

## UTILIZATION OF HYDROCORTISONE ACETATE PHONOPHORESIS IN COMBINATION WITH THERAPEUTIC EXERCISE IN THE REHABILITATION MANAGEMENT OF FUNCTIONAL LIMITATIONS CAUSED BY KNEE ARTHROFIBROSIS

<sup>1,2</sup>Akhalkatsi V., <sup>1,2</sup>Matiashvili M., <sup>1,2</sup>Maskhulia L., <sup>3</sup>Obgaidze G., <sup>3</sup>Chikvatia L.

*Tbilisi State Medical University, <sup>1</sup>Physical Medicine Department; <sup>2</sup>Clinical Center of Sports Medicine and Rehabilitation; <sup>3</sup>First University Clinic, Tbilisi, Georgia*

Arthrofibrosis is a joint pathology during which excessive collagen is produced resulting in movement limitation, inflammation and pain. It is caused by repeated injuries or surgical interventions, the latter of which can be the reason behind the irregular reaction of the immune system, excessive development of fibrous connective tissue inside and/or around the joint and the significant decrease of the quality of life in patients [12]. To manage the aforementioned processes, certain drugs like glucocorticoids are often used which limits the formation of scar tissue, suppress the production of collagen and decrease the synthesis of inflammatory mediators and fibroblasts [2].

The first attempts at influencing steroid anti-inflammatory drugs' ability to overcome the skin barrier using ultrasound waves were noted in the 1950s. However, despite the popularity of phonophoresis, there still are some unanswered questions in modern physiotherapy and rehabilitation regarding this matter which raises a certain amount of suspicion concerning the effectiveness of this method, including: 1. the parameters of ultrasound used in treatment; 2. the dosage and concentration of medication; 3. physiological processes that play the key role in achieving therapeutic effect during phonophoresis; 4. the scarcity of relevant research concerning the indications and contraindications of the abovementioned treatment method that does not allow us to draw unambiguous assumptions with regards to the effectiveness of phonophoresis [8].

Multiple researches, on the subject of using steroidal anti-inflammatory drugs (hydrocortisone and dexamethasone) in the cases of periarticular and muscular pathologies of osteoarthritis, have shown significant improvement with regards to decreasing pain and increasing range of motion. For instance, during one of these researches that involved the treatment of osteoarthritis, tendinitis or bursitis with hydrocortisone phonophoresis, 68% of patients showed significant improvement with regards to decreasing pain and increasing active range of motion and 18% showed partial improvement (partial decrease in pain and increase in range of motion with notable limitations of movement still present). In addition, from the patients that were treated only with ultrasound therapy, merely 27% showed significant improvement of the same parameters while 16% displayed partial improvement [3].

The goal of our research was to study the effect of therapeutic exercise and hydrocortisone acetate (HA) phonophoresis combination therapy on the management of the rehabilitation process of knee joint functional limitations caused by arthrofibrosis and to establish the optimal parameters of ultrasound needed to achieve therapeutic effect.

To achieve this goal, the following tasks were outlined:

1. Participants had to be selected for research from patients with clinical signs of arthrofibrosis after they had undergone a surgical intervention of the damaged joint or lengthy immobilization due to an injury 3-4 months prior.

2. The assessment of patients had to be performed at the start of the research as well as 3 weeks after its conclusion using the

Modified Cincinnati Rating System Questionnaire (MCSc) and by taking into account their Pain-free ROM (PF-ROM).

3. Patients were to be divided up randomly into 5 groups with each group going through an individual rehabilitation program.

4. Statistical analysis and assessment of the results.

**Material and methods.** 25 male patients between the ages of 18 and 50 (mean age  $39 \pm 3.4$  years) with moderate contracture of the knee and limitation of knee flexion, which varied between  $70^\circ$  and  $90^\circ$  participated in the randomized controlled experimental research [6]. In addition, modified Cincinnati questionnaire scale (MCSc) [4] was utilized, which consists of 44 questions divided into 8 sections that adds up to a maximum of 100 points and the results of this assessment were distributed in the following way:  $<30$  - Poor; 30-54 - Average; 55-79 - Good;  $>80$  - Excellent. Patients were divided randomly and equally into 1 control and 4 experimental groups. The following 3-week rehabilitation programs were developed: I - the control group was assigned an individual home exercise program (HEP) 5 times a week; the experimental group II was assigned a treatment program which included the same exercise in addition to phonophoresis with 10% hydrocortisone gel (mixed ultrasound gel), duration - 10 minutes, frequency - 1.0 MHz, duty cycle - 50% (Pulsed),  $1.0 \text{ W/cm}^2$  high intensity ultrasound (HEP+PWHi); the experimental group III was assigned an almost identical program to the group II with the difference being 100% (Constant) duty cycle of the ultrasound (HEP+CWHi). As for groups IV and V - these groups were assigned the same home exercise programs alongside 10 minutes of low intensity  $0.5 \text{ W/cm}^2$ , 1.0 MHz, 50% (HEP+PWL<sub>i</sub>) and 100% (HEP+CWL<sub>i</sub>) ultrasound accordingly with 10% hydrocortisone gel, 15 procedures total. (Table 1)

Functional assessment of the knee and the measurement of flexion using a questionnaire (MCSc) was performed twice, once at the initial stage of research and again in 3 weeks, after the conclusion of the rehabilitation program.

The resulting data was statistically analyzed at two stages using the *Real Statistics Using Excel* program: I - At the first stage, a repeated measures ANOVA was conducted with the differences between groups being assessed according to the F - criteria, where the calculated probability value or P was  $<0.05$  in every measurement; II - During the second stage, a paired sample t-test was conducted with the aim to reveal the groups where the differences resulting from the experiment were deemed significant ( $p < 0.05$ ).

Every participant consented to the study in written form after being informed fully about the content and possible complications of the experiment.

**Results and discussion.** Table N1 showcases the changes in knee flexion (in degrees) according to groups before the research and after the completion of the rehabilitation program as well as the difference between the first and second tests in percentages. In comparison to the initial data, the improvement of ROM in the injured knee is equal to 50% in the II and III groups where hydrocortisone acetate (HA) phonophoresis with high intensity ultrasound was utilized in combination with the home exercise

Table 1. Rehabilitation programs according to different groups

	n=25	HEP*	HiUS**		LiUS***	
			PPWHi (50%)	CWHi (100%)	PWLi (50%)	CWLi(100%)
I	5	+				
II	5	+	+			
III	5	+		+		
IV	5	+			+	
V	5	+				+

\* Home exercise program; \*\* High intensity ultrasound; \*\*\* Low intensity ultrasound.

Table 2. Knee flexion (PF-K.Flex.) prior to the start of the research (Test 1) and after its completion (Test 2)

	Group I	Group II	Group III	Group IV	Group V
Test 1	78.6±1.34	82.4±3.36	78.8±6.30	71.8±6.30	71.7±1.82
Test 2	88.8±2.77	124.6±7.63	119.6±6.87	91.2±1.3	99.0±2.92
df %	12	51	52	28	29

Table 3. Assessment of knee functioning according to the modified Cincinnati rating system questionnaire (MCSc) before the start of the study (Test 1) and after completion (Test 2)

	Group I	Group II	Group III	Group IV	Group V
Test 1	46.8±2.39	50.2±2.68	53.2±1.92	47.0±2.92	45.4±2.61
Test 2	53.8±3.56	77.6±0.89	76.0±3.46	50.8±1.92	52.2±1.48
df %	15	54	43	6	15

Table 4. The results of the repeated measures ANOVA (RM-ANOVA)

Parameters	Within Groups		Between Groups	
	F	PP	F	P
K.flex.	12.94	6.85E-09	15.47	1.88E-07
MCSc.	6.43	2.12E-05	19.09	1.65E-08

Table 5. The differences between groups according to the t-criteria

Groups		P
I	II	0.0040
I	III	0.0007
I	IV	0.1376
I	V	0.0908
II	III	0.6288
II	IV	0.0045
II	V	0.0020
III	IV	0.0011
III	V	0.0003
IV	V	0.9059

program while in the IV and V groups, where HA phonophoresis was used with low intensity ultrasound, the improvement of flexion was around 28%. At the same time, the control group (group I) only achieved a 12% improvement in PF-ROM using solely a home exercise program. (Table 2)

After the completion of rehabilitation programs, according to the data provided by the Cincinnati modified scale, significant improvement of knee function was found in groups II and III,

54% and 43% respectively in comparison to groups I (control group), IV and V (experimental groups) where the improvement didn't exceed 15% (Table 3).

The dispersion analysis of data acquired through the experiment has shown significant difference with regards to pain free flexion between groups (P=1.88E-07) as well as within the groups (P=6.85E-09) where the difference between the F-criteria was less than 20%, moreover, the functioning of the injured

knee joint was improving reliably in both cases according to the Cincinnati scale ( $P<0.05$ ). However, the size of the F-criteria was almost 3 times larger (200%↑) between the groups than within the groups. (Table 4)

At the final stage of the statistical analysis, after repeated measurements, the comparison of groups according to the t-criteria revealed significant differences ( $p<0.05$ ) only with regards to groups II and III, where hydrocortisone phonophoresis with high intensity ultrasound was included in the rehabilitation program alongside with therapeutic exercise. In addition to this, it should be noted that the difference between the II and III groups was not significant ( $p=0.6288$ ). (Table 5)

The graphical representation of the data acquired through the experiment clearly demonstrates a significant improvement with regards to both of the parameters (Functional assessment scale and flexion of the knee) in groups II and III, where phonophoresis with high intensity ultrasound combined with rehabilitation exercise program was utilized (Diagram 1).

The analysis of these results has shown that the methods of rehabilitation were effective in all 5 groups. The comparison of data before and after the aforementioned interventions has demonstrated a significant increase ( $P<0.05$ ) in pain-free knee flexion and knee functional status (according to MCSc), however the improvement of knee ROM and its function was more apparent in experimental groups II and III, where alongside therapeutic exercise, hydrocortisone phonophoresis with high intensity ultrasound was used. Dispersion analysis of the data showed significant differences ( $P<0.05$ ) between groups according to the F-statistical criteria. The difference is most noticeable when comparing the functional assessment scale of the knee of the groups, which must be associated with the decrease of pain and inflammation processes caused by the influence of ultrasound, the improvement of usual activities through exercise and therefore facilitation of the activities of daily life.

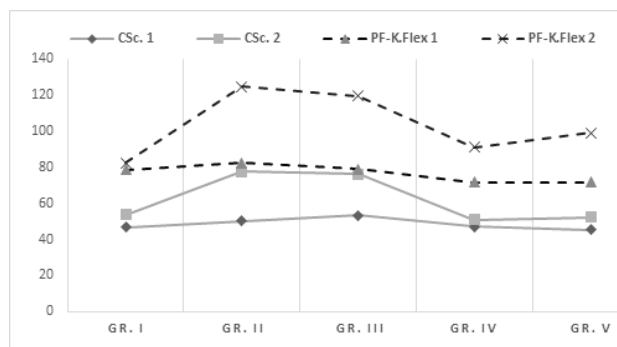


Diagram 1. Dynamics of the changes in the results following Test 1 and Test 2

According to Terri Hoppenrath et al. 2006, it was suggested that the advantage of the effect of phonophoresis compared to ultrasound alone was not backed up by hard evidence [4], however in several new studies by Saime AY [1], Kaya K. [7], Toopchizadeh V. [11], have shown notable superiority of phonophoresis with corticosteroids over ultrasound when used during symptomatic osteoarthritis of temporomandibular and knee joints as well as myofascial pain. In recent studies, including our own research, the active substance (medication) for phonophoresis is mixed with the gel that is intended for ultrasound which in turn enables the chemical components of the gel to overcome the skin barrier in accordance to their properties (Ex: Propylene glycol, Carbopol 940, etc.)and increases their rate of penetra-

tion [9]. It has been suggested that transdermal penetration rate of medications (especially hydrophobic ones) is higher in the form of emulgel applications [12], however there's insufficient practical experience and research on the effect of ultrasound in this case.

The goal of the research above never was to determine and study the isolated effects of phonophoresis or ultrasound on arthrofibrosis. Since the inception of this study our aim was to assess the possibilities of positive impact of high concentration hydrocortisone gel phonophoresis in combination with therapeutic exercise with regards to hindering fibrous connective tissue formation inside or around the knee joint. The paired up comparison of groups at the final stage of statistical analysis of the results while taking into account each possible variant according to the t-criteria (paired t-test) has shown significant ( $P<0.05$ ) differences only within the pairs of groups where II and III experimental groups had participated, additionally, the difference between these 2 groups itself was not found significant ( $P=0.6288$ ). We have to assume that high concentration hydrocortisone phonophoresis with high intensity ultrasound alongside therapeutic exercises still had positive impact on decreasing the limitations of knee functioning caused by arthrofibrosis which, in our opinion, should be attributed to the ability of glucocorticoids to hinder the formation of scar, fibrous connective tissue within damaged soft tissues, to decrease pain and inflammation in cooperation with ultrasound and also to assist in improving the effect of therapeutic exercises with the aim to increase the elasticity of soft tissues as well as to extenuate contractures.

According to the results of the aforementioned study, the intensity of ultrasound is a decisive factor while the waveform has no notable impact on the processes mentioned above when utilizing hydrocortisone phonophoresis. However, if we also take into consideration the fact that this method of therapy is conducted using high intensity ultrasound, it would be better to make use of pulsed ultrasound waves to achieve the desired effect without the threat of skin damage or decreasing the time of exposure.

**Conclusion.** Our research has shown that using phonophoresis with high concentration hydrocortisone acetate that's mixed with ultrasound gel alongside therapeutic exercise in the treatment and rehabilitation of moderate post-traumatic or post-operative extension contracture of the knee caused by arthrofibrosis can be successful, which could enable us to achieve 40-50% of progress regarding knee flexion and functioning in 3 weeks in case 1.0 MHz, 1 W/cm<sup>2</sup>, 50% pulsed ultrasound is utilized during 10 minutes, 5 times per week.

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## SUMMARY

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*Tbilisi State Medical University, <sup>1</sup>Physical Medicine Department; <sup>2</sup>Clinical Center of Sports Medicine and Rehabilitation; <sup>3</sup>First University Clinic, Tbilisi, Georgia*

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The goal of our research was to study the effect of therapeutic exercise and hydrocortisone acetate (HA) phonophoresis combination therapy on the management of the rehabilitation process of knee joint functional limitations caused by arthrofibrosis and to establish the optimal parameters of ultrasound needed to achieve therapeutic effect.

25 male patients between the ages of 18 and 50 (mean age 39±3.4 years) with moderate contracture of the knee and limitation of knee flexion, which varied between 70° and 90° participated in the randomized controlled experimental research. In addition, modified Cincinnati questionnaire scale (MCSc) was

used. The following 3-week rehabilitation programs were developed: I - the control group was assigned an individual home exercise program (HEP) 5 times a week; the experimental group II was assigned a treatment program which included the same exercise in addition to phonophoresis with 10% hydrocortisone gel (mixed ultrasound gel), duration - 10 minutes, frequency - 1.0 MHz, duty cycle - 50% (Pulsed), 1.0 W/cm<sup>2</sup> high intensity ultrasound (HEP+PWHi); the experimental group III was assigned an almost identical program to the group II with the difference being 100% (Constant) duty cycle of the ultrasound (HEP+CWHi). As for groups IV and V - these groups were assigned the same home exercise programs alongside 10 minutes of low intensity 0.5 W/cm<sup>2</sup>, 1.0MHz, 50% (HEP+PWL) and 100% (HEP+CWL) ultrasound accordingly with 10% hydrocortisone gel, 15 procedures total.

The results of the study revealed that using phonophoresis with high concentration hydrocortisone acetate that's mixed with ultrasound gel alongside therapeutic exercise in the treatment and rehabilitation of moderate post-traumatic or post-operative extension contracture of the knee caused by arthrofibrosis can be successful, which could enable us to achieve 40-50% of progress regarding knee flexion and functioning in 3 weeks in case 1.0 Mhz, 1 W/cm<sup>2</sup>, 50% pulsed ultrasound is utilized during 10 minutes, 5 times per week.

**Keywords:** arthrofibrosis; hydrocortisone acetate; phonophoresis; ultrasound; contracture.

## РЕЗЮМЕ

### ПРИМЕНЕНИЕ ФОНОФОРЕЗА С АЦЕТАТОМ ГИДРОКОРТИЗОНА В СОЧЕТАНИИ С ЛЕЧЕБНЫМИ УПРАЖНЕНИЯМИ В РЕАБИЛИТАЦИОННОМ ЛЕЧЕНИИ ФУНКЦИОНАЛЬНЫХ ОГРАНИЧЕНИЙ, ВЫЗВАННЫХ АРТРОФИБРОЗОМ КОЛЕННОГО СУСТАВА

<sup>1,2</sup>Ахалкаци В.Ю., <sup>1,2</sup>Матиашвили М.К.,  
<sup>1,2</sup>Масхулия Л.М., <sup>3</sup>Обгаидзе Г.О., <sup>3</sup>Чикватия Л.В.

*Тбилисский государственный медицинский университет, <sup>1</sup>Департамент физической медицины; <sup>2</sup>Клинический центр спортивной медицины и реабилитации; <sup>3</sup>Первая университетская клиника, Тбилиси, Грузия*

Артрофиброз является патологией суставов, во время которой образуется избыток коллагена, что приводит к ограничению движения, воспалению и боли. Это состояние вызвано повторными травмами или хирургическими вмешательствами, при которых часто используются определенные лекарственные средства, такие как глюкокортикостероиды.

Целью исследования явилось определение влияния комбинированной терапии с использованием лечебных упражнений и фонофореза с ацетатом гидрокортизона на управление процессом реабилитации функциональных ограничений коленного сустава, вызванных артрофиброзом, и установление оптимальных параметров ультразвука, необходимых для достижения терапевтического эффекта.

В рандомизированных контролируемых экспериментальных исследованиях участвовали 25 пациентов мужского пола в возрасте от 18 до 50 лет (средний возраст 39±3,4 лет) с умеренной контрактурой колена и ограничением сгибания в коленном суставе, которое колебалось от 70° до 90°. Использовалась также модифицированная шкала анкет Цин-



ცინნატი (MCSc). Разработаны трех-недельные программы реабилитации: I - контрольной группе назначалась индивидуальная программа домашних упражнений (HEP) 5 раз в неделю; II экспериментальной группе назначена программа лечения, которая включала вышеуказанные лечебные упражнения, в сочетании с фонофорезом с 10% гелем гидрокортизона, смешанного с ультразвуковым гелем, продолжительность сеанса - 10 минут, частота - 1,0 МГц, рабочий цикл - 50% (импульсный), 1,0 Вт/см<sup>2</sup> ультразвук высокой интенсивности (HEP+PWHi); III экспериментальной группе назначена практически идентичная со второй группой программа, однако с добавлением 100% (постоянный) рабочего цикла ультразвука (HEP+CWHi). Что касается IV и V групп, этим группам назначены одни и те же домашние программы упражнений, в сочетании с процедурами ультразвука низкой интенсивности - 0,5 Вт/см<sup>2</sup>, с 10% гелем гидрокортизона, 1,0 МГц, 50% (HEP+PWLi) и 100% (HEP+CWLi), соответственно, в течение 10 минут, всего 15 процедур.

Результаты исследования показали, что использование фонофореза с ацетатом гидрокортизона высокой концентрации, смешанного с ультразвуковым гелем, в сочетании с лечебными упражнениями, во время реабилитации умеренной тяжести посттравматической или послеоперационной контрактуры коленного сустава, вызванного артрофиброзом, может быть успешным и позволит достичь 40-50% прогресса в отношении сгибания коленного сустава и улучшения его функции за 3 недели в случае применения 1,0 МГц, 1 Вт/см<sup>2</sup>, 50% импульсного ультразвука в течение 10 минут, 5 раз в неделю.

#### რეზიუმე

ჰიდროკორტიზონის აცეტატით ფონოფორეზისა და სამკურნალო ვარჯიშის კომბინირებული მოქმედება მუხლის ართროფიბროზით გამოწვეული ფუნქციური შეზღუდვების სარეაბილიტაციო მართვაში

<sup>1</sup>გ. ახალკაცი, <sup>12</sup>მ.მათიაშვილი, <sup>12</sup>ლ.მასხულია,

<sup>3</sup>გ. ობგაიძე, <sup>3</sup>ლ.ჩიკვატია

თბილისის სახელმწიფო სამედიცინო უნივერსიტეტი, <sup>1</sup>ფიზიკური მედიცინის დეპარტამენტი, <sup>2</sup>სპორტული მედიცინის და რეაბილიტაციის კლინიკური ცენტრი; <sup>3</sup>პირველი საუნივერსიტეტო კლინიკა, თბილისი, საქართველო

ართროფიბროზი წარმოადგენს სახსრის პათოლოგიას, რომლის დროსაც ხდება კოლაგენის მოჭარბებული გამოთქმა, რის შედეგადაც ვითარდება მოძრაობის შეზღუდვა, ანთება და ტკივილი, გამოწვეულია

განმეორებითი ტრავმებით ან ქირურგიული ჩარევით. აღნიშნული პროცესების მართვაში ხშირად გამოიყენება ისეთი მედიკამენტოზური საშუალებები, როგორც არის გლუკოკორტიკოსტეროიდები.

კვლევის მიზანს წარმოადგენდა ფიზიკური ვარჯიშისა და ჰიდროკორტიზონის აცეტატით (HA) ფონოფორეზის კომბინირებული მოქმედების შესწავლა ართროფიბროზით გამოწვეული მუხლის სახსრის ფუნქციური შეზღუდვების რეაბილიტაციის პროცესში და თერაპიული ეფექტის მისაღწევად გამოყენებული ულტრაბგერის ოპტიმალური პარამეტრების დადგენა.

რანდომიზირებულ კონტროლირებულ ექსპერიმენტულ კვლევაში მონაწილეობდა 18-50 წლის 25 მამაკაცი საშუალო ასაკით 39±3.4 წ. და მუხლის სახსრის საშუალო სიძიძის კონტრაქტურით, სადაც შეზღუდული იყო მხოლოდ მოხრა, რომელიც მერყეობდა 70°-დან 90°-მდე. მუხლის ფუნქციის შეფასების მიზნით დამატებით გამოყენებული იყო ცინცინატის მოლიფიცირებული (MCSc) კითხვარის სკალა. დიაგნოზმა 3-კვირიანი შემდეგი შინაარსის სარეაბილიტაციო პროგრამები: I - საკონტროლო ჯგუფს კვირაში 5-ჯერ დაენიშნა დამოუკიდებელი სავარჯიშო პროგრამა (HEP), II საკვლევ ჯგუფს იმავე პერიოდში სავარჯიშო პროგრამასთან ერთად, კვირაში 5-ჯერ 10%-იანი ჰიდროკორტიზონის გელით (Ultrasound Gel) ფონოფორეზის გამოყენება 10 წთ-ის განმავლობაში, 1,0 მჰც სიხშირის, 50%-იანი, მაღალი ინტენსივობის 1,0 ვტ/სმ<sup>2</sup> ულტრაბგერით (HEP+PWHi), III საკვლევ ჯგუფს - ვარჯიშებთან ერთად იდენტურ პირობებში ჩაუტარდა ფონოფორეზი მხოლოდ 100%-იანი ულტრაბგერით (HEP+CWHi). რაც შეეხება IV და V საკვლევი ჯგუფების პაციენტებს, სავარჯიშო პროგრამასთან ერთად, 10 წუთის განმავლობაში გამოყენებული იყო დაბალი ინტენსივობის 0,5 ვტ/სმ<sup>2</sup> სიმძლავრის, 1,0 მჰც, 50%-იანი (HEP+PWLi) და 100%-იანი (HEP+CWLi), შესაბამისად, ულტრაფონოფორეზი 10% ჰიდროკორტიზონის გელით, სულ 15 პროცედურა.

კვლევის შედეგებით გამოვლინდა, რომ მუხლის პოსტტრავმული ან პოსტოპერაციული ართროფიბროზის მკურნალობასა და რეაბილიტაციაში წარმატებით შეიძლება გამოყენებული იყოს ფონოფორეზი, ულტრაბგერის გელთან შერეული მაღალი კონცენტრაციის ჰიდროკორტიზონის აცეტატით, სამკურნალო ვარჯიშთან კომბინაციაში, რომელიც 3 კვირაში უზრუნველყოფს მუხლის მოხრის კუთხის 40-დან 50%-მდე გაუმჯობესებას და დაზიანებული სახსრის ფუნქციონირებას იმ შემთხვევაში, თუ თერაპიისათვის გამოყენებული იქნება 1,0 მჰც, 1 ვტ/სმ<sup>2</sup>, იმპულსური 50%-იანი ულტრაბგერა 10 წთ-ის განმავლობაში კვირაში 5-ჯერ.