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INVESTIGATION OF THE EFFICIENCY OF SHORTWAVE DIATHERMY DEVICES WITH FREQUENCY AND POWER MEASUREMENT APPLICATION

Ömer Şahin ŞİMŞEK[1]*

[1]*Department of Biomedical Engineering, Graduate Education Institute, Sakarya University of Applied Sciences, Türkiye*

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ABSTRACT

Shortwave Diathermy (SWD) devices are a physical therapy application working with the electromagnetic current in radio frequency (RF) value, which is used in pathologies such as pain control, osteoarthrosis, fracture healing, joint contracture, muscle spasm, fibromyalgia, peripheral nerve repair, soft tissue healing. method. As SWD devices have therapeutic properties, they can cause serious biological damage such as tissue burns in the patient due to excessive radio frequency exposure due to malfunctioning and malfunctioning of the device. Likewise, the targeted effective treatment cannot be provided in cases such as insufficient output values for treatment due to lack of maintenance and calibration in the device. For this reason, it is necessary to check the output frequency and RF power values of SWD devices used in healthcare facilities at regular intervals. In this study; The output frequency of different types of SWD devices in Bursa İlker Çelikcan Physical Therapy and Rehabilitation Hospital, which are actively used in patient treatments for Physical Therapy, was measured with a designed hand-held frequency meter, and RF power values were measured by applying the static calorimetric method. It is aimed to determine device performances and efficacy in treatment by evaluating the measurement results. As a result of this study; It has been observed that the SWD devices selected as the sample operate at the acceptable frequency and power values within the manufacturer's standards.

1. INTRODUCTION

Shortwave Diathermy (SWD); It is a physical therapy application method working with a high-frequency electromagnetic current that is preferred in pathologies such as pain control, osteoarthritis, fracture healing, joint contracture, muscle spasm, fibromyalgia, peripheral nerve repair, soft tissue healing in musculoskeletal injuries [1]. SWD began to be used in physical therapy practices at the beginning of the 20th century. Diathermy means heat medium. Diathermy generally provides an increase in temperature in deep tissues such as muscles, tendons, ligaments, and bones. With the increase in temperature in the tissues, acceleration in blood flow, decrease in pain, increase in nerve conduction velocity, and relaxation of muscles occur [2][3]. Electromagnetic energy is a high-frequency current that generates heating in deep tissues by being absorbed through the skin and converted into heat energy (conversion). This current is 10-100 MHz. It has a frequency between 3 and 30 meters in wavelength. The higher the frequency level, the more the heating feature in the deep tissues increases. The frequency of SWD therapy is usually 27.12 MHz. and its wavelength is 11.06 meters [4].

In SWD devices, radio frequency (RF) waves are applied to the patient in continuous or intermittent mode [5]. While the current form applied in the continuous mode is constant, the pulse length varies between 25-400 microseconds and the number of pulses varies between 15-800 in the intermittent mode [6]. Capacitive and inductive treatment applications are performed with the SWD device [7]. The capacitive method consists of two metal plates in the form of a circle standing opposite each other. It is applied by placing it on both sides of the area to be treated. The high-frequency currents given create an electrical field that changes rapidly between the electrodes and in the tissues and fluids in the electrical field; ion movement, dipole movement, and molecular distortion occur, and as a result heat occurs [1]. In the inductive method; The electrode is in the form of a cable and is made with an induction coil. The induction coil is generally used in the extremities

* Corresponding Author: y205003016@subu.edu.tr

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by wrapping it around, and in the spine as a flat spiral. If there is a contracture, if the area to be treated is large or indented, it is appropriate to use the induction method instead of the condenser technique [8].

Frequency, RF power, and treatment time accuracy applied in SWD devices, whether they are within international standards, are of great importance in terms of patient and user safety and the effectiveness of treatment [9]. SWD devices can cause serious biological effects such as tissue burns in the patient due to excessive radio frequency exposure due to malfunctioning and malfunctioning of the device, as well as having therapeutic properties. Likewise, the targeted effective treatment cannot be provided in cases such as insufficient output values for treatment due to lack of maintenance and calibration in the device [2][9]. For this reason, it is recommended to periodically check the output frequency and power values of SWD devices used in healthcare facilities [2], however, it is observed that only electrical safety tests of the devices are still carried out in practice because the special equipment required for this process is monopolized by the device manufacturer and it is high cost. In SWD devices; although it is different on the model basis, the RF power can be up to 1100 Watts (in intermittent mode). This value is in the high RF power range and special methods should be used for its direct measurement [10]. In this study, SWD device operating frequency values and output RF power level measurements were made, and the details of the experimental study are explained in the next material and method section.

2. METHODS

2.1. Frequency Measurement

The operating frequency of SWD devices is 27.12 Mhz. This frequency value can be measured with an oscilloscope from the high-frequency cable entry on the device [11], but this measurement is laborious and risky. In addition, it is a disadvantage that the actual frequency value applied to the patient through the electrodes cannot be determined. In this study; A non-contact and fast-acting hand-held wireless frequency meter, which enables frequency measurement directly over the device electrodes shown in Fig 1, was designed and frequency measurements were carried out. With this method, it is recommended to measure the frequency value transmitted directly to the patient. In the study; It has also been observed whether there is a frequency change at different power values randomly set in the device.

Fig 1. Frequency Meter

2.2. Radio Frequency Power Measurement

The maximum output power of SWD devices varies according to the device type. The RF power values in continuous and pulsed modes of the devices used in the study are given in Table 1 [13-17]. Output power is directly proportional to the performance of the device and is an important criterion in terms of its commercial value. Although there are various methods for radio frequency power measurement in the literature, it is seen that the static calorimetric power measurement method is the most appropriate method due to the high RF power level of SWD devices [10]. With the static calorimetric method; The heat conversion of radio frequency energy and the heat change in the liquid in which this energy is applied is calculated. The average power calculation formula used in this method and the explanations of the units in the formula are given below [10].

$$P\ (\text{Watt}) = \frac{4.187 \times m \times \Delta T}{\Delta t} \quad (1)$$

m = Volume of RF applied fluid(cc)
ΔT = Temperature difference (°C)
t = Time (seconds)

6 mm for RF Power measurement. thick, transparent, PVC material, a phantom was formed, 1 lt. distilled water and 100 grams of salt were added, mixed, and kept at room temperature for 2 hours. The distilled water used was obtained from the KROS Rentro 4000 water purification system and the conductivity level was measured as 1.62 micro siemens/cm. The salt solution has a value close to the average conductivity of human tissues [12]. It is important to minimize the heat loss caused by the environment in the measurement, so the phantom is designed as closed in order not to be affected by the outdoor temperature [10].

Before the application, the internal liquid temperature of the phantom was measured, then the application was started by setting the power value of the SWD device to the highest level, the application time to be 3 minutes, and the distance between the electrodes and the phantom to be 1 cm [11]. At the end of the application period, the phantom liquid temperature value was measured, compared with the initial value, and noted. The temperature values obtained with the measurements are given in Table 2. Fluke 54II was used for liquid temperature measurements, and Lutron HT-305 thermometers were used for ambient temperature and humidity measurements (Fig 2).

Fig 2. Thermometers

2.3. Shortwave Diathermy Device Information

Within the scope of this research, shortwave diathermy devices, which are actively used in Bursa İlker Çelikcan Physical Therapy and Rehabilitation Hospital and whose basic features are written in Table 1, were used as a sample. In device no. 4, diplode electrodes are used, in other devices, capacitive disc electrodes are used.

Table 1. Shortwave diathermy (SWD) devices

Device No	Trademark	Model	Product Year	Frequency (Mhz)	Electrode Type	Device Max. Power (W)	
						Continous	Pulsed
1	Elettronica Pagani	DX-500	2014	27.12	Cap. disk	470	1100
2	Nemectron	Thermo 2000	1999	27.12	Cap. disk	400	800
3	Chattanooga	Intelect SW 100	2014	27.12	Cap. disk	100	200
4	Enraf Nonius	Curapuls 970	2014	27.12	Diplode	400	1000
5	Chattanooga	Shortwave 400	2011	27.12	Cap. disk	400	1000

3. EXPERIMENTAL

In SWD devices, the power adjustment level differs on a unit basis, depending on the model. For this reason, in the measurements made, frequency measurements were carried out by adjusting the power level by random selection method for each device in intermittent and continuous operating modes. The frequency values measured at the time of operation of the SWD devices included in the study are given in Table 2.

Table 2. Measured Frequency Values

Device No	Set Power	Operating Mode	Electrode Type	Device Frequency (Mhz)	Measured Frequency (Mhz)
1	% 20	Continuous	Capacitive disc	27.12	26.84
1	% 80	Pulsed	Capacitive disc	27.12	27.43
2	Level 1	Continuous	Capacitive disc	27.12	26.98
2	Level 4	Pulsed	Capacitive disc	27.12	27.15
2	Level 8	Continuous	Capacitive disc	27.12	27.37
3	25 W	Continuous	Capacitive disc	27.12	26.89
3	75W	Pulsed	Capacitive disc	27.12	27.25
3	100 W	Continuous	Capacitive disc	27.12	27.31
4	INT. Level 4	Pulsed	Diplode	27.12	27.11
4	INT. Level 7	Pulsed	Diplode	27.12	27.18
5	100 W	Continuous	Capacitive disc	27.12	27.10
5	300 W	Pulsed	Capacitive disc	27.12	27.44

The image of device no. 1 during frequency measurement is in Fig 3. In this study, frequency measurement processes were carried out simultaneously with the power test. Device outputs were also checked with a fluorescent test lamp applied for daily control at the user level. When the frequency measurement results of the SWD devices in the research are examined; No significant difference was observed between the manufacturer's data and the measured values, and the frequency outputs of the devices were considered to be at an acceptable level [13-17].

Fig 3. Frequency Measurement (SWD device no. 1)

RF Power measurement application was carried out on different days for each device. After the intermittent mode application, the phantom temperature was expected to come back to the ambient temperature, then continuous mode tests were carried out. Before starting the test process, ambient and phantom liquid temperature values were measured. It is ensured that the phantom fluid is equal to the ambient temperature as much as possible. The values obtained according to the power measurement results are shown in Table 2. In the measurements, a treatment application time of 3 minutes was chosen. Since the power level cannot be set as a numerical value in some devices, the power level is set as the highest level for each. Separate calculations were made in a batch and continuous operating modes.

Table 3. RF power measurement values

Device No	Operating Mode	Test Room Temp. (°C)	Phantom First Temp. (°C)	Phantom Final Temp. (°C)	Operating Time (minute)	Calculated Power (W)	Device Power (W)	Deviation (%)
1	Pulsed	23.8	23.9	66.8	3	997.9	1100	-9.3
1	Continuous	23.8	23.8	43.9	3	467.5	470	-0.5
2	Pulsed	23.5	23.5	56.2	3	760.6	800	-5
2	Continuous	23.5	23.5	39.7	3	376.8	400	-5.8
3	Pulsed	23.7	23.8	32.1	3	193	200	-3.5

3	Continous	23.7	23.8	28.3	3	104.6	100	+4.6
4	Pulsed	22.8	22.9	64.3	3	963	1000	-3.7
4	Continuous	22.8	22.9	39.5	3	386.1	400	-3.2
5	Pulsed	22.6	22.6	65.1	3	988.6	1000	-1.1
5	Continous	22.6	22.6	40.2	3	409	400	+2.3

The visual of the RF power measurement stage of device no. 3 is seen in Fig 4.

Fig 4. RF power measurement (Device no. 3)

Power values were found by calculating the temperature change in the phantom fluid depending on the SWD device application time with the static calorimetric calculation formula given below [10].

$$P\ (\text{Watt}) = \frac{4.187 \times m \times \Delta T}{\Delta t} \qquad (1)$$

m = Volume of RF applied fluid(cc)

ΔT= Temperature difference (°C)

t = Time (seconds)

4. CONCLUSION

The values obtained from frequency and power measurements in SWD devices within the scope of this study were compared with the device manufacturer's technical data. It has been observed that the power values in device no. 3 and 5 are higher than the generator values in the continuous mode, and the measured values in the other devices are below the generator power values. However, it was evaluated that this difference was not at a significant level that would affect the operation of the devices and patient treatment. In this context, it has been observed that the SWD devices within the scope of the test have acceptable power and frequency values. As a result of the study; It has been determined whether the SWD devices operate within the manufacturer's parameters in terms of power and frequency. It is important for the healthy operation of the devices that similar controls are carried out at regular intervals by the technical personnel in the health facilities, and that the device user personnel make the daily lamp controls without interruption.

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