BMJ Open

Exploring vibroacoustic therapy in adults experiencing pain: a scoping review

Jiří Kantor ,[1] Elsa A Campbell,[2] Lucia Kantorová,[1,3] Jana Marečková,[4] Vojtěch Regec,[1] Kristýna Karasová,[1] Dagmar Sedláčková ,[1] Miloslav Klugar [5]

To cite: Kantor J, Campbell EA, Kantorová L, *et al*. Exploring vibroacoustic therapy in adults experiencing pain: a scoping review. *BMJ Open* 2022;**12**:e046591. doi:10.1136/bmjopen-2020-046591

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2020-046591).

Received 18 May 2021
Accepted 10 March 2022

For numbered affiliations see end of article.

Correspondence to
Dagmar Sedláčková;
dagmar.sedlackova01@upol.cz

ABSTRACT

Objective To explore the characteristics and outcomes of vibroacoustic therapy (VAT) in adults experiencing pain. To give directions for future research and clinical applications of VAT in pain management for adults.

Design Scoping review.

Data sources BMČ, CINAHL Plus, Cochrane Library, EBSCOhost, EBM Reviews, EMBASE, Epistemonikos, ERIC, MEDLINE complete, Scopus, Web of Science, Google Scholar, ProQuest, hand search in unpublished sources.

Study selection All quantitative and qualitative research studies and systematic reviews, without any date or language limit.

Data extraction Two independent reviewers extracted data on the study design, location and setting, the causes of pain, participants, vibroacoustic intervention, measurement tools, and key findings related to pain.

Results From 430 records, 20 were included for narrative synthesis. Fifteen studies researched chronic pain, two studies acute pain, two studies both types of pain and one study experimentally induced pain. The description of VAT applied in studies usually included the description of research experiments, vibroacoustic devices and frequencies of sinusoidal sound. There was high heterogeneity in study protocols, however, 40 Hz was predominantly used, most sessions ranged between 20 and 45 min, and the frequency of treatment was higher for acute pain (daily) compared with chronic pain (daily to once a week). Outcomes related to pain focused mainly on perceived pain; however, other surrogate measures were also considered, for example, an increased number of treatment days or pain medication usage.

Conclusions Research in this area is too sparse to identify properties of VAT that are beneficial for pain management. We suggest VAT researchers describe a minimum of four measurements—frequency, amplitude, pulsation and loudness. Randomised controlled trials are needed to establish reliable scientific proof of VAT effectiveness for both acute and chronic pain. Furthermore, clinical practice would benefit from researching patients' experiences and preferences of vibroacoustic treatment and its psychosocial components.

Strengths and limitations of this study

- We used a systematic search strategy and the Joanna Briggs Institute standardised methodology for scoping reviews in this paper.
- A comprehensive search in a wide range of databases, including grey literature, was carried out and the interprofessional team interpreted the results.
- Authors of primary studies were not contacted for any missing information.

INTRODUCTION

Vibroacoustic therapy (VAT) is a complementary psychosocial approach in rehabilitation defined as 'a combination of low-frequency sound vibration, (and) music listening combined with therapeutic interaction' (p. 128).[1] Synonyms and other related terms for VAT are vibroacoustic treatment,[2] physioacoustic therapy,[3] rhythmic sensory stimulation[4] and vibroacoustic music,[5] and it is sometimes referred to as a vibrotactile intervention.[6] Vibroacoustic stimuli can be delivered using various devices that are based on sound-induced sinusoidal waves. Other devices in vibration therapies, such as whole-body vibration (WBV), are based on mechanical rather than sound vibration. As there may be essential differences between WBV and VAT in terms of application methods and results,[7] this review focuses solely on the effects of sinusoidal sound-based vibration. The variables of low-frequency sound (LFS) interventions may include frequencies (measured in Hz), amplitude (refers to the intensity of a sound wave, perceived by the ear as loudness), pulsation or cycle (refers to the speed of the amplitude change) and loudness or strength that is associated with amplitude and its energy.[2]

Although the effects of the various VAT parameters such as amplitude are relatively unknown, previous authors have addressed the impact of specific frequencies (Hz). In Tony Wigram's work on VAT and the physical responses to certain frequencies,[8] when commonly used frequencies such as 50, 68 or 86 Hz were applied, participants perceived

the sensation in similar areas of their bodies (chest, shoulders and head). However, when 40 Hz was applied, given that larger muscles' resonant frequencies are generally lower, the stimulation was perceived in for example, the thigh muscles, as well as affording a general relaxation response. This has also been repeatedly found in clinical practice. Neurological studies also show that the brain communicates with itself on the gamma frequency band (which centres around 40 Hz). When a disruption to this band occurs, VAT may act as a driving force to reset this dysfunction.[9]

Some authors[8 10] recommend using VAT to treat acute and chronic pain. Previous research on pain response theories, such as the neuromatrix pain theory[11] and the potential impact of an induced relaxation response,[12] proposes first affording a pleasant physical sensation, as compared with one which causes pain (see also reference[13]), to reset the destructive response one develops over time to and from chronic pain, thereby enabling the potential for a therapeutic process in which one can understand and respond to the biopsychosocial factors associated with chronic pain.[14] VAT has been used for pain management in postoperative conditions[15] and syndromes such as fibromyalgia,[16] Ehler-Danlos syndrome[17] and temporomandibular disorders, among others. It is hypothesised that the combination of the two vibrational components used in VAT—auditory music and LFS vibrations—may be effective in pain management.[18 19] The effectiveness of music in pain management has been investigated mainly by music therapists,[20 21] whereas the effectiveness of low frequency vibration was found mainly within the literature on WBV.[7] Reporting on VAT has often omitted information on specific technologies or LFS parameters (eg, the frequency or amplitude), despite these elements being potentially determinative of effectiveness. Therefore, this scoping review attempts to compile and analyse data related to VAT characteristics (especially characteristics of the LFS stimulus) and outcomes related to pain. Furthermore, this study is not limited only to studies of effectiveness but aims to provide an overview of the field of VAT and pain (also including qualitative studies) and open a discussion about the specifics of this methodology. Based on the findings, it will be possible to determine if the research evidence found would be sufficient for conducting a systematic review of effectiveness or another type of systematic review. According to the Joanna Briggs Institute (JBI),[22] the scoping review is the most appropriate design for mapping and discussing intervention characteristics or concepts and their evidence sources.

Although there is some primary research on VAT and pain, a search of Epistemonikos, Cochrane Reviews, JBI Evidence Synthesis, Open Science Framework and Prospero showed no published or ongoing systematic/scoping review. The objective of this scoping review was to search for and analyse all available evidence on VAT used for the treatment of pain in all adult populations across the world. The PCC format was used to formulate two review questions.[23]

Review question 1: 'What are the characteristics of vibroacoustic therapy described in research studies in adults with pain?'

Review question 2: 'What are the outcomes related to pain in studies on vibroacoustic therapy in adults with pain?'

METHODOLOGY

The proposed scoping review was conducted in accordance with the JBI methodology for scoping reviews.[23] The objectives, inclusion criteria and methods for this scoping review were specified and documented in a protocol registered in Open Science Framework: https://osfio/6c3uh/. Only one deviation from the protocol was a decision to accept relevant conference abstracts.

Inclusion criteria:

- Participants: the review considered studies that included any adult populations older than 18 years suffering from pain.
- Concept: the review considered studies on sinusoidal, sound-induced, low-frequency vibration (applied locally or to the whole body) without therapeutic interaction (ie, applied solely as a stimulus but not as part of a therapeutic relationship) and with or without music listening (so-called VA treatment). Excluded were studies using technologies based on resonance (without technologically modified sinusoidal sound) or mechanical oscillations (eg, WBV) that is, sinusoidal vibration and displacement through oscillating platforms not comprising sound vibration.
- Context: the review considered studies conducted in a broad range of institutions or therapeutic settings without limitations (including self-care applications at home).
- Types of sources: the review considered all quantitative and qualitative research studies as well as systematic reviews. Text, opinion papers, clinical reports, all types of non-systematic reviews and bachelor and diploma theses were excluded. No date or language limits were set, but the title and abstract had to at least be available in English.

The searched databases were: Bibliographia Medica Čechoslovaca (BMČ, the Medvik interface), CINAHL Plus, Cochrane Library, EBSCOhost, EBM Reviews, EMBASE, Epistemonikos, ERIC, MEDLINE complete, Scop us and Web of Science. Sources of unpublished studies and grey literature searches included ProQuest and Google Scholar. A manual search was carried out in the publication Music Vibration and Health,[24] in the Annual Newsletter Soundeffects focused on VAT (Volume 4, 2007) and in all the issues of the journal *Music and Medicine*. The reference list of all relevant studies was screened for additional studies. The search was conducted on 6 March 2020 and updated on 9 January 2022. See the full-search strategy for each database supplemented by tables with the results in online supplemental appendix A.

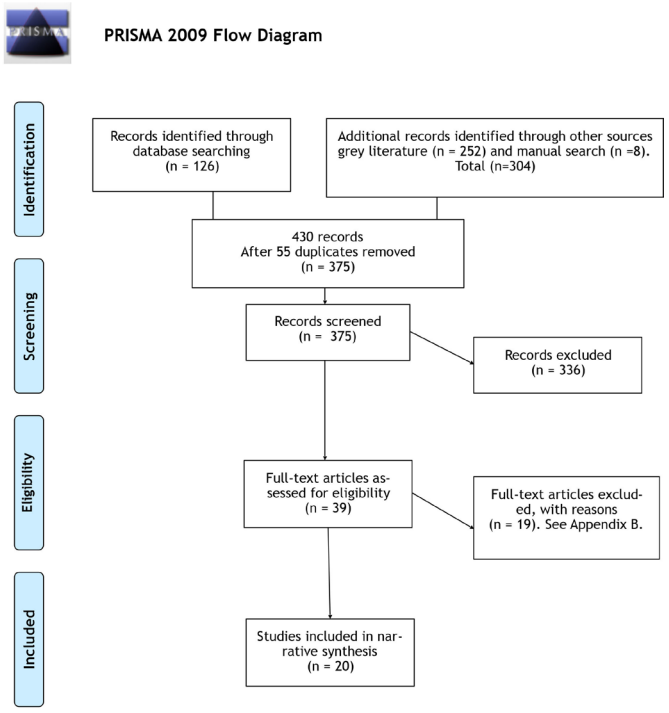

Figure 1 PRISMA 2009 flow diagram. From Moher *et al*.[45] PRISMA, Preferred Reporting Items for Systematic reviews and Meta-Analyses.

Following the search, all identified citations were collated and uploaded into Zotero-5.0.85, and duplicates removed. Titles and abstracts were then screened by two independent reviewers (JK and KK) for assessment against the inclusion criteria for the review. Potentially relevant studies were retrieved in full, and their full texts were assessed in detail against the inclusion criteria by two independent reviewers (JK and KK). Any disagreements that arose between the reviewers at each stage of the study selection process were resolved through discussion or with a third reviewer (EAC or MK). Studies excluded based on full-text analyses are in online supplemental appendix B with reasons for exclusion. The results of the search are reported in full below (figure 1) using a Preferred Reporting Items for Systematic Reviews and Meta-Analyses for Scoping Reviews (PRISMA-ScR) flow diagram.[25]

Furthermore, data were extracted by two independent reviewers (LK and KK) using a data extraction tool developed by the authors (see online supplemental appendix C). Any disagreements that arose between the reviewers were resolved in discussion with a third reviewer (EAC or MK). The extracted data were presented in tabular form in a manner aligned with the scoping review objectives. Finally, the studies were sorted alphabetically; the extracted data were summarised and are presented in the table in online supplemental appendices D and E, accompanied by a narrative summary.

Patient and public involvement

No patient was involved in the study.

RESULTS

The final data set from the original search from 3 March 2020 comprised of 16 studies (results from the updated search are described in section 3.3). Studies included participants with different forms of pain. Eleven studies were focused on chronic pain,[2 4 16 17 26–32] two on acute pain,[15 33] one study on experimentally induced pain[34] (from this point onwards referred to only as experimental pain), one study included patients with acute and chronic pain[35] and one study did not specify the type of pain (probably both acute and chronic pain patients were included).[5] Chronic pain included different types of presumed musculoskeletal pain (mostly fibromyalgia), psychosomatic and neuropathic conditions,[2 4 16 26–32 35] and, least prevalent, Ehlers-Danlos Syndrome Hypermobility Type.[17] The acute pain[15 33] studies included postoperative pain after gynaecological surgeries, after a total knee replacement and after an ankle sprain.[35] Experimental pain was evaluated in university students after exercise-induced muscle pain.[34]

The chronic pain studies were published beginning in 1991[35] with increasing frequency in recent years (eg, eight publications after 2017). Both studies on acute pain were published in 1997; the Chesky and Michel study from 1991 only included a short case study of a patient with acute pain. The one study on experimental pain was published in 2012.[34] Four of the studies on chronic pain were from Canada,[16 17 30 31] four from Finland,[2 4 26 27] three from the USA[28 29 35] and one from Estonia.[32] The studies on acute pain were from the USA,[15 33 35] and the study on experimental pain was from Canada.[34] The study without specification of type of pain was done in the USA.[5] Most studies were conducted in a clinical setting except for five studies with self-treatment in a home setting[2 17 27 30 31] (two studies were divided into two parts with the first realised in hospital and the second at home[2 27] and three studies at universities).[26 34 35]

The number of participants ranged from 1[17 26] to 56.[5] In most studies, the number of participants needed to achieve sufficient power had been underestimated, as noted by some authors.[31] Concerning participants' gender, the 230 females (F) far-exceeded the 82 males (M) in the pooled sample of all studies. The gender ratio in the samples according to the types of pain was 176F/66M for chronic pain, 30F/9M for acute pain and 22F/4M for experimental pain. The age range of the participants was 18[28] to 70 years.[32]

The studies were grouped according to research design; this was based on the levels of evidence paradigm from the JBI guidelines.[36] Two studies on acute pain[15 33] and one study on experimental pain[34] were classified as quasi-experimental prospectively controlled studies. Moreover, Chesky and Michel included one case study on acute pain in their paper.[35] In the area of chronic pain research, there were three randomised controlled trials,[28 30 31] one quasi-experimental prospectively controlled study,[29] five case series[2 4 16 27 31 32] and four case studies.[17 26 35] The one study that did not specify the type of pain was classified

as a case series.[5] Three studies used a mixed-methods design with a qualitative part; however, only two of these included qualitative findings relevant to pain and VAT.[2 27] No study with a qualitative design was found.

This review's findings are presented in two subsections according to the review questions: the first dealing with information on the characteristics of VAT and the second describing the pain-related outcomes.

The characteristics of vibroacoustic therapy

There was high variability in treatment protocols, VA devices and LFS treatment programme properties. The typical length of a session ranged between 20 and 45 min with one exception in the acute pain study[15] that applied VAT before, during and after physiotherapy, with the whole process lasting 40–50 min. Some sessions included therapeutic discussion between patient and therapist.[4 5 26]

Some studies applied VAT in a single session[5 28–30 35] and some over several consecutive days.[30–34] The regularity of the VAT sessions varied from taking place once to several times per week. In acute pain studies, the stimulation was delivered one[15 35] to three times per day,[33] while this ranged from twice a day[17] to once per week[4 26] in chronic pain studies. There was also high variability in the treatment procedures within the session. Several studies implemented treatment phases with wash-out periods and combinations with other stimuli or VA treatment programmes.[2 4 17 27 31]

The most commonly used VA devices as follows: the Next Wave Physioacoustic Chair,[2 4 15 26 27 33 34] the Sound Oasis VTS1000 (also the Next Wave system),[17 30] the Music Vibration Table, MVT,[28 29 35] the Taikofon FeelSound Player for self-application at home,[2 27] the Multivib 10 mattress,[32] the Somatron[5] and the SL5 Nexneuro.[16]

One of these devices—the Taikofon Feel Sound Player—was applied for local stimulation; the other devices were capable of delivering whole-body or upper-body (Sound Oasis VTS1000) LFS application. There was a wide range of frequencies applied (lower end of the range was 26 Hz) during the whole treatment process and within individual sessions, for example, because of a scanning/radar-like effect in which there is a focal frequency and two frequencies either side to which the vibration 'scans'. This is used in the Physioacoustic System to avoid numbness; 40 Hz was most applied across all studies. It was used either as the single frequency,[16 30 32] or as the fundamental frequency within a treatment programme for all sessions.[2 4 26 27] Only some studies included information about the duration of the VA treatment programme parameters, spectral analysis of the vibration, music, or the patient positioning.

Most studies included listening to music as part of the treatment, except for two studies on chronic pain[16 30] and the experimental pain study[34] that did not use any music. Two studies let the participants choose whether to use music or silence in addition to LFS.[2 26] Findings from two studies were related to the role of music as part of the VA treatment:

- One study found LFS to be more effective with music compared with LFS alone.[17]
- Participants noted that music was a more potent stimulus for the affective dimension than LFS.[29]
- Some of the various musical instruments seemed to be able to hold patients' attention longer than others.[35]

Several VA treatment programmes were mentioned—General Relaxation,[4] Energise[17 26] and Sleep.[17]

Outcomes related to pain

Most data were collected using quantitative measurement tools, with some qualitative methods also utilised. Nearly all studies (except Chesky and Michel)[35] used the Visual Analogue Scale for Pain (VAS-P) or its modifications. Various forms of questionnaires, usually standardised, were used: McGill Melzack Present Pain Intensity scale,[33] Brief Pain Inventory-Short Form,[17 30] Revised Fibromyalgia Impact Questionnaire (FIQ),[16 30] McGill Pain Questionnaires (MPQ),[29 33 35] Tender Point Index (TPI) Test,[28] Dolorimeter Pain Threshold Test (TPA)[28] and Pain Disability Index (PDI).[16] Some studies collected data on the use of pain medication,[16 33] the duration of sitting and standing time without pain[16] or duration of pain relief.[35] Some studies were complemented by qualitative information either from the therapists or participants.

Some outcomes indicated pain relief after VAT. These were analysed according to the type of pain (acute, chronic and experimental) and according to the study design with specific attention given to the presence or absence of a control group.

Both studies on acute pain with a quasi-experimental design reported some pain relief. In one of these studies, statistical significance between experimental and control groups was reported on 1 out of the 6 days of daily VAT sessions.[15] Among other outcomes was a decline in the use of intravenous pain medication[33] and positive verbal feedback of patients about their VAT experience.[15] One case study on acute pain reported pain relief after one VAT session.[35] There was no statistical difference between the experimental and control groups in the study exploring experimental pain using a quasi-experimental design.[34]

Among the three studies on chronic pain that used control groups, one reported pain relief with statistical significance.[29] Another study[28] showed better scores for reduction of pain—although not statistically significant—in the experimental group compared with the control group. The same study observed significantly decreased pressure pain thresholds (in TPA and TPI scores). Janzen and colleagues[30] did not observe significant differences between groups (except for statistically significantly improved pain interference in the control group). Howard[31] used a cross-over design and did not find any differences between VAT and listening to self-selected songs.

The studies with an observational design used pretest post-test measurements on individual participants (in case studies) or whole samples (in case series). Of the five

studies where significance was calculated, four studies showed significant pain relief,[4 5 17 32] whereas one found no difference.[15] In the four studies with descriptive statistics, trends showing improvement rather than worsening in pain sensation are reported.[2 31 33 35]

Table 1 (see the end of Results) shows the designs of studies on chronic pain with emphasis on control and intervention, where applicable and the effect of VAT on the perception of pain. This table also includes the study that does not specify type of pain but probably included at least some patients with chronic pain.[5]

Some studies[2 27] included a qualitative part and identified several categories closely connected to pain in the context of VA treatment. Those findings concerned reactions reporting immediate pain relief after the VA sessions and recurrence of pain in some phases of the research experiment,[2] comparisons between sessions in hospital (useful and empowering) and self-care treatment (comparatively weak),[2] active involvement in seeking pain relief,[2] integrating the self-care practice into daily life befitting schedules and needs[27] and observations of any relaxation response leading to pain relief.[27]

Updated search results

During the updated search (conducted on 9 January 2022), we found three research studies (one double-blind RCT pilot study,[37] one pretest post-test study without a control group,[38] one case study)[39] and one RCT protocol published at ClinicalTrial.gov. The three studies include participants with chronic pain caused by Ehler-Danlos syndrome,[38] postherpetic neuralgia[39] and chronic musculoskeletal pain.[37] Interventions were delivered using the Sound Oasis VTS1000 using the 'Energise' programme,[38] a wearable music player (XINYIBAO),[39] and a Pacini-Medico ApS chair device playing rhythmically aligned music.[37] All studies reported improvements on pain sensation due to the intervention (although Eshuis *et al*[37] also reported significant improvements in the active control group). Vuong *et al*[38] also applied the concept of intervention responders and non-responders according to the Minimal Clinically Important Difference (MCID) as a means of tracking clinically relevant improvement. However, the findings do not change the outcomes of the initial search. Table 1 includes the relevant findings from this updated search.

On top of the three published studies, we found one RCT protocol on VAT and chronic back pain registered on clinicaltrails.gov (NCT04468516), last updated 16 September 2021, participants not yet recruited.

Discussion

The findings of this scoping review show that research on the use of VAT for managing pain has been increasing in recent years, and the majority of the publications are from English-speaking countries. The use of VAT may be somewhat controversial (mainly caused by the lack of and quality of scientific evidence, discussed later). This scoping review offers suggestions on how to improve inconsistencies in the description of VAT in research studies and how to address challenges typical in researching VAT and pain-related outcomes.

Characteristics of vibroacoustic therapy

There were significant differences in research design, technologies and the properties of the LFS stimulation. The disparity in reporting of intervention characteristics, treatment procedures, types of pain, duration and frequency of intervention and additional potentially uncontrolled aspects of the experimental research have added to the difficulty in interpreting its efficacy and comparison across studies. In most studies, comprehensive information on the characteristics of the LFS stimulation is challenging to find, mainly in studies published earlier. Most studies only report the frequencies of the LFS treatment programme/stimulus (with particular interest in 40 Hz frequency), while other characteristics of LFS are described inconsistently. Researchers should use comparable treatment and measurement procedures as much as possible. Standardised reporting will encourage more thoughtful planning of experiments as well as enable efficacy reviews once enough systematic and well-reported research is available. The following reporting suggestions may support transparency in reporting:

- The description of LFS could include frequency, amplitude, pulsation and loudness. Duration of stimulus (time and days), and area of the body to which it is applied (whole body and local) could also be included.
- Given the many unknowns in effectiveness, we suggest using 40 Hz,[40] sessions lasting at least 20 min, more frequent applications for acute pain (daily) and further concentration on the psychological impact of music listening on pain perception,[2] as recommended by Campbell *et al* (2019). This recommendation could also be applied in clinical practice until more evidence on effectiveness is available.
- Currently, it is not known how long the effects of VAT last; follow-up measurements are needed to assess this.

Vibroacoustic therapy and outcomes related to pain

Most studies measured changes in pain sensation combined with other measurements, such as pain medication dosage. In this review, we found that studies on acute postoperative and experimentally induced pain (all of them being quasi-experimental studies) describe a decrease in pain sensation over time. However, the differences between experimental and control groups were mostly statistically insignificant (or both groups were significantly improved, such as in Eshuis *et al*).[37] Acute pain literature is rather scarce, with small sample sizes and other methodological issues. One example of this is Shivani *et al*[41] in which frequencies between 6 and 14 kHz were used, with small sample sizes and with no significant results, yet suggestive of having potential effects in a larger sample. When exploring the effects of VAT on acute pain, it is necessary to take the expected spontaneous pain

Table 1 Summarised outcomes of studies on chronic pain

Author, reference	Design	Pain relief (subjective scale, usually VAS-P)	Statistical significance
Chronic pain—experimental			
Chesky *et al*[28]	PseudoRCT (prospective, randomised, double-blinded, (pseudo) placebo-controlled parallel intervention, 1.d) *Control:* Constant 20 Hz sine wave signal with the same music. *Intervention:* Music with vibration using the MVT	✓	✗
Janzen *et al*[30]	RCT (with two parallel arms (control group), double-blind, 1.c). *Control:* Vibrotactile stimulation from randomly intermittent sounds consisting of complex wave gamma-range noise with pitch peaks at 33 and 45 Hz. *Intervention:* 40 Hz, continuous sine wave.	✓	Improvement within groups with statistical significance p<0.005. However, not when two groups compared.
Eshuis *et al* 2021[37]	RCT (International multicentre, randomised, double-blind, pilot trial, 1.c) *Control:* music with higher-frequency vibration (200–300 Hz) *Intervention:* music with low-frequency stimulation (20–100 Hz)	✓	✗
Howard[31]	RCT (cross-over design without a control group, 2.d) *Control:* Music-listening to 25 self-selected songs. *Intervention:* Vibroacoustic chair with music.	✓	✗
Chronic pain—quasi-experimental			
Chesky[29]	Quasi-experimental prospectively controlled study (2.c) *Control:* Two control groups: music alone and 100 Hz sine wave with no music. *Intervention:* Low-frequency sound with music using MVT	✓ (for both control groups)	✓ P<0.001 (for both control groups)
Vuong *et al*[38]	Pretest post-test study without control group (2.d) *Intervention:* Self-administered intervention using Sound Oasis VTS1000 device and the programme 'Energise'	✓ (for 73% of participants)	✓ P<0.05
Chronic pain—observational (case series)			
Campbell *et al*[4]	Case series (4.c)	✓	NA
Naghdi[23]	Case series (4.c)	✓	NA
Campbell *et al*[2]	Case series with mixed design (4.c for quantitative part)	✓	NA
Campbell *et al*[4]	Case series with mixed design (4.c for quantitative part)	✓ (in 5/8 improvement, in 3/8 minimal worsening)	NA
Naghdi *et al*[16]	Case series (4.c)	✓	NA
Patrick[5]	Case series—single session, types of pain not specified (4.c)	✓	✓ P<0.001
Rüütel *et al*[32]	Observational study without a control group (4.c)	✓	✓ P<0.05
Chronic pain—observational (case study)			
Chesky[27]	Case studies of 3 participants with different types of pain (4.c)	✓	NA
Campbell *et al*[26]	Case study with mixed design (4.d), 1 participant	✓	NA
Picard *et al*[24]	Case study (4.d), 1 participant	✗	NA
Wang *et al*[39]	Case study (4.d), 1 participant	✓	NA

MVT, Music Vibration Table; NA, not applicable; RCT, randomised controlled trial; VAS-P, Visual Analogue Scale for Pain.

relief due to the body's healing processes after an injury or surgery (or other causes of acute pain) into account, as well as the unethicality of delivering inadequate pain management. Therefore, researchers must compare the results of both VAT and control groups in relation to a comprehensive pain management plan (including medication). In brief, RCTs with optimal sample size that would explore the effects of VAT on the subjective pain perception and pain medication usage (or on other pain relief methods) are needed to understand the possible effects of VAT on acute pain.

More primary evidence of the effectiveness of VAT has been conducted on chronic pain, however, mostly in the form of observational studies. These studies (with the exception of Picard *et al*[17]) have shown an improvement compared with findings from three double-blinded randomised controlled trials.[28 30 37] Research on VAT and chronic pain would also benefit from RCTs with optimal sample size. However, it is neither easy to blind the participants, nor find a true sham in VAT research (see extraction process of a study by Janzen *et al*).[30] This constitutes a serious methodological issue mainly because of the subjective nature of pain and outcome measures used to assess change. Considering the results presented here, it does not seem that any sound-induced vibration could be considered a fully adequate control intervention with any certainty. We suggest researchers explore the suitability of the following options:

- Using music or sound as a control (eg, experimental group with VAT and control group only with music without LFS).
- To design RCTs that compare VAT against conventional methods for managing pain (eg, RCT with a group receiving physical therapy, a group with both physical therapy and VAT and a group with VAT only).[42]
- There are alternatives to RCT methodologies that may be considered for future research in VAT, for example, using dose-responsive curves or demonstration of loss of effect during a washout period (however, this procedure is not applicable to acute pain research). Furthermore, researchers should consider applying the MCID as a means of understanding the clinically important change in pain scores to supplement other methods, since the patient's subjective response to the pain (especially in chronic pain patients) is potentially more relevant than objective measures.

Outcome assessors should not be present for the duration of VAT application, thus ensuring their blinding (as was done by Janzen *et al*[30] and Chesky *et al*).[28] We strongly recommend that researchers describe the whole research process in greater detail,[43] documenting and explaining any decisions made.

Apart from effectiveness, there may be many other important details related to a patient's experience and preferences that are useful for clinicians and gained primarily from qualitative data.[44] However, no relevant qualitative studies were found in this review.

The strength of this scoping review is a comprehensive database search and collaboration in a team consisting of many specialisations—VAT (EAC), music therapy (EAC and JK), medicine (LK), nursing (JM), physiology, methodology and epidemiology (MK) and special education (JK, VR, KK and DS). This is the first complete overview of VAT in adult patients with pain. There are also some weaknesses of this scoping review (see PRISMA for Scoping Review Checklist in online supplemental appendix F):

- We limited the selection to the availability of an abstract written in the English language. There may be papers in various languages not fulfilling this criterion.
- Relevant information concerning the review questions was missing in some studies. We did not approach the authors of these papers.

Conclusions

Research on the effects of VAT on pain deals mainly with chronic pain. There is considerable heterogeneity in the characteristics of VA treatment/therapy and research designs. Although most studies indicate the positive effect of VAT on both acute and chronic pain populations, the effectiveness must be established based on reliable scientific proofs. Studies using an RCT design or alternative approaches with control groups should be considered in order to reduce issues related to blinding participants, and the subjectivity of measurements and other methodological challenges should be carefully discussed.

For researchers and practitioners in the field, we recommend using 40 Hz, stimulation lasting at least 20 min, more frequent treatment for acute pain (daily) and the use of music listening to impact the psychological aspect of pain perception. Reporting in the studies should at least include measurements of frequency (Hz), amplitude, pulsation and loudness (dB).

Further research is needed to explore properties of VAT that are effective for pain management with replication studies to confirm previous results. Qualitative evidence on patients' experiences could be beneficial for the development of VAT clinical practice and research. Foundational work for VAT is still sparse and a better understanding of how individuals respond to the treatment would in turn inform larger, controlled studies.

Author affiliations
[1]The Institute of Special Education Studies, Center of Evidence-based Education and Arts Therapies: A JBI Affiliated Group, and Institute of Special Education Studies, Palacky University Olomouc Faculty of Education, Olomouc, Olomoucký, Czech Republic
[2]VIBRAC Skille-Lehikoinen Centre for Vibroacoustic Therapy and Research; Caritas Association for the Karlsruhe Region, Ettlingen Germany, University of Jyväskylä, Jyvaskyla, Finland
[3]The Czech National Centre for Evidence-Based Healthcare and Knowledge Translation (Cochrane Czech Republic, Czech CEBHC: JBI Centre of Excellence, Masaryk University GRADE Centre), Institute of Biostatistics and Analyses, Masaryk University Faculty of Medicine, Brno, Jihomoravský, Czech Republic
[4]Center of Evidence-based Education and Arts Therapies: A JBI Affiliated Group, and Department of Anthropology and Health Education, Palacky University Olomouc Faculty of Education, Olomouc, Olomoucký, Czech Republic

[5]Czech National Centre for Evidence-Based Healthcare and Knowledge Translation (Cochrane Czech Republic, Czech EBHC: JBI Center of Excellence, Masaryk University GRADE Centre), Masaryk University Faculty of Medicine, Brno, Czech Republic

Acknowledgements Panorama I.L.A. for professional proofreading.

Contributors Conceptualisation, JK, LK, EAC, VR, JM and MK; methodology, MK, JM and JK; validation, JK, LK, EAC and JM; formal analysis, JK, LK and DS; investigation, JK, LK, DP and KK; resources, JK and VR; data curation, JK, LK and JM; writing—original draft preparation, JK, LK, EAC and DS; writing—review and editing, JK, LK, JM and DS; visualisation, LK, KK and DS; supervision, JM, MK and EAC; project administration, JK and VR; funding acquisition, JK, guarantor; JK.

Funding Research of Inclusion in People with Special Needs, IGA_PdF_2021_024

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting or dissemination plans of this research.

Patient consent for publication Not required.

Ethics approval Ethics approval is not required. We will disseminate the findings through professional networks and conference presentations and will publish the results.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement No data are available.

ORCID iDs
Jiří Kantor http://orcid.org/0000-0001-6016-3408
Dagmar Sedláčková http://orcid.org/0000-0001-7221-3724
Miloslav Klugar http://orcid.org/0000-0002-2804-7295

REFERENCES

1 Punkanen M, Ala-Ruona E. Contemporary vibroacoustic therapy: perspectives on clinical practice, research, and training. *Music Med* 2012;4:128–35.
2 Campbell EA, Hynynen J, Burger B, *et al*. Exploring the use of vibroacoustic treatment for managing chronic pain and comorbid mood disorders: a mixed methods study. *Nordic J Music Ther* 2019;28:291–314.
3 Lehikoinen P. Physioacoustic therapy. In: Dileo C, Wigram T, eds. *Music vibration and health*. Cherry Hill: Jeffrey Books, 1997.
4 Campbell EA, Hynynen J, Ala-Ruona E. Vibroacoustic treatment for chronic pain and mood disorders in a specialized healthcare setting. *Music Med* 2017;9:187–97.
5 Patrick G. The effects of vibroacoustic music on symptom reduction inducing the relaxation response through good vibrations. IEEE Eng. in medicine and biology magazine 1999;18:97–100.
6 Walters CL. The psychological and physiological effects of Vibrotactile stimulation, via a Somatron, on patients awaiting scheduled gynecological surgery. *J Music Ther* 1996;33:261–87.
7 Dong Y, Wang W, Zheng J, *et al*. Whole body vibration exercise for chronic musculoskeletal pain: a systematic review and meta-analysis of randomized controlled trials. *Arch Phys Med Rehabil* 2019;100:2167–78.
8 Wigram T. The effects of vibroacoustic therapy on clinical and non-clinical populations. Ph.D. Thesis, London University, London, UK 1996.
9 Bartel LR, Chen R, Alain C, *et al*. Vibroacoustic stimulation and brain oscillation: from basic research to clinical application. *Music Med* 2017;9:153–66.
10 Boyd-Brewer C, McCaffrey R. Vibroacoustic sound therapy improves pain management and more. *Holist Nurs Pract* 2004;18:111–8.
11 Melzack R. Pain and the neuromatrix in the brain. *J Dent Educ* 2001;65:1378–82.
12 Benson H, Klipper MZ. *The relaxation response*. New York: HarperCollins, 1975.
13 Punkanen M. "On a journey to mind and emotions"- the physioacoustic method and music therapy in drug rehabilitation. In dialogue and debate-conference proceedings of the 10th World Congress on Music Therapy. 1333 2004.
14 Campbell EA. *Vibroacoustic treatment and self-care for managing the chronic pain experience: an operational model. JYU dissertations*. Jyväskylä, Finland: University of Jyväskylä, 2019.
15 Burke M, Thomas K. Use of physioacoustic therapy to reduce pain during physical therapy for total knee replacement patients over age 55. In: Wigram T, Dileo C, eds. *Music vibration and health*. Cherry Hill, NJ: Jeffrey Books, 1997: 99–106.
16 Naghdi L, Ahonen H, Macario P, *et al*. The effect of low-frequency sound stimulation on patients with fibromyalgia: a clinical study. *Pain Res Manag* 2015;20:e21–7.
17 Picard LM, Bartel LR, Gordon AS. Vibroacoustic therapy for EhlersDanlos syndrome: a case study. *Ann Clin Case Rep* 2018;3:1504 http://www.anncaserep.com/pdfs_folder/accr-v3-id1504.pdf
18 Hollins M, McDermott K, Harper D. How does vibration reduce pain? *Perception* 2014;43:70–84.
19 Cepeda MS, Carr DB, Lau J. Music for pain relief. *Cochrane Database Syst Rev* 2006;2:CD004843.
20 Lin C-L, Hwang S-L, Jiang P, *et al*. Effect of music therapy on pain after orthopedic surgery-a systematic review and meta-analysis. *Pain Pract* 2020;20:422–36.
21 Gao Y, Wei Y, Yang W, *et al*. The effectiveness of music therapy for terminally ill patients: a meta-analysis and systematic review. *J Pain Symptom Manage* 2019;57:319–29.
22 Peters MDJ, Marnie C, Tricco AC, *et al*. Updated methodological guidance for the conduct of scoping reviews. *JBI Evid Synth* 2020;18:2119–26.
23 Peters MDJ, Godfrey C, McInerney P. Chapter 11: Scoping Reviews (2020 version). In: Aromataris E, Munn Z, eds. *Joanna briggs institute reviewer's manual*, 2020. https://reviewersmanual.joannabriggs.org/
24 Wigram T, Dileo C. *Music, vibration and health*. Cherry Hill, NJ: Jeffrey Books, 1997.
25 Tricco AC, Lillie E, Zarin W, *et al*. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. *Ann Intern Med* 2018;169:467–73.
26 Campbell E, Burger B, Ala-Ruona E. A single-case, mixed methods study exploring the role of music listening in vibroacoustic treatment. voices: a world forum for music therapy 2019;19:27.
27 Campbell EA, Hynynen J, Burger B, *et al*. Vibroacoustic treatment to improve functioning and ability to work: a multidisciplinary approach to chronic pain rehabilitation. *Disabil Rehabil* 2021;43:1–16.
28 Chesky KS, Russell IJ, Lopez Y, *et al*. Fibromyalgia tender point pain: a double-blind, placebo-controlled pilot study of music vibration using the music vibration table ™. *J Musculoskelet Pain* 1997;5:33–52.
29 Chesky KS. The effects of music and music vibration using the MVT on the relief of rheumatoid arthritis pain. Dissertation. In: Abstracts international 1992;53:2725B.
30 Braun Janzen T, Paneduro D, Picard L, *et al*. A parallel randomized controlled trial examining the effects of rhythmic sensory stimulation on fibromyalgia symptoms. *PLoS One* 2019;14:e0212021.
31 Howard A. *Music medicine: an alternative approach for managing symptoms of temporomandibular disorder. Dissertation*. Toronto, Canada: University of Toronto, 2017.
32 Rüütel E, Vinkel I, Eelmäe P. The effects of short-term vibroacoustic treatment on spasticity and perceived health conditions of patients with spinal cord and brain injuries. *Music Med* 2017;9:202–8.
33 Burke M. Effects of Physioacoustic® intervention on pain management of postoperative gynecological patients. In: Wigram T, Dileo C, eds. *Music vibration and health*. Cherry Hill, NJ: Jeffrey Books, 1997: 107–24.
34 Tiidus PM, Markoulakis R, Murray D, *et al*. Physioacoustic therapy: placebo effect on recovery from exercise-induced muscle damage. *Acta Kinesiologiae Universitatis Tartuensis* 2012;13:117–28.
35 Chesky KS, Michel DE. The music vibration table (MVT): developing a technology and conceptual model for pain relief. *Music Therapy Perspectives* 1991;9:32–8.

36 Klugarová J. Vyhledávání nejlepších dostupných vědeckých důkazů. [Searching for the best scientific evidence]. In: Klugarová J, Marečková J, Olomouc Eds.:, eds. *Evidence based healthcare: Zdravotnictví Založené Na Vědeckých Důkazech*. 1st edn. Czech Republic: Univerzita Palackého v Olomouci, 2015: 17–33.
37 Eshuis TAH, Stuijt PJC, Timmerman H, *et al*. Music and low-frequency vibrations for the treatment of chronic musculoskeletal pain in elderly: a pilot study. *PLoS One* 2021;16:e0259394.
38 Vuong V, Mosabbir A, Paneduro D, *et al*. Effects of rhythmic sensory stimulation on ehlers–danlos syndrome: a pilot study. *Pain Res Manag* 2020;2020:3586767.
39 Wang X, Ye J, Yang B, *et al*. Low frequency sound stimulation greatly improved the outcome of a refractory postherpetic neuralgia patient with mood and sleep disorder: a case report. *Ann Palliat Med* 2021;10:11221–5.
40 Ahonen H. Low frequency research—client populations and common frequencies used—literature review, 2007. Available: https://www.researchgate.net/publication/319016221_Low_frequency_research-client_populations_and_common_frequencies_used-literature_review
41 Shivani A, Kiran Rao U, Abhilash G. Impact of vibroacoustic sound therapy on dental pain relief. *Res J Biotechnol* 2021;16:30–5.
42 Sluka KA. *Mechanisms and management of pain for the physical therapist*. Wolters Kluwer, 2016: 19–32.
43 Kantor J, Kantorová L, Marečková J, *et al*. Potential of vibroacoustic therapy in persons with cerebral palsy: an advanced narrative review. *Int J Environ Res Public Health* 2019;16:3940.
44 Oravec S*et al*. Naše skúsenosti S kombinovanou liečbou V rámci rehabilitácie pacientov S chronickou bolesťou. *Rehabilitácia* 2012;49:139–44.
45 Moher D, Liberati A, *et al*, The PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med* 2009:6–7.