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Parameters of vibration stimulation for the relief of pain of different origins and locations

Parametry stymulacji drganiami w łagodzeniu dolegliwości bólowych różnego pochodzenia i lokalizacji

Alicja Pasterczyk-Szczurek [1 (A, B, D,E,F)], Paweł Pogwizd [1 (E,F)], Monika Bigosińska [2 (E,F)]

[1] Research and Development Department of Vitberg, Nowy Sącz, Poland
[2] Department of Physical Education, Institute of Physical Education, State University of Applied Science, Nowy Sącz, Poland

Key words
pain, vibration, WBV, analgesics

Abstract
Introduction: The use of vibration stimulation in alleviating pain is an issue appearing more and more often in modern rehabilitation.
Aim of study: The aim of the work was to review literature regarding the therapeutic usage of vibrations in analgesic activity.
Material and methods: Searches based on the effect of alleviating pain with the help of vibrotherapy in the therapy of diseases of various origins and localizations, as well as with various physical therapy treatments and modalities. The most important parameters were determined, such as: frequency, amplitude, places of application, and exposure time, and were described on the basis of selected tests. Both the Polish and English-language literature has been discussed. Most of the studies were English-language (over 93%). The searches were carried out among the following databases: Medline, Embase, Cochrane, ScienceDirect, PubMed, IEEE Xplore, Wiley Online Library. The key words used were: pain, vibration, WBV, analgesics. The mentioned sources were qualified on the basis of: availability, data verification, selection of research material and regularity of update.
Summary and conclusions: While acute pain is, by definition, a short and self-limiting process, chronic pain begins to dominate life and concerns the patient and his/her family. In addition to significant deterioration in quality of life, chronic pain imposes a large financial burden. The use of vibrotherapy can be a solution. Therefore, it is proposed to further analyse the parameters of vibrotherapy in analgesic activity, which may lay the foundation for "personalized pain relief medicine", which will clearly define the standards of vibrational therapy parameters.

Słowa kluczowe
ból, wibracja, WBV, przeciwbólowy

Streszczenie
Wstęp: Wykorzystanie stymulacji drganiami w łagodzeniu dolegliwości bólowych różnego pochodzenia i lokalizacji jest zagadnieniem pojawiającym się coraz częściej we współczesnej rehabilitacji.
Cel pracy: Celem pracy było dokonanie przeglądu piśmiennictwa, dotyczącego terapeutycznego wykorzystywania wibracji w działaniu przeciwbólowym.
Materiał i metody: Poszukiwania oparto na wynikach, dotyczących łagodzenia bólu przy pomocy wibroterapii w terapii schorzeń różnego pochodzenia i lokalizacji oraz przy rozmaitych zabiegach fizykoterapeutycznych/leczniczych. Opisano najważniejsze parametry takie jak: częstotliwość, amplituda, miejsca aplikacji do ciała, czy czas ekspozycji, które zostały opisane na podstawie wybranych testów. Rozpatrywano piśmiennictwo w języku polskim i angielskim. Większość znalezionych opracowań stanowiły artykuły anglojęzyczne (ponad 93%). W celu zgromadzenia danych przeszukano następujące bazy danych: Medline, Embase, Cochrane, ScienceDirect, PubMed, IEEE Xplore, Wiley Online Library. Słowa kluczowe: ból, wibracja, WBV, przeciwbólowy. Wymienione źródła zostały zakwalifikowane na podstawie: dostępności, weryfikacji danych, wyboru materiału badawczego i systematyczności aktualizacji.

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

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Podsumowanie i wnioski: Podczas, gdy ból ostry jest z definicji krótkim i samo ograniczającym się procesem, ból przewlekły zaczyna dominować w życiu wielu chorych oraz ich rodzin. Oprócz znacznego pogorszenia jakości życia, ból przewlekły narzuca duże obciążenia finansowe. Wykorzystanie stymulacji drganiami może stanowić rozwiązanie. Dlatego proponuje się dalsze analizy parametrów wibroterapii w działaniu przeciwbólowym, które mogą stworzyć podwaliny do „spersonalizowanej medycyny łagodzenia bólu", która jasno określi standardy parametrów terapii wibracyjnej.

INTRODUCTION

The year 2018 was defined by the International Association for the Study of Pain (IASP) as a year of global improvement in pain education. The society is an organization that deals with the scientific, practical and educational aspects of the pain problem, which proposed one of the most frequently cited definitions of pain. According to IASP, pain is a: subjectively unpleasant and negative sensory and emotional sensation arising under the influence of stimuli, damaging the tissue or threatening damage. The feeling of pain should primarily be perceived as a system that notifies us of irregularities and allows the creation of appropriate forms of behaviour. Nevertheless, pain is a subjective, often immeasurable and incomparable sensation. Many ill people are unable to live with it, and that is why it is everything and anything the patient perceives this way, regardless of objective symptoms associated with it[1].

Mechanisms of muscle pain, such as e.g. a stiff neck or lumbago, largely remain a mystery, although this type of pain is one of the key reasons for anxiety of patients, clinic visitors and hospitals with different profiles. Musculoskeletal pain is so common that some types are considered a normal part of life. Spinal pain syndromes are a serious problem due to their frequent occurrence, as well as costs incurred by the health service for hospitalization of patients and are the main cause of incapacity to work (frequent absenteeism). Many published studies show that up to 39.5% of adolescents suffer from low back pain, and more and more people above the age of 30 suffer from pain in the course of discopathy of a different location[2]. In many cases, it is associated with great discomfort and a feeling of pain covering the whole body. According to Debono et al.[3], in an EBM review (evidence-based medicine), pain is defined as the most common indication for medical consultation. This is confirmed, among others, by the Eurostat survey from 2017, showing that almost half of the European population suffer from pain of various localization, origin and clinical expression almost every day[4].

Often, contra-stimulation treatments are used in widely understood physiotherapy. We use them unconsciously, for example, when we hit our hand, we wave it to relieve pain, or tap a place other than where the pain occurs. And on the basis of similar experiments it was found possible to eliminate pain discomfort by means of contra-stimulation in the form of mechanical vibration[5]. One of the first to study this issue were Gammon and Starr from the University of Pennsylvania in Philadelphia[5]. The authors used stimulus at frequencies from 50 to 60 Hz, because on the basis of their patients' opinions, they observed that this frequency was the most effective in analgesic activity. They also noted that the best results are obtained if the vibratory stimulus is used on the exact site of pain[5]. Another publication that described pain relief using vibrations is an article published in "Perceptual and Motor Skills" during the mid-1960s by Blitz et al.[6]. The authors of this report showed that vibration stimulation significantly increases pain threshold and, as a result, suppresses the pain itself. Exactly 20 years later, i.e. in 1984, Lundeberg et al. published the results of research on relieving pain with vibration stimulation.

Today, we already know that vibration with strictly defined parameters activates nerve fibers with large diameters, interacting with the impulses transmitted on pain pathways, which leads to alleviation of pain[8]. Following Moayedi and Davis[9], in 1965, Ronald Melzack presented a theory called the gate theory of pain. It assumes that if there is another stronger impulse on the path of the pain pulse, the first one may not reach the brain and be omitted. This theory can be explained by the reduction in pain when massaging one place of the body and resolving it in another (trigger pain). In 2014, Imtiyaz et al.[10] proved that vibration stimulates muscle spindles and increases their afferent functions. Both vibration and TENS (transcutaneous electrical nerve stimulation) reduce the perception of pain via the mechanism referred to in the gate theory of pain. This leads to increased background activity and synchronization of motor system functions in muscles subjected to vibrations[10]. Vibration stimulates skin-surface as well as deep sensation mechanoreceptors that are sensitive to vibrational stimulation. Lamellar receptors highly sensitive to vibrations include lamellar bodies and annulo-spiral ring ends of muscle spindles. The same authors believe that pain relief is the result of the activation of lamellar corpuscles in the connective tissue, ligaments or joints, as well as the endings of the annulo-spiral ring spindles of the muscles. Activation of other receptors in the skin, subcutaneous tissues and bones can also affect the feeling of pain relief[10]. Another consequence of the use of vibration stimulation is the weakening of motor neuron excitability, which innervate the antagonistic muscle by way of retardation. This phenomenon may explain the reduction of pain in patients undergoing vibrational therapy in the area of the antagonistic muscles. Interestingly, regular vibration stimulation lasting from 30 to 45 minutes may cause redness of the skin and a feeling of warmth in the area of its application. Therefore, it cannot be ruled out that the effect of pain relief may be partly due to an autonomic reaction[8]. Numerous studies also indicate that vibration stimulates both superficial-

ly and deeply located receptors. Subsequent activity in myelinated sensory axons may interact with nociceptive processing at various levels of the nervous system, including the spinal cord. One of the effects of this state is prolonged increase in pain threshold, which causes it to be less experienced[11]. Vibrations are a non-pharmacological therapeutic technique used to relieve pain by triggering superficial and deep mechanoreceptors. Vibrational stimuli are transmitted through the Meissner body, which is sensitive to a frequency of about 40 Hz, and through the Vater-Pacini body at above 100 Hz. It was also found that high vibration frequencies (≥100 Hz) are more effective than lower ones, which leads to the suggestion that afferents of the Vater-Pacini body play a special role in the modulation of pain. Among others, Bushnell and Casey[12], Pertovaara[13] and Mendes et al.[14] suggest that a key role in the so-called vibrational elimination of pain is played by the Vatera-Pacini body, and this particular possibility of modulation explains the greater efficiency of high frequencies. Alsuhibni et al.[15] and Hollins et al.[16] decided to explore this possibility. They used high-frequency vibrations on the face and lips, where it is impossible to prove the existence of afferents of Vater-Pacini bodies, as well as the functioning of the Vater-Pacini body canal. In spite of the absence of Vater-Pacini bodies, high frequency vibration stimulation was still effective in reducing pain[15,16]. Therefore, it can be assumed that the Vater-Pacini body canal does not play a significant role in the vibration mechanism of pain relief, at least not in the area of the face. The most probable explanation for greater effectiveness of high frequencies is the intensity of stimulus sufficient enough to engage mechanoreceptive afferents, where the dependence of discharges of those afferents increases directly with the function of the vibration-touch frequency. Given the above, more continuous and greater activity can be triggered to a greater extent by high frequency vibrations than by those which are lower. Thanks to this, they interfere more effectively with nociceptive signals within the Central Nervous System (CNS)[17]. Under the influence of rhythmic shocks, the excitability of pain receptors increases while the excitability of proprioceptors reduces. The reflex route is affected by changes in the nervous system and increased vascular flow[18]. Vibration therapy can improve the functioning of the musculoskeletal system. Vibration stimuli cause increased neuronal discharges, initiating an increase in the excitability of neuromuscular spindles, which leads to elevated muscle fibre activity, providing improved muscle strength and increased range of motion, while abating painful pain sensations[14]. Hollins et al.[19] believe that vibrations primarily distract attention from the pain caused by the detrimental stimulus.

METHODOLOGY

In order to collect data for the review, it was decided to conduct searches among the largest databases indicated in medical directives for clinical evaluation, such as: Medline, Embase and PubMed. At the same time, databases such as Cochrane, ScienceDirect, IEEE Xplore and Wiley Online Library were also searched. The search process was carried out by one author during the period from 15th to 20th April, 2018. The following keywords were used: pain, vibration, WBV, analgesics, and their combinations. The first stage of the search consisted in assessing the relevance of the results in terms of their compliance with the topic. 89 titles were qualified for the next stage, in which subjects were exposed to therapeutic vibrations with a significant analgesic effect. The types of tests qualified for review were the following: prospective clinical trials, pilot studies, preliminary reports, case studies, meta-analyses and reviews. The next step was to assess the content value according to the inclusion criteria in line with the PICO standard. Individuals, regardless of race, sex, age and diseases, were indicated as the population. Interventions, i.e. treatments using mechanical vibrations, were determined by the authors as therapeutic – not as a part of the vibration sensation test. The control group was assumed as acceptable at the level of all types of controls, including other therapeutic procedures. In the results, the trials for which the endpoints indicated an effective and safe analgesic effect of vibration were selected. Those with incomplete data on the intervention or study population were rejected. The length of the follow-up period was not taken into account due to insufficient data. The results had to be characterized by access to full texts. If possible, the authors were contacted in order to obtain information on the full content of the publication. The main aim was to show the characteristics of the most important parameters regarding vibrational therapy stimulus, effective and safe in reducing pain. The literature was considered in Polish and English. No weight values were assigned to individual items due to the descriptive nature of the work.

RESULTS

After initial evaluation of the content of the articles, 89 publications were identified. 55 positions were indicated as irrelevant. According to the inclusion criteria, 30 tests were identified that met the criteria of this review and 4 were used to describe the general technical state. The subjects were adults aged 18-65, complaining of pain with various etiologies. The most frequently assessed interventions concern local vibrations with a probe or using vibrating surfaces such as a cushion or blanket. All the individuals tolerated vibrational therapy well. No study provided information about adverse events. Based on 43 publications, the 4 most important parameters of vibro-therapy are described: frequency, amplitude, area of application and duration of treatment. The oldest study was from 1941, and the most current, 2018. The results of the review are described below. Each study was aimed at assigning one of the categories of stimulus characteristics to which it was most appropriate and with a unique parameter value. Only two

literature items were simultaneously classified into two groups. Most often, by providing information about the stimulus, the authors describe frequency. Amplitude is a difficult parameter to determine, especially in local therapy. The authors of only 3 of the qualified studies provided this data. The location of stimulus application was determined in most of the studies. 9 such positions were qualified. The duration of treatments was evaluated on the basis of 6 publications.

Frequency is the most important parameter described during treatments using vibration stimulation. Vibrotherapy in analgesic activity most often uses vibrations in the form of constant stimulus, unchanged over time. The range used is wide – from 0.5 Hz to even 18 kHz, using local vibration. The frequency most commonly applied in clinical practice is within the range of 20 Hz to 100 Hz. The study by Kessler and Hong[20] confirms the effective application of the lower vibration limit in pain reduction. These authors have shown that the levelling of pain after applying the vibration continues directly after each session for an average of 3 hours. They used a vibrating platform that works on the basis of so-called whole-body vibration (WBV). In addition, the results of this study confirm the results of previous deliberations, indicating the effectiveness of whole-body vibration as potential treatment for diabetic peripheral neuropathy[20]. Mechanical stimulation is also used as a local anaesthetic during cosmetic or dental procedures. In those cases, vibrations with frequencies up to 100 Hz are usually used. Vibration anaesthesia can potentially help in a variety of procedures, including Botulin Type A injections in patients treated for excessive sweating, subcutaneous introduction of so-called filling substances or injection with steroids, laser therapy of the varicose veins, laser ablation of tattoos, epidermal needle excision, patients afraid of subcutaneous and intramuscular injections, incisions and thermoablation of warts on the face[21-24]. Topical vibrations at 60 Hz turned out to be an effective manner of pain reduction during scar treatment with a CO_2 fractional laser. As it can be seen from the research by Song et al.[25], the average VAS score (visual analogue pain scale) before application of vibration was 6.11 points, while after using vibration, it was 4.6 points[25]. Biomechanical changes that arise after surgical resection of breast cancer increase the need for new rehabilitation programmes. The aim of the Mendes et al.[14] study was to assess the mean and long-term effects of vibration therapy on the intensity of pain, range of motion, myoelectrical effect and muscle strength after oncological surgery. This time, it was proved that vibration therapy up to 40 Hz was effective in reducing the intensity of pain in women after breast resection surgery with a simultaneous increase in the range of arm movement. Using a vibratory stimulus on the postoperative site leads to an increase in muscle fibre activity, providing improved muscle strength, increased range of movement and reduction in pain[14]. Many authors have shown that vibrations alleviate muscle soreness after damage due to intense exercise. The frequency range used in these procedures is between 12 and 120 Hz. Reduction of pain after exercise especially important in novice athletes – is not negligible. Among others, it is necessary to create quick possibility for further exercises, facilitating the return to proper training, increasing their effectiveness and reducing the risk of injury[27-31].

The applied amplitudes range from a hundredth of a millimeter to even 8 mm. The most sensitive ends of the main muscle spindles could be activated at a vibration amplitude of <10 μm. As it can be seen, the range of parameters is very vast, and both micro amplitudes and higher ones are successfully used in pain reduction therapy with a similar effect. Maddalozzo et al.[6] used amplitudes ranging from 0.6 mm to 1.2 mm at a frequency of 20 Hz to 50 Hz in the treatment of non-specific chronic back pain in the lower spinal segment. In the group of patients who underwent vibrations, better clinical results were achieved in the area of the NRS (numeric rating scale) and disability assessment, which is caused by pain in the lumbar region of the spine (ODI – Oswestry Disability Index)[26]. However, the use of a 3 mm amplitude at 12.5 Hz allowed to improve the quality of life indices in women with fibromyalgia, previously unable to perform physical efforts[32]. Amplitudes within the range of 0.0001 to 0.05 mm and frequencies up to 18,000 Hz are used, inter alia, in patients suffering from osteoarthritis of the knee joints[33]. Based on the reported results, it should be assumed that various amplitude ranges are used to treat various types of disorders using vibrations.

Vibrotherapy is used, inter alia, to reduce the sensation of muscular-skeletal, chronic and neuropathic pain. Among others, Gammon and Starr[5] and Naro et al.[34] argue that it works best when used on the pain-site or within its immediate vicinity. In patients with pain in the cervical spondylosis or lumbar-sacral spine (LS), local application of vibrations reduced pain not only in this place, but also in other, distant locations. This position is shared, among others, by Lundeberg et al.[7] and Dahlin et al.[11]. The authors believe that the best method for pain reduction is the usage of vibrations directly on its location, but on remote ones as well. Dahlin et al.[11] also suggest that a beneficial analgesic effect is achieved by using vibration at a height of no more than two segments of the spine lower than its location or in the same dermatome on the opposite side. Vibration stimulates both superficial and deeply located receptors. Subsequent afferent activity in myelinated sensory axons may interact with nociceptive processing at various levels of the nervous system, including the spinal cord. One of the effects is a prolonged increase in pain threshold[11]. Ruan et al.[35] demonstrated that after 3 months of using vibro-therapy, there was a definite reduction in chronic back pain. Similar conclusions were drawn, inter alia, by Boucher et al.[36]. The authors' research shows that local muscle vibrations lead to significant improvement in the neuromuscular control of the trunk in these patients. Mus-

Table 1

The results qualified into particular categories (frequency, amplitude, place of stimulus application, time)

Publication	Population	Intervention	Control intervention	Results	Type of research	Qualification
Kessler and Hong 2013[20]	6 M, 2 F / type-1 or type-2 diabetes with peripheral neuropathies / age: 56.12 ± 6.78	4 weeks, 4 x 3 min of whole-body vibration / 25 Hz 5 mm, 3 times a week / standing position on platform	None	Significant decrease in the pain score expressed on the VAS scale, as well as a decrease in chronicity after 4 weeks of therapy and a significant increase in the duration of pain reduction.	Pilot study	F
Lee et al. 2018[21]	14 M, 16 F / pain in the lumbar region (lasting longer than 3 months) / age: exposed 60.0 ± 11.0 control 63.6 ± 7.6	Exercises using Flexi-Bar / 5 times a week for 6 weeks / 5 Hz	7 M, 9 K – without exposition to vibrations	Comparing groups, there was greater improvement in VAS and ODI results in the group with vibro-therapy.	Randomized clinical trial with control group	F
Li et al. 2017[23]	53 individuals / subjected to cosmetic procedures / age: above 18	Anaesthesiologic vibration at injection	The part of the face that was not exposed to vibrations	40 patients (75%) considered the vibrations to be effective. 5 patients (9%) did not consider them effective. 2 patients (4%) stated that vibrations worsened the pain. One patient (2%) expected vibrations with a higher frequency and amplitude.	Multicentre, prospective, randomized trial with control group	F
Park et al. 2017[24]	9M, 31F / 58 keloid scars / age: 17-57	Anaesthesiologic vibration at injection	Half of the keloids	Vibration anaesthesia is a promising solution in reducing pain during keloid treatment with steroid injections.	Prospective clinical trial with control group	F
Song et al. 2016[25]	19 M, 34 F / liver donors for transplantation / age: 16-44	Vibration device (UM-30M, Unix Electronics Co. Ltd., Seoul, Korea) / 60 Hz	None	The mean value of pain intensity obtained from VAS using a vibrating device was 4.60, but without its usage, 6.11. The average difference between the results was 1.51.	Prospective clinical trial	F
Mendes et al. 2016[14]	28 F / following breast cancer surgery / age: 56.3 ± 10.9	Vibration blanket developed by the authors of this study in cooperation with Vibra IND. e com. production Electronics LTD/ 40 Hz; 1.8 mm	14 healthy women, aged 50.28 ± 7.40	In this study, it was proven that vibrational therapy is effective in minimizing pain intensity in women following breast cancer surgery after just 15 minutes of experimental protocol sessions.	Prospective clinical trial with control group	F, T
Cochrane 2017[27]	13 M / physically active / age: 21.7 ± 2.6	MyoVolt, applied to the biceps muscle and the second device to the forearm / 15 min / 120 Hz; 1.2 mm	14-day elimination time of the factor influence (wash out)	In conclusion, the use of vibro-therapy immediately - 24, 48 and 72 h after eccentric elbow flexor training significantly alleviated muscle soreness, improved mobility.	Randomized clinical trial with control group	F
Veqar and Imtiyaz 2014[28]	Healthy, trained	5-50 Hz	None	Vibration therapy improves muscle strength, energy development, kinesthetic awareness, reduces muscle pain, increases range of motion and subcutaneous blood flow.	Review	F
Ayles et al. 2011[29]	16 M / healthy / age: 24.2 ±3.8	Manual vibration device, 1 cm2 probe diameter (Breville P33, Hong Kong) / 50 Hz / applied to the shank	No vibrations on the same limb	The present study shows an increase in mechanical sensitivity when vibrations are simultaneously applied to a muscle segmentally connected to DOMS.	Prospective clinical trial with control group	F
Wheeler and Jacobson 2013[30]	10 F, 10 M / age: 20.85 ± 1.81	WBV Platform / 10 min / 20-45 Hz	10 minute walk on treadmill	Whole-body vibrations are just as effective as active exercises in reducing the negative effects of DOMS and can be more attractive to athletes as a new method of treatment.	Prospective clinical trial with control group	F

Table 1 (continued)

Publication	Population	Intervention	Control intervention	Results	Type of research	Qualification
Timon et al. 2016[31]	20 healthy / non-trained	Whole-body vibrations 3 x 1 min / 12 Hz, 4 mm	10 individuals without exposition to vibrations	A single session of vibrations after eccentric exercises reduces delayed muscular pain but does not affect muscle strength regeneration.	Prospective clinical trial with control group	F
Maddalozzo et al. 2016[26]	50 M, 75 F / age: 51.3 ± 15.2 years for men and 50,5 ±17.2 years for women	Whole-body vibration and vibration pad / 0.6-1.2 mm, 20-30 Hz and 40-50 Hz	Secondary analysis	The results of the study suggest that NRS and ODI results statistically improved in both NSCL-BP groups that received full care.	Comparing the results of two clinical trials	A
Olivares et al. 2011[32]	36 F / fibromyalgia	12-week whole-body vibration - platform / 12.5 Hz; 3 mm / standing position / 30 min	No vibration therapy	Whole-body vibration improved quality of life in women with fibromyalgia previously unable to exercise.	Randomized clinical trial with control group	A
Skopowska et al. 2014[33]	20 M, 24 F / gonarthrosis / age: 64.84	10 sessions, lasting 15 min each - Vitafon-T / 30-18,000 Hz; 0.0001-0.05 mm	None	Vibroacoustic therapy induced positive therapeutic effects of analgesic and anti-swelling properties, which also influenced improvement of functional capacity in the group of patients with gonarthrosis.	Preliminary report	A, P
Gammon and Starr 1941[5]	Lack of information	Local / 50-60 Hz; 1 mm	None	The best method of analgesic counter-stimulation is applying the stimulus to the site of pain.	Case study	P
Lundeberg et al. 1984[7]	123 M, 144 F / with chronic neurogenic or musculoskeletal pain	6 cm2 probe or 200 cm2 cushion covered with foam rubber / 45 min; 100 Hz	None	From the 18-month research, it is clear that vibratory stimulation is an effective method of combating chronic pain. In this study, 68% of patients started therapy at home, 30% of patients experienced benefits from therapy after 3 months, 18% after 6 months, 12% after 12 months, and 9% after 18 months of therapy.	Prospective clinical trial	P
Dahlin et al. 2006[11]	29 F, 27 M / healthy	Vibrations (Vitamed, Germany) were applied to the dorsal part of the forearm / rectangular probe 13 x 20 cm, covering dermatomy C5-8 / 3000 Hz / 20 min	None	The obtained results demonstrate the potential usefulness of vibration stimulation in the treatment of pain and show that gender differences should be considered in future assessment of this method.	Prospective clinical trial	P
Ruan et al. 2008[35]	94 F / following menopause, osteoporosis / age: exposed group 61.23 ± 8.20 and control group 63.73 ± 5.45	Vibration platform ZD-10 / 30 Hz / 5 mm	43 F – without vibration therapy.	In conclusion, vibrational therapy can be effective in reducing chronic back pain and increasing the lumbar BMD and BMD of the femoral neck in postmenopausal women suffering from osteoporosis.	Randomized clinical trial with control group	P
Boucher et al. 2015[36]	14 F, 26 M chronic back pain / age: exposed 33.7 ± 14.4; control: 29.1 ± 7.8.	Vibrating devices mounted on the back / in a standing position j / 30 s / 80 Hz; 0.85 mm	1 F, 13 M – no exposure to vibration therapy.	Local muscle vibrations led to significant improvement in neuromuscular control of the trunk in patients with chronic back pain in the lumbar region before and after the muscle fatigue protocol.	Prospective clinical trial with control group	P

Table 1 (continued)

Publication	Population	Intervention	Control intervention	Results	Type of research	Qualification
Macintyre and Kazemi 2008[37]	1 M / footballer with elbow-joint injury (arthroplasty) / age: 28 years.	VMTX Vibromax Therapeutics™ Palmpercussion™ (Ho-Medics Inc.) / approx. 37 Hz.	None	Vibrational therapy has the potential to rehabilitate patients who report acute inflammation of soft tissues and injuries resulting from non-use or immobilization of the organ. After three weeks of treatment (3 / week), the symptoms decreased. The patient no longer reported pain during any daily or resting activities, and the VAS score decreased by 50% (6 / 10-3 / 10). The patient no longer complained of weakness or feelings of instability in the elbow.	Case study	P
Beinert et al. 2018[38]	26 individuals / 15 pain in the cervical area + 11 healthy / age: exposed 18-55; control 21-54.	Locally to hands, (Vibrasens, Techno Concept, France); 5 x 5 min/100 Hz; 1 mm	11 healthy	Vibrations of the neck muscles caused short-term general as well as long-lasting specific effects on analgesia and sensory-motor function. Future research should investigate the potential benefits of neck vibration as a complement to physical therapy to improve sensorimotor function of the cervical spine.	Prospective clinical trial with control group	P
Chochowska et al. 2011[39]	60 F, 40 M / chronic back pain in the lumbosacral spinal area / age: 70.9.	10 classic back massages / 20 min. every other day, with a break for Saturday-Sunday) and a series of 10 Massinet trigger point vibration massages, AKA Electronic / 12 min.	None	It was found that after applying a series of massages, the average level of pain was statistically significantly reduced (2.8 - which means “moderate pain”) in relation to the level before therapy (4.6 - which means “severe pain”) assessed subjectively on the 11-point VAS, where “0” means “no pain” and “10”: “unbearable pain”.	Prospective clinical trial	T
Stambolieva et al. 2017[40]	6 M, 6 F / type-2 diabetes, neuropathy/ age: 57.2 ± 3.6.	8 weeks of plantar vibration / 30 min/10 Hz.	None	Summarizing, the results provide evidence of the beneficial effect of applying vibration for 8 weeks in patients with type-2 diabetes including neuropathies. No negative effects of therapy were observed and we believe that this may be an appropriate method used in the simultaneous treatment of type-2 diabetes, especially in the elderly and those not systematically training or undergoing constant physical activity.	Prospective clinical trial	T
Bily et al. 2016[41]	43 F, 19 M / total knee-joint arthroplasty / age: 55-80 years	Vibration therapy / 15 min, 6 weeks (twice a week).	31 / functional physical therapy without vibration therapy	Isokinetic training with vibro-therapy is as effective as functional physical therapy in terms of muscle strength and mobility, but isokinetic training is less time-consuming.	Randomized clinical trial with a control group	T

Table 1 (continued)

Publication	Population	Intervention	Control intervention	Results	Type of research	Qualification
Yang and Seo 2015[42]	21 M, 19 F / lower back pain / age: exposed 32.8; control 30.95	Galileo 2000 (Novotec, Pforzheim, Germany) / 18 Hz / 5 min / standing position.	9 M and 11 F / without vibration therapy	Significant differences were found after intervention in the WBV group in terms of fall index, spinal balance, lordosis angle, VAS and ODI scores. More improved statistically significant indicators were found in the WBV group for the fall rate and VAS score compared to the control group. Whole-body vibration can be recommended to improve balance and alleviate pain in patients with chronic lower back pain.	Randomized clinical trial with control group	T
Korzekwa et al. 2013[43]	19-27 lower extremities / advanced symptoms of chronic venous insufficiency / age: 28-68 years	Vitafon Vibroacoustic treatments / up to 20 min/30-18,000 Hz.	None	All patients felt significant improvement in their well-being without side effects. There was a reduction in the subjective feeling of pain in the lower limbs. Three patients undergoing vibroacoustic therapy experienced a feeling of warmth in the area treated.	Prospective clinical trial	T

Qualification: F – determining an effective and safe frequency range; A – determination of an effective and safe amplitude range; T – determining an effective and safe range of exposure time; P – designation of effective and safe placement location of the stimulus.
Other applied abbreviations: DOMS – Delayed Onset Muscle Soreness NRS – Numerical Rating Scale; NSCLBP – Nonspecific Chronic Low Back Pain; ODI – Oswestry Disability Index; WBV – Whole Body Vibration; VAS – Visual Analogue Scale.

cle vibration stimulation during motor control exercise is likely to affect motor adaptation and may be a beneficial solution in the treatment of chronic low back pain (cLBP)[36]. Macintyre and Kazemi[37] also indicate that the best place to reduce pain is the belly or tendon of the muscle. Local application of vibrations to the knee joints, in the tests by Skopowska et al.[33] and Beinert et al.[38], reduced the joint pain and cervical spondylosis, which have a positive effect on mobility of the arms.

Exposition to vibration proposed by many authors ranges from 80 seconds to even 60 minutes. It can consist of several, 1-minute stimulations with intervals or 1 continuous session. This is confirmed, among others, by Chochowska et al.[39], who, in the years 2009-2011 subjected patients with chronic spinal pain to vibrations under outpatient conditions, and compared the results with those of classical massage. According to the authors of this report, the use of vi-

Table 2

Commercially available vibration equipment

Device	Manufacturer	Frequency (Hz)	Amplitude (mm)	Location	Duration of treatment (min)	Application
Galileo Delta A Title Table	Novotec Medical GmbH	5-30	3.4	Whole-body	-	S
Galileo S25	Novotec Medical GmbH	10-30	3.4	Whole-body	-	S
MyoVolt	MYOVOLT Limited	120	1.2	Locally	15	S
Rehabilitacyjny Aparat Masujacy Vitberg+ (RAM Vitberg+)	Vitberg	10.10-52.2	0.01-0.21	Locally, Whole -body	30	MSK
TRATAC Active Roll	Naum Care	62	-	Locally	-	MS
UM-30M	Unit Electronics Co. Ltd	60	-	Locally	-	MS
V-Actor	Storz Medical Ag	1-35	1-4	Locally	-	K
Vitafon	Vitafon Ltd.	30-18000	0.0001-0.05	Locally	40-60	MS

M – medical vibration; S – sports vibration; C – cosmetic vibration; MSC – medical, sport and cosmetic vibration

brations in the amount of 10 sessions, lasting 12 minutes each, provides better results compared to those obtained in patients who underwent classical massage. Alleviation of pain in the group of patients undergoing vibrations with the above-mentioned characteristics took place earlier than in the case of patients from the second group[39]. Similar observations are reported by, among others, Stamboliev et al.[40], using this method in patients diagnosed with diabetic neuropathy. After 8 weeks, they noted significant improvement in postural stability, reduced paraesthesia of the limbs and in pain[40]. In the study by Mendes et al.[14], applying a vibration blanket for 10 days, in sessions lasting 15 minutes each, caused a long-lasting decrease in pain, an increase in muscle strength and mobility of the glenohumeral joint. Bily et al.[41] used vibrations in patients following total knee arthroplasty (TKA) in 12 group sessions, which resulted in significant pain reduction. Yang and Seo[42], however, applying vibrations 3 times a week for 6 weeks in sessions lasting 5 minutes each among patients suffering from chronic back pain (spinal), noted a reduction in pain, especially in the distal part[42]. Therefore, it is difficult to adopt a unified duration of applying vibrations to overcome pain-related problems of various origins and locations, which seems to require further observation and research[43].

Table 1 presents detailed results of tests selected for the review (Table 1).

SUMMARY AND CONCLUSIONS

Living with specific pain is primarily a struggle with disease, but also with oneself, based on continuous compromises. Often, it causes the necessity to give up professional dreams and ambitions, as well as being a threat of elimination from social activity or any other activity. This struggle is accompanied by support from analgesic pharmacology, surgical treatment and broadly understood physiotherapy. We are convinced that in this area, there is also room for vibro-therapy. The use of vibrations in analgesic therapy is an extremely interesting and still developing subject. However, it should be borne in mind that only vibration with properly correlated parameters will ensure the safety of patients and its effectiveness. Therefore, it is proposed to create standardized prognostic methods that would take many factors into account directly. By creating "personalized pain relief medicine" (PPRM) identifying a unique patient profile, one could maximize the potential for beneficial responses to treatment using vibration. This provides much room for more insightful research, especially since many vibration functions in reducing pain remain undiscovered. It is necessary to investigate which vibration parameters best relieve pain of a given type for a given patient's characteristics, in addition to developing the most optimal application method, position and duration of exposure. In addition, many studies lack information on the duration of pain relief after using vibro-therapy. This makes it difficult to develop a potential schedule or stimulus dose that could be tailored to the specificity of pain. What also needs to be taken into account is that vibration can be harmful or an initiator of pain. There is a modulation of the response direction to the stimulus from hypoalgesia to hyperalgesia. This change suggests that at a neuronal level, there is the possibility of switching from inhibition to excitation when the signals become strong enough. Therefore, it is very important that the stimulus parameters in vibrational therapy be thoroughly tested and controlled. Despite the fact that the pain complaints analysed in the cited scientific publications were characterized by different location and etiology, and also related to different populations, they were joined by a common element, which is the use of vibrations in their treatment. It is difficult not to notice the clear and beneficial effect among patients with the presented ailments.

At this point, it should be recalled that the authors of the presented reports determine and characterize the vibration parameters in the research criteria, the duration of exposure and location, as well as the frequency of treatments and the number of sessions. The vibrational devices used to treat these patients had different technological characteristics (Table 2).

The subject of applying vibration in the treatment of certain diseases certainly requires further research, but it is difficult to resist the belief that it is definitely justified.

Conflict of interest: none

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Address for correspondence

Alicja Pasterczyk
Vitberg
ul. Borelowskiego 29, 33-300 Nowy Sącz, Poland
e-mail: alicja.pasterczyk@vitberg.com