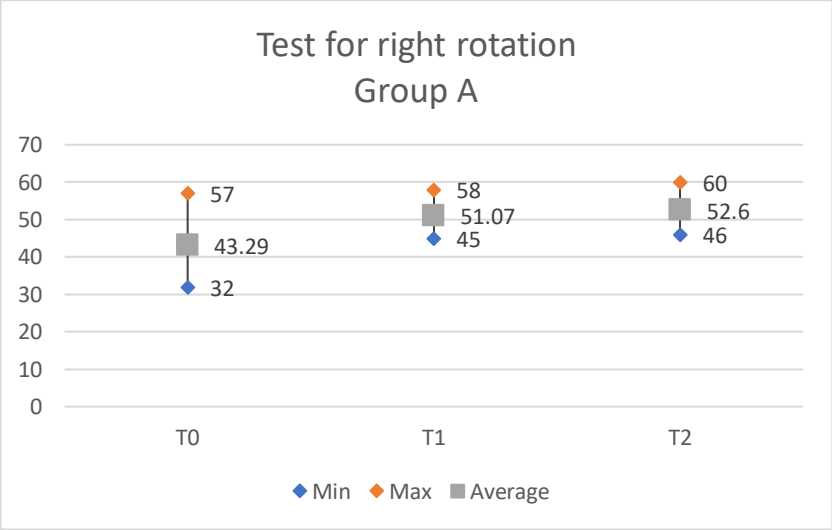


Fig. 21. *Mean, minimum, and maximum value for right rotation test in degrees measured at the three follow-up time points for group A patients*

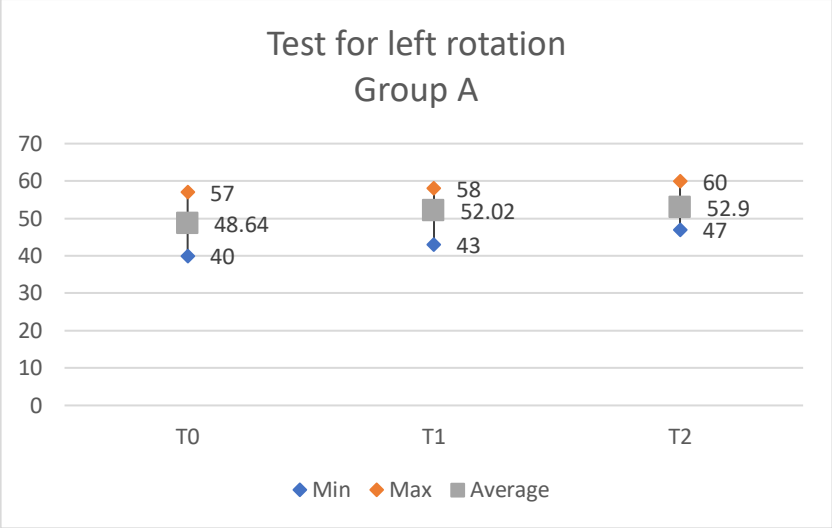


Fig. 22. *Mean, minimum, and maximum value for left rotation test in degrees measured at the three follow-up time points for group A subjects*

Intragroup statistical analysis regarding the functional test for right rotation in the thoracic spine for group A patients showed a statistically significant difference ($p < 0.05$) when comparing the mean values for the three time intervals tracked (T1-T0, T2-T1 and T2-T0) (Table 6).

Table 6. *Intragroup statistical analysis between the right rotation values for the three follow-up time intervals, in group A patients*

Test for right rotation	Mean	Std. Deviation	Std. Error Mean	t	df	95% Confidence Interval of Difference Lower	Upper	One-Sided P -value	Two-Sided P-value
T1–T0	7.780	5.382	0.840	9.255	40	6.0814	9.4795	<0.001	<0.001
T2–T1	1.536	2.169	0.338	4.536	40	0.8519	2.2212	<0.001	<0.001
T2–T0	9.317	6.105	0.953	9.772	40	7.390	11.244	<0.001	<0.001

Intragroup statistical analysis regarding left rotation testing in Group A patients is presented in Table 7. The difference found presented a statistically significant increase in the mean values at the end of treatment compared to the start of the study (T1–T0). This tendency for statistically significant improvement is also preserved when we analyze the results on the

45th day from the beginning of the study, both regarding the end of treatment (T2-T1) and the baseline condition (T2-T0).

Table 7. *Intragroup statistical analysis between the left rotation values for the three follow-up time intervals, in group A patients*

Test for left rotation	Mean	Std. Deviation	Std. Error Mean	t	df	95% Confidence Interval of Difference Lower	Upper	One-Sided P -value	Two-Sided P-value
T1–T0	3.390	3.745	0.585	5.793	40	2.2078	4.5731	<0.001	<0.001
T2–T1	0.878	2.227	0.347	2.525	40	0.1751	1.5809	<0.001	<0.001
T2–T0	4.268	4.268	0.799	5.339	40	2.6526	5.8839	0.008	0.016

For group B study participants, the results (mean, minimum and maximum) of the functional test for rotational movements in the thoracic spine in both directions measured in degrees are presented in Figure 23 and Figure 24.

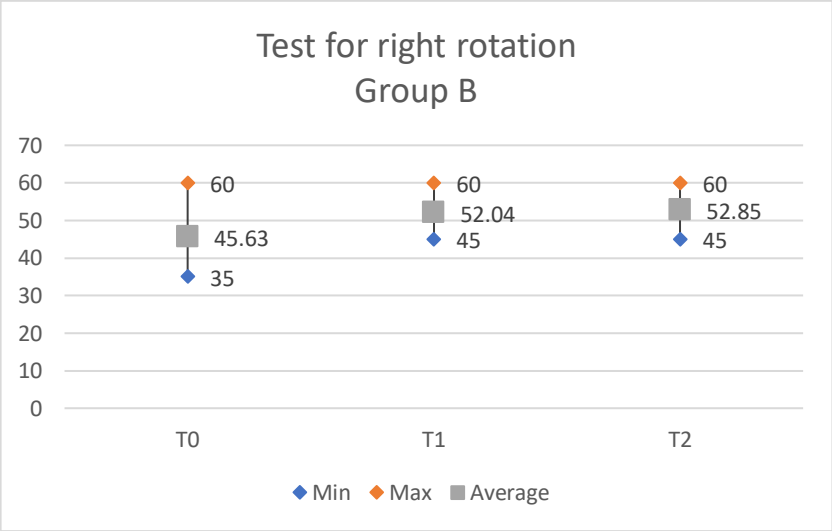


Fig. 23. *Mean, minimum, and maximum value for right rotation test in degrees measured at the three follow-up time points for group B patients*

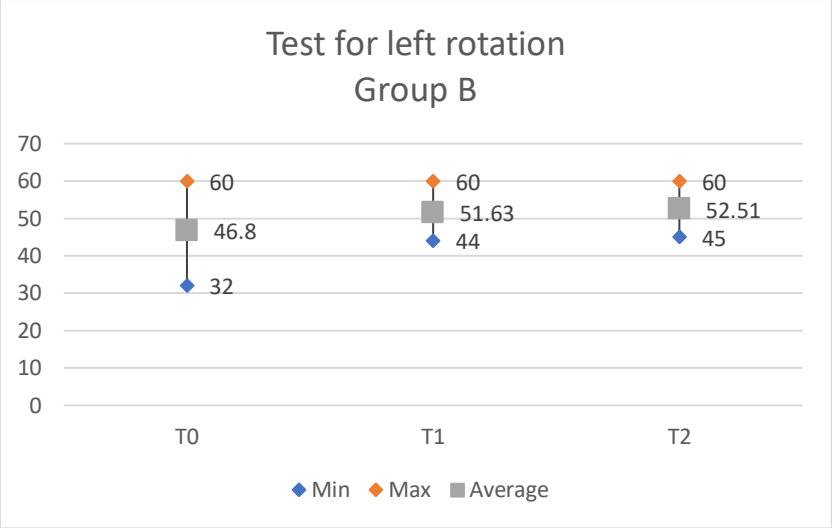


***Fig. 26**. Mean, minimum, and maximum value for left rotation test in degrees measured at the three follow-up time points for group B patients*

The intragroup statistical analysis with respect to the functional test for rotation in both directions for the patients of group B are presented in Table 8 and Table 9. Their analysis showed a statistically significant difference ($p < 0.05$) when comparing the mean values for the three time intervals followed. The difference found presented a statistically significant increase in the mean values at the end of treatment compared to the start of the study (T1–T0). This tendency for statistically significant improvement is also preserved when we analyze the results on the 45th day from the beginning of the study, both regarding the end of treatment (T2-T1) and the baseline condition (T2-T0).

***Table 8.** Intragroup statistical analysis between the right rotation values for the three follow-up time intervals, in group B patients*

Test for right rotation	Mean	Std. Deviation	Std. Error Mean	t	df	95% Confidence Interval of Difference Lower	Upper	One-Sided P -value	Two-Sided P-value
T1–T0	6.414	4.852	0.757	8.464	40	4.8829	7.9463	<0.001	<0.001
T2–T1	0.804	1.400	0.218	1.246	40	0.3628	1.2468	<0.001	<0.001
T2–T0	7.219	5.236	0.817	8.872	40	5.5665	8.8725	<0.001	<0.001

Table 9. *Intragroup statistical analysis between the left rotation values for the three follow-up time intervals, in group B patients*

Test for left rotation	Mean	Std. Deviation	Std. Error Mean	t	df	95% Confidence Interval of Difference Lower	Upper	One-Sided P -value	Two-Sided P-value
T1–T0	4.829	4.852	0.757	6.373	40	3.2976	6.3608	<0.001	<0.001
T2–T1	0.878	1.169	0.264	3.325	40	0.3442	1.411	<0.001	<0.001
T2–T0	5.707	6.112	0.954	5.979	40	3.7779	7.6366	<0.001	0.002

The following baseline values (T0) for spontaneous pain are recorded using the visual analogue scale for patients in group A: mean - 3.19, minimum - 2, maximum - 5. On the 15th day after the end of the therapeutic course (T1) for the same trait are: mean - 1.87, minimum - 1, maximum - 4. The data obtained on day 45 after the start of the study (T2) for VAS spontaneous pain are, respectively: mean - 1.48, minimum - 0, maximum - 3 (Figure 25).

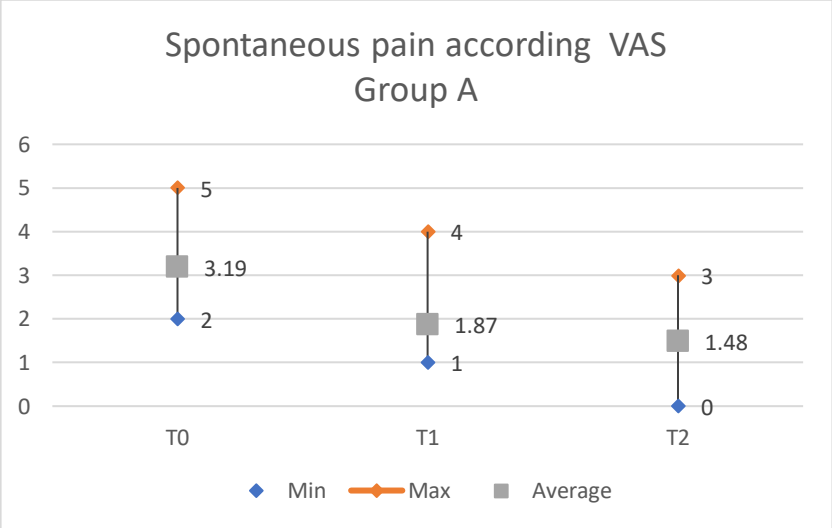


Fig. 25. *Mean, minimum, and maximum for spontaneous pain according VAS at the three follow-up time points for patients in group A*

Intragroup statistical analysis data for related samples for spontaneous pain according VAS for test subjects of group A showed a statistically significant difference ($p < 0.05$) when comparing the means over the three time periods (Table 10). We had a statistically significant reduction in spontaneous pain reported through VAS at the end of treatment from baseline (T1–

T0), from the beginning of the course of therapy and the 45th day (T2–T0), as well as in the T2-T1 intermediate time period.

Table 10. *Intragroup statistical analysis between the values for spontaneous pain according VAS for the three follow-up time intervals, in patients of group A*

Spontaneous pain according VAS	Mean	Std. Deviation	Std. Error Mean	t	df	95% Confidence Interval of Difference Lower	Upper	One-Sided P -value	Two-Sided P-value
T1–T0	-1.317	0.788	0.123	-10.69	40	-1.5660	-1.068	<0.001	<0.001
T2–T1	-0.390	0.627	0.098	-3.981	40	-0.5883	-0.1921	<0.001	<0.001
T2–T0	-1.70	0.901	0.140	-12.13	40	-1.9918	-1.4229	<0.001	<0.001

For patients in group B, the reported baseline values (T0) for spontaneous pain according to VAS are: mean value – 3.53, minimum – 1, maximum – 6. On the 15th day (T1), the data for the same criteria are: mean value – 1.58, minimum – 0, maximum – 3. The data reported on day 45 after initiation of therapy (T2) for VAS spontaneous pain are respectively: mean value – 1.15, minimum – 0, maximum – 3 (Figure 26).

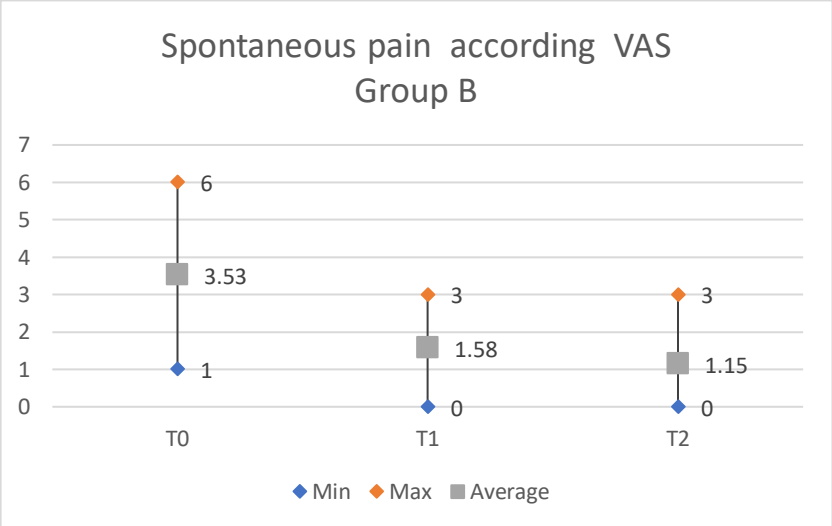


Fig. 26. *Mean, minimum, and maximum for spontaneous pain according VAS at the three follow-up time points for patients in group B*

The intragroup statistical analysis regarding VAS spontaneous pain for group B subjects is presented in Table 11. The results showed a statistically significant ($p < 0.05$) reduction in

spontaneous pain according to VAS at the end of therapy compared to baseline (T1–T0), from the beginning of the treatment course and the 45th day (T2–T0), as well as in the intermediate time period T2-T1.

Table 11. *Intragroup statistical analysis between the values for spontaneous pain according VAS for the three follow-up time intervals, in patients of group B*

Spontaneous pain according VAS	Mean	Std. Deviation	Std. Error Mean	t	df	95% Confidence Interval of Difference Lower	Upper	One-Sided P -value	Two-Sided P-value
T1–T0	-2.243	1.178	0.184	-12.19	40	-2.6159	-1.8719	<0.001	<0.001
T2–T1	-0.463	0.552	0.086	-5.374	40	-0.6377	-0.2891	<0.001	<0.001
T2–T0	-2.707	1.123	0.175	-15.43	40	-3.0619	-2.3527	<0.001	<0.001

Using the VAS, at the initial assessment (T0), baseline values for palpatory pain in a thoracic spine are recorded for patients of group A: mean value – 4, minimum – 2, maximum – 7. On the 15th day, after the end of the therapeutic course (T1) for the same criteria are: average value – 2.43, minimum – 1, maximum – 4. The data obtained on the 45th (T2) for VAS palpatory pain are respectively: mean value – 1.92, minimum – 0, maximum – 3 (Figure 27).

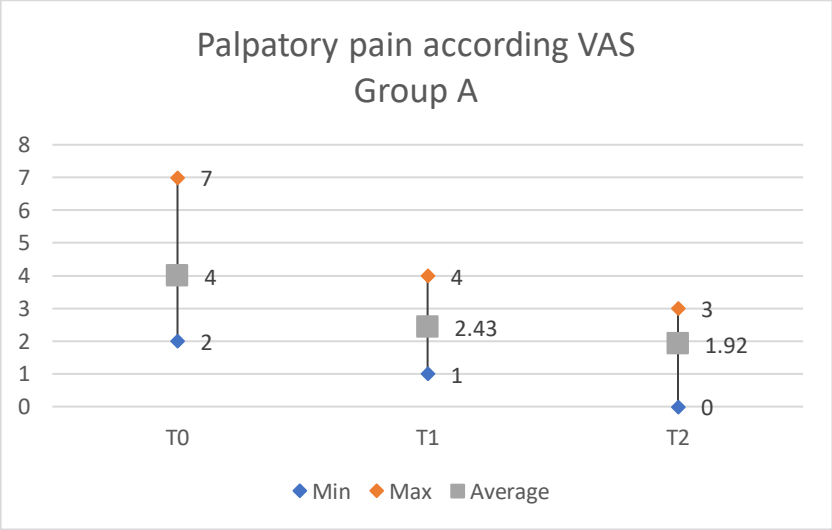


Fig. 27. *Mean, minimum, and maximum for palpatory pain according VAS at the three follow-up time points for patients in group A*

Intragroup statistical analysis for related samples regarding palpatory pain according VAS for group A subjects showed a statistically significant difference ($p < 0.05$) when

comparing the mean values for the three time points followed. The results showed a statistically significant reduction in palpatory pain reported by VAS in all three time intervals followed (Table 12).

Table 12. *Intragroup statistical analysis between the values for palpatory pain according VAS for the three follow-up time intervals, in patients of group A*

Palpatory pain according VAS	Mean	Std. Deviation	Std. Error Mean	t	df	95% Confidence Interval of Difference Lower	Upper	One-Sided P -value	Two-Sided P-value
T1–T0	-1.561	0.807	0.126	-12.374	40	-1.8159	-1.306	<0.001	<0.001
T2–T1	-0.512	0.675	0.105	-4.856	40	-0.7254	-0.299	<0.001	<0.001
T2–T0	-2.073	1.191	0.186	-11.142	40	-2.4492	-1.697	<0.001	<0.001

For patients in group B, the reported baseline values (T0) for palpatory pain according VAS are: mean value – 4.24, minimum – 2, maximum – 7. On the 15th day (T1) the data for the same attribute are: average value – 1.78, minimum – 0, maximum – 3. The data obtained on the 45th day (T2) for VAS palpatory pain are respectively: average value – 1.24, minimum – 0, maximum – 2 (Figure 28).

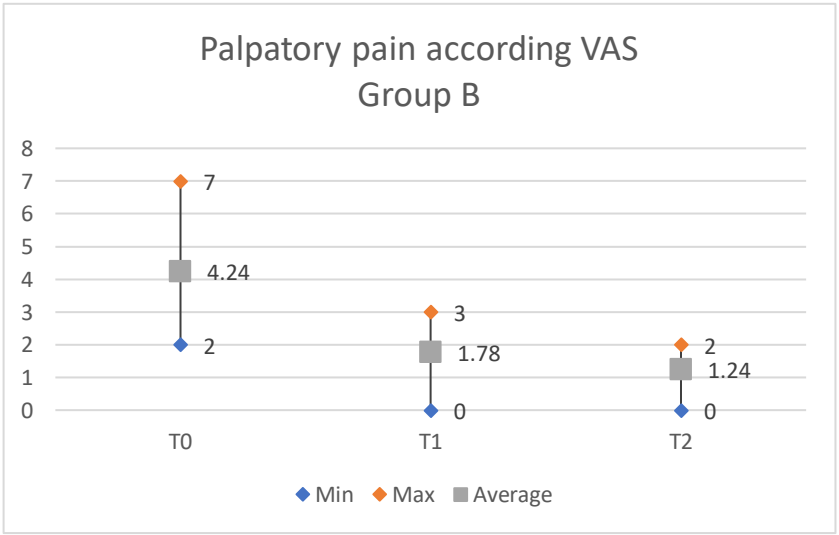


Fig. 28. *Mean, minimum, and maximum for palpatory pain according VAS at the three follow-up time points for patients in group B*

The intragroup statistical analysis for related samples for palpatory pain according VAS for the tested subjects of group B is presented in Table 13. The data showed a statistically significant ($p < 0.05$) reduction in palpatory pain reported through VAS at the end of therapy from baseline (T1–T0), from the beginning of the treatment course and the 45th day (T2–T0), as well as in the intermediate time period T2-T1.

Table 13. *Intragroup statistical analysis between the values for palpatory pain according VAS for the three follow-up time intervals, in patients of group B*

Palpatory pain according VAS	Mean	Std. Deviation	Std. Error Mean	t	df	95% Confidence Interval of Difference Lower	Upper	One-Sided P -value	Two-Sided P-value
T1–T0	-2.463	1.074	0.167	-14.678	40	-2.8026	-2.1242	<0.001	<0.001
T2–T1	-0.536	0.636	0.099	-5.400	40	-0.7374	-0.3357	<0.001	<0.001
T2–T0	-3.000	1.224	0.191	-15.684	40	-3.3866	-2.6134	<0.001	<0.001

For patients in group A, the reported baseline values (T0) for the McGill questionnaire are: mean value – 12.29, minimum – 7, maximum – 23. On the 15th day (T1) the results for the same attribute are: average value – 8.75, minimum – 5, maximum – 17. The data recorded on the 45th day (T2) for the followed criteria is respectively: mean – 6.7, minimum – 2, maximum – 10 (Figure 29).

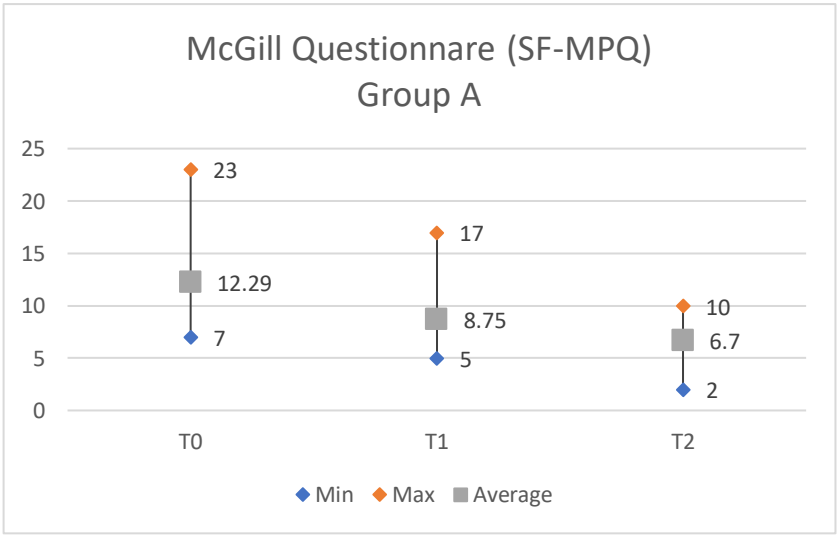


Fig. 29. *Mean, minimum, and maximum for McGill pain questionnaire at the three follow-up time points for patients in group A*

The data from the intragroup statistical analysis for related samples for McGill questionnaire for the group A patients showed a statistically significant difference ($p < 0.05$) when comparing the means over the three time periods (Table 14). We had a statistically significant reduction for sensory and emotional perception of pain in all three time intervals tracked (T1-T0, T2-T1, T2-T0).

Table 14. *Intragroup statistical analysis between the values for McGill pain questionnaire for the three follow-up time intervals, in patients of group A*

McGill pain questionnaire	Mean	Std. Deviation	Std. Error Mean	t	df	95% Confidence Interval of Difference Lower	Upper	One-Sided P -value	Two-Sided P-value
T1–T0	-3.536	1.963	0.306	-11.53	40	-4.156	-2.916	<0.001	<0.001
T2–T1	-2.048	2.224	0.347	-5.898	40	-2.750	-1.346	<0.001	<0.001
T2–T0	-5.585	3.556	0.555	-10.05	40	-6.707	-4.462	<0.001	<0.001

At baseline testing (T0), the following baseline parameters for the McGill questionnaire are recorded for group B individuals: mean – 12.87, minimum – 5, maximum – 28. On the 15th day (T1) the data for the same criteria are: average value – 6.75, minimum – 0, maximum – 17. The results obtained on the 45th day (T2) for the followed criteria is respectively: mean value – 4.17, minimum – 0, maximum – 14 (Figure 30).

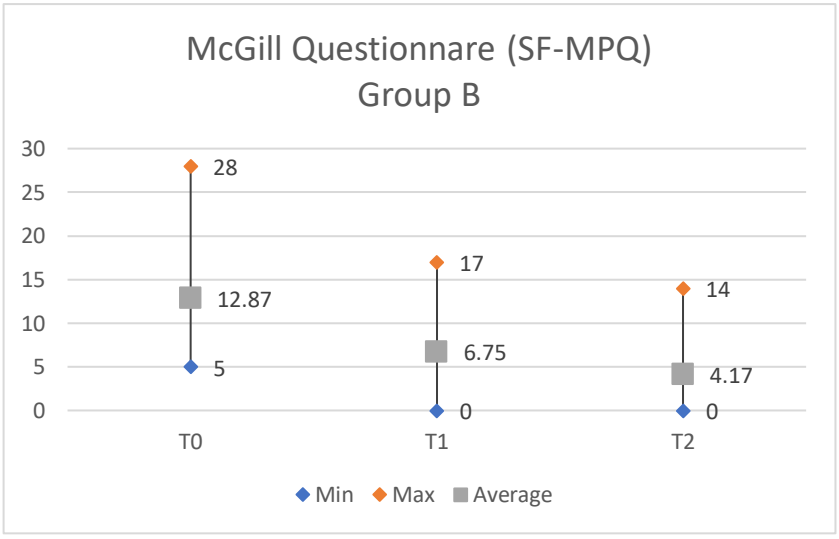


Fig. 30. *Mean, minimum, and maximum for McGill pain questionnaire at the three follow-up time points for patients in group B*

Table 15 presents the intragroup statistical analysis for related samples with respect to the McGill questionnaire for group B surveys. The data conclusively show a statistically significant difference ($p < 0.05$) when comparing the means over the three time intervals tracked (T1-T0, T2-T1, T2-T0).

Table 15. *Intragroup statistical analysis between the values for McGill pain questionnaire for the three follow-up time intervals, in patients of group B*

McGill pain questionnaire	Mean	Std. Deviation	Std. Error Mean	t	df	95% Confidence Interval of Difference Lower	Upper	One-Sided P -value	Two-Sided P-value
T1–T0	-6.121	2.531	0.395	-15.48	40	-6.921	-5.322	<0.001	<0.001
T2–T1	-2.585	1.843	0.287	-8.980	40	-3.167	-2.003	<0.001	<0.001
T2–T0	-8.707	3.451	0.539	-16.15	40	-9.796	-7.617	<0.001	<0.001

For patients in group A, the reported baseline values (T0) for the FRI functionality index are: mean value – 12.92, minimum – 8, maximum – 20. On the 15th day (T1) the data for the same attribute are: average value – 8.92, minimum – 4, maximum – 15. The data recorded on the 45th (T2) for the traced criteria are respectively: mean value – 7.09, minimum – 2, maximum – 13 (Figure 31).

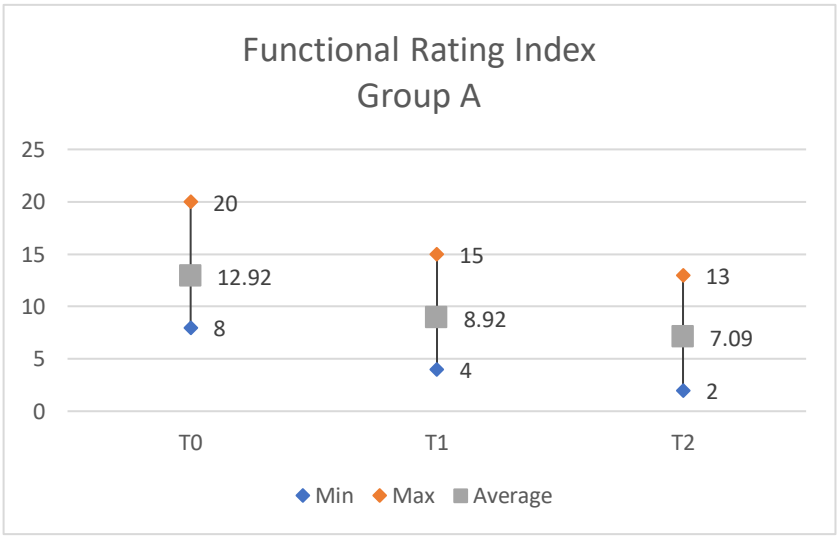


Fig. 31. *Mean, minimum, and maximum for Functional Rating Index at the three follow-up time points for patients in group A*

The data from the intragroup statistical analysis in terms of FRI for the group A subjects showed a statistically significant difference ($p < 0.05$) in the mean values calculated for the three time intervals tracked (Table 15). The difference found presented a statistically significant decrease in the mean values at the end of treatment compared with the start of the study (T1–T0). This tendency for statistically significant improvement is also preserved when we analyze the results on the 45th day from the beginning of the study, both regarding the end of treatment (T2-T1) and the baseline condition (T2-T0).

Table. 15. *Intragroup statistical analysis between the values for Functional Rating Indexl pain questionnaire for the three follow-up time intervals, in patients of group A*

Functional Rating Index	Mean	Std. Deviation	Std. Error Mean	t	df	95% Confidence Interval of Difference Lower	Upper	One-Sided P -value	Two-Sided P-value
T1–T0	-4.000	1.449	0.2263	-17.67	40	-4.4574	-3.5426	<0.001	<0.001
T2–T1	-1.829	1.948	0.3042	-6.013	40	-2.4441	-1.2143	<0.001	<0.001
T2–T0	-5.829	2.478	0.3871	-15.05	40	-6.6117	-5.0468	<0.001	<0.001

During the initial diagnostic test (T0), baseline values for the Functional Rating Index were recorded in patients from group B: mean value – 13.68, minimum – 6, maximum – 22. On the 15th day (T1) the data for the same attribute are: mean value – 7.58, minimum – 1, maximum – 17. The data reported on the 45th (T2) for the traced criterion are respectively: mean value – 4.87, minimum – 0, maximum – 13 (Figure 34).

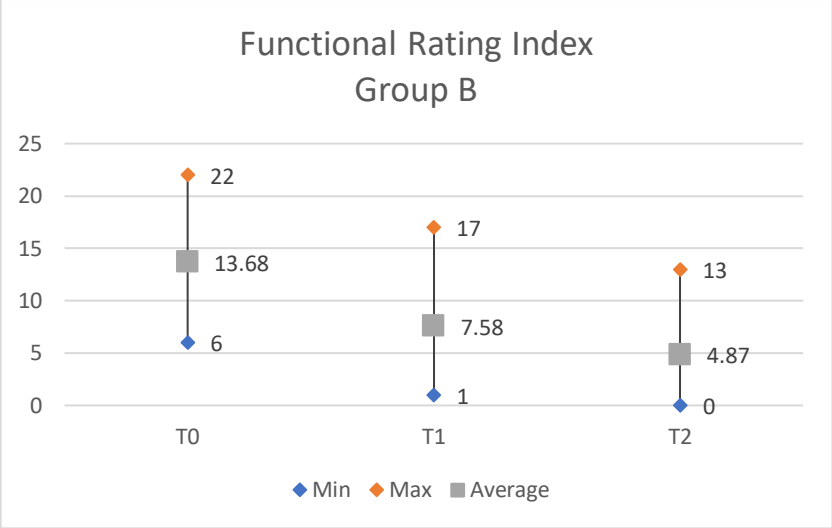


Fig. 32. *Mean, minimum, and maximum for Functional Rating Index at the three follow-up time points for patients in group B*

Table 16 presents the intragroup statistical analysis for related samples for FRI in group B. The data show a statistically significant decrease in the scores for the index of self-assessment of functionality in the thoracic spine ($p < 0.05$) when comparing the mean values for the three tracking time intervals (T1-T0, T2-T1, T2-T0).

Table 16. *Intragroup statistical analysis between the values for Functional Rating Indexl pain questionnaire for the three follow-up time intervals, in patients of group B*

Functional Rating Index	Mean	Std. Deviation	Std. Error Mean	t	df	95% Confidence Interval of Difference Lower	Upper	One-Sided P -value	Two-Sided P-value
T1–T0	-6.097	2.071	0.323	-18.85	40	-6.7513	-5.4437	<0.001	<0.001
T2–T1	-2.707	1.616	0.252	-10.72	40	-3.2174	-2.1971	<0.001	<0.001
T2–T0	-8.804	3.026	0.472	-18.62	40	-9.7602	-7.8495	<0.001	<0.001

4. Comparative analysis of the clinical effectiveness between the two treatment methods according to the results achieved for the monitored indicators

The main aim of the present study was to demonstrate whether there was a statistically significant difference in the condition of patients with functional thoracic disorders treated with two different therapeutic approaches. Since the analysis of baseline values for the two groups did not show statistically significant differences, we hypothesized that the two groups were homogeneous with respect to their primary assessment from functional examinations and rating scales. To compare the clinical effectiveness of the two therapeutic approaches, we compared the mean values for each of the eight follow-up signs detected after the completion of the therapeutic course (T1) and on the 45th day of treatment initiation (T2) between patients in group A and group B.

Figure 33 presents a comparison of results in terms of mean values with 95% confidence intervals for Ott's test for flexion at the end of treatment (T1) and at day 45 from the start of therapy (T2) for group A and group B. The data presented show that the results achieved for the tracking trait were similar for both measurements made.

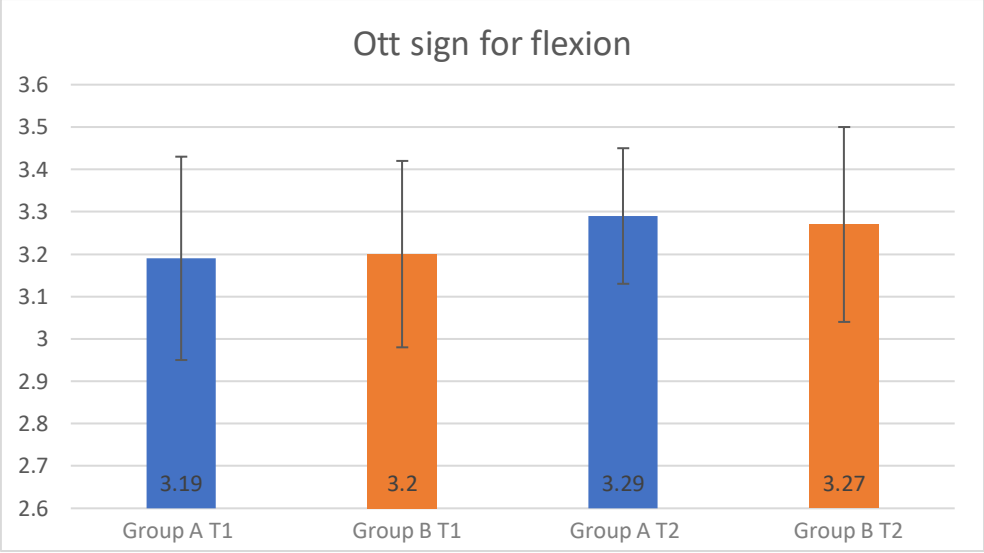


Fig. 33. *Mean value with 95% confidence interval (CI) of Ott's flexion test data in centimeters compared between Group A and Group B*

The data for an Ott test for flexion in centimeters from the intergroup analysis for comparison of mean values from both groups is presented in Table 17. The results showed that

there were no statistically significant differences between the two groups after the end of treatment T1 (p=0.9440) and on the 45th day of the start of study T2 (p=0.8658).

Table 17. *Intergroup statistical analysis comparing Ott's test data for flexion in centimeters in the two groups at the end of treatment (T1) and at day 45 after initiation of therapy (T2)*

Ott test flexion	Group A Mean (SD)	Group B Mean (SD)	Difference	Stand. error	p-value
T1	3.19 (0.752)	3.20 (0.789)	0.01	0.170	p=0.9440
T2	3.29 (0.711)	3.27 (0.730)	0.02	0.159	p=0.8658

The sample means, with 95% confidence intervals, for the Ott sign for extension in centimeters are the same for posttreatment for both groups and were comparable at day 45 (Figure 34).

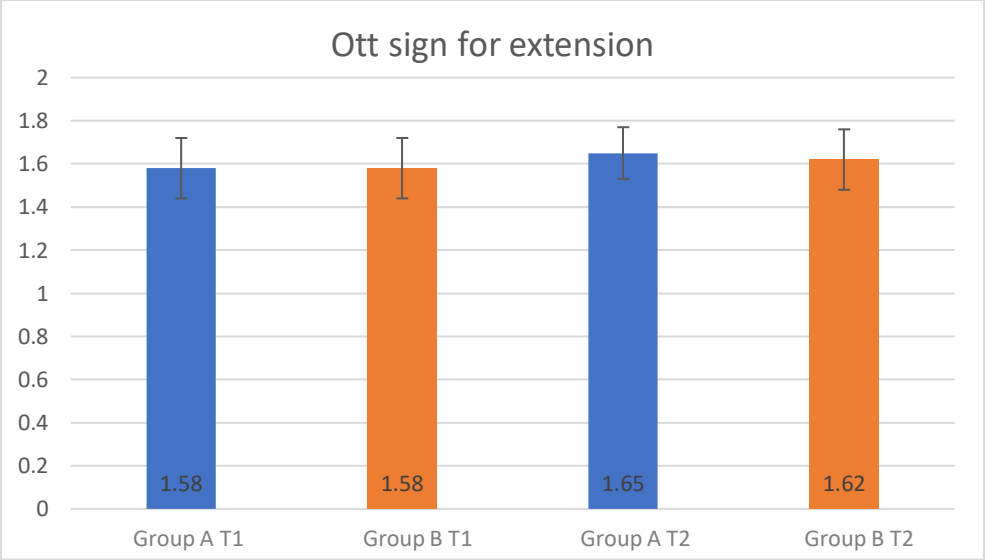


Fig. 34. *Mean value with 95% confidence interval (CI) of Ott's extension test data in centimeters compared between Group A and Group B*

The intergroup statistical analysis for the two therapeutic methods presented in Table 18 proves that we have no statistically significant difference when comparing the mean values after the end of the therapeutic course (p=0.9763) and at day 45 (p=0.7551).

Table 18. *Intergroup statistical analysis comparing Ott's test data for extension in centimeters in the two groups at the end of treatment (T1) and at day 45 after initiation of therapy (T2)*

Ott test extension	Group A Mean (SD)	Group B Mean (SD)	Difference	Stand. error	p-value
T1	1.58 (0.447)	1.58 (0.463)	0.003	0.101	p=0.9763
T2	1.65 (0.405)	1.62 (0.460)	0.030	0.096	p=0.7551

Figure 35 presents a comparison of the results of the mean values with 95% confidence intervals for the right rotation test in degrees after the end of treatment (T1) and on the 45th day from the start of therapy (T2) for group A and group B. The results obtained for the tracking sign are comparable for both measurements made.

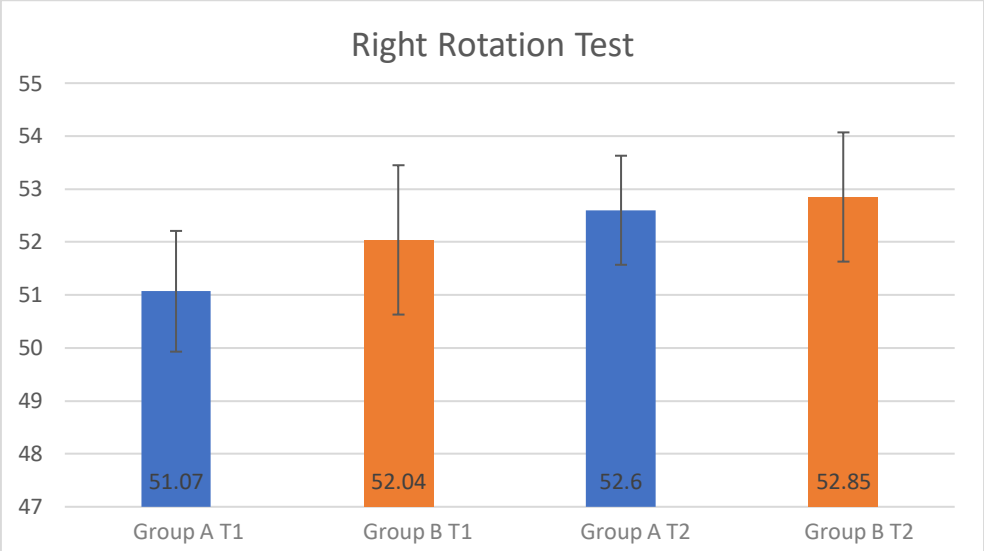


Fig. 35. *Mean value with 95% confidence interval (CI) of right rotation test data in centimeters compared between Group A and Group B*

The intergroup statistical analysis for the two therapeutic modalities, regarding the right thoracic rotation test presented in Table 19, proves that we have no statistically significant difference when comparing the mean values after the end of the therapeutic course (p=0.2802) and at day 45 (p=0.309).

Table 19. *Intergroup statistical analysis comparing right rotation test data in degrees for the two groups at the end of treatment (T1) and at day 45 after initiation of therapy (T2)*

Right rotation test	Group A Mean (SD)	Group B Mean (SD)	Difference	Stand. error	p-value
T1	51.07 (3.615)	52.04 (4.466)	0.976	0.897	p=0.2802
T2	52.60 (3.285)	52.85 (3.850)	0.244	0.791	p=0.309

Figure 36 presents a comparison of the results of the mean values with 95% confidence intervals for the left thoracic rotation test, after completion of treatment (T1) and at day 45 from the start of the study (T2) for group A and group B.

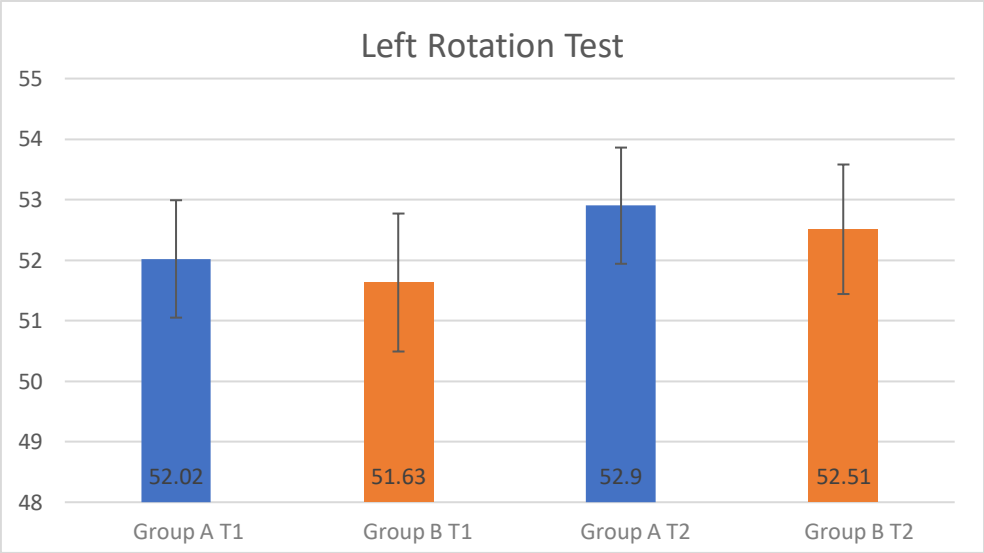


Fig. 36. *Mean value with 95% confidence interval (CI) of right rotation test data in centimeters compared between Group A and Group B*

The intergroup statistical analysis proved that we did not find a statistically significant difference when comparing the mean values after the end of the treatment course (p=0.5994) and at day 45 (p=0.5835) between the two groups (Table 20).

Table 20. *Intergroup statistical analysis comparing left rotation test data in degrees for the two groups at the end of treatment (T1) and at day 45 after initiation of therapy (T2)*

Left rotation test	Group A Mean (SD)	Group B Mean (SD)	Difference	Stand. error	p-value
T1	52.02 (3.069)	51.63 (3.610)	0.390	0.740	p=0.5994
T2	52.9 (3.023)	52.51 (3.384)	0.390	0.709	p=0.5835

Comparative performance between the sample means with 95% confidence intervals for the VAS spontaneous pain indicator at the two measurements taken T1 and T2 is presented in Figure 37. When comparing the values obtained, a significantly greater reduction in spontaneous pain is observe in Group B compared to Group A, both after the end of the treatment course and on the 45th day of the study.

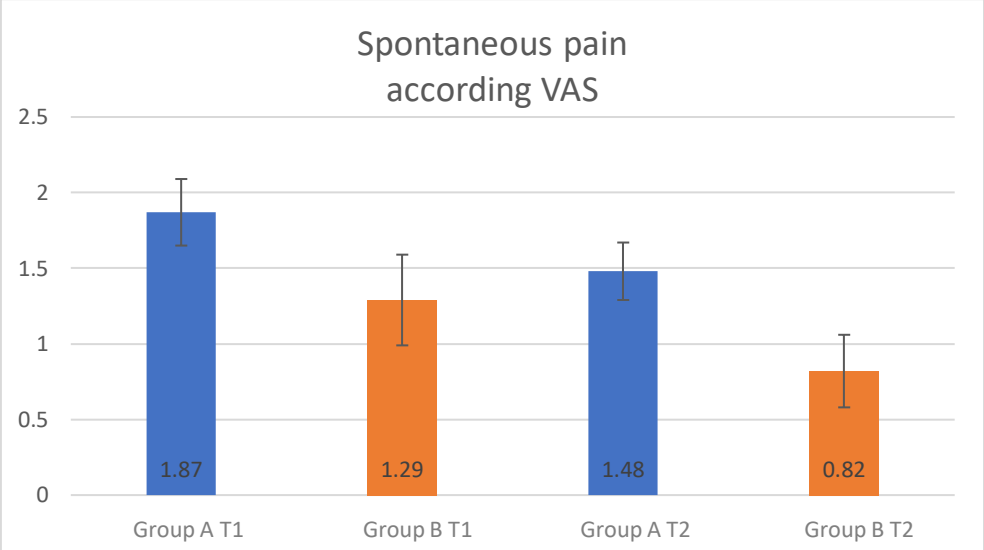


Fig. 37. *Mean value with 95% confidence interval (CI) of spontaneous pain VAS data compared between group A and group B*

The intergroup statistical analysis for spontaneous pain according VAS (Table 21) showed a statistically significantly greater effect of this feature ($p < 0.05$) in favour of the treatment protocol applied in group B, both after the end of treatment T1 ($p=0.0024$) and on the 45th day after the start of the study T2 ($p<0.0001$).

Table 21. *Intergroup statistical analysis comparing spontaneous pain VAS data for the two groups at the end of treatment (T1) and at day 45 after initiation of therapy (T2)*

VAS spontaneous pain	Group A Mean (SD)	Group B Mean (SD)	Difference	Stand. error	p-value
T1	1.87 (0.714)	1.29 (0.955)	0.585	0.186	p=0.0024
T2	1.48 (0.596)	0.82 (0.771)	0.659	0.152	p<0.0001

Comparative performance between the sample means with 95% confidence intervals for the palpatory pain according VAS at the two measurements taken, T1 and T2, for group A and group B is presented in Figure 38.

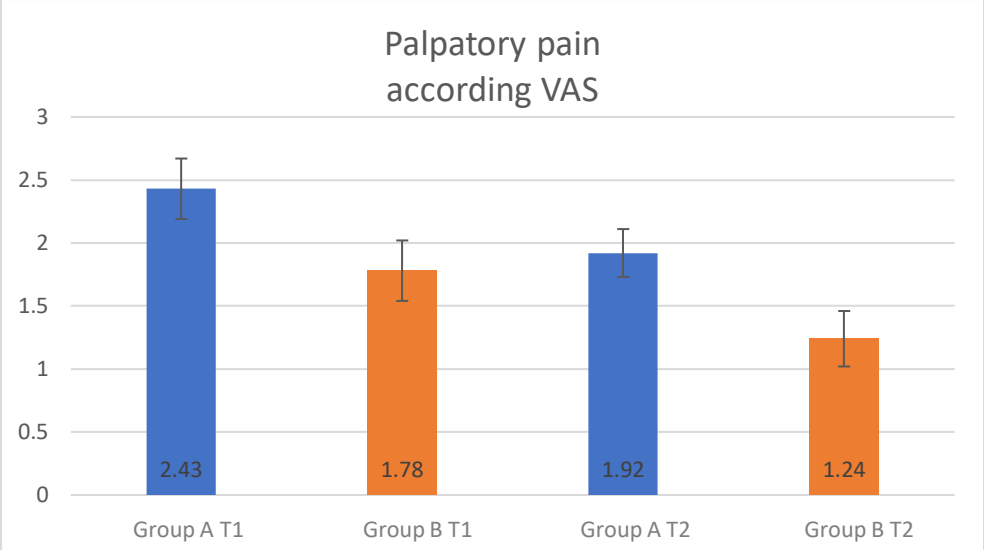


Fig. 38. *Mean value with 95% confidence interval (CI) of palpatory pain VAS data compared between group A and group B*

The intergroup statistical analysis for the palpatory pain recorded by VAS (Table 22) showed a statistically significantly greater effect of this feature ($p<0.05$) in favor of the treatment protocol applied in group B, both after the end of treatment T1 ($p=0.0002$) and on the 45th day after the start of the study T2 ($p<0.0001$).

Table 22. *Intergroup statistical analysis comparing palpatory pain VAS data for the two groups at the end of treatment (T1) and at day 45 after initiation of therapy (T2)*

VAS palpatory pain	Group A Mean (SD)	Group B Mean (SD)	Difference	Stand. error	p-value
T1	2.43 (0.776)	1.78 (0.758)	0.659	0.170	p=0.0002
T2	1.92 (0.699)	1.24 (0.699)	0.683	0.145	p<0.0001

A comparative representation between the means with 95% confidence intervals for the short form of the McGill questionnaire at the two measurements taken after the end of the treatment course T1, and on the 45th day of the study T2, are shown in Figure 39.

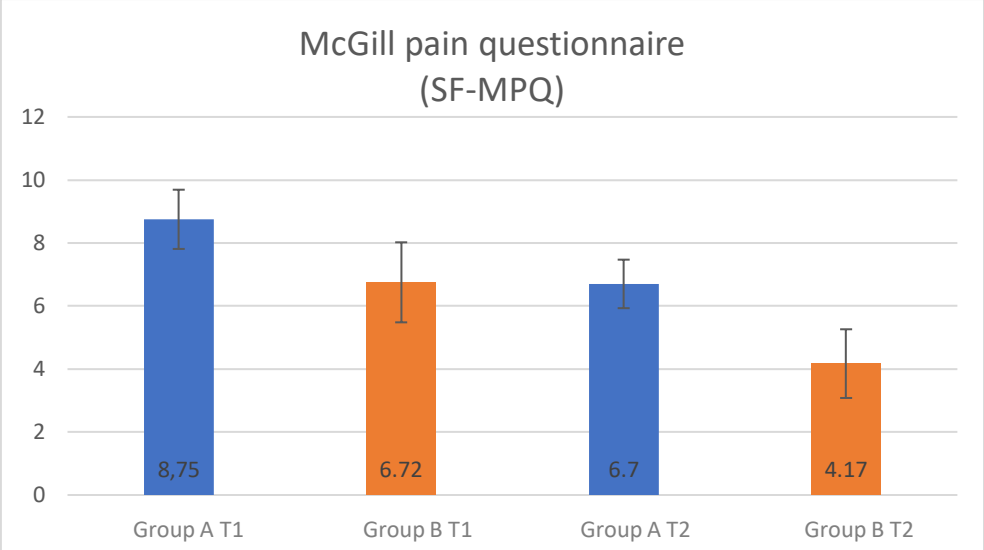


Fig. 39. *Mean value with 95% confidence interval (CI) of McGill pain questionnaire data compared between group A and group B*

The intergroup statistical analysis regarding the McGill short form questionnaire between the two different therapeutic approaches are presented in Table 23. The results convincingly present a statistically significant difference ($p<0.05$) in the mean values in favor of the treatment protocol used in group B, both after the completion of the T1 treatment ($p=0.0127$) and in the long term - on the 45th day of the T2 study ($p<p=0.0002$).

Table 23. *Intergroup statistical analysis comparing McGill pain questionnaire data for the two groups at the end of treatment (T1) and at day 45 after initiation of therapy (T2)*

McGill questionnaire	**Group A Mean (SD)**	**Group B Mean (SD)**	**Difference**	**Stand. error**	**p-value**
T1	8.75 (2.981)	6.75 (4.042)	2.000	0.784	p=0.0127
T2	6.7 (2.431)	4.17 (3.441)	2.537	0.658	p=0.0002

A comparative representation between the sample means with 95% confidence intervals for the Functional Rating Index for group A and group B, at the two measurements taken T1 and T2 is presented in Figure 40.

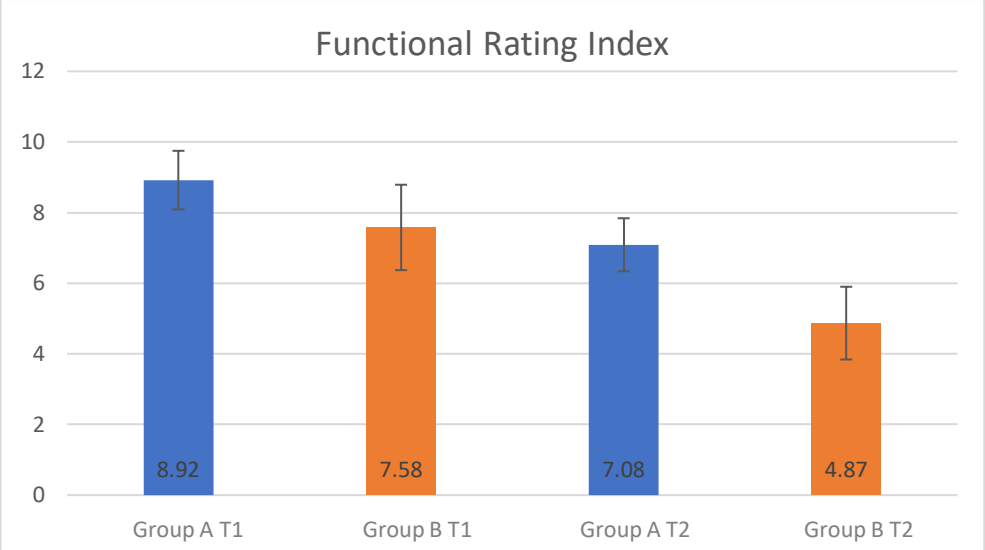


Fig. 40. *Mean value with 95% confidence interval (CI) of Functional Rating Index data compared between group A and group B*

The intergroup statistical analysis for the Functional Rating Index (Table 24), showed that there is no statistically significant difference ($p>0.05$) in the mean values for the two groups after completion of treatment T1 ($p=0.0678$). However, analysis of the data showed that at the 45th of the start of the administered therapy T2, we have a statistically significant difference for the Functional Rating Index in favor of the therapeutic approach used in group B patients ($p=0.0007$).

Table 24. *Intergroup statistical analysis comparing Functional Rating Index data for the two groups at the end of treatment (T1) and at day 45 after initiation of therapy (T2)*

Functional Rating Index	Group A Mean (SD)	Group B Mean (SD)	Difference	Stand. error	p-value
T1	8.92 (2.620)	7.58 (3.827)	1.341	0.724	p=0.0678
T2	7.09 (2.374)	4.87 (3.27)	2.220	0.631	p=0.0007

DISCUSSION

The demographic profile of the patients examined in the present study matches the data cited in the literature Thoracic spine functional disorders are more common in the young and active age (Dimopoulos A., 2002; Briggs AM, 2009). With advancing age, structural pathologies (osteoarthrosis, spondyloses, etc.) begin to dominate over functional disorders in the thoracic spine as a cause of pain. The mean age of the study participants was 34.36 ± 8.77 years. The largest share of the population is between 30 and 39 years old - 42%. Studies on the prevalence of functional disorders in the thoracic region according to gender have shown a higher prevalence of female over male (Leboeuf-Yde C. et al., 2009; Fouquet N. et al., 2015). In the present study, the higher prevalence among females is also proved, which is 56% as compared to males - 44%. Currently, the data reported in the literature present a higher prevalence of functional disorders in the middle thoracic spine region. Shiller's (1999) study showed that 77% of segmental dysfunctions were found between T5 and T9 levels in the thoracic spine (Schiller L., 2001). Dimopolous' (2002) study also found the prevalence of thoracic blockages in the mid-thoracic region to be 57.5% between the T5 and T9 thoracic vertebrae (Dimopoulos A., 2002). Benjamin (1995-2005) presented similar results in his 10-year study, 58.5% between T5 and T8 (Benjamin RL., 2005). Similar data were reported in our study: middle thoracic (T5-T8) - 52%, upper thoracic (T1-T4) - 32%, and lower thoracic (T9-T12) - 16%.

In the present study, we proved the data brought by Petersen research that functional blockage of the thoracic facet joints is often accompanied by functional impairment of the adjacent rib (Petersen G., 2017). In 65.9% of participants, somatic dysfunction were also found for the costovertebral and costotransverse joints. This finding has a great diagnostic value because clinical examination for thoracic spine also requires testing for adjacent ribs. When a functional disorder is detected in them, their manual manipulation or mobilization is also necessary.

In terms of employment, it was found that the majority of the study participants performed work activities associated with physical strain in the thoracic region, with frequent repetitive movements of the same type for the spine. The highest proportion of 46% are people engaged in occupations related to static body position from a sitting or standing position - office workers, computer specialists, teachers, doctors, etc. These findings are consistent with Benjamin's study on the prevalence of thoracic pain in the older working population (Benjamin RL., 2005).

Another risk factor is physical activity. In this study it was found that people with moderate physical activity predominate - 40.2%. A large proportion of the subjects regularly performed sports activities associated with upper back strain, requiring forced rotatory movements in the trunk area (fitness, table tennis, tennis, volleyball, aerobics). This type of movements is a prerequisite for the occurrence of acute thoracic blockage. Prevention of these risk factors, through better ergonomics at work, correction of wrong posture, use of the dynamic sitting in office professions, combined with a complex of exercises for better mobilization of the spine, would significantly reduce the occurrence of functional disorders in the thoracic region.

Pain and limited range of motion are the main symptoms in functional disorders of the thoracic spine (Dreyfuss P. et al., 1994; Young BA. et al., 2008; Scaringer J. et al., 2009). In the present study, the main criteria by which we objectified the restricted range of motion for the thoracic motor segments were the Ott sign for flexion and extension, and the rotation in the thoracic region in both directions. The baseline values in terms of limited flexion, extension and rotation show similarity to previously reported data in the literature (Schiller L., 2001; Tsolakis, N., 2001; Takatalo J. et al., 2016; Petersen G., 2017).

The other main symptom was pain, which was objectified using the VAS (visual analogue scale) for spontaneous and for palpatory pain and the short form of the McGill questionnaire. The data obtained in all three measurements showed a greater intensity of palpatory versus spontaneous pain, which is an important diagnostic criterion. Baseline values regarding the VAS and the McGill questionnaire confirm previous reports in the literature that pain severity and intensity in segmental dysfunctions in the thoracic spine is less compared to lumbar and cervical dysfunctions (Pillay K., 2001; Takatalo J. et al., 2016). This may be one of the reasons why there are fewer studies on this type of pathology in the thoracic spine compared to the lumbar and cervical region. Self-assessment of pain sensation using the short form of the McGill questionnaire indicates that in functional thoracic disorders we have a dominance of sensory over emotional perception of pain.

The baseline data, for the Functional Rating Index, showed similar results to data reported in the literature (Petersen G., 2017). The use of the FRI in studies of lumbar functional impairment have shown significantly greater scores reported with this questionnaire (Feise RJ, Michael Menke J., 2001). Therefore, it can be argued that lumbar dysfunctions have a greater impact on the normal performance of basic daily activities compared to thoracic ones.

There is no difference in the demographic indicators, the assessment for pain and the functional status of the thoracic spine between the patients studied in the two groups, leading

to their mutual homogeneity. This is an important condition for the reliability of the results from the comparative analysis which is an objective of the present study.

The results for Ott's sign for flexion and extension in the thoracic spine presented a statistically significant improvement at the end of the treatment course compared to baseline (T1-T0) for subjects in group A and group B. This tendency for improvement is also preserved when reading the results on the 45th day from the start of treatment, both regarding the end of treatment (T2-T1) and the baseline condition (T2-T0). The data analysis proves the hypothesis that patients in both groups had an increase in flexion and extension range of motion in the thoracic spine recorded by Ott's test, both at the end of the treatment course and on the 45th day after the start of the study. These results are expected because both treatment protocols include manual therapy for the blocked thoracic motor segments. The main effects of manual manipulation are improvement in joint biomechanics due to spacing of joint surfaces and reduction of increased muscle tone in the affected joint segment (Schekelle P., 1994; Indahl A. et al., 1997; Cramer GD. et al., 2000). By these mechanisms, the increased range of flexion and extension in the thoracic spine is achieved.

Functional testing in terms of joint biomechanics in the thoracic spine using a rotation test is an important diagnostic sign (Dreyfuss P. et al., 1994). Available studies have demonstrated that restricted rotatory range of motion is most commonly found in thoracic somatic dysfunction (Young BA. et al., 2008). Using an inclinometer, we confirmed data previously reported in the literature that when thoracic facet joints are blocked on one side of the spine, we have limitation in contralateral rotation. From the results presented for the rotation in the thoracic spine for both directions for the patients in Group A and Group B, it was observed that there was a statistically significant improvement ($p < 0.05$) in the means calculated according to the three follow-up time periods. Analysis of the data showed an increase in rotation at the end of treatment, compared to baseline (T1-T0), and this trend of improvement was maintained when the results at day 45 (T2-T1) were reported. For the intermediate time period between day 45 and day 15 (T2-T1), we also have a statically significant improvement. We can validate the hypothesis that the manual manipulations included in the treatment protocol in both groups were responsible for the increased rotation volume at the end of therapy as well as on the 45th day of the study. This shows that their effect is not only temporary but persists and improves after the therapy is completed.

Pain is the primary and first symptom in functional thoracic spine disorders (Young BA. et al., 2008; Scaringer J. et al., 2009). From its influence we can evaluate the effectiveness of the applied treatment. The mean values for spontaneous and palpatory pain measured by

VAS for this study were lower compared with available data in the literature regarding lumbar and cervical pain in the presence of functional impairment in these regions. In both groups we use manual therapy of the blocked motor segments as a therapeutic factor. One of the main effects of manual manipulations is pain reduction. This is achieved by altering sensory pain impulses at the spinal cord level and activating pain inhibitory efferent impulses (Pickar JG., 2002). Petersen demonstrates a reduction in pain sensations recorded by VAS after thoracic facet and costovertebral manipulation application in patients with thoracic pain (Petersen G., 2017).

There are also a number of scientific publications that prove the effect of MLS-laser therapy in reducing pain. The analgesic effect of high-energy laser is explained on the one hand by the constant MLS emission, which improves microcirculation and influences the life cycle of inflammatory mediators (Hegedus B., 2009). While pulse emission effects on the superficial nociceptors and afferent nerve fibers by affecting nerve conduction. The final effect is an increase in the nociceptive threshold, which lowers the sensation of pain (Konstatinovic LM. et al., 2010). Laser radiation can partially or completely inhibit nerve conduction along Aδ and C fibers and block the transmission of nociceptive stimuli to the central nervous system (Micheli L. et al., 2017).

Analysis of the spontaneous and palpatory pain data recorded by VAS in the thoracic spine showed that there was a statistically significant reduction in pain at the end of therapy relative to baseline (T1-T0) for subjects in group A and group B. This trend for both groups was maintained when the results at day 45 of the study were reported relative to baseline (T2-T0). For the intermediate time period of day 45, day 15 (T2-T1), we also have static significant improvement. We can hypothesize that the use of both therapeutic approaches for group A and group B will lead to a reduction in spontaneous and palpatory pain by VAS at the end of the treatment course, as well as on day 45 from the start of therapy in patients with functional disorders in the thoracic spine.

Through the reported data on the patients' sensory and emotional perception of pain recorded with the short form of the McGill questionnaire, we demonstrated that both treatment groups had a statistically significant reduction in the reported scores. Analysis of the data shows that there is a statistically significant improvement at the end of the treatment course relative to baseline (T1-T0) for patients in Group A and Group B. The data reported at day 45 relative to baseline (T2-T0), and for the intermediate time period of day 45, day 15 (T2-T1) also have a statically significant improvement in terms of the pain questionnaire follow-up scores. We can hypothesize that the therapeutic approach used in patients from both groups will lead to

improvement according to the results of the McGill short form questionnaire, both after the end of treatment and in the long term - on the 45th day after the beginning of the therapeutic course.

Another important criterion by which we monitor the effect of treatment in spinal dysfunctions is the change in quality of life in terms of basic activities of daily living. Using the Functional Rating Index questionnaire to self-assess how much pain and limited range of motion affect activities of daily living allows us to evaluate the effect of the two therapeutic approaches. From the results presented in this dissertation, both groups showed statistically significant improvement for FRI data, at the end of therapy compared to baseline values (T1-T0). This trend persisted when reporting results on day 45 from the start of treatment, both relative to day 15 (T2-T1) and baseline (T2-T0). These data support the hypothesis that patients in Group A and Group B improved according to Functional Rating Index scores after therapy, as well as on day 45 of the study.

The main aim of this dissertation is to show whether the combined use of manual therapy and high-energy laser has a better clinical effectiveness than monotherapy with manual manipulation in patients with functional disorders in the thoracic spine.

For thoracic range of motion objectified by Ott's flexion-extension test and measurement of rotation in both directions, there were no statistically significant differences ($p>0.05$) between the results in group A and group B, both after the end of the treatment course (T1) and on the 45th day of treatment (T2). Based on these data, we can conclude that the combined use of manual therapy and high-energy laser, in patients with functional thoracic spine disorders, will not lead to a greater increase in the range of motion compared to monotherapy with manual manipulations. Since patients in group A received the manual therapy twice (1st and 15th day) and those in group B only on the first day of treatment, we can assume that the use of MLS-laser therapy eliminated the need to perform a second manipulation for thoracic motor segments.

The results of spontaneous pain according to VAS from the intragroup analysis for comparison of the mean values of the application of the two methods present a statistically significant difference ($p < 0.05$) in favor of the therapeutic protocol used for treatment in group B, after the completion of the therapeutic course (T1) ($p=0.0024$). In the long term at the 45th day from the beginning of the study (T2), the better results in favor of the therapeutic approach in group B were even more convincing ($p<0.0001$). The data analysis shows that the combination of manual therapy and high-energy laser in patients with functional disorders in the thoracic spine will lead to a better short-term and long-term therapeutic effect in terms of spontaneous pain compared to monotherapy of manual manipulations. These results were

expected due to the large number of publications reported in the literature regarding the analgesic effects of MLS – laser therapy (Vignali., 2011; Monici., 2012; Iacopetti., 2015).

Palpatory pain is an important diagnostic sign in patients with functional disorders in the thoracic department. The results for palpatory pain according to VAS from the intragroup analysis for comparison of the mean values from the application of the two methods present a statistically significant difference ($p<0.05$) in the mean values in favor of the method of treatment used in the group B, both after the completion of the therapeutic course ($p=0.0002$) and in the long term - 45 days from the start of treatment ($p<0.0001$). The proof of the superiority of the MLS laser therapy with regard to palpatory pain according to VAS is due to the direct therapeutic effect in the damaged structures themselves, as reported in the literature review. The data analysis shows that the combination of manual therapy and high-energy laser in patients with functional disorders in the thoracic spine will lead to a better short-term and long-term therapeutic effect for the palpatory pain according to VAS compared to monotherapy of manual manipulations.

Results for the short form of the McGill questionnaire demonstrated a statistically significant difference ($p < 0.05$) in favor of the method used in Group B after completion of the treatment course (T1) ($p = 0.0127$). In the long term, at day 45 after initiation of therapy (T2), the better results in favor of the treatment protocol in group B were even more convincing ($p=0.0002$). This demonstrates the superiority of combined treatment with manual therapy and MLS laser in terms of McGill Pain Questionnaire scores compared to monotherapy of manual manipulations.

The Functional Rating Index results from the intragroup analysis showed no statistically significant differences ($p > 0.05$) in the mean values between the two groups after completion of the therapeutic procedures (T1) ($p = 0.0678$). In the long term, at day 45 of the study (T2), we had a statistically significant difference ($p < 0.05$) in the mean values in favor of the treatment protocol in group B ($p = 0.0007$). These data indicated that the short-term effects of both therapeutic protocols for FRI would be the same. But for the long-term therapeutic effects, we can conclude that combining manual therapy and high-energy laser in patients with functional disorders in the thoracic spine will result in better Functional Rating Index scores compared with monotherapy of manual manipulation.

The hypothesis that patients treated with the combined application of manual therapy and high-energy MLS laser radiation would have a better clinical and functional recovery, than those treated with manual therapy alone, both after the end of treatment and on the 45th day of starting the treatment has been partially proved. Categorically, the treatment protocol using

MLS laser therapy outperformed in terms of spontaneous and palpatory pain according VAS, McGill pain questionnaire, and Functional Rating Index. For the range of motion in the thoracic spine measured by Ott's flexion-extension test and rotation anglemetry, both therapeutic methods had equal short- and long-term therapeutic efficacy.

A limitation of the present study is that it was conducted in the setting of a coronavirus (SARS-CoV-2) pandemic, which did not allow us to cover a larger number of participants. Concerning the methodology for assessment of the disease, an imaging method, such as radiography or computed tomography scan are necessary to be done in a future study. Despite the fact that functional disorders are diagnosed only by specific manual testing, imaging studies would confirm the dominance of somatic dysfunctions over structural pathologies as the causative factor of thoracic complaints. Another disadvantage is the lack of a third group of patients in which no therapeutic method is applied or placebo treatment is done. By using such a control group, we may have greater validation and reliability of the results obtained in this study.

CONCLUSIONS

1. The use of manual therapy in patients with functional thoracic spine disorders has resulted in short- and long-term therapeutic effects in terms of range of motion, pain, and quality of life.
2. The combined use of manual therapy and a high-energy MLS laser in patients with functional thoracic spine disorders resulted in short- and long-term therapeutic effects in terms of range of motion, pain, and quality of life.
3. Combined use of manual therapy and high-energy MLS laser in patients with functional thoracic spine disorders has better therapeutic efficacy over monotherapy with manual manipulation, in terms of spontaneous and palpatory pain according to the VAS scale, McGill questionnaire and Functional Rating Index.
4. The comparative analysis showed equal therapeutic effectiveness for both methods in terms of affecting the range of motion recorded by Ott's flexion-extension test and rotations in the thoracic spine.
5. The use of the high-energy MLS laser with the manual treatment eliminates the need for a second manipulation of the thoracic motor segments.
6. Manual therapy and MLS laser treatment were safe methods that did not lead to adverse reactions and exacerbation in the patients' condition.

CONTRIBUTION

1. For the first time in Bulgaria, a comparative study of the effects of manual therapy as monotherapy and its combined application with a high-energy laser in patients with functional disorders in the thoracic department was conducted.
2. The short-term and long-term efficacy of the treatment with manual therapy and combined complex of MLS laser and manual manipulations was proved in patients with functional thoracic spine disorders.
3. It was proved that the effects of combined use of manual therapy and a high-energy MLS laser are superior to the treatment with a manual therapy as a monotherapy for most of the indicators for follow- up in the patients studied.
4. A protocol was established for conducting manual therapy using a pistol grip technique for manipulation of thoracic motor segments in patients with functional thoracic disorders.
5. A protocol for MLS laser therapy in patients with functional thoracic disorders was established.

DISSERTATION RELATED PUBLICATIONS

1. Yankov T, Panayotova L. Functional disorders as a cause of nonspecific pain in the thoracic spine - modern approaches in their treatment. Varna Medical Forum, vol. 9, 2020, issue 2.

2. Yankov T, Panayotova L, Todorov I. Treatment with high energy laser and manual therapy in patients with functional disorders in thoracic spine. Physical Medicine Rehabilitation and Health issue 3/2021.

3. Yankov T, Todorov I. Clinical efficacy of manual therapy for functional thoracic spine disorders. Varna Medical Forum, vol. 12, 2023.