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

ABSTRACT

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SCIENTIFIC JURY

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The defense materials are published on the website of the Medical University "Professor Dr. Paraskev Stoyanov" - Varna and are available at the Department of General Medicine at the Medical University "Professor Dr. Paraskev Stoyanov" - Varna.

CONTENTS

LIST OF ABBREVIATIONS USED IN THE TEXT

BAC	visual-analog scale
GS	ankle joint
TO	deep oscillations
DF	dorsal flexion
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 Football League
PRICE	protection, rest, ice, compression, elevation
PTFL	lig. talofibulare posterius
ROS	reactive oxygen species
TT	talar tilt test

I. RELEVANCE OF THE PROBLEM

Physical activity is a prerequisite 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 indispensable part of the everyday life of modern man, both as a hobby and as a professional activity. Despite the many benefits of regular physical activity, there is a serious risk of musculoskeletal injuries during sporting activity. Injuries can also occur in a person's normal daily life, but they are less frequent than those occurring during sport. The recovery and preservation of the motor activity of affected persons is of considerable medical, social and economic importance. Severe injuries can lead to fractures, functional impairment, limited mobility and peripheral nerve damage. Musculoskeletal injuries, especially to the lower limb, limit activities of daily living and the performance of physical or sporting activities. Later in life, they can be a prerequisite various joint disorders.

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

A team of American researchers identified ankle joint distortion as the most common condition in emergency medicine practice with 4.4 million reported visits per year (Caldwell et al., 2013). Almost half of all ankle ligament injuries are the result of sporting activity (49.3%) (Waterman BR et al., 2010). In Europe, the incidence of ankle joint distorsion ranges from 5.3 to 7.0 per 1000 persons per year (Hølmer P et al., 1994). The same condition accounts for up to 10% all emergency department visits daily in the United Kingdom (Bridgman SA et al., 2003) and about one in 10,000 visits (8,000) in (Halabchi F et al., 2020).

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

Approximately 30% of patients with distorsion develop chronic ankle instability. Evidence is found in multiple literature sources. One of these sources (Lin CI et al.) a meta-analysis in 2021 in which the systematic review included a total of 3804 participants between the ages of 15 and 32 years with a history of prior ankle joint distortion (soldiers, students, athletes, and active individuals). Long-term disability in the form of chronic ankle instability was found among 46% - data from 9 to 76% (Lin CI et al., 2021). An assessment of the objective facts in this case confirms beyond doubt that, despite the high incidence of the condition observed, and in assessing the risk of complications, there is as yet no clearly established standard for the optimal treatment of injured ligaments (Garrick JG et al., 1987).

In order to recover quickly and efficiently in the acute phase and to minimize the chronification of the condition at a later stage, the search for new and effective models for early and late rehabilitation, respectively, 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 instrumental methods, physical therapy provides such an opportunity.

II. AIM, OBJECTIVES AND HYPOTHESES OF THE STUDY

2.1. Objective

To comparatively evaluate the effect of electrostatic field by deep oscillation method, "PRICE" protocol and their combined application in early rehabilitation of patients with talocrural joint dys- torsion.

2.2. Tasks

1. To monitor the presence or absence of immediate and long-lasting effects of the combined deep oscillation therapy and the PRICE protocol;
2. To determine the extent to which the combined course of therapy eliminates the need for repeat pro- vention of rehabilitation therapy;
3. To investigate the therapeutic effectiveness of the long-arm oscillation method for the treatment of the main symptoms of ankle joint distortions: pain, swelling, limited range of motion, and daily functional activity;
4. To make a comparative analysis of the therapeutic effects of deep oscillation therapy and con- ventional therapy (PRICE protocol) as a stand-alone therapeutic approach and as a combined treatment.
5. To investigate functional activity and quality of life in the early (inflammatory) phase in patients with ankle joint dys- torias;
6. To investigate the possibility of side effects and adverse reactions during the therapeutic course with deep oscillations.

2.3. Hypotheses

1. We assume that the combined therapy of DO and protocol "PRICE" had better results than the groups with independent application of the methods in terms of the parameters studied;
2. We assume that the results of the two groups for the self-administration of deep oscillation therapy and protocol "PRICE" will not differ significantly from each other in terms of the parameters examined;
3. We assume that the effect of complex therapy is longer lasting and reduces the need for repeated rehabilitation.

CHAPTER III. STUDY MATERIAL AND METHODS

3.1. Subject of the study

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

3.2. Contingent of the study

For the purpose of the study, a total of 120 patients aged 18 to 50 years with clinical manifestations of ankle joint distorsion with a symptom duration of no more than 7 were evaluated. The patients were selected according to certain criteria that met the needs for the present work, namely:

3.2.1. 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 verified by imaging and physical examination talocrural joint dys- torsion, with the presence of clinical manifestations and with a duration of symptoms not more than 7 days;
3. They were consulted by a specialist in orthopaedics and traumatology, who defined the condition as not requiring urgent chiropractic intervention;
4. Patients who do not use topical or oral medications that affect the symptom complex in the post-trauma period;
5. Patients who did not undergo treatment by physical factors in the period after the occurrence of the injury.

3.2.2. Criteria for exclusion from the study

1. Refusal to participate in the study;
2. Patients diagnosed with a bone fracture involving the ankle joint;
3. Patients with proven ligament rupture - ankle joint stabilizers (grade III);
4. Patients with symptomatology more than a week old or chronic recurrent complaints;
5. Patients consulted by a specialist in orthopaedics and traumatology who assessed the condition as requiring urgent surgical intervention;
6. Topical or oral medications administered, influencing the symptom-complex of the disease in the post-trauma period;
7. Comorbidities forming contraindications for physical therapy (systemic neoplastic, infectious, autoimmune diseases, decompensated states, rhythm pathologies, presence of pacemaker);
8. Previous surgical intervention in the ankle area;
9. Inability to understand and follow instructions in the study;
10. Persons under 18 and over 60 years of age;
11. Pregnancy.

3.3. Clinical principle of assessment

In order to achieve the set objectives and solve the set tasks, the necessary data were studied and analyzed:

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

2. Functional status:

- examination of the ankle joint - skin color, deformity;
- palpation performed by the Ottawa ankle rules method to rule out the presence of a fracture;
- BAC pain assessment (visual analogue scale);

- specialized manual tests: anterior drawer test - ADT (anterior drawer test 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 - examines stability of lig. deltoideum;
- centimetry (circumference) of the ankle joint;
- ankle joint angulometry.

3. Patients complete a short form of The foot questionnaire and Ankle Disabilitty Index (FADI).

3.4. Study design

1. *Study period:* 01.04.2022 to 20.09.;

2. *Study site.* Varna, in the Clinic of Physical and Rehabilitation Medicine and the Rehabilitation Department, located on the territory of the St. Marija University Hospital, Varna. "Constantine and Helena";

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

4. All patients were detailed according to *sex, age, functional status* and followed up before the start of treatment, non-intermediately after its end (day 7) and on day 21 from the start of treatment;

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

6. Patients are included in the treatment group in the order of presentation for examination, with the selection step for the combined application of therapeutic modalities being through two, i.e. every third patient falls into group "2".

Therapeutic group "0" (applied protocol "PRICE"); Therapeutic group "1" (applied monotherapy with deep ossi-
lation);

Therapeutic group "2" (combined therapy with deep oscillation and protocol "PRICE");

7. The survey data were organized in MS Office Excel 2021 and SPSS Statistics for Windows v. 26.0 was used for the analysis.

3.5. Methods of study

3.5.1. Clinical and functional examination

3.5.1.1. Anamnestic data

The data are taken from the information given by the patient, from the available medical records: an examination by a specialist in orthopaedics and traumatology, who describes the condition as not requiring the application of surgical treatment, and radiography, which excludes the presence of a fracture in the ankle joint area. The age of the incident and the nature and intensity of the complaints were of decisive importance.

3.5.1.2. Functional status

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

Palpation of a painful area is intended to help identify injury in specific areas or structures. If palpatory pain is present in any of the areas on the Ottava Ankle Rules, the patient is suspicious for a fracture and an X-ray is appropriate.

Assessment of spontaneous and palpatory pain by BAC:

The visual analog scale (VAS) is designed to measure pain intensity. It is a continuous scale in the form of a horizontal or vertical line 10 cm long with two endpoints located on it: 'no pain' and 'extreme pain', which only be imaginary. The patient is asked to place a line perpendicularly crossing the visual-analogue scale at the point corresponding to his pain intensity. The following scores and pain levels are used to report results: 0 - no pain, 1-3 - mild pain, 4-6 moderate pain, 7-10 severe pain.

Specialized manual tests:

- **Apterior drawer test (ADT).** The front drawer test follows the lig stability. talofibulare anterior. To perform the test, the patient lies supine, the knee joint is in flexion, and the ankle joint is in 10-15° of plantar flexion. The heel is grasped, the patient's tibia and fibula are stabilized with the other hand, and the leg is pulled forward. On a positive test, increased anterior translation is felt compared with the contralateral ankle; a dimpling may also be seen along the anterolateral projection of the talus **(Figure 1).**

(a) Front view (b) Side view

Figure 1. Front drawer test (Anterior drawer test)

- **Talar tilt test (TT).** The inversion stress test examines the status 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 rotated inward. The eversion forces from the test load the *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 (**Fig. 2. a)** .

- **Eversion thalar-tilt (stress) test.** This stress test examines the stability of lig. deltoideum. To perform the test, the patient lies or sits comfortably, the knee is flexed at 90 degrees, and the m. gastrocnemius is relaxed. The heel is held with one hand while the other hand holds the distal aspect of the lower leg. Keeping the ankle in a neutral position, an abduction movement is applied along the calcaneus axis, this is to perform a movement in the talus **(Fig. 2. b)** .

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

Figure 2. Inversion and eversion stress test.

Sanitometry: the circumference of the ankle and foot gives information about the presence or absence of soft tissue oedema. The measurement is symmetrically for both feet. For this purpose, a tailor's caliper is , taking into account the difference in circumference between the two malleoli of the ankle and the metatarsals of the foot.

Angulometry: joint range of motion is a key parameter for the assessment of motor function and the examination and diagnosis of impaired function. The measurement is carried out with a device-angle meter, SFTR-method is used, taking into account the movement of the joint in different planes: S - sagittal, F - frontal, T - transversal, R - rotation. The ankle joint performs movement in the sagittal direction. The angulation in a healthy patient is S 20-0-45, 20° dorsal flexion and 45° plantar flexion.

3.5.2. The foot and ankle disability index (FADI) modified ankle joint functional limitation scale

We use a modified scale of The Foot and Ankle Disabilitty Index (FADI), which consists of 15 questions divided into two categories: the *first category* consists of 11 questions related to perform- the activities of everyday life. The assessment is carried out as follows: 0 - impossible to perform, 1 - extremely difficult, 2 - medium difficulty, 3 - slight difficulty, 4 - no difficulty.

The second category consists of 4 questions and assesses the degree soreness in the ankle joint. It is scored as follows: 0 - unbearable pain, 1 - severe pain, 2 - moderate pain, 3 - mild pain, 4 - no pain.

The result is reported with the following formula:

Total score:_____ /60 pts x 100= %

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

3.6. Methods of treatment

Patients in all three groups received treatment on 7 consecutive days - a daily, single administration of each factor. The results were recorded in the respective individual patient protocols before the start of treatment, after the completion of the treatment course (7th day), and on the 21st day after the start of therapy.

- Therapeutic group "0" underwent standard treatment of ankle joint distorsion - protocol " PRICE". The injured leg can be protected by restricting movement in the joint or by limiting the own weight; the use of crutches, a cane or a hiking cane is recommended. Immobilisation of the joint using rigid immobilisation is desirable. Elevation and compression are intended to minimise developing traumatic soft tissue oedema. Elevating the injured limb to the of the heart or higher allows the excess amount of

the interstitial fluid is 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 sec with a pause period for a total time of 2-3 min.

- Therapeutic group "1". Patients were subjected to monotherapy using the deep oscillation method. The therapeutic course is performed with the device of the German company Physiomed **(Figure 3)** . The working frequencies used consistently are 120-180 Hz - 5 min, 14-30 Hz - 5 min, 85 Hz - 5 min.

Figure 3. Deep oscillation device of the German company Physiomed

- Therapeutic group "2". Patients receive combination therapy. The "PRICE" protocol is applied, followed by therapeutic deep oscillations with operating frequencies 120- 180 Hz -5 min, 14-30 Hz - 5 min, 85 Hz - 5 min **(Figure 4)**.

Figure 4. Therapy with deep oscillation device

3.7. Statistical methods

The following statistical methods were used in the processing of the data obtained from this dissertation:

3.7.1. Descriptive (descriptive) methods

- Alternative analysis. Represents a structural distribution of the variables;
- Variance analysis. The quantitative variables are represented by mean (Me) and interquartile range (IQR);
- Graphical methods to compare and illustrate the statistical results obtained;
- Statistical estimation methods. Determined for 95% confidence intervals for means and relative proportions.

3.7.2. *Methods for testing hypotheses*

The parameters monitored were: centimetry, dorsal flexion, plantar flexion, VAS scale scores, and FADI scores.

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 normality check was performed on the samples in the three treatment groups (TG PRICE, TG TO and TG "PRICE+ TO") for the five criteria (centimetry, dorsal flexion, plantar flexion, VAS and FADI) at the three time points (day 1, day 7 and day 21) using the Kolmogorov- Smirnov test;
- The results of the Kolmogorov-Smirnov test required the use of Me and IQR in establishing baseline numerical characteristics in patients treated under three therapeutic approaches;
- The resulting numerical characteristics were used to perform within-group analysis;
- The results obtained from the Kolmogorov-Smirnov test necessitated the use of a non-parametric Mann-Whitney U test in performing the between-group analysis;
- The sampling uniformity on day 1 (statistically insignificant between-group difference) across the three different therapeutic approaches served as the control for the between-group comparison;
- A between-group comparison of therapeutic approaches was performed at the end of treatment and at 21 days. Depending on whether or not there is a statistically significant difference when comparing one therapeutic approach versus another, conclusions are drawn about the treatment effect;
- All statistical tests are performed at the significance level (first-order error);
- The survey data were organized in MS Office Excel 2021, and IBM SPSS Statistics for Windows v. 26.0 was used for the analysis.

CHAPTER IV. RESULTS

4.1. Socio-demographic characteristics of the study subjects

For the purpose of the study, 120 individuals were surveyed. =The frequency distribution by age was as follows.
and 18, 33% (n= 22) in the age range 40-50 years **(Figure 5)** .

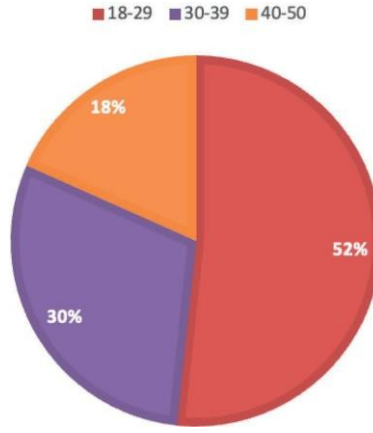

Figure 5: Distribution of patients by age

The study involved 54 men and 66 women. The gender distribution shows that the female gender (55%) prevails over the male gender (45%) by 10% **(Figure 6)**.

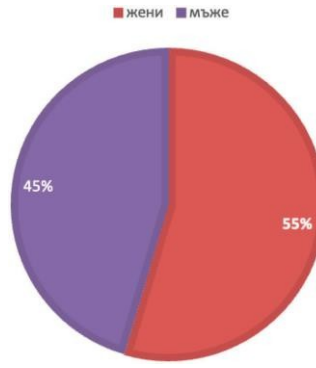

Figure 6: Distribution of patients by sex

When studying the social structure of the study subjects, it was found that the group with the largest number was the group of employees (workers), exercising different types of physical or mental labor in their work activities - from those working mainly at a desk (doctors, accountants, teachers, etc.) to employees with a medium level of physical exertion (suppliers, waiters, cooks, etc.); these patients represented 83.33% (n = 100) of the sample. The remainder of the study participants were students, representing 9.17% (n= 11), and actively in sporting activities (athletes), 7.50% (n= 9) **(Figure 7)** .

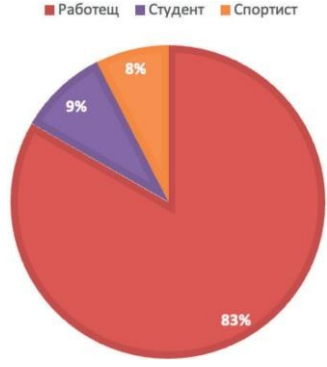

Figure 7: Distribution of patients by social status

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

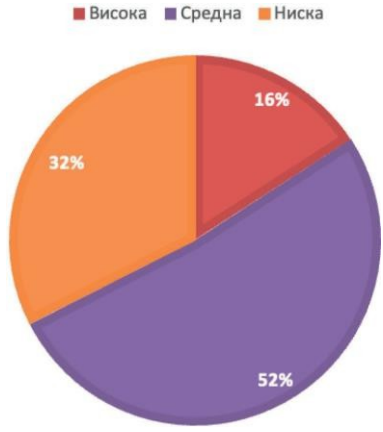

Figure 8: Distribution of study subjects by level physical activity

The study found that the cause of distorsion in a higher of affected individuals, 75% (n= 90), was an injury sustained during a sporting activity, and in 25% (n= 30) it was sustained during routine daily activities outside of the patients' sports or hobbies **(Figure 9)**. The results showed that 100% of the cases were associated with excessive loading of the ankle complex and with displacement of motion outside the normal biomechanics of the joint.

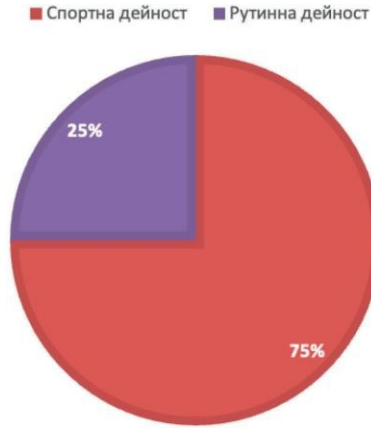

Figure 9. Distribution of patients by cause of trauma

After applying the manual diagnostic tests to report ankle lig stability. talofibulare anterior, lig. calcaneofibulare and lig. deltoideum, the following distribution was found. The data showed that 52 patients had grade II ligamentous damage of lig. talofibulare anterior, and 68 of them had grade I sprain without ligament integrity disorder **(Figure 10)** .

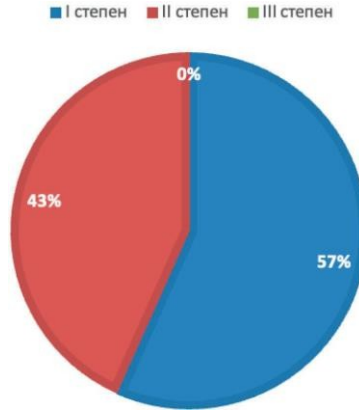

Figure 10. Distribution by degree of ligamentous damage

4.2. Characteristics of the results obtained from the within-group and between-group analysis of the subjects

The following results were found from the Kolmogorov-Smirnov test: normally distributed samples or Asymp. Sig. (2-tailed) values greater than the significance level at:

- Day 1 in all three therapy groups and on day 7 in the PRICE therapy group and the TO therapy group, with the results of the ankle joint circumference recorded;
- 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 on the modified FADI Activities of Daily Living Scale scores.

The remainder, most of the samples, have Asymp. Sig. (2-tailed) values less than the significance level and cannot said to be normally distributed.

The results obtained from the Kolmogorov-Smirnov test to the normality of the samples required the use of the median-mean (Median-Q2) and interquartile range for variance (IQR- Q3-Q1) when performing within-group analysis and the application of the Mann-Whitney U test when performing between-group analysis.

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

The first indicator tracked represents the difference in circumference of the symmetrically measured values of the two ankle joints in centimeters (cm). Values were recorded at the beginning of treatment, at the end of treatment (day 7) and on day 21 to ascertain the presence or absence of dynamics in ankle joint circumference and soft tissue swelling.

Taking into account the main numerical characteristics of the measurements of the GS of the patients treated in the treatment group

"0" (standard of care "PRICE"), "1" (therapy DO) and "2" (combined administration of "PRICE" and DO) at the three time points, the following means (Me) and interquartile range (IQR) were found **(Table 1)** .

Table 1. Main numerical characteristics of the patients centimetry on day 1, day 7 and day 21 in TG "0", "1" and "2".

THERAPEUTIC GROUP	N	Me (Q2) ± IQR(Q3-Q1)		
		CM Day 1	CM Day 7	CM Day 21
0 "PRICE"	40	2,25 ± 1,50	2,00 ± 1,00	1,00 ± 0,50
1 "TO"	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, the mean value of the difference in ankle circumference 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 of therapy it was significantly lower - 1.00± 0.50. The dynamics of the mean values is similar TG "1" and "2", where the following mean values of the circumference in cm are reported: in TG "1" (therapy DO) the baseline mean 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 value is the lowest on the 21st day - 0,50± 0,50. In the combined administration group ('2'), the mean value at the beginning treatment was 2.50 ± 1.00, on day 7 it was 1.00 ± 1.00, and at the end of the third week from the start of the incident it was 0.50± 0.375. The obtained results show that in each of the treatment groups the ankle joint circumference decreased at the end of the treatment (7) and at the follow-up of the duration of the effect of the therapy on day 21, which is evidence that all three applied treatment approaches have therapeutic value, although manifested in different degrees. The best results and the greatest reduction in edema were observed among patients in treatment group "2" (combined administration of "PRICE" and DO) **(Figure 11)** .

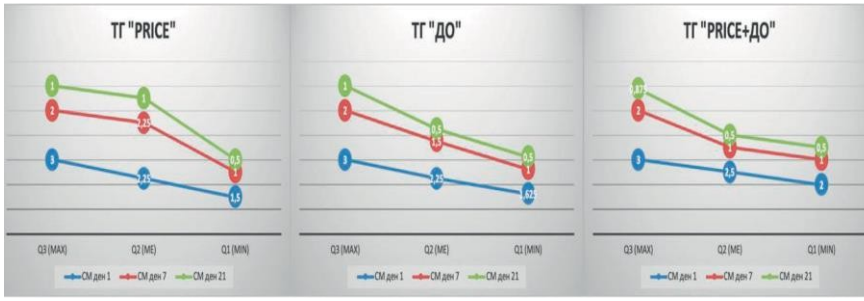

Figure 11. Sentimetry, Me (Q2), IQR (Q-Q1)
day 1, day 7 and day 21 in TG "0", "1" and "2"

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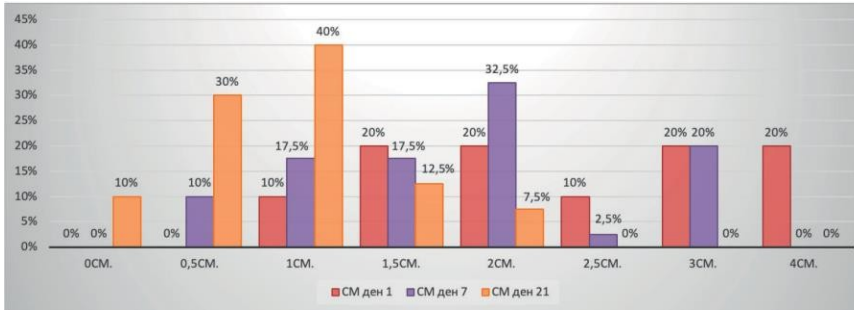

Figure 12. Tour of GS day 1, 7 and 21, treatment group "PRICE"

In the self-administered deep oscillation therapy group on day 1, the largest percentage of patients had a 2 cm difference in GS circumference, representing 25% (n = 10), 4 cm in 20% (n= 8), and 3 cm in 17.5% (n= 7) of patients; only 10% (n= 4) represented patients with 1 cm of GS edema. At the end of treatment, there was a decrease the percentages of patients with 4 cm GS edema from 20% to 0%, 3 cm from 17.5% to 15% (n= 6). The percentage of patients with 1 cm of GS edema increased from 10% to 25% (n= 10) and 0.5 cm from 0% to 20% (n = 8). Data showed that edema in the treatment group decreased after the administration of deep oscillation therapy. At day 21, the largest difference reported was 1.5 cm in 12.5% (n= 5) of patients, absent edema was observed among 17.5% (n= 7) of patients, and the highest percentage was 45% (n = 18) of patients with 0.5 cm of ankle joint edema **(Figure 13)** .

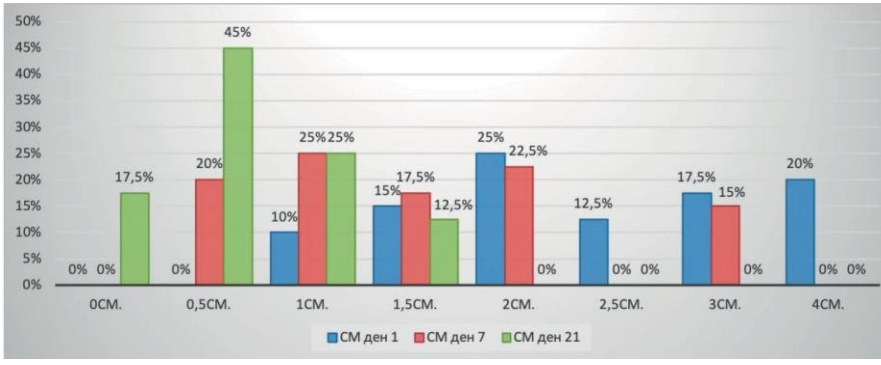

Figure 13. Tour of GS day 1, 7 and 21, treatment group "TO"

In the combination therapy group, the percentages on day 1 were as : 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) of patients, 3 cm in 20% (n= 8) and 4 cm in 17.5% (n= 7) of patients. On day 7, the percentage of patients with 4 cm GS edema decreased from 17.5% to 0%, 3 cm from 20% to 10%. There was an increase
the percentage of patients with 1 cm from 10% to 40% and 0.5 cm from 0% to 22.5%. The results showed that after the application of the therapeutic course the edema

of the SG decreases. The results persisted through day 21 of treatment, where the highest percentage, 52.5% (n= 21) of patients with 0.5 cm edema was observed, and absent edema was reported in 22.5% (n= 90) of the results **(Figure 14)** .

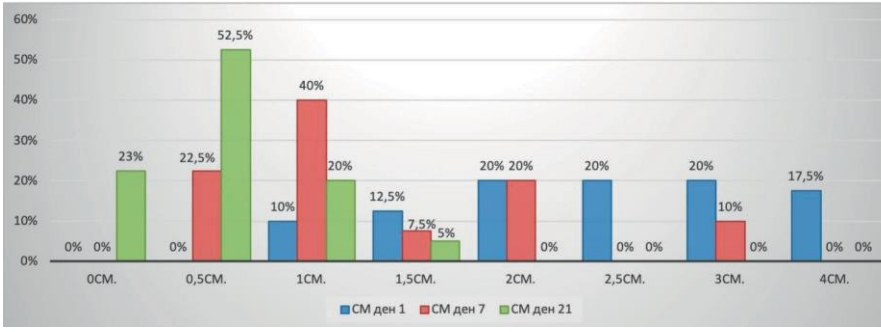

Figure 14. Tour of GS day 1, 7 and 21, treatment group "PRICE+DO"

4.2.1.1. Intergroup analysis

- ***Santimetry day 1 (control)***

To properly report the results and prove the hypotheses, it is necessary to set a starting point for the comparisons and to prove the equality of the indicators on day 1 between the three treatment groups.

The obtained numerical characteristics of Asymp. Sig. (2-tailed) from the Mann-Whitney U test were greater than the significance level α= 0.05. There was no statistically significant difference in the reported values of Asymp. Sig. (2-tailed) of the GS circumference in the between- du-group analysis of the results. These data prove sampling uniformity on day 1 - the groups are homogeneous. In this case, the patients were allocated according to the inclusion and exclusion criteria (on a case-by-case basis), and the treatment groups were indistinguishable from each other on the reported ankle joint circumference criterion **(Table 2)** .

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

Santimetry day 1	Mann-Whitney test (Asymp. Sig. (2-tailed)
TG "PRICE" and "TO"	0.922
TG "TO" and "PRICE+ TO"	0.822
TG "PRICE" and "PRICE+ TO"	0.784

- ***Santimetry day 7***

The examination of the ankle joint circumference continues on day 7. The results obtained represent the immediate outcome of the different therapeutic approaches. The Mann-Whitney U test found that there was no statistically significant difference between TG "0" (standard care "PRICE") versus TG "1" (DO therapy), the resulting value of Asymp. Sig. (2-tailed) was 0.092, respectively. Similarly, when comparing TG "1" (therapy with DO) versus "2" (combined administration of "PRICE" and DO), the value of Asymp. Sig. (2-tailed) was greater than the significance level $\alpha = 0.05$. The comparison between TG "0" and TG "2" revealed the presence of statistically significant difference, namely 0.006. The data do not exclude the reduction of ankle joint circumference in each treatment group. The observed results show that when comparing the TG "0" (PRICE protocol) and TG "1" (DO therapy) approaches, it cannot be stated which of the two methods is better in terms of reduction in ankle joint circumference and swelling at the end of treatment, as there is no statistically significant difference between them. The analysis of results between TG "1" (DO therapy) and TG "2" (PRICE protocol and DO) was similar. In the comparison of the combined factor administration therapy group (TG "2") and the standard care group (TG "0"), there was a statistically significant difference in the indicators reported with an Asymp. Sig. (2-tailed) value less than $\alpha = 0.05$. This indicates that the combined application of "PRICE" and DO reduced ankle circumference and swelling to a greater extent than the standard care "PRICE" applied, or TG "2" was superior to TG "0" **(Table 3)** .

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

Santimetry day 7	Mann-Whitney test (Asymp. Sig. (2-tailed)
TG "PRICE" and "TO"	0.092
TG "TO" and "PRICE+ TO"	0.287
TG "PRICE" and "PRICE+ TO"	0.006

- ***Santimetry Day 21***

The results obtained from the between-group comparison of the numerical characteristics (Asymp. Sig. (2-tailed) by the Mann- Whitney U test on day 21 reported the presence or absence of a prolonged effect, reduction in GS circumference and edema from the administration the three therapeutic approaches. The test confirmed that there was no statistically significant difference between TG "0" "PRICE" and TG "1" (therapy with DO), the recorded value of Asymp. Sig. (2-tailed) was 0.051. The result was similar for TG "1" and "2" (combined administration of "PRICE" and DO) with a value of Asymp. Sig. (2-tailed) = 0.224 greater than the α= 0.05 significance level. The results did not exclude the reduction of ankle joint pain and swelling at day 21 post-injury in the self-administration groups, TG "0" ("PRICE") and TG "1" (DO therapy). There was a statistically significant difference with an Asymp. Sig. (2-tailed) value less α= 0.05, : Asymp. Sig. (2-tailed): 0.002, in TG "0" vs. and TG "2". Data demonstrate that among patients treated with a complex approach (PRICE protocol and DO), the trend of edema reduction was maintained up to 3 weeks with statistical significance, compared to the PRICE protocol alone group (TG "0") **(Table 4)** .

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

Santimetry day 21	Mann-Whitney test (Asymp. Sig. (2-tailed)
TG "PRICE" and "TO"	0.051
TG "DO" and "PRICE+DO"	0.224
TG "PRICE" and "PRICE+DO"	0.002

4.2.2. Dorsal flexion (DF) values tracked across the three treatment groups, at three time points. Between-group analysis

Dorsal flexion accounts for the movement of the ankle joint in the frontal plane. In a healthy individual it represents a 20° angleof movement in the cranial direction. The main numerical characteristics (Median and IQR) of the ankle joint motion measurements (dorsal flexion) in degrees reported an increase in the movement of the GS among the patients in the three treatment groups (**Table 5)** .

Table 5. Numerical characteristics of dorsal 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)		
		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 "TO"	40	10,00± 5,00	15,00 ± 10,00	15,00± 5,00
2 "PRICE+ TO"	40	10,00± 5,00	15,00± 5,00	20,00± 5,00

On day 1, the means in all three treatment groups were the same 10.00± 5.00. At the end of the treatment, the degrees of dorsal flexion showed a tendency to increase in the volume of , and after 3 weeks the means were even higher.

In TG "0" (standard of care "PRICE") at the end of treatment, the mean values of movement volume increased to 12.50± 5.00 degrees, on the 21st day, values up to 15.00±5.00 were recorded.

At the end of the therapy (7th day) in TG "1" (therapy DO) the mean values increased to 15,00± 10,00, and on the 21st day the values remained relatively the same with a tendency to an increase in the volume of movement evidenced by a decrease in the interquartile range values 15,00 ± 5,00.

An identical movement of the indicators was also reported in TG "2" (com- bined application "PRICE" and DO), where the values of the angle dorsal flexion increased gradiently from 10.00 ± 5,00 on the first day to 15,00± 5,00 at the end treatment and 20,00± 5,00 at follow-up of long-term trends on day 21, where the greatest increase in degrees of dorsal flexion was also observed (**Figure 15)** .

Figure 15. Dorsal ankle joint flexion, Me (Q2), IQR (Q3-Q1) at day 1, day 7 and day 21 in TG "0", "1" and "2"

In the PRICE treatment group, 16 patients (40%) were found with 5 dorsal flexion, 20 patients (50%) with 10, 4 patients (10%) with 15 DF on day 1. After completion of the treatment course, there was an increase in the number of patients who increased their degrees of - 35% (n= 14) reached 15 DF and 15% (n= 6) reached full range of motion of 20 DF. There was also a decrease in the number of patients with a 5 DF restriction from 40% (n= 16) to 5% (n= 2). On day 21, there was an increase in the number of patients reaching 15 - 47.5% (n= 19) and 14 patients (35.5%) with an established full range of motion of 20 **(Figure 16)** .

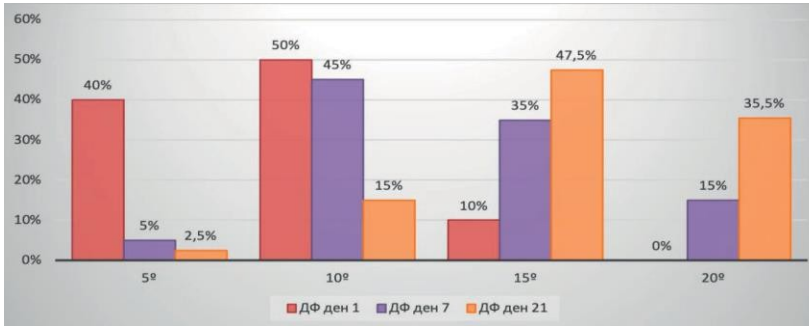

Figure 16. Dorsal flexion of GS day 1, 7 and 21. Therapeutic group "PRICE"

In the therapeutic group for self-administration of deep oscillation, 42.5% (n= 17) of patients were found to have 5 DF, 50% (n= 20) with 10, and 7.5% (n= 3) with 15. The number patients during day 7,

reaching 15- 42.5% (n= 17), and 20- 27.5% (n= 11), patients with 5 DF are missing. Patients reaching full range of in DF, 47.5% (n= 19), were observed at follow-up for long-term outcomes at day 21 **(Figure 17)** .

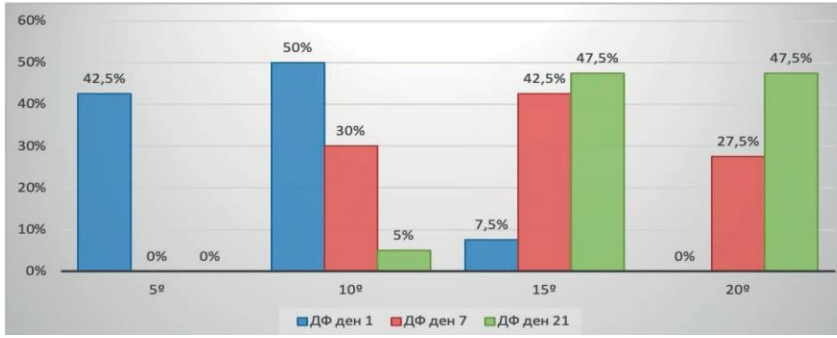

Figure 17. Dorsal flexion of GS day 1, 7 and 21.
Therapeutic group "TO"

In the third treatment group "PRICE + DO", the same trend was found - a reduction in the number of patients at the end of treatment (day 7) by 5 DF from 37.5% (n= 15) to 0%, 10 DF from 52.5% (n= 21) to 17.5% (n= 7), increasing 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 outcome was maintained at follow-up of exercise volume at day 21, where 57.5% (n= 23) of patients reached full exercise volume of 20 DF **(Figure 18)** .

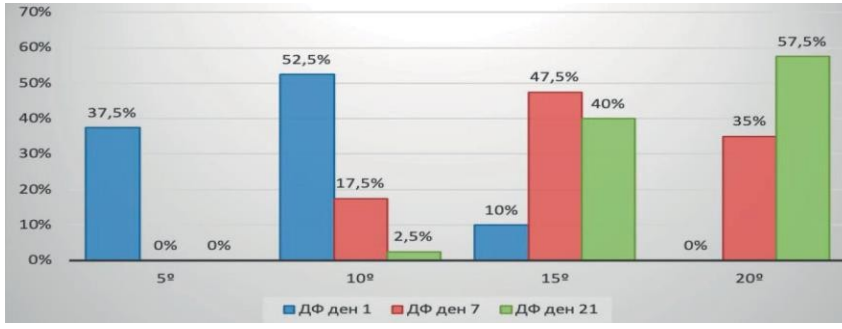

Figure 18. Dorsal flexion of GS day 1, 7 and 21.
Therapy Group "PRICE+ TO"

4.2.2.1. Intergroup analysis

- ***Dorsal flexion day 1 (control)***

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

Table 6. Asymp. Sig. (2-tailed) values of dorsal flexion of GS on day 1 (Control)

Dorsal flexion day 1	**Mann-Whitney test (Asymp. Sig. (2-tailed)**
TG "PRICE" and "TO"	0.748
TG "TO" and "PRICE+ TO"	0.602
TG "PRICE" and "PRICE+ TO"	0.847

- ***Dorsal flexion day 7***

At the end of the 7-day treatment course, the data of the three therapeutic approaches and the increase in the degrees of motion in ankle dorsiflexion were reported. The results of the Mann- Whitney U test confirmed that there was no statistically significant difference between: TG "1" (therapy with DO) and "2" (combined administration of "PRICE" and DO), the values of Asymp. Sig. (2-tailed) were greater than the significance level α = 0.05. For 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 argued 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 dorsal flexion after application of the two therapeutic approaches, the values obtained from the comparison are close and have no statistical significance.

The results of the between-group comparison of TGs "0" (application of "PRICE") and "2" (combined application of "PRICE" and DO) are sta-

statistically significant, with an Asymp. Sig. (2-tailed) value less than the significance level α = 0.05. The analysis of the obtained results, pro- tecting the changes in the range of of the dorsal flexion, vides that the combined application of DO and "PRICE" leads to a more significant increase in the ankle jointangleofmotion in the cranial direction with statistical significance **(Table 7)** .

Table 7. Asymp. Sig. (2-tailed) values of dorsal flexion of GS on day 7

Dorsal flexion day 7	**Mann-Whitney test (Asymp. Sig. (2-tailed)**
TG "PRICE" and "TO"	0.042
TG "TO" and "PRICE+ TO"	0.236
TG "PRICE" and "PRICE+ TO"	0.002

- ***Dorsal flexion day 21***

At the end of the third week from the start of treatment (21-days), changes in ankle joint motion are reported. The test results showed that there was no significant difference in therapeutic approaches
"PRICE" and DO therapy. The volume of motion retained its positive increase in degrees, but the reported values of Asymp. Sig. (2-tailed) were greater than the significance level α = 0.05, and hence the statistical insignificance of the indices. The results were similar for TGs "1" (treatment with DO) and "2" (combined application of "PRICE" and DO) with a value of Asymp. Sig. (2-tailed)= 0.343 greater than statistical significance.

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

Table 8. Asymp. Sig. (2-tailed) values of dorsal flexion of GS on day 21

Dorsal flexion day 21	Mann-Whitney test (Asymp. Sig. (2-tailed)
TG "PRICE" and "TO"	0.115
TG "DO" and "PRICE+DO"	0.343
TG "PRICE" and "PRICE+DO"	0.016

4.2.3. Plantar flexion (PF) values monitored in the three treatment groups, at three time points. Between-group analysis

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

Taking into account the main numerical characteristics (Me± I QR) of the measurements made of plantar flexion of the ankle joint in degrees on day 1, day 7 and day 21 of the patients treated with the therapeutic approach TG "0" (standard care "PRICE"), TG "1" (therapy DO) and TG "2" (combined application "PRICE" and DO), ascending dynamics of the indicator was found **(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 "TO"	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 results in an increase in the range of motion in the ankle joint. On day , the numerical characteristics in the three treatment groups were the same. Increases in range of motion were observed at the end of treatment and on day 21. In TG "0" (standard care "PRICE") the mean value of plantar degrees

flexion changed from 15.00± 5.00 on day 1 to 25.00± 5.00 at the end of treatment, and an even greater increase in measured degrees was reported on day 21 - 35.00± 5.00. The values in TG "1" (therapy DO) were similar. The baseline mean value of the plantar flexion index 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 twofold increase compared to the baseline results for the group - 35.00 ± 10.00.

The mean values of the degrees of movement of 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. Plantar flexion of ankle joint, Me (Q2), IQR (Q3-Q1) on day 1, day 7 and day 21 in TG "0", "1" and "2"

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

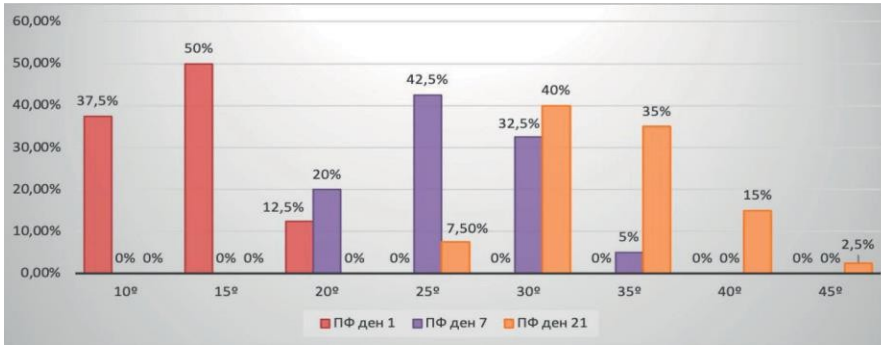

Figure 20. Planar flexion of GS day 1, 7 and 21.
Therapeutic group "PRICE"

In the second treatment group, self-administration of deep oscillation therapy, there were 55% (n= 22) patients with 15 PF, 31.5% (n= 13) with 10, and 12.5% (n= 5) patients with 20 reported PF on day 1 before administration of a therapeutic course. There were no patients with 10 and 15 PF at the end of treatment on day 7. The number of patients reaching 20 remained unchanged, but 40% (n= 16) reached a PF of 25, 42.5% (n= 17) reached a PF of 30, and in 5% (n= 2) a PF of 35 was measured. The trend in improvement of exercise volume was found at day 21, where the lowest measured PF was 30 in 32.5% (n= 13) patients. The highest percentage was 35 PF representing 40% (n= 16) patients. And 7.5% (n= 3) patients reached full range of motion **(Figure 21)** .

Figure 21. Planar flexion of GS day 1, 7 and 21.
Therapeutic group "TO"

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

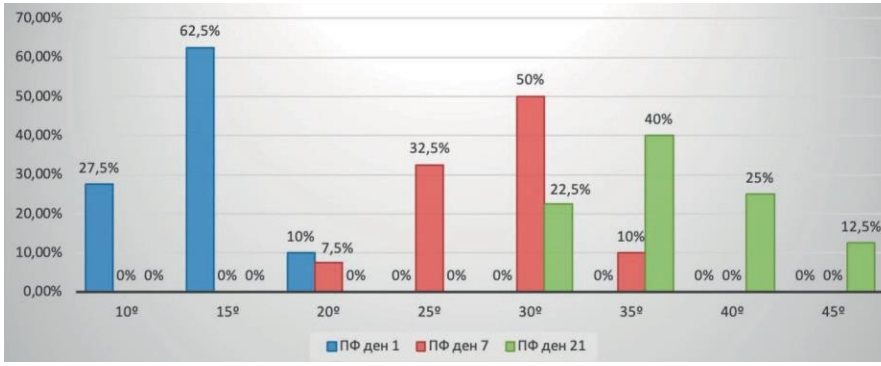

Figure 22. Planar flexion of GS day 1, 7 and 21.
Therapy Group "PRICE+ TO"

4.2.3.1. Intergroup analysis

- ***Plantar flexion - day 1 (control)***

The data obtained from the between-group analysis by the Mann-Whitney U test on day 1 showed Asymp. Sig. (2-tailed) values greater than the α= 0.05 significance level. In all three between-group comparisons, the values indicate that there was no statistically significant difference between the means for plantar flexis on day 1. The Mann-Whitney U test confirmed the similarity of baseline angulometry values when considering ankle joint motion restriction in the three treatment groups **(Table 10)** .

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

Plantar flexion day 1	Mann-Whitney test (Asymp. Sig. (2-tailed)
TG "PRICE" and "TO"	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 of the Mann-Whitney U test do not reflect the increase in ankle joint degrees of motion in each treatment group, but the data obtained show that when comparing the approaches of TG "0" (the "PRICE" protocol) and TG "1" (DO therapy), it cannot be stated which of the two methods is better than the other in terms of increasing the arc of motion, as there is no statistically significant difference between the values obtained. Similar results with no statistically significant difference with Asymp. Sig. (2-tailed) values greater than $\alpha = 0.05$ were also noted between TG "1" and TG
"2". In the third between-group comparison, there was a statistically significant difference between the treatment group with combined application of the factors (TG "2") and the "PRICE" protocol (TG "0"). This indicates that combined application "PRICE" and DO increased ankle joint motion degrees to a greater extent in comparison with the standard care "PRICE" applied **(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 "TO"	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 within-group analysis noted that there was no significant difference in the PRICE and DO therapy approaches. The range of motion maintained its positive increase in degrees, but the reported value of Asymp. Sig. (2-tailed) was greater than the significance level of $\alpha = 0.05$, and hence the statistical insignificance of the indicators. The results were similar for TG "1" (therapy with DO) and "2" (combined administration of "PRICE" and DO) with a value of Asymp. Sig. (2-tailed) = 0.236 greater than $\alpha = 0.05$, proving the lack of statistical significance.

For TG "0" (PRICE protocol) vs. and TG "2" (combined PRICE and DO application), there was a statistically significant difference with an Asymp. Sig. (2-tailed) value less than $\alpha = 0.05$. The reported data show that among the patients treated with the complex approach, there is an increase in the degrees of ankle joint motion in the caudal direction, as evidenced by the better results in the established angulometry and statistically significant values of the results **(Table 12)** .

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

Plantar flexion day 21	**Mann-Whitney test (Asymp. Sig. (2-tailed)**
TG "PRICE" and "TO"	0.092
TG "TO" and "PRICE+ TO"	0.236
TG "PRICE" and "PRICE+ TO"	0.006

4.2.4. Visual analogue scale values tracked across the three treatment groups, at three time points. Between-group analysis

The visual-analogue scale is a horizontal line with a fixed length of 10 cm, designed to measure the intensity of pain. The data obtained from the mean values (Me± IQR) for ankle joint motion showed a progressive decrease in the reported pain intensity along the BAC at the end of treatment (day 7) and at the

follow-up of the long-term effects of therapy in each group, regardless of treatment method **(Table 13)** .

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

THERAPEUTIC GROUP	N	Me (Q2) ± IQR(Q3-Q1)		
		YOU Day 1	YOU Day 7	YOU Day 21
0 "PRICE"	40	4,00 ± 1,00	1,00 ± 3,00	0,00 ± 1,00
1 "TO"	40	4,00 ± 1,00	0,00 ± 2,75	0,00 ± 0,00
2 "PRICE+ TO"	40	4,00 ± 1,00	0,00 ± 0,75	0,00 ± 0,00

The mean values of pain intensity reported by the VAS on the first day in all three treatment groups were the same, and during the two follow-up periods showed a trend towards a limitation of pain sensation. Thus, in the group treated with standard care "PRICE" (TG "0"), the mean 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 the intensity was also reported 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. The progressive reduction in pain intensity found by the BAC scale was also maintained with this therapeutic approach.

After the therapeutic course with combined administration "PRICE" and DO (TG "2"), the most significant decrease in subjective pain sensation was noted, namely: the mean values of the po- sizer from day 1 were 4.00 ± 1.00, at the end of treatment they reached 0.00 ± 0.75, and on day 21 again no pain was noted on the BAC, which indicates the preservation and increase of the effect of therapy over time **(Figure 23)** .

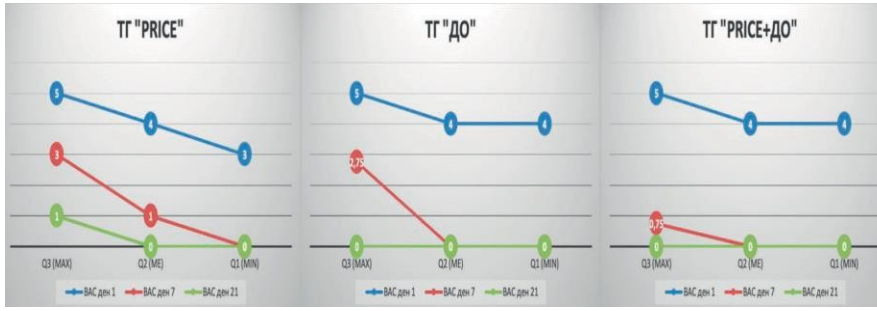

Figure 23. Visual-analog scale, Me (Q2), IQR (Q3-Q1) day 1, day 7 and day 21 in TG "0", "1" and "2"

On day 1, the following BAC scores were recorded in the PRICE treatment group: the highest percentage was 4 points in 37.5% (n= 15) patients, 5 points in 27.5% (n= 11) patients. The highest reflected painfulness was in the moderate pain range, 6 points in 7.5% (n = 3) patients, and the lowest in the mild pain range, 2 points in 2.5% (n= 1) patients. At the end of the treatment, day 7, the highest score was 5, again in the moderate pain range in 10% (n= 4), and the lowest was no pain with a score of 0 in 37.5% (n= 15) patients. On day 21, the number of patients with absent pain increased to 72.5% (n= 29), and the highest reported value was 4 pts. in 2.5% (n= 1), the remaining percentages corresponded to mild pain **(Figure 24)** .

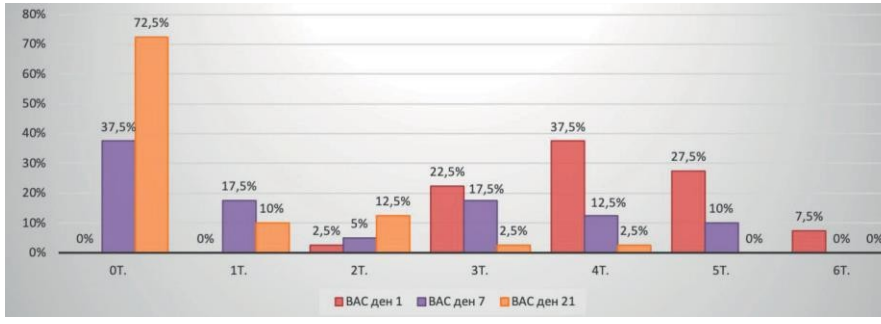

Figure 24. YOU day 1st, 7th and 21st. Therapy group "PRICE"

In the second treatment group, again, the highest value recorded on the VAS 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 pts at 40% (n= 16) and 35% (n= 14) patients reported 5 pts. After completion of the therapeutic course with deep oscillation, the percentage with no pain increased to 55% (n= 22) patients, and the highest point value on the BAC was in the range of moderate pain at 7.5% (n= 3) - 4 pts. The remaining patients scored in the mild pain range on the BAC - .5% (n= 7) scored 3 points, 12.5% (n= 5) patients reported 2 pts and 7.5% (n= 3) patients reported 1 pt. On day 21 of the follow-up, the therapeutic potential of the method was found to be absent pain among 80% (n= 32) of the trial participants, and the lowest point value was within mild pain - 3 pts at 2.5% (n = 1) **(Figure 25)** .

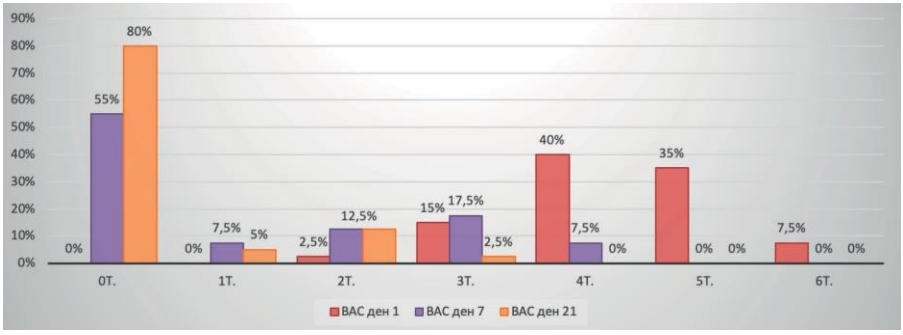

Figure 25. YOU day 1st, 7th and 21st. Therapy group "TO"

On day 1, 47.5% (n= 19) patients scored 4 pts, 17.5% (n= 7) patients scored 5 pts, and 12.5% (n= 5) patients scored 6 pts in the factor combination group. The remaining demonstrated VAS scores in the mild pain category. After completing the treatment course, 47% (n= 30%) of patients were given 0 points or no soreness. And at day 21, no soreness was found among 87.5% (n= 35) of patients, mild pain of 2 pts in 5% (n= 2) and 1 pt in 7.5% (n= 3) **(Figure 26)** .

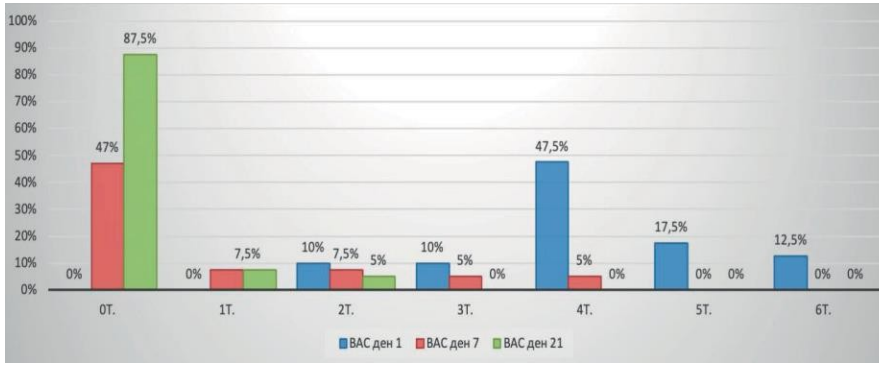

Figure 26. YOU day 1st, 7th and 21st.
Therapy Group "PRICE+ TO"

4.2.4.1. Intergroup analysis

- ***YOU Day 1 (control)***

The obtained numerical characteristics of Asymp. Sig. (2-tailed) from the conducted test are greater than the significance level $\alpha = 0.05$. The results confirm the uniformity of the three samples of therapeutic approaches. For ankle joint motion in the three between-group analyses on day 1, there was no statistically significant difference in reported pain intensity - patients were equally distributed according to the set criteria **(Table 14)** .

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

YOU Day 1	**Mann-Whitney test (Asymp. Sig. (2-tailed)**
TG "PRICE" and "TO"	0,367
TG "DO" and "PRICE+DO"	0,339
TG "PRICE" and "PRICE+DO"	0,927

- ***YOU Day 7***

From the nonparametric test conducted, Asymp. Sig. (2-tailed) results were obtained showing that the subjective pain perception reported by the BAC in group "0" (standard care "PRICE") did not differ

different from group "1" (therapy with DO). The same correlation was in group "1" (therapy with DO) and group "2" (combined application of the PRICE protocol and therapy with DO). The values of Asymp. Sig. (2-tailed) are greater than the significance level α= 0.05 and there 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 the "PRICE" protocol and DO therapy) data significantly demonstrated an Asymp. Sig. (2-tailed) value less than the α= 0.05 significance level and defined the therapeutic approach of combined application of the "PRICE" protocol and DO therapy (TG "2") as superior and statistically significant in terms of pain reduction relative to standard care (TG "0") **(Table 15**).

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

YOU Day 7	**Mann-Whitney test (Asymp. Sig. (2-tailed)**
TG "PRICE" and "TO"	0,081
TG "TO" and "PRICE+ TO"	0,065
TG "PRICE" and "PRICE+ TO"	0,001

- ***YOU Day 21***

The results of the Asymp. Sig. (2-tailed) Mann-Whitney U test found that there was no statistically significant difference between therapeutic approaches on day 21. The values are greater than the significance level, and it cannot be argued which therapeutic approach maintains the tendency to reduce pain, as reported by the VAS, to a greater at the third time point **(Table 16)** .

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

YOU Day 21	Mann-Whitney test (Asymp. Sig. (2-tailed)
TG "PRICE" and "TO"	0,848
TG "TO" and "PRICE+ TO"	0,852
TG "PRICE" and "PRICE+ TO"	0,961

4.2.5. Modified FADI scale values tracked across the three treatment groups, at three time points. Between-group analysis

The modified FADI scale reports the quality of performance of activities of daily living by patients with ankle impairment. It has a total point value of 60, representing 100%. The main numerical characteristics (Me± IQR) of the FADI scores are reported as percentages (%) on day 1, day 7, and day 21 in the three treatment groups. The data show that in all three treatment groups, patients improved their performance of activities of daily living both at the end of treatment and at follow-up for long-term effects. The obtained regarding the percentage improvement in the ability to perform of daily living, as measured by a modified FADI scale, demonstrate that all three treatment approaches have therapeutic value. The results for the percentage improvement on the 7th day are as : for treatment group TG "0" it is 88.33%, for treatment group "1" it is 90.00% and for treatment group "2" it is 91.66%, respectively. On the 21st day, the percentage improvement reported by FADI also followed this course, with the percentage values being: TG "0" - 93.33%, TG "1" - 93.33%, and TG "2" - 95.83%, respectively. The most significant improvement in the performance of activities of daily living was observed among patients in treatment group "2" (com- bined application "PRICE" and DO) **(Table 17).**

Table 17. FADI numerical 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 "TO"	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 mean FADI percentages were 61.66± 6.25, at the end of the treatment the percentage increased to 88.33± 6.24, and on the 21st day of therapy it was significantly higher - 93.33± 5.00 (**Figure 27)** .

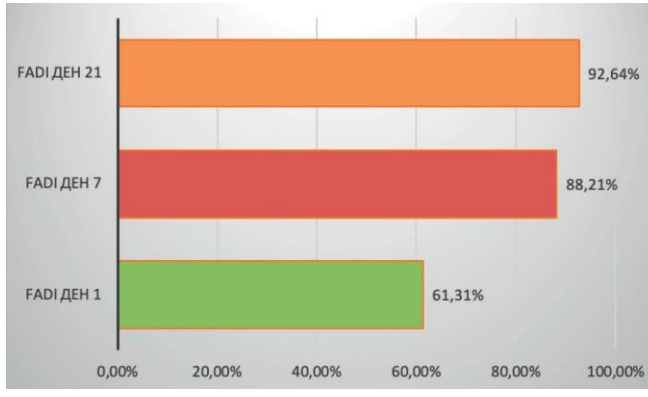

Figure 27. FADI days 1, 7 and 21 (mean values), treatment group "PRICE"

The dynamics of the averages is similar in TGs "1" and "2", where the following are reported, measured in percentage by FADI. In TG "1" (therapy DO) the baseline mean value of the percentage indicator for performing daily activities was 60.83 ± 7.50, at the end of treatment the indicator increased to 90.00 ± 4.58, and its highest value was on the 21st day - 93.33± 5.24 **(Figure 28)** .

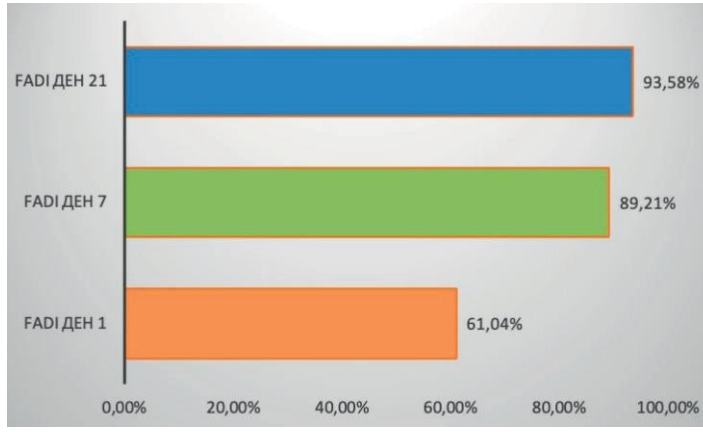

Figure 28. FADI days 1, 7 and 21 (mean values), treatment group "TO"

In the combination group ("2"), the mean percentage at the beginning of treatment was 61.66± 7.92, on day 7 it was 91.66± 3.33, and at the end of the third week of treatment it was 95.83± 3.33. The day 7 and day 21 results in the third treatment group were better than the self-administration groups, indicating a faster and better recovery of the patients **(Figure 29).**

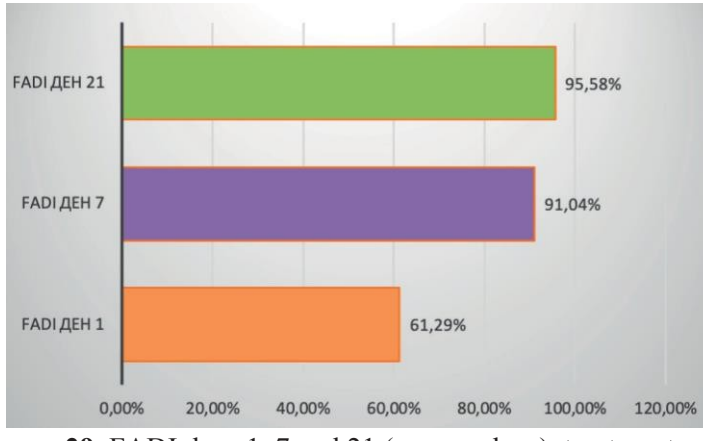

Figure 29. FADI days 1, 7 and 21 (mean values), treatment group "PRICE+DO"

4.2.5.1. Intergroup analysis

- ***FADI Day 1 (control)***

In all three between-group comparisons, Asymp. Sig. (2-tailed) values were greater than the $\alpha = 0.05$ significance level. This meant that there was no statistically significant difference between the mean pro- cents reported by the modified Performing Activities of Daily Living Scale on Day 1. The test demonstrates an even distribution of patients across the three treatment groups prior to treatment **(Table 18)** .

Table 18. Asymp. Sig. (2-tailed) values of % FADI on day 1. (control)

FADI Day 1	Mann-Whitney test (Asymp. Sig. (2-tailed)
TG "PRICE" and "TO"	0,458
TG "TO" and "PRICE+ TO"	0,712
TG "PRICE" and "PRICE+ TO"	0,738

- ***FADI Day 7***

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

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

FADI Day 7	Mann-Whitney test (Asymp. Sig. (2-tailed)
TG "PRICE" and "TO"	0,089
TG "TO" and "PRICE+ TO"	0,368
TG "PRICE" and "PRICE+ TO"	0,017

- ***OFADI Day 21***

At the end of the third week from the beginning of treatment (21-day), changes in the performance of activities of daily living are reported. The results of the Asymp. Sig. (2-tailed) values in the between-group analysis were similar to the results on day 7. The Mann-Whitney test indicated that there was no difference in the therapeutic approaches

"PRICE" and DO therapy on the 21st day. The Asymp. Sig. (2-tailed) values from the between-group analysis of the two applied tests showed values greater than the α= 0.05 significance level, and hence the statistical significance of the indicators. It cannot be argued which treatment group (TG "0" or TG "1") retains the trend towards better performance of activities of daily living as reported by the FADI. Results were similar for TG "1" (DO therapy) and "2" (combined "PRICE" and DO administration) with Asymp. Sig. (2-tailed) values greater than α= 0.05 and no statistical significance. For TG "0" (protocol "PRICE") vs. and TG "2" (combined application "PRICE" and DO), there was a statistically significant difference with Asymp. Sig. (2-tailed) values less than α= 0.05, namely: Asymp. Sig. (2-tailed): 0.009. The reported data show that among patients treated with a comprehensive approach, there is a trend of improvement in the performance of of daily living, as evidenced by statistically significant results of the percentage values on day 21st **(Table 20)** .

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

FADI Day 21	Mann-Whitney test (Asymp. Sig. (2-tailed)
TG "PRICE" and "TO"	0,165
TG "DO" and "PRICE+DO"	0,100
TG "PRICE" and "PRICE+DO"	0,009

CHAPTER V. DISCUSSION

Physical activity is a prerequisite for better psycho- ho-emotional health, underpinning a higher quality of life. Practicing sport-related activities not only brings positive benefits, but is also a prerequisite for negative consequences - musculoskeletal injuries.

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

The study is aimed at treating the acute phase of ankle sprain. To achieve it, goals and objectives were set to achieve symptom relief in the early phase of suffering, reduction of recovery time and negative long-term effects, restoration of the patient's normal rhythm of life, and satisfaction in the process of his/her treatment. In order to realize the study, the therapeutic effects of low-frequency pulsed electrostatic field by deep oscillation method, PRICE protocol and their combined application are investigated and analyzed.

The described positive trends in the treatment of talocrural joint distorsion with the chosen physical factor are supported by both clinical methods of assessing the functional status of the ankle joint (circumference and angulation) and by methods of pain using the BAC and the modified quality of life scale (FADI). The results correlate with the available studies in the databases, and some of them show superiority in terms of follow-smoke criteria.

5.1. Analysis of socio-demographic survey data

The demographic characteristics of the patients studied in this dissertation coincide with the data presented in the literature. The largest number of patients was in the age range 18-29 years, representing 51.67% (n= 62). The higher prevalence of ankle sprains in younger patients is explained by the characteristics of body development: muscle mass, ability to perform athletic movements, hormonal factors, and incomplete sensory and motor function of the skeletal muscle system (Doherty C et al., ; Doherty C et al., 2016; Adirim TA et al., 2003; Quatman-Yates CC et al., 2011).

The gender distribution shows that the female gender (55%) outnumbered the male gender (45%) by 10% (Doherty C et al., 2014). Biological sex is considered a risk factor for ankle distorsion due to the prevalence of hormonal factors among females (factors that are responsible for higher joint hypermobility) - reduced sensory control, specific behaviour patterns in collegiate sports and many others (Ikarashi K et al., 2020; Wilkerson RD et al., 2000; Doherty C et al., 2014). Evidence for this can be found in independent studies conducted in different parts of the world, which have found evidence to support the influence of menstrual cycle phases on neural excitability in the cortex and a reduction in sensorimotor evoked potential in the ovulatory phase (Ikarashi K et al., 2020). A relationship between estrogen and connective tissues has also been found to increase joint and muscle mobility and influence postural stability (Yim J et al., 2018). The results obtained in this thesis are consistent with the literature.

Social engagement in sports activity or the practice of different types of recreational activities (hobbies) was observed 100% (n= 120) of the study participants. In 75% (n= 90) of cases, the injury was received during purposeful physical activities, and in 25% (n= 30) of cases, the injury was received outside of performing such activities (Waterman BR et al.,). According to the literature reviewed, ankle joint distorsion is one of the most common injuries associated with sports exertion. Almost half of all

ankle ligament injuries are the result of sporting activity (49.3%) as shown by numerous analyses (Waterman BR et al. ; Hølmer P et al. 1994; Bridgman SA et al. ; Halabchi F et al. 2020; Lin CI et al. 2021; Garrick JG et al. 1987).

Based on their level of physical activity, patients were divided into three groups: high physical activity - 15.83% (n= 19), medium physical activity - 51.67% (n= 62) and low physical activity - 32.50% (n= 39). The data show that the highest number of patients with ankle injury is found in the group of medium physical activity. Poor knowledge of internal and external factors, prevention, protection, and underestimation of their importance underlie the high risk of developing this pathology (Verhagen EA et al, 2010; Dizon JM et al. ; Hagen M et al. 2016; Lee SY et al. ; Tyler et al. 2006; Fousekis K, et al. 2012; Watson AW 1999; Beynnon BD et al. 2002; Fousekis K, et al. 2012; Mason J et al. 2022; Wilkerson RD et al. 2000; Doherty C et al. ; Doherty C et al. 2016; Adirim T A et al. 2003).

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

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

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

The results obtained showed a reduction in ankle joint swelling at the end of treatment (7th) and on the 21st day. The data demonstrate

the therapeutic value of each approach and correspond to literary sources.

In the therapeutic group for the self-administration of the proto-col "PRICE" we associated the reduction of ankle joint swelling with 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 of which we find in a number of studies on the effect of standard care treatment in ankle joint distorsion (van Rijn RM, 2008; Benca E et al., 2019; Lamb SE 2009; Vuurberg G et al., 2018; Boyce SH et ., 2005). Reduced ankle joint edema 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 the inflammatory exudate formed (Cooke MW et al., 2003; Tsang KK et al., 2003; Sultan MJ et al., 2012; Bilgic S et al., 2015). *The application of ice* correspondingly reduces edema formation through 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 hardness of edema and hematomas, converting them into easily resorbable substances, as well as reducing lymphatic stasis. In addition to its mechanical impulses, the therapeutic effect of the DO method is by its influence on the endothelial structures of the lymphatic vessels. The collagen fibers of the lymphatic vessels are subjected to forces of elastic deformation, promoting the creation of connective tissue anastomoses in the endothelial structures. The resulting conditions enhance drainage function and reduce tissue edema (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 approach used is found in a plethora of 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 studies have on edema of a sports and traumatic nature, where it has been shown to achieve a higher efficiency in the DO modality compared to classical manual lymphatic drainage and cryotherapy (Teo, Isabel et al., 2016; Aliiyev R et al., 2009).

Concerning the therapeutic value of our proposed method (combining the two treatment approaches), the results obtained from the patients examined are categorical that ankle joint swelling is reduced to the greatest extent and the fastest with a statistically significant difference when the standard "PRICE" care and the DO therapy are combined. We believe that the proven therapeutic effects of the two stand-alone methods potentiate each other, leading to the better results in the combination group compared to the stand-alone groups. Edema decreased at a greater rate, and the trend up to 3 weeks.

5.3. Analysis of the data obtained from ankle joint angometry

The ankle joint range of motion is a key parameter in the assessment of ankle joint motor function and in the examination and diagnosis of ankle joint damage. In a healthy individual, dorsal flexion represents a 20º angle of movement in the cranial direction, and plantar flexion represents the movement of the ankle joint in the frontal plane with a 45º angle in the caudal direction.

The data from the within-group analysis showed an improvement in the volume of movement in the three applied treatment methods - the greatest pro- gress with a statistically significant difference was observed among patients treated with the combined application of the 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, by means of ***protec- tion, po-tion, compression, and elevation***, the amount of fibrous tissue is reduced, ligamentous fibre re-injury is prevented, and the risk of adhesions and contracture formation is reduced, while motion volumes in the joint are more easily regained. This statement is supported by the results of studies on the type of immobilization of the

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 cannulas) (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). The *application of ice not* only reduces the formation of soft tissue edema, but also induces local analgesia, a circumstance that favours the performance of dose- rations to improve range of motion. For example, a study by Bleakley CM and his team convincingly demonstrated the positive effect of cryotherapy on reducing pain and volumes of motion among patients with acute ankle joint distorsion (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 fibrosis-reducing capabilities are explained on the one hand by the mechanical vibrations in the tissues, resulting the stimulation of fibroblast proliferation, and on the other hand by 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; Hernández Tápanes S et al. 2018; Reinhold J et al. , Reinhold J, 2017; Boisnic S et al, 2013), but most significant is the finding of Gao YC's team, who treated a patient diagnosed with fibrous adhesion of the musculi extensor capri ulnaris and extensor digitorum communis of the right elbow dating back more than 35 years. After a pro- cess using the deep oscillation method, the elbow joint range of motion increased by 30 degrees and the effect of compounded inflammatory conditions leading to fibrotic changes was reduced (Gao YC et al., 2015). It is the antifibrotic and antiedematous properties of the method that are the main factors responsible for the obtained improvements in functional joint capacity. The ability to increase joint range of motion has been demonstrated 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 demonstrated an improvement in the functional activity of the posterior group of thigh muscles - semitendinosus, semimembranosus, biceps femoris, as well as increased

Hip range of motion after deep oscillation therapy (Winkelmann ZK et al., 2018).

5.4. Analysis of data obtained from the visual analogue scale (VAS)

Pain, according to the International Association, is an unpleasant sensory sensation associated with actual or potential organ damage. It is the earliest symptom of tissue damage or the onset of disease. To track it in the musculoskeletal association we studied, we used a visual analog scale (VAS), which is a continuous horizontal line 10 cm long with two endpoints. Tracking and analysis of the VAS results are important to demonstrate both the physical and psycho-emotional recovery of the individual. The data from the three within-group analyses showed a positive trend of reduced soreness from the applied therapeutic approaches.

In the standard care "PRICE" group, analgesic properties result primarily from the administration of *cryotherapy,* which achieves a reduction in secondary hypoxic injury, a reduction in the metabolic demands of injured tissues, and inhibition of nerve conduction stiffness (Palmer JE et al., 1996; Bleakley CM et al., 2007; Tittley J et al., 2020). Evidence of a similar analgesic effect, more lou- shed by short periods of ice application during the later, sub-acute phase of inflammation, is also found in a study conducted by Bleakley CM and his team on the effect of the PRICE protocol. The conclusion they reach is that cryotherapy facilitates earlier application of therapeutic exercises (Bleakley CM et al., 2007). According to a number of authors***, compression*** controls the amount inflammatory exudate and fibrin, thus contributing to lower soreness (Sultan MJ et al., 2012; Bilgic S et al., 2015; Rohner- Spengler M et al., 2014).

In the second therapeutic group***, the analgesic and anti-inflammatory effect*** of deep oscillation is explained and proved by multiple mechanisms studied during its application: reduction of the stimulation of ion channels (TRPV1) of nociceptors acting as molecular transducers for de-

polarization of neurons that trigger nociceptive impulses along pain pathways, decreased amount of stimulatory noci, decreased amount of prostaglandins and IL-8. Through mechanical oscillations and the influence of low frequencies of deep oscillations on afferent neurons, the propagation of pain impulses is suppressed by the "Gate control theory of pain" mechanism 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 reported a decrease in neutrophil migration and free radicals as well as an increase in antioxidant activity having a positive effect on limiting inflammation and in reducing pain (Korkina L et al., 2006). Aliyev RM proved the anti-inflammatory and analgesic effect based on the clinical symptomatology in patients with ankle injury with values of the indicators meeting the statistical significance Aliyev RM, 2012). An ex vivo study of a skin model demonstrated a significant reduction in dilated capillaries and IL-8 in soft tissue (Boisnic S et al., 2013), and a significant reduction in CRP in patients' blood samples after deep oscillation therapy indicated the multifactorial anti-inflammatory effect of deep oscillation therapy (Oestervemb K et al., 2023).

All this evidence supports the better results of the application of the combined therapy "PRICE + DO". In this case, the complex approach and the synergism of the modalities showed a more significant reduction in the reported pain scores on the BAC in the third treatment group.

5.5. Analysis of data obtained from the modified Activities of Daily Living Scale (FADI)

The modified activities of daily living scale for patients with ankle impairment (FADI) is an important self-assessment indicator of joint function - described in 1999 and to meet the needs of the therapist to detect ankle deficits. Clinical outcome data in orthopaedics has traditionally focused on measuring functional activity. Several studies have evaluated the effec-

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, focusing mainly on the dysfunction in the ankle joint. The scale allows to assess both the functional limitation and the subjective emotional attitude of patients regarding the performance of activities of daily living. It has a total score of 60, representing 100%. The closer the reported value is to 100%, the better the recovery is for the papacies.

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

The data obtained in this dissertation show that in all three treatment groups patients improved their performance of activities of daily living both at the end of treatment and at the pro- follow-up of the long-term effects (21st) day. The obtained regarding the percentages reported by the FADI scale demonstrate that all three treatment approaches applied have therapeutic value. The results for the percentage improvement from the 7th day were as follows: in the TG "PRICE" group it was 88.33%, in the "TO" treatment group it was 90.00% and in the "PRICE + TO" group it was 91.66%, respectively. On the 21st day, the FADI readings also followed the presented course, with the values being: TG "PRICE" 93.33%, TG "TO" 93.33% and TG
"PRICE+ TO" - 95.83%. The most significant improvement in performance

of daily activities was observed among patients in treatment group "2" (combined application "PRICE" and DO). The indexed FADI scale is the last tool that confirms the established trend towards improvement of objective and subjective ankle joint limitations after acute onset of distorsion. The results demonstrate once again the superiority of the combined application of the standard care "PRICE" + DO over the application of the methodologies alone.

5.6. Analysis of the data obtained from the hypotheses

After the application of the three therapeutic approaches and the between-group analysis on the seventh day, the first of the hypotheses set out in the thesis was proved, that the combined therapy using the deep oscillation method and the PRICE protocol had better results compared to the standard care PRICE group. The results obtained from the between-group comparison of the indices: centimetry, dorsal flexion, plantar flexion, BAC pain and modified FADI scale, showed statistically significant values (Asymp. Sig. (2-tailed)< from the significance level "α").

In addition, the between-group comparison of the indicators on day 7 and day 21 also confirmed the second hypothesis of the thesis, that the two self-administration groups - TG
"PRICE" and TG "TO" are not significantly different from each other. The data do not exclude the improvement of the indicators from the within-group comparison, but in the between-group analysis, the results of the hypothesis test prove the statistical insignificance between the two approaches - it cannot be claimed which of the two independent methods is a better choice for the treatment of acute talocrural joint distorsion. The data correlate with the studies available in the databases, prove that there is no definite difference in the effectiveness of the deep oscillation therapy and the PRICE protocol in patients with acute ankle distortion. The described results indicate an improvement in the patients' condition, but when analysed, the results were statistically insignificant (Winkelmann Z et al., 2015; Friesen, L, 2010).

The dissertation results demonstrate that by day 21, combination therapy reduces the need for additional re-habilitation intervention. These findings 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 of the thesis, that complex therapy can have a long-lasting effect and reduce the non-necessity of repeated rehabilitation, is partially proven. Examination of the literature base regarding chronic ankle instability shows that approximately half of patients with acute ankle injury report recurrent pain, swelling, and discomfort during their activities of daily living 6 months to a year after the incident, and 40% of cases develop chronic ankle instability up to 1 year after the initial 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).

The data from this study suggest that the combined use of deep oscillation therapy combined with the PRICE standard care protocol is an appropriate method for improving symptom complex and functional impairment in the ankle joint. No local or general side-effects were noted from the applied therapeutic factors, and no exacerbation of current symptoms was found after the procedures. The positive results obtained indicate that the combination therapy used (protocol
"PRICE+TO), and the low-frequency pulsed electrostatic field parameters were correct.

5.7. Limitations of the study

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

CHAPTER VI. CONCLUSION

Ankle joint distorsion is a common injury but under-appreciated in its significance. This misconception of the insignificance of the problem is a prerequisite for improper treatment and insufficient time interval for recovery, which lead to the chronification of the functional problem, predisposing to financial losses and psycho- emotional destabilization of patients.

Unresolved questions about the appropriateness of the assigned therapy have led to the creation of numerous studies in emergency and sports medicine practice. Available database studies have found that the standard in post-traumatic care after ankle joint distortion is best accomplished by the application of the "PRICE" protocol.

Based on our knowledge of the physiological effects of phy- zical factors and their potential to skeletal muscle injuries, the aim was to investigate, compare and evaluate the therapeutic efficacy of the PRICE protocol, low-frequency electrostatic pulsed field (PEF) and their combined application. The results of the study showed that deep oscillation therapy in combination with standard care provided complexity from the earliest stage of the condition to day 21. The obtained values were statistically significant and proved by examining the applied follow- up parameters (ankle joint centimetry, range motion, BAC pain and daily activity (modifi-FADI scale).

The synergy in the interaction of the combination therapy is supported by both the literature data and the results of this dissertation.

Combination therapy shows a shortening of time, improves the general and functional condition of patients, and the effect of treatment is maintained up to 3 weeks from the onset of trauma. To the advantages of the method we can attribute the easy application and accessibility of the therapy.

The summarized data are pathogenetically sound.

The approved combined therapeutic approach can be easily applied in practical settings in the acute phase of ankle sprain rehabilitation.

CHAPTER VII. CONCLUSIONS

1. The comparative evaluation of the presence or absence of immediate and long-term effects of the combined deep oscillation therapy and protocol
   "PRICE" showed that the effect of the combined application is maintained up to the 21st day after the treatment.
2. The results of the study prove that based on the set time point of follow-up (21st day), a repeated rehabilitation course of treatment is not unnecessary among the patients treated in the combined group.
3. Therapeutic efficacy regarding pain, swelling, range of motion, and daily functional activity in ankle joint distorsion has been demonstrated in both deep ossification therapy alone and in combination with DO and standard care.
4. The comparative within-group analysis proved the superiority of the applied complex approach, including the deep oscillation method and the PRICE protocol, compared to the single application of these therapeutic factors.
5. Combined therapy with DO and PRICE protocol improved functional activity and quality of life among the patients faster and with greater effectiveness than either method alone.
6. No side effects were found from the administration of te- rapia with DO in the self-administration and com- bined group. The method is considered safe and multi-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 on the effect of deep oscillation method in talocrural joint dys- torsion was conducted.
- The short- and long-term therapeutic efficacy of complex deep oscillation therapy in the treatment of talocrural joint distorsion was demonstrated.
- The superiority of the combined administration over the single administration of deep oscillation therapy and the PRICE protocol was demonstrated.

2. Practical-applied contributions

- A new non-invasive method for influencing the main symptoms of talocrural joint distortion with preformed physical factors is being app- proved.
- A protocol for low-frequency alternating electrostatic field therapy applied by deep oscillation in patients with ankle joint distorsion was developed.
- A new therapeutic method is proposed for the treatment of patients in the acute phase of talocrural joint distorsion.
- A new focus is proposed to influence the long-term effects, minimizing the possibility of the condition becoming chronic and the need for surgical treatment.

CHAPTER IX. PUBLICATIONS RELATED TO THE DISSERTATION

1. Д. Nedyalkova, M. Mikhailova, Y. Petrov. The place of physical factors in the treatment of ankle distorsion. Varna Medical Forum, vol. 11, 2022, appendix 2.
2. Д. Nedyalkova, M. Mikhailova. Key points in the diagnosis, treatment and prevention of ankle joint distortion. Management and Education, vol. 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 PAPERS

1. Tenth scientific session for lecturers and students of Medical College - Varna with international participation. 20-21 October 2022
2. International Scientific Conference "Education, Science, Economics and Technology" - 22-23 June 2023, Sofia, Bulgaria. Burgas.