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Article *in* Rehabilitacja Medyczna · February 2019

DOI: 10.5604/01.3001.0013.0109

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The effects of a 4-week vibrotherapy programme on the reduction of adipose tissue in young women with cellulite – a pilot study

Wpływ 4 tygodniowej wibroterapii na redukcję tkanki tłuszczowej u młodych kobiet z cellulitem – badania pilotażowe

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Key words
lipodystrophy, oscillating-cycloid vibration, adipose tissue, body composition, dermatoscopy

Abstract
Introduction: Lipodystrophy is a common problem for modern women. So far, no fully effective therapeutic methods have been developed to eliminate this type of change. Vibration massage is a method that has not yet been studied in the prevention and elimination of lipodystrophy symptoms.
Aim of the study: The aim of this study was to evaluate the effectiveness of vibrotherapy on the reduction in lipodystrophic changes.
Material and method: 10 volunteers with cellulite changes at the age of 21-23 with physical activity levels described by the international IPAQ questionnaire participated in the study. All women included in the study were evaluated on the basis of 5-day nutrition analysis. Before and after 4 weeks of vibrotherapy, waist, hip and thigh circumferences were measured, and body composition was assessed using bioimpedance and dermatoscope photos were taken. Oscillating cycloidal vibration was generated by the Vitberg+ Rehabilitation Device (Nowy Sącz).
Results: After the 4-week series of vibrations, the following average reduction in thigh circumference was observed (Δ1.55 cm, $p = 0.002$ for right thigh, Δ1.50 cm, $p = 0.000$ for left), hips (Δ1.25 cm, $p = 0.006$) and waist (Δ2.30 cm, $p = 0.002$). The proposed treatment series caused a reduction in body fat mass (Δ0.42 kg, $p = 0.009$) without affecting the body's water content, and the analysis of dermatoscopic imaging results revealed improvement in skin perfusion.
Conclusion: Oscillating-cycloidal vibration therapy can be an effective tool to alleviate lipodystrophic changes.

Słowa kluczowe
lipodystrofia, wibracja oscylacyjno-cykloidalna, tkanka tłuszczowa, skład ciała, dermatoskopia

Streszczenie
Wprowadzenie: Lipodystrofia jest problemem o dużym nasileniu u współczesnych kobiet. Do tej pory nie opracowano w pełni skutecznych metod terapeutycznych całkowicie niwelujących tego typu zmiany. Mało poznaną i jak do tej pory nie badaną metodą w profilaktyce i niwelowaniu objawów lipodystrofii może być masaż wibracyjny.
Cel pracy: Celem pracy była ocena skuteczności wibroterapii na zmiany lipodystroficzne.
Materiał i metoda: W badaniach uczestniczyło 10 wolontariuszek ze zmianami cellulitowymi w wieku 21-23 lata o określonej aktywności fizycznej mierzonej międzynarodowym kwestionariuszem IPAQ. U wszystkich osób włączonych do badania dokonano oceny żywienia na podstawie 5-dniowej analizy żywienia, wykonano pomiar obwodów talii, bioder i ud, oszacowano skład ciała za pomocą bioimpedancji oraz wykonano zdjęcia z dermatoskopu. Zastosowano 4 tygodniową wibroterapię oscyla-

The individual division of this paper was as follows: a – research work project; B – data collection; C – statistical analysis; D – data interpretation; E – manuscript compilation; F – publication search

Article received: 25.09.2018; Accepted: 04.01.2018

Please cite as: Pilch W., Nastałek M., Piotrowska A., Czerwińska-Ledwig O., Zuziak R., Maciorowska A., Golec J. The effects of a 4-week vibrotherapy programme on the reduction of adipose tissue in young women with cellulite – a pilot study. Med Rehabil 2018. DOI: 10.5604/01.3001.0013.0109 (Ahead of print)

Internet version (original): www.rehmed.pl

cyjno-cykloidalną z zastosowaniem Rehabilitacyjnego Aparatu Masującego Vitberg+ (Nowy Sącz). Badania wykonano 2-krotnie, przed i po zastosowanej 4 tygodniowej wibroterapii.
Wyniki: Po 4 tygodniowej serii zabiegów wibracyjnych zaobserwowano średnie zmniejszenie obwodów ud (Δ1,55 cm, $p=0,002$ dla uda prawego, Δ1,50 cm, $p=0,000$ dla lewego), bioder (Δ1,25 cm, $p=0,006$) oraz talii (Δ2,30 cm, $p=0,002$). Zaproponowana seria zabiegowa wywołała redukcję masy tkanki tłuszczowej całego ciała (Δ0,42 kg, $p=0,009$) bez wpływu na zawartość wody w organizmie, a analiza wyników obrazowania dermatoskopowego ujawniła poprawę ukrwienia skóry.
Wniosek: Wibroterapia oscylacyjno-cykloidalna może być skutecznym narzędziem niwelowania zmian lipodystroficznych.

INTRODUCTION

Cellulite (paniculopathy, lipodystrophy) is the non-inflammatory degeneration of fat tissue with features of local edema and fibrous-scleral changes. It is characterised by uneven shape of the skin, which is accompanied by the accumulation of adipose tissue in predisposed areas[1-4]. Due to the build, the method of formation and the surface on which it is formed, two main types may be distinguished: water (hard) and fat (soft) cellulite. It has been shown that because of differences in the structure of adipose tissue, women are more likely to develop cellulite than men, in whom the fatty lobules are smaller and divided by partitions arranged obliquely to the dermis, which counteracts the folding[3,4]. Also, according to the literature, the build of the dermis has significance[5,6]. Cellulite changes are most often located in typically fat areas of the hips, thighs, buttocks and abdomen[2,6-8]. Cellulite mainly affects women during periods of estrogen level changes[3,4,10-12]. It occurs in overweight people, but also in young and active women, greatly decreasing their quality of life[2]. The main symptoms of cellulite include the appearance of skin topography unevenness, flaccidity and a characteristic "mattressed" appearance. Areas affected by lipodystrophy are irregularly undulated and unevenly tightened[4]. Degeneration is also manifested by nodules and lumps, which may be accompanied by pain[3]. In addition, stretch marks and teleangiectasias and characteristic change in skin tone may occur. Clinical symptoms may also be accompanied by various types of edema[2]. Cellulite changes usually start with stagnation of blood and lymph in vessels. The consequence of microcirculation disorders is thinning of the vascular walls, an increase in their permeability, which leads to the accumulation of liquids in the intercellular spaces. As a result, the cells are not provided with the necessary nutrients[2], and then, local dystrophy of adipocytes arises and the balance between the synthesis and breakdown of triacylglycerols is disturbed[3]. It is widely recognised that the causes of lipodystrophy are genetic factors[4], disorders in hormone management and modifiable factors such as: poorly composed diet, sedentary lifestyle and inappropriate clothing. Current reports also indicate the involvement of the fascia in the etiopathogenesis of these changes[13].

Different techniques and treatments are used to eliminate symptoms of cellulite: lymphatic drainage, infrared and ultrasound treatments, and often surgical methods (liposuction)[3,9]. In the treatment pharmacological or cosmetic active substances introduced into the skin (iontophoresis, mesotherapy) are also used. Vibration massage is little known and so far, it remains a method not investigated in preventing and eliminating the symptoms of cellulite.

Vibration (mechanical vibrations) is a physical phenomenon based on spreading low-frequency acoustic oscillations within solid media. It can be applied to the human body via direct contact with the source of vibrations[14]. Vibration therapy has been known for a long time, but it started to gain more interest in the 20th century. Currently, the most popular research target are the curative and rehabilitative applications of vibro-therapy generated by a vibrating platform and transferred to the body (Whole-Body Vibration, WBV)[15]. Different possible mechanisms of the influence of vibration on the body are indicated. The first one is the change in muscle tone caused by reflexes arising as a result of vibrations and strain of the fascia[16]. During therapy, vasodilatation was observed, which leads to an increase in skin temperature, improving microcirculation and lymph redistribution[16,17]. A greatly beneficial effect on the elasticity of the arteries has also been noted[18]. Thanks to better blood supply, tissues become properly nourished and oxygenated, trophic and repairing factors reach the ischemic regions, which results in faster healing and general improvement of the skin's appearance. It has been proven that vibrations can favourably affect skin changes associated with diabetes and aging[19]. They indirectly affect cleaning the respiratory tract[20], indicating a beneficial effect on improving physical fitness, especially among seniors[21].

In the light of the above reports, it can be concluded that vibro-massage can have an effect on eliminating cellulite symptoms and improves body composition.

STUDY AIM

The aim of the work was to evaluate the effectiveness of vibratory treatments in cellulite changes among women and, above all, to answer the following research questions:

1. Does and how does the use of the 4-week vibro-therapy programme influence the change in selected body circumferences?
2. Does and how does the use of a 4-week vibro-therapy programme influence the change in body mass composition?
3. Does and how does the use of a 4-week vibro-therapy programme influence the change in the dermatoscopic image of the skin?

4. Does the application of a 4-week vibrotherapy programme affect lipodystrophic changes?

MATERIAL AND METHODS

Characteristics of the studied group

The study involved 10 women (female students of the University of Physical Education – AWF – in Krakow) between the age of 21-23 (mean age: 21.5 years), the average body mass 62.47 kg, the average height 165.7 cm, the average BMI 22.79 kg/m^2. Inclusion criteria were: the presence of lipodystrophic changes (stage 1 or 2 in Nürnberger-Müller scale[22]). Women with similar physical activity (Physical Activity Level, PAL 1.40-1.69) were qualified for the study. Physical activity was assessed using the international IPAQ questionnaire (short version)[23]. The level of physical activity (PAL) was calculated, which is the ratio of the total to resting energy expenditure within 24 hours and refers to that portion of the total energy expenditure resulting from physical activity[24]. Exclusion criteria included: no cellulite changes, history of endocrine disruption or use of hormonal contraception, special or exclusion diets up to 3 months before the beginning of the study and contraindications to vibration (pregnancy, metastatic tumours, cardiac pacemaker, acute inflammation, heart and/or vascular disease, thrombosis, recovery period after hip and/or knee endoprosthesis, and others within the musculoskeletal system, acute back pain, advanced diabetes, infectious diseases).

Research methods

For all subjects included in the study, nutrition assessment was conducted on the basis of 5-day nutrition analysis using the nutritional diary and the Diet 5 program (Food and Nutrition Institute, Warsaw). Circumferences were measured at the widest point of the waist, hips and thighs, using an anthropometric measuring tape. Body composition was estimated using the method of electrical bioimpedance with the BC-418 MA scale (Tanita, Japan), and dermatoscopic images were taken with the Delta 20 T diode dermatoscope (Heine, Germany) in the lipodystrophic area. Measurements were performed twice, before and after completion of the 4-week vibration therapy, in the morning, at a fixed time (± 1 hour), in the same room and by one researcher each time.

Research protocol

The research was carried out at the Vibration Laboratory of the University of Physical Education in Krakow. The female volunteers took part in 1-hour session per day in a seated position for 4 weeks, from Monday to Friday. The therapeutic stimuli were the cycloidal vibrations directed in 3 mutually perpendicular directions. The RAM Vitberg+ Base Module and Hip Module Rehabilitation Massaging Device were used for therapy. Placing the body on a mattress generating a vibratory stimulus allowed the buttocks and thighs to be subjected to its action. Information on the Vitberg+ RAM performance parameters for the 'Hips programme' at level IV intensity is given in Table 1.

Statistical analysis

The results are presented as means±standard deviation. The type of distribution was tested using the Shapiro-Wilk test. Differences between the results before and after the introduction of therapy for variables with normal distribution were analysed using the Student's *t*-test for dependent groups. The Wilcoxon signed-rank test was applied in the

Table 1

Ranges of acceleration (a), amplitude (A) and frequency (f) of the Rehabilitation Massage Device for the Hips programme (empirical results provided by the manufacturer)

a [m/s^2] min-max	A [Mm] min-max	f [Hz] min-max
1.1-27	0.01-0.58	17.5-46.5

a – acceleration, A – amplitude, f – frequency

Table 2

Values of nutritional parameters in the studied women

	mean ± *SD*	**Norm according to Jarosz 2017 (PAL 1.6)**
Energy (kcal)	1966.98 ±556.32	2100
Protein (g/kg b.m./24h)	0.75 ±0.13	0.85
Fats (g)	78.65 ±22.17	56
Carbohydrates (g)	243.84 ±46.62	130

Measurements are expressed as mean ± *SD*

case of variables with other types of distribution, assuming statistically significant differences to be at the level of $p<0.05$. All analyses were performed using the Statistica 10.0 (StatSoft, USA) program.

RESULTS

Results of nutrition analysis among the studied women did not differ significantly from the standards adopted by the Institute of Food and Nutrition (in Polish: Instytut Żywności I Żywienia – IŻiŻ). There were slightly lower values of the analysed nutrition parameters (energy, protein), while values of the analysed fats and carbohydrates were slightly higher than in the presented standards[23] (Table 2).

1.00 kg), but the result did not reach the assumed significance threshold. The average increase in lean body mass by 0.17 kg was not significant. Differences in the total water content did not reach the assumed level of significance. Data on body composition are presented in Table 4.

In the dermoscopic image of the skin among all the examined women after the performed vibration treatments, noticeable improvement in the appearance of the skin was noted, which is shown in the attached dermatoscopic photos (Figure 1). Before the beginning of vibrotherapy treatments, all of the tested volunteers were referred to as having clearly dry and pale or palish-pink skin, with a very poorly visible capillary network or with point-shaped capillaries. After the completion of a series of 20 treatments using oscillating-cycloid vibrations, the slightly visible erythema was observed, thanks to dilatation of the capillaries. In addition, the capillary network became clearly visible. In all patients, dilatation of capillaries was noted. Photograph 4 indicates a rich network of capillary vessels in the shape of dots arranged in an arch or line.

Before the beginning of the study, 60% of women had grade-2 cellulite, which after the treatments, was reduced to grade-1. In the remaining women with diagnosed grade-1 cellulite, no lipodystrophic changes were observed after the application of vibro-therapy.

DISCUSSION

Lipodystrophy poses a great problem for modern women. To date, no fully effective therapeutic methods have been developed that would completely eliminate skin changes. Available treatment methods are characterised by variable efficacy or allow only temporary improvement[1]. In the available literature, there are no studies on the effects of vibrational therapy on eliminating cellulite changes. Milanese

Table 3

Change in circumference measurements in the studied women

	Before	After	Δ	*p*
Right thigh circumference [cm]	59.95 ±2.37	58.4 ±2.91	**1.55 ±1.12***	0.002
Left thigh circumference [cm]	59.7 ±2.02	58.2 ±2.37	**1.50 ±0.67***	0.000
Hip circumference [cm]	101.05 ±4.81	99.8 ±5.00	**1.25 ±1.25***	0.006
Waist circumference [cm]	74.1 ±5.61	71.8 ±5.51	**2.30 ±1.93***	0.002

Measurements are expressed as mean ± *SD*; *$p<0.05$

Table 4

Changes in body composition of the studied women

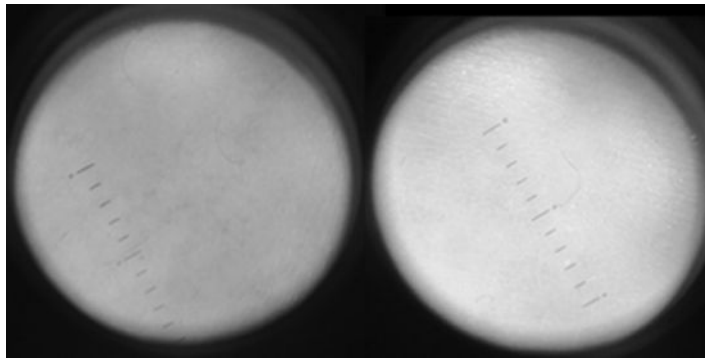
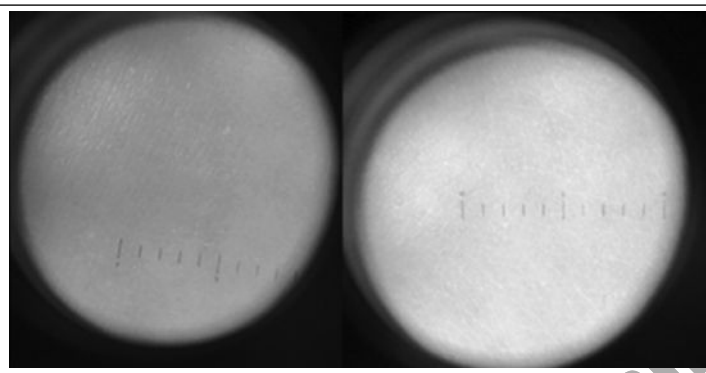
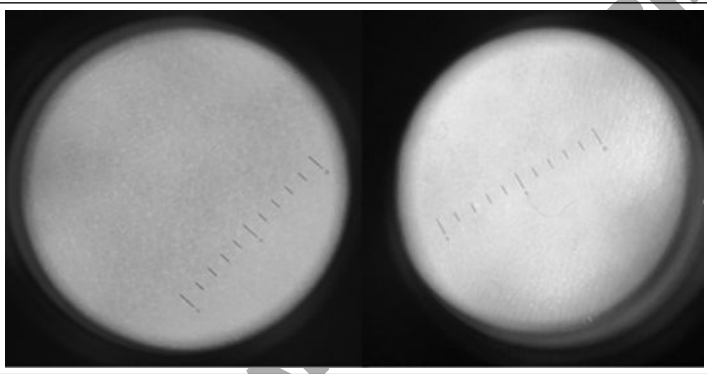
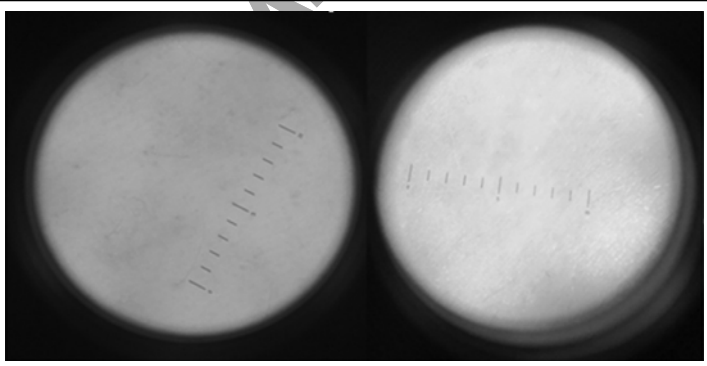
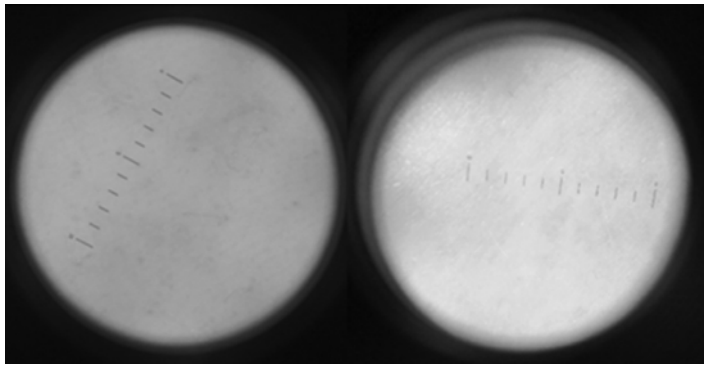
	Before	After	Δ	*p*
Body mass [kg]	62.47 ±4.54	62.22 ±4.15	**0.25 ±0.81**	0.178
Fat tissue mass [kg]	17 ±3.48	16.58 ±3.42	**0.42 ±0.46***	0.009
Lean body mass [kg]	45.11 ±2.67	45.28 ±2.2	**0.17 ±2.15**	0.404
Total water content [%]	33.1 ±2.35	33.58 ±1.92	**0.88 ±0.73**	0.124

Measurements are expressed as mean ± *SD*; *$p<0.05$

The results of body circumference measurements are presented in Table 3. The greatest reduction in thigh circumference was 3.00 cm, the average 1.55 cm. The largest reduction in hip circumference was 2.50 cm (average 1.25 cm). The largest reduction in waist circumference was by 6.00 cm, which significantly exceeded the average result of 2.30 cm for the group.

The average body mass loss in the subjects was 0.25 kg (maximum –

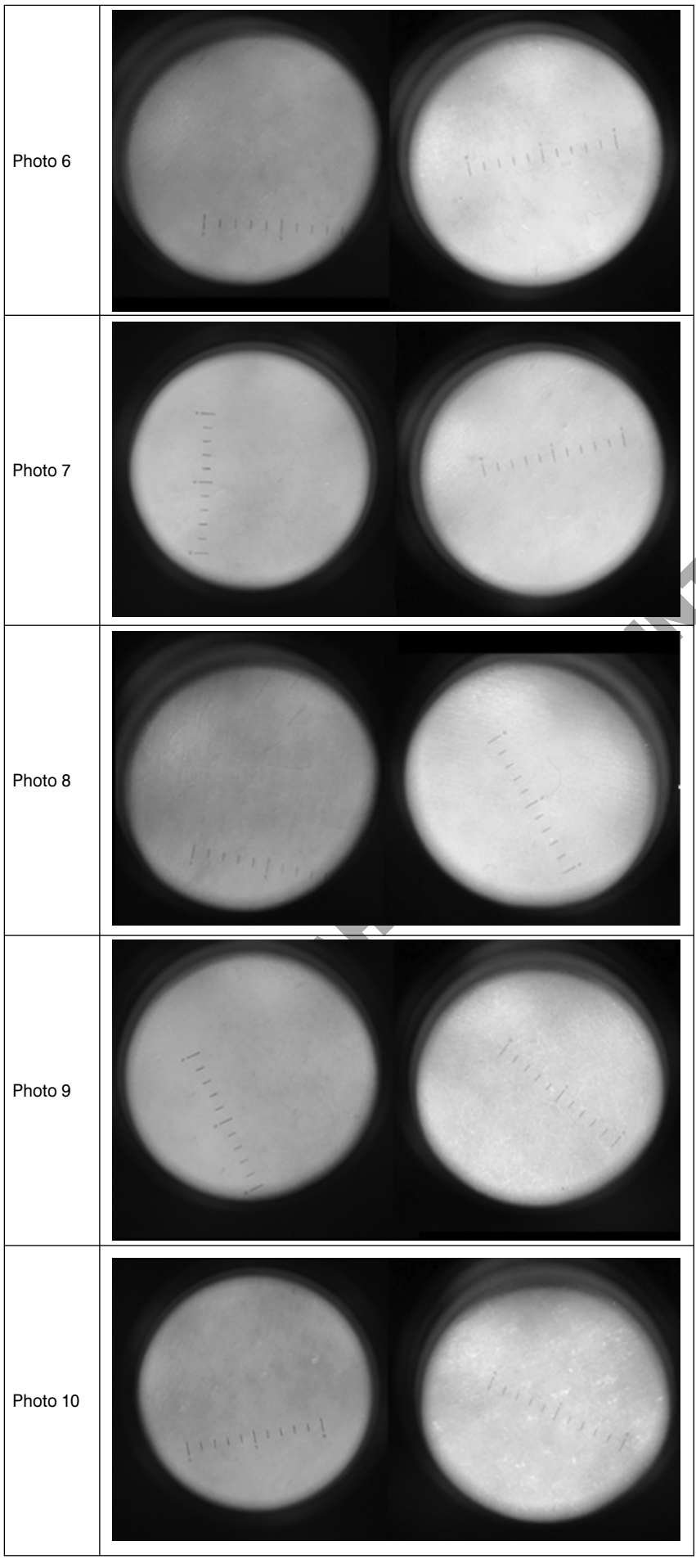
et al.[25] proved that whole-body vibration (WBV) is an effective tool for improving muscle composition, strength and maintaining bone density in obese women. However, there is no assessment of the long-term effectiveness, tolerance and adaptation to the WBV action. Studies by Nam et al.[26] show that to improve body composition of middle-aged obese women, long-term WBV combined with the reduction of calories provided in

No.	Before series of treatments	After series of treatments
Photo 1		
Photo 2		
Photo 3		
Photo 4		
Photo 5		

the diet are as effective as combining diet with aerobic exercise. Vibro-training sessions were effective without being detrimental to bone mineral density. Similarly, Drewniak et al.[27] proved that along with a balanced diet, vibrational procedures stimulating intestinal peristalsis and the function of absorption of nutrients lead to improvement in the weight loss process. Montero et al.[28] noticed that vibration training seems to be related to 3 pathways involved in weight loss: adipogenesis inhibition which leads to reduction of adipose tissue mass, increase of energy expenditure and increase of muscle mass. Each of them can effectively improve the condition of tissues affected by lipodystrophy.

Analysing the results of the presented research, significant influence can be noted in the case of oscillating-cycloidal vibrations on the reduction of the circumferences of both thighs and hips, as well as the waistline of volunteers participating in the project. Small changes observed in volunteers also concerned body composition. A significant decrease in fat mass (by 0.42 kg) was observed, which proves the beneficial effect of vibrotherapy on fat tissue metabolism, and therefore, of soft type cellulite. Changes in body composition did not result from increased water loss because its amount (total body water) estimated via the BIA method did not change significantly. Convergent results on changes in body composition were obtained for studies in which the therapeutic factor was vibration applied in a standing position in healthy people and those suffering from type-2 diabetes. According to Sanudo et al.[29], whole-body vibration can be a modern intervention training type, which is a safe and effective way to improve body composition, also affecting muscle strength in individuals for whom traditional exercise is a contraindication.

In the present study, vibrations acting both comprehensively and locally were used, which allowed for whole-body modifications (body composition) as well as the local image directly related to tis-



sues affected by cellulite changes, as illustrated by the dermatoscopy used in this project. Dermatoscopy is a modern method of *in vivo* imaging of the epidermis and dermis. So far, it has not been routinely used to assess deeper dermis, including diagnosis of the degree of cellulite, for which visual or instrumentally assisted assessment is used, which, however, did not fully correlate with the cellulite image[5-8,10]. Modern dermoscopes providing 10x magnification use polarised light that enables monitoring of vascular structures in the dermis. By assessing the degree of the dermal vasculature, one can indirectly make conclusions regarding its nutrition and structure[30,31]. The results of the dermatoscopic examination carried out in this project indicate improvement in skin condition. Visibility of blood vessels confirms the improvement of blood circulation. Our results confirm that vibration can increase blood flow through the muscles and the skin locally. Convergent results were obtained by Button et al.[32].

Observing the changes in selected body composition parameters and the skin condition of the thighs and buttocks indicate that the proposed form of treatment is characterised by features that provide cosmetic benefits resulting from improved skin appearance and reduction of cellulite changes. As shown in the studies by other authors, this effect may result from the improvement of cardiovascular and lymphatic system performance and may lead to improvement of skin tone, but it may also strengthen the care-effects supporting the fight against lipodsytrophy[33-35]. Vibration treatment is a stimulating micro-massage for the skin[35], lymph flow is improved, the level of nitric oxide increased. Thus, it may affect the effectiveness of anti-cellulite treatments[34,35]. Vibro-therapy may also have bene-

Figure 1

Dermatoscopic images of the volunteers' skin before and after a series of treatments

ficial effects related to the already recognised effect on the fascia, the role of which in the emergence of cellulite changes is increasingly indicated. Benefits of treatments can also be obtained by people struggling with other skin problems (tendency to dryness, scaling, flaccid skin, grey, tired and aging)[35,36], and therapy may be especially recommended for those overweight and obese[37,38].

This study involved subjects with normal body composition, without the most severe forms of cellulite changes. Another limitation may also be the small number of subjects who underwent vibration treatment. However, the indicated significant changes confirm the effectiveness of the proposed therapy and encourage broadening the scope of research.

CONCLUSIONS

1. After the 4-week series of vibrations involving direct propagation of a stimulus on cellulite-modified tissues, reduction in thigh, hip and waist circumferences was observed.
2. The proposed series influenced the reduction of adipose tissue mass without affecting the water content.
3. Analysis of dermatoscopic imaging revealed improved blood supply to the skin.
4. After the 4-week series of vibrations involving direct propagation of a stimulus on cellulite-modified tissues, reduction in lipodystrophic changes was observed.

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