Medical University
Prof. Dr. Paraskev Stoyanov – Varna

Faculty of Public Health

Department of Physiotherapy, Rehabilitation and Thalassotherapy

YASEN TODOROV PETROV, MD

A COMPARATIVE STUDY OF THE EFFECTS OF DEEP OSCILLATION /DEEP OSCILLATION/ AND PHYSICAL THERAPY MODALITIES IN PATIENTS WITH CERVICAL SPONDYLOSIS

THESIS SUMMARY
of a PhD Thesis for awarding the educational and scientific degree "Philosophy Doctor"

Research Supervisor:

Assoc. Prof. Mariyana Mihaylova Krasteva-Ruseva, MD, PhD

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The thesis contains 205 pages and it is illustrated with 47 tables, 68 figures and includes 8 applications. The bibliographic list consists of 336 literary sources, of which 31 are in Cyrillic and 307 in Latin.

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

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Scientific Council Chair:

Assoc. Prof. Evgeniya Petrova Vladeva-Dimova, MD, PhD

Members:

Prof. Dr. Veselinka Dimitrova Nestorova, MD, PhD

Prof. Dr. Zlatka Borisova Stoineva – Paskaleva, MD, PhD

Assoc. Prof. Dr. Galina Petrova Mratskova - Delieva, MD, PhD

Assoc. Prof. Dr. Irena Yordanova Stoilova, MD, PhD.

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CONTENTS

ABBREVIATIONS USED 4

INTRODUCTION 5

OBJECTIVE 6

TASKS 6

HYPOTHESIS 6

MATERIALS AND METHODS 7

1. Study criteria 7

2. Design of the study 7

3. Methods for following up on the indicators 9

4. Conduction and organization of the study..... 9

5. Statistical methods 11

RESULTS 12

1. Demographic characteristics 12

2. Analysis of baseline values of the measurement indicators tracking the effectiveness of the treatment in the three groups 16

3. Evaluation of the clinical effectiveness of the three treatment methods according to the monitored indicators in the three time periods 23

4. Comparison and analysis of the clinical effectiveness between the three treatment methods according to the obtained results for the monitored indicators 61

DISCUSSION 75

CONCLUSIONS 82

CONTRIBUTIONS OF THE THESIS WORK 84

THESIS RELATED PUBLICATIONS 85

ABBREVIATIONS

TENS – transcutaneous electrical nerve stimulation

VAS – Visual analogue scale

US – ultrasound

NDI – Neck disability index

PP – phonophoresis

DO – deep oscillation

LFAESF – low-frequence alternating elestrostatic field /Deep oscillation/

INTRODUCTION

Diseases of the spine have been known to mankind since antiquity (Xarchas & Bourandas, 2003). Cervical spondylosis also belongs to them. It is a disease characterized by degenerative changes of the intervertebral discs, and gradually with the progression of the degenerative process, all other components of the cervical vertebrae are affected. The prevalence of the disease is 3.3 per 1000 population (Reddy et al., 2019).

For the first time in 1949 Ruth Jackson has published information related to the main symptoms of cervical spondylosis. In his work, the causes of pain in the neck radiating to the shoulders, shoulders and arms are discussed. The anatomical features of the cervical spine and their close relationship with the nerve roots, the compression of which is the source of pain symptoms, are described in detail (Jackson, 2010).

Cervical spondylosis is the most common neuromuscular-skeletal cause of neck pain. The chronic pain with which the disease is associated leads to disruption of the work process, to disability and has a negative effect on the quality of life of the affected persons. It is also lead to expenses for individuals and their families, businesses, insurance and healthcare systems (Kuo & Tadi, 2021; Miao et al., 2018).

It is the search for a new therapeutic approach in the treatment of cervical osteochondrosis that provokes our interest to study and evaluate the therapeutic effectiveness of a relatively new modality in physical practice, such as the low-frequency pulsed electrostatic field (Deep Oscillation).

After analyzing the literature sources regarding the therapeutic effects of Deep oscillation established so far in different nosologies, we estimated that the application of a low-frequency electrostatic field has the potential and could affect the main symptoms in cervical spondylosis and improve the quality of life of the affected persons.

OBJECTIVE

To research the effect of the combined application of Deep Oscillation and some physical factors and to compare it with a combination of routine physical factors used for treatment in patients with cervical spondylosis.

TASKS

1. To study the effect of the combined application of Deep Oscillation, TENS and kinesitherapy in patients with cervical spondylosis.

2. To establish the potential of DO to increase the effectiveness of physical therapy in cervical spondylosis by comparison with: a) placebo Deep Oscillation, TENS and kinesitherapy; b) ultrasound, TENS and kinesitherapy.

3. To evaluate and compare the change in the subjective sensation of static and dynamic pain by visual analog scale (VAS) at three time points for the patients of the three treatment groups.

4. To evaluate and compare the influence of the applied treatment in the three therapeutic groups on the indicators of the functional status - goniometry for extension, flexion, rotation and lateral flexion in the three considered moments.

5. To analyze the impact of the applied treatment on the psycho-emotional state of the monitored patients, using the Zung test in the short and long term.

6. To analyze the effect of the applied treatment on the quality of life of the examined patients, using the modified Neck Disability Index (NDI) questionnaire in the short and long term.

7. To analyze and compare the short-term and long-term effects of the applied treatment in the three treatment groups.

8. To establish the presence or absence of side effects and unwanted local or general reactions to the applied treatment.

HYPOTHESES

1. We assume that therapeutic group "A", in which treatment with a low-frequency variable electrostatic field (Deep Oscillation) is carried out, to the main physiotherapy complex, will have better clinical and functional recovery than group "B" and group "C".

2. We assume that the obtained effects of clinical and functional improvement in therapeutic group "A" will be much better compared to those of group "C" conducting a placebo low-frequency alternating electrostatic field /Deep Oscillation/ to the main physiotherapy complex.

3. We assume that therapeutic group "A", which conducts treatment with a low-frequency alternating electrostatic field /Deep Oscillation/, to the main physiotherapeutic complex, will have a clinical and functional recovery equal to or better than group "B" conducting treatment with therapeutic ultrasound to the main physiotherapy complex.

MATERIALS AND METHODS

1. Study criteria

A total of 135 patients between the ages of 18 and 55 with cervical spondylosis were evaluated for the purpose of the study. Subjects of the study are persons with verified pathology through imaging and clinical manifestations. 121 patients were admitted to the study, and they completed the study. 13 patients were not admitted to the study because they had contraindications for treatment. One patient experienced an adverse reaction after the second therapeutic day and voluntarily discontinued the treatment course. All subjects who consented to participate signed an informed consent (Appendix #1). All subjects have signed and received a copy of a notice on data protection of the subjects (Appendix #2).

2. Design of the study

This prospective, parallel study was conducted in the Clinic of Physical and Rehabilitation Medicine of the UMBAL "St. Marina" - Varna and the Department of Rehabilitation, located on the territory of the hotel "Estreya Residence" in the resort complex "St. st konstantin and Elena". The researchers received permission from the hospital administration to conduct the study at the hospital. The scientific research was conducted in accordance with the principles laid down in the Declaration of Helsinki and received permission from the Committee on Ethics in Scientific Research (CESR) appointed to the Medical University of Varna - protocol No. 116/28.04.2022. The duration of the study is 19 months - from 28.04.2022 to 4.12.2023 At the end of this period, a final summary report was prepared to CESR.

Conducting the observation is the leading researcher, determining the therapeutic scheme and evaluating the effect of the applied treatment, in accordance with previously formulated tasks and objectives.

According to the study design, the patients were divided into three groups - group "A" (Deep Oscillation therapy, TENS and kinesitherapy); group "B" (PP with NSAIDs, TENS and kinesitherapy) and a third group "C" (Placebo-Deep Oscillation, TENS and kinesitherapy).

The allocation of patients to the treatment groups "A", "B" and "C" respectively takes place in the order of examination appearance, and the selection step is sequential, i.e. every second patient who sought treatment falls into group "B", and every third falls into group "C".

The study design was single-blind, i.e. there is no "blinding" of the doctor who performed the procedure, and in the patients of the placebo group, therapy is "simulated" by means of "Deep oscillation", by making movements on the patient with the handle of the device, and the voltage is zero, without scaling the potentiometer.

A total of 121 cases of patients with cervical spondylosis, conducting their therapeutic program at the Clinic for Physical and Rehabilitation Medicine at UMBAL "St. Marina" EAD in the city of Varna.

Patients are randomly assigned to one of three groups.

All patients were followed up at three different time points: at baseline before the start of treatment (T0), after completion of the therapeutic course (T1) (10th day from start) and on day 45 after the start of treatment (T2).

Inclusion criteria:

• Patients of both sexes aged between 18 and 55 years

• Clinical manifestations - complaints of pain in the neck, impaired range of motion in the cervical spine

• Radicular symptoms from upper extremities

• Imaging studies proving damage to the intervertebral discs and vertebrae in the cervical region

• No application of medical treatment after the onset of complaints

• No applied course of physical therapy in the period after the onset of the complaints

• All patients had to declare their written consent for inclusion in clinical monitoring and assistance in the study in a statement of informed consent approved by the Ethics Committee at the Medical University - Varna.

Exclusion criteria:

• Persons under 18 and over 55 years of age

• Presence of indication of severe spinal pathology such as tumors

• Fractures of the spine in the cervical region

• Severe arthrosis and bone bridges of the spine

• Presence of symptoms of severe root compression in the cervical region

• Weakened reflexes and sensation for upper limbs

• Paralysis and paresis originating from cervical pathology

• Comorbidity forming contraindications for physical therapy: rhythm pathology; presence of a pacemaker, ischemic heart disease, increased body temperature, diseases in the acute stage and decompensated conditions, infections, malignancy.

• Pregnancy

• Inability to understand and follow study instructions

• Persons who have undergone physiotherapy in the last 3 months on this occasion

• Refusal to sign an informed consent regarding therapeutic procedures; unwillingness to participate in treatment for personal reasons.

• Refusal to participate in the study.

3. Methods for following up on the indicators

• Evaluation of static and dynamic pain by VAS (visual analogue scale).

• Determining the tone of the paravertebral musculature by palpation and classifying it into three grades, using a specially developed scale

• Goniometry of the cervical spine using an inclinometer to assess movements: extension, flexion, left and right lateral flexion, left and right rotation

• Patients complete the Zung self-report anxiety and depression test for psychoemotional state objectification

• Patients fill out the Neck Disability Index questionnaire to determine the impact of neck pain on everyday activities

4. Conduction and organization of the study

All patients were detailed according to gender, age, occupation and physical examination results (static and dynamic VAS, muscle tone, goniometry, Zung test and NDI). Status follow-up was performed at three different time points: at baseline before starting treatment (T0), after completing the therapeutic course (T1) and on day 45 after starting treatment (T2). The data are

reflected in an individual patient protocol for each patient of the three groups (Appendix #5, 6 and 7).

Patients are assigned to one or the other group randomly. The principal investigator determined the allocation of patients to the groups.

For the therapeutic method applied in group A, the Deep Oscillaton Personal device manufactured by PHYSIOMED ELEKTROMEDIZIN AG was used.

The therapeutic approach includes:

1. Deep oscillation using the DEEP OSCILLATION® Personal apparatus from Physiomed on a 160-180Hz program with a duration of 10 minutes, then 85Hz with a duration of 5 minutes;

2. Transcutaneous electrical nerve stimulation - TENS by methodology: paravertebral at the level of the injury with parameters - Normal, 80-140Hz, 15 min;

3. Kinesitherapy representing a complex of exercises aimed at preserving and increasing the range of motion in the cervical spine, by applying active skeletal-muscular exercises and stretching, as well as those for strengthening the muscles stabilizing the cervical spine. (Appendix #8)

The therapeutic course is a total of 10 procedural days, distributed within two working weeks as follows: daily, single application of each of the factors.

The therapeutic approach for group "B" includes 10 procedural days distributed over two working weeks as follows: daily, single application of each of the factors:

1. Phonophoresis with NSAIDs, used in the form of a contact gel, is performed according to a labile methodology: paravertebral at the level of the injury with parameters - 0.2W/cm^2, 3+3 min;

2. TENS;

3. Kinesitherapy.

The therapeutic approach for group "C" includes 10 procedural days distributed within two working weeks as follows: daily, single application of each of the factors:

1. Placebo "Deep oscillation"

2. TENS

3. Kinesitherapy.

In this group, patients received placebo therapy through Deep Oscillation, with the device turned on to the selected program, voltage applied to the potentiometer to 10% to activate the timer of the device, then turned off to 0%. Movements are made through the handle of the device imitating the conduct of real therapy until the end of the procedure is signaled by the device. The application of TENS and kinesitherapy is carried out in the previously mentioned manner applied to groups "A" and "B".

5. Statistical methods

Descriptive methods:

• Alternative analysis – presents the structural distribution of qualitative variables

• Variation analysis – the mean value (Mean), minimum (Minimum), maximum (Maximum), standard error of the mean (Std. Error Mean) and standard deviation (Std. deviation) of each of the indicators (variables) are presented.

• Graphical methods for comparing and visualizing statistical data.

• Statistical evaluation methods: 95% confidence intervals were determined for average values and relative proportions.

Hypothesis testing methods:

• The level of significance of the null hypothesis is taken as $p = 0.05$.

• Parametric methods – Student's t-test for paired samples (Paired Samples t-test) to compare the difference in mean values; Student's t-test for independent samples (Independent Samples t-test) to compare the difference in mean values; ANOVA (analysis of variance) to analyze the difference between the means of more than two groups.

• Non-parametric methods - for independent samples Kruschkel-Wallis test - non-parametric test for ranked data comparing three or more groups simultaneously and MannWhitney Test.

The organization of the survey data was carried out using MS Office Excel 2019, and the SPSS Statistics for Windows v. program was used for their analysis. 29.0.

RESULTS

1. Demographic characteristics

For the purposes of the study, 121 individuals with cervical spondylosis were examined. The mean age of the studied patients was 39.85 ± 7.43 years. The prevalence of cervical spondylosis by age was as follows: 2 (2%) in the 18–25 age range, 27 (22%) in the 26–35 age range, 48 (40%) in the 36– 45 years and 44 (36%) were in the 46–55 years range (Figure 1).

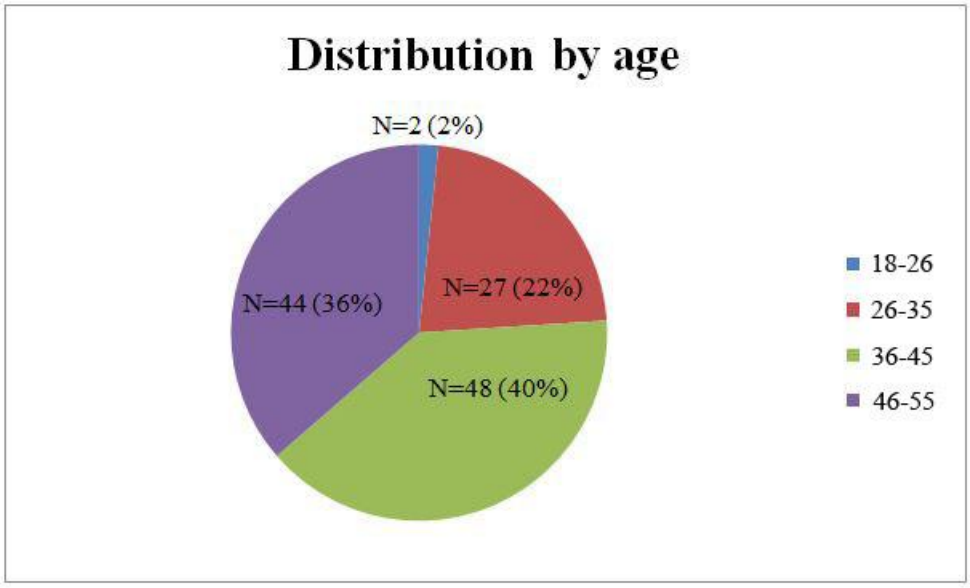

Figure 1. Distribution of the examined patients by age

In total 45 (37.19%) men and 76 (62.81%) women took part in the study. The gender distribution shows that women are more frequently affected than men (Fig. 2).

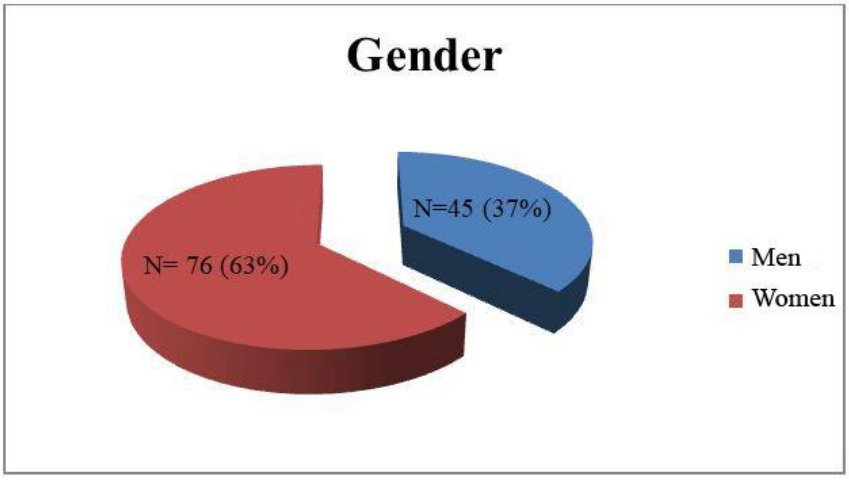

Figure 2. Distribution by gender.

Patients were randomly assigned to three groups (Fig. 3):

In Group A there are 44 patients, whose average age is 39.84 ± 7.09 years. (27-54 years

old). Of them, 29 (65.9%) were women with an average age of 40.2 ± 7.6 years. and 15 (34.1%) men with a mean age of 39.1 ± 6.0 years.

There were 39 patients in group B. The average age in the group was 40.23 ± 7.35 years. (26-53 years old). Of them, 23 (59.0%) were women with an average age of 40.0 ± 7.8 years. and 16 (41.0%) were men with a mean age of 40.56 ± 6.7 years.

In group C there are 38 patients with an average age of 39.47 ± 8.06 years. (23-55 years old). Of them, 24 (63.2%) were women with an average age of 38.6 ± 8.9 years. and 14 (36.8%) men with a mean age of 48.8 ± 6.4 years.

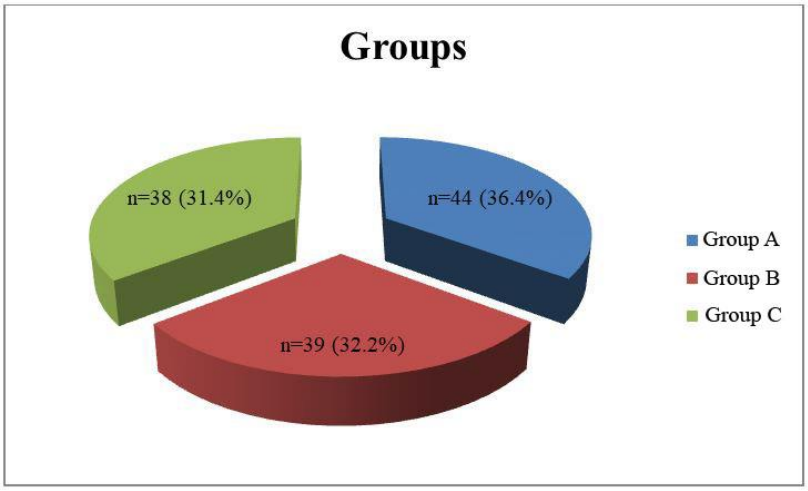

Figure 3. Distribution of patients by group.

In the distribution of patients by group, no statistically significant difference was found between the age of the patients - F=0.098; p=0.906. There is no statistically significant difference in the gender distribution in the groups - $\chi 2$=0.425; p=0.809 (Fig 4).

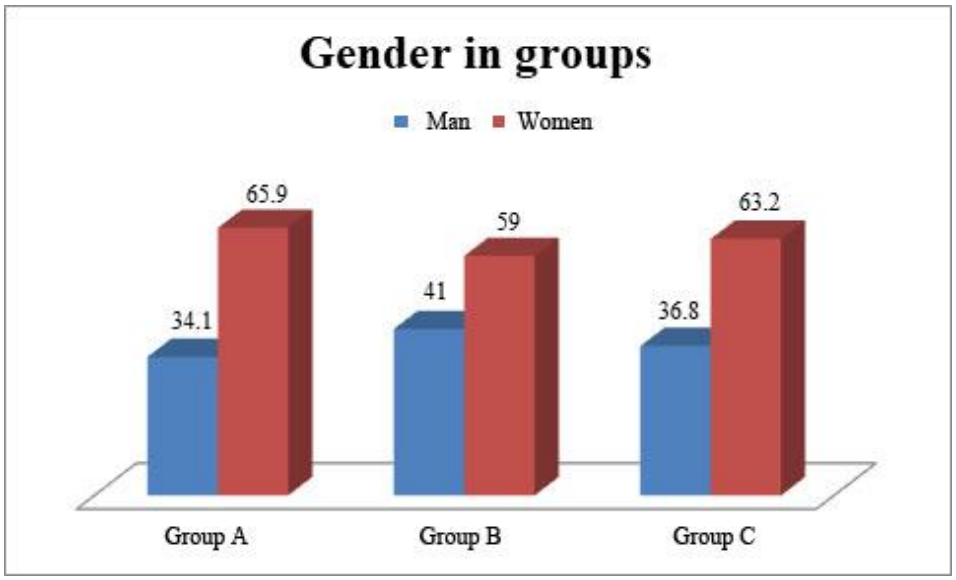

Figure 4. Distribution of patients by gender in the groups in %.

With regard to occupation and the type of load, which are risk factors for the development

of cervical spondylosis, patients can also be conditionally divided into three subgroups. Most of the participants in the study perform work activities associated with a static working position of the cervical spine when performing their official duties. The largest share with 67% percent of all surveyed persons are people working in a static position - office workers, computer specialists, doctors and others. 25% of the participants practice professions related to a dynamic work environment - couriers, cooks, waiters, technicians and others, and the remaining 8% perform heavy physical labor - warehouse workers, builders, dockers, caregivers, orderlies and others.

The distribution by groups according to the type of workload related to the work process in percentages is as follows (Fig. 5):

– Group A - static load 70.5%, dynamic load 22.7%, heavy duty 6.8%;

– Group B - static load 59.0%, dynamic load 30.8%, heavy duty 10.3%;

– Group C - static load 71.1%, dynamic load 21.1% heavy duty 7.9%.

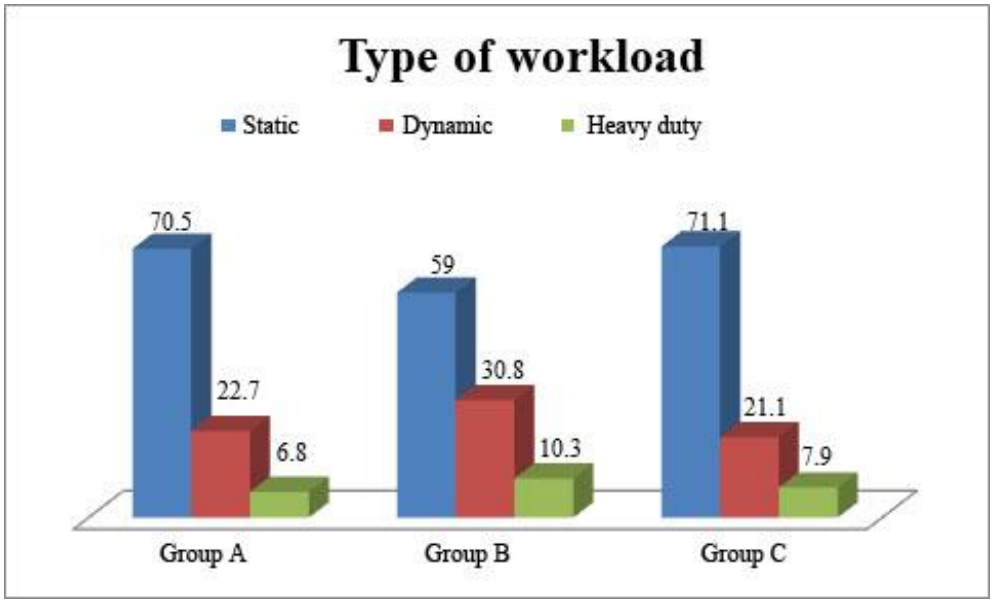

Figure 5. Distribution of patients according to the type of workload during work in the groups (%).

Regarding the level of physical activity of the entire studied cohort, 67 of the patients had low physical activity, 47 had moderate physical activity and 7 had high physical activity (Fig. 6). The percentage of patients with low physical activity (55%) was the highest, followed by average physical activity (39%) and the lowest was the percentage of patients with high physical activity (6%). Lack of physical activity is also a prerequisite for complaints from the cervical spine.

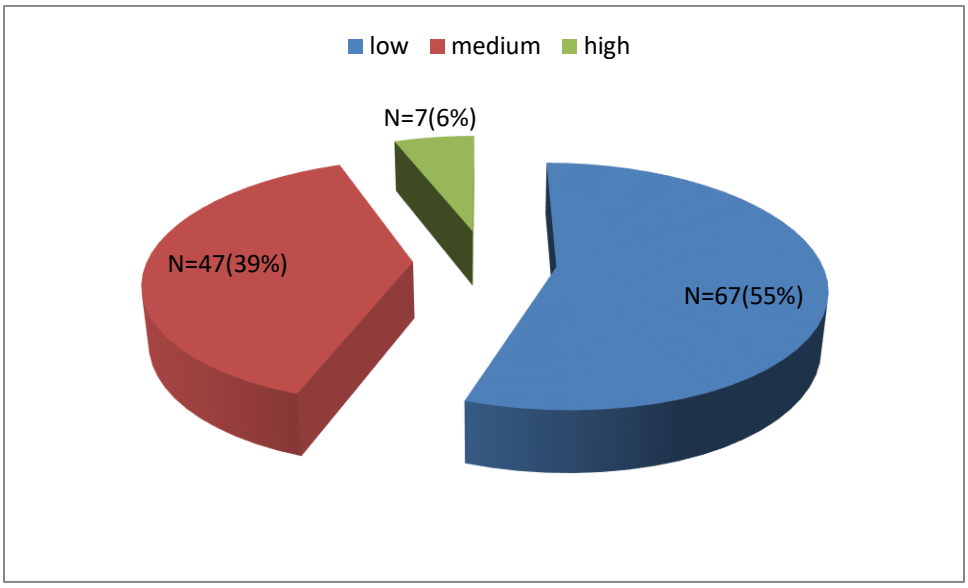

Figure 6. Distribution of all patients according to their physical activity**.**

According to the group distribution of physical activity, there is a predominance of patients with low and medium motor activity. In group A, 54% have low, 39% medium and 7% high physical activity. In group B, the distribution is respectively 56% with low, 36% with medium and 8% with high physical activity. In group C, 55% of the examined persons had low, 42% medium and 3% high physical activity (Fig. 7).

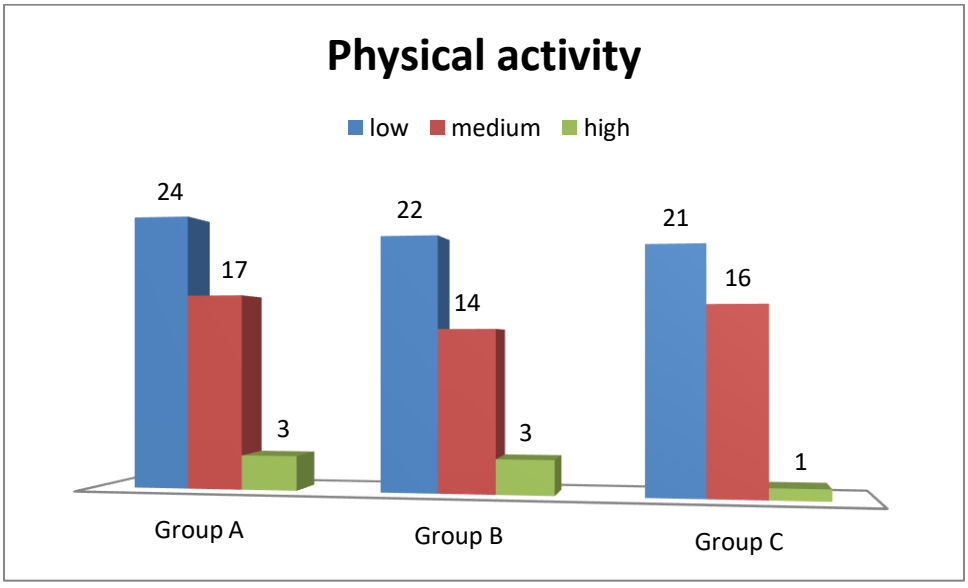

Figure 7. Distribution according to physical activity in group A, group B and group C.

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

All of the 121 patients included in the study had their cervical spine pain assessed prior to the start of the rehabilitation course with physical factors. The mean baseline values for all patients regarding static pain as measured by the visual analog scale (VAS) was 4.20 ± 1.44 (Fig. 8).

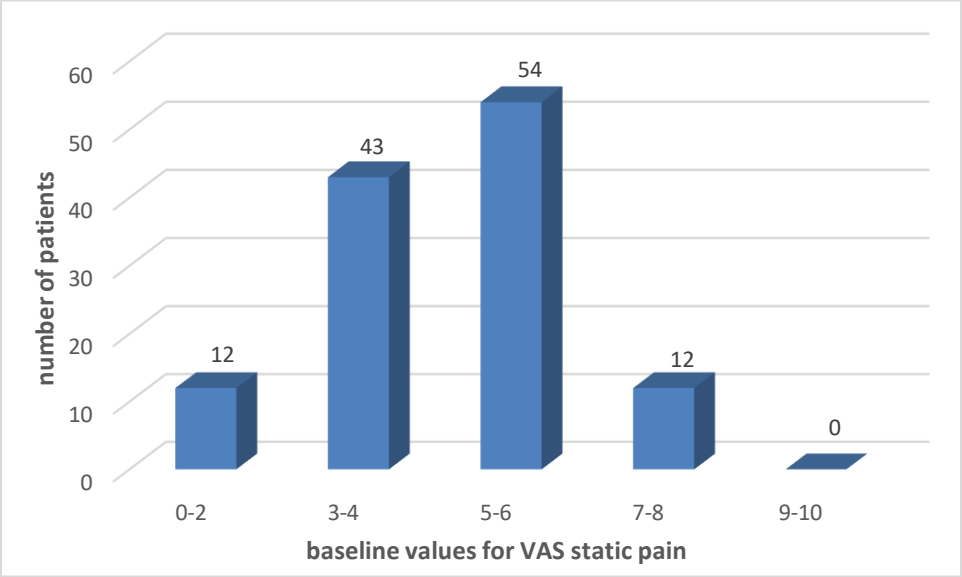

Figure 8. Distribution of the number of patients according to the baseline values obtained for VAS static pain.

For group A, the mean value for VAS static pain at baseline was 5.13 ± 1.09, for group B it was 4.27 ± 1.44, while for group C it was 4.25 ± 1.27.

The mean baseline values for dynamic pain measured by the visual analog scale (VAS) for all test subjects was 5.35 ± 1.43 (Fig. 9).

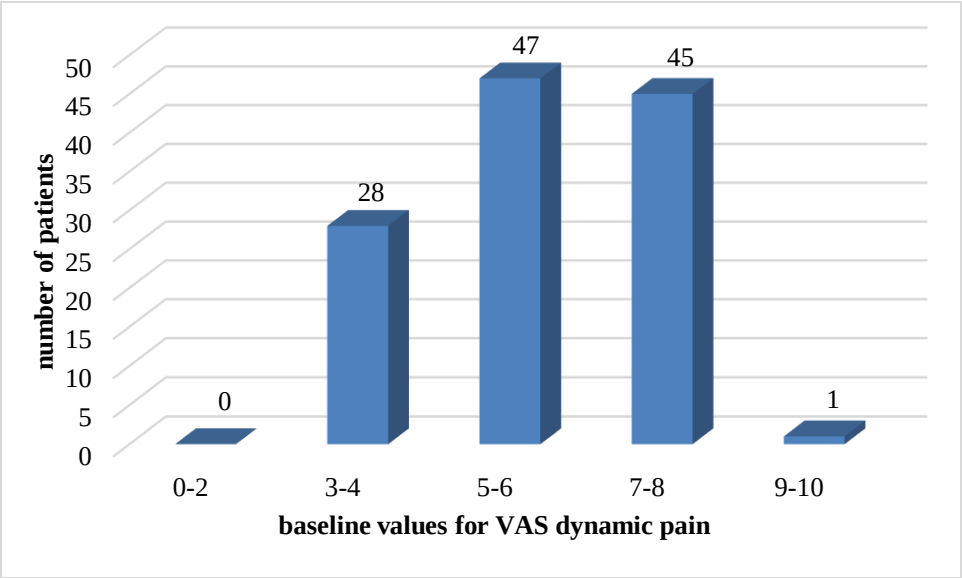

Figure 9. Distribution of the number of patients according to the obtained initial values for VAS dynamic pain.

For group A, the mean VAS dynamic pain at baseline was 5.30 ± 1.48, for group B it was 5.44 ± 1.46, while for group C it was 5.32 ± 1.37.

The average values of the initial data for all patients in the study of the muscle tone in the cervical spine are reflected numerically, and for all the examined persons it is 2.20 ± 0.55 (Fig. 10). For group A, the mean baseline value for muscle tone was 2.27 ± 0.62, in group B it was 2.23 ± 0.53, and in group C it was 2.08 ± 0.48.

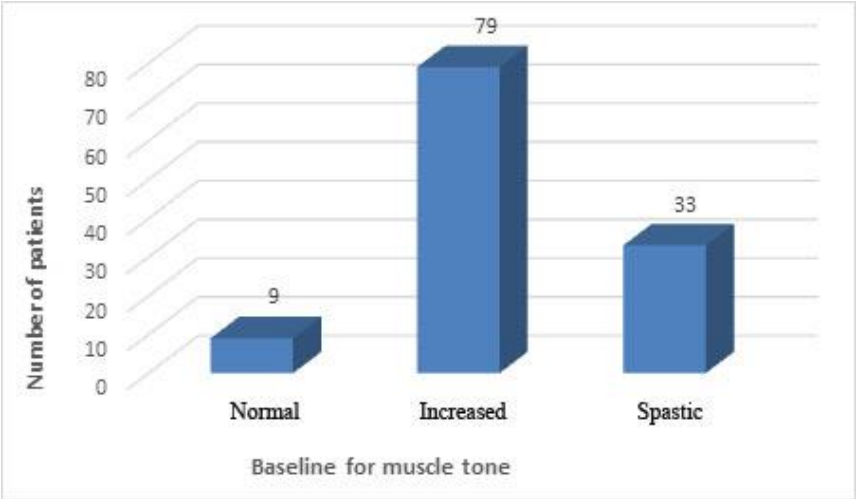

Figure 10. Distribution of the number of patients according to the initial values obtained from the muscle tone study.

The mean baseline values for cervical spine extension and flexion measured in degrees for all study participants were as follows: for extension it was 59.06 ± 4.94 and for flexion it was 56.51 ± 4.05 (Figs. 11 and 12).

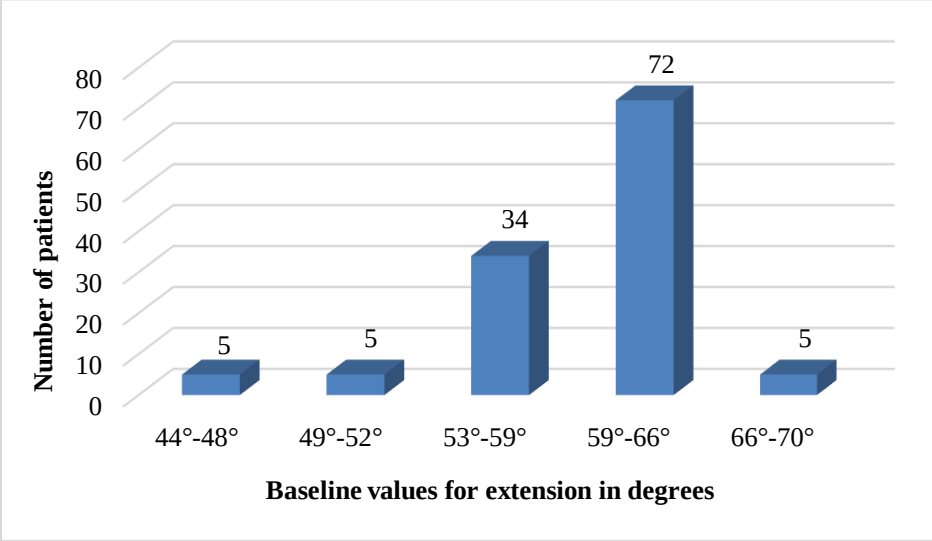

Figure 11. Distribution of the number of patients according to the obtained baseline values for extension in degrees.

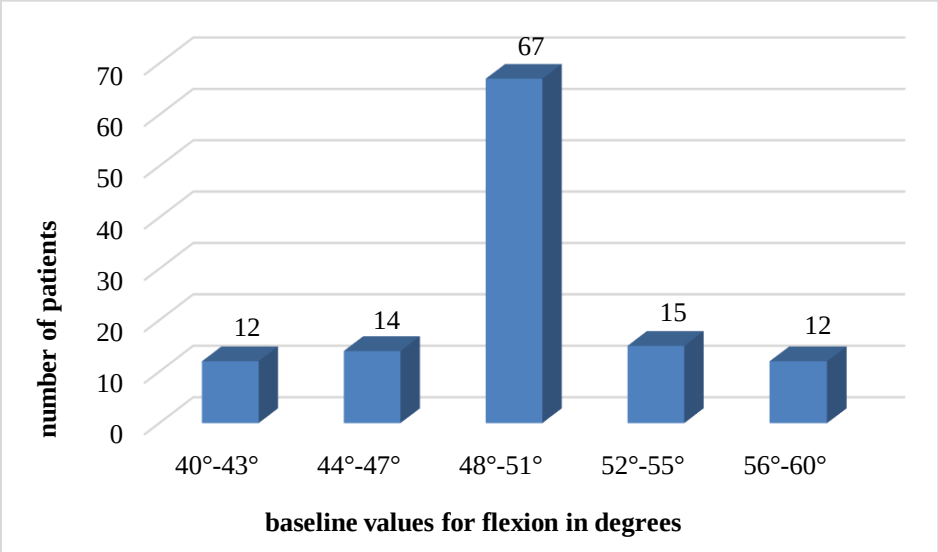

Figure 12. Distribution of the number of patients according to the obtained baseline values for flexion in degrees.

For group A, the mean baseline values for extension and flexion measured in degrees were 59.30 ± 5.45 for extension and 50.86 ± 5.33 for flexion. In group B, the corresponding baseline mean values were 58.72 ± 4.79 for extension and 50.36 ± 4.91 for flexion. For group C,

the mean baseline values were 59.13 ± 4.52 for extension and 50.97 ± 3.78 for flexion in the cervical spine.

The mean baseline values for cervical rotation in both directions measured in degrees for all study participants were as follows: for left rotation was 65.31 ± 5.17 and for right rotation was 65.63 ± 5.39 (Figs. 13 and 14).

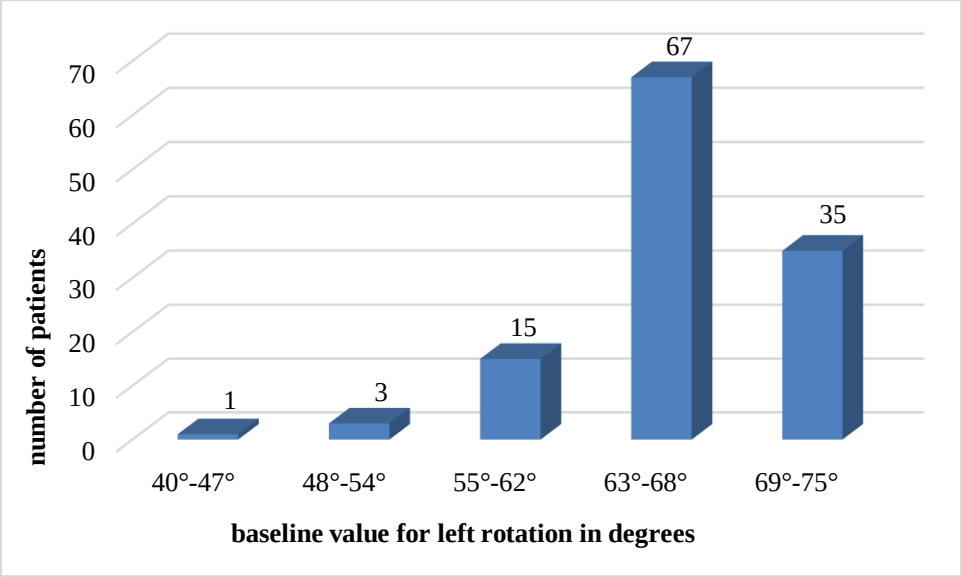

Figure 13. Distribution of the number of patients according to the obtained baseline values for left rotation in degrees.

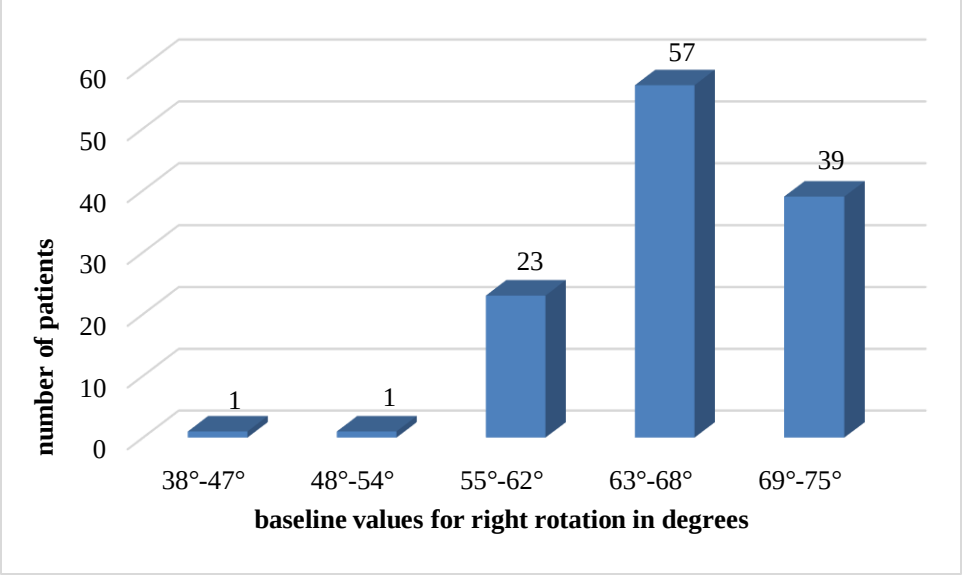

Figure 14. Distribution of the number of patients according to the obtained baseline values for right rotation in degrees.

For group A, the mean baseline value for rotation in both directions measured in degrees was 64.89 ± 6.44 for left rotation and 65.07 ± 6.38 for right rotation. In group B, the corresponding baseline mean values were 65.28 ± 4.78 for left rotation and 65.31 ± 4.95 for right rotation. For group C, the mean initial values for rotator movements in the cervical region were 65.82 ± 3.81 for rotation to the left and 66.61 ± 4.49 to the right.

The mean baseline values for cervical lateral flexion to the left and right measured in degrees for all study participants were as follows: for left lateral flexion was 38.11 ± 3.22 and for right rotation was 38.30 ± 3.15 (Fig. 15 and 16).

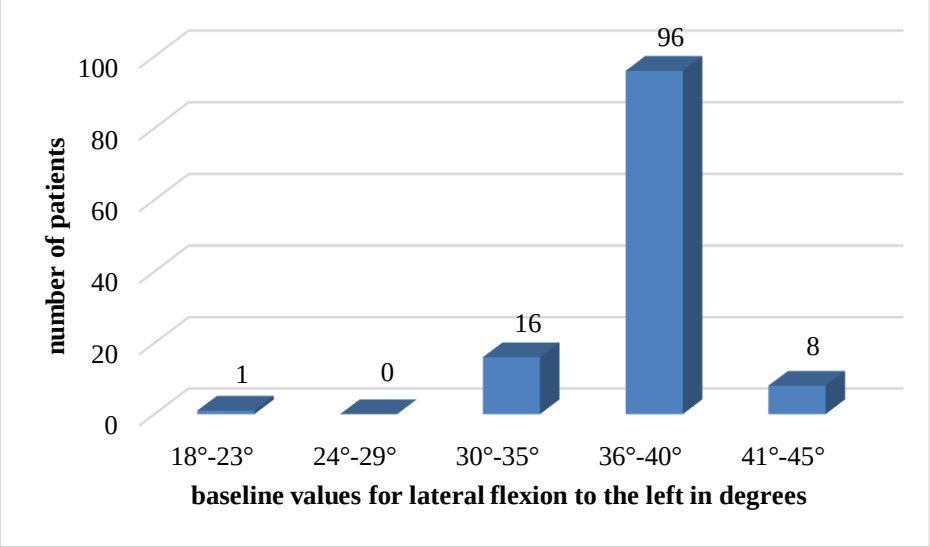

Figure 15. Distribution of the number of patients according to the obtained baseline values for lateral flexion to the left in degrees.

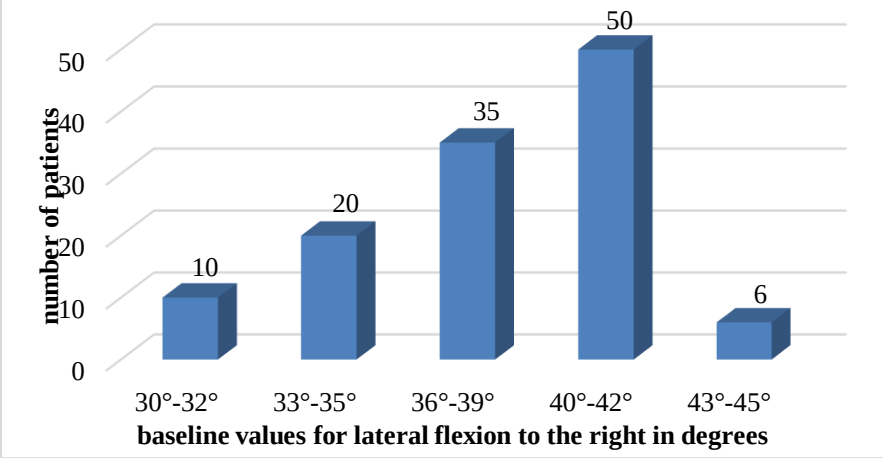

Figure 16. Distribution of the number of patients according to the obtained baseline values for lateral flexion to the right in degrees.

For group A, the mean initial value for lateral flexion in both directions measured in degrees was respectively: 37.41 ± 4.23 for lateral flexion on the left and 38.09 ± 3.42 on the right. In group B, the corresponding initial mean values were: 38.46 ± 2.64 for lateral flexion on the left and 38.31 ± 3.16 on the right. For group C, the mean baseline values for lateral flexion in the cervical region were: 38.55 ± 2.19 for lateral flexion on the left and 38.53 ± 2.88 on the right.

The mean baseline values for all patients from the Zung test for assessing the psychoemotional state was 39.71 ± 7.53 (Fig. 17).

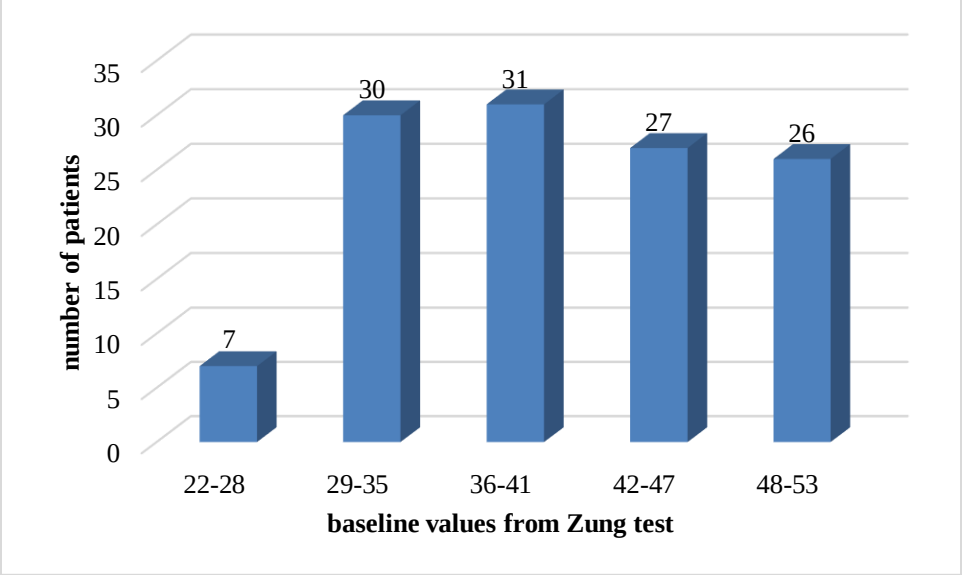

Figure 17. Distribution of the number of patients according to the obtained baseline values from the Zung test.

For group A patients, the mean value of the Zung test at baseline was 40.32 ± 8.29, for group B it was 39.05 ± 7.61, and for group C it was 39.74 ± 6.51.

The mean baseline values for all patients from the Neck Disability Index (NDI) questionnaire was 40.90 ± 10.59 (Fig. 18).

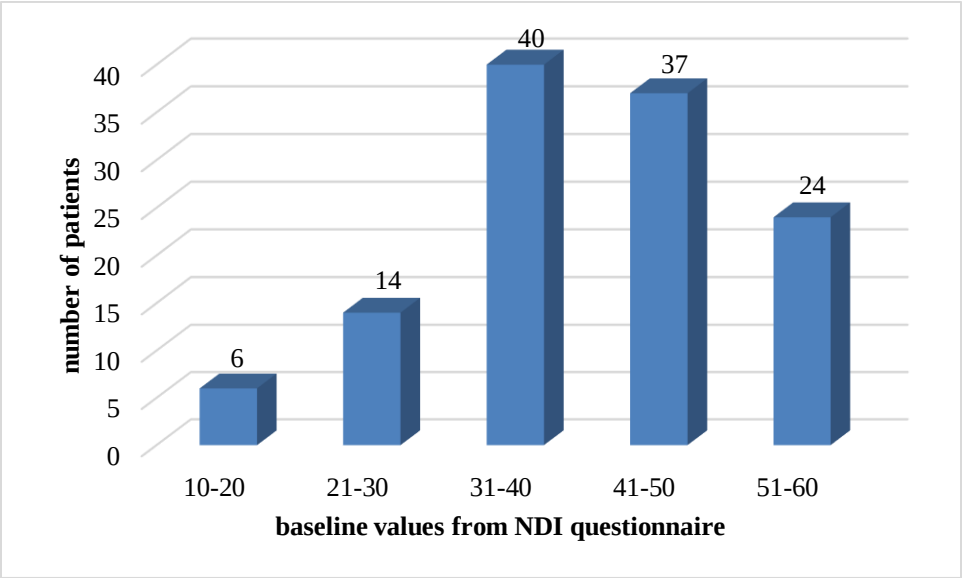

Figure 18. Distribution of the number of patients according to the obtained baseline values from the NDI questionnaire.

For group A patients, the mean value of the NDI questionnaire at baseline was 39.64 ± 13.44, for group B it was 41.50 ± 8.38, and for group C it was 41.45 ± 8.97.

The analysis of demographic data (age, sex, occupation, physical activity) for all patients in terms of their distribution in the three groups showed statistical similarity. A comparison of the obtained mean values regarding the functional examination of the neck, pain and self-assessment of the patient through the questionnaires used also shows a great similarity. In the statistical study by means of the ANOVA test (analysis of variance) in the average values regarding the main observed characteristics, in the three groups it shows that we do not have a statistically significant difference ($p>0.05$) in all indicators. This proves that there are no differences in demographic indicators, pain score and functional status of the cervical spine in the three groups (Table 1).

Table 1. Comparative analysis between group A, group B and group C patients in terms of basic demographic characteristics and baseline values of the monitored signs.

	Group A	Group B	Group C	p
Age (years)	39.84 ± 7.09	40.23 ± 7.35	39.47 ± 8.06	0.906
Gender (women, n/%)	n=29 (66%)	n=23 (59%)	n=24 (63%)	0.809
Occupation (static job)(n/%)	n=31 (70%)	n=23 (60%)	n=27 (71%)	0.790
Physical activity (low)(n/%)	n=24 (54%)	n=22 (56%)	n=21 (55%)	0.881
Static pain on VAS(Mean±SD)	5.13 ± 1.09	4.27 ± 1.44	4.25 ± 1.27	0.600
Dynamic Pain VAS(Mean±SD)	5.30 ± 1.48	5.44 ± 1.46	5.32 ± 1.37	0.892
Muscle tone (Mean±SD)	2.27 ± 0.62	2.23 ± 0.53	2.08 ± 0.48	0.221
Goniometry in the cervical department				
Extension (Mean±SD)	59.30 ± 5.45	58.72 ± 4.79	59.13 ± 4.52	0.865
Flexion (Mean±SD)	50.86 ± 5.33	50.36 ± 4.91	50.97 ± 3.78	0.831
Left rotation (Mean±SD)	64.89 ± 6.44	65.28 ± 4.78	65.82 ± 3.81	0.723
Right rotation (Mean±SD)	65.07 ± 6.38	65.31 ± 4.95	66.61 ± 4.49	0.398
Left lateral flexion (Mean±SD)	37.41 ± 4.23	38.46 ± 2.64	38.55 ± 2.19	0.198
Right lateral flexion (Mean±SD)	38.09 ± 3.42	38.31 ± 3.16	38.53 ± 2.88	0.826
Zung's test (Mean±SD)	40.32 ± 8.29	39.05 ± 7.61	39.74 ± 6.51	0.723
Neck Disability Index(Mean±SD)	39.64 ±13.44	41.50 ± 8.38	41.45 ± 8.97	0.609

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

The set goals and aims of this thesis is to check whether there is a statistically significant difference in the condition of the treated patients in the three groups. This is established by comparing the mean values for the eleven monitored signs (VAS static and VAS dynamic pain, muscle tone test, range of motion test - extension, flexion, rotation in both directions, lateral flexion in both directions, Zung test and NDI) at the three time points considered (at baseline (T0), after completion of treatment (T1) and at day 45 after initiation of treatment (T2)).

Before the beginning of the therapeutic course (T0), the following static pain values measured by VAS were reported: mean value – 4.08, minimum – 0.6, maximum – 6.5. At the end of the therapeutic course (T1) - the results for static pain according to the VAS were as follows: average value - 2.11, minimum - 0, maximum - 6.5. The data recorded on the 45th day after the start of treatment (T2) for static pain on the VAS were respectively: mean value - 1.69, minimum - 0, maximum - 6.2 (Figure 19).

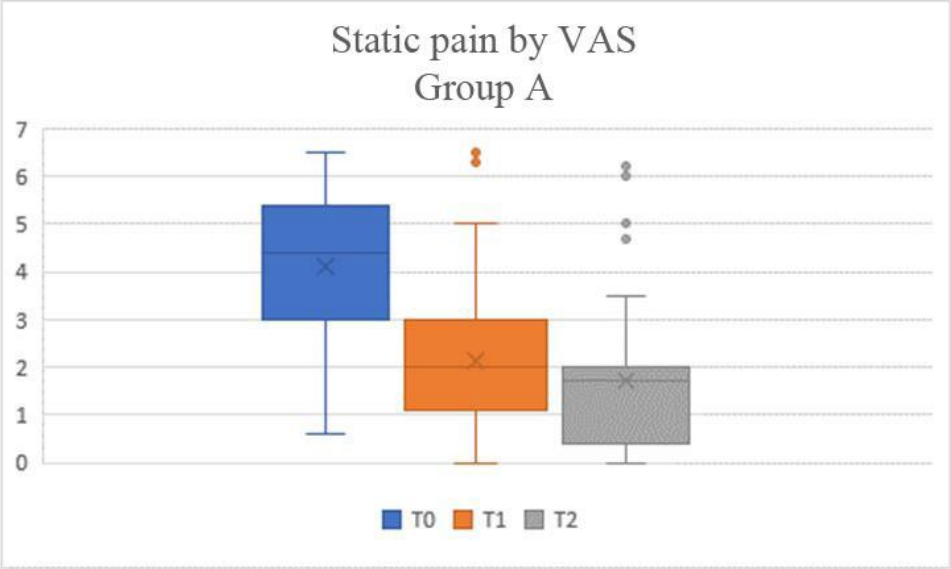

Figure 19. Mean, minimum, and maximum static pain VAS scores assessed at the three follow-up time points for Group A patients.

The results of the within-group statistical analysis for paired samples obtained for the static pain VAS for the patients in group A showed a statistically significant difference ($p < 0.05$) when comparing their mean values for the three time points. A statistically significant reduction of the static pain recorded by VAS was found when comparing the initial values compared to the end of treatment (T0–T1), in the intermediate time period (T1-T2), as well as from the beginning of the therapeutic course compared to the 45th day (T0 –T2) (Table 2).

Table 2. Within-group statistical analysis between the VAS static pain values in the three monitored time intervals, in the patients of group A.

VAS static pain	Paired Differences					t	df	p value
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
T0 - T1	3.014	7.123	1.074	0.848	5.179	2.807	43	0.007
T1 - T2	0.420	0.538	0.081	0.257	0.584	5.183	43	0.000
T0 - T2	3.434	7.133	1.075	1.265	5.603	3.193	43	0.003

Before the start of the therapy (T0), the following values for VAS static pain were recorded: mean value – 4.27, minimum – 1.5, maximum – 7. At the end of the therapeutic course (T1) the results for static pain according to VAS were as follows: mean value – 2.90 , minimum –

1, maximum – 7.1. The data recorded on the 45th day after the start of treatment (T2) for static pain according to VAS were respectively: mean value - 2.60, minimum - 0.3, maximum - 6.5 (Figure 20).

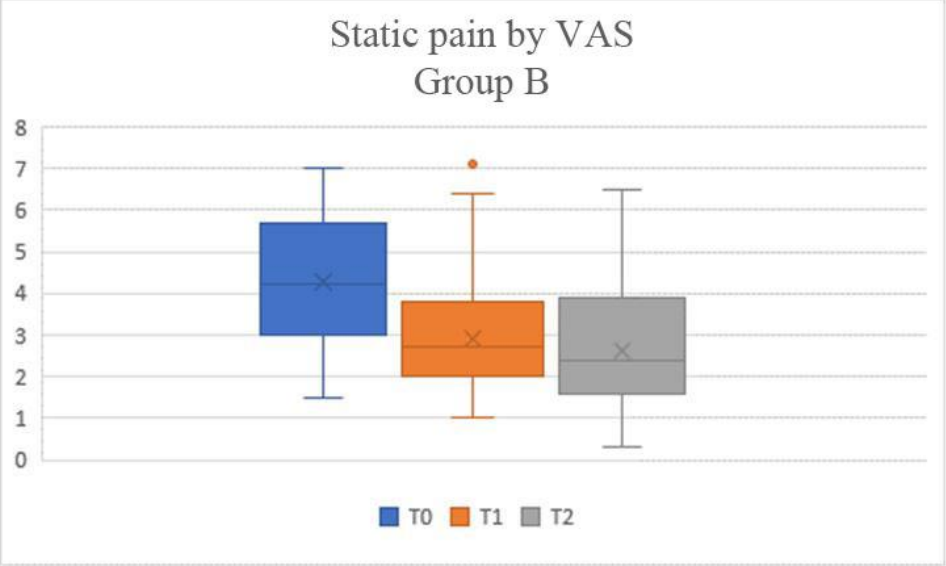

Figure 20. Mean, minimum, and maximum static pain VAS scores assessed at the three follow-up time points for Group B patients.

When following up the data from the intragroup statistical analysis performed for related samples obtained for static pain on the VAS for the patients in group B, a statistically significant difference ($p < 0.05$) was reported when comparing their mean values for the three time points. A statistically significant reduction of the static pain recorded by VAS was found when comparing the baseline values compared to the end of treatment (T0–T1), in the intermediate time period (T1-T2), as well as from the beginning of the therapeutic course compared to the 45th day (T0–T2) (Table 3).

Table 3. Intragroup statistical analysis between static pain VAS values in the three monitored time intervals, in group B patients.

VAS static pain	Paired Differences					t	df	p value
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
T0 - T1	1.408	0.887	0.140	1.124	1.691	10.039	39	0.000
T1 - T2	0.308	0.439	0.069	0.167	0.448	4.433	39	0.000
T0 - T2	1.715	1.081	0.171	1.369	2.061	10.036	39	0.000

Before the beginning of the therapeutic course (T0), the following values for static pain measured by VAS were reported in group C: average value – 4.25, minimum – 1.3, maximum – 7. At the end of the therapeutic course (T1), the results for static pain according to VAS were the following: average value – 2.90, minimum – 1, maximum – 6.2. The data recorded on the 45th day after the start of treatment (T2) for static pain according to VAS were respectively: mean value - 2.90, minimum - 0.5, maximum - 6.4 (Figure 21).

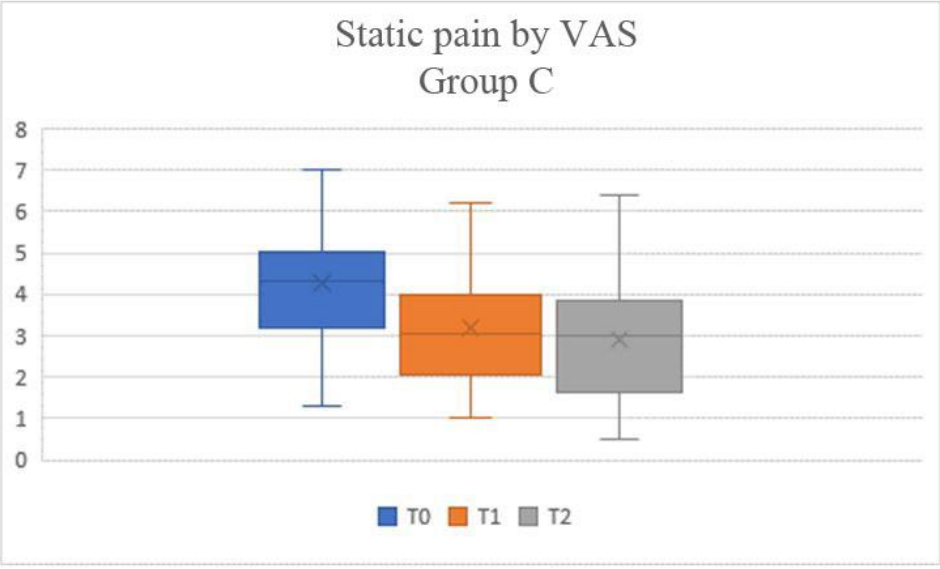

Figure 21. Mean, minimum, and maximum static pain VAS values assessed at the three follow-up time points for Group C patients.

The results of the within-group statistical analysis for paired samples obtained for static pain by VAS for the patients of group C showed a statistically significant difference ($p < 0.05$) when comparing their mean values for the three time points. There was a statistically significant

reduction in static pain measured by VAS when comparing the initial values compared to the end of treatment (T0–T1), in the intermediate time period (T1-T2), as well as from the beginning of the therapeutic course compared to the 45th day (T0 –T2) (Table 4).

Table 4. Intragroup statistical analysis between static pain values by VAS in the three monitored time intervals, in the patients of group C.

VAS static pain	Paired Differences					t	df	p value
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
T0 - T1	1.058	0.605	0.098	0.859	1.257	10.775	37	0.000
T1 - T2	0.295	0.334	0.054	0.185	0.404	5.445	37	0.000
T0 - T2	1.353	0.756	0.123	1,104	1.601	11.022	37	0.000

Before the beginning of the therapeutic course (T0), the following values were recorded for dynamic pain according to VAS: mean value – 5.30, minimum – 2.4, maximum – 7.3. At the end of the therapeutic course (T1), the results for dynamic pain according to VAS were as follows: mean value - 3.26, minimum - 0.8, maximum - 7. The data reported on the 45th day after the start of treatment (T2) for dynamic pain according to VAS , are respectively: average value – 2.85, minimum – 0.3, maximum – 7.4 (Figure 22).

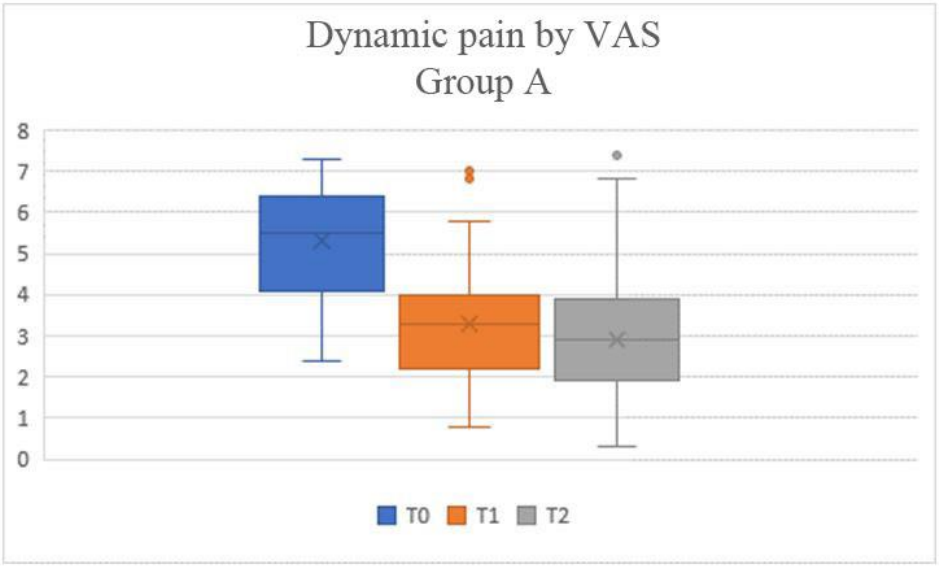

Figure 22. Mean, minimum and maximum value for dynamic pain by VAS assessed at the three follow-up time points for patients in group A.

The within-group statistical analysis of related samples obtained for dynamic pain using the visual analog scale for subjects from group A showed a statistically significant difference ($p < 0.05$) when comparing the mean values for the three time points. A statistically significant reduction of the dynamic pain recorded by VAS was found when comparing the baseline values compared to the end of treatment (T0–T1), in the intermediate time period (T1–T2), as well as from the beginning of the therapeutic course compared to the 45th day (T0– T2) (Table 5).

Table 5. Intragroup statistical analysis between VAS dynamic pain values in the three monitored time intervals, in group A patients.

VAS dynamic pain	Paired Differences					t	df	p value
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
T0 - T1	2.041	1.028	0.155	1.728	2.353	13.171	43	0.000
T1 - T2	0.407	0.586	0.088	0.229	0.585	4.608	43	0.000
T0 - T2	2.448	1.173	0.177	2.091	2.804	13.844	43	0.000

The following dynamic pain values were recorded by VAS before the start of therapy (T0): average value – 5.44, minimum – 2.2, maximum – 8.1. At the end of the therapeutic course (T1), the results for dynamic pain according to VAS were as follows: average value – 3.85, minimum – 0.7, maximum – 8.6. The data recorded on the 45th day after the start of treatment (T2) for dynamic pain according to VAS were respectively: mean value – 3.60, minimum – 0.6, maximum – 7.9 (Figure 23).

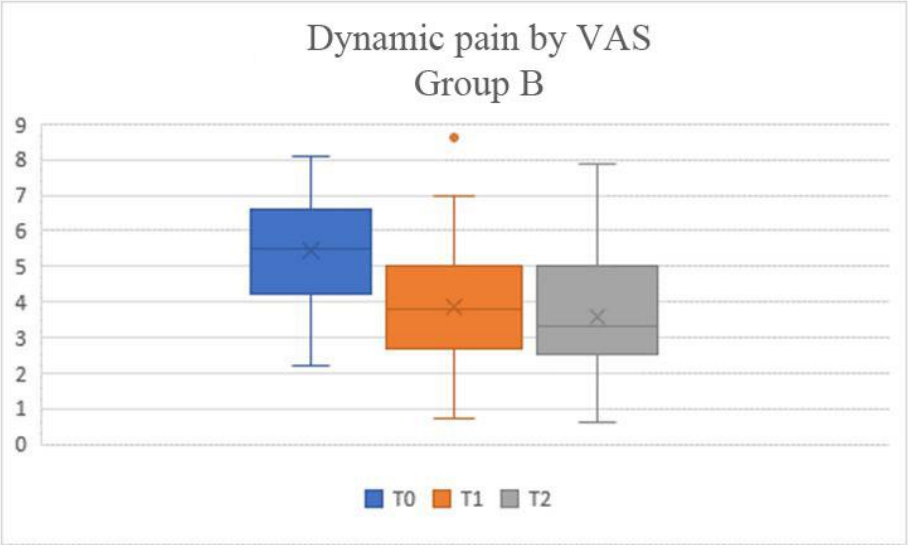

Figure 23. Mean, minimum, and maximum value for dynamic pain by VAS assessed at the three follow-up time points for Group B patients.

The results of the within-group statistical analysis for paired samples obtained for dynamic pain measured by VAS for the patients in group B showed a statistically significant difference ($p < 0.05$) when comparing their mean values for the three time points. There was a statistically significant reduction in dynamic pain measured by VAS when comparing the baseline values to the end of treatment (T0–T1), in the intermediate time period (T1–T2), as well as from the beginning of the therapeutic course to day 45 (T0–T2) (Table 6).

Table 6. Intragroup statistical analysis between VAS dynamic pain values in the three monitored time intervals, in the patients of group B.

VAS dynamic pain	Paired Differences					t	df	p value
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
T0 - T1	1.614	0.885	0.140	1.331	1.897	11.539	39	0.000
T1 - T2	0.266	0.486	0.077	0.110	0.421	3.458	39	0.001
T0 - T2	1.880	0.997	0.158	1.561	2.199	11.923	39	0.000

Before starting the therapy (T0), the following values for dynamic pain according to VAS were reported: mean value – 5.32, minimum – 2.8, maximum – 7.5. At the end of the therapeutic course (T1), the results for dynamic pain according to VAS were as follows: mean value - 4.25,

minimum - 1.9, maximum - 7. The data reported on the 45th day after the start of treatment (T2) for dynamic pain according to VAS , are respectively: average value – 3.83, minimum – 1.4, maximum – 7.3 (Figure 24).

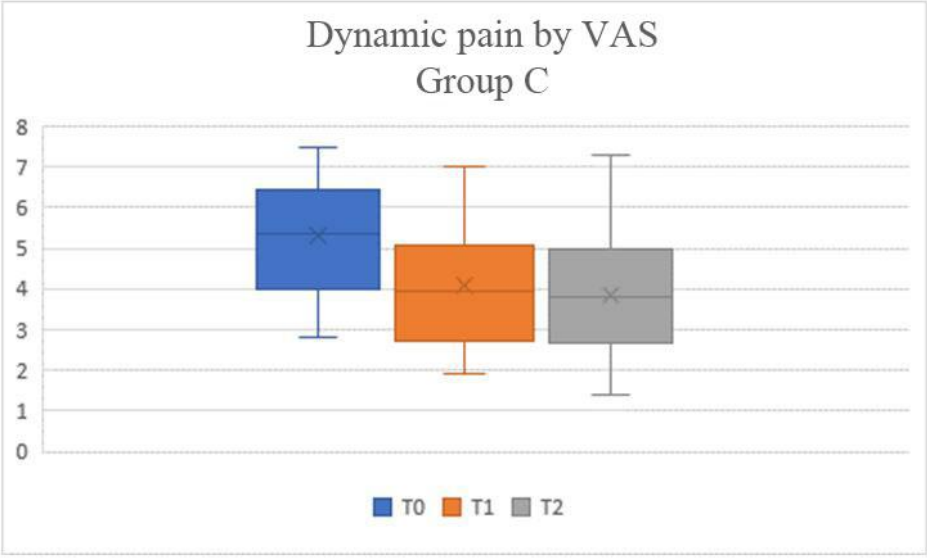

Figure 24. Mean, minimum, and maximum values for dynamic pain by VAS assessed at the three follow-up time points for Group C patients.

Table 28 presents the results of the dynamic pain indicators according to the VAS for the examined persons from group C. There is a statistically significant difference ($p < 0.05$) when comparing the average values for the time point T0-T2, which is an indicator of a statistically significant reduction of the dynamic pain reported by VAS when comparing data from the beginning of the therapeutic course to day 45 (T0–T2). A reduction in dynamic pain measured by VAS was observed, but no statistical significance ($p > 0.05$) was found when comparing baseline values versus the end of treatment (T0–T1) as well as in the intermediate time period T1–T2 (Table 7).

Table 7. Intragroup statistical analysis between the values for VAS dynamic pain in the three monitored time intervals, in the patients of group C.

VAS dynamic pain	Paired Differences					t	df	p value
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
T0 - T1	0.353	5.405	0.877	-1.424	2.129	0.402	37	0.690
T1 - T2	1.137	5.381	0.873	-0.632	2.906	1.302	37	0.201
T0 - T2	1.489	0.826	0.134	1.218	1.761	11.118	37	0.000

Before the start of the treatment (T0), the following initial values for muscle tone expressed numerically were reported: average value – 2.27, minimum – 1, maximum – 3. Immediately after the end of the therapeutic course (T1), the results for muscle tone were: average value – 1.25 , minimum – 1, maximum – 2. The results reported on the 45th day after the start of treatment (T2) for muscle tone were respectively: average value – 1.11, minimum – 1, maximum – 2 (Fig. 25).

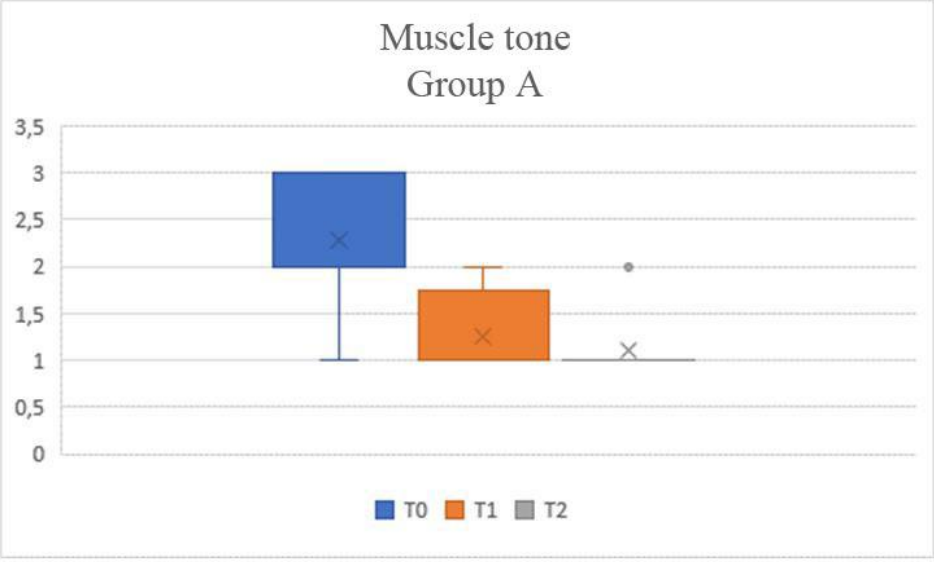

Figure 25. Mean, minimum, and maximum values for muscle tone expressed numerically, assessed at the three time points monitored for Group A patients.

The results of the within-group statistical analysis for related samples for the muscle tone for the patients in group A showed a statistically significant difference ($p < 0.05$) in the mean

values calculated according to the three time periods (Table 8). The established difference represents a statistically significant reduction in the average values of muscle tone obtained at the beginning of the study when compared to the end of the treatment course (T0–T1). The analysis of the results between the data obtained from the comparison between the end of treatment and the 45th day after the start of therapy (T1–T2) and when comparing the initial values with the 45th day (T0–T2) is also similar.

Table 8. Intragroup statistical analysis between muscle tone values for the three monitored time intervals, in group A patients.

Muscle tone	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of Difference		t	df	p value
T0 – T1	1.023	0.628	0.095	0.832	1.214	10.797	43	0.000
T1 – T2	0.136	0.409	0.062	0.012	0.261	2.213	43	0.032
T0 – T2	1.159	0.645	0.097	0.963	1.355	11.921	43	0.000

Before the start of the treatment (T0), the following initial values for muscle tone expressed numerically were recorded: average value – 2.23, minimum – 1, maximum – 3. Immediately after the end of the therapeutic course (T1), the results for muscle tone were: average value – 1.43 , minimum – 1, maximum – 3. The results reported on the 45th day after the start of treatment (T2) for muscle tone were respectively: average value – 1.30, minimum – 1, maximum – 2 (Fig. 26).

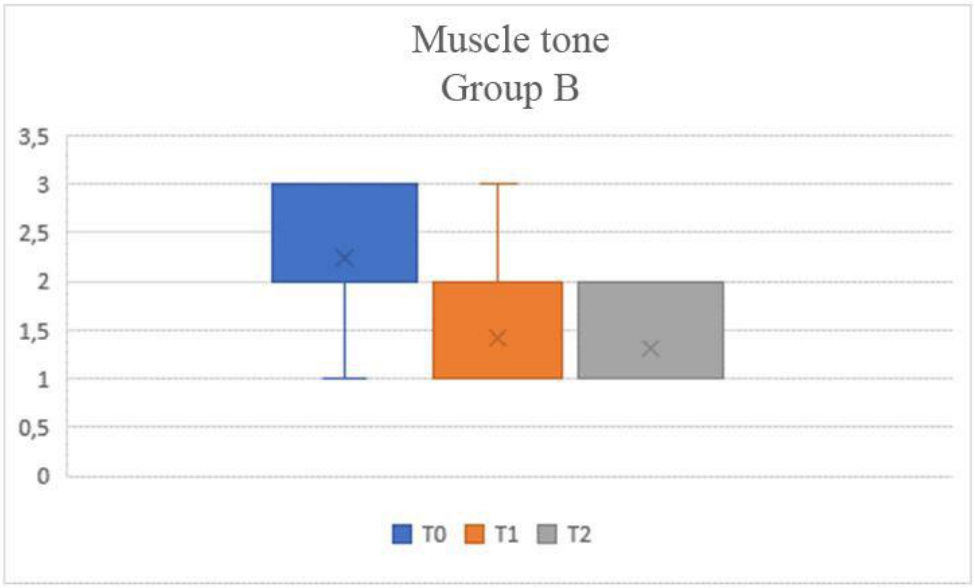

Figure 26. Mean, minimum, and maximum values for muscle tone expressed numerically, assessed at the three time points monitored for Group B patients.

The results of the within-group statistical analysis for related samples with respect to muscle tone for the patients in group B showed a statistically significant difference ($p < 0.05$) in the mean values calculated according to two of the three time periods (Table 9). The established difference represents a statistically significant reduction in the mean values of muscle tone at the beginning of the study compared to those at the end of the treatment course (T0–T1). The analysis of the results between the initial values of the muscle tone and the data obtained on the 45th day after the start of the therapy (T0–T2) is similar. No statistically significant improvement was found when comparing the results between the end of treatment and the 45th day from the start of therapy (T1–T2).

Table 9. Intragroup statistical analysis between muscle tone values for the three monitored time intervals, in group B patients.

Muscle tone	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of Difference		t	df	p value
T0 – T1	0.800	0.405	0.064	0.670	0.930	12.490	39	0.000
T1 – T2	0.125	0.404	0.064	0.004	0.254	1.955	39	0.058
T0 – T1	0.925	0.417	0.066	0.792	1.058	14.036	39	0.000

Before starting the treatment (T0), the following initial values for muscle tone expressed numerically were reported: average value – 2.08, minimum – 1, maximum – 3. Immediately after the end of the therapeutic course (T1), the results for muscle tone were: average value – 1.55 , minimum – 1, maximum – 3. The results recorded on the 45th day after the start of treatment (T2) for muscle tone were respectively: average value – 1.53, minimum – 1, maximum – 3 (Figure 27).

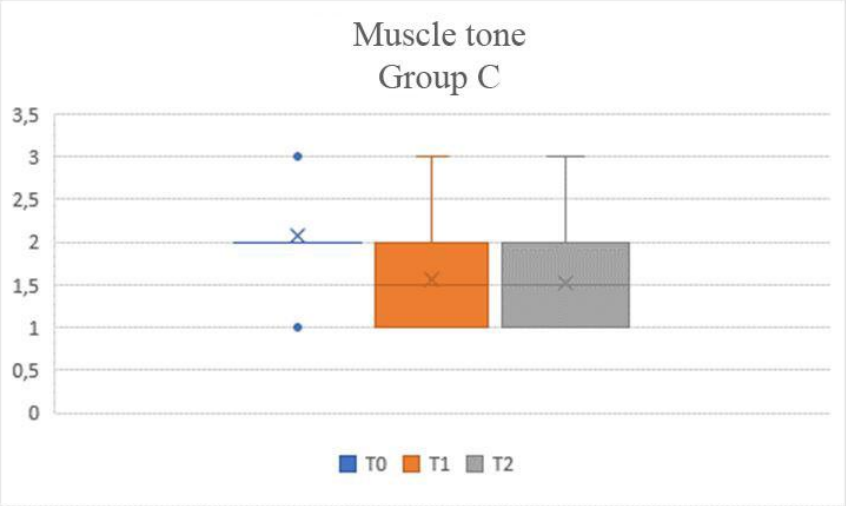

Figure 27. Mean, minimum, and maximum value for muscle tone expressed numerically, assessed at the three time points monitored for Group C patients.

The results of the within-group statistical analysis for related samples with respect to muscle tone for the patients in group C showed a statistically significant difference ($p < 0.05$) in the means calculated according to two of the three time periods (Table 10). The established difference represents a statistically significant reduction in mean muscle tone values from the beginning of the study compared to those at the end of treatment (T0–T1). Similar is the analysis of the results between the baseline values compared with the data obtained on the 45th day after the initiation of therapy (T0–T1). No statistically significant improvement was found when comparing the results between the end of treatment and the 45th day from the start of therapy (T1–T2).

Table 10. Intragroup statistical analysis between muscle tone values for the three monitored time intervals, in group C patients.

Muscle tone	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of Difference		t	df	p value
T0 – T1	0.526	0.506	0.082	0.360	0.693	6.412	37	0.000
T1 – T2	0.026	0.545	0.088	-0.153	0.205	0.298	37	0.767
T0 – T2	0.553	0.602	0.098	0.355	0.750	5.662	37	0.000

For patients in group A, the results (mean, minimum and maximum) of the functional test of cervical spine extension and flexion movements measured in degrees are presented in Figure 28 and Figure 29.

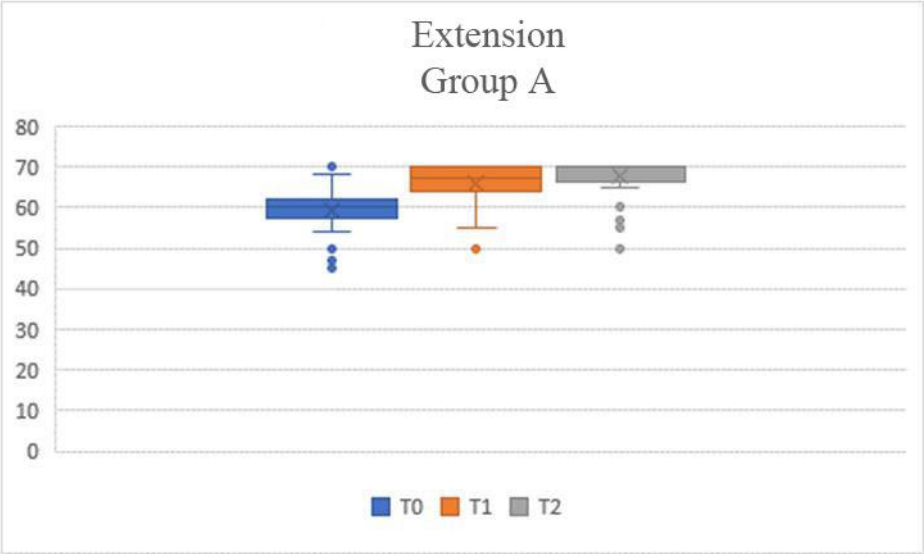

Figure 28. Mean, minimum and maximum extension in degrees assessed at the three follow-up time points for the studied patients of group A.

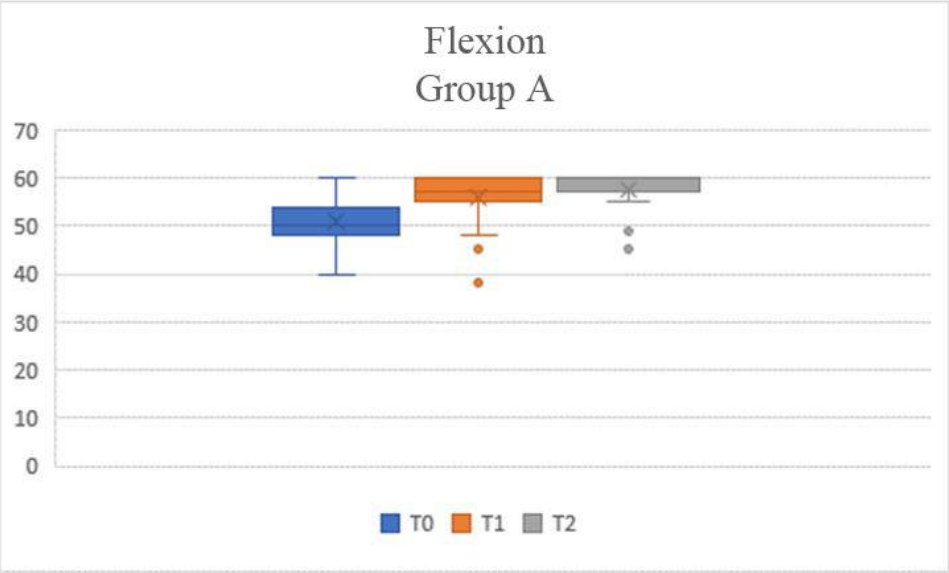

Figure 29. Mean, minimum, and maximum for flexion in degrees assessed at the three follow-up time points for study patients in Group A.

Table 11 presents the results of the within-group statistical analysis regarding the extension test for individuals in group A. It shows a statistically significant improvement ($p < 0.05$) when comparing the mean cervical extension values at the three time intervals followed (T0- T1, T1-T2 and T0-T2).

Table 11. Intragroup statistical analysis between extension values for the three monitored time intervals, in the subjects of group A.

Extension	Paired Differences					t	df	p value
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
T0 - T1	-6.523	3.317	0.500	-7.531	-5.514	-13.046	43	0.000
T1 - T2	-1.773	3.057	0.461	-2.702	-0.843	-3.847	43	0.000
T0 - T2	-8.295	3.813	0.575	-9.455	-7.136	-14.431	43	0.000

The results of the intragroup statistical analysis for the assessment of flexion in the patients of group A is presented in Table 12. It is found that for the patients of group A there is a statistically significant difference ($p < 0.05$) in the average values of flexion calculated according to the three time points. There was a statistically significant improvement when comparing baseline to end of treatment (T0–T1). This trend toward improvement was maintained when

comparing end-of-treatment versus day 45 post-treatment outcomes (T1–T2) and comparing pre-treatment versus day 45 post-treatment outcomes. (T0–T2).

Table 12. Intragroup statistical analysis between flexion values for the three monitored time intervals, in the subjects of group A

Flexion	Paired Differences					t	df	p value
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
T0 - T1	-5.068	3.030	0.457	-5.989	-4.147	-11.095	43	0.000
T1 - T2	-1.773	2.541	0.383	-2.545	-1.000	-4.627	43	0.000
T0 - T2	-6.841	3.735	0.563	-7.976	-5.705	-12.149	43	0.000

For the subjects tested in Group B, the results (mean, minimum and maximum) of the test of cervical spine extension and flexion movements measured in degrees are presented in Figure 30 and Figure 31.

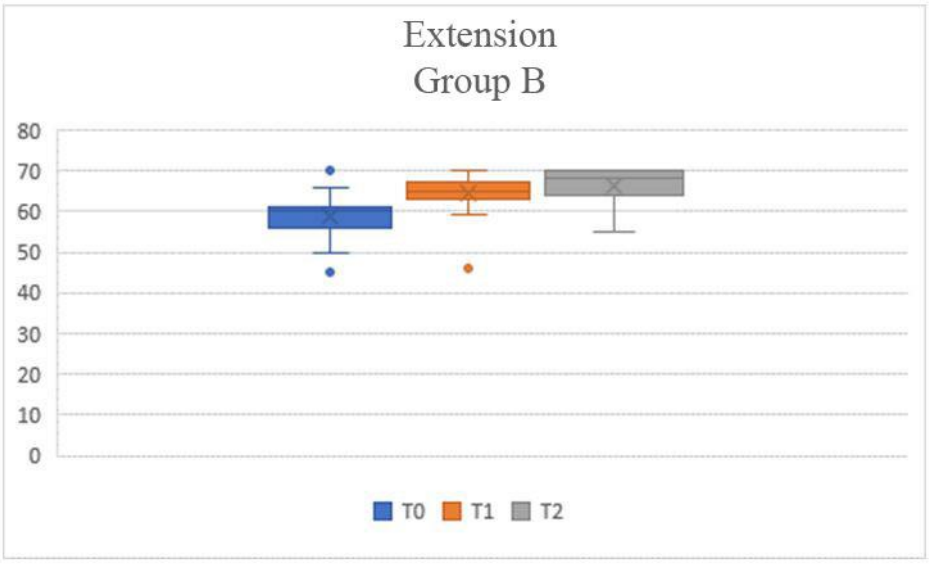

Figure 30. Average, minimum and maximum extension in degrees assessed at the three follow-up time points for the studied patients of group B.

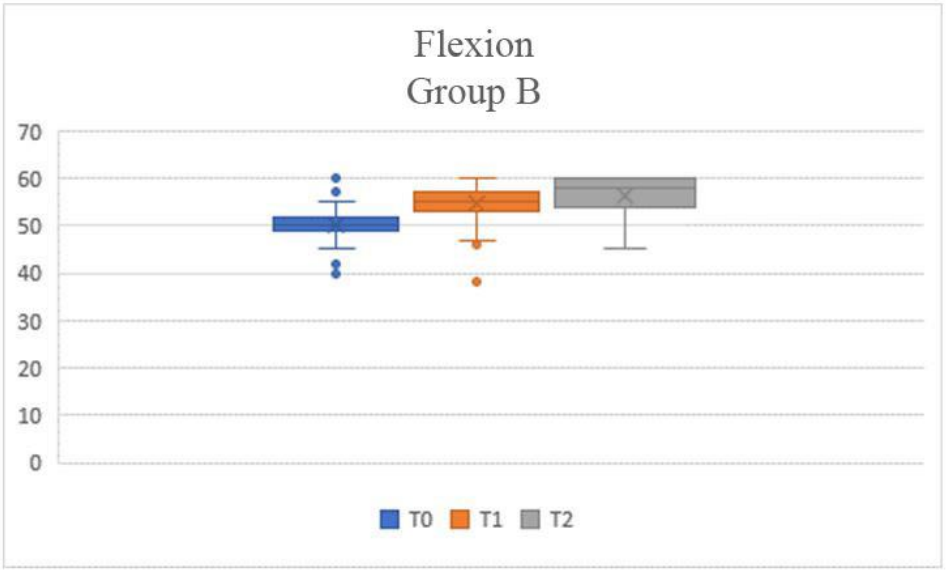

Figure 31. Mean, minimum, and maximum for flexion in degrees assessed at the three follow-up time points for study group B patients.

Table 13 presents the results of the within-group statistical analysis regarding the functional extension test for individuals in group B. It shows a statistically significant improvement ($p < 0.05$) when comparing the mean values for cervical extension at the three time intervals followed (T0 -T1, T1-T2 and T0-T2).

Table 13. Intragroup statistical analysis between extension values for the three monitored time intervals, in patients from group B.

Extension	Paired Differences					t	df	p value
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
T0 - T1	-5.550	3.630	0.574	-6.711	-4.389	-9.670	39	0.000
T1 - T2	-1.950	3.121	0.493	-2.948	-0.952	-3.952	39	0.000
T0 - T2	-7.500	3.419	0.541	-8.594	-6.406	-13.872	39	0.000

The results of the within-group statistical analysis for the evaluation of flexion in the patients of group B are presented in Table 14. It was found that for the patients of group B there was a statistically significant difference ($p < 0.05$) in the mean flexion values calculated according to the three time points. There was a statistically significant improvement when comparing baseline to end of treatment (T0–T1). This trend toward improvement was maintained

when comparing end-of-treatment versus day 45 post-treatment outcomes (T1–T2) and comparing pre-treatment versus day 45 post-treatment outcomes (T0– T2).

Table 14. Intragroup statistical analysis between flexion values for the three monitored time intervals, in the subjects of group B.

Flexion	Paired Differences					t	df	p value
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
T0 - T1	-4.350	2.957	0.468	-5.296	-3.404	-9.303	39	0.000
T1 - T2	-1.250	3.144	0.497	-2.255	-0.245	-2.515	39	0.016
T0 - T2	-5.600	4.534	0.717	-7.050	-4.150	-7.812	39	0.000

For the subjects tested in group C, the results (mean, minimum and maximum) of the functional test of the cervical spine extension and flexion movements measured in degrees are presented in Figure 32 and Figure 33.

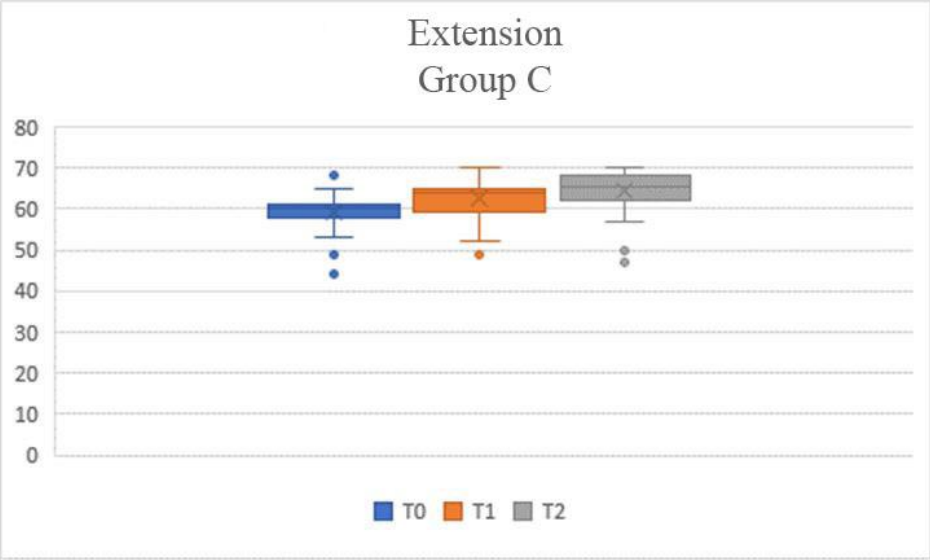

Figure 32. Mean value, minimum and maximum extension of in degrees, assessed at the three monitored time points for the studied patients of group C.

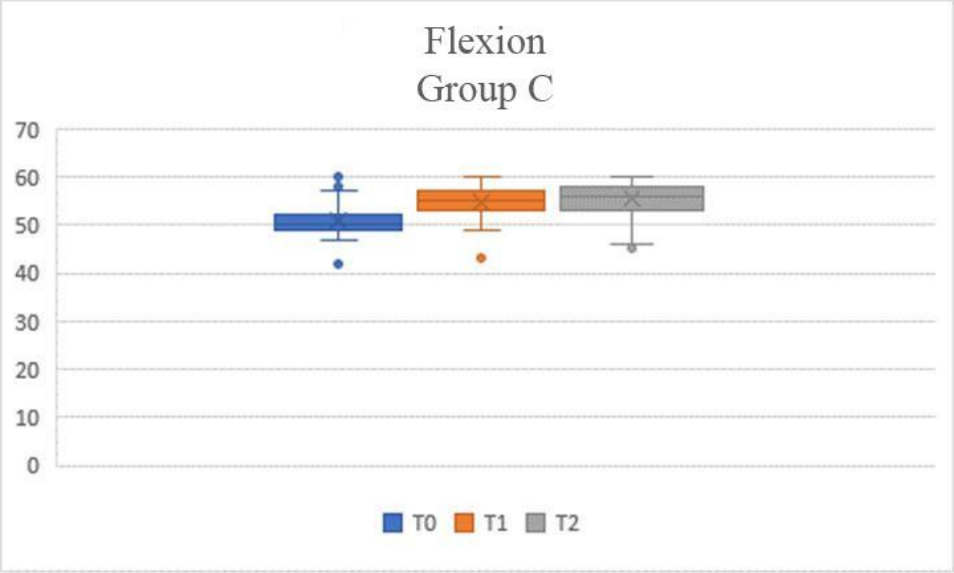

Figure 33. Mean, minimum, and maximum for flexion in degrees assessed at the three follow-up time points for study patients in Group C.

Table 15 presents the results of the within-group statistical analysis regarding the functional extension test for individuals from group C. It shows a statistically significant improvement ($p < 0.05$) when comparing the mean cervical extension values at the three time intervals followed (T0 -T1, T1-T2 and T0-T2).

Table 15. Intragroup statistical analysis between extension values for the three monitored time intervals, in the subjects of group C.

Extension	Paired Differences					t	df	p value
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
T0 - T1	-3.342	1.438	0.233	-3.815	-2.869	-14.323	37	0.000
T1 - T2	-1.921	2.519	0.409	-2.749	-1.093	-4.701	37	0.000
T0 - T2	-5.263	2.333	0.378	-6.030	-4.496	-13.907	37	0.000

The results of the within-group statistical analysis for the assessment of flexion in patients from group C are presented in Table 16. It was found that for patients in group C there was a statistically significant difference ($p < 0.05$) in the mean values for flexion calculated according to the three time points. There was a statistically significant improvement when comparing

baseline to end of treatment (T0–T1). This trend toward improvement was maintained when comparing end-of-treatment versus day 45 post-treatment outcomes (T1–T2) and comparing pre-treatment versus day 45 post-treatment outcomes (T0– T2).

Table 16. Intragroup statistical analysis between flexion values for the three monitored time intervals, in the subjects of group C.

Flexion	Paired Differences					t	df	p value
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
T0 - T1	-3.605	2.034	0.330	-4.274	-2.937	-10.926	37	0.000
T1 - T2	-1.026	2.199	0.357	-1.749	-0.303	-2.877	37	0.007
T0 - T2	-4.632	2.454	0.398	-5.438	-3.825	-11.634	37	0.000

Figure 34 and Figure 35 present the results (mean value, minimum and maximum) of the patients of group A obtained when testing the rotation of the cervical spine in both directions measured in degrees.

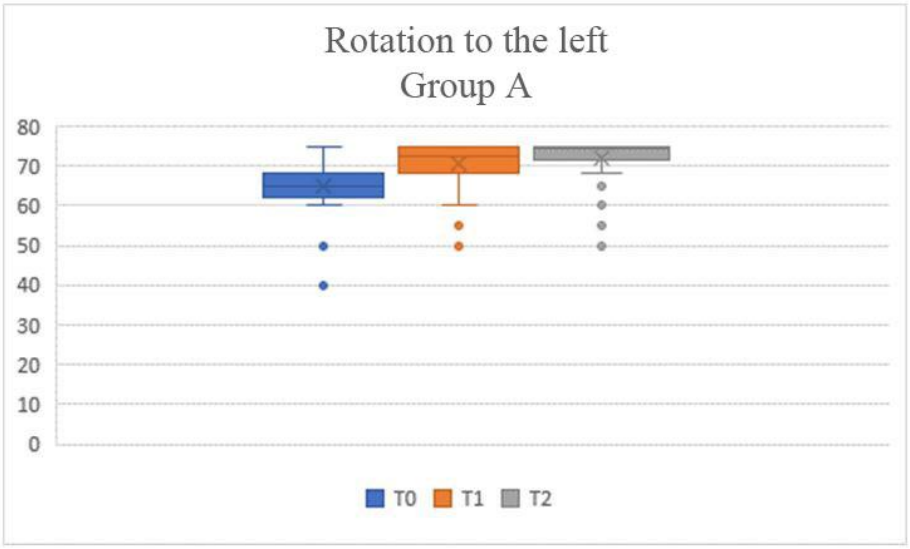

Figure 34. Mean, minimum, and maximum for rotation to the left in degrees assessed at the three follow-up time points for Group A patients.

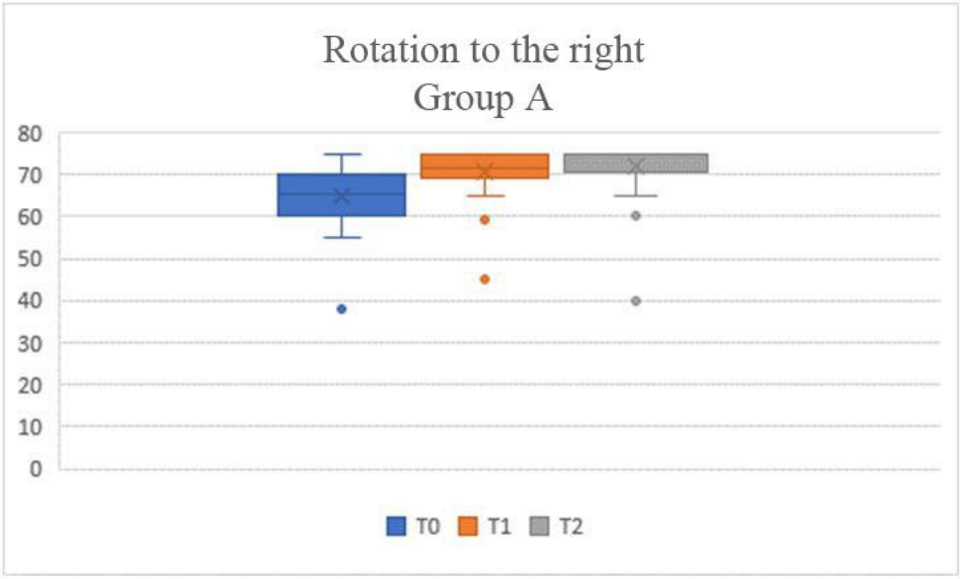

Figure 35. Mean, minimum, and maximum for rotation to the right in degrees assessed at the three follow-up time points for Group A patients.

The within-group statistical analysis for the assessment of left rotation in patients in group A is presented in Table 17. For patients in group A, there was a statistically significant difference ($p < 0.05$) in the mean values calculated according to the three time points. A statistically significant improvement was found when comparing the initial state to the end of treatment (T0–T1). This trend toward improvement was maintained when comparing end-of-treatment versus day 45 post-treatment outcomes (T1–T2) and comparing pre-treatment versus day 45 post-treatment outcomes (T0– T2).

Table 17. Intragroup statistical analysis between rotation to the left values for the three monitored time intervals, in the subjects of group A.

Rotation to the left	Paired Differences					t	df	p value
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
T0 - T1	-5.773	3.234	0.488	-6.756	-4.790	-11.840	43	0.000
T1 - T2	-1.364	2.660	0.401	-2.172	-0.555	-3.401	43	0.001
T0 - T2	-7.136	3.400	0.513	-8.170	-6.103	-13.921	43	0.000

With regard to rotations for the patients of group A, intragroup statistical analysis was performed, which showed a statistically significant difference ($p < 0.05$) when comparing the mean values for the three monitored time intervals (T0-T1, T1-T2 and T0-T2), for rotations in the cervical region on the right (Table 18).

Table 18. Within-group statistical analysis between rotation to the right values for the three time intervals followed, in the patients of group A.

Rotation to the right	Paired Differences					t	df	p value
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
T0 - T1	-5.318	3.233	0.487	-6.301	-4.335	-10.910	43	0.000
T1 - T2	-1.432	2.960	0.446	-2.332	-0.532	-3.208	43	0.003
T0 - T2	-6.750	4.018	0.606	-7.972	-5.528	-11.143	43	0.000

Figure 36 and Figure 37 present the results (mean value, minimum and maximum) of patients in group B, obtained when examining rotational movements in the cervical spine in both directions measured in degrees.

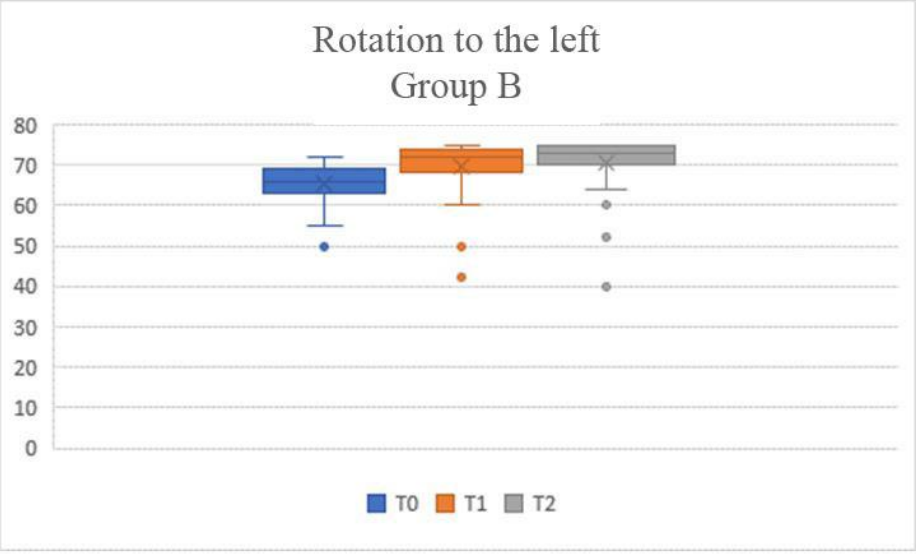

Figure 36. Mean, minimum, and maximum for rotation to the left in degrees assessed at the three follow-up time points for Group B patients.

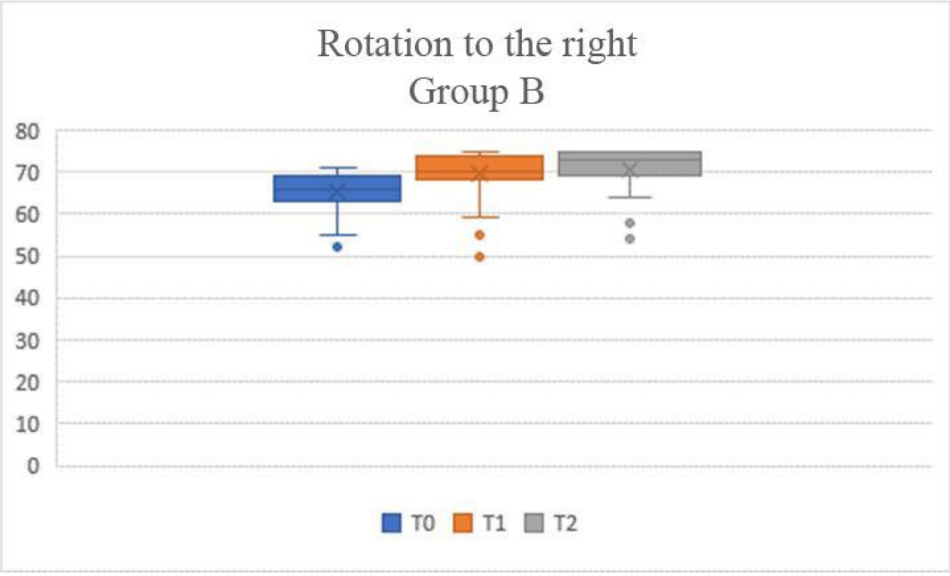

Figure 37. Mean, minimum, and maximum for rotation to the right in degrees assessed at the three follow-up time points for Group B patients.

The within-group statistical analysis for the assessment of rotation to the left in patients in group B is presented in Table 19. For patients in group B, there was a statistically significant difference ($p < 0.05$) in the mean values calculated according to the three time points. A statistically significant improvement was found when comparing baseline to end of treatment (T0–T1). This trend toward improvement was also maintained when comparing pre-treatment versus day 45 post-treatment results (T0–T2). However, when comparing the end-of-treatment results to the 45th day after the start of therapy (T1–T2), an improvement was observed in terms of indicators, but without statistical significance (p=0.474).

Table 19. Intragroup statistical analysis between rotation to the left values for the three monitored time intervals, in the subjects of group B.

Rotation to the left	Paired Differences					t	df	p value
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
T0 - T1	-4.175	5.674	0.897	-5.990	-2.360	-4.653	39	0.000
T1 - T2	-0.850	7.430	1.175	-3.226	1.526	-0.724	39	0.474
T0 - T2	-5.025	5.498	0.869	-6.783	-3.267	-5.780	39	0.000

Regarding rotation results for group B patients, intragroup statistical analysis was performed, which showed a statistically significant difference ($p < 0.05$) when comparing the mean values for the three time intervals followed (T0-T1, T1-T2 and T0-T2). , for the rotations in the cervical region on the right (Table 20).

Table 20. Intragroup statistical analysis between values for rotation to the right for the three time intervals followed, in the patients of group B.

Rotation to the right	Paired Differences					t	df	p value
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
T0 - T1	-4.175	2.782	0.440	-5.065	-3.285	-9.492	39	0.000
T1 - T2	-1.175	2.845	0.450	-2.085	-0.265	-2.612	39	0.013
T0 - T2	-5.350	3.034	0.480	-6.320	-4.380	-11.151	39	0.000

Figure 38 and Figure 39 present the results (mean value, minimum and maximum) of the tested subjects of group C, obtained when examining rotational movements in the cervical spine in both directions measured in degrees.

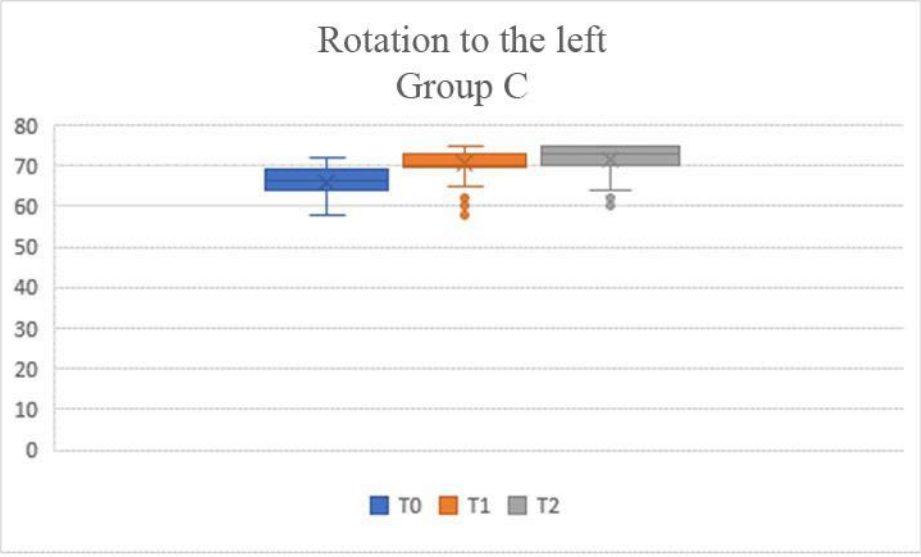

Figure 38. Mean, minimum, and maximum for rotation to the left in degrees assessed at the three follow-up time points for Group C patients.

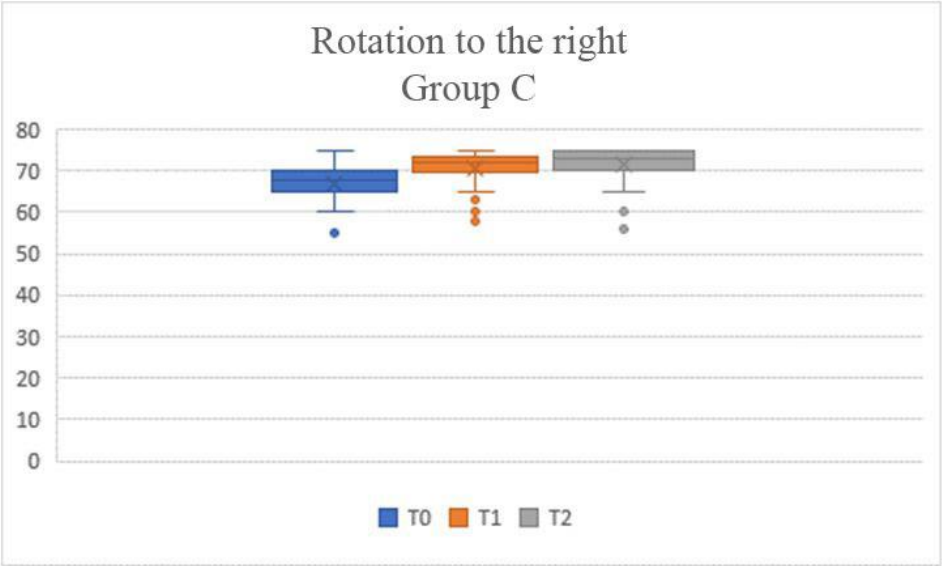

Figure 39. Mean, minimum, and maximum for rotation to the right in degrees assessed at the three follow-up time points for group C patients.

The within-group statistical analysis for the assessment of rotation to the left in patients from group C is presented in Table 21. For patients from group C, there was a statistically significant difference ($p < 0.05$) in the mean values calculated according to the three time points. A statistically significant improvement was found when comparing the initial state to the end of treatment (T0–T1). This trend toward improvement was maintained when comparing end-of-treatment versus day 45 post-treatment outcomes (T1–T2) and comparing pre-treatment versus day 45 post-treatment outcomes (T0– T2).

Table 21. Intragroup statistical analysis between rotation to the left values for the three monitored time intervals, in the subjects of group C.

Rotation to the left	Paired Differences					t	df	p value
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
T0 - T1	-4.553	1.899	0.308	-5.177	-3.929	-14.780	37	0.000
T1 - T2	-1.132	2.195	0.356	-1.853	-0.410	-3.177	37	0.003
T0 - T2	-5.684	2.207	0.358	-6.410	-4.959	-15.877	37	0.000

Regarding the rotations test, for the patients of group C, an intragroup statistical analysis was performed, which showed a statistically significant difference ($p < 0.05$) when comparing the

mean values for the three monitored time intervals (T0-T1, T1-T2 and T0-T2), for the rotations in the cervical region on the right (Table 22).

Table 22. Intragroup statistical analysis between values for rotation to the right for the three monitored time intervals, in the patients of group C.

Rotation to the right	Paired Differences					t	df	p value
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
T0 - T1	-3.868	1.742	0.283	-4.441	-3.296	-13.685	37	0.000
T1 - T2	-0.789	2.016	0.327	-1.452	-0.127	-2.415	37	0.021
T0 - T2	-4.658	2.496	0.405	-5.478	-3.837	-11.503	37	0.000

The results (mean, minimum and maximum) of patients in group A obtained in the functional test of lateral flexion to the left and right in the cervical spine measured in degrees are presented in Figure 40 and Figure 41.

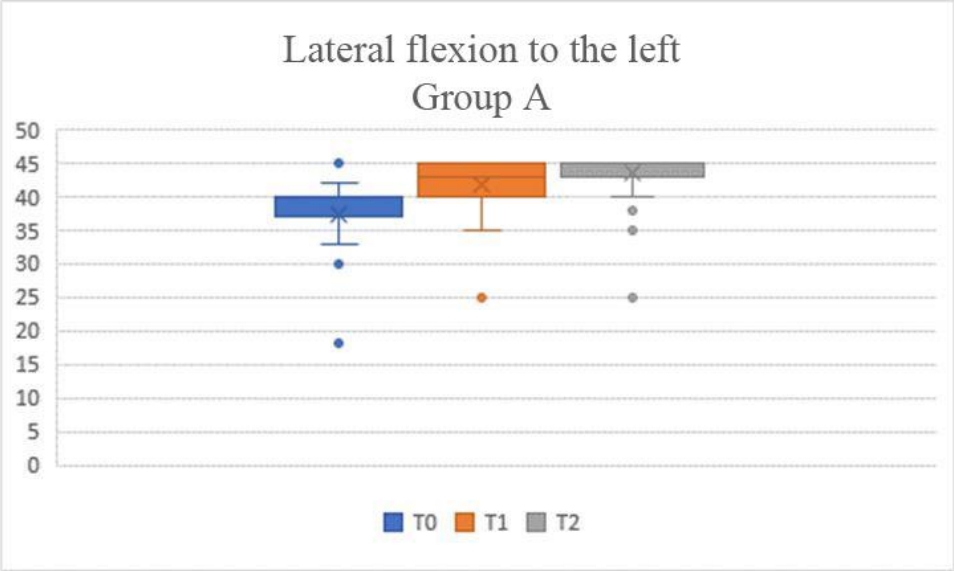

Figure 40. Mean, minimum, and maximum for lateral flexion to the left in degrees assessed at the three follow-up time points for Group A patients.

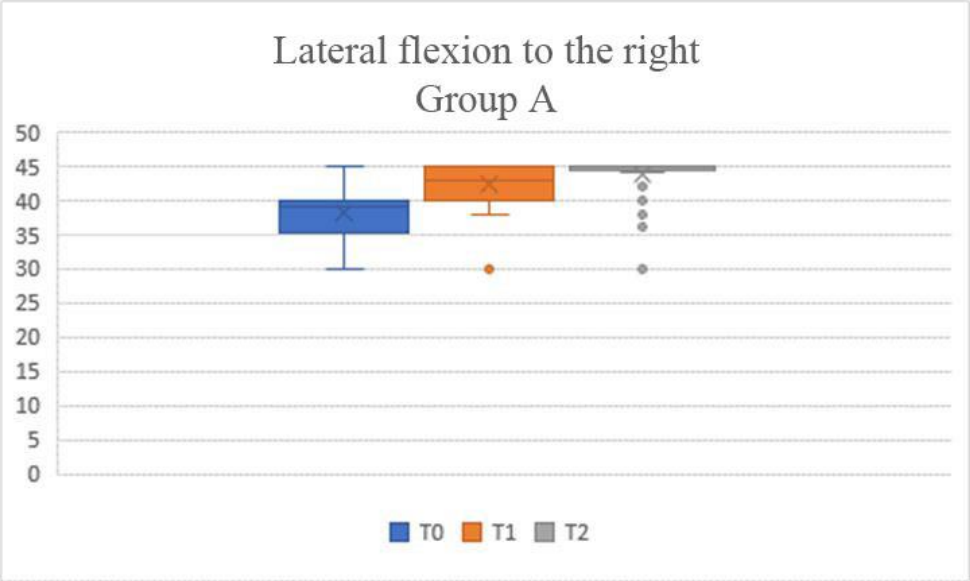

Figure 41. Mean, minimum and maximum for lateral flexion to the right in degrees assessed at the three follow-up time points for Group A patients.

The within-group statistical analysis of the results obtained from the functional test of lateral flexion to the left for the patients of group A is presented in Table 23. It shows a statistically significant improvement ($p < 0.05$) when comparing the mean values for lateral flexion to the left in the cervical region between baseline condition and the 45th day after starting therapy (T0-T2). There was an improvement in lateral flexion to the left range at each time point, but no statistically significant difference ($p > 0.05$) was observed when comparing the results from baseline to the end of treatment (T0-T1) and when comparing the end of treatment compared to the 45th day after the start of therapy (T1-T2).

Table 23. Intragroup statistical analysis between values for lateral flexion to the left for the three time intervals followed, in the patients of group A.

Lateral flexion to the left	Paired Differences					t	df	p value
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
T0 - T1	-3.545	2.441	0.412	-4.921	-2.830	-1.487	43	0.144
T1 - T2	-2.945	2.121	0.364	-3.733	-2.024	-1.832	43	0.410
T0 - T2	-6.000	2.615	0.394	-6.795	-5.205	-15.221	43	0.000

The results of the intragroup statistical analysis for the assessment of lateral flexion to the right in the patients of group A are presented in Table 24. The data show that for the patients of group A there is a statistically significant difference ($p < 0.05$) in the mean values calculated according to the three time points. A statistically significant improvement was found when comparing the initial state to the end of treatment (T0–T1). This trend toward improvement was maintained when comparing end-of-treatment versus day 45 post-treatment outcomes (T1–T2) and comparing pre-treatment versus day 45 post-treatment outcomes (T0– T2).

Table 24. Intragroup statistical analysis between values for lateral flexion to the right for the three monitored time intervals, in the subjects of group A.

Lateral flexion to the right	Paired Differences					t	df	p value
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
T0 - T1	-4.341	2.496	0.376	-5.100	-3.582	-11.536	43	0.000
T1 - T2	-1.295	2.474	0.373	-2.048	-0.543	-3.474	43	0.001
T0 - T2	-5.636	3.250	0.490	-6.624	-4.648	-11.504	43	0.000

The results (mean, minimum and maximum) of patients in group B obtained in the functional test of lateral flexion of the left and right for the cervical spine measured in degrees are presented in Figure 42 and Figure 43.

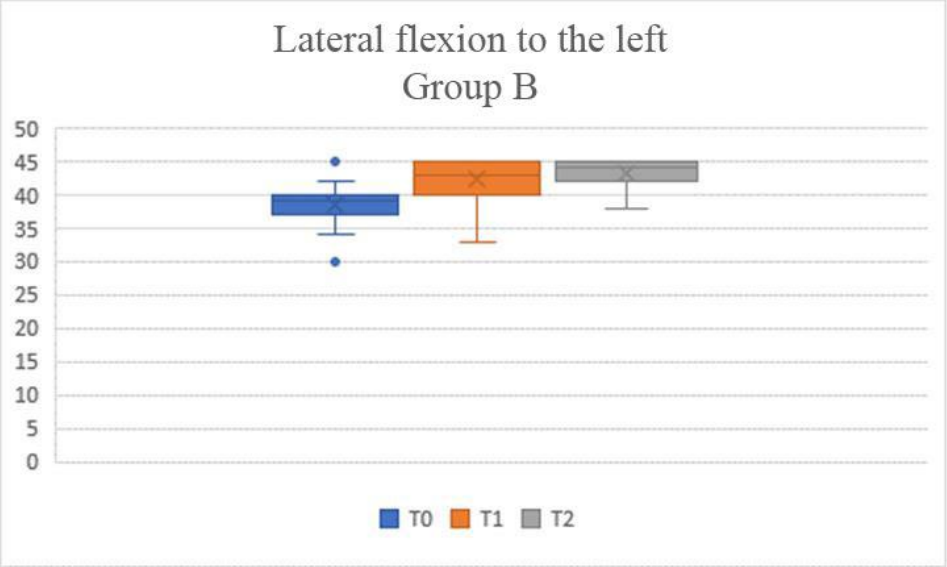

Figure 42. Mean, minimum, and maximum lateral flexion to the left in degrees assessed at the three follow-up time points for hroup B patients.

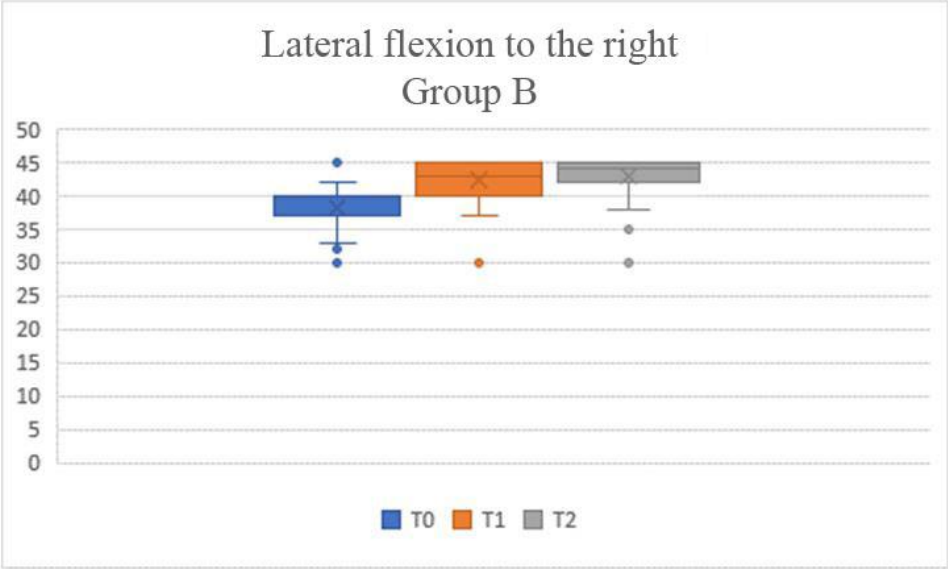

Figure 43. Mean, minimum, and maximum lateral flexion to the right in degrees assessed at the three follow-up time points for group B patients.

The within-group statistical analysis of the results obtained from the lateral flexion to the left test for the individuals in group B is presented in Table 25. It shows a statistically significant improvement ($p < 0.05$) when comparing the mean values for left lateral flexion in the cervical region in the three follow-ups time intervals (T0-T1, T1-T2 and T0-T2).

Table 25. Intragroup statistical analysis between the values for lateral flexion to the left for the three time intervals followed, in the patients of group B.

Lateral flexion to the left	Paired Differences					t	df	p value
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
T0 - T1	-3.800	2.003	0.317	-4.440	-3.160	-12.001	39	0.000
T1 - T2	-0.875	2.127	0.336	-1.555	-0.195	-2.602	39	0.013
T0 - T2	-4.675	2.314	0.366	-5.415	-3.935	-12.779	39	0.000

The results of the within-group statistical analysis for the assessment of lateral flexion to the right in the patients of group B are presented in Table 26. The data show that for the patients of group B there is a statistically significant difference ($p < 0.05$) in the mean values calculated according to with the three time points. A statistically significant improvement was found when comparing the initial state to the end of treatment (T0–T1). This trend toward improvement was maintained when comparing end-of-treatment versus day 45 post-treatment outcomes (T1–T2) and comparing pre-treatment versus day 45 post-treatment outcomes (T0– T2).

Table 26. Intragroup statistical analysis between lateral flexion to the right values for the three follow-up time intervals for group B patients.

Lateral flexion to the right	Paired Differences					t	df	p value
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
T0 - T1	-3.925	2.093	0.331	-4.594	-3.256	-11.863	39	0.000
T1 - T2	-0.825	2.099	0.332	-1.496	-0.154	-2.486	39	0.017
T0 - T2	-4.750	2.405	0.380	-5.519	-3.981	-12.493	39	0.000

The results (mean value, minimum and maximum) of the patients of group C, obtained in the functional test of lateral flexion to the left and right in the cervical spine measured in degrees, are presented in Figure 44 and Figure 45.

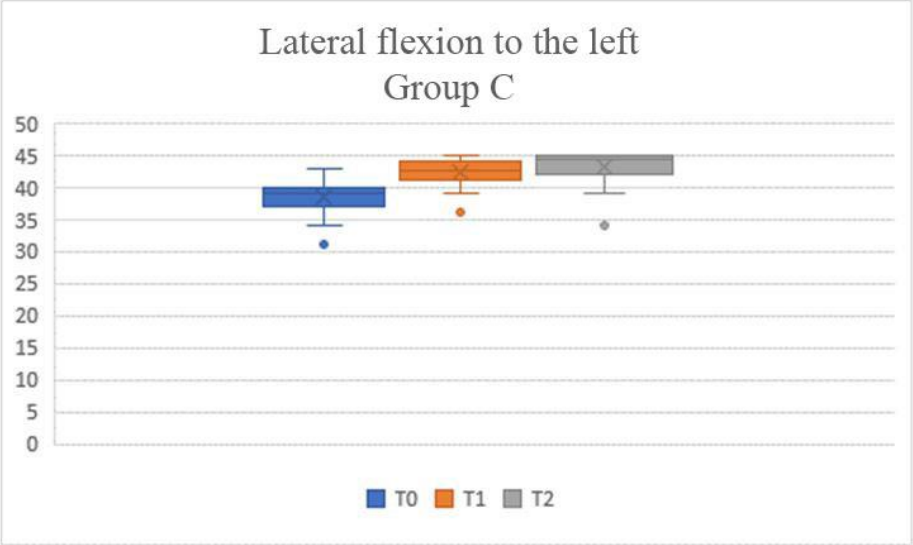

Figure 44. Mean, minimum and maximum for lateral flexion to the left in degrees assessed at the three follow-up time points for Group B patients.

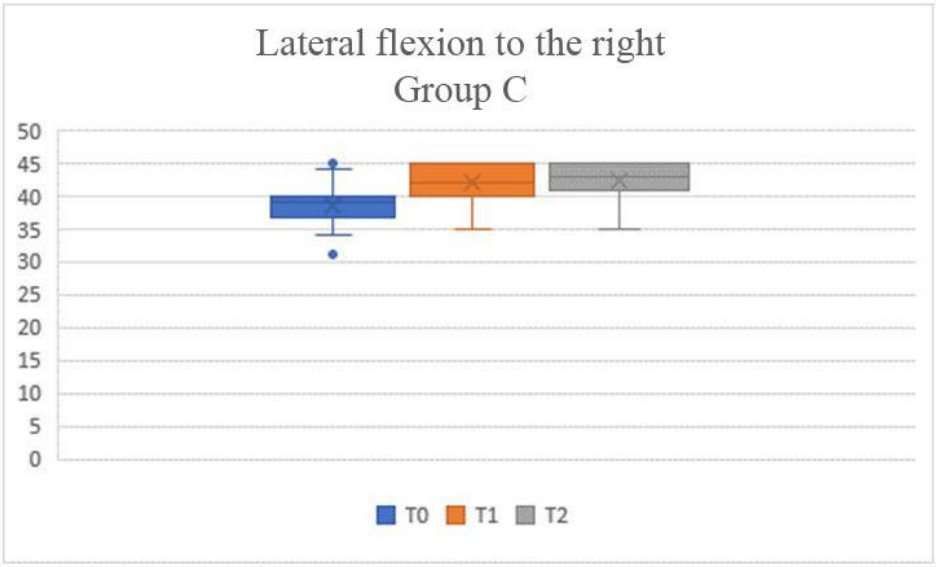

Figure 45. Mean, minimum, and maximum lateral flexion to the right in degrees assessed at the three follow-up time points for group B patients.

The within-group statistical analysis of the results obtained for lateral flexion to the left for individuals from group C is presented in Table 27. It shows a statistically significant improvement ($p < 0.05$) when comparing the average values for left lateral flexion in the cervical region at the three time intervals followed. (T0-T1, T1-T2 and T0-T2).

Table 27. Intragroup statistical analysis between the values for lateral flexion to the left for the three monitored time intervals of the patients in group C.

Lateral flexion to the left	Paired Differences					t	df	p value
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
T0 - T1	-3.789	1.255	0.204	-4.202	-3.377	-18.607	37	0.000
T1 - T2	-0.763	1.747	0.283	-1.337	-0.189	-2.694	37	0.011
T0 - T2	-4.553	1.899	0.308	-5.177	-3.929	-14.780	37	0.000

The results of the intragroup statistical analysis for the assessment of lateral flexion to the right in patients from group C are presented in Table 28. The data show that for patients from group C there is a statistically significant difference ($p < 0.05$) in the mean values calculated according to the three time points. A statistically significant improvement was found when comparing the initial state to the end of treatment (T0–T1). This trend toward improvement was also maintained when comparing pre-treatment versus day 45 post-treatment results. (T0–T2). When comparing the results from the end of treatment to the 45th day after the start of therapy (T1–T2), no statistically significant improvement was found, but a positive trend of the results was noted.

Table 28. Intragroup statistical analysis between values for lateral flexion to the right for the three follow-up time intervals for patients in group C.

Lateral flexion to the right	Paired Differences					t	df	p value
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
T0 - T1	-3.447	1.751	0.284	-4.023	-2.872	-12.139	37	0.000
T1 - T2	-0.447	1.982	0.322	-1.099	0.204	-1.391	37	0.172
T0 - T2	-3.895	2.264	0.367	-4.639	-3.151	-10.607	37	0.000

Baseline values (T0) for group A individuals obtained from the Zung test were: mean value – 40.32, minimum – 25, maximum – 52. After completion of therapy (T1) the reported data from the questionnaire were: mean value – 31.82, minimum – 25, maximum – 47. The results

registered on the 45th day from the start of treatment (T2) for the monitored criteria were respectively: average value – 30.11, minimum – 25, maximum – 45 (Figure 46).

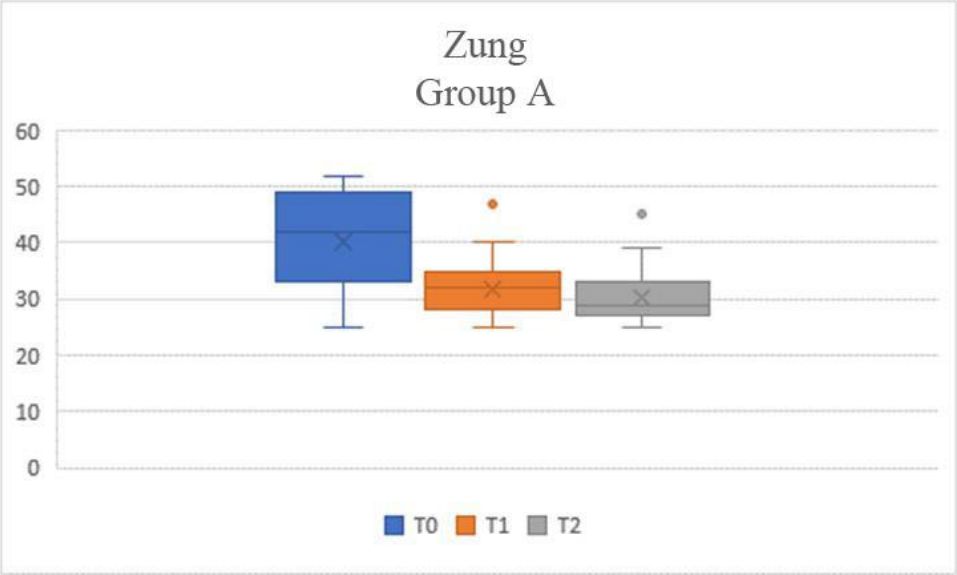

Figure 46. Mean, minimum, and maximum of the Zung test values assessed at the three time points followed for Group A patients.

The results of the intragroup statistical analysis regarding the Zung test for the patients of group A showed a statistically significant difference ($p < 0.05$) in the mean values calculated for the three time intervals followed (Table 29). The established difference represents a statistically significant reduction in the mean values when comparing the results at the beginning of the study versus the end of the therapeutic course (T0–T1). Analysis of outcomes between end-of-therapy versus day 45 post-initiation (T1-T2) data was similar. as well as when comparing baseline values compared to the 45th day (T0–T2).

Table 29. Intragroup statistical analysis between Zung's test values, for the three follow-up time intervals in group A patients.

Zung	Paired Differences					t	df	p value
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
T0 - T1	8.500	6.010	0.906	6.673	10.327	9.382	43	0.000
T1 - T2	1.705	3.303	0.498	0.700	2.709	3.423	43	0.001
T0 - T2	10.205	6.886	1.038	8.111	12.298	9.829	43	0.000

Before the beginning of the treatment (T0), the following results were recorded for the Zung test in the patients in group B: average value – 39.00, minimum – 22, maximum – 54. At the end of the therapeutic course (T1) the results for the same sign were as follows: average value - 34.08, minimum - 22, maximum - 47. The data reported on the 45th day after the start of treatment (T2) for the Zung test are as follows: mean - 33.64, minimum - 24, maximum - 46 (Figure 47).

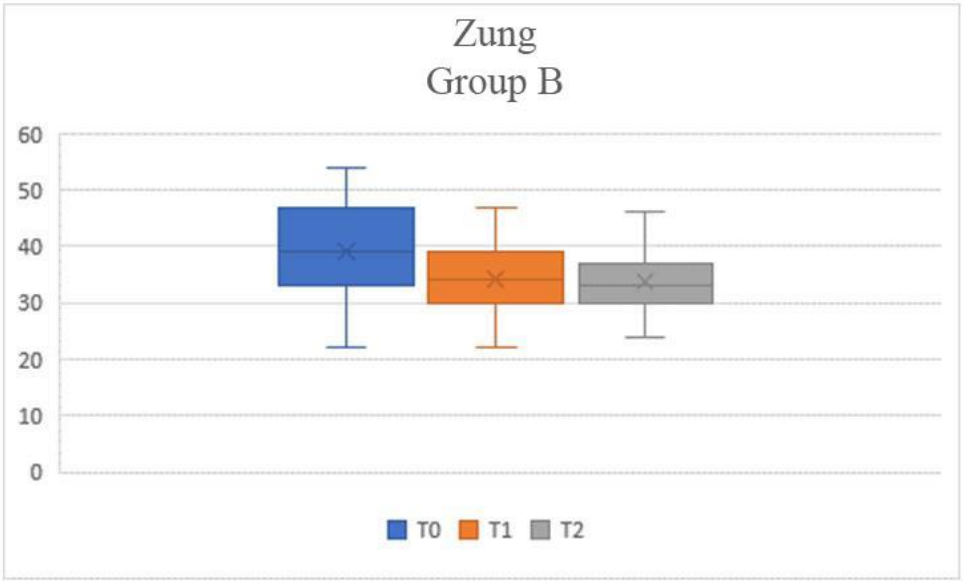

Figure 47. Mean, minimum, and maximum of the Zung test values assessed at the three follow-up time points for Group B patients.

Table 30 presents the results of the intragroup statistical analysis for related samples according to the Zung test, for the patients in group B. A statistically significant difference (p <

0.05) was found when comparing the mean values for two of the three time periods. Statistically significant improvement was found when comparing baseline vs. end of treatment (T0–T1) as well as before starting therapy vs. day 45 (T0–T2). This trend is interrupted when comparing the results at the end of the treatment course compared to the 45th day from the beginning (T1-T2), where no statistically significant improvement is found.

Table 30. Intragroup statistical analysis between Zung's test values, for the three monitored time intervals, in group B patients.

Zung	Paired Differences					t	df	p value
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
T0 - T1	5.000	3.581	0.566	3.855	6.145	8.832	39	0.000
T1 - T2	0.525	2.864	0.453	-0.391	1.441	1.159	39	0.253
T0 - T2	5.525	4.151	0.656	4.197	6.853	8.418	39	0.000

Baseline values (T0) for subjects from group C obtained from the Zung test were: mean value – 39.74, minimum – 29, maximum – 53. After completion of therapy (T1) the reported data from the questionnaire were: mean value – 35.68, minimum – 27, maximum – 47. The results registered on the 45th day from the start of treatment (T2) for the monitored criteria were respectively: average value – 34.74, minimum – 26, maximum – 46 (Figure 48).

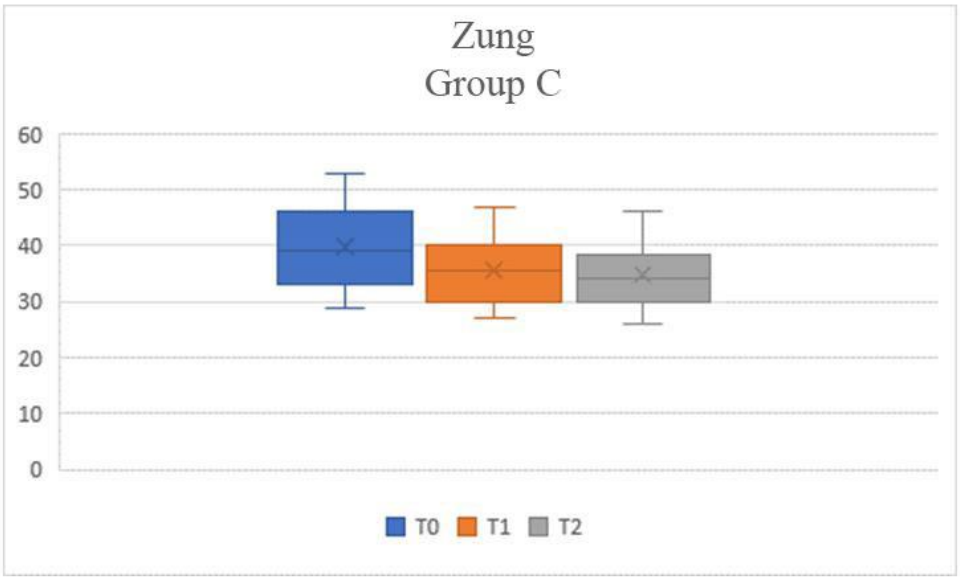

Figure 48. Mean, minimum and maximum of the Zung test values assessed at the three follow-up time points for Group A patients.

The results of the intragroup statistical analysis regarding the Zung test for the patients of group C showed a statistically significant difference ($p < 0.05$) in the mean values calculated for two of the three time intervals followed (Table 31). The established difference represents a statistically significant reduction in the mean values when comparing the results at the beginning of the study versus the end of the therapeutic course (T0–T1). The analysis of the results between the obtained data when comparing the baseline values to the 45th day (T0–T2) is similar. The improvement in scores when comparing data after completion of therapy versus day 45 after initiation (T1-T2) was not statistically significant.

Table 31. Intragroup statistical analysis between the values of the Zung test, for the three monitored time intervals, in the patients of group C.

Zung	Paired Differences					t	df	p value
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
T0 - T1	4.053	2.701	0.438	3.165	4.940	9.250	37	0.000
T1 - T2	0.947	3.238	0.525	-0.117	2.012	1.804	37	0.079
T0 - T2	5.000	2.721	0.441	4.106	5.894	11.326	37	0.000

Before the start of treatment (T0), the following NDI results were reported for patients in group A: mean value – 39.64, minimum – 10, maximum – 60. At the end of the therapeutic course (T1), the results for the same sign were as follows: mean value – 21.34, min - 0, max - 50. The data reported on the 45th day after the start of treatment (T2) for NDI are as follows: mean - 15.80, min - 0, max - 47 (Figure 49).

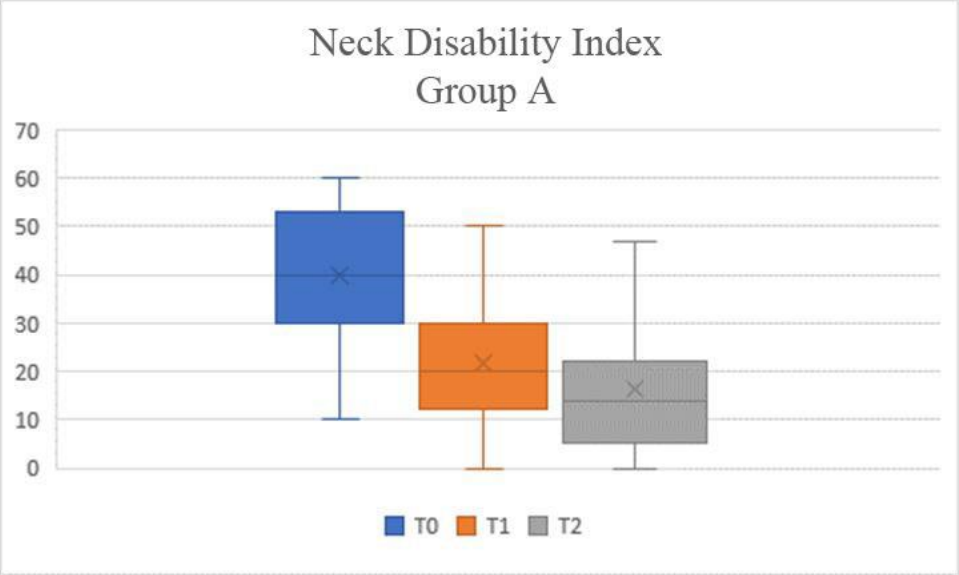

Figure 49. Mean, minimum and maximum for the NDI questionnaire assessed at the three follow-up time points for group A.

Table 32 presents the results of the within-group statistical analysis for related samples with respect to the NDI questionnaire, for patients in group A. A statistically significant difference ($p < 0.05$) was found when comparing the mean values calculated according to the three time periods. A statistically significant improvement was found when comparing baseline to end of treatment (T0–T1). This trend of improvement is also preserved when comparing the results at the end of the treatment course compared to the 45th day from the beginning (T1-T2), as well as before the start of therapy compared to the 45th day (T0-T2).

Table 32. Within-group statistical analysis between the results of the NDI questionnaire, for the three follow-up time intervals, in the patients of group A.

Neck Disability Index	Paired Differences					t	df	p value
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
T0 - T1	18.295	10.787	1.626	15.016	21.575	11.251	43	0.000
T1 - T2	5.545	8.114	1.223	3.079	8.012	4.534	43	0.000
T0 - T2	23.841	11.519	1.737	20.339	27.343	13.728	43	0.000

Before the start of treatment (T0), the following NDI results were reported for patients in group B: mean value – 41.79, minimum – 20, maximum – 58. At the end of the therapeutic course (T1), the results for the same sign were as follows: mean value – 30.56, minimum – 7, maximum – 50. The data reported on the 45th day after the start of treatment (T2) for NDI are as follows: mean – 28.23, minimum – 2, maximum – 43 (Figure 50).

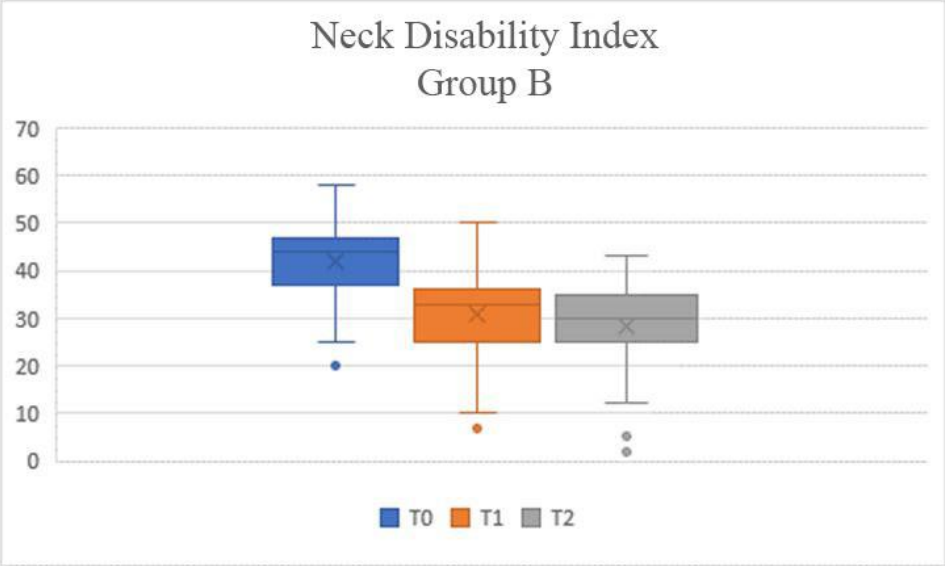

Figure 50. Mean, minimum and maximum value for the NDI questionnaire assessed at the three follow-up time points for group B.

Table 33 presents the results of the intragroup statistical analysis for related samples of the NDI questionnaire, for patients in group B. A statistically significant difference ($p < 0.05$)

was found when comparing the average values calculated according to the three time periods. A statistically significant improvement was found when comparing baseline to end of treatment (T0–T1). This trend toward improvement was also maintained when comparing the results at the end of the treatment course versus day 45 from the start (T1-T2), as well as before starting therapy versus day 45 (T0–T2).

Table 33. Within-group statistical analysis between the results of the NDI questionnaire, for the three follow-up time intervals for patients in group B.

Neck Disability Index	Paired Differences					t	df	p value
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
T0 - T1	11.400	5.679	0.898	9.584	13.216	12.697	39	0.000
T1 - T2	2.575	5.411	0.856	0.845	4.305	3.010	39	0.005
T0 - T2	13.975	7.266	1.149	11.651	16.299	12.164	39	0.000

Before the start of treatment (T0), the following NDI results were obtained for patients in group C: average value – 41.45, minimum – 25, maximum – 57. At the end of the therapeutic course (T1), the results for the same sign were as follows: average value – 33.42, min – 17, max – 53. Data reported on day 45 after initiation of treatment (T2) for NDI were as follows: mean – 30.11, min – 10, max – 50 (Figure 51).

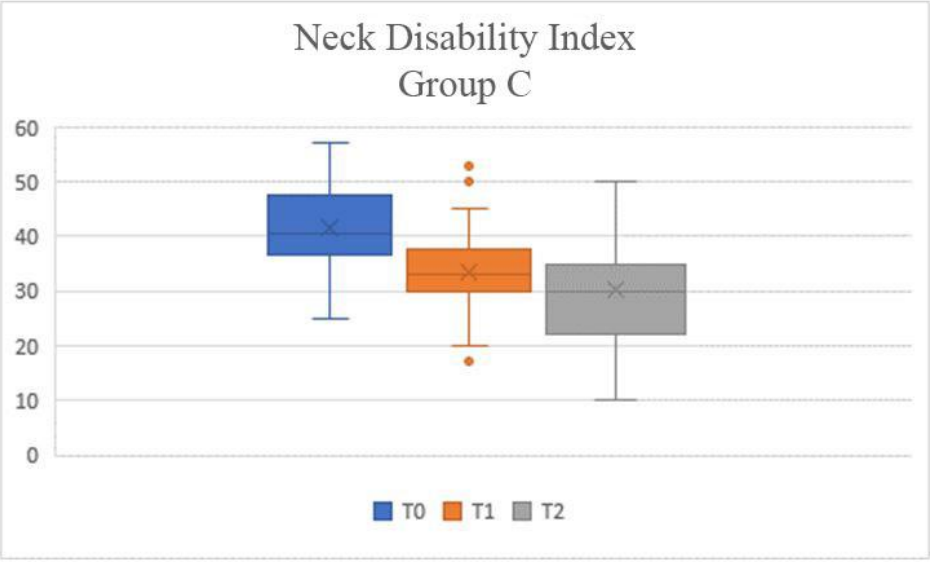

Figure 51. Mean, minimum and maximum value for the NDI questionnaire assessed at the three follow-up time points for group C.

Table 34 presents the results of the intragroup statistical analysis for related samples of the NDI questionnaire, for the patients of group C. A statistically significant difference ($p < 0.05$) was found when comparing the mean values calculated according to the three time periods. A statistically significant improvement was found when comparing baseline to end of treatment (T0–T1). This trend of improvement was also maintained when comparing the results at the end of the treatment course versus the 45th day from the beginning (T1-T2), as well as before the start of therapy versus the 45th day (T0-T2).

Table 34. Within-group statistical analysis between the results of the NDI questionnaire for the three follow-up time intervals for patients in group C.

Neck Disability Index	Paired Differences					t	df	p value
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
T0 - T1	8.026	5.664	0.919	6.165	9.888	8.736	37	0.000
T1 - T2	3.316	4.827	0.783	1.729	4.902	4.234	37	0.000
T0 - T2	11.342	8.204	1.331	8.645	14.039	8.522	37	0.000

4. Comparison and analysis of the clinical effectiveness between the three treatment methods according to the obtained results for the monitored indicators.

The objective of this thesis is to check whether there is a statistically significant difference in the health status of patients affected by cervical spondylosis treated with the three therapeutic methods. For this purpose, a comparison of the average values of each of the eleven indicators in the patients of group A, group B and group C is carried out.

The baseline analysis performed for the three groups did not show statistically significant differences, therefore we accepted the hypothesis that the three groups were homogeneous in terms of the mean values of the follow-up indicators at baseline. To establish the clinical effectiveness, the three groups were compared after the completion of the therapeutic course (T1), as well as on the 45th day after the start of the treatment (T2).

Figure 52 presents the comparison of the results obtained when examining the VAS static pain indicator represented by the mean values with the standard deviation after the end of the therapeutic course (T1) and on the 45th day from the start of treatment (T2) for group A, group B and group C.

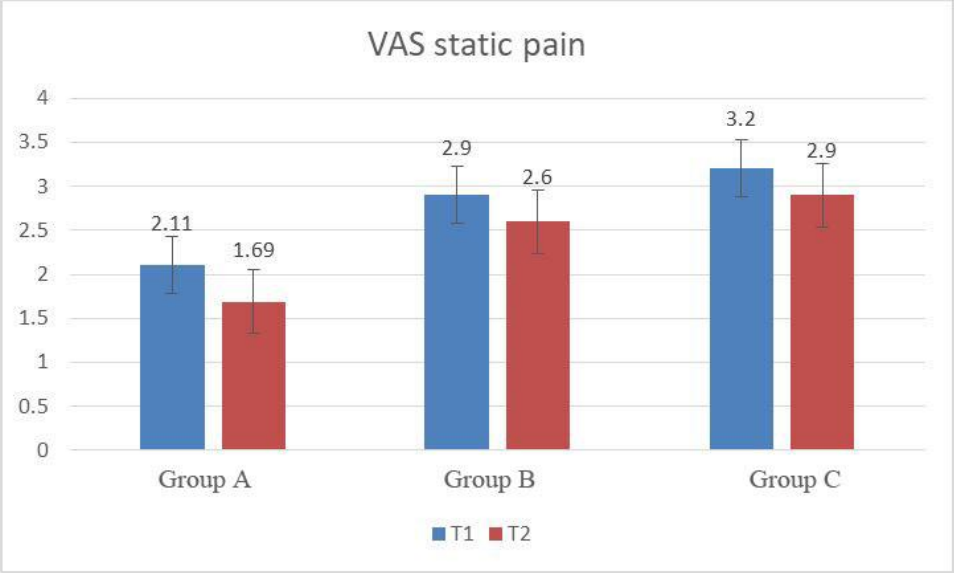

Figure 52. Mean value with standard deviation of VAS static pain data compared between group A, group B and group C.

A statistically significant difference F=6.516, p=0.002 in T1 and F=7.437, p=0.001 in T2 was found for the VAS static pain value between the three groups. Analysis of the results showed that after completion of therapy (T1), the mean value for group A was statistically significantly different from the mean value for group B (p=0.035) and group C (p=0.002). The mean value for group B was not statistically significantly different from that of group C (p=0.622). In the long term - on the 45th day from the start of treatment (T2) the results are similar, the mean value for group A is statistically significantly different from the mean value for group B (p=0.018) and group C (p=0.001), and the mean value for group B was not statistically significantly different from that of group C (p=0.647). The results are presented in Table 35.

Table 35. Intergroup statistical analysis comparing VAS static pain data in the three groups at the end of treatment (T1) and on the 45th day after initiation of therapy (T2).

VAS static pain	Therapeutic group (I)	Therapeutic group (J)	Mean Difference (I-J)	Std. Error	p-value
T1	Group A	Group B	-0.7841*	0.3110	0.035
		Group C	-1.0841*	0.3132	0.002
	Group B	Group A	0.7841*	0.3110	0.035
		Group C	-0.3000	0.3223	0.622
T2	Group A	Group B	-0.9071*	0.3277	0.018
		Group C	-1.2098*	0.3299	0.001
	Group B	Group A	0.9071*	0.3277	0.018
		Group C	-0.3027	0.3396	0.647

Figure 53 presents the comparison of the obtained VAS dynamic pain results represented by the mean values with the standard deviation after the end of the therapeutic course (T1) and on the 45th day from the beginning of the treatment (T2) for group A, group B and group C.

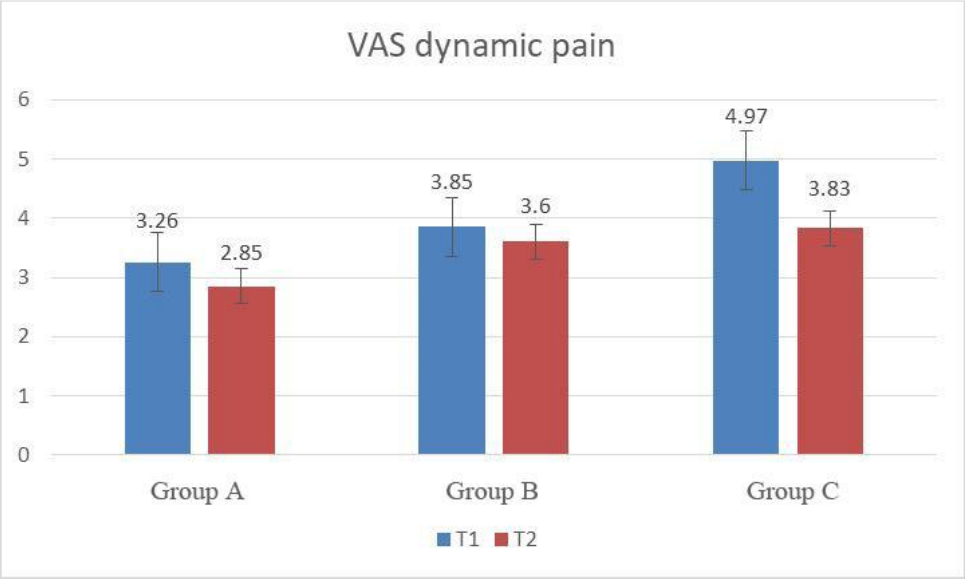

Figure 53. Mean value with standard deviation of VAS dynamic pain data compared between group A, group B and group C.

The results show that there are no statistically significant differences F=2.715, p=0.070 between the three groups after the end of treatment (T1) in terms of mean values. A statistically significant difference F=4.511, p=0.013 was found at T2 for VAS dynamic pain between the three groups. Analysis of the results on the 45th day from the start of treatment (T2) showed that the mean value of group A was statistically significantly different from the mean value of group C (p=0.015), and the mean value of group B was not statistically significantly different for group C (p=0.792) and group A (p=0.078). The results are presented in Table 36.

Table 36. Intergroup statistical analysis comparing VAS dynamic pain data in the three groups at the end of treatment (T1) and on the 45th day after starting therapy (T2).

VAS dynamic pain	Therapeutic group (I)	Therapeutic group (J)	Mean Difference (I-J)	Std. Error	p-value
T1	Group A	Group B	-0.5935	0.7363	0.700
		Group C	-1.7127	0.7414	0.058
	Group B	Group A	0.5935	0.7363	0.700
		Group C	-1.1191	0.7631	0.311
T2	Group A	Group B	-0.7509	0.3434	0.078
		Group C	-0.9827*	0.3458	0.015
	Group B	Group A	0.7509	0.3434	0.078
		Group C	-0.2318	0.3559	0.792

The comparison of the obtained results regarding the mean rank with standard deviation for muscle tone in the neck, after the end of the therapeutic course (T1) and on the 45th day from the beginning of the treatment (T2) for group A, group B and group C, is presented in Figure 54.

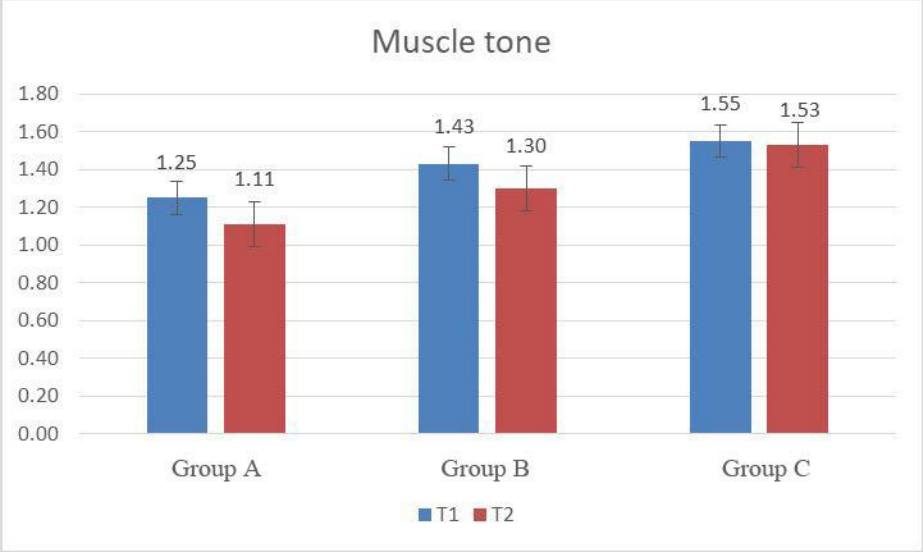

Figure 54. Mean rank with standard deviation of muscle tone scores compared between group A, group B and group C.

The statistical analysis between groups regarding muscle tone between the three different therapeutic approaches is presented in Table 37. No statistically significant difference was found, despite the marginal values (p=0.051) in the intergroup comparison at the end of the treatment course (T1). The results convincingly presented a statistically significant difference ($p < 0.05$) in

the group means at day 45 from the start of the study T2 (p=0.001) according to the Kruschkel-Wallis test.

Table 37. Intergroup statistical analysis comparing muscle tone data in the three groups at the end of treatment (T1) and on the 45th day after initiation of therapy (T2).

Muscle tone	Therapeutic group	N	Mean Rank	Chi-Square	df	p
T1	Group A	44	53.25	5.963	2	0.051
	Group B	39	61.77			
	Group C	38	69.18			
T2	Group A	44	49.82	14.757	2	0.001
	Group B	39	61.46			
	Group C	38	73.47			

In order to determine exactly where the difference lies, i.e. which groups are statistically significantly different, the Mann-Whitney post hoc test was conducted, one for each pair of groups, using the Bonferroni corrected value. At α=0.05 the Bonferroni corrected value is equal to p =0.05/3=0.0167 or only at $p \leq 0.0167$ the Mann-Whitney test is considered statistically significant (Table 38). The results convincingly presented a statistically significant difference ($p<0.000$) in the mean values in favor of the therapeutic approach used in group A compared to group C at day 45 from the start of treatment T1. When comparing group C versus group B, no statistically significant difference was found, similar to the results between group A and group B.

Table 38. Between-group statistical analysis comparing the data regarding the mean rank for muscle tone on the 45th day from the start of treatment (T1) with the adjusted Bonferroni value.

T2				
Therapeutic group	Mean Rank	Sum of Ranks	Mann-Whitney U	p
Group A	34.10	1500.50	510.500	0.000
Group C	50.07	1902.50		
Group B	35.19	1372.50	592.500	0.076
Group C	42.91	1630.50		
Group A	38.22	1681.50	691.500	0.03
Group B	46.27	1804.50		

Figure 55 shows the comparison of the results obtained when examining the extension range in degrees represented by the average values with the standard deviation after the end of the therapeutic course (T1) and on the 45th day from the beginning of the treatment (T2) for group A, group B and group C.

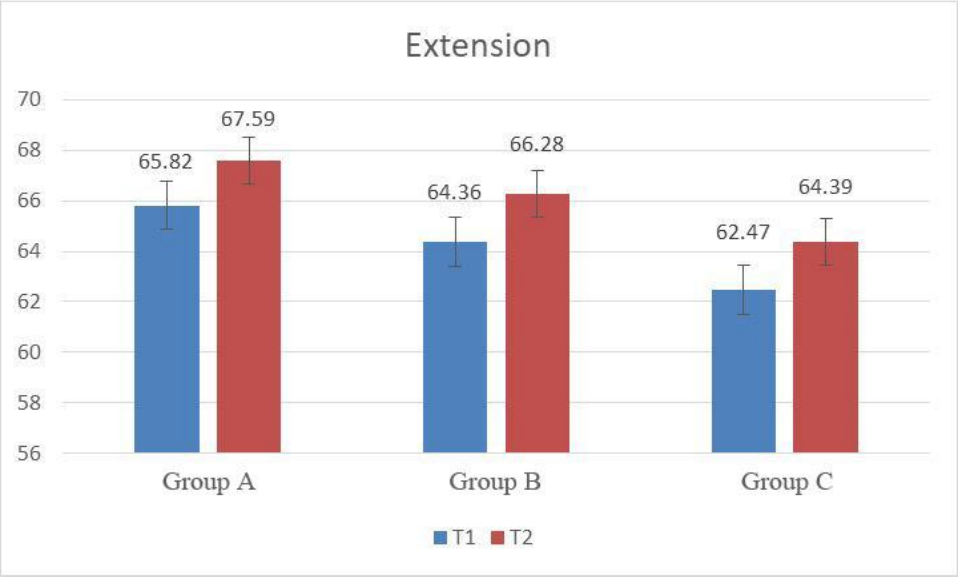

Figure 55. Mean value with standard deviation of extension data compared between group A, group B and group C.

A statistically significant difference F=5.276, p=0.006 in T1 and F=4.716, p=0.011 in T2 was found for the extension value between the three groups. Tukey's post hoc test was used, which showed that at T1 the mean value for group A was statistically significantly different from the mean value for group C (p=0.004). The mean value for group B was not statistically significantly different for group A (p=0.331) and group C (p=0.181). In the long term - on the 45th day from the start of treatment (T2) the results are similar, the mean value for group A is statistically significantly different from the mean value for group C (p=0.008), and the mean value for group B is not statistically significant significantly different for group C (p=0.188) and group A (p=0.418). The results are presented in Table 39.

Table 39. Between-group statistical analysis comparing the data of the extension in the three groups at the end of treatment (T1) and on the 45th day after initiation of therapy (T2).

Extension	Therapeutic group (I)	T Therapeutic group (J)	Mean Difference (I-J)	Std. Error	p-value
T1	Group A	Group B	1.459	1.023	0.331
		Group C	3.344*	1.030	0.004
	Group B	Group A	-1.459	1.023	0.331
		Group C	1.885	1.060	0.181
T2	Group A	Group B	1.309	1.035	0.418
		Group C	3.196*	1.043	0.008
	Group B	Group A	-1.309	1.035	0.418
		Group C	1.887	1.073	0.188

The comparison of the obtained results when examining the range of flexion in degrees represented by the mean values with the standard deviation after the end of the therapeutic course (T1) and on the 45th day from the beginning of the treatment (T2) for group A, group B and group C, is presented in Figure 56.

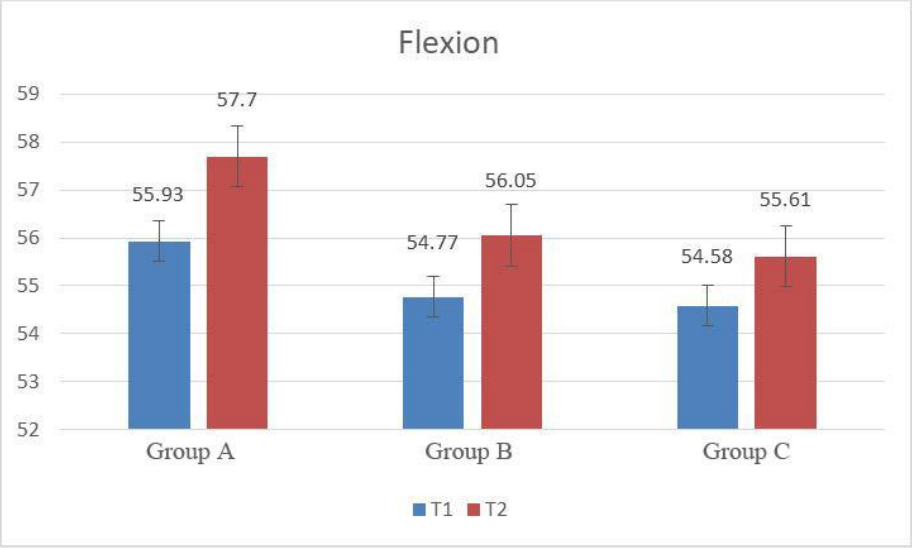

Figure 56. Mean value and standard deviation of flexion data compared between Group A, Group B and Group C.

The results showed that there were no statistically significant differences F=1.226, p=0.297 between the three groups after the end of treatment (T1) in terms of mean values. A statistically significant difference was found on the 45th day after the start of therapy (T2) F=3.214, p=0.044 for the flexion value between the three groups. Analysis of the results on the 45th day from the start of treatment (T2) showed that the mean value for group A was statistically

significantly different from the mean value for group C (p=0.049), and the mean value for group B was not statistically significantly different for group C (p=0.876) and group A (p=0.147). The results are presented in Table 40.

Table 40. Intergroup statistical analysis comparing the flexion data of the three groups at the end of treatment (T1) and at day 45 after initiation of therapy (T2).

Flexion	Therapeutic group (I)	Therapeutic group (J)	Mean Difference (I-J)	Std. Error	p-value
T1	Group A	Group B	1.163	0.941	0.435
		Group C	1.353	0.948	0.330
	Group B	Group A	-1.163	0.941	0.435
		Group C	.190	0.975	0.979
T2	Group A	Group B	1.653	0.876	0.147
		Group C	2.099*	0.883	0.049
	Group B	Group A	-1.653	0.876	0.147
		Group C	0.446	0.908	0.876

Figure 57 shows the comparison of the results obtained when examining the range of rotation to the left in degrees represented by the mean values with the standard deviation after the end of the therapeutic course (T1) and on the 45th day from the beginning of the treatment (T2) for group A, group B and group C.

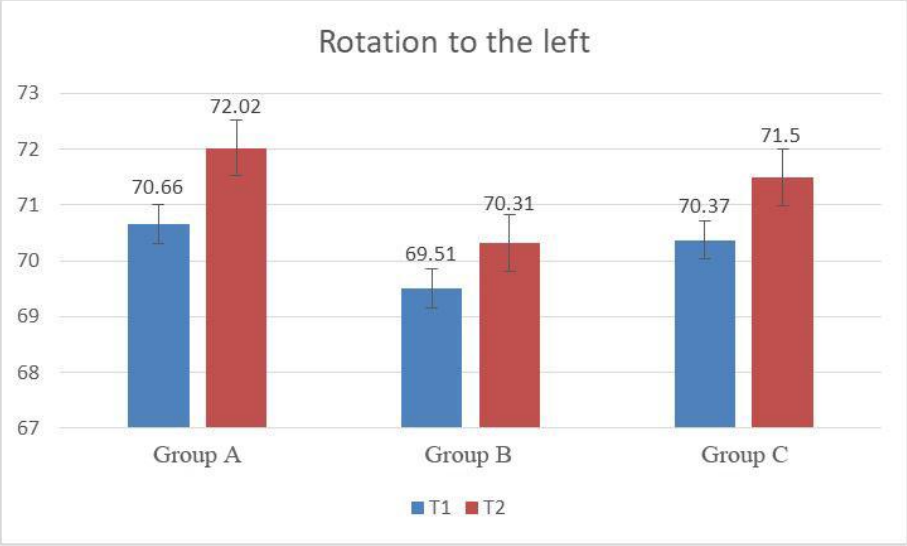

Figure 57. Mean value with standard deviation of rotation to the left data compared between Group A, Group B and Group C.

The results show that there are no statistically significant differences F=0.457, p=0.634 between the three groups after the end of treatment (T1) in terms of mean values. No statistically

significant difference was found on the 45th day after the start of therapy (T2) F=0.952, p=0.389 for the value of rotation to the left between the three groups. The results for rotation to the left range are presented in Table 41.

Table 41. Between-group statistical analysis comparing data from the rotation to the left in the three groups at the end of treatment (T1) and at day 45 after initiation of therapy (T2).

Rotation to the left	Therapeutic group (I)	Therapeutic group (J)	Mean Difference (I-J)	Std. Error	p-value
T1	Group A	Group B	1.146	1.234	0.623
		Group C	0.291	1.242	0.970
	Group B	Group A	-1.146	1.234	0.623
		Group C	-0.856	1.279	0.782
T2	Group A	Group B	1.715	1.264	0.367
		Group C	0.523	1.273	0.911
	Group B	Group A	-1.715	1.264	0.367
		Group C	-1.192	1.310	0.635

Figure 58 shows the comparison of the results obtained when examining the range of rotation to the right in degrees represented by the mean values with the standard deviation after the end of the therapeutic course (T1) and on the 45th day from the beginning of the treatment (T2) for group A, group B and group C.

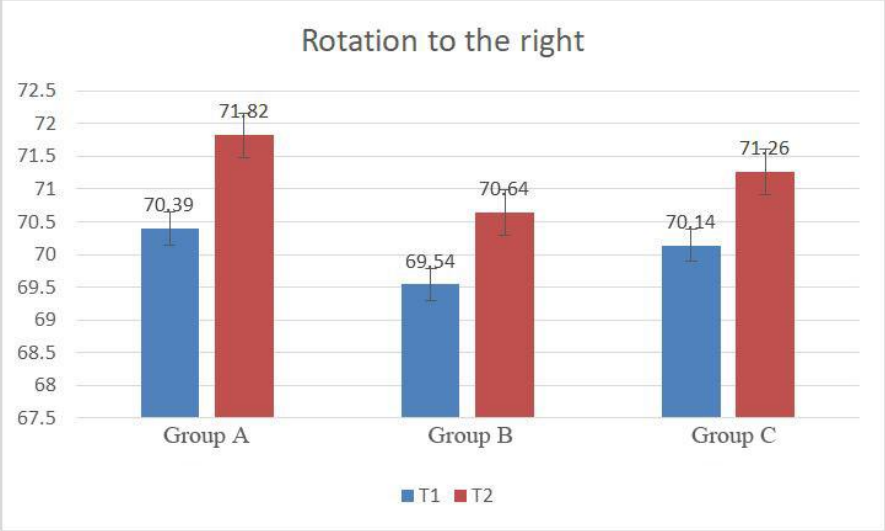

Figure 58. Mean value with standard deviation of rotation to the right data compared between group A, group B and group C.

The results show that there are no statistically significant differences F=0.357, p=0.700 between the three groups after the end of treatment (T1) in terms of mean values. No statistically

significant difference was found on the 45th day after the start of therapy (T2) F=0.443, p=0.643 for the value of rotation to the right between the three groups. The results of comparing the range of rotation to the right are presented in table 42.

Table 42. Between-group statistical analysis comparing rotation to the right data in the three groups at the end of treatment (T1) and at day 45 after initiation of therapy (T2).

Rotation to the right	Therapeutic group (I)	Therapeutic group (J)	Mean Difference (I-J)	Std. Error	p-value
T1	Group A	Group B	0.848	1.193	0.757
		Group C	-0.087	1.201	0.997
	Group B	Group A	-0.848	1.193	0.757
		Group C	-0.935	1.236	0.730
T2	Group A	Group B	1.177	1.251	0.615
		Group C	0.555	1.260	0.899
	Group B	Group A	-1.177	1.251	0.615
		Group C	-0.622	1.296	0.881

The comparison of the obtained results when examining the range of lateral flexion to the left in degrees represented by the mean values with the standard deviation after the end of the therapeutic course (T1) and on the 45th day from the beginning of the treatment (T2) for group A, group B and group C, is presented in figure 59.

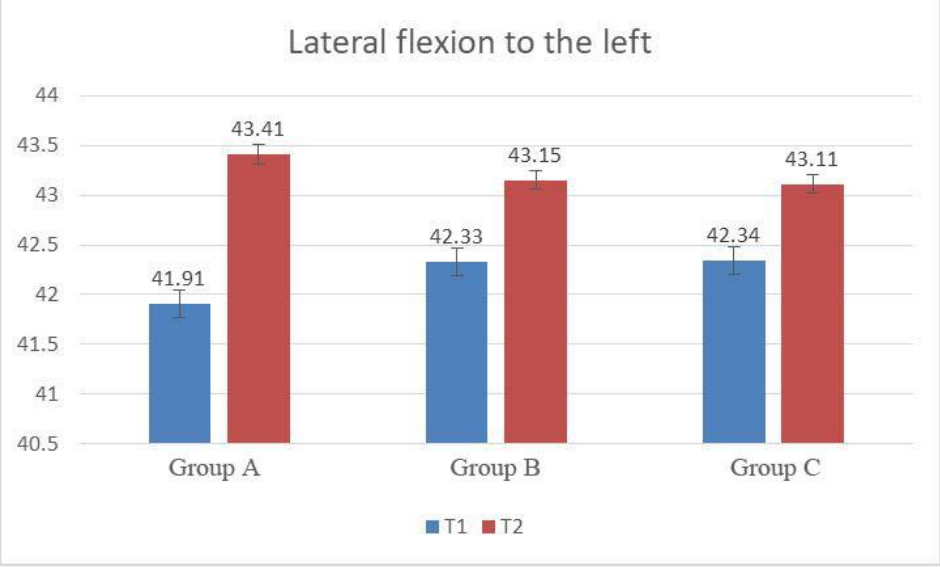

Figure 59. Mean value and standard deviation of lateral flexion to the left data compared between Group A, Group B and Group C.

The results showed that there were no statistically significant differences F=0.304, p=0.739 between the three groups after the end of treatment (T1) in terms of mean values. No statistically significant difference was found on the 45th day after the start of therapy (T2) F=0.133, p=0.876 for the value of lateral flexion to the left between the three groups. The results for the comparison of the range of lateral flexion to the left are presented in Table 43.

Table 43. Intergroup statistical analysis comparing lateral flexionto the left data in the three groups at the end of treatment (T1) and at day 45 after initiation of therapy (T2).

Lateral flexion to the left	Therapeutic group (I)	Therapeutic group (J)	Mean Difference (I-J)	Std. Error	p-value
T1	Group A	Group B	-0.424	0.640	0.785
		Group C	-0.433	0.644	0.780
	Group B	Group A	0.424	0.640	0.785
		Group C	-0.009	0.663	1.000
T2	Group A	Group B	0.255	0.637	0.915
		Group C	0.304	0.642	0.884
	Group B	Group A	-0.255	0.637	0.915
		Group C	0.049	0.661	0.997

The comparison of the obtained results when examining the range of lateral flexion to the right in degrees represented by the mean values with the standard deviation after the end of the therapeutic course (T1) and on the 45th day from the beginning of the treatment (T2) for group A, group B and group C, is shown in figure 60.

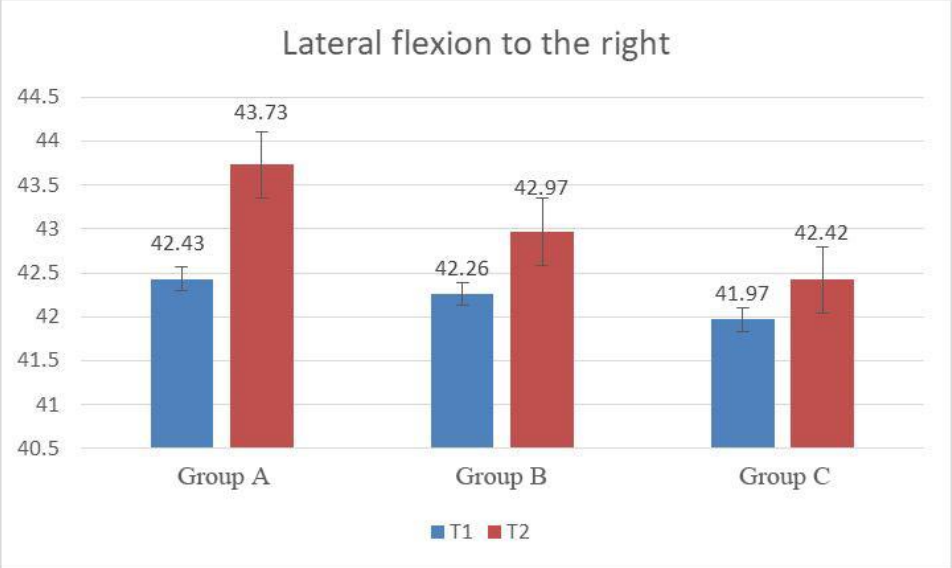

Figure 60. Mean value and standard deviation of lateral flexion to the right data compared between group A, group B and group C.

The results showed that there were no statistically significant differences F=0.211, p=0.810 between the three groups after the end of treatment (T1) in terms of mean values. No statistically significant difference was found on the 45th day after the start of therapy (T2) F=2.040, p=0.135 for lateral flexion to the right between the three groups. The comparison of the results for the range of lateral flexion to the right are presented in Table 44.

Table 44. Between-group statistical analysis comparing data for lateral flexion to the right in the three groups at the end of treatment (T1) and on day 45 after initiation of therapy (T2).

Lateral flexion to the right	Therapeutic group (I)	Therapeutic group (J)	Mean Difference (I-J)	Std. Error	p-value
T1	Group A	Group B	0.175	0.703	0.966
		Group C	0.458	0.708	0.794
	Group B	Group A	-0.175	0.703	0.966
		Group C	0.283	0.728	0.920
T2	Group A	Group B	0.753	0.648	0.478
		Group C	1.306	0.652	0.116
	Group B	Group A	-0.753	0.648	0.478
		Group C	0.553	0.671	0.689

The comparison of the obtained results by the mean values with the standard deviation for the Zung test after the end of the therapeutic course (T1) and on the 45th day from the beginning of the treatment (T2) for group A, group B and group C is presented in figure 61.

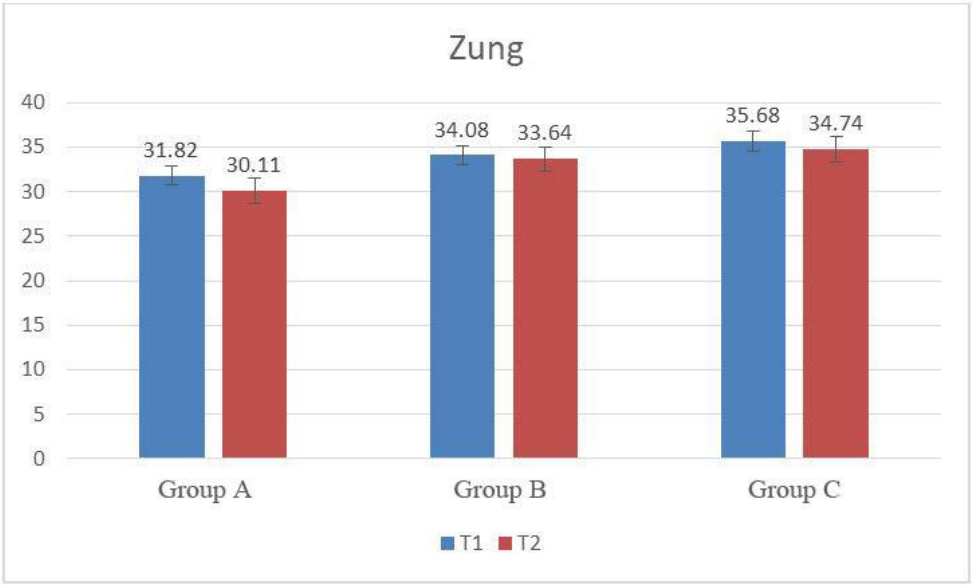

Figure 61. Mean values with standard deviation of Zung test data compared between group A, group B and group C.

A statistically significant difference F=5.026, p=0.008 in T1 and F=9.440, p<0.000 in T2 was found for the value obtained from the NDI questionnaire between the three groups. Analysis of the results showed that after completion of therapy (T1), the mean value for group A was statistically significantly different from the mean value for group C (p=0.006). The mean value for group B is not statistically significantly different from group C (p=0.453) and group A (p=0.159). In the long term - on the 45th day from the start of treatment (T2), the results undergo changes, with the average value for group A being statistically significantly different from the average value for group B (p=0.006) and group C (p<0.000). The mean value for group B was not statistically significantly different from group C (p=0.612). The results are presented in Table 45.

Table 45. Intergroup statistical analysis comparing the Zung test data in the three groups at the end of treatment (T1) and on day 45 after initiation of therapy (T2).

Zung	Therapeutic group (I)	Therapeutic group (J)	Mean Difference (I-J)	Std. Error	p-value
T1	Group A	Group B	-2.259	1.222	0.159
		Group C	-3.866*	1.231	0.006
	Group B	Group A	2.259	1.222	0.159
		Group C	-1.607	1.267	0.416
T2	Group A	Group B	-3.527*	1.116	0.006
		Group C	-4.623*	1.124	0.000
	Group B	Group A	3.527*	1.116	0.006
		Group C	-1.096	1.157	0.612

The comparison of the obtained results by the mean values with the standard deviation for the NDI questionnaire after the end of the therapeutic course (T1) and on the 45th day from the beginning of the treatment (T2) for group A, group B and group C is presented in figure 62.

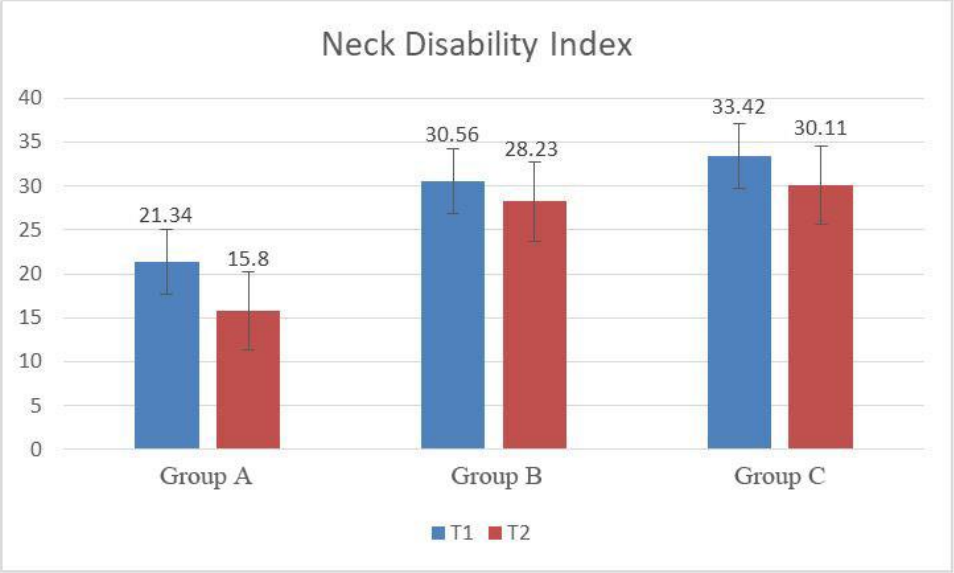

Figure 62. Mean value with standard deviation of NDI questionnaire data compared between group A, group B and group C.

A statistically significant difference F=15.332, p<0.000 in T1 and F=22.061, p<0.000 in T2 was found for the NDI questionnaire score between the three groups. Analysis of the results showed that after completion of therapy (T1), the mean value for group A was statistically significantly different from the mean value for group B (p<0.000) and group C (p<0.000). The mean value for group B is not statistically significantly different from group C (p=0.453). In the long term - on the 45th day from the start of treatment (T2) the results are similar, the mean value for group A is statistically significantly different from the mean value for group B (p<0.000) and group C (p<0.000), and the mean value for group B was not statistically significantly different from group C (p=0.724). The results are presented in Table 46.

Table 46. Between-group statistical analysis comparing the data from the NDI questionnaire in the three groups at the end of treatment (T1) and on day 45 after initiation of therapy (T2).

NDI	Therapeutic group (I)	Therapeutic group (J)	Mean Difference (I-J)	Std. Error	p-value
T1	Group A	Group B	-9.223*	2.289	0.000
		Group C	-12.080*	2.305	0.000
	Group B	Group A	9.223*	2.289	0.000
		Group C	-2.857	2.373	0.453
T2	Group A	Group B	-12.435*	2.357	0.000
		Group C	-14.310*	2.373	0.000
	Group B	Group A	12.435*	2.357	0.000
		Group C	-1.874	2.442	0.724

DISCUSSION

The demographic characteristics of the persons studied by us are similar to the data cited in the scientific literature (Hoy et al., 2010). The largest number of patients are in the 36-45 age group, which represented 40% of the entire sample, followed by those in the 46-55 age group. The average age of all examined persons was 39.85 ± 7.43 years.

In the current thesis, we found that cervical spondylosis affects both sexes unevenly, with the proportion of women being greater - 63% compared to 37% for men. Studies conducted to this date on the prevalence of this type of pathology in the cervical spine report similar results regarding the distribution of affected individuals according to age and gender (Theodore, 2020; Waheed et al., 2020).

The majority of persons participating in the study perform work activities related to static overload of the cervical spine. This type of work activity is a proven risk factor for the development of the disease (Alare et al., 2021). In our research, the largest share of people (67%) practice professions related to static overloading of the neck from a sitting or standing position - office workers, computer specialists, doctors and others. In a study by Côté et al. found similar data, which coincide with our results regarding work-related neck pain (Côté et al., 2000). Low physical activity is another risk factor associated with intervertebral disc degeneration. It was found that the majority of patients have physical activities that are lower than the norm for the respective age - 55%. People with reduced physical activity, who rarely practice sports, predominate. The lack of sufficient sports activity is a prerequisite for the occurrence of a number of diseases, one of which is related to pathology in the cervical spine (Binder, 2007). Management of risk factors that can be changed and controlled, by applying preventive measures aimed at creating an ergonomic work environment. Posture correction during work and rest, introduction of the so-called industrial gymnastics for professions related to a static working posture, to be carried out at a certain time interval during the working day and a number of other measures, would have a positive effect in terms of reducing the early onset of the disease.

The demographic characteristics of individuals in the current thesis show no difference in terms of profession, physical activity and the main monitored indicators of pain, muscle tone, functional and psychoemotional state between the studied patients in the three groups. This proves their homogeneity in relation to each other, which is a prerequisite for the reliability of the results of the comparative analysis.

Evaluation of the clinical effectiveness of the applied treatment in the three groups according to the results of the monitored indicators

The main function of the neck is to support the head and allow it to move painlessly through a full range of motion. The cervical region has the greatest mobility of the entire spine. Thanks to this, a person receives information about his surroundings and orients himself in space. Because of this, the neck takes a lot of static and dynamic overload (Gechev, 2002). In order to specify the disorders in the motor function of the neck caused by the presence of unpleasant painful sensations, it is necessary to examine the pain at rest and during movement. Neck pain is

the most common symptom of degenerative changes in the cervical spine (Scott & Kerr, 2006; Takagi et al., 2011). By tracking its change, we can determine the therapeutic effect of the applied treatment. The results obtained in the present thesis regarding the mean values for static and dynamic pain, assessed by VAS in the neck, correspond to the data available in the medical literature regarding cervical pain in the presence of degenerative changes of the structures in this area (Abdel-Aziem et al., 2022 ; Ravindra et al., 2016).

Analysis of static and dynamic pain data measured by VAS for the cervical spine showed that there was a statistically significant reduction in pain for the time period before the start of treatment compared to the end of the therapeutic course (T0-T1) for groups A and B. This trend for improvement is also preserved when considering the results at the end of treatment compared to the 45th day after the start of therapy (T1–T2), as well as when considering the results for the time period before the start of treatment compared to the 45th day after the start of therapeutic course (T0-T2). The analysis of static pain data measured by VAS for group C showed that there was a statistically significant reduction in pain in the three time intervals (T0-T1, T1-T2 and T0-T2), while the analysis of dynamic pain data showed a statistically significant reduction of pain only in the comparison between before the start of the therapy and the 45th after the start of the treatment (T0-T2). No statistically significant difference was found in the mean values in group C for the time period before the start of the treatment versus the end of the therapeutic course (T0-T1), and this tendency was preserved when considering the results at the end of the treatment versus the 45th day after initiation of therapy (T1–T2).

Intergroup analysis of VAS static pain scores demonstrated a statistically significant difference ($p < 0.05$) in mean values in favor of the therapeutic approach used for treatment in group A versus that in group B and group C after completion of the therapeutic course (T1), as this positive trend is also maintained in the long term until the 45th day from the start of the study (T2). VAS dynamic pain scores from between-group analysis demonstrated a statistically significant difference ($p < 0.05$) in mean values again in favor of group A versus group C in the long-term at 45 days from baseline (T2). A statistically significant difference between groups was not found at the end of therapy (T1).

In therapeutic groups A and B, we apply an additional therapeutic procedure Deep Oscillation for group A and ultrasound therapy for group B. Our clinical experience of the application of ultrasound therapy in cervical spondylosis, as well as the data from the literature prove the effect of analgesia by this method, especially when combined with other physical factors (Qing et al., 2021). The analgesic effect of US is achieved by several mechanisms. The heat produced lowers the pain threshold of the small nerve endings, together with the activation of the gate-mechanism in the large myelinated fibers. The stimulation of blood flow helps to disperse the chemical irritants causing pain, increases the amount of oxygen in the tissues and reduces muscle spasm (Takeva, 2022). US has therapeutic effectiveness proven over time by practice and literature. For this reason, we decided to compare the effect of Deep Oscillation with US. We performed the comparison to establish the potential of the studied method to affect patients with cervical spondylosis. Deep Oscillatoin therapy has an anti-inflammatory effect based on the inhibition of lipid oxidation and production of oxygen-containing radicals, which

leads to pain reduction (Gasbarro et al., 2006). Analgesia is also achieved through direct impact on the causes of pain, by removing metabolic waste, blood circulation and trophic improvement, oedema reduction, which leads to the absence of the irritating effect on the receptor apparatus (Fistetto et al., 2011). The resulting analgesic effect is also achieved through activation of the gate control mechanism from the oscillatory movements of the tissues during the procedure (Onose et al., 2009; Trybulski, 2008). The results we received clearly prove the effectiveness of the Deep Oscillation method, which is comparable to the effectiveness of ultrasound therapy, and we can even say that it surpasses it. The results of group A and group B are superior to the results obtained in group C, where we perform a placebo DO procedure, and this is logical, since here the specific upgrading effect of the third procedure is missing, which in one group is DO and in the other is US (Qing et al., 2021; Winkelmann et al., 2018). We believe that the main reason for the better results obtained in group A and group B is the cumulative effect of the applied three procedures.

The assessment of muscle tone is an important clinical feature in our study that provides information on the degree of functional neck impairment. In the presence of pain symptoms, ischemia or tissue damage, the body's protective mechanism is activated, which is manifested by an increase in muscle tone in the affected area. The increased tone of the muscles causes compression of the nerve structures, together with this, the blood supply to the surrounding tissues is disturbed, which leads to an additional increase in pain sensations, and thus the vicious circle is closed: pain-spasm-pain (D. S. Johnson, 2012). The results of our study regarding muscle tone show similarity with other studies tracking the changes in the tone of the paravertebral muscles in the neck, in degenerative diseases, before and after treatment (C. Cai, 2019; Malanga et al., 2009). Analysis of the results considering the change in the muscle tone of the paravertebral musculature in the cervical spine showed a statistically significant improvement when comparing the initial state to the end of the therapeutic course (T0–T1) for the patients of the three groups. This positive trend is also preserved when considering the results at the end of treatment compared to the 45th day after the start of therapy (T1–T2), but only for group A. In the same time interval (T1–T2) for group B and group C no significant difference was observed. When comparing the initial state with the 45th day (T0–T2), a positive trend is noted in all three groups. In the between-group analysis of muscle tone results, no statistically significant difference ($p > 0.05$) was found in the mean values between the three groups after completion of the therapeutic course (T1). In the long term, on the 45th day from the beginning of the study (T2), a statistically significant superiority ($p < 0.05$) of group A over group C was demonstrated. When comparing group B with group C and group A with group B, no statistical difference was found. These results are expected because in all three therapeutic approaches therapy including TENS and kinesitherapy is applied. Deep Oscillation therapy was added to group A, which has a specific effect on muscle tone and builds on the therapeutic effect of the other two procedures (Hinman et al., 2013; Winkelmann et al., 2018). Through it, tissue fibrosis is prevented, along with this, the density in the subcutaneous tissue is reduced (Aliyev, 2009). The application of the combination of the three factors leads to a summation of their therapeutic effects and to the better result obtained in group A. The positive effect in group B and group C is due to the effects of

TENS and kinesitherapeutic methods leading to muscle relaxation (Aydin et al. 2005; W.W. Peng et al. 2019), adding the effect of ultrasound waves, which also contribute to myorelaxation, in group B.

The study of biomechanics in the cervical spine is important to determine the degree of damage and disorders in the motor function of the neck (Rao et al., 2007). The data available in the medical literature show that the involvement of the cervical spine by musculoskeletal diseases is accompanied by disturbances in its biomechanics (Machino et al., 2016). Our pre-treatment data show similarity to data reported in the literature (Mukherjee et al., 2020; Pragassame et al., 2019). When comparing the changes that occurred in the neck extension and flexion values in the patients from the three groups, a statistically significant difference ($p < 0.05$) was found in the mean values calculated according to the three time periods. Analysis of the results showed an increase in extension and flexion at the end of treatment (T0–T1), as well as maintenance of this positive trend when reporting the results on day 45 (T0–T2). For the intermediate period of time between the end of treatment and the 45th day (T1-T2) we also find positive tendency.

From the obtained results of evaluation of motions to the left and right for the three groups, a similar trend was found, with a significant difference ($p < 0.05$) in the mean values calculated for the time period before the start of treatment versus the end of the therapeutic course (T0-T1) for all groups, and this positive tendency is preserved when considering the results at the end of treatment compared to the 45th day after the start of therapy (T1–T2), as well as for the time period before the start of treatment compared to the 45th day after the start of therapeutic course (T0-T2).

A comparison of our results for lateral flexion to the left in group A patients revealed the presence of a statistically significant difference ($p < 0.05$) in the mean values, calculated according to the third time period T0-T2. Regarding the lateral flexion to the right for group A, a statistically significant improvement was found in the mean values for the three time periods (T0-T1, T1-T2, T0-T3), corresponding to a significant increase in the range of motion. For group B patients, a statistically significant difference ($p < 0.05$) was found in the mean values for lateral flexion to the left and right for the three time periods (T0-T1, T1-T2 and T0-T2). In the analysis of the mean values of the results obtained in the treated persons in group C for lateral flexion to the left, a significant difference ($p < 0.05$) was established for the three time periods (T0-T1, T1-T2 and T0-T2). When comparing the obtained results for lateral flexion to the right for group C, the presence of a statistically significant difference ($p < 0.05$) was found when considering the mean values at the beginning of the treatment versus the end of the therapeutic course (T0-T1), as well as versus 45- the day after the start of therapy (T0-T2). There was no statistically significant improvement in the results in the time interval after the end of the treatment course compared to the 45th day from the beginning of the therapy (T1-T2).

The intergroup analysis of the results of the cervical extension goniometry showed a statistically significant difference ($p < 0.05$) between the data obtained for group A and group C after the end of the therapeutic course (T1) and on the 45th day from the start of treatment (T2), in favor of group A. No statistically significant difference ($p > 0.05$) was found in the remaining intergroup comparisons for extension between group A and group B, as well as between group B

and group C after the end of the therapeutic course (T1), as well as on the 45th day from the start of therapy. The data obtained from the measured flexion showed no statistically significant difference between the three groups after the end of the therapeutic course (T1). A statistically significant difference was found only between group A and group C on the 45th day from the start of therapy (T2) in terms of measured flexion, but this difference was absent between group A and group B, as well as between group B and group C. The obtained results regarding rotations to the left and right, as well as those for lateral flexion to the left and right, did not show statistically significant differences ($p > 0.05$) between the three groups after the end of the therapeutic course (T1), as well as on the 45th day of the beginning of therapy (T2).

This proves that the effect in terms of increased mobility in the neck thanks to the applied treatment programs is not only preserved, but also increases over time after the end of the therapeutic course. These results, we connect with the overlapping effect of physical factors and their long-lasting influence. The results are achieved due to the analgesia, drainage and muscle relaxation effects of the applied therapy, resulting in an increase in the range of motion. The impact on range of motion when applying this type of physical therapy has been documented by numerous literature sources (Huber et al., 2013; Llamas-Ramos et al., 2023). In a study conducted by Mratskova in 2021 regarding the effect of applied kinesitherapy and TENS in patients with cervical spondylosis, an increase in the range of motion in the neck was found, and the results of the treatment were similar to those obtained in the present thesis (Mratskova et al., 2021). The superiority of group A over group C, in the between-group comparison of the range of flexion and extension, is due to the complementary DO procedure, which builds on the effect of the other two procedures and thus achieves more significant therapeutic results. An example proving the influence of the applied Deep Oscillation on the range of motion is also found in a study conducted by Onose, who reported an increase in the range of motion in the treated joints in the patients studied by him (Onose et al., 2009). The achieved positive influence of group B is due to the ultrasound treatment procedure included in this therapeutic complex. Multiple studies have found an increase in range of motion of the nck when applying ultrasound therapy in patients with impaired biomechanics in the cervical spine (Saleh et al., 2021; Soysal & Aslan, 2013). We attribute the weak therapeutic effect of the patients in group C to the conducted placebo procedure with DO, which lacks the enhancing effects of DO and US. Thanks to those added therapies, the overall therapeutic effect in these groups is better, which also results in a better recovery of the neck moiton.

Pain is an unpleasant sensation that is associated with emotional and behavioral changes. The occurrence of neck pain disrupts the quality of sleep and the performance of various activities of daily life for the affected persons. These changes have a negative effect on a person's functional state and reflect on their self-esteem (F. G. Pereira et al., 2017). In the analysis of the studied literature and the research conducted by us, we found that along with functional disorders, changes in the psycho-emotional status are also observed. This finding of ours correlates with the findings presented in a study conducted by Juan, which confirms the existence of such a relation (Juan et al., 2020). Therefore, we conducted a Zung test to evaluate changes in the psycho-emotional state of patients due to the influence of pain caused by cervical spondylosis

(W. W. Zung, 1974). The goal is to determine the effectiveness of the treatment and better interpretation of the results obtained. Baseline test data for the three groups showed similarity due to their randomization. The results obtained at the end of the therapeutic course show a positive trend in the psycho-emotional state of the persons in the three therapeutic groups. The best results are for group A, where a statistically significant difference is found in the average values for the three time periods (T0-T1, T1-T2 and T0-T2). For groups B and C, a statistically significant improvement was found in the time period before starting therapy compared to the end of treatment (T0-T1), as well as compared to the 45th day after starting therapy (T0-T2). For groups B and C, no statistically significant improvement in results was found when comparing the results at the end of treatment compared to the 45th day from the start of therapy (T1-T2). Intergroup analysis of Zung's test results showed a statistically significant difference ($p < 0.05$) in the mean values obtained for group A versus those for group C after completion of the therapeutic course (T1). A statistically significant difference in favor of group A over group B and group C was found when comparing the data obtained in the long term at the 45th day from the beginning of the study (T2). The data demonstrate the superiority of the therapeutic plan used in group A compared to the treatment applied in group B and group C. These results are logical due to the documented effects of the applied DO therapy, which complements the other two procedures used in group A and leads to a better effect on the pain syndrome, along with this an increase in the range of motion (O'Brien & Watson, 2016; von Stengel et al., 2018). The improvement in the movements performed and the reduction of pain lead to an increased quality of life and favor the psycho-emotional recovery of the affected persons. DO therapy stimulates the nervous system and increases the pain threshold (Fistetto et al., 2011). The psychological improvement of patients when treated with Deep Oscillation has been proven in a number of studies investigating the change in the psycho-emotional state, which reported a reduction in depressive symptoms after LFAESF therapy (Mikhalchik et al., 2005; Zehtindjieva et al., 2013). The positive influence on the psycho-emotional status as a result of the application of LFAESF applied in group A is also supported by the presented data from a study conducted by I. Koleva regarding the influence of the Deep Oscillation procedure on the psychological status of patients with pain syndrome (Koleva et al., 2017). A positive impact of the psycho-emotional state, although to a lesser extent, is also noted in the other two groups, with the results achieved in group B surpassing those of group C, despite the lack of statistical significance between the obtained data. The better impact of group B is due to the applied additional procedure - therapeutic ultrasound, which contributes to the reduction of pain and depressive symptoms. Durmuş reports about the possibility of ultrasound therapy to positively affect the depression in patients. The application of US in patients with back pain accompanied by depression reported a significant reduction in reported complaints (Durmuş et al., 2010). A reduction in the degree of depression after the application of US treatment was also found in a study conducted in 2015 comparing the effect of therapeutic US with a placebo US procedure, with which the scientists proved the positive influence of the applied procedure on the psycho-emotional state of the patients (Ilter et al., 2015).

An important sign by which we evaluate the effect of the applied treatment in patients with cervical spondylosis is the change in the quality of life. Applying the Neck disability index questionnaire for self-assessment gives us information to what extent pain and limited range of motion in the neck affect the patient's daily activities and quality of life (Vernon & Mior, 1991). Based on this information, we can evaluate the treatment effect of the three therapeutic approaches. From the results presented in the present study, a statistically significant improvement in the data obtained from the Neck disability index questionnaire was reported in all three groups, when the comparison was made between the initial values and the values at the end of the therapy (T0-T1). This tendency is preserved when considering the results in the time period between the end of therapy and the 45th day from the start of treatment (T1-T2), as well as when comparing the baseline values compared to the 45th day (T0-T2).

The results of the intergroup analysis of the NDI questionnaire showed a statistically significant difference ($p < 0.05$) in the mean values obtained for group A compared to those in group B and group C after completion of the therapeutic course (T1). A statistically significant difference in favor of group A compared to group B and group C was also found when comparing the mean values in the long term at the 45th day from the beginning of the study (T2). The data demonstrate superiority of the treatment plan used in group A compared to the treatment applied in group B and group C.

The reported results of treatment in our study, regarding the impact on activities of daily living in patients with degenerative changes in the cervical spine, show common trends with independent studies by other researchers who applied therapeutic approaches including kinesitherapy and TENS (Clifford et al., 2014; Miao et al., 2018). A study by Zhao on kinesitherapy treatment of patients with cervical spondylosis using the NDI follow-up questionnaire found a statistically significant reduction in complaints, comparable to the results obtained in our study (Zhao et al., 2014).

The addition of US therapy to the main complex of physical factors in group B has a positive impact on the quality of life of the studied patients, according to our data. Similar results were found in Aslan's study, which tracked the change in data reported through the NDI in patients with chronic neck pain and found a positive effect on symptoms after the application of ultrasound therapy (Soysal & Aslan, 2013). When comparing the mean values for the quality of life, superiority of group B (at the end of treatment T1 – 30.56 and on day 45 of therapy T2 – 28.23) was found over group C (at the end of treatment T1 - 33.42 and on 45 day of therapy T2 – 30.11), despite the absence of a statistically significant difference. The obtained statistically significant result of the mean values of the quality of life for group A, reported through the NDI questionnaire, prove that the therapeutic effectiveness of our proposed methodology for group A (average NDI values for the second T1 – 21.56 and the third time period T2 – 15.80) significantly exceeds the result obtained not only in the "placebo" group C, but also significantly surpasses the results of group B, where the US procedure is included. In all three monitored groups, a positive trend was observed in the investigated indicators on the 45th day of the therapy, which we associate with the prolonged effect of the physical threaoy procedures and the occurrence of a lasting improvement for a certain period after the end of the therapy. However,

the results obtained in group A have a higher statistical significance compared to those of groups B and C.

Our results confirm the hypothesis that the patients in the therapeutic group A, in which treatment is carried out by LFAESF, have better clinical and functional recovery than those in group B and group C. The hypothesis was confirmed that the therapeutic effects of the applied treatment in group A have a higher statistical significance compared to those of group C. The analysis of the results also confirms the hypothesis that therapeutic group A, which conducts treatment with a low-frequency alternating electrostatic field /Deep Oscillation/, to the main physiotherapeutic complex, has clinical and functional recovery, which is better than in group B undergoing treatment with an additional procedure therapeutic ultrasound to the main physiotherapy complex.

The results of the conducted study show that the complex therapy including Deep Oscillation for patients with cervical spondylosis leads to a reduction of clinical manifestations, to improvement of motor capabilities, positively affects the psycho-emotional state and quality of life of the examined persons. An important point is that no worsening of the patient's condition was observed after the procedures. The positive results obtained show that the therapy could be effectively used in the complex treatment and rehabilitation of cervical spondylosis.

CONCLUSIONS

1. The high therapeutic efficiency of the combined application of Deep Oscillation, TENS and kinesitherapy in patients with cervical spondylosis was proven, by evaluating the dynamics of mobility, psycho-emotional status and quality of life..
2. Therapy including Deep Oscillation, TENS and kinesitherapy in patients with cervical osteochondrosis has a significantly better therapeutic efficiency compared to the combination of placebo Deep Oscillation, TENS and kinesitherapy, and the results obtained are of high statistical significance and prove the enhancing therapeutic effect of LFAESF.
3. It has been proven that the therapeutic effectiveness of the complex of physical factors - Deep Oscillation, TENS and kinesitherapy is comparable to and even superior to the routine combination of TENS, ultrasound and kinesitherapy, both in terms of short-term and long-term therapeutic effects.
4. The statistical significance of the dynamics in the tracked parameters of static and dynamic pain according to VAS proves that the complex methodology with Deep Oscillation included is more effective and leads to a faster and long-lasting results.
5. The analysis of the data regarding the influence of the applied treatment in the three therapeutic groups on the indicators of the functional status - goniometry for extension, flexion, rotation and lateral flexion, proved the superiority of the DO method, both in the short and long term.
6. The analysis of the data on the influence of the applied treatment on the psycho-emotional state, followed by the Tsung test, demonstrated the superiority of the complex program

including Deep Oscillation, to achieve a more significant clinical improvement, as a result of which the psycho-emotional improvement of the studied patients was also achieved.

7. It was established that the complex methodology including Deep Oscillation, due to its higher efficiency, contributes to a more significant increase in the quality of life, tracked by the modified Neck Disability Index questionnaire in the examined patients.

8. The comparative analysis between the three used treatment methods proved the superiority of the complex methodology with Deep Oscillation included, in terms of short-term and long-term therapeutic effects.

9. The application of a low-frequency variable electrostatic field (Deep Oscillation) in the complex treatment of cervical spondylosis can be considered an effective and safe method by which maximum clinical improvement is achieved.

CONTRIBUTIONS OF THE THESIS WORK

1. For the first time in Bulgaria, a study of the effect of the combined application of a low-frequency variable electrostatic field /Deep Oscillation/ and physical factors from routine practice in cervical spondylosis is being conducted.
2. Therapeutic effectiveness of the combined application of Deep Oscillation, TENS and kinesitherapy in patients with cervical spondylosis has been proven.
3. The Neck Disability Index is applied - a standardized tool for assessing and monitoring the functional status of patients with cervical spondylosis.
4. Tsung's test was applied to evaluate the psycho-emotional state and the effectiveness of the treatment of patients with cervical spondylosis.
5. A complex physiotherapy program including Deep Oscillation has been developed with proven effectiveness in the treatment of cervical spondylosis.
6. The therapeutic effectiveness of the combined therapy including TENS, ultrasound and kinesitherapy has been confirmed.

THESIS RELATED PUBLICATIONS:

Petrov Y, Mihailova M, Nedyalkova D. Possibilities of physical factors for prevention and treatment of cervical spondylosis. Varna Medical Forum, Item 11, 2022, Appendix 2.

Petrov Y, Mihailova M, Neck pain - risk factors and prevention, IV International Conference "Health care - contribution to the quality of life", 2023.

Petrov Y, Mihailova M, Application of deep oscillation therapy in patients with cervical spondylosis: a pilot study, Knowledge - Capital of the Future, Vol. 62 no. 4, 2024.

PARTICIPATION IN SCIENTIFIC FORUMS:

Tenth scientific session for teachers and students of the Medical College - Varna with international participation, October 20-21, 2022.

4th International Conference on the topic "Health care - contribution to the quality of life" at the Faculty of Public Health at the MU - Varna, June 9-10, 2023.