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THERAPEUTIC EFFECTIVENESS OF PHYSICAL FACTORS IN EARLY REHABILITATION IN PATIENTS WITH DISTORTION OF THE TALOCRURAL JOINT

ABSTRACT

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TABLE OF CONTENTS

LIST OF USED ABBREVIATIONS IN THE TEXT

VAS	visual analog scale
AJ	Ankle joint
DO	Deep oscillations
DF	dorsiflexion
PF	plantar flexion
CM	centimetry
ADT	anterior drawer test
ATFL	lig. talofibulare anterius
CL	chemiluminescence
CFL	lig. Calcaneofibulare
FADI	The foot and Ankle Disabilitty index
GSH	reduced glutathione
NFL	National Footbal League
PRICE	protection, rest, ice, compression, elevation
PTFL	lig. talofibulare posterius
ROS	reactive oxygen species
TT	talar tilt test

I. ACTUALITY OF THE PROBLEM

Physical activity is a necessary condition for better physical and mental health. This condition contributes to a higher quality of life by significantly reducing the risk of developing chronic non-communicable diseases.

Sport in the modern world is an invariable part of the modern man's daily life, both in the form of a hobby and as a professional occupation. Despite the numerous health benefits resulting from regular physical activity, there is a serious risk of acute musculoskeletal injuries during sports activity.

Injuries can also occur in a person's normal daily life, but they are less frequent than those occurring during sports.

Restoring and preserving the motor activity of the affected persons has a significant medical, social and economic importance.

Severe injuries can lead to fractures, functional impairment, limited mobility and peripheral nerve damage.

Musculoskeletal injuries, especially of the lower limb, limit the activities of daily life and the performance of physical or sports activities. At a later stage of life, they can be a prerequisite for various joint disorders.

One of the common problems in emergency medical care is damage to the lateral ligament complex of the ankle joint - from overstretching to complete rupture of the fibers of the joint ligaments.

A team of American scientists identified ankle sprain as the most common condition in emergency medical practice with 4.4 million reported visits per year (Caldwell et al., 2013). Almost half of all ankle ligament injuries result from sports activity (49.3%) (Waterman BR et al., 2010). In Europe, the incidence of ankle sprains ranges from 5.3 to 7.0 per 1000 people per year (H0lmer P et al 1994). The same condition accounts for up to 10% of all emergency medical center visits in the UK (Bridgman SA et al., 2003) and for one in 10,000 visits (8,000) in Germany (Halabchi F et al., 2020).

Ankle ligament injuries are mistakenly thought to be harmless injuries with no lasting consequences (McKay GD et al., 2001), but in fact they lead to reduced work capacity, physical activity and quality of life, and sufferers report repeated incidents months and years after the initial injury (Anandacoomarasamy A et al., 2005).

Approximately 30% of patients with sprains develop chronic ankle instability. Evidence is found in numerous literary sources. In one of these sources (Lin CI et al.) in 2021 conducted a meta-analysis study in which the systematic review included a total of 3804 participants aged between 15 and 32 years with a history of previous ankle sprain (soldiers, students, athletes and active people). Long-term disability in the form of chronic ankle instability was found among 46% - data varying between 9 and 76% (Lin CI With the aim of rapid and effective recovery in the acute phase and to minimize the chronicity of the condition in a later stage, the search for new and effectively working models for early and late rehabilitation is a challenge for modern medicine. As an important part of the complex conservative treatment of this pathology, with its continuous development and the introduction of new, more advanced apparatus methods, physical therapy provides such an opportunity (Garrick JG et al., 1987).

With the aim of rapid and effective recovery in the acute phase and to minimize the chronicity of the condition in a later stage, the search for new and effectively working models for early and late rehabilitation is a challenge for modern medicine. As an important part of the complex conservative treatment of this pathology, with its continuous development and the introduction of new, more advanced apparatus methods, physical therapy provides such an opportunity.

II. OBJECTIVE, TASKS AND HYPOTHESES OF THE STUDY

2.1. Objective

To make a comparative assessment of the effect of an electrostatic field by the deep oscillation method, the "PRICE" protocol and their combined application in early rehabilitation in patients with talocrural joint distortion.

2.2. Tasks

1. To track the presence or absence of immediate and long-lasting effects of the application of the combined therapy with Deep Oscillation and protocol "PRICE“;
2. To establish to what extent the conducted combined course therapy eliminates the need to repeat rehabilitation therapy;
3. To study the therapeutic effectiveness of the method of long-side oscillation to affect the main symptoms at distortions of the ankle joint: pain, edema, limited volume of movement, daily functional activity;
4. To make a comparative analysis of the therapeutic effects from the application of deep oscillation therapy and conventional therapy ("PRICE" protocol) as stand-alone teletherapeutic approach and as a combined treatment.
5. To study the functional activity and quality of life in the early phase (inflammatory) in patients with ankle sprains;
6. To investigate the possibility of occurrence of side effects and adverse reactions in the therapeutic course of deep oscillation.

2.3. Hypotheses

1. We assume that the combined therapy of DO and protocol "PRICE" have better results than groups with self-practical application of the methods in relation to the researched parameters;
2. We assume that the results of both groups for the self-administration of deep oscillation therapy and protocol "PRICE" will not differ significantly from each other in relation of the investigated parameters;
3. We assume that the effect of complex therapy is more long-lasting and reduces the need for repeated rehabilitation.

CHAPTER III. MATERIAL AND METHODS OF STUDY

3.1. Subject of study

Comparative evaluation of the conducted complex application of DO therapy and the "PRICE" protocol with their analogous monotherapy in early rehabilitation in patients with talocrural joint distortion.

3.2. Contingent of study

For the purposes of the study, a total of 120 patients between the ages of 18 and 50 with clinical manifestations of ankle joint distortion with a history of symptoms no more than 7 days were evaluated. The patients were selected according to certain criteria, meeting the needs for the development of the present work, namely:

Criteria for inclusion in the study

1. Signed informed consent to participate in the study;
2. Patients of both sexes aged between 18 and 50 years, with talocrural joint distortion verified by imaging and physical examination, with clinical manifestations and with a history of symptoms no more than 7 days;
3. Consulted by a specialist in orthopedics and traumatology, who defines the condition as not requiring urgent surgical intervention;
4. Patients who do not use topical or oral medications affecting the symptom complex of the disease in the period after the occurrence of the trauma;

5. Patients who did not undergo treatment by physical factors in the period after the occurrence of the trauma.

3.2.2 Exclusion criteria from the study

1. Refusal to participate in the study;
2. Patients diagnosed with a fracture of bones involving the ankle joint;
3. Patients with proven rupture of the ligaments - stabilizers of the ankle joint (grade III);
4. Patients with symptoms lasting more than a week or chronically recurring complaints;
5. Patients consulted by a specialist in orthopedics and traumatology, who assessed the condition as requiring urgent surgical intervention;
6. Administered local or oral medications affecting the symptom complex of the disease in the period after the trauma;
7. Comorbidity forming contraindications for physical therapy / systemic neoplastic, infectious, autoimmune diseases, decompensated conditions, rhythm pathologies, presence of a pacemaker;
8. Previous ankle surgery;
9. Inability to understand and follow study instructions;
10. Persons under 18 and over 60 years of age;
11. Pregnancy.

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3.3. Clinical principle of assessment

In order to achieve the set goals and solve the set tasks, the necessary data have been studied and analyzed:

1. Anamnestic data: pain, swelling, stiffness and subjective complaints of the patient;

2. Functional status:

- examination of the ankle joint - skin color, deformity;
- palpation performed according to the Ottawa ankle rules method to exclude the presence of a fracture;
- VAS pain assessment (visual analogue scale);
- specialized manual tests: anterior drawer test - ADT (anterior drawer examines the stability of the lig. talofibulare anterior), talar tilt test - TT - inversion stress test - examines the stability of the lig. calcaneofibulare, Eversion talar-tilt (stress) test; eversion stress test – investigates the stability of lig. deltoid;
- centimetry (circumference) of the ankle joint;
- ankle joint goniometry.

3. Patients complete a short form of The Foot and Ankle Disability Index questionnaire (FADI);

3.4 Study design

1. *Study period: 04/01/2022 to 09/20/2023*;
2. *Place of the study:* The territory of the UMBAL Sveta Marina EAD - the city of Varna, in the Clinic of Physical and Rehabilitation Medicine and the Department of Rehabilitation, located on the territory of the St. st

Konstantin and Elena;

3. According to the study design, the study was randomized and parallel;

4. All patients are detailed according to gender, age, functional status and monitored before the start of treatment, immediately after its end (7th day) and on the 21st day from the start of treatment;

5. Patients meeting the inclusion criteria were divided into three groups with an equal number of participants (40 per group);

6. Inclusion of patients in the treatment group is done in order of examination appearance, as the selection step for the combined application of therapeutic modalities is through two, ie. every third patient falls into group "2".

- Therapeutic group "0" (applied protocol "PRICE");
- Therapeutic group "1" (applied monotherapy with Deep Oscillation);
- Therapeutic group "2" (applied combined therapy with Deep Oscillation and protocol "PRICE");

7. The survey data was organized in MS Office Excel 2021, and a software product was used for its analysis SPSS Statistics for Windows v. 26.0").

3.5 **Methods of study**

3.5.1 ***Clinical and functional study***

3.5.1.1 Anamnestic data

The data is taken from information given by the patient, respectively from the available medical documentation: an examination by a specialist in orthopedics and traumatology, which describes the condition as not requiring the application of surgical treatment, and an X-ray, which excludes the presence of a fracture in the area of the ankle joint. From determinative point of view the length of time of the incident as well as the nature and intensity of the complaints are important.

3.5.1.2 Functional status

The examination aims to analyze the gait to determine the presence or absence of sparing caused by the presence of pain when performing the movements, followed by a symmetrical examination of both lower limbs (from the knee to the foot) for the presence of edema, erythema or ecchymosis, which can suggest the location of the injury.

Palpation of a painful area aims to help identify injury to specific areas or structures. If there is palpable pain in any of the Ottawa Ankle Rules zones, the patient is suspected of having a fracture and an X-ray is in order.

Assessment of spontaneous and palpable pain according to VAS:

The visual analog scale (VAS) is designed to measure the intensity of pain. It is a continuous scale in the form of a horizontal or vertical line with a length of 10 cm and two endpoints located on it: "absence of pain" and "extreme pain", which can only be imagined. The patient is suggested to place a line, perpendicularly intersecting the visual-analog scale at the point that corresponds to his pain intensity. The following points and levels of pain correspond to reporting the results: 0 - no pain, 1-3 - mild pain, 4-6 moderate pain, 7-10 severe pain.

Specialized manual tests:

- **Anterior drawer test (ADT).** The anterior drawer test investigates the stability of the lig. talofibulare anterior. To perform the test, the patient lies on his back, the knee joint is in flexion, and the ankle joint is in 10-15° plantar flexion. The heel is grasped, the patient's tibia and fibula are stabilized with the other hand, and the leg is pulled forward. With a positive test, increased anterior translation is felt compared to the contralateral ankle; a dimple can also be observed on the anterolateral projection of the talus **(Figure 1).**

(a) Front view (b) side view

Figure 1. Anterior drawer test

- **Talar tilt test (TT).** The inversion stress test investigated the stability of the lig. Calcaneofibulare. To perform the test, the patient's foot is placed in an anatomical position so that the ligamentum calcaneofibulare (CFL) is perpendicular to the long axis of the talus. The foot is then placed in inversion and internally rotated. Eversion forces from test load ligamentum deltoideus on the medial side. If lateral palpation of the talus reveals displacement or the patient reports pain, the test is defined as positive **(Figure 2.a)**.

- **Eversion talar-tilt (stress) test.** This stress test investigates the stability of lig. deltoid. To conduct the test, the patient lies or sits comfortably, the knee is flexed at 90 degrees, and m. gastrocnemius is relaxed. The heel is supported with one hand while the other hand holds the distal part of the lower leg. Keeping the ankle in a neutral position, abduction movement along the axis of the calcaneus, with this the aim is to make a movement in the talus **(Figure 2.b)**.

a) Talar tilt test (TT) b) Eversion talar-tilt (stress) test

Figure 2. Inversion and eversion stress test.

Centimetry: The circumference of the ankle and foot gives information for the presence or absence of soft tissue edema. The measurement is done symmetrically for both legs. For this purpose, a sewing centimeter is used, taking into account the difference in circumference between the two malleoli of the ankle and the metatarsal bones of the foot.

Angular measurement: The range of motion in the joints is a fundamental parameter for the assessment of motor function and the examination and diagnosis of impaired motor function. The measurement is carried out with a protractor, SFTR-methodology is used, taking into account the movement of the joint in different planes. S-sagittal, F-frontal, T-transverse, R-rotation. The ankle joint performs movement in the sagittal direction. The angulation in a healthy patient is S 20-0-45, 20° dorsiflexion and 45° plantarflexion.

3.5.2 The foot and ankle disability index - FADI

We use a modified scale of The foot and Ankle Disability index (FADI), which is 15 questions divided into two categories:

The first category consists of 11 questions related to activities of daily living. Grading is done as follows: 0 - impossible to do, 1 - extremely difficult, 2 - medium difficulty, 3 - slight difficulty, 4 - no difficulty.

The second category consists of 4 questions and assesses the degree of pain in the ankle joint. The assessment is carried out as follows: 0 - unbearable pain, 1 - acute pain, 2 - moderate pain, 3 - mild pain, 4 - no pain.

The result is calculated with the following formula:

Total result: _____ /60 points x 100 = %

The modified FADI scale has a total point value of 60 points, representing 100%. The lower the score, the worse the degree of ankle damage and vice versa.

3.6 Treatment methods

Patients in the three groups received treatment on 7 consecutive days - daily, single administration of each of the factors. The results are reflected in the respective individual patient protocols before the start of treatment, after the completion of the therapeutic course (7th day), as well as on the 21st day from the start of therapy.

- Treatment group "0" underwent the standard treatment of ankle joint distortion - "PRICE" protocol. Hurt leg can be protected by limiting movement in the joint or by limiting one's own weight; the use of crutches, canes or hiking poles is recommended. Immobilization of the joint using rigid immobilization is desirable. Elevation and compression are intended to minimize developing traumatic soft tissue edema. Elevating the injured limb to the level of the heart or higher allows excess interstitial fluid to be pumped back into the circulatory system. Cryotherapy is performed using an ice block. The area is gently

massaged with circular or longitudinal movements for 30-40 seconds. with a pause period for a total time of 2-3 min.

- Therapeutic group "1". Patients underwent monotherapy by the method of deep oscillation. The therapeutic course performed with an apparatus of the German company Physiomed (Figure 3).

The consecutive operating frequencies used are 120-180 Hz - 4 min., 14-30 Hz - 5 min., 85 Hz - 5 min.

Figure 3. Apparatus for deep oscillation of the German company Physiomed

• Therapeutic group "2". Patients receive a combined therapy. The "PRICE" protocol is applied, followed by the deep oscillation courses with operating frequencies 120-180 Hz -5 min., 14-30 Hz - 5 min., 85 Hz - 5 min.. **(Figure 4)**.

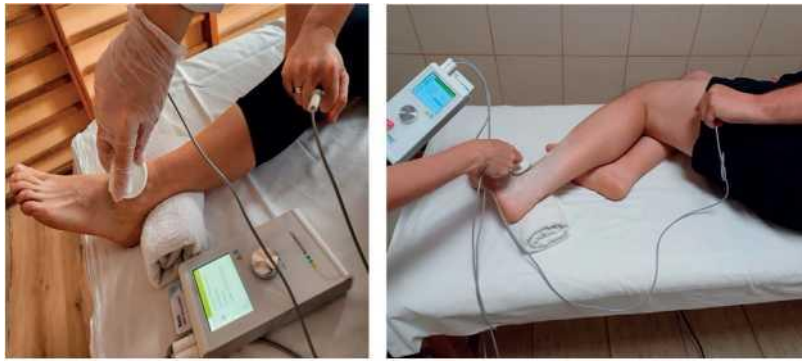


Figure 4. Deep Oscillation Machine Therapy

3.7. Statistic methods

In processing the data obtained from this dissertation, the following statistical methods were used:

3.7.1. Descriptive methods

- Alternative analysis. It represents a structural distribution of variables;
- Variational analysis. Quantitative variables are representative with mean magnitude (Me) and interquartile range for scatter (IQR);
- Graphical methods for comparing and visualizing the obtained statistical results;
- Statistical evaluation methods. Determined for 95% inter-confidence intervals for mean and relative values partitions.

3.7.2. Hypothesis verification methods

Monitored indicators are: centimeter, dorsiflexion, plantarflexion, VAS scale results, questionnaire results FADI.

Each of the indicators was measured at three time points - day one (before the start of treatment), day seven (after the end of treatment) and day twenty-one.

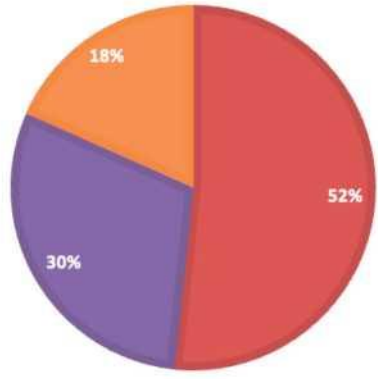
The study proceeds in the following steps:

- Initially, a sample normality check was performed in the three therapeutic groups (TG "PRICE", TG "DO" and TG "PRICE + DO") for the five criteria (centimeter, dorsal flexia, plantar flexion, VAC and FADI) in the three time points (day 1, day 7 and day 21) by the Kolmogorov – Smirnov test;
- Kolmogorov-Smirnov test results require the use of Me and IQR in establishing the basic numerical values characteristics in patients treated with three therapeutic approach;
- The obtained numerical characteristics were used to perform intragroup analysis;
- The obtained results of the Kolmogorov-Smirnov test require using the non-parametric Mann-Whitney U test when performing intergroup analysis;
- The uniformity of the samples on day 1 was proved (statistically non-significant between-group difference) in the three different therapeutical approach, serving to control not the intergroup comparison;
- An intergroup comparison of the therapeutic approaches at the end of the treatment and during the 21st day. Depending on that whether there is a statistically significant difference or not when comparing comparisons of one therapeutic approach to another are made inferences about treatment effect;
- All statistical tests are performed at a significance level of bridge (error of the first kind);
- Survey data is organized in MS Office Excel 2021, and an IBM statistical product was used for their analysis SPSS Statistics for Windows v. 26.0.

CHAPTER IV. RESULTS

4.1. Socio-demographic characteristics of the researched persons

For the purposes of the study, 120 persons were examined. The frequency distribution by age is as follows: 51.67% (n=62) in the range of 18-29 years, 30% (n = 6) in the age group between 30 and 39 years



and 18, 33% (n = 22) in the age range of 40-50 years **(Figure 5)**.

54 men and 66 women took part in the study. The distribution by gender shows that females (55%) predominate over males (45%) by 10% **(Figure 6)**.

Figure 5. Distribution of patients by age

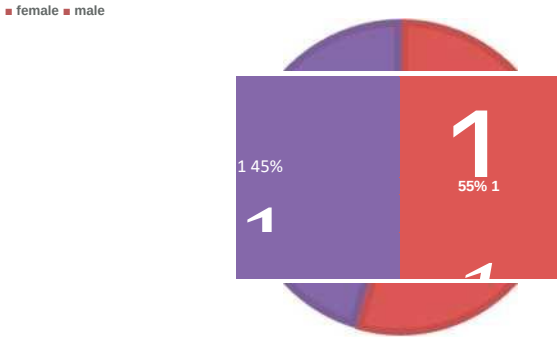


Figure 6. Distribution of patients by gender

When studying the social structure of the people studied, it was found that the group with the largest number is the group of employed persons (workers) who perform different types of physical or mental work in their official activities - from those who work mainly at a desk (doctors, accountants, teachers, etc. .) to employees with an average level of physical exertion (delivery staff, waiters, cooks, etc.); these patients represented 83.33% (n=100) of the sample. The rest of the respondents study participants were students, representing 9.17% (n=11), and those actively engaged in sports activities (athletes) - 7,50% (n=9) **(Figure7)**.

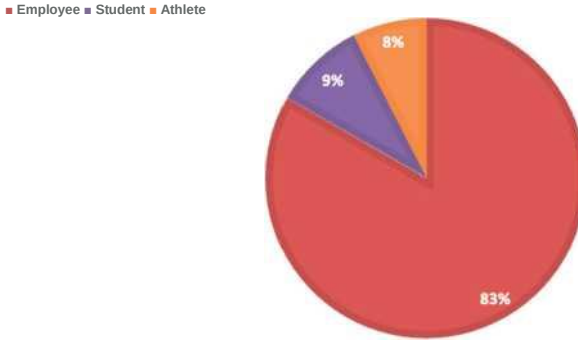


Figure 7. Distribution of patients by social status

It is characteristic of all examined persons (n=120) that they practice activities or hobbies related to physical tension of the ligamentous complexes of the ankle joint to varying degrees - hiking, fitness, jogging, aerobics, group competitive sports (volleyball, basketball, etc.). With regard to the degree of physical activity, the patients are divided into three groups: with a high degree of physical activity (in this group are 15.83% (n=19) of the examined persons), with an average degree of physical activity - 51.67% (n =62) and with a low degree of physical activity 32.50% (n=39) (Figure **8)**.

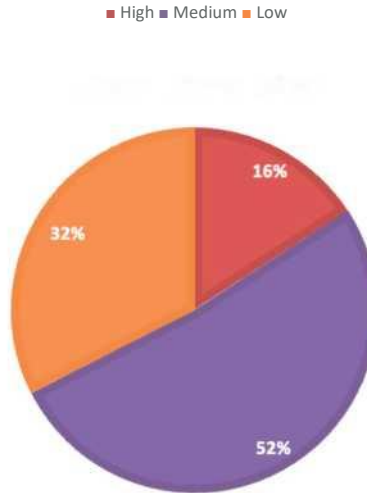


Figure 8. Distribution of the examined persons by degree of physical activity

The study found that the cause of distortion in the greater percentage of affected individuals - 75% (n=90) was trauma received during sports activity, and in 25% (n=30) - during routine daily activities , outside the sports or hobbies practiced by the patients (Figure 9). The results show that 100% of cases are associated with excessive loading of the ankle complex and displacement of movement outside the normal biomechanics of the joint.

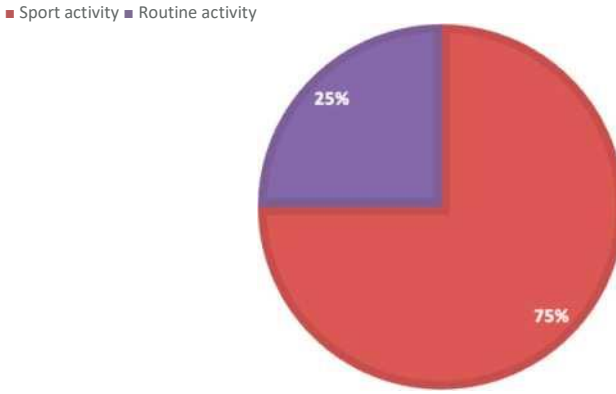
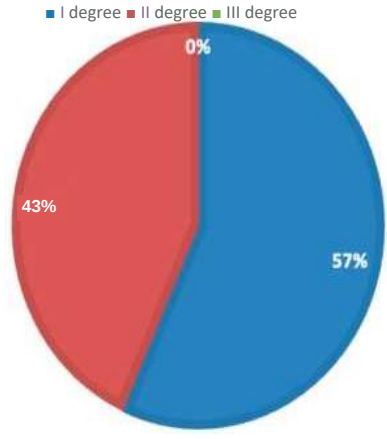


Figure 9. Distribution of patients by reason of admission of the trauma

After applying the manual diagnostic tests to measure ankle stability of the lig. talofibulare anterior, lig. calcaneofibulare and lig. deltoideum, the following distribution was found: 43.33% positive anterior drawer test, and in 56.67% all three tests were negative. The data show that 52 patients have grade II ligamentous damage to the lig. talofibulare anterior, and 68 of them are with I degree sprain, without violation of the integrity of the ligaments **(Figure 10)**.



4.2. Characterization of the results obtained from the intragroup and intergroup analysis of the examined persons

From the verification made with the Kolmogorov-Smirnov test,

establish the following results: normally distributed samples or the values of Asymp. Sig. (2-tailed) greater than the significance level at:

- day 1 in the three treatment groups and on day 7 in the "PRICE" treatment group and the "DO" treatment group, when considering the results of the circumference of the ankle joints;
- day 1 in therapy group "PRICE" and therapy group
- "TO" when reporting the results of the visual-analog scale;
- at the three time points and in the three treatment groups when reporting the results of the modified FADI daily activities scale.

The rest, the greater part of the samples, have values of

Asymp. Sig. (2-tailed) less than the significance level and cannot be claimed to be normally distributed.

The results obtained from the Kolmogorov-Smimov test for normality of samples require the use of mean-median (Median-Q2) and interquartile range for scatter (IQR-Q3-Q1) when performing intragroup analysis and applying the Mann- Whitney U when performing inter-group analysis.

4.2.1. Centimetry (CM) values tracked in the three treatment groups, at three time points. Between-group analysis

The first metric tracked is the difference in circumference of symmetrically measured values of both ankle joints in centimeters (cm). Values were recorded at the beginning of treatment, at the end of treatment (day 7) and at day 21 to determine the presence or absence of dynamics in ankle circumference and soft tissue edema.

When taking into account the main numerical characteristics of the measurements of the AJ of the patients treated in therapeutic group "0" (standard care "PRICE"), "1" (therapy DO) and "2" (combined application "PRICE" and DO) in the three time points, the following mean values (Me) and interquartile range (IQR) were found (Table 1**)**.

Table 1. Basic numerical characteristics of centimeter at patients on day 1, day 7 and day 21 in TG "0", "1" and "2“.

THERAPEUTIC GROUP	N	Me (Q2) ± IQR(Q3-Q1)		
		CM day1	CM day 7	CM day 21
0 „PRICE“	40	2,25 ± 1,50	2,00 ± 1,00	1,00 ± 0,50
1 „DO“	40	2,25 ± 1,375	1,50 ± 1,00	0,50 ± 0,50
2 „PRICE+DO“	40	2,50 ± 1,00	1,00 ± 1,00	0,50 ± 0,375

For TG "0" (standard care "PRICE") before the start of therapy and the average value of the difference in the circumference of the ankle in centimeters was 2.50 ± 1.50, at the end of the treatment the value decreased to 2.00 ± 1.00, and on the 21st day from the beginning of the therapy it was significantly lower - 1.00 ± 0.50. The dynamics of the average values are similar in TG "1" and "2", where the following average values of the circumference in cm are reported: in TG "1" (DO therapy) the initial average value of the circumference indicator is 2.25 ± 1.375 , at the end of the treatment the indicator decreases to 1.50±1.00, and its lowest value is on the 21st day - 0.50±0.50. In the combined application group ("2"), the mean value at the beginning of treatment was 2.50±1.00, on the 7th day it was 1.00±1.00, and at the end of the third week from the beginning of the incident it is 0.50±0.375. The results obtained showed that in each of the treatment groups the circumference of the ankle joint decreased at the end of the treatment (day 7) and at follow-up the duration of the effect of the therapy on day 21, which is evidence that all three applied treatment approaches have therapeutic value, although pronounced to varying degrees. The best results and the greatest reduction in edema were observed among patients in treatment group "2" (combined application "PRICE" and DO) **(Figure 11)**.

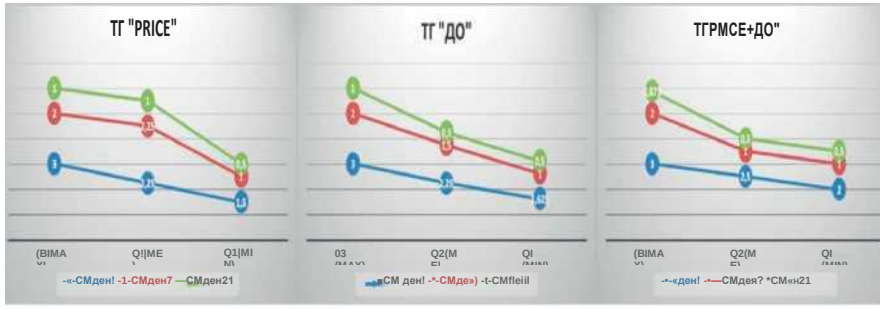


Figure 11. Centimetry, Me (Q2), IQR (Q-Q1)
day 1, day 7 and day 21 in ТГ „0“, „1“ and „2“.

According to calculations made in therapeutic group "PRICE"
a relatively equal distribution of percentage difference in AJ circumference was observed: a difference of 1 cm was observed among 10% (n=4) of patients, 1.5 cm among 20% (n=8), 2 cm in 20% (n = 8), 2.5 cm in 10% (n=4), 3 cm in 20% (n=8) and 4 cm in 20% (n=8) of patients on day 1. At the end of the therapeutic course (7th day), a decrease in the number of patients with a AJ difference of 4 cm was found from 20% to 0%, an increase in percentages with a AJ difference of 1 cm from 0% to 17.5% (n=7) and 2 cm from 20% to 32.5% (n=13), indicating a reduction in ankle swelling at the end of treatment. At day 21, patients with a 0.5 cm AJ difference representing 30% (n=12) and 1 cm in 40% (n=16) of patients had the highest percentage, indicating that AJ swelling in treatment group continued to decline up to 3 weeks after the start of treatment **(Figure 12)**.

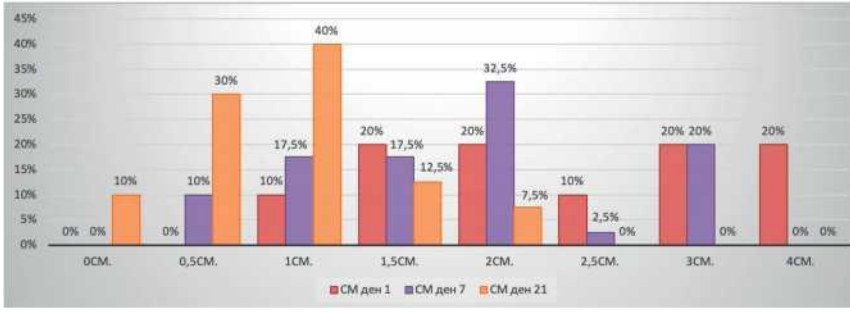


Figure 12. Tour of AJ day 1st, 7th and 21st, therapeutic group "PRICE ”

In the self-administered deep oscillation therapy group, on day 1, the largest percentage were patients with a 2 cm girth difference representing 25% (n = 10), 4 cm in 20% (n = 8) and 3 cm in 17.5% (n=7) of the patients, only 10% (n=4) represented the patients with 1 cm edema of the AJ. At the end of the treatment noted a reduction in rates in patients with 4 cm AJ edema from 20% to 0%, 3 cm from 17.5% to 15% (n=6). An increase in the percentage of patients with 1 cm of AJ edema from 10% to 25% (n = 10) and 0.5 cm from 0% to 20% (n = 8). The data showed that the edema in the treatment group decreased after the application of deep oscillation therapy. At day 21, the largest reported difference was 1.5 cm in 12.5% (n=5) of patients, absent edema was observed in 17.5% (n=7) of patients, and with the largest percentage value 45% (n = 18) were the patients with 0.5 cm edema of the ankle joint (Figure 13).

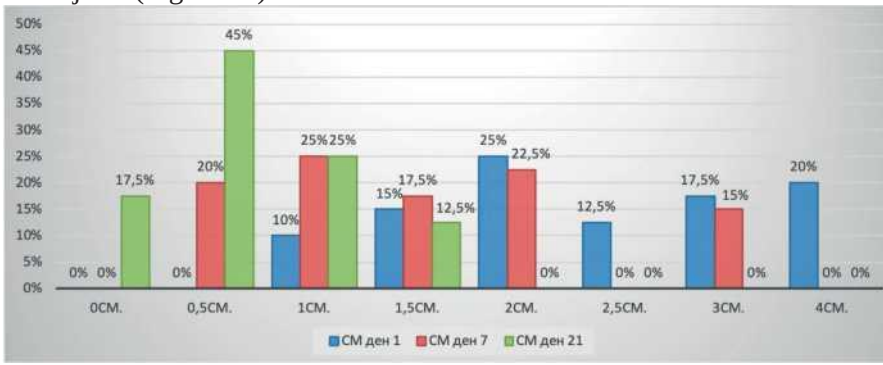


Figure 137. Tour of AJ day 1, 7 and 21, therapy group "TO"

In the combination treatment group, percentage values were observed on day 1 as follows: 1 cm in 10% (n=4) patients, 1.5 cm in 12.5% (n=5) patients, 2 cm in 20% (n=8), 2.5 cm in 20% (n=8) patients, 3 cm in 20% (n=8) and 4 cm in 17.5% (n=7) of patients. On the 7th day, the percentage of patients with 4 cm AJ edema decreased from 17.5% to 0%, 3 cm from 20% to 10%. The percentage of patients with 1 cm from 10% to 40% and 0.5 cm from 0% to 22.5% increased. The results show that after applying the therapeutic course the swelling of AJ decreases. The results were maintained on the 21st day from the start of treatment, where the highest percentage of 52.5% (n = 21) of patients with edema 0.5 cm was observed, and absent edema was reported in 22.5% (n=90) from the results (Figure 14**)**.

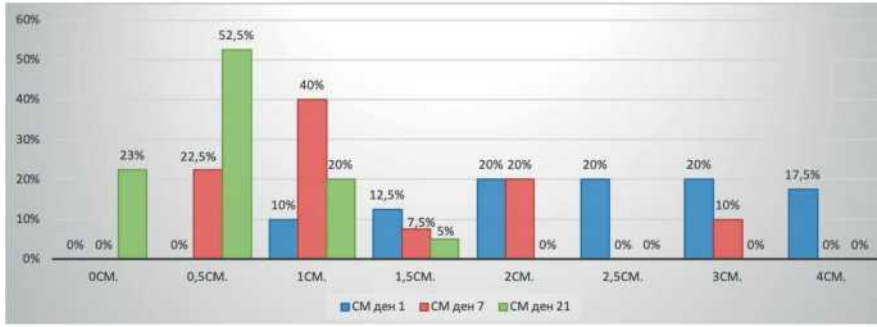


Figure 14. Tour of AJ day 1st, 7th and 21st, therapeutic group "PRICE+DO ”

4.2.1.1. Inter-group analysis

• ***Centimetry Day 1 (referent)***

To properly report the results and prove the hypotheses, it is necessary to set a starting point for the comparisons and to demonstrate the sameness of the indicators on day one between the three treatment groups.

The obtained numerical characteristics of the Asymp. Sig. (2-tailed) from the Mann-Whitney U test performed are greater than the significance level a = 0.05. No statistically significant difference was observed in the reported Asymp values. Sig. (2-tailed) of the circumference of the AJ in the between-group analysis of the results. These data demonstrate homogeneity of the sample on day 1 - the groups are homogeneous. In this case, patients were allocated according to the inclusion and exclusion criteria (on a matched basis), and the treatment groups were indistinguishable from each other another according to the reported criterion for the circumference of the ankle joint **(Table 2)**.

Table 2. Values of Asymp. Sig. (2-tailed) on the circumference of the GS in day 1 (Reference)

Centimetry day 1	**Mann-Whitney Test (Asymp. Sig. (2-tailed)**
TG „PRICE"and „DO"	0.922
TG „DO" and „PRICE + DO"	0.822
TG „PRICE" and „PRICE + DO"	0.784

• ***Centimetry day 7***

The examination of the index centimeter (circumference) of the ankle joint continues on day 7. The obtained results represent the immediate result of the application of the different therapeutic approaches. The Mann-Whitney U test found no statistically significant difference between: TG "0" (standard care "PRICE") vs TG "1" (DO therapy), the obtained value of Asymp. Sig. (2-tailed) is 0.092, respectively. The result is similar in the comparisons of TG "1" (therapy with DO) against "2" (combined application "PRICE" and DO), the value of Asymp. Sig. (2-tailed) is greater than the significance level a = 0.05. In the comparison made between TG "0" and TG "2", a statistically significant difference was found, namely 0.006. The data do not exclude a decrease in ankle joint circumference in each treatment group. The observed results show that when comparing the approaches TG "0" ("PRICE" protocol) and TG "1" (DO therapy) it cannot be claimed which of the two methods is better in terms of reducing ankle circumference and swelling at the end of treatment, as there is no statistically significant difference between them. The analysis of the results between TG "1" (therapy with DO) and TG "2" ("PRICE" protocol and DO) is similar. In the comparison of the therapeutic group for the combined application of the factors (TG "2") and the standard care (TG "0"), a statistically significant difference was observed in the indicators reported with the value of Asymp. Sig. (2-tailed) less than a=0.05. This shows that the combined application of "PRICE" and DO reduces ankle circumference and swelling to a greater extent than the standard care "PRICE" applied, or TG "2" is superior to TG "0" (Table 3**)**.

Table 3. Values of Asymp. Sig. (2-tailed) of the AJ circumference on day 7

Centimetry day 7	**Mann-Whitney Test (Asymp. Sig. (2-tailed)**
TG „PRICE“and „DO“	0.092
TG „DO“ and „PRICE + DO“	0.287
TG „PRICE“ and „PRICE + DO“	0.006

• ***Centimetry day 21***

The results obtained from the intergroup comparison of the numerical characteristics (Asymp. Sig. (2-tailed) by the Mann-Whitney U test at day 21 account for the presence or absence of a sustained effect, reduction in girth and edema of the application The test confirms that there is no statistically significant difference between TG "PRICE" and TG "1", the value of Asymp. is 0.051 and at TG "1" and "2" (combined application "PRICE" with a value of Asymp. Sig. (2-tailed) greater than the significance level a = 0.05). of the ankle joint and edema on the 21st day after the injury in the groups for self-administration - TG "0" ("PRICE") and TG "1" (therapy with DO). found a statistically significant difference of Asymp. Sig. (2-tailed), namely: Asymp. Sig. (2-tailed): 0.002 with a complex approach ("PRICE" protocol and DO), the tendency to reduce edema was maintained up to 3 weeks with statistical significance, compared to the group for self-application of the "PRICE" protocol (TG "0") (Table 4**)**.

Table 4. Values of Asymp. Sig. (2-tailed) of the GS circumference on the 21

Centimetry day 21	**Mann-Whitney Test (Asymp. Sig. (2-tailed)**
TG „PRICE“ and „DO“	0.051
TG „DO“ and „PRICE+DO“	0.224
TG „PRICE“ and „PRICE+DO“	0.002

4.2.2. Dorsiflexion (DF) values tracked in the three treatment groups, at three time points. Between-group analysis

Dorsiflexion accounts for the movement of the ankle joint in the frontal plane. In a healthy individual, it represents a 20° angle of movement in the cranial direction. Baseline numerical characteristics (Median and IQR) of ankle motion measurements (dorsiflexion) in degrees reported increases in ankle motion among patients in the three treatment groups (**Table 5)**.

Table 5. Numerical characteristics of dorsiflexion of patients on day 1, day 7 and day 21 in TG "0", "1" and "2“

THERAPEUTIC GROUP	N	Me (Q2)± IQR(Q3-Q1)		
		DF day 1	DF day 7	DF day 21
0 „PRICE“	40	10,00 ± 5,00	12,50 ± 5,00	15,00 ± 5,00
1 „DO“	40	10,00 ± 5,00	15,00 ± 10,00	15,00 ± 5,00
2 „PRICE + DO“	40	10,00 ± 5,00	15,00 ± 5,00	20,00 ± 5,00

On day one, the mean values in all three treatment groups were the same 10.00 ± 5.00. At the end of treatment, the degrees of dorsiflexion showed a tendency to increase the range of motion, and after 3 weeks the mean values were even higher.

In TG "0" (standard care "PRICE") at the end of the treatment the average values of the range of motion increased to 12.50 ± 5.00 degrees, and on the 21st day values up to 15.00 ± 5 were reported. 00.

At the end of the therapy (7th day) at TG "1" (therapy DO) the average values rose to 15.00 ± 10.00, and on day 21 the values remained relatively the same with a trend towards an increase in the volume of movement, evidenced by a decrease in the values of the interquartile range 15,00 ± 5,00.

An identical movement of the indicators is also reported in TG "2" (combinned application "PRICE" and DO), where the dorsiflexion angle values increased gradually from 10.00 ± 5.00 on the first day, to 15.00 ± 5.00 at the end of treatment and 20.00 ± 5, 00 when tracking long-term trends at day 21, which is also the largest increase in degrees of dorsiflexion (**Figure 15)**.

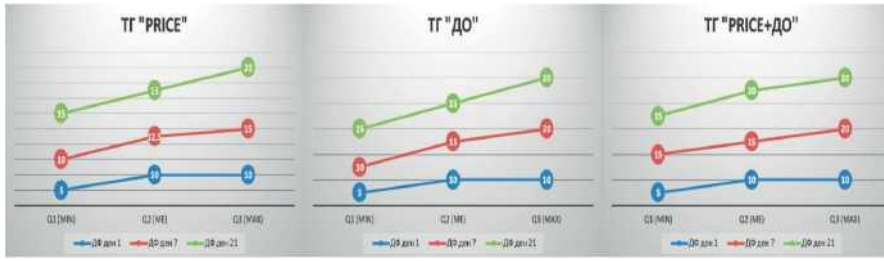


Figure 15. Ankle dorsiflexion, Me (Q2),
IQR (Q3-Q1) on day 1, day 7 and day 21 in TG „0“, „1“ и „2“

In the "PRICE" therapeutic group, 16 patients (40%) with 5 dorsiflexion, 20 patients (50%) with 10, 4 patients (10%) with 15 DF on day one. After completing the treatment course, an increase in the number of patients who increased their range of motion was found - 35% (n=14) reached 15 DF, and 15% (n=6) reached a full range of motion of 20 DF. There was also a decrease in the number of patients with a 5-fold limitation from 40% (n=16) to 5% (n=2). On day 21, the number of patients increases, reaching 15 - 47.5% (n=19) and 14 patients (35.5%) with established full range of motion 20 **(Figure 16)**.

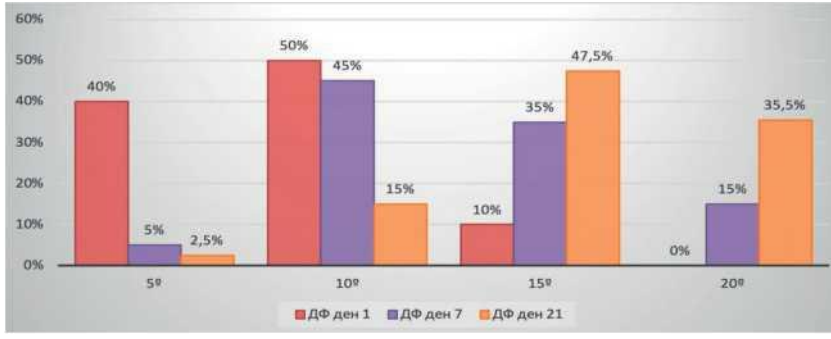


Figure 16. Dorsiflexion of AJ day 1, 7 and 21.
Therapeutic group „PRICE”

In the therapeutic group for self-administration of Deep Oscillation, 42.5% (n=17) patients were found with 5 DF, 50% (n=20) with 10 and 7.5% (n=3) with 15. During 7- my day, the number of patients increases, reaching 15 - 42.5% (n= 17), and 20- 27.5% (n= 11), there are no patients with 5 DF. Patients achieving full range of motion in DF - 47.5% (n = 19) observed at day 21 long-term follow-up **(Figure 17)**.

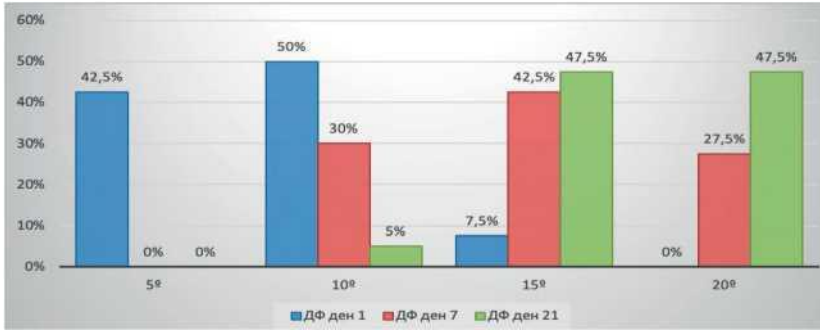


Figure 17. Dorsiflexion of AJ day 1, 7 and 21.
Therapeutic group "DO“

In the third therapeutic group "PRICE + TO" the same is found trend - decrease in the number of patients at the end of treatment (7th day) with 5 DF from 37.5% (n=15) to 0%, 10 DF from 52.5% (n=21) to 17.5% (n=7), an increase in the number of patients reaching 15DF from 10% (n=4) to 47.5% (n=19) and 20 from 0% to 35% (n=14). The improvement in outcomes was also maintained at day 21 range of motion follow-up, where 57.5% (n=23) of patients reached a full range of motion of 20 DF **(Figure 18)**.

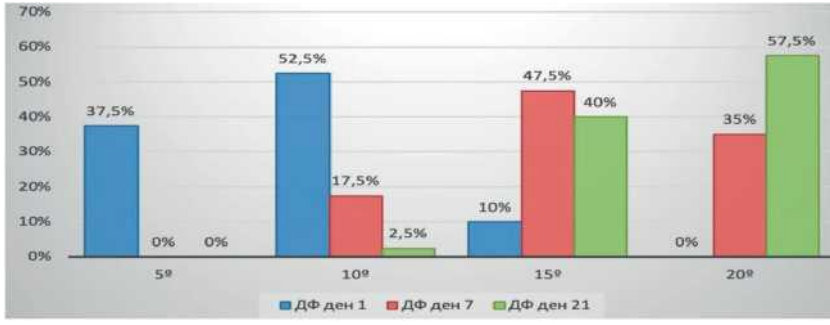


Figure 18. Dorsiflexion of AJ day 1, 7 and 21.
Therapeutic group "PRICE + DO“

4.2.2.1. Intergroup analysis

• ***Dorsiflexion Day 1 (referent)***

The numerical characteristics obtained on day 1 of the application of the Mann-Whitney test of the between-group analysis showed the following results of Asymp. Sig. (2-tailed). In all three intergroup comparisons, the values were greater than the α=0.05 significance level. There is no statistically significant difference between indicators of dorsal flawet on day 1. The Mann-Whitney U test confirmed the hypothesis of homogeneity among patients allocated to the three treatment groups with respect to reported limitation of ankle joint motion **(Table 6)**.

Table 6. Values of Asymp. Sig. (2-tailed) of dorsiflexion of AJ on day 1 (Referent)

Dorsiflexion day 1	**Mann-Whitney Test (Asymp. Sig. (2-tailed)**
TG „PRICE“ and „DO“	0.748
TG „DO“ and „PRICE + DO“	0.602
TG „PRICE“ and „PRICE + DO“	0.847

• ***Dorsiflexion Day 7***

At the end of the 7-day therapeutic course, the data of the three therapeutic approaches and the increase in the degrees of motion in dorsiflexion of the ankle joint are reported. The results of the Mann-Whitney U test confirm that there is no statistically significant difference between: TG "1" (therapy with DO) and "2" (combined application "PRICE" and DO), the values of Asymp. Sig. (2-tailed) are greater than the significance level a = 0.05. At TG "0" (standard care "PRICE") and TG "1" (therapy with DO) the value of Asymp. Sig. (2-tailed) is borderline (0.042) and it cannot be claimed that there is a statistically significant difference between the approaches, i.e. the test is inconclusive. The data show that although there is an increase in the degrees of dorsiflexion after the application of both therapeutic approaches, the values obtained from the comparison are close and do not have statistical significance.

The results of the intergroup comparison of TG "0" (application of "PRICE") and "2" (combined application of "PRICE" and DO) are statistically significant, with a value of Asymp. Sig. (2-tailed) less than the significance level a = 0.05. The analysis of the obtained results tracking the changes in the range of motion of dorsiflexion prove that the combined

application of DO and "PRICE" leads to a more significant increase in the angle of movement of the ankle joint in the cranial direction with statistical significance **(Table 7)**.

Table 7. Values of Asymp. Sig. (2-tailed) of dorsiflexion of AJ on day 7

Dorsiflexion day 7	**Mann-Whitney Test (Asymp. Sig. (2-tailed)**
TG „PRICE“ and „DO“	0.042
TG „ДО“ and „PRICE + DO“	0.236
TG „PRICE“ and „PRICE + DO“	0.002

• ***Dorsiflexion Day 21-ви***

At the end of the third week from the start of treatment (21st day), the changes in the movement of the ankle joint are recorded. The results of the test show that there is no significant difference in the therapeutic approaches "PRICE" and DO therapy. The volume of motion retains its positive increase in degrees, but the reported values of Asymp. Sig. (2-tailed) are greater than the significance level a = 0.05, and hence statistical insignificance of the indicators. The results are similar at TG "1" (therapy with DO) and "2" (combined application "PRICE" and DO) with value of Asymp. Sig. (2-tailed) = 0.343 greater than no statistical significance.

At TG "0" ("PRICE" protocol) against and TG "2" (combined application "PRICE" and DO) the presence of a statistically significant difference with the value of Asymp is established. Sig. (2-tailed), less than α = 0.05, namely: Asymp. Sig. (2-tailed): 0.016. The reported data demonstrate that among patients treated with a complex approach, there is a pattern of increase in the achieved degree of motion of ankle joint, demonstrated by statistically significant values at day 21 **(Table 8)**.

Table 8. Values of Asymp. Sig. (2-tailed) of dorsiflexion of AJ on the 21st

Dorsiflexion day 21	**Mann-Whitney Test (Asymp. Sig. (2-tailed)**
TG „PRICE“ and „DO“	0.115
TG „DO“ and „PRICE+DO“	0.343
TG „PRICE“ and „PRICE+DO“	0.016

4.2.3. Plantar flexion (PF) values tracked in the three treatment groups, at three time points. Intergroup analysis

Plantar flexion is the movement of the ankle joint in the frontal plane. In a healthy individual, it is a 45° angle of movement from the motor arch in the caudal direction.

When considering the main numerical characteristics (Me±IQR) of the measurements of ankle plantar flexion in degrees on day 1, day 7 and day 21 of the patients treated with therapeutic approach TG"0" (standard "PRICE" care"), TG"1" (DO therapy) and TG"2" (combined application "PRICE" and OD), an ascending dynamics of the indicator is established **(Table 9)**.

Table 9. Numerical characteristics of plantar flexion of patients on day 1, day 7 and day 21 in TG "0", "1" and "2“

THERAPEUTIC GROUP	**N**	**Me (Q2)± IQR(Q3-Q1)**		
		PF day 1	**PF day 7**	**PF day 21**
0 „PRICE“	40	15,00 ± 5,00	25,00 ± 5,00	35,00 ± 5,00
1 „DO“	40	15,00 ± 5,00	25,00 ± 5,00	35,00 ± 10,00
2 „PRICE+DO“	40	15,00 ± 5,00	30,00 ± 5,00	35,00 ± 5,00

Each of the therapeutic approaches leads to an increase in the range of motion in the ankle joint. On day one, the numerical characteristics in the three treatment groups were the same. An increase in range of motion was observed at the end of treatment and on day 21. In TG "0" (standard care "PRICE"), the mean plantar flexion degrees changed from 15.00 ± 5.00 on day 1 to 25.00 ± 5.00 at the end of treatment, and on day 21 an even greater increase in measured degrees 35.00 ± 5.00 was reported. The indicators in TG "1" (DO therapy) are also similar. The baseline mean plantar flexion score of 15.00 ± 5.00 increased to 25.00 ± 5.00 at the end of therapy (day 7),

and on day 21 the value reached a two-fold increase from baseline for the group 35,00 ± 10,00.

The average values of the degrees of movement of the GS in the caudal direction in TG "2" (combined application "PRICE" and DO) show a development from 15.00 ± 5.00 on day 1 to 30.00 ± 5.00 at the end of treatment (day 7) and 35.00 ± 5.00 on day 21 **(Figure 19)**.

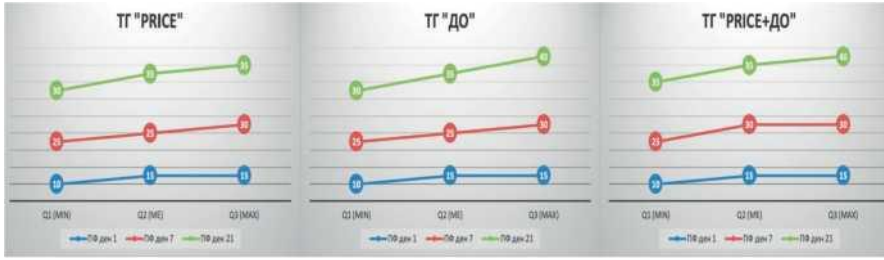


Figure 19. Ankle plantar flexion, Me (Q2),
IQR (Q3-Q1) on day 1, day 7 and day 21 in TG '0', '1' and „2“

In the standard care treatment group "PRICE" on day one 37.5% (n=15) of the patients reached 10 plantar flexion of the GS, 50% (n = 20) - 15 and only 12.5% (n=5) of the patients had a volume of movement 20. At the end of the treatment, there are no patients with a movement volume of 10 and 15, there is an increase in the number of patients reaching 35. Thus, 20% (n=8) of patients have 20, 42.5% (n=17) have 25 PF, 32.5% (n=13) - 30 PF, and 5% (n=2) reached 35 plantar flexion in the ankle joint. The highest percentage of patients is noted in the follow-up of the long-term results of the treatment 40% (n=16) reaching a stroke volume of 30 and 35% (n=14) reaching 35. In 15% (n=6) of patients achieved 40 PF and in 2.5% (n=1) full range of motion with 45 PF **(Figure 20)**.

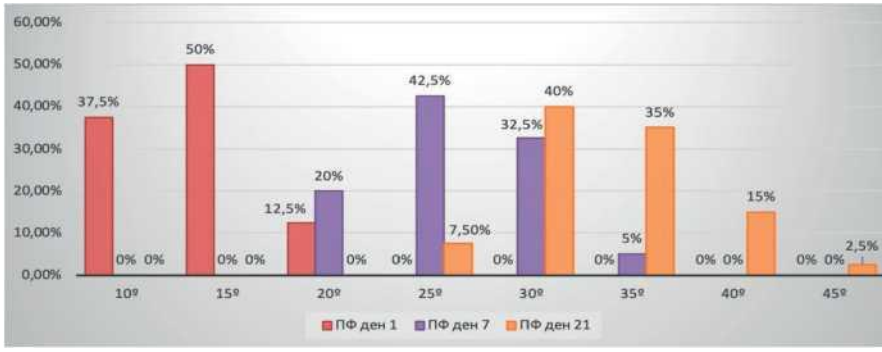


Figure 20. Plantar flexion on AJ day 1, 7 and 21.
Therapeutic group „PRICE“

In the second therapeutic group - self-administration of deep oscillation therapy, 55% (n = 22) patients with 15 PF, 31.5% (n = 13) with 10 and 12.5% (n = 5) patients with 20 were observed reported AF on day one before administration of the therapeutic course. At the end of treatment on day 7, there were no patients with PF 10 and 15. The number of patients reaching 20 remained unchanged, but 40% (n = 16) reached PF 25, 42.5% (n = 17) reached PF 30, and in 5% (n=2) PF was measured 35. The trend in improvement in motion volume was seen on day 21, where the lowest measured PF was 30 in 32.5% (n=13) of patients. The highest percentage were patients with 35 PF, representing 40% (n=16). And 7.5% (n=3) patients reach full range of motion **(Figure 21)**.

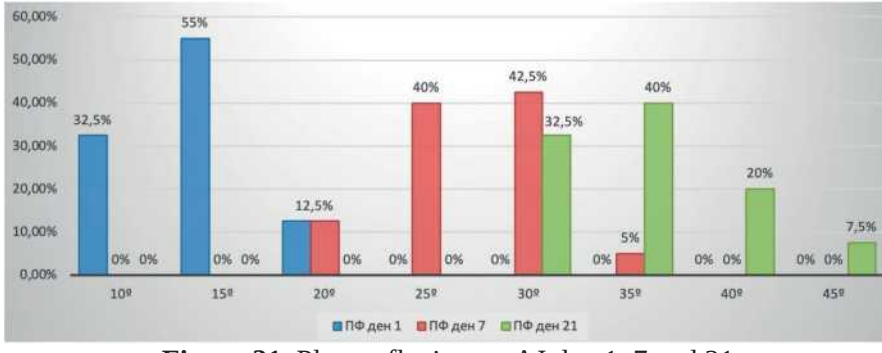


Figure 21. Plantar flexion on AJ day 1, 7 and 21.
Therapeutic group "DO“

In the final combined modality treatment group, the pattern of improvement in range of motion was repeated. Thus, on day 1, 27% (n = 11) of patients reached 10 PF, 62.5% (n = 25) reached 25 PF, and 10% (n = 4) - 20 PF. At the end of the treatment, there were again no patients reaching 10 and 15 PF. In 50% (n=20) of the patients plantar flexion up to 30, 32.5% (n=13) reached up to 25, and in 10% (n=4) PF was recorded up to 35. On day 21 40 % (n=10) of patients reached 35 stroke volume, 25% (n=10) reached 40, and in 12.5% (n=5) had full stroke volume with PF 45 **(Figure 22)**.

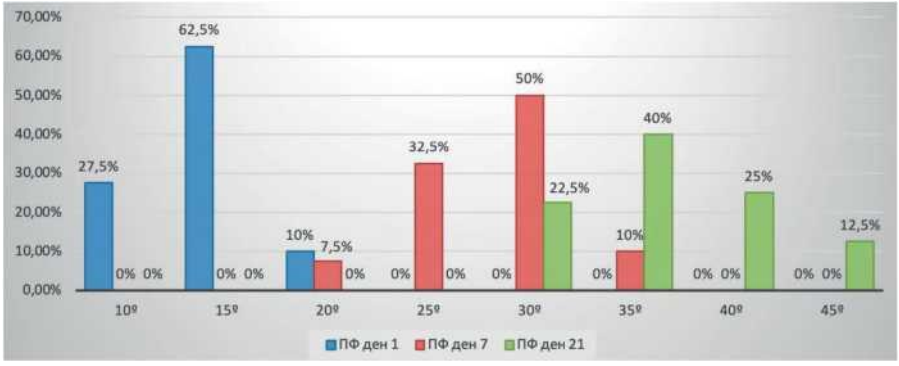


Figure 22. Plantar flexion on AJ day 1, 7 and 21.
Therapeutic group "PRICE + TO“

4.2.3.1. Intergroup analysis

• ***Plantar flexion - Day 1 (referent)***

Data obtained from between-group analysis by applying the Mann-Whitney U test on day 1 showed values of Asymp. Sig. (2-tailed) greater than the significance level a = 0.05. In all three between-group comparisons, the values indicated that there was no statistically significant difference between the mean plantar flexion scores on day 1. The Mann-Whitney U test confirms the similarity of baseline angulation values for ankle range of motion in the three treatment groups **(Table 10)**.

Table 10. Values of Asymp. Sig. (2-tailed) of plantar flexion of AJ on day 1 (Control)

Plantar flexion day 1	Mann-Whitney Test (Asymp. Sig. (2-tailed)
TG „PRICE“ and „DO“	0.708
TG „DO“ and „PRICE+DO“	0.813
TG „PRICE“ and „PRICE+DO“	0.533

• ***Plantar flexion - Day 7***

At the end of the treatment course, the obtained values of Asymp. Sig. (2-tailed) from the between-group analysis by the Mann-Whitney U test did not reject the increase in the degrees of motion of the ankle joint in each treatment group, but the obtained data showed that when comparing the approaches from TG "0" ("PRICE" protocol) and TG "1" (DO therapy), it cannot be claimed which of the two methods is better than the other in terms of increasing the arc of motion, since there is no statistically significant difference between the values obtained. Similar results with no statistically significant difference with values of Asymp. Sig. (2-tailed) greater than a = 0.05 are also noted between TG "1" and TG "2". In the third intergroup comparison, a statistically significant difference was noted between the therapeutic group with combined application of the factors (TG "2") and the "PRICE" protocol (TG "0"). This shows that the combined application of "PRICE" and DO increased ankle range of motion to a greater extent compared to "PRICE" standard care. **(Table 11)**.

Table 11. Values of Asymp. Sig. (2-tailed) of plantar flexion of GS on day 7

Plantar flexion day 7	Mann-Whitney Test (Asymp. Sig. (2-tailed)
TG „PRICE“and „DO“	0.315
TG „DO“ and „PRICE+DO“	0.202
TG „PRICE“ and „PRICE+DO“	0.029

• ***Plantar flexion - Day 21***

On day 21, the results of the intragroup analysis noted that there was no significant difference in the therapeutic approaches "PRICE" and DO therapy. The volume of motion retains its positive increase in degrees, but the reported value of Asymp. Sig. (2-tailed) is greater than the significance level a = 0.05, hence statistical non-significance of indicators. The results are similar for TG "1" (therapy with DO) and "2" (combined application "PRICE" and DO) with the value of Asymp. Sig. (2-tailed) = 0.236 greater than a = 0.05, proving the lack of statistical significance.

At TG "0" (protocol "PRICE") against and TG "2" (combined application "PRICE" and DO) the presence of a statistically significant difference, with a value of Asymp. Sig. (2-tailed) less than a = 0.05.

The reported data show that among patients treated with a complex approach, there was an increase in the degrees of motion of the ankle joint in the caudal direction, as evidenced by better results in established angulation and statistically significant result values **(Table 12)**.

Table 12. Values of Asymp. Sig.(2-tailed) of plantar flexion of the AJ on day 21

Plantar flexion day 21	**Mann-Whitney Test (Asymp. Sig. (2-tailed)**
TG „PRICE“ and „DO“	0.092
TG „ДО“ and „PRICE + DO“	0.236
TG „PRICE“ and „PRICE + DO“	0.006

4.2.4. The values from a visual-analog scale, followed in the three treatment groups, in three moments of time. Inter-group analysis

The visual-analog scale is a horizontal line with a fixed length of 10 cm, designed to measure the intensity of the side. The obtained data from the mean values (Me ± IQR) during movement at the ankle joint show a progressive decrease in the reported VAS pain intensity at the end of treatment (day 7) and at follow-up of long-term effects of therapy in each group, regardless of treatment method **(Table 13)** .

Table 13. Numerical characteristics of VAS pain on day 1, day 7 and day 21 in TG "0", "1" and "2"

THERAPEUTIC GROUP	N	Me (Q2) ± IQR(Q3-Q1)		
		VAS day 1	VAS day 7	VAS day 21
0 „PRICE“	40	4,00 ± 1,00	1,00 ± 3,00	0,00 ± 1,00
1 „DO“	40	4,00 ± 1,00	0,00 ± 2,75	0,00 ± 0,00
2 „PRICE + DO“	40	4,00 ± 1,00	0,00 ± 0,75	0,00 ± 0,00

The average values of the intensity of pain reported by VAS on the first day in all three treatment groups were the same, and during the next two follow-up periods showed a tendency to limit the sensation of pain. Thus, in the group treated with standard care "PRICE" (TG "0"), the average value on day 1 was 4.00 ± 1.00, and at the end of treatment, the pain intensity decreased to 1.00 ± 3, 00; at follow-up on day 21, a significant decrease in intensity was reported and to values close to its absence 0.00 ± 1.00. In the therapeutic group treated by the DO method (TG "1"), the reported mean values were as follows: day 1 4.00 ± 1.00, day 7 0.00 ± 2.75 and day 21 0 .00 ± 0.00 no pain reported. And with this therapeutic approach, the progressive reduction in pain intensity established by the VAS scale is preserved.

After the therapeutic course with the combined application of "PRICE" and DO (TG "2"), the most significant decrease in the subjective feeling of pain was noted, namely: the average values of the indicator from the first day were 4.00 ± 1.00, at the end of treatment reached 0.00 ± 0.75, and on the 21st day there was again no reported pain on the VAS, which testifies to the preservation and increase of the effect of the therapy with time **(Figure 23)**.

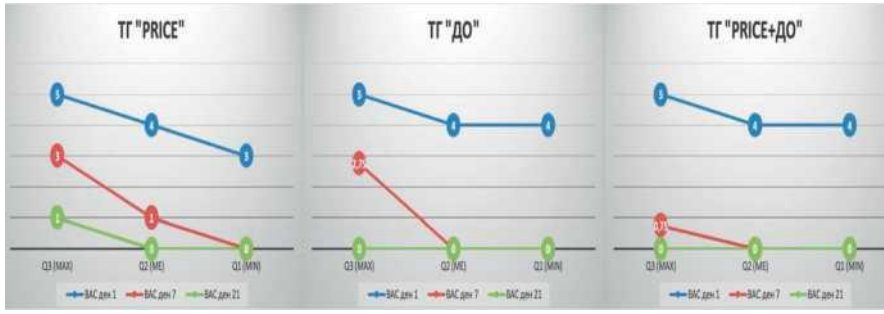


Figure 23. Visual-Analog Scale, Me (Q2), IQR (Q3-Q1) on day 1, day 7 and day 21 in TG "0", "1" and „2“

On the 1st day in the "PRICE" therapeutic group, the following VAS point values were registered: the highest percentage was 4 points in 37.5% (n=15) patients, 5 points in 27.5% (n =11) patients. The highest reflected relief was in the range of moderate pain - 6 in 7.5% (n=3), and the lowest in the range of mild pain - 2 points in 2.5% (n=1) of patients. At the end of treatment, day 7, the highest score reported was 5, again in the moderate pain range at 10% (n=4), and the lowest was absent pain with a score of 0 at 37.5 % (n=15) patients. On the 21st day, the number of patients with no pain increased to 72.5% (n=29), and the highest reported value was 4 points at 2.5% (n=1), the remaining percentages ratio correspond to mild pain **(Figure 24)**.

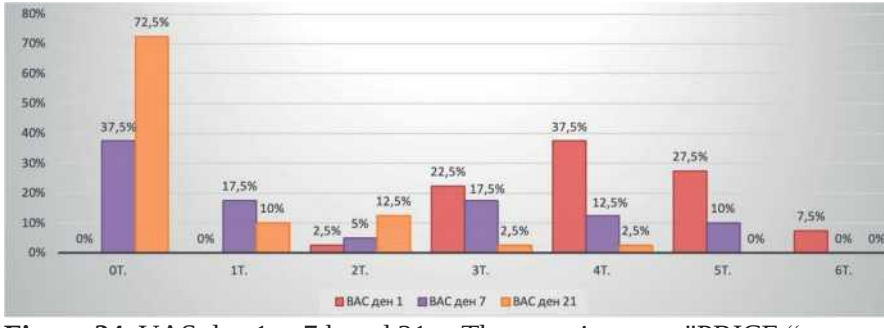


Figure 24. VAS day 1st, 7th and 21st. Therapeutic group "PRICE “

In the second treatment group, again the highest recorded VAS value on day 1 was 6 points at 7.5% (n=3) and the lowest was 2 points at 2.5% (n=1) . The highest percentage was 4 points in 40% (n=16) and 35% (n=14) patients reported 5 points. After the completion of the therapeutic course with deep oscillation, the percentages with missing pain increased - 55% (n= 22) patients, and the highest VAS point value is in the range of moderate pain in 7.5% (n=3) - 4 points. The rest of the patients noted values according to VAC in the mild pain column - 17.5% (n=7) reported 3 points, 12.5% (n= 5) patients reported 2 points and 7.5% (n=3) patients reported 1 point. On day 21 of the follow-up of the therapeutic potential of the method, absent pain was found among 80% (n=32) of the study participants, and the lowest point value is within mild pain - 3 points at 2.5% (n=1) **(Figure 25)**.

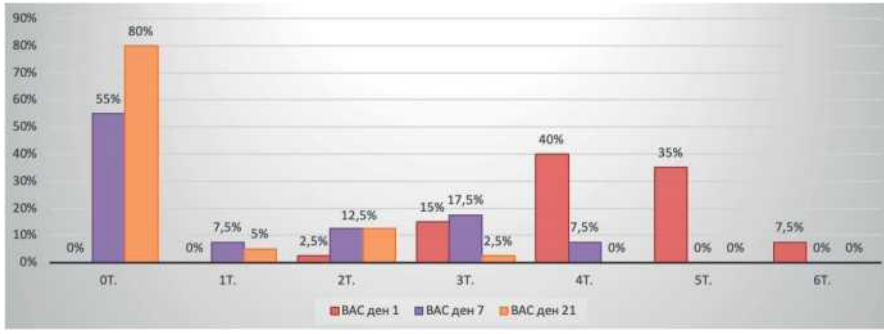


Figure 25. VAS day 1st, 7th and 21st. Therapeutic group "DO“

On day 1, 47.5% (n=19) patients with 4 pts, 17.5% (n=7) patients with 5 pts and 12.5% (n =5) patients reported 6 pts. The remaining percentage ratios demonstrate VAS results in the mild pain column. After completion of the therapeutic course, 47% (n=30%) of patients were given 0 points or no pain. And on the 21st day, absence of pain was found among 87.5% (n=35) of patients, mild pain of 2 points in 5% (n=2) and 1 point in 7.5% (n= 3) **(Figure 26)**.

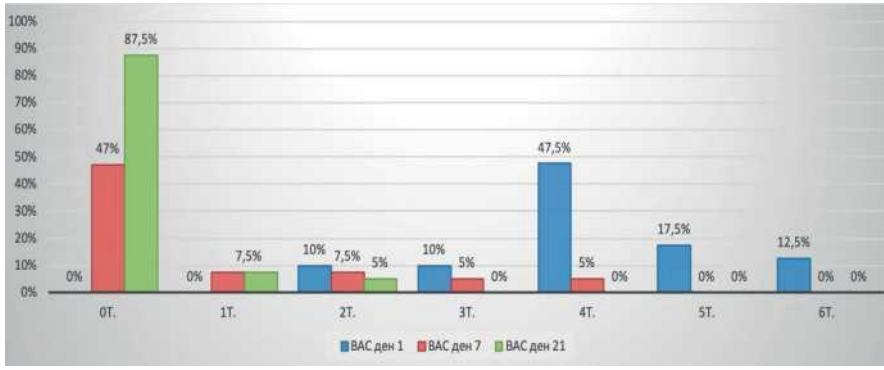


Figure 26. VAS day 1, 7 and 21.
Therapeutic group "PRICE + DO“

4.2.4.1. Inter-group analysis

• ***VAS day 1 (referent)***

The obtained numerical characteristics of the Asymp. Sig. (2-tailed) from the test performed are greater than the significance level a = 0.05. The results confirm the homogeneity of the three samples of therapeutic approaches. When moving the ankle joint, in the three intergroup analyzes on day one, no statistically significant difference was observed in the reported intensity of pain - the patients were evenly distributed according to the established criteria **(Table 14)**.

Table 14. Values of Asymp. Sig. (2-tailed) of pain reported by VAS on day 1 (Referent)

VAS day 1	**Mann-Whitney Test (Asymp. Sig. (2-tailed)**
TG „PRICE“ and „DO“	0,367
TG „DO“ and „PRICE+DO“	0,339
TG „PRICE“ and „PRICE+DO“	0,927

• ***VAS day 7***

From the conducted non-parametric test, results of Asymp. Sig. (2-tailed), showing that the subjective pain sensation reported on the VAS in group "0" (standard care "PRICE") was not significantly different from group "1" (DO therapy). The same correlation was observed in group "1" (DO therapy) and group "2" (combined application of the "PRICE" protocol

and DO therapy). The values of Asymp. Sig. (2-tailed) are greater than the significance level a = 0.05 and there is no statistically significant difference between the compared therapeutic approaches. No conclusion can be drawn as to which approach is better than the other on day 7.

Regarding the analysis between TG "0" (standard care "PRICE") and "2" (combined application of "PRICE" protocol and DO therapy) data significantly demonstrate a value of Asymp. Sig. (2-tailed) less than the level of significance a = 0.05 and define the therapeutic approach of combined application of "PRICE" protocol and DO therapy (TG"2") as better and statistically significant in terms of pain reduction versus standard care treatment (TG "0") **(Table 15**).

Table 15. Values of Asymp. Sig. (2-tailed) of pain reported by VAS on day 7

VAS day 7	**Mann-Whitney Test (Asymp. Sig. (2-tailed)**
TG „PRICE“ and „DO“	0,081
TG „DO“ and „PRICE + DO“	0,065
TG „PRICE“ and „PRICE + DO“	0,001

• ***VAS day 21***

The results of the Asymp. Sig. (2-tailed) by the Mann-Whitney U test found no statistically significant difference between treatment approaches at day 21. Values are greater than the significance level and it is not possible to state which therapeutic approach maintains the tendency to lower VAS-reported pain to a greater extent at the third time point **(Table 16)**.

Table 16. Values of Asymp. Sig. (2-tailed) of pain reported by VAS on day 21

VAS day 21	Mann-Whitney Test (Asymp. Sig. (2-tailed)
TG „PRICE“ and „DO“	0,848
TG „DO“ and „PRICE + DO“	0,852
TG „PRICE“ and „PRICE + DO“	0,961

4.2.5. Values from the modified FADI scale, followed in the three treatment groups, in three moments of time. Inter-group analysis

The modified FADI scale assesses the quality of daily activities performed by patients with ankle impairment. It has a total point value of 60, representing 100%. Baseline numerical characteristics (Me±IQR) of FADI scores are reported as percentages (%) at day 1, day 7 and day 21 in the three treatment groups. The data showed that in all three treatment groups, patients improved carrying out activities of daily living both at the end of treatment and during follow-up of long-term effects. The results obtained regarding the percentage improvement in the ability to perform daily activities as measured by the modified FADI scale demonstrate that all three applied treatment approaches have therapeutic value. The percentage improvement results from day 7 are as follows: in group TG "0" it is 88.33%, in therapy group "1" it is 90.00% and in group "2" it is 91.66% respectively. On the 21st day, the percentage improvement reported by FADI also follows this trend, with the percentage values respectively: TG "0" - 93.33%, TG "1" - 93.33% and TG "2" - 95 .83%. The most significant improvement in the performance of daily activities was observed among patients in the treatment group "2" (combined application "PRICE" and DO) **(Table 17).**

Table 17. Numerical FADI characteristics of patients on day 1, day 7 and day 21 in TG "0", "1" and „2“

THERAPEUTIC GROUP	N	Me (Q2)± IQR(Q3-Q1)		
		FADI day 1	FADI day 7	FADI day 21
0 „PRICE“	40	61,66±6,25	88,33±6,24	93,33±5,00
1 „DO“	40	60,83±7,50	90,00±4,58	93,33±5,24
2 „PRICE+DO“	40	61,66±7,92	91,66±3,33	95,83±3,33

For TG "0" (standard care "PRICE") before the start of therapy the average value of the FADI percentages was 61.66 ± 6.25, at the end of the treatment the percentage increased to 88.33 ± 6.24, and on the 21st day from the beginning of therapy it was significantly higher 93,33 ± 5,00 (**Figure 27)**.

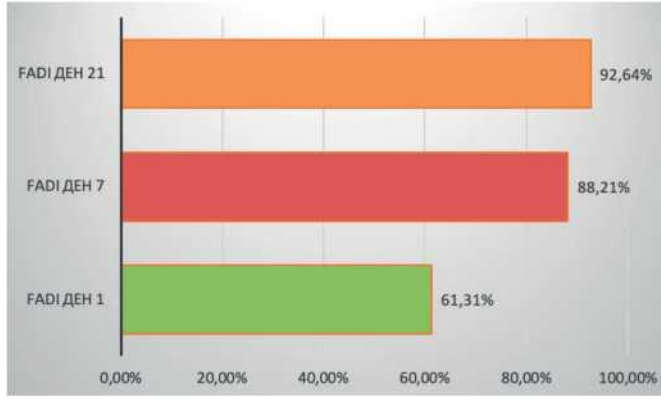


Figure 27. FADI day 1, 7 and 21 (average values), therapy group "PRICE ”

The dynamics of the average values in TG "1" and "2" are similar, where the following average values measured in FADI percentages are reported. In TG "1" (DO therapy), the baseline average value of the percentage indicator for performing daily activities was 60.83 ± 7.50, at the end of the treatment the indicator increased to 90.00 ± 4.58, and the highest was its value on the 21st day - 93,33 ± 5,24 **(Figure 28)**.

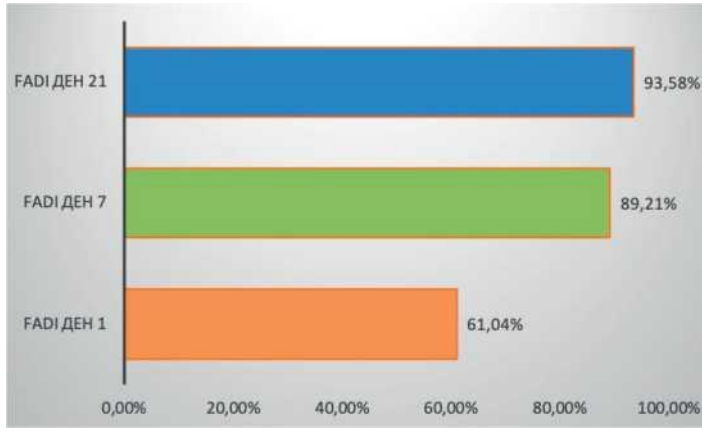


Figure 28. FADI day 1, 7 and 21 (average values), therapeutic group "DO“

In the group of the combined application ("2"), the average percentage value at the beginning of treatment was 61.66 ± 7.92, on the 7th day, 91.66 ± 3.33, and at the end of the third week from the beginning of treatment was 95.83 ± 3.33. The data on the 7th and 21st days in the third treatment group were better than the self-administration groups, which also indicated the faster and better recovery of the patients **(Figure 29).**

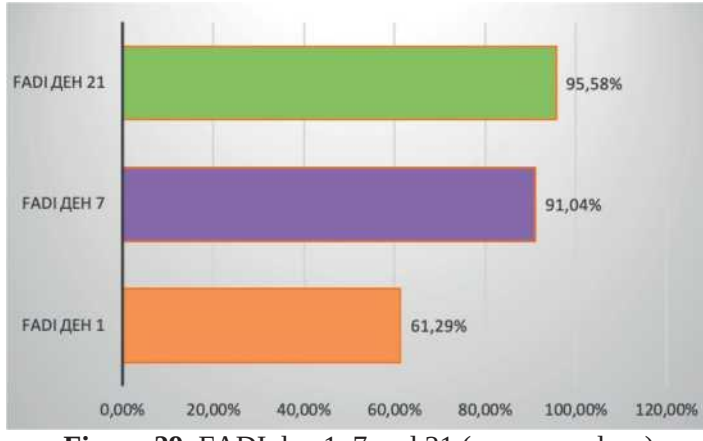


Figure 29. FADI day 1, 7 and 21 (average values), therapy group "PRICE+DO“

4.2.5.1. Inter-group analysis

• ***FADI day 1 (referent)***

In all three intergroup comparisons, the values of Asymp. Sig. (2-tailed) are greater than the significance level a = 0.05. This means that there was no statistically significant difference between the mean percentages reported by the modified daily activities scale on day 1. The test proves an even distribution of patients in the three treatment groups before the start of the treatment **(Table 18)**.

Table 18. Values of Asymp. Sig. (2-tailed) of % FADI per day 1 (referent).

FADI day 1	**Mann-Whitney Test (Asymp. Sig. (2-tailed)**
TG „PRICE“ and „DO“	0,458
TG „DO“ and „PRICE + DO“	0,712
TG „PRICE“ and „PRICE + DO“	0,738

• ***FADI day 7***

At the end of the treatment course (7th day), the reported comparative values show the following results: when comparing the approaches from TG "0" ("PRICE" protocol) and TG "1" (DO therapy), it cannot be claimed which of the two methods is better than the other ie. there is no statistically significant difference between the percentage values reported. Similar results with no statistically significant difference with values of Asymp. Sig. (2-tailed), greater than a=0.05, are also noted between TG "1" (therapy with DO) and TG "2" (combined application of "PRICE" and DO). In the last intergroup comparison, a statistically significant difference was found between the treatment group with the combined application of the factors (TG "2") and the "PRICE" protocol (TG "0"). This shows that the combined administration of "PRICE" and DO improves the performance of daily activities to a greater extent than standard care "PRICE" at 7 days. The obtained results do not exclude the improvement in performance of daily activities found with the FADI scale in each treatment group **(Table 19)**.

Table 19. Values of Asymp. Sig. (2-tailed) of % FADI on day 7

FADI day 7	**Mann-Whitney Test (Asymp. Sig. (2-tailed)**
TG „PRICE“ and „DO“	0,089
TG „DO“ and „PRICE + DO“	0,368
TG „PRICE“ and „PRICE + DO“	0,017

• ***FADI day 21***

At the end of the third week from the start of treatment (21st day), the changes in the performance of the activities of daily life are recorded. The obtained results of the values of Asymp. Sig. (2-tailed) in the between-group analysis were similar to results on day 7. The Mann-Whitney test showed that there was no difference in the therapeutic approaches "PRICE" and DO therapy at day 21. The values of Asymp. Sig. (2-tailed) from the inter-group analysis from the two tests applied show values greater than the significance level a = 0.05, and hence statistical insignificance of the indicators. It cannot be argued which treatment group (TG '0' or TG '1') maintained the trend towards improvement in activities of daily living as measured by the FADI.

The results are similar for TG "1" (therapy with DO) and "2" combined application "PRICE" and DO) with the values of Asymp. Sig. (2-tailed), greater than and lack of statistical significance.

At TG "0" ("PRICE" protocol) versus TG "2" (combined application "PRICE" and DO) a statistically significant difference with Asymp values is established. Sig. (2-tailed), smaller than a=0.05, namely: Asymp. Sig. (2-tailed): 0.009. The reported data show that among patients treated with a complex approach, there was a trend of improvement in the performance of daily activities, as evidenced by statistically significant results of percentage values at day 21 **(Table 20)**.

Table 20. Values of Asymp. Sig. (2-tailed) of % FADI on day 21

FADI day 21	**Mann-Whitney Test (Asymp. Sig. (2-tailed)**
TG „PRICE“ and „DO“	0,165
TG „DO“ and „PRICE+DO“	0,100
TG „PRICE“ and „PRICE+DO“	0,009

CHAPTER V. DISCUSSION

Physical activity is a necessary condition for better mental psycho-emotional health underlying a higher quality of life. Practicing sports-related activities brings not only positives, but is also a prerequisite for negative consequences - injuries of the musculoskeletal system.

One of the common problems in emergency medical care is the distortion of the ankle joint, occurring both during sports and when performing routine physical activities in everyday life. It is a mistake to think that a sprained ankle is a harmless injury with no lasting consequences (McKay GD et al., 2001). It can lead to a decrease in working capacity and physical activity. Often, injured patients report recurrent incidents months and years after the initial injury (Anandacoomarasamy A et al., 2005).

The study is aimed at treating the acute phase of ankle sprain. For its implementation, goals and objectives are set, through which alleviation of symptoms in the early phase of suffering, reduction of recovery time and negative long-term effects, return of the patient's normal rhythm of life and satisfaction in the process of his treatment are achieved. To the study is carried out, the therapeutic effects of the low-frequency pulsed electrostatic field by the method of deep oscillation, the "PRICE" protocol and their combined application are investigated and analyzed.

The described positive trends in the treatment of talocrural joint distortion with the selected physical factor are supported both by clinical methods for assessing the functional state of the ankle joint (circumference and goniometry) and by methods for assessing pain according to the VAS and the modified quality of life scale. life (FADI).

The obtained results correlate with the available studies in the databases, and some of them show superiority in terms of the traceable criteria.

5.1 Analysis of socio-demographic data from the survey

The demographic characteristics of the examined patients in the current dissertation coincide with the data presented in the literature. The largest number are patients in the age range of 18-29 years, which represent 51.67% (n=62). The higher incidence of sprains of the ankle in younger patients is explained by the characteristics of physical development: muscle mass, ability to perform sports movements, hormonal factors and insufficient sensory and motor function of the skeletal-muscular system (Doherty C et al., 2014, Doherty C et al., 2016, Adirim T A et al., 2003; Quatman-Yates CC et al., 2011).

The gender distribution shows that females (55%) have an advantage over males (45%) by 10% (Doherty C et al., 2014). Biological gender is considered a risk factor for ankle sprain due to the prevailing hormonal factors among women (factors that are responsible for higher joint hypermobility) - reduced sensorimotor control, specific behavior patterns in team sports and many others. (Ikarashi K et al., 2020; Wilkerson RD et al., 2000; Doherty C et al., 2014). Evidence for this is found in independent studies conducted in different parts of the world, in which data were found to support the influence of the phases of the menstrual cycle on neuronal excitability in the cerebral cortex and a decrease in the "sensorimotor evoked potential in the ovulatory phase (Ikarashi K et al., 2020). A link between estrogen and connective tissues has also been established, which increases the mobility of joints and muscles and affects the stability of body posture (Yim J et al., 2018). The obtained results of the dissertation correspond to the data from the literary sources.

Social engagement with sports activity or the practice of different types of recreational activities (hobbies) is observed in 100% (n=120) of the study participants. In 75% (n=90) of the cases, the trauma was received during purposeful physical actions, and in 25% (n=30) of the cases - outside the performance of such (Waterman BR, et al., 2010). According to the studied literature sources, ankle sprain is one of the most common injuries associated with sports activity. Almost half of all ankle joint ligament injuries are a result of sports activity (49.3%)

show numerous analyzes worldwide (Waterman BR, et al., 2010; H0lmer P et al. 1994; Bridgman SA et al., 2003; Halabchi F et al., 2020; Lin CI et al., 2021; Garrick JG et al., 1987).

Based on the degree of their physical activity, the patients were divided into three groups - with a high degree of physical activity 15.83% (n=19), with an average degree of physical activity 51.67% (n=62) and with a low degree of physical activity (32.50% (n=39). The data show that the highest number of patients with ankle trauma is observed in the moderate physical activity group. Poor knowledge of internal and external factors, prevention, protection, as well as underestimation of their importance, underlies the high risk of developing this pathology (Verhagen EA et al., 2010; Dizon JM et al., 2020; Hagen M et al., 2017; Fousekis K, 2012; Fousekis K, 2002. , 2012; Mason J et al., 2000; Doherty C et al., 2003).

The results of the specific manual tests performed demonstrated I degree of distortion in 56.67% (n = 68) proven by negative tests and II degree in 43.33% (n = 52) with a positive anterior drawer test. The obtained results correlate with the information available in the databases, in which involvement of the lateral collateral ligament complex is found in 85% of cases (ATFL in 65-85% and CFL 75-85%). The medial collateral ligament complex is more resistant to trauma than the lateral one - accounting for only 5-15% of ankle sprains (Jungmann PM et al., 2023; Fong DT et al., 2007).

5.2. Analysis of the obtained data from the circumference difference (centimetry) of the ankle joint

The difference in circumference of symmetrically measured values of both ankle joints in (cm) gives important information about the presence or absence of soft tissue edema, as well as the degree of damage to anatomical structures.

The results obtained showed a reduction in the swelling of the ankle joint at the end of the treatment (7th) and on the 21st day. The data demonstrate the therapeutic value of each approach and are consistent with the literature.

In the self-administered therapy group of the PRICE protocol, we attribute the reduction in ankle swelling to the combination of protective and therapeutic measures. For example, protection and rest lead to a reduction in increased blood flow in the injured area, evidence for which we find in a number of studies on the effect of standard care for the treatment of ankle sprains (van Rijn RM, 2008; Benca E et al., 2019; Lamb SE 2009; Vuurberg G et al., 2018; Boyce SH et al., 2005). Reduced edema of the ankle joint by compression and elevation methods is evidenced by studies on the effect of elastic bandages and elevation of the limb above the level of the heart, exerting control over the inflammatory exudate formed (Cooke MW et al., 2003; Tsang KK et al., 2003; Sultan MJ et al., 2012; Bilgic S et al., 2015). Application of ice accordingly reduces edema formation by induced vasoconstriction (Bleakley CM et al., 2006, 2007; van den Bekerom MP et al., 2012; Lamb SE et al., 2005).

In the second group for self-administration by the deep oscillation method, we believe that the reduction of soft tissue edema is due to the mechanical oscillations in depth, helping to reduce the stiffness of edemas and hematomas, turning them into easily resorbable substances, as well as the reduction of lymphatic stagnation. In addition to its mechanical impulses, the therapeutic effect of the DO method manifests itself by affecting the endothelial structures of the lymphatic vessels. The collagen fibers of the lymphatic vessels are subjected to forces of elastic deformation, supporting the creation of connective tissue anastomoses in the endothelial structures. Thus semiconditions, enhance drainage function and reduce tissue swelling (Gasbarro, V et al., 2005; Kulikov AG et al., 2013; Reinhold J.2017; Kashilska Y et al., 2015; Gasbarro V et al., 2006; Theys S et al., 2008). Evidence for the value of the applied approach is found in numerous studies of the method, the main ones focusing on minimizing adverse effects among mastectomized patients, including upper extremity lymphedema (Brenke R et al., 1996; Jahr S et al., 2008; Petkov A et al., 2016; Mikhalchik E et al., 2005). Another part of the research is focused on sports and traumatic edemas, where it is proven that the DO method is

more effective than classical manual lymphatic drainage and cryotherapy (Teo, Isabel et al., 2016; Aliiyev R et al., 2009).

Regarding the therapeutic value of the methodology proposed by us (combination of the two treatment approaches), the results obtained from the examined patients are categorical that the swelling of the ankle joint decreases to the greatest extent and fastest with a statistically significant difference in the combination of standard care. PRICE" and DO therapy. We believe that the proven therapeutic effects of the two independent methods are potentiated, leading to better the results in the combined application group compared to the individual groups. The swelling decreases at a greater rate, and the trend is maintained for up to 3 weeks.

5.3. Analysis of the obtained data from the goniometry of the ankle joint

The range of motion in the ankle joint is a basic parameter for evaluating motor and function, as well as in the study and diagnosis of damage in it. In a healthy individual, dorsiflexion represents a 20° angle of movement in the cranial direction, and plantarflexion represents the movement of the ankle joint in the frontal plane with a 45° angle in the caudal direction.

Data from the intragroup analysis showed improvement in range of motion in the three applied treatment methods - the greatest progress with a statistically significant difference was observed among patients treated with the combined application of standard care "PRICE" and deep oscillation. We assume that the improvement is again due to the increased therapeutic value of the combination of the two stand-alone protocols. In the standard care group, protection, rest, compression and elevation reduce the amount of fibrous tissue, prevent re-injury of the ligamentous fibers, creating conditions to lower the risk of adhesions and formation of contractures, at the same time it is easier to return motor volumes in the joint. This statement of ours is also found in reported results of studies on the type of

immobilization of the joint (hard or soft, elastic or not) and the period required to wear the orthosis, as well as the need to use assistive devices (crutches and crutches) (van den Bekerom MP et al., 2012; Bleakley CM et al., 2010; Sultan MJ et al., 2012; Cooke MW et al., 2003; Vuurberg G et al. 2018). By applying ice, not only the formation of soft tissue edema is reduced, but also local analgesia is induced - a circumstance that favors the performance of dosed exercises to improve the range of motion. For example, a study by Bleakley CM and his team convincingly demonstrates the positive effect of cryotherapy on pain reduction and improvement of range of motion among patients with acute distortion of the ankle joint (Bleakley CM et al., 2006, 2007).

The effect of DO therapy in the self-administration group, we believe, is primarily due to the ***antifibrotic properties*** of the therapy. The possibilities of reducing fibrosis are explained on the one hand by the mechanical vibrations in the tissues, as a result of which stimulates the proliferation of fibroblasts, and on the other - with the modulating effect on the secretion of growth factors (TGF-8). Evidence is found in a large number of studies (Gasbarro V et al., 2006; Gao YC et al., 2015; Hernandez Tapanes S et al., 2018; Reinhold J et al., 2014; Reinhold J, 2017; Boisnic S et al. ., 2013), but the most significant is the study of the Gao YC team, which treated a patient diagnosed with fibrous adhesion of the musculi extensor capri ulnaris and extensor digitorum communis of the right elbow more than 35 years ago. After taking a course on the deep oscillation method, the volume of movement of the elbow joint is increased by 30 degrees and the effect of complicated inflammatory conditions leading to fibrotic changes is reduced (Gao YC et al., 2015). It is the anti-fibrotic and anti-edematous properties of the method that are the main factors responsible for the obtained improvements in the functional capacity of the joints. The possibilities for increase in joint range of motion has been proven in publications at different time intervals (Jenifer A et al., 2017 Aliyev R et al., 2009; von Stengel S et al., 2018; Winkelmann ZK et al., 2018; Hinman MR et al., 2013). For example, in 2018 Winkelmann ZK, proves the improvement in the functional activity of

the posterior group of thigh muscles - semitendinosus, semimembranosus, biceps femoris, as well as the increase in the range of motion in the hip joint after the application of deep oscillation therapy (Winkelmann ZK et al., 2018).

5.4. Analysis of the received data from the visual-analog scale (VAS)

According to the International Association, pain is an unpleasant sensory sensation associated with actual or potential damage to the body. It is the earliest symptom of tissue damage or the onset of disease. In order to track it in the state of the musculoskeletal system we are studying, we use the visual analog scale (VAS), which is a continuous horizontal line with a length of 10 cm and two endpoints. Tracking and analysis of VAS results is important to demonstrate both physical and psycho-emotional recovery of the individual. Data from all three within-group analyzes showed a positive trend for reduction of pain from applied therapeutic approaches.

In the "PRICE" standard care group, the analgesic properties are primarily the result of the application of cryotherapy, which reduces secondary hypoxic damage, lowers metabolic demands of damaged tissues and inhibits nerve conduction velocity (Palmer JE et al., 1996; Bleakley CM et al., 2007; Tittley J et al., 2020). Data on a similar analgesic effect, obtained by short periods of ice application during the latter, subacute phase of inflammation, we also find in a study conducted by Bleakley CM and his team on the effect of the "PRICE" protocol.

They concluded that cryotherapy facilitated earlier application of therapeutic exercises (Bleakley CM et al., 2007). According to a number of authors, compression controls the amount of inflammatory exudate and fibrin, thus helping to reduce pain (Sultan MJ et al., 2012; Bilgic S et al., 2015; Rohner-Spengler M et al., 2014).

In the second therapeutic group, the pain-relieving and anti-inflammatory effect of deep oscillation is explained and proven by multiple investigated mechanisms that are observed during its application: reduction of stimulation of ion channels (TRPV1) of nociceptors acting as molecular transducers for depolarization of neurons that cause nociceptive impulses along the pain pathways, decreased amount of stimulating noxes, decreased

amount of prostaglandins and IL-8. Through mechanical oscillations and the influence of low frequencies of deep oscillations on afferent neurons, the spread of pain impulses according to the mechanism of "Gate control theory of pain" and muscle spasm is reduced (Jahr S et al., 2008; Christian et al., 2003; Koleva I, 2008; Aliyev R et al., 2008; Reinhold J, 2017). For example, a study by Korkina, l. and team studies report a decrease in neutrophil migration and free radicals, as well as an increase in antioxidant activity, having a positive effect on limiting inflammation and reducing pain (Korkina L et al.q 2006). Aliyev RM proved the proto-inflammatory and analgesic effect based on the clinical symptoms in patients with ankle injury with the values of the indicators corresponding to the statistical significance (Aliyev RM, 2012). An ex-vivo study in a skin model demonstrated a significant reduction in dilated capillaries and IL-8 in soft tissue (Boisnic S et al.q 2013), and a significant reduction in CRP in patients' blood samples after applied deep oscillation therapy shows the multifactorial anti-inflammatory effect of deep oscillation therapy (Oestervemb K et al.q 2023).

All these evidences support the better results of the application of the combination therapy "PRICE + DO". In this case, the complex approach and the synergism of the modalities shows the more significant decrease in the reported pain values according to the VAS in the third therapeutic group.

5.5. Analysis of the data obtained from the modified scale for carrying out activities of daily living (FADI)

The Modified Activities of Daily Living Scale for Patients with Ankle Impairment (FADI), an important self-report indicator of joint function, was first described in 1999 and is designed to meet the needs of the therapist to detect ankle deficiencies. Clinical data outcomes in orthopedics have traditionally focused on measuring functional activity. Several studies have evaluated the effectiveness and reliability of the scale, and their conclusions are identical - the scale is reliable in detecting functional limitations of the ankle joint (Hale SA et al., 2005; Pugia ML et al., 2001; Martin RL et al., 2007).

Doctors often ignore the psycho-emotional state, paying attention primarily to dysfunction in the ankle joint. The scale makes it possible to

assess both the functional limitation and the subjective emotional attitude of the patients regarding the performance of activities of daily living. It has a total point value of 60 representing 100%. The closer the reported value is to 100%, the better the recovery in papaciets.

An Italian team adapted the FADI questionnaire in 2020 to reduce cultural and linguistic differences. The results obtained reveal a high level of receptivity, assessed by two correlation indices (Pearson CC and Intra-Class CC). The adapted FADI questionnaire is reliable, valid and tailored to different medical diagnoses. This finding leads the research team to present the use of the adapted FADI questionnaire as a reliable instrument that can be used in clinical practice. In addition, an additional PCC analysis was performed with the visual-analogue scale (VAS). The correlation analysis of the Italian FADI with the BAC confirms the validity of the modified scale as well as its importance in determining the effect of pain on the psychological state of patients (Leigheb M et al., 2020).

The data obtained from the current dissertation show that in all three treatment groups, patients improved their activities of daily living both at the end of treatment and at the follow-up of long-term effects (21st) day. The results obtained regarding the reported percentages using the FADI scale demonstrate that all three applied treatment approaches have therapeutic value. The 7th day percentage improvement results are as follows: in the Tr "PRICE" group it is 88.33%, in the "DO" therapy group it is 90.00% and in the "PRICE + DO" group it is 91.66% respectively. On the 21st day, the reported values according to FADI also follow the presented trend, and the values in percentages are respectively: TG "PRICE" - 93.33%, TG "DO" - 93.33% and TG "PRICE + ДО" - 95, 83%. The most significant improvement in the performance of daily activities was observed among patients in therapeutic group "2" (combined application "PRICE" and DO). The indexed one FADI scale is the latest instrument that confirms the established trend towards improvement of objective and subjective limitations of the ankle joint after an acute sprain. The results show once again the superiority of the combined application of standard care "PRICE" + DO over the independent application of the methods.

5.6. Analysis of the data obtained from the established hypotheses

After applying the three therapeutic approaches and the between-group analysis, on the seventh day the first of the hypotheses laid down in the thesis was proven, that the combined therapy using the method of deep oscillation and the PRICE protocol had better results compared to the standard care group PRICE". The obtained results of the intergroup comparison of the indicators: centimeter, dorsiflexion, plantarflexion, VAS pain and modified FADI scale, show statistically significant values (Asymp. Sig. (2-tailed) < the level of significance „a").

In addition, the intergroup comparison of indicators on the 7th and on the 21st day, it also confirmed the second hypothesis put forward in the dissertation, that the two groups for the independent application: TG "PRICE" and TG "DO" do not differ significantly from each other. The data did not exclude the improvement of indicators from the intragroup comparison, but in the intergroup analysis the test results for hypothesis testing proves the statistical insignificance between the two approaches - it cannot be argued which of the two independent methods is a better choice for the treatment of acute talocrural joint distortion. The data correlates with studies available in the databases that prove that there is no definite difference in the effectiveness of applied deep oscillation therapy and the "PRICE" protocol, in patients with acute ankle sprain. The described results noted an improvement in the condition of the patients, but when analyzed, the results were statistically insignificant (Winkelmann Z et al., 2015; Friesen, L, 2010).

The results of the dissertation demonstrate that by day 21, combined therapy reduces the need for additional rehabilitation intervention. These facts also correlate with established guidelines for partial immobilization of the injured limb for up to 3 weeks (Lamb SE, 2009; Vuurberg G et al., 2018; Boyce SH et al., 2005). The last hypothesis laid down in the dissertation, that complex therapy can have a long-lasting effect and reduce the need for repeated rehabilitation, is also partially proven. The database survey of literature sources regarding chronic ankle nonstability shows that approximately half of patients with acute ankle trauma report recurrent pain, swelling, and discomfort during their daily activities 6 months to a year after the accident, and 40% of cases develop chronic ankle instability up to 1 year after the original incident (Herzog MM et al., 2019; Lin CI et al., 2021; Attenborough AS et al., 2014; McCriskin BJ et al., 2015; Hershkovich O et

al., 2015; Wang DY et al., 2020; Desai SS et al., 2022).

Data from the conducted study show that the combined application of deep oscillation therapy combined with a standard care protocol "PRICE" is an appropriate method to improve the symptom complex and functional disorders in the ankle joint. No local or general side reactions from the applied therapeutic factors were observed, and no exacerbation of current symptoms was detected after the procedures were performed. The positive results obtained show that the combined therapy used (the "PRICE" protocol + DO) as well as the parameters of a low-frequency pulsed electrostatic field were correct.

5.7. Limitations of the study

The need for a longer follow-up of patients is considered: at the 6th month and at the 12th month from the start of treatment and the lack of a sufficiently long period of time for follow-up, proving 100% of the assumed third hypothesis. In order to update the information, it is recommended that the study be continued.

CHAPTER VI. CONCLUSION

Ankle sprain is a common injury, but underestimated in its importance. This misconception of the insignificance of the problem is a prerequisite for improperly implemented treatment and insufficient time interval for recovery, which lead to the chronicity of the functional problem, predisposing to financial losses and psycho-emotional destabilization of the patients.

Unsolved questions about the correctness of the prescribed therapy are the reason for the creation of numerous studies in emergency and sports medicine practice. Available studies in the databases found that the standard of care for posttraumatic ankle sprains was most successfully achieved by the application of the protocol “PRICE“.

Based on our knowledge of the physiological effects of physical factors and their potential to influence musculoskeletal injuries, the aim was to study, compare and evaluate the therapeutic effectiveness of the "PRICE" protocol, the low-frequency electrostatic impulse field (DO) and their combined application.

The results of the study show that deep oscillation therapy in combination with standard care provides comprehensiveness from the earliest stage of treatment of the condition to the 21st day. The obtained values are statistically significant and proven by examining the set follow-up parameters (centimeter of the ankle joint, range of motion, pain according to VAC and daily activity (modified FADI scale).

Synergy in the interaction of combination therapy is supported, both by the data from literature sources and by the results of the present dissertation work.

Combined therapy shows a shortening of the recovery time, improves the general and functional condition of the patients, and the effect of the treatment is maintained up to 3 weeks from the beginning of the trauma. The advantages of the method include the easy application and accessibility of the therapy.

The summarized data are pathogenetically justified.

The approved combination therapy approach can be easily implemented in a practical setting in the acute phase of ankle sprain rehabilitation.

CHAPTER VII. EXTRACTS

1. The comparative assessment regarding the presence or absence of immediate and long-term effects of the application of the combined deep oscillation therapy and protocol "PRICE" showed that the effect of the combined application persists until the 21st day after the treatment.
2. The results of the study prove that based on the current follow-up time point (day 21) is not necessary a repeated rehabilitation course of treatment among patients treated in the combination group.
3. Proven therapeutic effectiveness regarding pain, swelling, range of motion and daily functional activity in ankle joint distortion, as in powerful application of deep oscillation therapy, as well as with combined application of DO and standard care.
4. Comparative intragroup analysis proved the superiority of the nature of the applied complex approach involving the method deep oscillation and “PRICE” protocol, compared to the powerful application of these therapeutic factors.
5. The combination therapy with DO and "PRICE" protocol improved functional activity and quality of life among patients faster and more efficiently than self-application of the two methods.
6. No side effects have been identified from the application of these therapy with DO in the group for self-administration and combined one. The method is considered safe and very functional in terms of indications for use.

CHAPTER VIII. CONTRIBUTIONS

1. **Theoretical and methodological contributions**

- For the first time in Bulgaria, a randomized parallel study is being conducted on the effect of the deep oscillation method in talocrural joint distortion.
- The short-term and long-term therapeutic effectiveness of complex deep oscillation therapy in the treatment of talocrural joint distortion has been proven.
- The superiority of the combined application over the single application of deep oscillation therapy and the "PRICE" protocol has been proven.

2. **Practical and applied contributions**

- A new non-invasive method to influence the main symptoms of talocrural joint distortion with reshaped physical factors is approved.

- A protocol was created for conducting therapy with a low-frequency variable electrostatic field applied by the deep oscillation method in patients with ankle joint distortion.
- A new therapeutic method is proposed for the treatment of patients in the acute phase of talocrural joint distortion.
- A new approach is proposed to influence long-term effects, minimizing the possibility of chronicity of the condition and the need for surgical treatment.

CHAPTER IX. PUBLICATIONS RELATED TO DISSERTATIO

1. D. Nedyalkova, M. Mihailova, Ya. Petrov. The place of physical factors in the treatment of ankle sprain. Varna medical forum, item 11, 2022, appendix 2.
2. D. Nedyalkova, M. Mihailova. Main points of diagnosis the diagnosis, treatment and prevention of ankle sprains it's happening. Management and education, item 19, (6), 2023.
3. D. Nedyalkova, M. Mihaylova, The effect of early physical factors on the recovery of an acute ankle sprain: initial results. KNOWLEDGE - International Journal, Vol. 60, 2023.

PARTICIPATION IN SCIENTIFIC FORUMS WITH REPORTS

1. Tenth scientific session for TUTORS and students at Medical College - Varna with international participation. 20-21 October 2022.
2. International Scientific Conference "Education, Science, Economy and Technologies" - June 22-23, 2023, Burgas