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ORIGINAL CONTRIBUTIONS

Effect of local vibrotherapy in sitting or lying position in two time protocols on the cellulite grade and change of body circumferences in women with cellulite

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Abstract

Background: Vibrotherapy is becoming a new tool which can help to improve aesthetic appearance. One of its basic uses in cosmetology is eliminating cellulite changes.

Aim: The aim of the study was to analyze the effect of a 3-week series of local vibrotherapy in two positions and in two time protocols on selected body circumferences, WHR, WHtR and BAI, and the grade of cellulite.

Patients and Methods: Volunteers underwent vibration treatments in a lying or sitting position for 30 or 60 minutes a day, for 3 weeks. Waist, hip, thigh and calf circumferences were measured before and after the first, and before and after the last treatment. The WHR, WHtR and BAI indicators were calculated. The grade of cellulite was assessed with use of the Nürnberger-Müller scale. A multivariate analysis of variance was performed to assess the impact of individual parameters.

Results: After a series of treatments, a significant decrease in the grade of cellulite was noted, regardless of the treatment time or position. The circumferences of the thighs and hips didn't change. Both, the first and the last treatment allowed for change the calf circumference. The applied series of treatments allowed for lower the waist circumference also for change the WHR and WHtR indicators.

Conclusion: A series of vibration interventions reduced cellulite symptoms without affecting the hip and thigh circumferences. The treatment positions can be adjusted to the individual needs of the client and time of single treatment can be minimized to 30 min a day.

KEYWORDS
cellulite, local vibrotherapy, oscillating-cycloid vibration, vibrotherapy

1 | INTRODUCTION

Cellulite is a common cosmetic defect concerning changes in the topography of the skin and subcutaneous tissue. It occurs even in 80–90% of women in the post-pubertal age.[1] The following factors are associated with the occurrence of cellulite: high level of estrogens, insufficient or incorrectly selected form of physical activity, lifestyle, and nutrition habits. Although these factors are not directly related to the appearance of cellulite, they may exacerbate the existing defect.[2] Cellulite typically appears on the thighs and buttocks, much more often in women than in men.[3] The decrease in the quality of life depends on the severity of cellulite.[4] Pregnant women with skin lesions, including cellulite, declare their willingness to try to eliminate them after childbirth.[5]

It has been indicated that chronic microcirculation disorders and their consequences concerning intercellular endocrine communication lead to the formation of fibrous septa in the subcutaneous tissue and thus play an important role in the formation of cellulite lesions.[6]

The effectiveness of treatments stimulating lymphatic drainage[7] and microcirculation, including treatments with the use of vibrotherapy,[8–10] in improving the appearance of thighs and buttocks seems to confirm the importance of this mechanism.

Noninvasive treatment methods aimed at improving the appearance of the skin, for example, cryolipolysis, radiofrequency treatments (RF), low-level laser therapy (LLLT), high-intensity focused ultrasound (HIFU), are introduced to cellulite therapy.[11] However, their effectiveness, especially in the long term, is debatable.[1] Invasive methods such as tissue stabilized guided subcision, microfocused ultrasound, and minimally invasive calcium hydroxylapatite injections are also used.[12]

Vibration treatments (VT) can be carried out in various forms. Most of the scientific research concentrate on whole-body vibration (WBV). It is recommended for various preventive and therapeutic purposes.[13] Locally applied vibration is a safer form of vibrotherapy, and its beneficial effects can be also used in cosmetology,[14] training and sports medicine,[15] rehabilitation, and wellness.[13]

The expected anti-cellulite effect of local vibrations may be obtained due to the lymphatic drainage of tissues generated by oscillatory-cycloidal vibration[7] or the increase in NO release in blood vessels.[16] However, the patient's position during local form of vibration stimulus propagation and the time of its propagation require experimental verification. Therefore, it seems necessary to define the minimum, effective conditions in which multifunctional massage table with a multi-section active surface (MMT) can be used in cellulite therapy. The direct aim of the research was to determine the optimal treatment position and the minimum effective time of a single treatment with use of this device.

2 | MATERIAL AND METHOD

2.1 | Characteristics of the device used for vibrotherapy

In this study, the vibration stimulus was generated by MMT (Vitberg, Poland). The basic module can be combined with additional active (vibrating) or passive (non-vibrating) modules. One of the active ones is the hips module, which is intended for the massage of the buttocks, back of the thighs, hip, and waist, and seems to be an effective mean of helping to improve aesthetic appearance or even completely eliminate the symptoms of cellulite.

The oscillatory-cycloidal vibrations used in this research study were propagated according to the established algorithm, and the transmission of vibrations was carried out by a motor with a vibration anvil. The active module is equipped with an engine operating in the range of 18–39 Hz. The vibrations were transmitted to the body by three vibrating modules, working independently through the use of various forms of propagation: fast 2-second peaks—reaching the maximum vibration frequency within 1s and its rapid decrease to zero; alternatively used frequencies (18 Hz, 38 Hz) were maintained for a predetermined time; long periods of smooth frequency increase, for example, from zero to maximum (38 Hz) or drop from the indicated maximum frequency. The symmetrical work of the side modules in the cushions placed on the sides of the body was assumed. The program characteristics are shown in Figure 1. Figure 2 shows the patient in a seated position. The lying position consisted of tilting the backrest (angle: 45˚), and the calves were placed at an angle of 135° to the thighs. Figure 1.

2.2 | Study group

Sixty healthy women (age range: 18–45) were recruited to participate in the project. They were randomly assigned to the groups undergoing treatments in a sitting ($n = 30$) or lying ($n = 30$) position. Participants of each group were divided into the subgroups participating treatments lasting for 30 ($n = 15$) or 60 minutes (two 30' treatments; $n = 15$). The full 3-week study protocol was completed by 57 participants. Characteristics of study participants are shown in Table 1.

The exclusion criteria were as follows: contraindications to the use of VT (Table 2), infectious diseases during the project, and absence for more than 85% treatments.

The research was approved by the Bioethical Committee (No. KB/56/N02/2019), and its protocol was comply with the ethical principles for medical research involving human subjects included in the Declaration of Helsinki. The subjects were informed about the possibility of withdrawing from the program at its each stage, signed declarations of informed consent to participate in the study, to perform measurements included in the protocol, and to publish the results (without data that could allow to identify individual participants).

2.3 | Study protocol

Women from all 4 experimental groups participated in a series of treatments lasting 3 weeks, which consisted of 15 treatments: 1 (30') or 2 treatments a day (60'), performed from Monday to Friday, in the afternoon. After completing the interview containing the personal questionnaire, height (Martin anthropometer GPM Model 100, USA) and body weight (Tanita MC-780MA P, Korea) were measured. Participants were asked to come fasting on the first and last treatment. Before (I) and after (II) the first treatment, and before (III) and after (IV) the last treatment, measurements were taken: The selected body circumferences were measured using an anthropometric tape; after vibromassage, the grade of cellulite changes was assessed according to the Nürnberger-Müller scale.

3 | METHODS

3.1 | Measurements of anthropometric indicators

Measurements of circumferences of arm (AC), waist (WC), hip (HC), thigh (TC), and calf (CC) were performed in accordance with the standards adopted by Bronczyk-Puzon et al.[17] with use of the

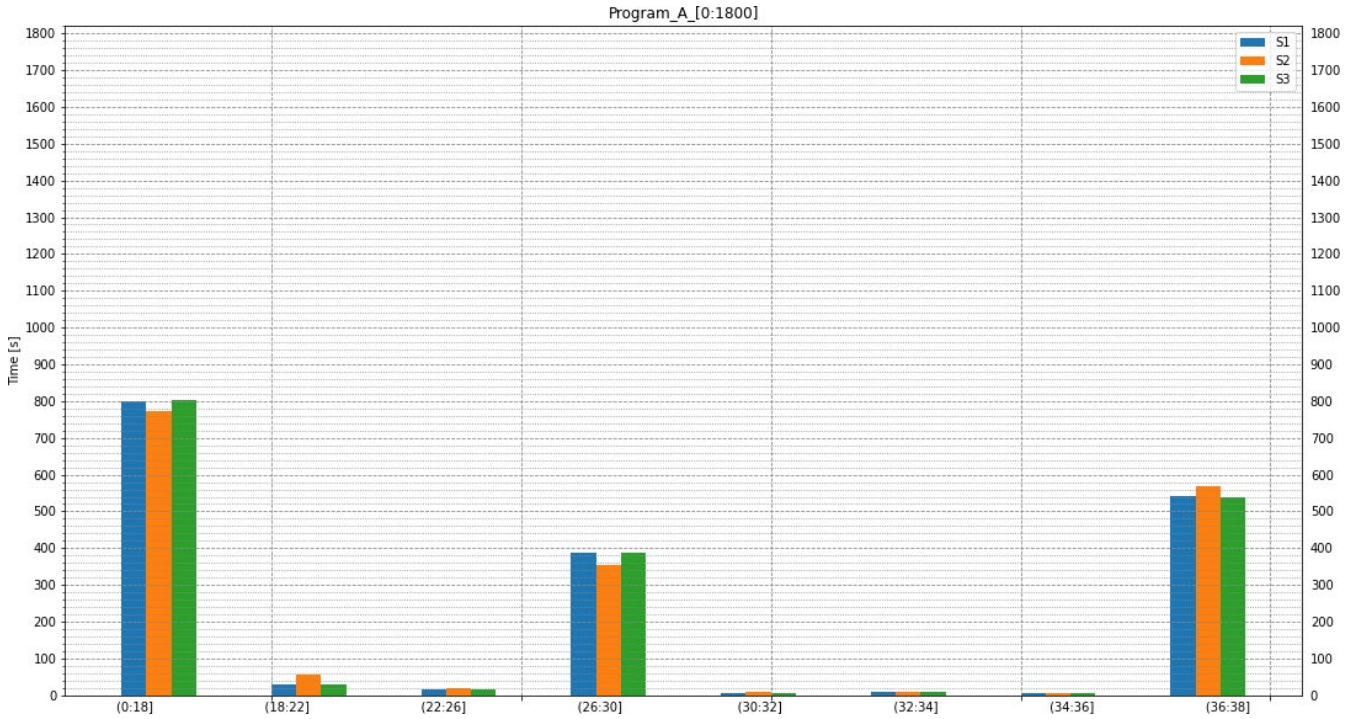

FIGURE 1 Program characteristics describe the distribution of the frequencies used during the full treatment time (30 minutes). The Y axis represents the time in seconds. The X axis shows frequency ranges (intervals). For example, the interval (0:18) is frequency 0

FIGURE 2 Patient is in a sitting position during the vibromassage treatment

anthropometric tape (Baseline, Poland), each time by the same researcher, on the non-dominant limb, in triplicate each. The mean value was taken into account as the result. HC was measured at their widest point.

3.2 | Calculation of anthropometric parameters

Using the obtained results of measurements of the circumferences of individual parts of the body and height, the following anthropometric indices were calculated according to commonly used formulas: waist-hip ratio (WHR), waist-height ratio (WHtR), and body adiposity index (BAI).[17]

3.3 | Assessment of the grade of cellulite

The grade of cellulite changes was assessed by palpation-visual method according to the Nürnberger and Müller scale widely used in research.[18] The assessment was always made by the same researcher, qualifying the condition of skin according to the following scheme: grade 0—healthy skin, no unevenness even when the skin was pressed; grade 1—smooth skin, both in standing and lying positions, unevenness becomes visible only after pressing the skin; grade 2—skin irregularities visible only in the standing position, smooth skin in the lying position; grade 3—uneven skin visible both in the standing and lying positions.

3.4 | Statistical analysis

The results from the questionnaire were tested using the chi-square test. After evaluating the distribution type (Shapiro-Wilk test), the effects of the treatments were assessed by multivariate analysis of variance or by Student's *t* test for dependent groups (paired test). The Huynh-Feldt correction was used for the variables where the assumption of sphericity required for the ANOVA test has not been met. The level of significance was set at $p < 0.05$. All analyzes were

TABLE 1 Characteristics of the study group

	Total	Sitting position	Lying position		
Number (*n*)	57	30	27		
Variable				Chi^2	*p*
Grade of cellulite	I 22 (38.6%)	I 14 (46.7%)	I 8 (29.6%)	1.740	0.1870
	II 35 (61.4%)	II 16 (53.3%)	II 19 (70.4%)		
Contraception	Yes 21 (36.8%)	Yes 13 (43.3%)	Yes 8 (29.6%)	1.147	0.2840
	No 36 (63.2%)	No 17 (56.7%)	No 19 (70.4%)		
Tabaco smoking	Yes 9 (15.8%)	Yes 6 (20.0%)	Yes 3 (11.1%)	0.844	0.3580
	No 48 (84.2%)	No 24 (80.0%)	No 24 (88.9%)		

TABLE 2 Contraindications to participation in local vibrotherapy treatments

Occurring in the past	Currently present	Occurring during or after the treatment
• Metastatic malignant tumors • Cardiovascular diseases • Thrombosis • Surgical interventions involving the musculoskeletal system • Acute back pain • Advanced diabetes	• Pregnancy and lactation • Pacemaker • Acute inflammation • Recovery period after endoprosthesis of the hip or knee joint • Infectious diseases	• Headache or dizziness • Nausea

performed using the STATISTICA software (version 13, SoftStat, Poland).

4 | RESULTS

The results of anthropometric parameters measurements in study participants are presented in the Table 3. The results of arm circumferences (AC) measurements at four time points did not indicate any changes in this feature. There was no effect of treatment duration, treatment position, or interactions between these parameters.

The analysis performed for the hip circumferences (HC) showed similar results: The measurements did not differ significantly. Neither the treatment time nor the treatment position differentiated the groups in terms of this parameter. The interaction effect between these parameters was also not indicated.

Differences in the results of measurements of waist circumferences (WC) were identified ($p = 0.036$). The post hoc test used showed that there were significant differences between the measurements I and III ($p = 0.023$). ANOVA analysis indicated no effect of the position and duration of the procedure and no interaction between these factors.

As for the previous parameter, calf circumferences (CC) changed significantly over the course of the treatment series duration ($p < 0.001$). It was indicated in ANOVA that the differences appeared between measurement I and II ($p < 0.001$) and between measurement III and IV ($p = 0.041$). There was no effect of treatment duration or treatment position. There was also no interaction between the studied parameters.

For the thigh circumferences (TC), the changes were similar to those for the AC and HC. There was no difference between the measurements performed at the four points indicated in the study protocol. There was no effect of the duration of the procedure or the treatment position on the results of the measurement of TC in the participants of the project.

The values of the calculated anthropometric indices for each of the groups at all four time points are presented in Table 4. The WHR and WHtR indices in the ANOVA showed statistically significant differences between the measurements ($p = 0.009$ and $p = 0.032$, respectively). The analysis of the WHR values obtained in 4 time points with use of the post hoc test showed statistically significant differences for the measurements obtained for the following time points: I vs. III ($p = 0.009$), I vs. IV ($p = 0.003$), II vs. III ($p = 0.045$), and II vs. IV ($p = 0.017$). No statistically significant differences were

TABLE 3 Descriptive statistics of somatic characteristics in women who underwent a series of vibrotherapy treatments in two positions (sitting or lying) and the results of testing the type of distribution of variables (Shapiro-Wilk test)

		Mean	SD	Min	Max	W	*p*
A	Lying	23.7	6.4	19	43	0.657	<0.001
	Sitting	22.1	4.1	19	38	0.587	<0.001
BH	Lying	167.6	6.0	158	180	0.969	0.569
	Sitting	165.4	5.1	156	176	0.955	0.236
AC I	Lying	27.6	3.2	22	36	0.971	0.640
	Sitting	27.8	2.6	21.5	32.5	0.972	0.603
AC II	Lying	27.4	2.9	22.5	35	0.975	0.744
	Sitting	27.7	2.7	22	32.5	0.970	0.552
AC III	Lying	27.4	3.1	22	35	0.980	0.871
	Sitting	27.5	2.5	22.5	34	0.987	0.961
AC IV	Lying	27.3	3.2	22	35	0.980	0.867
	Sitting	27.8	3.5	22	41.4	0.823	<0.001
HC I	Lying	98.4	6.4	81.5	108	0.961	0.394
	Sitting	96.9	6.9	82	109.5	0.957	0.260
HC II	Lying	98.0	6.4	82	108	0.959	0.359
	Sitting	97.4	6.8	82.8	109.5	0.953	0.201
HC III	Lying	98.1	5.9	87	107	0.954	0.261
	Sitting	98.7	5.3	88.8	107	0.950	0.171
HC IV	Lying	98.1	5.9	87	107	0.946	0.172
	Sitting	98.8	5.2	88.5	107.2	0.961	0.337
WC I	Lying	73.5	7.1	59.8	93.3	0.966	0.509
	Sitting	71.7	5.6	62.5	83.5	0.959	0.293
WC II	Lying	73.3	7.4	59.5	94	0.967	0.520
	Sitting	71.6	5.4	63	83	0.955	0.224
WC III	Lying	72.5	7.6	60.2	93	0.957	0.320
	Sitting	71.0	5.6	62.5	82.1	0.953	0.207
WC IV	Lying	72.3	7.4	59.5	93	0.956	0.301
	Sitting	71.0	5.3	63	82	0.961	0.330
CC I	Lying	36.7	2.6	32	42.5	0.945	0.158
	Sitting	36.1	2.5	30	42.5	0.985	0.937
CC II	Lying	36.0	2.4	32	41.5	0.937	0.100
	Sitting	35.5	2.9	28	42.5	0.975	0.691
CC III	Lying	36.4	2.6	32	42	0.939	0.118
	Sitting	35.7	2.3	30.7	41	0.985	0.940
CC IV	Lying	36.0	2.7	31	42	0.959	0.345
	Sitting	35.4	2.2	31.1	40.5	0.984	0.916
TC I	Lying	57.4	4.3	48	66.5	0.992	0.998
	Sitting	56.6	4.3	49	64.5	0.953	0.206
TC II	Lying	57.4	4.2	49	67	0.983	0.931
	Sitting	56.6	4.1	50	64.5	0.953	0.197
TC III	Lying	57.3	4.0	47.5	65	0.967	0.531
	Sitting	56.5	4.1	46.4	65	0.985	0.934
TC IV	Lying	57.5	4.3	47.5	65.5	0.965	0.468
	Sitting	56.8	4.1	47.7	64	0.975	0.679

Abbreviations: A, age; AC, arm circumference; BH, body height; CC, calf circumference; HC, hip circumference; I, measurement performed before first treatment; II, measurement performed after first treatment; III, measurement performed before last treatment; IV, measurement performed after last treatment; MAX, maximum value; MIN, minimum value; SD, standard deviation; TC, thigh circumference; WC, waist circumference.

TABLE 4 Descriptive statistics of the calculated anthropometric indicators in women who underwent a series of vibrotherapy treatments in two positions (sitting or lying) and the results of the variable distribution type test (Shapiro-Wilk test)

		Mean	SD	Min	Max	W	*p*
WHR I	Lying	0.75	0.05	0.65	0.88	0.956	0.295
	Sitting	0.74	0.05	0.66	0.83	0.975	0.676
WHR II	Lying	0.75	0.06	0.65	0.90	0.958	0.331
	Sitting	0.74	0.04	0.66	0.83	0.974	0.653
WHR III	Lying	0.74	0.06	0.65	0.88	0.964	0.453
	Sitting	0.72	0.04	0.63	0.84	0.978	0.780
WHR IV	Lying	0.74	0.05	0.66	0.89	0.943	0.141
	Sitting	0.72	0.04	0.62	0.84	0.972	0.589
WHtR I	Lying	0.44	0.04	0.37	0.57	0.933	0.083
	Sitting	0.43	0.03	0.38	0.50	0.968	0.483
WHtR II	Lying	0.44	0.05	0.36	0.58	0.941	0.131
	Sitting	0.43	0.03	0.39	0.50	0.959	0.291
WHtR III	Lying	0.43	0.05	0.37	0.57	0.922	0.044
	Sitting	0.43	0.03	0.38	0.50	0.967	0.472
WHtR IV	Lying	0.43	0.04	0.36	0.57	0.916	0.031
	Sitting	0.43	0.03	0.38	0.49	0.965	0.404
BAI I	Lying	27.4	2.9	19.8	32.9	0.981	0.876
	Sitting	27.6	2.6	21.0	31.5	0.953	0.208
BAI II	Lying	27.2	2.9	20.0	32.5	0.983	0.923
	Sitting	27.8	2.6	21.5	31.5	0.956	0.251
BAI III	Lying	27.3	2.8	22.3	32.9	0.969	0.581
	Sitting	28.4	2.3	23.0	33.4	0.977	0.728
BAI IV	Lying	27.3	2.8	22.8	32.5	0.955	0.282
	Sitting	28.5	2.3	23.0	33.4	0.980	0.836

Abbreviations: BAI, body adiposity index; I, measurement performed before first treatment; II, measurement performed after first treatment; III, measurement performed before last treatment; IV, measurement performed after last treatment; MAX, maximum value; MIN, minimum value; SD, standard deviation; WHR, waist-hip ratio; WHtR, waist-height ratio.

TABLE 5 Results of statistical analysis (Wilcoxon test) of cellulite grade in women who underwent a series of vibrotherapy treatments in two positions: sitting or lying and with the use of a 30' or 60' protocol (2 treatments of 30')

	Sitting position		Lying position	
Time	Z	*p*	Z	*p*
30'	3.516	<0.001	2.803	0.004
60'	3.920	<0.001	3.521	<0.001

found for the position and the duration of the procedure. There was also no interaction between these parameters. For the WHtR index, the post hoc test used showed statistically significant differences between measurements I and IV ($p = 0.020$). There were no statistically significant differences for the duration of treatment and position used.

The ANOVA analysis showed no statistically significant changes in the BAI values between the measurements in four time points, as well as in the treatment time. Only a trend was observed for the treatment position ($p = 0.085$). There was also no significant interaction between the treatment time and the treatment position.

After 3 weeks of participation in VT treatments, cellulite reduction assessed with a visual palpation scale was demonstrated in all study groups. These changes were statistically significant (Table 5).

5 | DISCUSSION

A retrospective study by Alizadedh et al[1] proves that some noninvasive methods lead to reduction of thickness of the subcutaneous tissue and the visibility of cellulite in selected body areas. The most common tool for observing the end point, which proves the effectiveness of the procedure, was the reduction of body circumferences. Therefore, this method seems to be one of the primary methods that can be used to compare the effectiveness of different anti-cellulite treatments. Some researchers do not support the use of body circumferences measurements, pointing out that they are not an indicator of the grade of cellulite changes, and their reduction does not necessarily correlate with the severity of cellulite. An innovative and interesting diagnostic tool used for modeling the surface of the skin affected by cellulite is a 360° 3D whole-body scans which allows for an objective assessment of therapy effectiveness.[19]

In our project, the observation of differences in circumferences was used as a simple tool and allowed to monitor the dynamics of changes generated by a vibrating stimulus. However, the analysis of the results did not show any significant changes in the TC and HC in the subjects participating in the vibration procedures for the period of 3 weeks. Regardless of the treatment position (sitting or lying) and the duration of the treatment (30 or 60 minutes), these body circumferences did not change. However, post-treatment reduction in CC was indicated. Statistically significant differences were observed both after the first and the last treatment. In our opinion, it is related to the stimulation of lymphatic drainage caused by the vibration stimulus applied during treatment sessions. Similar observations were already indicated earlier by Stewart et al.[20] Interestingly, our project showed that after 3 weeks of vibromassage sessions, no adaptation was observed and favorable changes occurred both after the first and the last treatment. We believe that the observations of CC changes were possible due to the most distal location of the calves and the most common lymph retention in this part of the body. The beneficial effect of vibrations is also associated with the effect of vibrations on the muscles, which, as indicated in the work of Cakar et al, is related to the direction of the vibration stimulus.[21] The oscillating-cycloidal vibration generated by the MMT device has a complex effect in this respect, resulting from the alternating action of force. The use of more sensitive assessment methods, such as in the study by Cakar et al,[21] could probably identify similar post-treatment changes in other areas of the body, which was observed in this project. However, in our project, it was possible to show an interesting influence of a series of vibromassages on the WC. Significant differences were observed for the measurement before the first and the last treatment, which indicates that the applied treatment series allowed for the reduction of the WC. There was no effect of a single treatment on the size of this circumference, so its change is not a simple lymph drainage effect. It seems likely that the prokinetic influence of the vibration stimulus on the functioning of the gastrointestinal tract may be responsible for the observed changes. The regulation of bowel function can, with repeated use of the vibration stimulus, have the effect of lowering the WC. This action of vibration was the basis for the use of various vibration generating tools to improve the functioning of the gastrointestinal tract in seniors. And despite the differences in technology and the characteristics of the vibrations used, the results of the research were positive and the proposed devices generating vibrations were well tolerated by project participants.[22]

The change of the WC allowed for visualizing the influence of a series of VT on the WHR and WHtR. We indicated statistically significant differences for changes in both indicators, without the influence of the treatment position and the time of a single treatment. The most important observation is the difference between the WHR values before the first and the last treatment shown in post hoc tests. These results confirm the effect of the treatment series. A single procedure did not give such an effect, which was shown for both the first procedure (I vs. II) and the last one (III vs. IV). In the case of the WHtR index, which includes body height, the effect was less visible. For this indicator, significant differences between the measurement I (before the first treatment) and the IV (after the last treatment) were noted. The observed difference is not easy to explain. In our opinion, it is the result of the cumulative effect of changes caused by the series of treatments and minor changes generated by a single treatment. The last of the analyzed anthropometric parameters, BAI, did not change significantly in participants during the project duration. This indicator allows for calculating the percentage of body fat in a simple and noninvasive manner. The lack of changes in BAI should be understood as an evidence that a series of VT with the use of MMT, regardless of body position and duration of vibrations, is a stimulus that seems to be too small to change the body fat content.

An additional tool allowing for the monitoring of the treatment effects was the Nürnberger and Müller scale of cellulite.[18] Assessment made according to this scale is also a simple and reliable tool for a trained researcher.[6] With use of this method, we obtained different results when assessing the body circumferences. The cellulite grade in all groups improved significantly. It was demonstrated that both tested body positions resulted in a significant improvement in the appearance and condition of the skin of the thighs and buttocks, assessed using the Nürnberger and Müller scale. We also indicated that both time protocols showed a statistically significant improvement, which shows that a 30' treatment can be an effective tool in reducing the symptoms of cellulite in women.

Available research on the influence of vibrations transmitted through the skin has shown that this kind of stimulation leads to an increase in microcirculation and in the flow of fluids in soft tissues. As a result of the frictional forces generated by the oscillating vibration, the force of lymphatic drainage increases, which supports the removal of tissue fluids. A similar phenomenon was observed in our previous studies, where we showed the effect of topical vibration on the increase in skin temperature of the thighs and buttocks.[9] An additional mechanism of the influence of this type of vibration on blood vessels, with a potentially beneficial effect, is associated with a direct impact on the arteriolar endothelium, leading to an increase in the synthesis of nitric oxide (NO).[16]

It can be assumed that vibration therapy activates the fat burning mechanism. This was confirmed in the population of young women. The study of Winters-Stone et al has shown that training on the vibration platform (WBV) could be an effective tool against unfavorable changes in body composition.[23] Vibration applied locally is characterized by a different stimulus propagation mechanism and a different effect on tissues; hence, its effect on systemic parameters may be smaller or may require a longer period of stimulus application. Therefore, comparing the effects of local vibration and WBV is of a limited importance. Our previous studies in which young women participated in 20 local VT treatments also did not indicate the effect of local vibration on the body weight. However, a strong influence on the image of small blood vessels in the skin of the thighs and buttocks[10] and the skin temperature examined thermographically[9] was indicated. These observations are important in the regard of the mechanism of cellulite changes formation, which is associated with

significant microcirculation disorders. As a consequence, there may be insufficient blood supply to the tissues - the reaction of cells reaction to related hypoxia in the form of the release of cytokines and endocrine factors may occur. Vibration therapy improves vascular flows and starts lymphatic drainage.[7] This effect was shown in 10 healthy women with use of thermographic imaging in the work of Pilch et al[9].

In the study cited above, as in the present project, a reduction in the grade of cellulite was observed, measured using the Nürnberger-Müller scale. The main difference was the use of a vibration source with different vibration parameters and a different propagation algorithm and a longer treatment protocol (study by Pilch et al lasted for 4 weeks). The currently used MMT massage device allowed for visualizing the improvement in aesthetic appearance of thighs and buttocks after just 3 weeks.

In the available studies on reducing the severity of cellulite symptoms, apart from the studies by Pilch et al[9,10] and Sadowski et al,[8] systemic vibrations (WBV) were mainly used. These studies indicate the beneficial effects of combining with ultrasound[24] or LLLT.[25] However, as indicated above, the differences in the impact on the skeletal system and the form of vibration propagation between WBV and local vibration make it impossible to compare these two forms of vibration application directly (a local vibration stimulus may have a stronger effect because it is not absorbed by the skeletal system).

In the research of Sadowski et al,[8] vibration applied locally to eliminate cellulite was used, but the device generating vibrations was completely different than the one utilized in our project. A hand-held massage device was used with application of silicone oil on the skin. Forty women aged 30–55, body mass index (BMI) 18–30, and with symptoms of cellulite on the DERM 4–6 scale[26] were instructed how to use a vibration device. The vibration stimulus was applied every other day in a designated area of the thigh for 15 minutes for a period of 6 months. Initially, women used vibration on one leg, and the second one was a control. In the next phase of the study, one half of the women used treatments on both legs, and the other half stopped performing vibromassages. After 12 weeks, the volume of the cellulite changes determined by the three-dimensional photograph on the lateral thighs was significantly reduced compared to u skin. In the area of the biceps femoris muscle, the effect was slightly less visible, which the authors explain by an easier vibromassage application on the side of the thigh (easier access and better visibility). After another 12 weeks, the condition of skin returned to baseline in the non-massage group. However, in the group who continued the vibration treatment, the cellulite volume decreased even more compared to the level obtained after 12 weeks. These studies, like previously cited retrospective studies,[1] show that the effects of most cellulite-eliminating treatments are of short duration. Therefore, the price and simplicity of performing such procedures should be an important criterion for assessing new tools designed for this purpose. In this aspect, the MMT is an interesting tool which may be used for reducing the symptoms of cellulite.

Due to the fact that cellulite develops as a result of increased local tissue tension, inflammatory disorders, and tissue blood supply, the influence of the vibrational stimulus through the mechanisms described above may significantly reduce the existing defect. Importantly, the vibration stimulus can relieve the stress on the fibrous tissue that forms longitudinal dermal-subcutaneous columns, clinically manifested as pits, which will visually reduce the "orange peel skin."

Therapeutic use of vibrations improves the blood supply to the skin.[27] The cyclic stresses and loads exerted on the endothelial surface of the artery during the action of vibration stimulate the release of beneficial mediators, such as nitric oxide (NO), which may cause vasodilation.[16] The condition of the muscles has improved, which is important in the fight against fat cellulite. By increasing the microcirculation in the skin, its oxygenation and color may improve,[10] as well as lymph circulation.[24,25] In the mechanism of effects of repeated vibration on tissues, metabolic effects cannot be excluded. The influence of topically applied vibration on carbohydrate[28] and lipid metabolism[29] has already been shown, which could play an important role in reduction of cellulite lesions.

A series of VT applied in this study reduced cellulite symptoms without affecting the measured body circumferences. It was indicated that neither the treatment position nor the time of a single treatment caused significant changes. In the context of the available research, an effective anti-cellulite treatment should be performed regularly and should be easy to perform and within easy reach. All these elements are featured in a MMT device used in this study. Further research may allow, perhaps, for identification of the exact mechanisms of eliminating disturbances in skin aesthetics using vibrations.

6 | CONCLUSIONS

After a series of treatments, a significant decrease in the grade of cellulite was noted, regardless of the selected treatment time and body position. The type of position and the duration of the procedure did not play a significant role in the observed changes in the circumference of the thighs and buttocks. Both the first and the last procedure allowed for changing the CC, which may emphasize the importance of lymphatic drainage as an important mechanism stimulated by the application of vibrations. For the vibromassages sessions lasting 60 minutes, first treatment lowered the calf circumference (CC) by an average of 82 mm, and the last treatment in the series by 42 mm. For a 30-minute session, these values were 45 mm and 32 mm, respectively. After 3 weeks, we also observed a decrease in WC, a change in WHR and WHtR indices, which has no direct significance in the image of cellulite changes, but is an interesting, beneficial effect of the proposed treatment series. The tested device, its design, and the applied stimulus seem to be an effective method of reducing cellulite in women.

7 | STUDY LIMITATION

Subjective assessment, despite the use of the recognized tool of the Nürnberger-Müller scale, is always burdened with some error.

Therefore, it seems advisable to conduct further research with the use of fully objective tools, for example, thermography or ultrasound assessment.

CONFLICT OF INTEREST

The authors report no conflicts of interest in this work.

ETHICAL STATEMENT

The research was approved by the Bioethical Committee (No. KB/56/N02/2019).

AUTHOR CONTRIBUTION

Anna Piotrowska, PhD: involved in study design, performed research, performed data analysis, wrote the paper, and applied corrections after reviews. Olga Czerwińska-Ledwig, MSc: performed research, performed statistical analysis, wrote the paper, and applied corrections after reviews.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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