JYU DISSERTATIONS 95

Elsa A. Campbell

Vibroacoustic Treatment and Self-care for Managing the Chronic Pain Experience

An Operational Model

UNIVERSITY OF JYVÄSKYLÄ
FACULTY OF HUMANITIES AND SOCIAL SCIENCES

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ABSTRACT

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Chronic pain – pain which lasts longer than three months – is a physiological, psychological, and social phenomenon affecting approximately 20-33% of the world's population. It contributes to disability, work absenteeism and presenteeism, as well as having economic ramifications. The psychological aspect of chronic pain manifests most commonly in comorbid mood disorders, namely depression and anxiety. They are individually difficult to manage due to their inherently subjective nature; as a combination they are pervasively under-treated. It is understood that chronic pain and mood disorders have a common neurological basis, which supports the use of psychological approaches, such as Cognitive Behavioural Therapy, or mood-targeted pharmacotherapy such as antidepressants, in the management of pain. Vibroacoustic (VA) treatment is both a physiological and psychological approach, beneficial in pain and mood management, however the effects are generally short-term. This dissertation addresses the question of whether practitioner-led VA treatment can be used to manage the psychophysiological symptoms of chronic pain, and whether an adjunct self-care phase is helpful in prolonging the effects. *Article I*, an interview study, describes the development, current knowledge, and future directions of VA treatment; *Article II* outlines the standard protocol followed at the multidisciplinary rehabilitation unit at Seinäjoki Central Hospital for multi-symptom patients; *Article III* explores the role of music listening within VA treatment in a clinical setting; lastly, *Articles IV* and *V* investigate the relevance and effects of an adjunct self-care phase to VA treatment sessions offered at the rehabilitation unit. A layered system of outcome measures was also used in these mixed methods studies. Subjective reports were supported by quantitative scales which were further supported by the addition of exploratory physiological outcome measures. The comorbidity of pain and mood disorders was examined in addition to the impact this had on functioning and ability to work, a focal point of the rehabilitation unit featured in the work. Cumulatively, the findings from all five articles, as well as supporting literature, are the foundation upon which the proposed operational model of VA treatment with self-care is based.

Keywords: vibroacoustic treatment, chronic pain, depression, anxiety, functioning, operational model

TIIVISTELMÄ (FINNISH ABSTRACT)

Campbell, Elsa A.
Vibroakustinen- ja itsehoito kroonisen kivun hoidossa: Toimintamallin kehittäminen ja testaaminen
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Krooninen kipu – kipu, joka kestää pidempään kuin kolme kuukautta – on fysiologinen, psykologinen ja sosiaalinen ilmiö, joka vaikuttaa noin 20–33 % maailman väestöstä. Se on syynä työkyvyttömyyteen, työpoissaoloihin ja presenteismiin (sairaana töihin tuleminen) sekä niiden myötä ilmeneviin taloudellisiin seurannaisvaikutuksiin. Kroonisen kivun psykologiset vaikutukset ilmenevät yleisimmin mielialahäiriöinä, erityisesti masennuksena ja ahdistuneisuutena. Ne ovat erikseen vaikeahoitoisia subjektiivisen luonteensa vuoksi ja yhdistelmänä laaja-alaisesti alihoidettuja. Kroonisella kivulla ja mielialahäiriöillä tiedetään olevan yhteinen neurologinen perusta, joka tukee psykologisten lähestymistapojen, kuten esimerkiksi kognitiivis-behavioraalisen terapian tai farmakoterapian, kuten masennuslääkkeiden käyttöä kivun hoidossa. Vibroakustinen (VA-) hoito on fysiologinen ja psykologinen menetelmä, josta on hyötyä kivun ja mielialan hallinnassa. Hoidon vaikutukset jäävät kuitenkin yleisesti ottaen lyhytaikaisiksi. Tässä väitöstutkimuksessa selvitettiin, onko koulutetun VA-hoitajan antamaa VA-hoitomenetelmää mahdollista käyttää psykofysiologisten oireiden ja kroonisen kivun hoidossa, ja mikäli lisätty itsehoitovaihe edesauttaa vaikutusten ylläpitämistä. *Artikkeli I,* haastattelututkimus, kuvailee VA-hoidon taustaa ja kehittymistä, nykyistä tutkimustietoa, ja tulevaisuuden näkymiä; *Artikkeli II* hahmottelee nykyisen hoidon toimintamallin, joka on käytössä monioireisille potilaille Seinäjoen keskussairaalan moniammatillisessa kuntoutusyksikössä; *Artikkeli III* tutkii musiikin kuuntelun roolia VA-hoidon aikana kliinisessä tilanteessa; *Artikkelit IV* ja *V* tutkivat kuntoutusyksikössä annetun yksilöllisen VA-hoidon lisäksi käytetyn itsehoidollisen vaiheen merkitystä ja vaikutuksia. Näissä monimenetelmätutkimuksissa käytettiin useita erilaisia lopputulosmuuttujia; itsearviointien tukena oli määrällisiä asteikkoja, joiden lisäksi käytettiin myös fysiologisia mittareita. Kivun ja mielialahäiriöiden komorbiditeettiä (samanaikaisuutta) sekä niiden vaikutuksia työ- ja toimintakykyyn tutkittiin. Työ- ja toimintakyvyn edistyminen oli näiden potilaiden kuntoutuksen keskeisiä tavoitteita. Kaikki nämä viisi artikkelia, yhdessä taustakirjallisuuden kanssa, toimivat perustana esitetylle VA-hoidon ja itsehoidon yhdistävälle toimintamallille.

Avainsanat: vibroakustinen hoito, krooninen kipu, masennus, ahdistuneisuus, toimintakyky, toimintamalli

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After the graduate degree, I had a plan for remaining in Jyväskylä - and it didn't involve doing a PhD. As fate would have it, that plan was not realised and I'm so glad it wasn't. These years have been some of the most rewarding and fortunate, but also strenuous and challenging, of my life and I wouldn't change anything. I have found that doing a PhD is less about the final product and more about self-discovery. Many people have supported the work that is presented in these pages and in doing so you have individually and in many ways helped me to explore not only the topic but also myself. As a result, there are parts of all of you in the thousands of words describing the thousands of hours it took to complete this work. For your patience, support, advice, and the small acts that made a big difference, I humbly thank you.

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I carry your hearts with me,
in mine,
always.

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Elsa A. Campbell

LIST OF INCLUDED ARTICLES

I. Ala-Ruona, E., Punkanen, M., & Campbell, E. 2015. Vibroacoustic therapy: Conception, development, and future directions. Musiikkiterapia [*Finnish Journal of Music Therapy*], 30(1-2), 48-71.

II. Campbell, E. A., Hynynen, J., & Ala-Ruona, E. 2017. Vibroacoustic treatment for chronic pain and mood disorders in a specialised healthcare setting. Music and Medicine, 9(3), 187-197.

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V. Campbell, E. A., Hynynen, J., Burger, B., Vainionpää, A. & Ala-Ruona, E. Under peer review. Vibroacoustic treatment to improve functioning and ability to work: A multidisciplinary approach to chronic pain rehabilitation

Author's contribution to the articles

I. Authors EA-R and MP designed the study and conducted the interview which was the main source of data in this article. This author transcribed the audio-recorded interview, conducted the data analysis, and interpreted the results. She prepared the manuscript for publication with assistance from the co-authors.

II. The data were collected at the facility by second author and VA practitioner JH following standard procedures. This includes recording patients' experiences of VA treatment using qualitative documents in the form of clinical notes and quantitative Visual Analogue Scales. This author extracted patient data related to the project research questions, analysed the selected data and interpreted the results, and prepared the manuscript for publication with assistance from the co-authors.

III. This author designed the study, conducted the clinical work, collected the data, and carried out the data analysis and interpretation. Co-author EA-R conducted the member check interview with this author. Both co-authors supported the manuscript preparation for publication.

IV. This author designed the study, submitted the required ethical board documents with assistance from her primary supervisor, conducted the data analysis, and prepared the manuscript for publication with assistance from all co-authors.

V. This author designed the study, and prepared the required ethical board documents with assistance from both supervisors, collected and analysed the data, and prepared the manuscript for submission for peer review with assistance from the co-authors.

ABBREVIATIONS

BDI-II	Beck's Depression Inventory-II
GCT	Gate control theory (of pain)
HADS-A	Anxiety sub-scale of the Hospital Anxiety and Depression Scale
ICF	International Classification of Functioning, Disability and Health
MCID	Minimal Clinically Important Difference
NM	Neuromatrix theory (of pain)
PNS	Parasympathetic Nervous System
SNS	Sympathetic Nervous System
VA	Vibroacoustic(s)
VAS	Visual Analogue Scale
WHODAS	World Health Organization Disability Assessment Schedule

FIGURES

CONTENTS

1 INTRODUCTION

Pain is a highly individual experience situated within a ubiquitous phenomenon. It encompasses the word *feeling* in all senses of the word; a somatosensory mosaic constituting physiological, psychological, and social incursion. Living with chronic pain is complex and difficult to understand or adequately describe in relation to the categories into which it is so often placed. Rather than investigating the sensation of pain in terms of nerve stimulation, this project was concerned with what the *feeling* of pain means in an individual's daily life, exploring the use of an intervention to alleviate the effects thereof.

It is posited that chronic pain is the expression of a muted depressive state (Blumer & Heilbronn, 1982) and one's inability to cope with interpersonal stressors may augment and perpetuate the tendency to experience emotional distress in a somatic manner (Landa, Peterson, & Fallon, 2012). As humans, we have with an innate need and desire to emote, both in response to external sensory stimuli and to express ourselves (Schneck & Berger, 2005). Therefore, from this perspective the common co-occurrence of chronic pain and mood disorders (discussed in Section 2.2) could be viewed as the somatic expression of suppressed emotions. Chronic pain and comorbid mood disorders comprise more than their parts. They encapsulate loss for the suffering person; a loss of functioning, potential experiences, social interaction, one's former self. It possesses a whole person and can have dehumanising and devastating effects on the person suffering from persistent pain (Mann & Carr, 2009).

"One of the significant traits of what it means to be human is to be able to feel emotions" (Galasiński, 2004, p. 1). Music is one way in which we try to enhance or understand our emotions. In other words, "music helps us to feel more human" (Bunt, 1994, p. 2). So, if chronic pain is the manifestation of suppressed emotions, the somatic experience of that which we do not allow ourselves to feel, music could help us to be more engaged in the humanness of feeling our emotions. Music is a link to our innermost emotional, spiritual, and private selves, connecting us to those surrounding us, a telescope through which we can (re-)view ourselves on a myriad of levels (Bunt, 1994). Emotions evoked when listening to music are the unique impressions of the individual – whatev-

er is perceived by the listener is indeed what the music is expressing for that individual person, given that expression does not necessitate any correlation between what the listener perceives and what the composer or performer wished to express (Juslin, 2013). As Sloboda and O'Neill (2001) wrote, our emotions and emotional responses to music are influenced by the context in which they occur; this context includes our personal experience of pain. Our pain experience therefore can be understood indirectly through our experience of music. One's lived pain experience, and the influence various forms of music have thereon, is the theme of the work detailed in the following chapters.

The principle aim of this project was to explore how chronic pain and mood-related comorbidities may be managed using Vibroacoustic (VA) treatment – a multi-modal, music-based biopsychosocial approach. In order to comprehensively explore this approach, the prevalence, complexity, and implications of chronic pain as an experience are first outlined, discussed within the context of a biopsychosocial perspective. Following this, VA treatment is defined and contextualised in relation to the fields of music therapy and music medicine. The individual and combined elements of VA treatment are delineated, thereby establishing a rationale for applying this biopsychosocial intervention for managing chronic pain, both in a clinical setting and a multidisciplinary rehabilitation context. Five articles show the progression from the genesis of VA treatment to the addition of a self-care intervention within the rehabilitation setting, building gradually upon the intricacies and exploration of the subjective experience. The empirical studies, supported by the literature, culminate in the proposal of an operational model of VA treatment with an adjunct self-care intervention to support and promote improved physiological, psychological, and social functioning in those suffering from chronic pain.

2 THE CHRONIC PAIN EXPERIENCE

2.1 Defining and understanding pain

Pain is defined as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage" (International Association for the Study of Pain [IASP], n.d.). This definition underscores several important elements related to the pain experience. Firstly, pain is both a sensory and emotional experience. It includes an unpleasant, tactile sensation, but also highlights that the way in which one emotionally or psychologically responds to pain contributes to how one interprets the experience. Secondly, the fact that there may or may not be actual tissue damage as the genesis for the pain is articulated. One clear example of the disparity between the felt sensation and the objective possibility of feeling pain is psychologically-based phantom limb pain, the feeling of pain in a limb which no longer exists. Thirdly, the definition also notes the terminology we may use to describe this sensory and emotional experience. Due to the subjectivity associated with pain, the words and categories we use to describe it may not accurately represent our actual experiences, but are possibly useful in relaying information to healthcare professionals and/or trying to understand it on a subjective level.

Several types of pain exist, including transient, acute, and chronic (Loeser & Melzack, 1999). Transient pain refers to that which protects one from physical damage potentially incurred from one's environment, or related to procedural pain such as that felt during inoculation. Acute pain is experienced when substantial injury or harm has befallen one's tissues which activate the nociceptive transducers at the site of damage. Usually this pain is seen after trauma, surgery, and some diseases; the healing process lasts days or weeks. When pain persists past the duration of what would be considered relevant for healing, pain becomes chronic; three months is the standard cut-off point. Chronic pain is also commonly caused by injury or disease but the injury supersedes the body's ability to heal or is related to nervous system damage, preventing a return to the normal, painless state. The pain experienced from chronic pain syn-

dromes is disproportionate to the original tissue damage, but treatments provide only temporary relief. Chronic pain is not divergent from acute pain because of the duration thereof, rather by the body's inability to restore homeostasis (Loeser & Melzack, 1999). Whilst transient and acute pain may signal injury and disease, chronic pain no longer serves that purpose, and rather than being a warning signal to seek help, avoid noxious stimuli, or rest, the chronic pain itself becomes the disease (Melzack, 2001).

Chronic pain disorders such as musculoskeletal pain, common to all participants of this work, are the second-greatest contributor to impaired functioning (Bookwala, Harralson, & Parmelee, 2003), and affect approximately 20-33% of the world's population (G.B.D. Disease and Injury Incidence and Prevalence Collaborators, 2017). They are the leading cause of work disability, work absenteeism and presenteeism, as well as a loss of productivity in all European Union member states; the productivity loss is estimated to cost as much as 2% of the Gross Domestic Product (Bevan, 2015). Musculoskeletal conditions include more than 150 various diagnoses affecting the locomotor system – the muscles, bones, joints, and associated tissues. They involve both acute and sudden issues, such as fractures, as well as lifelong conditions, often typically characterised by persistent pain and related disability (WHO, 2018). Chronic pain is often accompanied by other disorders or symptoms, especially mood disorders such as depression and anxiety. (Chronic pain comorbidities are discussed in more detail in Section 2.2.)

Although Melzack and Wall's gate control theory (GCT) (1965) accounts for the influence of emotions, past experiences, and attention on pain response and perception, the neuromatrix (NM) theory further supports their role in chronic pain, especially due to the frequency of pain and mood disorder co-occurrence. Even though the NM theory was not developed to negate the concepts of the GCT, Melzack (2005) described four conclusions underpinning the development of a new conceptual nervous system based on his research of phantom limb syndrome. Firstly, we may feel sensation in a missing body part because the neural processes responsible for the perception can be activated in the absence of any bodily inputs. Secondly, because we may feel sensations in the absence of input, the genesis resides in the brain's neural networks. Thirdly, our own body is distinct from others around us and our environment. Finally, the neural processes related to the body-self are genetically in-built but modified through experiences.

The NM theory is so named because the network, which includes synaptic links which are genetically determined but also experientially developed, is termed the *neuromatrix*. "Cyclical processing and synthesis of nerve impulses" (p. 86) serves to build up an individual's unique pattern, their *neurosignature,* which is produced from the patterns in the synaptic links throughout the neuromatrix. Characteristic patterns are developed based on all input from the body; portions of the neuromatrix are also specific to processing major sensory information such as injury. The constant stream of nerve impulses is transformed into a continuously modulating awareness, converted into homeostatic

processes and potentially resulting in the experience of movement. Muscle patterns of complex actions are based on similar patterns throughout the neuromatrix which activate spinal cord neurons. The theory underscores the wholeness that is perceived through a pain experience, because the neuromatrix produces a pattern felt as a whole body. The continuous message delivered through the neuromatrix is representative of the whole body, but highlights certain details as differentiated from this whole as a function of specific input at any given time. Compared to the necessity of certain chemical activations (such as cortisol) for survival purposes, prolonged excretion is destructive through producing myopathy, fatigue, a suppressed immune system, and bone decalcification; Melzack (2005) proposed these conditions may lay the foundations for various types of chronic pain.

The NM theory supports the notion that despite the genetic basis of the neuromatrix pattern, input and experiences can modulate how pain is perceived and how one may respond to it. Stress, as a phenomenon denoting any threat to biological homeostasis as well as the psychological threat to the body-self, exerts a great deal of influence on our neurosignature. Indeed, dysregulated stress responses are also posited as the cause of disorders such as melancholic depression from increased stress system activity or chronic fatigue syndrome from decreased activity in the stress system (Chrousos & Gold, 1992). Inappropriate adaptive responses to stressors could, Chrousos and Gold posit, themselves act as stressors, prolonging and sustaining the vicious circle. This also supports the idea that chronic pain may be a somatisation of suppressed emotional distress (Blumer & Heilbronn, 1982; Landa, Peterson, & Fallon, 2012).

Therefore, this project – and the application of VA treatment to manage chronic pain – is founded on the proposed theory that learned experiences can also influence how we perceive and respond to pain. Sensory input can influence the degree to which action or behavioural responses are required to return to homeostasis. Based on the interlinked nature of pain and comorbid mood disorders, the NM theory supports the application of interventions which may allow us to reset or reprogramme our neurosignature. Disrupted homeostatic processes initiate activity on the neural, hormonal, and behavioural levels (Melzack, 2001), which are represented by the biological, psychological, and social implications of chronic pain. The complexity of our response to pain, and the exhibited behaviours as a result of the noxious input and previous pain experiences, means the NM theory is representative of the biopsychosocial perspective to pain as a means of managing it. (This is discussed further in Section 2.3.)

2.2 Comorbidities and ramifications of pain

Characteristic of chronic pain is the common occurrence of comorbid symptoms or conditions. Chronic pain predicts the onset of depression, whilst depression also significantly predicts the onset of chronic pain and other medical complaints (Tunks, Crook, & Weir, 2008). Yet, for those suffering from chronic pain,

the combination of comorbid depression and anxiety is more common than either mood disorder being individually associated with pain (Scott et al., 2007). Insomnia is another common comorbidity of chronic pain (Finan & Smith, 2013). Patients with chronic widespread pain – such as in fibromyalgia – present strong associations with other pain-related issues such as joint pain, headaches, and irritable bowel syndrome (Kato, Sullivan, Evengård, & Pedersen, 2006). Those with chronic lower back pain also have a higher instance of musculoskeletal or neuropathic pain comorbidities, in addition to the common occurrences of depression, anxiety, and sleep disorders. As a result, the number of pain-related and non-pain-related (e.g. anti-depressants) pharmacotherapy interventions prescribed are significantly greater, as well as signifying more significant healthcare costs (Gore, Sadosky, Stacey, Tai, & Leslie, 2012).

Due to the overlap in psychological and physical symptoms, chronic pain has been described as a psychophysiological phenomenon (Garland, 2012), however this is perhaps too simplistic a synopsis, given the potential genetic and learned pain-related responses proposed to be important in the NM theory (Section 2.1). Nevertheless, the common comorbidities of chronic pain and mood disorders complicates their management, as these are both fundamentally subjective experiences. The extent of the issue is also clear in relation to how pain is managed and the fact that chronic pain is also often reported by patients to be under-treated by their physician and/or pain specialist (Glajchen, 2001), even resulting in patients misusing prescribed medications or sourcing illicit substances to manage their symptoms (Levi-Minzi, Surrat, Kurtz, & Buttram, 2013).

People suffering from persistent pain and its commonly-associated comorbid symptoms/disorders face the repercussions thereof in their daily lives. The chronic pain experience exerts influence not only on the person suffering from the long-term condition, but also their working environment and social life, with economic consequences on a societal level. Chronic pain impacts patients' functioning and ability to work (Chwastiak & Von Korff, 2003). Disability was in the past defined as beginning at the point where health ended, meaning that – regardless of the cause of disability – once a disability label was assigned, no matter how seemingly insignificant, one was immediately marginalised from those classified as healthy. The International Classification for Functioning, Disability and Health (ICF) shifted the focus from a "consequences of disease" classification to one based on the "components of health", supporting the idea that a person can experience varying degrees of functioning and not be labelled as "disabled" (WHO, 2001, p. 4).

The negative pain-related emotions one may experience as a result of persistent discomfort influence how the pain is perceived – i.e. whether one feels a stimulus as mild or strong – and ensuing the behavioural processes (such as limiting activity) – in which one engages, in turn increasing the amount one suffers (Scott et al., 2007). These negative emotions manifest also in the beliefs one develops when suffering from chronic pain, such that restrictions in familiar functions or activities represent are perceived as a complete loss of function-

ing, and one's previous ability to carry out the act is now utterly lost (Ojala et al., 2015). The cycle of negative emotional responses to chronic pain (e.g. anxiety, frustration, fear) over longer periods of time, affecting one's behavioural and biological responses, repeats to cumulatively impinge upon one's emotional responses to the – at this point – much more distressing situation. This uninterrupted cycle, according to Truchon (2001), results in disability. Furthermore, the fear of pain – based on the belief that increasing activity is potentially harmful – is also related to prolonged disability in those suffering from chronic pain. However, positive changes apropos work-specific fears were shown to be more important in predicting improved ability to work than changes in pain intensity or fear of pain (Vowles & Gross, 2003). One's past experiences influence how one may be fearful of greater activity, given the difference between one's previous ability to carry out daily activities compared to one's newfound disability, leading to frustration (Ojala et al., 2015).

Emotional responses to fear are also related to one's decisions of going to work despite being ill. Presenteeism refers to the concept of employees' reduced productivity when they choose to work when ill instead of staying at home (Callen, Lindley, & Niederhauser, 2013). Some people suffering from chronic pain also make the conscious decision not to take medication because it hinders their ability to find their physical limitations and boundaries, and are thereby trying to be more conscious of the messages their bodies may be trying to relay (de Vries, Reneman, Groothoff, Geertzen, & Brouwer, 2012). Frequent severe and moderate pain is negatively associated with working and employment status, as well as absenteeism and presenteeism. Daily severe and moderate pain is furthermore associated with a reduced likelihood of being in full-time employment (Langley et al., 2010). For those who remain at work despite being in pain, motivators include themes such as feeling the need to be a useful member of society or to feel valued by others. For some, distraction from pain is also possible when working, or using work as a source of energy. Social contact is furthermore a motivator to remain in working life. In addition to these, and the financial and social responsibilities workers with chronic pain feel, personal characteristics are also a factor, such as perseverance, as well as workplace flexibility and support (de Vries et al., 2012). Interventions in the workplace are reported to be important for reducing sickness absence for those with musculoskeletal disorders (van Oostrom et al., 2009). However, in a systematic review, Carroll et al. (2010) found that only workplace interventions which included active and structured consultation between the employee, employer, and occupational health practitioners to incorporate relevant work modifications were more beneficial than standard care or exercise programmes for helping those on long-term sick leave return to work. This highlights the importance of interactive support from both the workplace and the healthcare provider in affording the patient the best possible occupational outcome.

One's acceptance of pain is also related to functioning; patients with greater acceptance reported better emotional, social, and physical functioning, less medication intake, and better working status. McCracken and Eccleston

(2005) suggested that one's pain acceptance and disregarding willingness to be active may lead to better functioning in those suffering from chronic pain. Self-reported functioning of patients with chronic pain is related to the somatic and cognitive components of depression, although Holzberg and colleagues (1996) found that subjective pain was not significantly related to self-reported functioning. Tan and others (2008) reported that pain severity directly affects pain interference, and indirectly affects disability, depression, anxiety, and anger. Additionally, depression was found to indirectly affect disability, whilst anxiety directly affected it. These outcomes suggest that people suffering from chronic pain have lower functioning when they experience increased pain interference and anxiety, with pain severity and depression as indirect factors.

One mediator in the relationship between pain, disability, and depression in those suffering from chronic pain is self-efficacy (i.e. how much one may doubt one's own capabilities). Pain intensity and self-efficacy contribute to the development of disability and depression in patients with chronic pain, however, this did not discount the impact of high pain intensity on pain-related disability and depression. One who believes that they are disabled by their pain is less functional than one who presents with higher self-efficacy (Arnstein, Caudill, Mandle, Norris, & Beasley, 1999).

Social and participatory functioning is included in the ICF classification, and understood to be an important element of one's rehabilitation. One's ability to be socially active, however, is influenced by one's biological functioning, i.e. general functioning and the extent to which one's activities are limited thereby. Further, lower social and biological functioning, from the other perspective, predict higher pain severity (Koenig et al., 2014), which implies the potentially cyclical nature of the influence of these factors on each other.

Although the chronic pain experience primarily has ramifications for the person suffering from the disorder, one's immediate family and social circles are also negatively impacted. The person suffering from chronic pain accepts their pain as reaching beyond their own boundaries, imparting severe emotional distress on their spouse/partner, and seeping into the lives of older and younger generations. The need to share and receive understanding and empathy from loved ones is also important (De Souza & Fran, 2011). Consequences of living with a person suffering from chronic pain include loss of family connections, friendships, and social interactions (e.g. through inability to attend social events resulting in fewer invitations over time), as well as changes in career prospects and emotional backlash such as (self-)blame (West, Usher, Foster, & Stewart, 2012). Despite not necessarily wishing to direct blame towards their significant other, partners of those with chronic pain partly wanted to do so because of the changes pain required in their family unit, then feeling guilty for finding the situation frustrating. Limitations in social interactions manifest also in terms of parenting and sexual relations (Strunin & Boden, 2004).

Due to the under-treatment of chronic pain, as stated earlier, and the personal and social repercussions described in the preceding sections, chronic pain is more than an individual issue. There are consequences also for the socioeco-

nomic climate through people leaving the labour market and entering long-term disability, and costs related to workplace absence and incapacity to work (Phillips, 2009). In Europe, the direct and indirect costs of chronic pain conditions account for approximately half of the total healthcare costs. Direct costs are mostly attributed to hospitalisation, whilst indirect costs are related to disability welfare and unemployment benefits. Chronic pain and associated conditions are at least as great a burden – if not greater – than conditions conventionally prioritised as public health concerns. Presenteeism, absenteeism, and early- and disability retirement are substantial contributors to the costs of chronic pain (Breivik, Eisenberg, & O'Brien, 2013). Given the all-compassing nature of chronic pain, the experience must be viewed and managed by incorporating all of its aspects; this is supported by the biopsychosocial approach to pain management.

2.3 The biopsychosocial perspective

The traditional biomedical model considering the body and mind as functioning separately has been subsumed by a more comprehensive view – the biopsychosocial model – which focuses on both disease and illness (Gatchel, 2004). Disease is defined as the objective experience of disrupted systems via anatomical, pathological, or physiological changes, whereas illness is the subjective experience or perception that a disease exists, as well as how the person with said disease and those surrounding them respond to the resultant disability. In this way, the biopsychosocial approach incorporates the biological, psychological, and social aspects of the chronic pain experience. The biopsychosocial experience is multi-faceted. The biological aspect is fundamental to pain perception in terms of neurobiology and nociception processes (nerve stimulation which leads to subjective pain perception). The psychosocial element is also multi-layered in itself, as it pertains to both emotion and cognition, the former being the more immediate reaction attached to nociception, whilst the latter is the meaning attributed to the emotional experience, potentially amplifying the experience. It is in this context that the nociception-pain-distress-disability connection lies (Gatchel, Peng, Peters, Fuchs, & Turk, 2007). Although the NM theory (Section 2.1.) presumes genetic predisposition to be one part of the whole in terms of how one processes and perceives pain, the learned responses and experiences related to pain are also a major element of one building up – and also potentially having the ability to later alter – one's neurosignature (Campbell, Clauw, & Keefe, 2003; Melzack, 2005).

The model underscores the interaction between the individual biological, psychological, and social aspects of disease and health. Due to the comorbidities and ramifications of pain, this perspective is especially relevant to improving interventions for, and understanding the subjective experiences of, those suffering from chronic pain. Chronic pain demands "considerable emotional resilience" (Turk & Monarch, 2002, p. 3), with unsuccessful, repeated attempts

to relieve pain leaving one feeling demoralised and hopeless. Interventions which support the relief of both the physical and psychological symptoms may offer respite and by extension support one's ability to increase one's social and participatory functioning. This is supported by IASP's definition of pain (see Section 2.1) as a sensory and emotional experience, as well as interventions currently widely used, including e.g. mood-targeted pharmacological interventions.

From a biopsychosocial perspective, examining the physiological processes related to pain may be helpful in understanding how it can be managed. There are two important inhibitory neuronal pathways implicated in chronic pain – norepinephrine and serotonin. These are usually active in a resting state, helping to block out irrelevant input. Pain may still be experienced in the absence of noxious stimuli if these pathways are not sufficiently inhibited; therefore, medications such as antidepressants which work on these systems to inhibit neurotransmitter release can help in managing chronic pain (Shetty & Trivedi, 2017). The pain-mood connection is also relevant for using psychological interventions for managing pain, such as Cognitive Behavioural Therapy and self-regulatory treatments; positive effects include reduced pain intensity, pain-related interference, and depression, and improved quality of life (Hoffman, Papas, Chatkoff, & Kerns, 2007). Evidence suggests, however, that multidisciplinary approaches have higher effectiveness compared to receiving only one treatment such as physiotherapy. Furthermore, strong evidence supports multidisciplinary approaches as more effective than no treatment or standard medical interventions (Scascighini, Toma, Dober-Spielmann, & Sprott, 2008). Multidisciplinary approaches incorporate both the psychological and physiological aspects of the chronic pain experience, and by extension support the biopsychosocial approach to chronic pain and comorbidity management.

In sum, pain perception is a subjective sensory experience influenced by comorbidities, functioning, self-efficacy, learned experiences, and the economic as well as personal and extended social ramifications. The intricate network, in addition to the biological underpinnings of nociception, is involved in the behavioural and emotional responses we have to the pain experience, as dictated by the NM theory (Melzack, 2005). Multidisciplinary pain management programmes may adhere to the biopsychosocial model, as a combination of, for example, pharmacological, physical (i.e. physiotherapy), and psychological (music therapy) interventions may be applied, all working towards the same goal. Furthermore, applying interventions comprised of both psychologically- and physiologically-supportive elements within a multidisciplinary model may be beneficial for pain management and increasing functioning. One example of such an intervention is Vibroacoustic (VA) treatment. Before outlining how VA treatment is used as a biopsychosocial approach within multidisciplinary care for managing chronic pain, the VA treatment method, its applications, and proposed underlying mechanisms are defined and contextualised with reference to the related fields of music therapy and music medicine.

3 MUSIC AS THERAPY OR MEDICINE

Vibroacoustic (VA) treatment is a music intervention applied to achieve a client's pre-defined therapeutic goals, such as pain relief, supported by a practitioner and the experiences afforded by the music stimuli. Its three main elements are low frequency sound vibration (20-120 Hz), the client's preferred music listening, and practitioner support (Campbell, Hynynen, & Ala-Ruona, 2017; Punkanen & Ala-Ruona, 2012). The application of low frequencies and music is also referred to in the literature as Vibroacoustic Therapy (VAT), Physioacoustic Therapy (PAT), Rhythmic Sensory Stimulation (RSS), (Campbell et al., 2017) or referred to as a vibrotactile intervention (e.g. Walters, 1996). Vibroacoustic stimuli can be delivered using various devices developed in Norway, Finland, and North America (discussed in Section 3.4), and in the present work the term *VA treatment* is used as the umbrella term to describe the process-oriented delivery of the sound vibration-music listening-therapeutic interaction triad, rather than specific devices or programme parameters used (see Ala-Ruona & Punkanen, 2017). In order to understand the fundamental principles and applications of VA treatment, the context within which it resides must be established. This context is the intersect between music therapy and music medicine. Therefore, the similarities and differences between these two areas are discussed before finally situating VA.

Music therapy is "a reflexive process wherein the therapist helps the client to optimise the client's health, using various facets of music experience and the relationships formed through them as the impetus for change" (Bruscia, 2014, para. 5). Optimising a client's health includes improving physical, social, and psychological functioning, using music to affect physiological parameters (e.g. heart rate, respiration, stress hormones), relieving pain, or reducing physiological arousal (i.e. music for relaxation) (Dileo & Bradt, 2009). Health is a multifaceted phenomenon, and helping one to make connections and support the interrelatedness of oneself is intrinsic to a music therapy process (Bruscia, 2014). The intersect between one's parts and oneself as a whole resides in taking a biopsychosocial perspective to health, as discussed in Section 2.3. Music therapy is dissimilar to other methods because of the use of music experiences as the

catalyst for change. The music experience itself comprises various features, including improvisation and music listening. These features may emphasise various sensory systems, include or exclude verbal discourse, and be combined with various other modalities. In other words, elements of music experiences can be applied to optimise physical, emotional, psychological, relational, or the spiritual facets of one's health. Although music in itself may be therapeutic, only the theoretically driven, research-based approach used to achieve predefined clinical goals through music experiences afforded by a therapist may be defined as *music therapy* (Bruscia, 2014). However, in the literature, music *therapy* is often used as a misnomer for music *medicine* (Gold, 2009).

Bradt et al. (2015) described music interventions as belonging to a continuum from patient-initiated music listening and music medicine, to music therapy, or psychotherapeutically-applied music. The authors define music medicine as pre-recorded music offered by medical personnel to support symptom management. Compared to a music therapy setting which offers the possibility to process emotional or psychological material having arisen during a session, music medicine is driven by the direct effects of the music delivered (Gold, 2009). It is therefore defined as lacking a systematic process, despite the effects thereof including the possibility to escape reality through distraction, imagery, and pleasant memories (Bradt et al., 2015). Although music medicine interventions may be goal-oriented in the fashion that symptom management is a desired outcome, the goals in a music therapy setting are negotiated within the therapeutic relationship. Music listening may also be used as an intervention within the context of a therapeutic relationship, a so-called receptive approach (Grocke & Wigram, 2007). The absence of the therapeutic relationship is therefore a main component of the difference between music therapy and music medicine, even if the motivations behind the chosen music stimulus are similarly founded.

In a clinical setting, the therapist chooses the music based on the client's needs and whether the music should enhance, reduce, or retain the client's current state. The music's innate qualities – such as tempo and structure – are factors in this choice, along with the client's music preferences (Dileo & Bradt, 2009). During a music intervention, one may express themselves and process emotions and sensations through the non-verbal medium; when a receptive intervention is used, the act of processing occurs afterwards, with the assistance of the therapist (Hüther, 2009).

An example of a possible tool and outcome of a music intervention is *entrainment*; it is based on the intrinsic physiological phenomenon of *periodicity* evidenced by, among other things, the intervallic nature of the heartbeat, and mirrored in the basic musical element *rhythm* (Schneck & Berger, 2005). Music has been shown to have an effect on our heart rate and blood pressure (Trappe & Voit, 2016), potentially related to biological entrainment with the rhythm of the music. A receptive relaxation music intervention described by Guétin and colleagues (2012) was designed to relax according to a "U" sequence, gradually reducing the musical tempo, instrumentation, frequencies, and volume in the

first arm to reach the deepest relaxation phase (the lowest point of the "U" shape), before "redynamizing" in the second arm by reversing the process. In this example, it is clear that musical elements can be altered to achieve relaxation by means of entrainment of the heartbeat to the musical tempo; music which may evoke higher emotional arousal (that with a stronger beat) is associated with higher heart rate, and more tranquilising music is associated with lower heart rate (Koelsch & Jänke, 2015).

So, a music therapist can actively manipulate musical elements to achieve clinical goals. The fundamental physiological effect music can have on us (and by extension the rationale for listening to certain music over others) theoretically applies also to music medicine interventions. However, according to Bradt and colleagues' (2015) definition of music medicine, those interventions do not afford the possibility for goal-oriented processing. Although Bradt et al. (ibid.) explain that music therapy offers the chance to process and validate one's emotions and support meaning-making, the definition of music medicine as an intervention facilitated by medical personnel is somewhat problematic. VA treatment is essentially a music intervention, but given the difficulty in delineating the exact separation between music therapy and music medicine, its position is potentially controversial.

3.1 Vibroacoustics: Music therapy or music medicine?

Interventions which are neither delivered by medical personnel nor music therapists do not belong to either category under this definition. Therefore, the question arises as to how one should denote a non-medical-personnel-afforded, goal-oriented intervention founded on research and clinical expertise. Hooper (2001) has classified VA as a music therapy intervention by exploring its characteristics according to Bruscia's definition of music therapy. Three essential criteria – a systematic intervention, the therapeutic relationship, and a music experience – are met by VA practice, supporting Hooper's argument for denoting VA as a music therapy intervention.

Firstly, VA treatment is systematic, as it is a goal-oriented, assessment- and evaluation-based intervention supporting a client's individual needs. The process of introducing a client to VA, ensuring an experience conducive to achieving the pre-defined goals, choosing the treatment programme parameters, monitoring the client's response, and being reassuring, guiding, and supportive (Grocke & Wigram, 2007) is definitive of a systematic individualised treatment. Secondly, the therapeutic relationship is afforded also through the music listening as it is a part of the therapist's interpretation of individual responses. As the therapist has an active role in creating the therapeutic space before, during, and after the low frequency sound vibration stimulus, the process is inherently an inclusive experience, enabling a therapeutic relationship. Bruscia's 2014 definition of music therapy also includes the *reflexive* nature of the process, where the therapist enables a client to *optimise their own health*, us-

ing the music experience and the therapeutic relationship. If we maintain Bunt's articulation that "music helps us to feel more human" (1994, p. 2), it is the therapeutic relationship and the reflexive process afforded by the therapist that create the boundaries within which music can help us to feel more human. Based on these principles, the therapeutic relationship within VA treatment between a practitioner and client is similar to that of a music therapy therapist-client relationship. Thirdly, music experiences include all types of experiences offered by music, through e.g. playing or listening to music. VA treatment includes two modes of music experience - music listening and the tactile perception of sound vibration. Therefore, VA treatment adheres to Bruscia's three criteria.

According to Grocke and Wigram (2007), VA therapy is a receptive music therapy approach, whereby the client has no active role in music creation or participation, and the music listening combined with pulsed sinusoidal low frequency sound vibration is the intended therapeutic agent. The facilitator is defined as a music therapist who carries out the intervention for specified clinical reasons, working towards achieving therapeutic goals. The authors reiterate that the intervention itself adheres to Bruscia's music therapy definition and may therefore be categorised as VA therapy, a form of music therapy. The qualifications of the therapist, however, are subject to scrutiny if VA is termed as a music therapy intervention.

Dileo and Bradt (2009) outlined that the four fundamental components of music therapy are (1) a credentialed music therapist; (2) an individualised process with assessment, intervention, and evaluation; (3) music-based experiences; and (4) the therapist-client relationship which develops through the music. VA afforded by a credentialed therapist as a receptive intervention within music therapy fulfils these four components.

Although VA may not necessarily be delivered by a certified music therapist, thereby not supporting Dileo and Bradt's (2009) definition, nor does it fall under Bradt and colleagues' (2015) definition of music medicine. Music medicine does not involve a systematic therapeutic process because it is experienced as pre-recorded music delivered by medical personnel. However, using music for health-related goals, but in ways that do not qualify as music therapy, is also defined as music medicine (Gold, 2009). Gold asserts that music medicine relies more on the direct effect music may induce in us, rather than the therapeutic relationship. This partly removes VA from the umbrella term of a music medicine intervention, because of the integral role the VA practitioner plays in the process. Where VA lies on the spectrum of music interventions – specifically under music medicine or music therapy – is therefore founded on whether or not there is a therapeutic relationship facilitated by a credentialed music therapist. In this sense, despite both Hooper (2001) and Grocke and Wigram (2007) characterising VA as music therapy, if the person delivering the intervention is not a music therapist, it may not be termed as such. Yet, if the practitioner is certified to deliver VA treatment (see Section 3.4), the intervention is not to be considered a music medicine approach because music medicine generally implies the intervention is afforded by medical personnel and lacks a systematic

therapeutic relationship as a result. VA treatment therefore may be more clearly defined and understood as a practitioner-supported music medicine intervention.

Unlike applications of music medicine requiring little to no therapeutic education, VA treatment can only safely be administered by a practitioner who has received adequate training in this method. Music therapists – although not working under the frame of a protected professional title in most European countries – require sufficient education, skills, informed knowledge, and professional responsibility in order to safely apply the research-based approach according to best clinical practices (Wigram, Nygaard Pedersen, & Bonde, 2002). This is true also for VA treatment. Due to the relatively high level of inter-individual responses from this treatment modality, VA treatment practitioners should undergo training (see Section 3.4) in order to safely administer low frequency sound vibration with music listening to support the client's/patient's experiences, to optimise health, and to work towards clinical goals. Those inexperienced in this practice may not have sufficient proficiency to deliver VA. Based on the early practice and development of vibroacoustics, contraindications such as muscular overuse and asthma may ensue if offered without sufficient experience.

3.2 The foundations of vibroacoustic treatment

As the context within which VA resides has been discussed, the foundations of the treatment modality will now be presented. VA is comprised of three elements; low frequencies, music listening, and practitioner-client interaction. The basis and role that each element plays are forthwith individually delineated.

3.2.1 Tactile low frequency sound vibration

Music is fundamental to VA; music is sound, and sound waves manifest in two forms of energy: sound and mechanical (Gunther, 2012). The elements constituting mechanical and sound energy are fundamentally the same, but the frequencies in the mechanical form are lower in range than those heard in the sound energy range. Sound energy relates to that which is perceived primarily through the ear, whereas mechanical energy relates to that which is perceived primarily through taction (tactile perception). In this way, music perception is a combination of both the auditory and tactile experience (Schneck & Berger, 2005). The concepts of sound and mechanical energy are essential to our understanding of the elements comprising VA treatment.

The specific mechanical energy used in VA is sinusoidal waves or pure tones. These are oscillations at a single frequency, the simplest form of sound vibration (Parker, 2009). Hertz (Hz) is used to denote the number of oscillations per second, such that 20 Hz refers to 20 oscillations per second, i.e. the number of wave crests that pass a certain point in a second. In VA treatment, frequen-

cies oscillating between 20-120 Hz are most commonly used. Amplitude refers to the duration of time from silence to the designated crest of a frequency, i.e. the distance to the peak of the frequency crest from silence. In an analogy of plucking a violin string, the amplitude refers to how far the string may be plucked. In VA treatment, the *pulsation* or *cycle* refers to the speed of the amplitude change, the duration from silence to the designated peak volume (in decibels). The loudness – or *strength* in VA terms, is also associated with amplitude; the greater the amplitude, the louder the sound, and the greater the energy. Because intensity of the sound decreases in the medium through which it is travelling, the distance from the sound source (e.g. loudspeaker) dictates how the receptor (e.g. ear) responds to the vibration. The further from the source, the lower the intensity of the vibration which meets the body. In this way, because VA deals with the direct application of mechanical waves to the body, rather than focusing only on the auditory pathway, the intensity of the sound is greater (Ala-Ruona, Punkanen, & Campbell, 2015; Schneck & Berger, 2005; Wigram, 1996).

The rationale for applying a particular mechanical wave to the body is based on the concept of *sympathetic resonance*. Forms of energy vibrate at frequencies that govern how they are perceived (Schneck & Berger, 2005). So, energy that is mechanical will be perceived in a tactile manner, whereas that which is in the higher range of human hearing will be perceived primarily through the auditory system. The specific frequencies to which a system responds – its *resonant frequency* (Griffin, 2004) – are determined by the natural resonant frequency of that system, depending on, for example, the composition, size, state of muscle tension, and posture relative to vibrational direction. The natural resonant frequency of the chest wall, for instance, is 60 Hz, whereas the trunk naturally resonates at 3–7 Hz (Schneck & Berger, 2005). When acute resonators answering to different frequencies, such as individual organs, are coupled, they form a heterogeneous body; it is possible for this body to enter resonance with a frequency band which encompasses all of the acute resonators, thereafter named a wide resonator. An example of a wide resonator is the human body. Non-specific application of frequencies to entrain body structures with their resonant frequency may happen along the whole spectrum of the frequency band pertaining to this wide resonator (our bodies) (Fernandez, 1997). Therefore, if the natural frequency range of our bodies is from 4–14 Hz (Schneck & Berger, 2005), any frequency within that range could be applied to induce resonance.

Bartel, Chen, Alain, and Ross (2017) posited that, because stimulation at "one frequency also produces a resonant stimulant response at mathematical multiples" (p. 157), VA stimulation could be targeted towards specific tissues based on multiples of the natural frequency. Therefore, our wide resonator frequencies ranging from 4-14 Hz could be targeted by applying the mathematical multiples thereof which fall within the low frequency range used in VA treatment. Wigram (1996) showed that localised sensation is experienced when specific frequencies are applied. As mentioned earlier, 60 Hz is the resonant fre-

quency of the chest (Schneck & Berger, 2005); when applied to the body, it is typically felt in the thoracic area (chest). Wigram (1996) discovered that 40 Hz is felt consistently in the legs, calves, and thigh areas, and, as the frequencies move up through 50, 60, and 70 Hz, the sensation is consistently experienced higher up the body. This supports the idea of sympathetic resonance, such that if a specific frequency (60 Hz) is applied to a wide receptor (i.e. the body) comprising a multitude of natural frequencies for each acute resonator (e.g. muscle), only regions that resonate with this applied frequency (e.g. chest) will respond. VA acknowledges the physical effects of sound elicited from mechanical waves (Hooper, 2001) and applies this knowledge to achieve pre-defined clinical goals from their direct application to the body.

3.2.2 The role of music listening in vibroacoustic treatment

As presented at the beginning of this chapter, the theoretical underpinnings of music-related responses, which inform its use to achieve clinical goals, are similar for both music therapy and music medicine and thus by extension VA treatment. Music interventions have been shown to be effective in relieving both psychological and physical symptoms such as depression (Luebner & Hinterberger, 2017) with comorbid anxiety (Aalbers et al., 2017; Jasemi, Aazami, & Zabihi, 2016; Lai, Li, & Lee, 2012), pain (Tamplin & Clark, 2016), and anxiety (Nilsson, 2008), affecting vital signs (Liu & Petrini, 2015), regulating emotions (Lonsdale & North, 2011), reducing analgesic intake (Guétin et al., 2012; Lee, 2016), and increasing energy and lifting one's spirits (Gold & Clare, 2012). If music listening is employed in VA treatment, the specific choice must be clearly founded. A client's perception of their preferred music is based on past experiences (Gunther, 2012) and the ability to evoke images and memories (Grocke & Wigram, 2007). This capability could be used to influence the way one perceives pain, and is thus one rationale for the use of music within VA treatment processes. As Bradt et al. (2015) reported, listening to music can be a way for patients to escape their current reality, but familiar music may also be used as a way to ease the client into a unique and unfamiliar treatment context (Ala-Ruona, 1999). The potential of (preferred) music to elicit images and memories is also a counter-argument for its use – one might want to distract a client by either playing unfamiliar music to the client or asking them to focus more on the sensations perceived through taction. Music listening can therefore play several roles in VA treatment, simultaneously acting as a link between the client and the outside world, but also serving as a means to become more comfortable with the treatment environment (Ala-Ruona, ibid.). If music listening is not employed, the periodicity of the tactile stimulus (discussed at the beginning of this chapter) may be used as a point of focus for rhythmic entrainment.

The mechanical waves perceived through taction follow the "almost universally accepted principle of sound and music, namely that exposure to soft, low frequency and non-rhythmic music – 'sedative' music for short – results in physiological responses indicative of relaxation" (Hooper, 2001, p. 69). Therefore, despite the knowledge that slower, repetitive music with predictable

dynamics, consonant harmonics – referred to as "anxiolytic music" (Spintge & Droh, 1987) – can have physiological effects on us, the personal connotations we attribute to our preferred music are also relevant (Gunther, 2012). Numerous functions are attributed to our preferred music, such as the ability to improve our mood, to become energised, to feel nostalgia, and to perceive one's own thoughts and emotions more keenly (Schäfer & Sedlmeier, 2009). Schäfer and Sedlmeier also found that attributing the function of one's preferred music to qualitatively-depicted factors (i.e. that electronic music makes one feel more energetic) is problematic, given that participants in their study who preferred electronic music partly found it helped them to "chill and to reminisce" (p. 290). This supports the idea that the music potentially chosen to accompany the tactile stimulation of VA treatment could be client-preferred, rather than solely research-based, and support the therapeutic goals pre-defined by the client and practitioner. (This is exemplified in the music choices such as metal of patients receiving VA treatment at Seinäjoki Central Hospital, described in Articles II, IV, and V.)

3.2.3 Practitioner-client interaction

As in music therapy practice, the therapeutic alliance is important in the VA treatment context, as the practitioner's role is partly to facilitate the client's processing of the potentially-arising sensations, memories, and emotions elicited from the combined auditory and tactile music (Grocke & Wigram, 2007). Because the practitioner plays an important role in tailoring the treatment programme to the client's needs, and the preferred music is chosen based on preference and clinical goals, the practitioner should support the client's experiences of these applied interventions. In the same way that examining the dynamics of a music therapy process is an examination of how a client experiences, interacts with, and understands music (Bruscia, 2014), the practitioner's role in VA treatment is to facilitate a client's meaning-making related to the combined low frequency and music listening experience (Campbell et al., 2017; Grocke & Wigram, 2007; Hynynen, Aralinna, Räty, & Ala-Ruona, 2017).

Due to the multi-layered nature of VA treatment, capable of supporting health optimisation on a physiological, social, and psychological level, it can be viewed from the biopsychosocial perspective (as discussed in Section 2.3). Each arm of the stimulation – tactile and auditory – can be individually adapted and developed to suit the needs of the client and work towards achieving the therapeutic goals of the process.

3.3 Proposed underlying mechanisms of vibroacoustic treatment

Several hypotheses related to the underlying mechanisms of VA treatment exist. One relates to the relaxation response (Benson & Klipper, 1975). The relationship between our natural resonant frequencies and the sound vibration fre-

quencies in VA treatment are posited as the driving force for eliciting a sense of relaxation, one of the most commonly-reported outcomes of the treatment method (Punkanen & Ala-Ruona, 2012). Music listening has also been reported as predicting an increase in participants' sense of control over pain, especially when the music was positive in valence and when applied for either activation or relaxation purposes (Linnemann et al., 2015). Individually, the low frequency vibration and music listening can be altered based on the clinical goals; slower pulsation relaxes and faster pulsation activates, and the elements of the music listening element can be tailored to these needs also. The combination of VA treatment and music listening can therefore be used to either activate or relax a client (Punkanen & Ala-Ruona, 2012).

Another hypothesis is connected to the frequency range used in the Music Vibration Table described by Chesky and Michel (1991). They propose that Pacinian corpuscles, related to the neuronal inhibition of pain and responsive to pressure, could account for pain relief when frequencies which activate said corpuscles (above 60 Hz) are applied in a tactile manner. Based on the gate control theory (GCT) of pain (see Section 2.1), stimulation of large-diameter afferent fibres to modulate nociceptive processing using transcutaneously-applied vibration raises experimental pain thresholds; for chronic conditions, the application of vibration within the Pacinian corpuscles' sensitivity range close to the painful area is most effective (Chesky, Russel, Lopez, & Kondraske, 1997). Lim and co-authors (2018) also posited that applying vibration between 16-160 Hz to the hands and feet, which contain many cutaneous mechanoreceptors, inhibited nerve impulses sent to the brain resulting in improved pain and functioning outcomes in patients with chronic shoulder or back pain.

The effect of vibration on the brain has been discussed in relation to the Jindrak postulate (Jindrak & Jindrak, 1986, cited in Skille & Wigram, 1995), and in relation to thalamocortical dysregulation (Bartel, Chen, Alain, & Ross, 2017). Cellular cleansing is linked to the absence of a lymphatic system in the brain. Applying vibration is proposed to have a cleaning effect on the brain; as VA treatment is whole-body stimulation, cellular cleansing is hypothesised to occur on a grander scale, rather than simply in the brain. The aggregated effect on the whole body based on the Jindrak postulate is also loosely related to the aggregate outcomes of the body resonating with mathematical multiples of applied frequencies, as discussed by Bartel et al. (2017). Bartel and colleagues put forth that brain-related interventions for regulating thalamocortical functioning, such as deep brain stimulation, support the use of VA treatment as a comparative, non-invasive intervention. In the case of chronic pain, a connection to thalamocortical oscillatory dysrhythmia – linked to conditions including Parkinson's disease and neurogenic pain – has been shown. Thalamocortical loops function optimally at around 10 Hz in the alpha band, and around 40 Hz in the gamma band. Therefore, applying 40 Hz may act as a driving force to reset the dysrhythmia, especially important if 40 Hz dysregulation contributes to the development and maintenance of chronic pain (Bartel et al., 2017; Llinás, 2003).

Despite the uncertainty related to the underlying mechanisms of VA treatment, safe and ethical practice is nonetheless warranted.

3.4 Practicing vibroacoustic treatment: Certification training and devices

Sufficient training and knowledge are required in order to safely deliver VA treatment. Currently, the only comprehensive training offered worldwide to this author's knowledge is that offered by the Vibrac Skille-Lehikoinen Centre for Vibroacoustic Therapy and Research, administered by the Eino Roiha Foundation in Jyväskylä, Finland. National and international training is offered on three levels; an introduction to the method and research (Level I); practitioner certification (Level II), and advanced training in two streams: supervisors' and trainers' training, and psychotherapeutically-oriented vibroacoustics (Level III). After Level II, comprised of multiple contact-teaching meetings with several modules, assignments, and internships, one is certified to practice vibroacoustics. The training outlines the various ways in which VA can be safely administered, suitable evaluation and assessment methods based on target groups and therapeutic goals, and application regulation based on the previous (clinical) experience of the intern/trainee practitioner. Lectures, demonstrations, and clinical work under supervision are the teaching methods employed. The training allows interns to become familiar with the safest means of applying this treatment based on clinical evidence and current research, in order to be sufficiently equipped to deal with individual treatment responses, and capable of tailoring the treatment programmes and the music listening choices to most effectively achieve the treatment goals (Ala-Ruona, Punkanen, & Campbell, 2015).

Participants of the training are also introduced to a selection of devices which may be used in VA treatment practice. Many devices have been designed to deliver low frequency stimulation, including the Next Wave Physioacoustic chair and Flexound products such as Taikofon and Humu from Finland, Multivib devices from Norway, Somatron, Sound Oasis, and the Music Vibration Table from the USA. These devices, in the form of recliner chairs, mattresses, cushions, and hand-held/portable devices, vary in the means by which the frequencies can be played. For example, in the Physioacoustic system, the recliner chair is computer-controlled and treatment programmes are pre-programmed using software such as PhysAc Pro or Sonus Health. For others, such as Multivib or Flexound products, the treatment programmes can be played using software such as VibLab or one can play one's preferred music through the loudspeakers.

The Next Wave Physioacoustic chair used in the practitioner-led phases of this project (Figure 1, p. 37) contains six speakers located in the neck, back, thigh, and calf areas which produce audible and tactile sound vibration controlled by computer software. The frequency range is from 27-113 Hz. The ther-

apist or practitioner can use pre-designed treatment programmes installed in the computer software used to play stimuli through the speakers. These programmes are either activating or relaxing, and the various parameters in the various speakers can be individually altered to suit the client's particular needs (Next Wave Physioacoustic PRO chair, 2013).

There are several parameters in the Physioacoustic system. These include *time, scan, speed, cycle* or *pulsation, strength,* and *action* or *direction.* Treatment programmes are divided into several phases, usually lasting two-three minutes each; this refers to the *time* parameter. During each phase, the programme *scans* around the designated fundamental frequency within that phase; if the fundamental frequency is 40 Hz, the programme can be set to scan from e.g. 39–41 Hz. *Speed* refers to how fast the frequencies change whilst scanning. *Cycle* is the volume change from silence to the set maximum. A longer cycle can be useful for eliciting a relaxation response, whilst shorter cycles can be useful for activating the client. The *strength* can be programmed for each individual speaker. *Action* or *direction* dictates whether the sound moves from head to toe, toe to head, or remains constant. All treatment programme parameters can be tailored to suit a client's specific needs in terms of, for example, targeted areas of the body or strength and direction of the stimulus. Trained practitioners or therapists can also create their own treatment programmes using the computer software. The Physioacoustic chair is designated as low-risk and non-invasive and approved by the Food and Drug Administration (FDA) in the USA, the Canadian Standards Association (CSA), and the British Standards Institution (BDI), permitting claims of pain and stress relief, muscle relaxation, and benefits for blood and lymphatic circulation.

The Taikofon FeelSound Player used in the self-care phases of this project (Figure 2, p. 37) is a cushion which contains a loudspeaker through which music or sound vibration can be played using either the AUX jack or Bluetooth. The frequency range is from 20-20,000 Hz. Taikofon's design enables one to play any audio content (e.g. radio, Spotify, TV, audiobooks) through a smartphone, tablet, MP3 player, or other audio equipment (Instructions for use [Taikofon manual], n.d.). The treatment programme parameters depend on the input, i.e. music or sound vibration. When programmes such as VibLab are used to create and play low frequency sound vibration treatment programmes, parameters like those in the Physioacoustic system can be customised to suit a client's needs. The parameters in VibLab are named *frequency, volume, rise time, hold, decay, scan, speed,* and *duration. Rise time, hold,* and *decay* – as equivalents to creating a cycle in the Physioacoustic system – can be individually adjusted to create the most optimal *pulsation* or *cycle* of each phase or step (VibLab guides [manual], 2019). The volume of the intensity can be adjusted with the device used to play the stimulus.

FIGURE 1. Physioacoustic recliner chair used in practitioner-led sessions. Dimensions 184cm long, 78.5cm wide, 120cm high. Reproduced with kind permission from Next Wave Ltd.

FIGURE 2. Taikofon FeelSound Player used in self-care sessions. Dimensions: 48cm long, 12 cm wide, 35cm high. Reproduced with kind permission from Flexound Systems Oy.

3.5 Vibroacoustic treatment: A biopsychosocial intervention

To summarise, VA treatment is characterised by three elements: low frequency mechanical sound vibration between 20–120 Hz, music listening based on the clinical goals (client-preferred music for eliciting memories and images, unfamiliar music possibly as distraction, or no music at all), and the therapeutic alliance between practitioner and client. Together, these elements are employed systematically to achieve outcomes such as pain relief, as research and clinical experience have shown VA treatment can be beneficial for both physiological and psychological outcomes. Based on the NM theory (Section 2.1), the underlying mechanisms of pain perception are based on both genetic factors and past experiences. Given music's potential to engage us in memory and meaning-making processes (discussed in Section 3.1), this project is founded on the potential of music listening experiences afforded by a trained practitioner for altering our *neurosignature* (see Section 2.1), ultimately influencing our behavioural and social processes. The biopsychosocial model highlights the intricacies related to the chronic pain experience, and interventions – especially those adhering to a multidisciplinary approach – are reported to be the most beneficial for managing chronic pain. The following chapter discusses VA treatment within a multidisciplinary rehabilitation unit at Seinäjoki Central Hospital in South Ostrobothnia, Finland. This unit adheres to the biopsychosocial model and works towards improving functioning and occupational health, and was the context in which the main body of this research project was conducted.

4 VIBROACOUSTIC TREATMENT IN CONTEXT

The empirical studies of this project examined VA treatment within two contexts; a clinical setting and a multidisciplinary rehabilitation setting. Both applications adhere to the biopsychosocial approach (Section 2.3), as they (1) address the psychological and physiological symptoms associated with the chronic pain experience, and (2) as a principle aim of this unit is occupational rehabilitation, the social ramifications of pain are addressed in improving patients' ability to return to work. The clinical setting explored in Article III details how an individual responds to this treatment modality, whilst the rehabilitation setting (Articles II, IV, and V) explored how an individual may respond to VA as one treatment within a coordinated multidisciplinary process. Although there may be differences in the possibilities afforded in a clinical setting (e.g. longer sessions and process, possibilities for more time-consuming outcomes assessment), the fundamental principles of VA treatment which drive the clinical process are equally as valid in a rehabilitation context. For this reason, only the rehabilitation setting is discussed here in detail.

4.1 Multidisciplinary rehabilitation

The multidisciplinary rehabilitation unit featured in this project is located in the South Ostrobothnia healthcare district of Finland, in the municipality of Seinäjoki. VA treatment, offered by a certified VA treatment practitioner (see Section 3.4), falls under Conservative Management at Seinäjoki Central Hospital. Other therapies offered there include physiotherapy, occupational therapy, speech therapy, neuropsychological rehabilitation, active music therapy, and standard pharmacotherapy (Etelä-Pohjanmaan sairaanhoitopiiri, n.d.). This is the only location worldwide in which a VA treatment practitioner is employed full time, serving almost 100 patients each year (approximately 870-940 visits) (Hynynen at al., 2017). This specialised healthcare unit was also the location of a development project exploring the use of VA treatment for

patients with multiple symptoms including pain, depression, and anxiety, the most common pain disorders being fibromyalgia and neck-shoulder-related (musculoskeletal) issues. Positive effects were noted on a physical, psychological, and social level (Ala-Ruona, 1999). The project, from the planning to reporting stages, took place between 1995-1999. The continued existance of a full-time VA treatment practitioner is a result of this early seminal work and this current project is therefore a continuation and augmentation of the development project.

Multidisciplinary treatment, as defined by Marin et al. (2017), is treatment that targets physical as well as psychological or social aspects, involving a team of healthcare professionals with varied professional backgrounds. The multidisciplinary team at Seinäjoki rehabilitation unit fulfils such criteria in that they operate according to the biopsychosocial perspective offering both physiologically- and psychologically-directed treatments in various configurations but aiming for the same goal(s). Each configuration of treatments or therapies offered in the unit is individually tailored to meet the client's needs and may involve combinations such as physiotherapy followed by VA treatment. VA treatment has been shown to be beneficial for reducing spasticity (Rüütel, Vinkel, & Eelmäe, 217) and physiotherapy outcomes are greater when supplemented with VA treatment (Burke & Thomas, 1997). This knowledge, and keenly documented clinical experience, has informed the treatment practices at the unit (Campbell et al., 2017).

Within this team, the VA treatment itself is also a biopsychosocial multidisciplinary approach, because it provides individually-tailored psychologically- and physiologically-oriented treatments, with the primary clinical goal being improved quality of (working) life through comprehensively addressing symptoms such as chronic pain and mood disorders.

4.2 Vibroacoustic treatment as a multidisciplinary biopsychosocial approach

VA treatment in a rehabilitation setting (as well as a clinical setting) is based on the interaction between a practitioner and their client. The tools utilised by the practitioner are the combination of low frequency sound vibration and client-preferred music. Chesky and Michel (1996) termed VA as a "two-pronged" approach because it utilises the inherent qualities of each form of music (affective experiences through sound waves/music listening and physiological sensations with low frequency vibration/mechanical waves) to achieve therapeutic goals (Hooper, 2002). Although the biopsychosocial principle is accepted within the rehabilitation unit, the interaction between the client and practitioner is missing from Chesky and Michel's (ibid.) description. This is an essential element in VA treatment, as the practitioner's role in helping the client to process their experiences and carry over the effects into the client's daily life is important for the

long-term goals of the treatment. The social aspect of the biopsychosocial approach is therefore addressed in the combined music and vibration effects in addition to practitioner-client interaction. The transfer of session effects to daily life is supported in the client listening to the same music at home as in the sessions to reinforce and potentially re-experience the relaxation response at home (cf. Hynynen et al., [2017] for a full description of the treatment protocol at this unit) or creating a bridge between the client and the outside world by listening to familiar music during a session (Ala-Ruona, 1999). Figure 3 shows the biopsychosocial approach, within which the three-armed, biopsychosocially-oriented VA treatment method is nestled, addressing each element of the chronic pain experience.

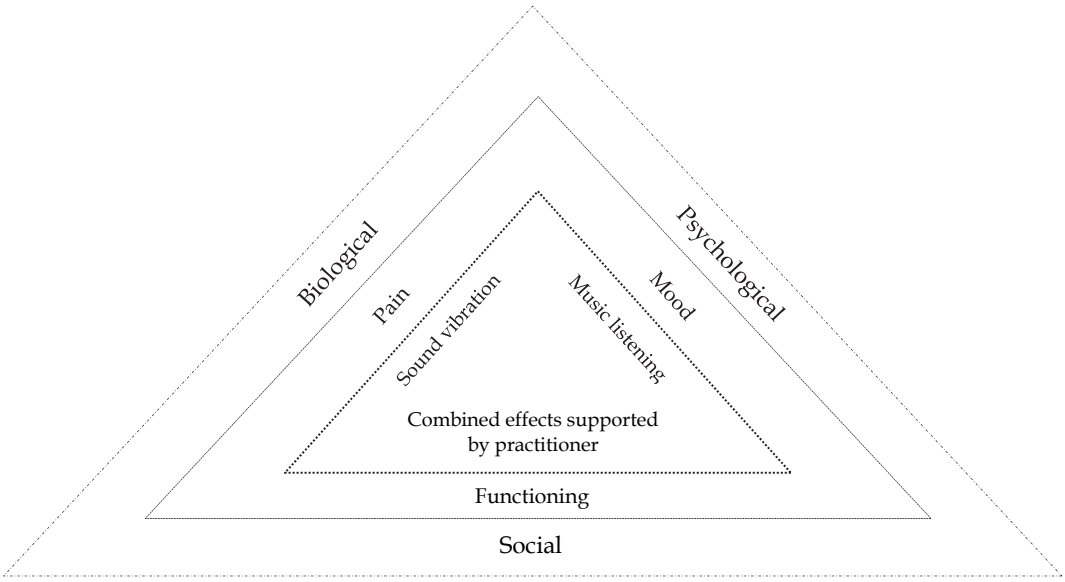

FIGURE 3. The biopsychosocial perspective of the multidisciplinary unit, with VA treatment as a biopsychosocial approach situated within this framework.

VA treatment addresses the three elements of the biopsychosocial approach; additionally, it is nestled within the biopsychosocial approach adhered to at the rehabilitation unit. Multidisciplinary rehabilitation, compared to standard, mono-modular approaches to pain management such as physiotherapy alone, have been shown to achieve significant pain relief, improve physical and perceived functioning, relieve emotional distress, increase pain acceptance and coping, and decrease the use of maladaptive coping strategies (Gagnon, Scholten, & Atchison, 2008; McCormick et al., 2015). Strategies for symptom management which include a coordinated approach such as that at Seinäjoki's rehabilitation unit, in which healthcare professionals of various training backgrounds discuss and provide a coordinated programme to best suit an individual client, are also the most cost-effective (Gatchel, McGeary, McGeary, & Lippe, 2014).

Given the combined low frequency sound vibration (focusing on the physiological experience of pain), music listening (effective for pain, depression, and anxiety relief), and practitioner support (for ensuring processing of the evoked experiences for optimising health and achieving clinical goals), the rationale for applying VA treatment as a biopsychosocial approach to managing the chronic pain experience is supported.

4.3 Augmenting vibroacoustic treatment outcomes with self-care

The disadvantage of VA treatment offered through the rehabilitation unit is that it is constrained by long waiting lists. Although a patient may receive 10 sessions, with the duration of effects increasing as the process continues (Articles IV and V), patients may often have to return for a second phase of treatments (Article II), as symptoms can return when the treatment ends (Articles IV and V), and the combination of physiological and psychological issues in these patients can be difficult to manage (Campbell et al., 2017; Hynynen et al., 2017). Given the dependence of patients on availability to receive VA treatment, a self-care intervention was added to the protocol (explored in Articles IV and V). Self-care, as an "essential human regulatory function" (Orem, 1985, p. 33), is ingrained in one's daily activities and to be viewed, therefore, as integral to successful rehabilitation. Especially when an illness is chronic, affecting not only the patient but also their social environment (see Section 2.2), symptom self-management empowers patients (McCorkle et al., 2011). Self-care also supports an individualised approach to healthcare, as a patient may be best suited to assessing that which is personally helpful or important. Furthermore, self-care may enhance patients' self-efficacy and perceived control over their own health. Indeed, healthcare providers are of the opinion that self-care is actually the first step in managing pain (Kovačević et al., 2018). Reported outcomes of self-care interventions include pain, depression, and anxiety relief (Mehlsen, Heegaard, & Frostholm, 2015; Reid et al., 2008), increased perception of control (Ruelman et al., 2012), and improvement in mental health and quality of life (Miaskowski et al., 2004). Managing one's own symptoms helps to alleviate feelings of impaired functioning, experiencing one's own body as a hindrance, struggling to understand one's illness, and dealing with feelings of loneliness in one's suffering (Öhman, Söderberg, & Lundman, 2003). Therefore, adding a self-care intervention to standard VA treatment protocol at Seinäjoki Central Hospital was based on self-care's ability to improve both physiological and psychological symptoms, and hypothesised to prolong positive outcomes and reduce the need for second VA treatment phases at the hospital. In this manner, the self-care element reinforces the biopsychosocial approach taken at this unit; this is represented in Figure 4, showing the role of self-care as a supportive addition to the biopsychosocial approach (cf. Articles IV and V for the empirical studies examining this addition to the protocol.

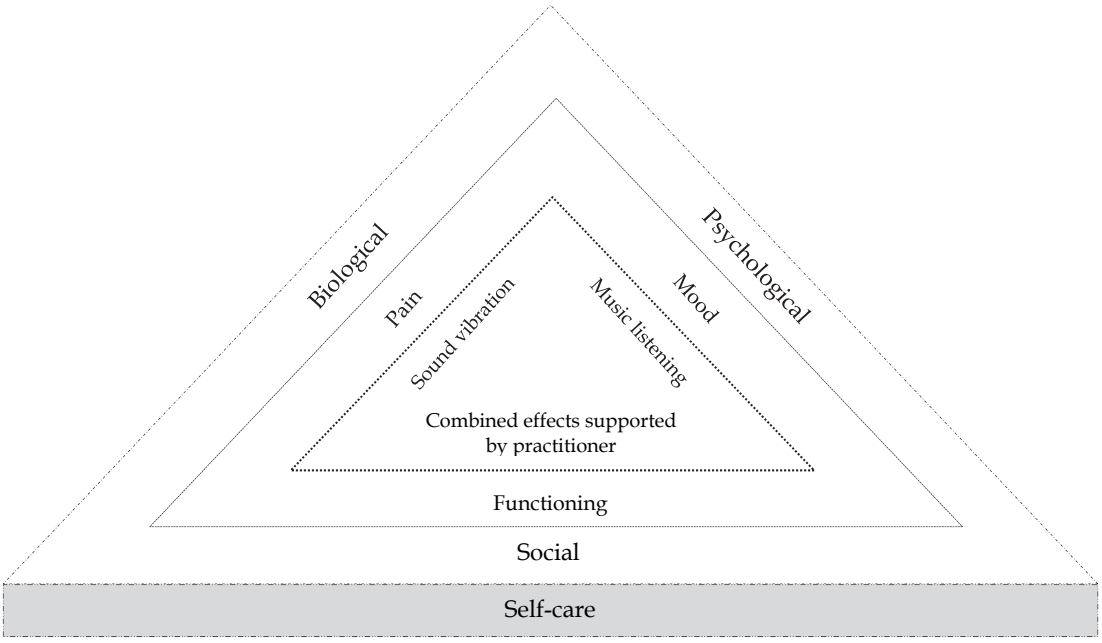

FIGURE 4. The biopsychosocial approach supported by the addition of self-care to the standard VA treatment protocol.

Despite the ambiguity related to how VA treatment may work (as discussed in Section 3.3), the theoretical underpinnings of this project rest on (1) the multi-faceted experience of chronic pain as a biological, psychological, and social phenomenon, (2) the relationship between affective and physiological aspects of pain (e.g. the pain-depression dyad, Goldenberg, 2010) and its potential to manage pain by affecting mood and vice versa, and (3) the potential to alter one's neurosignature within one's neuromatrix to ultimately influence one's behavioural and affective responses to pain (see Section 2.1). The research tools and evaluation methods used to explore VA treatment as a multidisciplinary biopsychosocial approach phase are presented in the next chapter, including justification for their implementation.

5 OVERVIEW OF THE ARTICLES

This chapter summarises each article according to the background and aims, applied tools and methods, and reported results and findings. Justification for the chosen research methods is provided and the relevance of each article to the overall objectives of the work is delineated.

5.1 Article I: Interview of a vibroacoustics expert

This qualitative study presented the conception of vibroacoustics situated within the context of current research and discussed potential future directions thereof. Although the concept of using sound vibration for therapeutic outcomes is not a new one, the mechanisms underlying the treatment are unknown as the knowledge in this area has been mostly from case studies or anecdotal in nature.

An interview of Olav Skille, a pioneer in the field, conducted by Esa Ala-Ruona and Marko Punkanen, two executors of VA research and training in Finland, was transcribed from an audio recording and analysed by this author, and the themes that emerged from the qualitative content analysis were presented and discussed. The objectives of the interview were to document Skille's process and also – as a pioneer of VA – to record his views, musings, and observations for posterity's sake. A second objective of this interview was to chronicle how the history of VA lead to the development and future directions of the field. The knowledge gained in discussing the genesis of VA influenced and augmented how future researchers and practitioners of VA could engage in this discourse. The interview, in this way, served as both an active and passive means of preserving and furthering knowledge, from the predecessor (Skille) to the successors (co-authors of the article).

Interviews are a means by which we gain insight into that which we cannot gain or know otherwise (Forsey, 2012). Asking questions of those more knowledgeable about a topic is a core ability of humans, with conversation as a long-established method of gaining this knowledge (Brinkmann, 2014). Brink-

mann argues that despite the perception of qualitative research as being too subjective, the qualitative interview could be the most accurate method of inquiry given the conversational underpinnings of our societies and methods of interacting, because interviews are uniquely capable of comprehending features of human experience, talk, and interaction. The structure of the interview in Article I could be described as an inverted version of the "two-person interview" described by Brinkmann (2014); in this case there were two interviewers and one interviewee rather than the usual one interviewer and two interviewees. As interviews are the exchange of views, despite their conversational and interactional foundations, qualitative interviews are conducted with a specific goal in mind – to gain and produce knowledge based on that which is offered by the interviewee(s).

The interview reported here was unstructured in the sense that there were no pre-defined questions; however, the structure was pre-defined to an extent by the goal of the interview. Olav Skille, as one of the Nordic pioneers of VA, is a primary data source. Beginning with how it developed and the underlying concepts upon which the treatment method is built, he gave the interviewers insight into his [Skille's] own views of important areas of further development. Having been aware of Skille's seminal role, the interviewers were conscious of the interview's importance for capturing his history and experiences of events leading up to the moment of the interview. In this way, Brinkmann (2014) highlights that, in defining the structure of an interview, nonleading questions do not exist – given that an interview has specific goals, and all questions lead the interviewee in certain directions - although one may discuss themes rather than offering specific opinions related thereto. Based on the interviewers' preconceptions of topics possibly arising during the interview / conversation, one could more constructively regard the differentiation between structured and non-structured interviews as resting on a spectrum with the more accurate definition and practice lying approximately in the middle thereof (semi-structured). Therefore, the interview – although unstructured in the traditional sense – could more accurately be described as semi-structured, given the interviewers' prior knowledge and the inherent preconceived ideas one generally has as an interviewer.

5.1.1 Transcription as a translation and interpretation of data

An important step in relaying the gained knowledge from the interview to a wider audience is the process of transcription. There are no standard rules for how one may uniformly transcribe an interview (Kvale, 2007); this depends on the research questions. Although the knowledge gained during an interview may be considered an exchange of information, the interviewer's context and research objectives may confound the interpretation. Transcribing is a matter of translation from one medium to another. The oral speech recorded in a conversation is translated to written format; this inherently gives rise to issues. This translation process is interpretative in nature, as the transcriber makes decisions as to what information is relevant to the research at hand, and the kind of knowledge that could be the most veraciously relayed (ibid.).

The interview was conducted by article co-authors EA-R and MP, and the audio recording thereof was used for transcription purposes by this author. A recording involves an "abstraction from the lived bodily presence of the conversing persons, with a loss of body language as posture and gestures. […] Transcripts are impoverished decontextualized renderings of interview conversations" (Kvale, 2007, para. 4). Thus, already at this point, a layer of the data was peeled away; with this audio-only data source, visual data of gestures and the general contextual information were not available to this author. The interpretation process of transcribing the interview may be seen both from the data-loss point of view but possibly also from a validity-gain perspective. As this author was not involved in the data collection, rather only in transcription, analysis, and interpretation of the audio-recording, one could argue the interpretation was candid and based on the research objectives rather than on the potential subterfuge behind which the "truth" may be hidden when the line between the conversational interviewer and engaged interviewee is ambiguous.

The transcript and consequent interpretation were based solely on the information relayed in the interaction rather than on auxiliary data sources such as gestures. Although the opinions of the interviewee are clear, these are contextualised by research related to vibroacoustics. Hence, this author attempted to balance the interpretative with the historically accurate, rather than emphasising the interviewee's (re-)interpretation of the narrative surrounding the development of VA. Skille's focus on events or moments which he considers pivotal in VA development are highly relevant, but contextualising his perceptions in the research output supported his sentiments. As the transcripts decontextualised the interview (Kvale, 2007), supporting this decontextualised material in empirical evidence could be argued as a means of re-contextualising the knowledge gained.

5.1.2 Qualitative content analysis

Qualitative content analysis was used to analyse the transcribed interview. Content analysis allows the researcher to condense words into categories sharing similar content (Elo & Kyngäs, 2008), but is more a research strategy than a single method of text analysis (Titscher, Meyer, Wodak, & Vetter, 2000). The "analysis [was] concerned only with the lexicon of the text" (ibid. p. 66), rather than including latent content such as gestures. The analysis process in qualitative content analysis may follow an inductive or deductive approach but is based on the research question. In this case, as the interview was constructed around the concepts of the past, present, and future of vibroacoustics from an expert's first-hand experience, an inductive approach was taken because the aim was to gain new knowledge of this experience rather than confirm theories or hypotheses.

The three main phases of qualitative content analysis are preparation, organising, and reporting. Only manifest content was analysed, as the interpretation of possible latent meaning, as residing in the gestures and facial expressions of the interviewee, were not available through the audio recording. By only focusing on the manifest content, the aim was to remain as close to the research aims as possible. This phase, in addition to choosing the unit of analysis

(in this case the whole interview), also comprises making sense of the data by reading the transcript several times. This author then engaged in open coding, creating categories, and abstraction. During open coding, when the text was being read repeatedly, notes and tentative categories were written on the transcript margins. The categories were freely created during this process and then gathered into similar or dissimilar groupings to condense the data even further. Abstraction then included formulating a description of the research aims and topic through the categories. As the two co-authors (EA-R and MP) were the interviewers, the discussions between them and this author surrounding the appropriateness and validity of the analysis and interpretation resembled member check interviews (discussed further in Section 5.3.2), examining whether this author's interpretation of the interview material resembled the co-authors' experiences thereof in the interview situation.

5.1.3 Results and their relevance

The importance of 40 Hz was described and denoted as the fundamental frequency, as it is most beneficial for eliciting a relaxation response through the massage-like sensation. The relaxation response induced during VA treatment, based on both clinical experiences and empirical research, is grounded in the concept of sympathetic resonance. When a certain frequency is applied, those muscles or tissues normally resonating at that particular frequency will respond. Further, the higher the frequency, the smaller the muscle which responds. Explanations of how vibroacoustic therapy may work were elaborated upon, and future areas of research – such as the effects of low frequencies on the autonomic nervous system – are proposed. The lack of a clear picture of how VA actually works points towards physiological measures such as heart rate variability being used to assess effectiveness of the treatment rather than relying only on subjective reports such as Visual Analogue Scales (VAS). The importance of training for safe application was also discussed; based on Skille's early work, some contraindications are known, but future research should also focus on this. Multidisciplinary, collaborative applications of VA were proposed as important for affording the best care possible, especially as VA treatment has been shown to elicit both physiological and psychological responses. This article laid the foundation for the model development work that followed. Here, in an interview with one of the pioneers in this field, the history, development, and applications of VA were discussed. From this, the proposed future directions of research and clinical practice could be outlined.

5.2 Article II: Presenting the multidisciplinary rehabilitation context

This article presented the application of VA treatment within a multidisciplinary context, focusing on its use for chronic pain and comorbid mood disorders. Mus-

culoskeletal pain is one of the most common antecedents to disability in the EU, leading to significant healthcare and social costs. Based on the previous multifaceted applications of VA treatment in various settings, its use within a naturalistic multidisciplinary rehabilitation setting was examined by describing typical procedures.

The Next Wave Physioacoustic chair (Figure 1, p. 37) described in this article is the standard device used at this multidisciplinary rehabilitation unit discussed in Section 3.4. The treatment programmes used are based on clinical experiences and development work described in Article I. Furthermore, the practitioner may alter or update treatment programmes based on the client's specific needs. The treatment programme presented in this article was an extended version of a pre-installed programme entitled *general relaxation* in the Physioacoustic system. Th fundamental frequencies in this treatment programme range from 29–61 Hz, with a focal point of 40 Hz. With the scanning parameter, however, the frequencies ranged from 27–72 Hz. As per standard practice at this unit, treatment programmes including other frequencies rather than a single frequency are used as patients often have several comorbid issues. Based on the principle that higher frequencies target smaller muscles (as discussed in Article I) and the concept of sympathetic resonance (Section 3.3), treatment programmes including 40 Hz and other frequencies may increase overall relaxation whilst also targeting specific areas of the body.

As the aim of this article was to outline standard VA treatment protocol at the multidisciplinary rehabilitation unit, the specific merits of the treatment programmes were not explored, nor were those of the Physioacoustic chair. Yet, based on more than two decades of clinical experience at this facility, and the proposed underlying mechanisms supporting the use of various frequencies in this treatment modality, the effectiveness of the general procedure could be explored.

Patients' responses to VA treatment (either in one or two treatment phases) were explored with VASs for pain and mood, the practitioner's clinical observations, and patients' comments and evaluations. VASs are routinely used to track outcomes and to report to the senior physician on the outcomes of interventions such as VA treatment at the multidisciplinary rehabilitation unit of Seinäjoki Central Hospital introduced in this article. Standard outcomes that are measured are pain, mood, relaxation, limb temperature, quality of sleep, mobility, general wellbeing, vitality/energy level, and quality of life. Measurements are taken at the beginning and end of a VA treatment process and – in addition to the practitioner's notes – form the practitioner's clinical evaluation that is sent to the senior physician. These subjective reports of change are one of the most common modes of outcome assessment used, as a patient's experiences (patient reported outcomes) are more relevant to clinical change and perceived treatment effectiveness than a practitioner's/doctor's evaluation. Patient reported outcomes are considered one of the most important representations of treatment effectiveness evaluations and changes in disease progression (Revicki, Hays, Cella, & Sloan, 2008). In this article, VAS outcomes for pain, mood, and relaxation were extracted. Initial-

ly, pain and mood were discussed, however in the course of analysis, it transpired that their ability to relax – or not – influenced their pain perception.

As reported by Chiarotto and colleagues (2018), how individuals assess their pain is influenced by factors which vary considerably between patients. Examples of this are the idea that scales may not be able to assess pain in a meaningful way, that pain measurement is affected by other factors such as medication intake, pain intensity is rated with a higher preference for the middle of the scale, and that patients may make comparisons with recent pain experiences as a reference point. Some feel that implying they have no pain or conversely the worst possible pain according to the extremes of a scale would be inappropriate as they always experience some degree of pain and the other extreme of the spectrum implies that they are completely unable to cope with the intensity.

The evaluation points at the beginning and end of a VA treatment process are a way of assessing how much – if any – change has occurred. Recall bias may be avoided if patients assess their symptoms at the time of evaluation, rather than reflecting on their state during the preceding week. Several factors such as social/work situation and history affect how one perceives their pain, and their experiences also differ within a time-period. Haefeli and Elfering (2006) explicated that, because pain perception varies over time, studies have mentioned that pain assessment should represent their "usual pain" rather than current pain at the evaluation point. This is consistent with the idea that pain perception may be skewed if pain is perceived as especially strong on assessment day whilst the previous weeks have been relatively pain-free. In this instance, the effectiveness of a given intervention is not reflected in patients' VAS outcomes alone. Indeed, pain perception in several studies was shown to be overestimated on more painful days and underestimated on days with lower pain (Haefeli & Elfering, 2006).

5.2.1 Supporting subjective reports with clinical documents

Supporting potentially ambiguous or misleading subjective reports (VAS) with, for example, a practitioner's clinical notes, offers credence to the overall evaluation of an intervention's effectiveness. Pain, and the comorbidities which so often accompany and define one's chronic pain experience, is a complex issue which is reflected in the growing number of multi-faceted approaches to investigation. The priority of health research to develop novel methodologies for improving data quality and scientific power indicates that interdisciplinary teams and various perspectives to clinical research are being met with greater acknowledgement (Klassen et al., 2012). Once a patient has been referred for a treatment, in this case VA treatment, the responsibility to improve symptoms and perception of illness lies with both the practitioner and the patient themselves. The practitioner, in the role of caregiver and facilitator, has the tools to help the client work towards an improved health state. This role includes the responsibility to the rest of the multidisciplinary team to report progress during the designated treatment period in the form of clinical documentation. This documentation records "observations, impressions, plans and other activities arising from episodes of patient care" (Rosenbloom et al., 2010, p. 233).

As VA treatment is an individualised, one-on-one treatment modality, the practitioner's observations were proposed as a means of augmenting the context in which VAS outcomes were viewed. The clinical notes recorded at this facility include comments on experiences or sensations that patients relay to the practitioner. In this sense, the clinical documentation possesses a certain duality; they include the practitioner's objective observations of how a client may respond to the treatment (e.g. falling asleep during the treatment, being visibly less tense, having improved range of movement after the stimulation) as well as the patient's subjective comments. Adding this type of secondary data sources could serve to strengthen the presentation of intervention effectiveness; this may be especially important in the reasonably young field of VA. The relatively high variability in individual treatment response is foundation for investigating the feasibility of larger, randomised trials to assess intervention efficacy (Barlow et al., 2002). The clinical documentation routinely recorded at Seinäjoki Central Hospital is, in this sense, a useful tool in authentically portraying how patients with chronic pain respond to this treatment modality, providing a more detailed narrative of effectiveness, especially during the episodes between assessment points.

5.2.2 Results and their relevance

When analysing the data for this article, the disparity between patients' subjective reports and their verbal reports recorded in the clinical documents became clear, as the verbal reports did not systematically support the patients VAS outcomes. As a result, the pain and mood VAS outcomes were relatively difficult to interpret. Patients who appeared to exhibit only marginal pain and mood relief from the sessions reported vast improvements in relaxation. Relaxation is a commonly reported outcome of VA treatment. The verbal reports from patients also seemed to contradict the VAS outcomes; although pain, mood, and relaxation remained relatively unchanged for one patient, she verbally reported that she felt much better afterwards, especially on both the treatment day and the day following. Another confounding issue was the individual variation across patients, even when having similar diagnoses. Patients reported improved sleep, reduced analgesic intake, and relaxation. The VAS outcomes – despite showing improvement for monophasic patients – are only one aspect of a patient's treatment responses. The exploration of their verbal reports to the practitioner were important for elucidating whether patients responded well to the treatment or not; the incongruent responses in the quantitative and qualitative data represent the complexity of the pain experience. The relaxation response often reported as an effect of VA treatment may help to reset one's learned, dysfunctional pain processing associated with chronic pain; as stress is described as an agent of pain chronicity and related to individual differences in pain perception, counteracting the stress response may be valuable in resetting one's learned pain responses.

This article outlined the influence of the reported relaxation response on patients' overall experience of VA treatment. The results also highlight the in-

dividual differences across patients treated at this rehabilitation unit as well as their incongruent VAS and verbal reports. Patients may have the possibility to return for a second phase of VA treatment after several months, and the pre-treatment scores of the second phase suggest that the effects do not appear to last long after a process has ended. The importance of randomised controlled trials in discussing the efficacy of an intervention is recognised, however, the importance of individuals' experiences – given the subjective nature of both pain and mood disorders – is also to be recognised. This paper highlighted elements of the rehabilitation process – longevity of treatment effects and multi-faceted individual treatment responses – that are explored further in the empirical research reported in Articles IV and V.

The first article gave an overview of VA development and the future directions of clinical work and research practices. The interviewers and interviewee highlighted the importance of accurately representing treatment effects, working towards implementing more objective physiological measures such as heart rate variability, and outlining how there may be incongruencies between subjective reports such as VASs and patients' verbal reports to the practitioner. Therefore, the knowledge gained from the interview reported in Article I about individual patient responses supported the addition of clinical documentation in Article II as a way to avoid misrepresenting patients' individual experiences of VA treatment. This was seen as a step towards expanding upon patients' subjective evaluations and reinforcing the evidence, and comprehensively presenting patient experiences of VA treatment situated within the multidisciplinary rehabilitation context.

5.3 Article III: A mixed methods single case study in a clinical setting

Due to the biological overlap between chronic pain and mood symptoms, and the relief felt through one positively influencing the other (see Section 2.2), chronic pain is often managed with approaches known to relieve depression and anxiety (such as Cognitive Behavioural Therapy or pharmacological mood stabilisers). As VA treatment is considered a practitioner-supported "two-pronged approach" targeting both physiological and psychological symptoms, this article argued for using this method for managing the chronic pain experience. Despite this dual-purpose application, the individual influence of each element of VA treatment – low frequency vibration, music listening, and practitioner support – for managing comorbid pain and anxiety are unknown. The aim of this mixed methods, single case experimental design study was to assess the effect of music listening within this triad for relieving both pain intensity and anxiety. This was explored by alternating sessions including music listening (VA-Music) with the low frequency vibration sessions without music listening (VA-Silence).

The same treatment programme (*general relaxation*) described in Article II was used in this study, also delivered using the Physioacoustic chair (Figure 1, p. 37). The frequency range was the same (29-61 Hz, 27-72 Hz with the scanning parameter setting, focusing on 40 Hz) but the duration was the standard length of this pre-installed programme (20 rather than 37 minutes). The same treatment programme was used throughout the whole process, meaning the sound vibration stimulus was consistent throughout. This programme was chosen based on the previously discussed rationale of blending 40 Hz as the basic focal point of a treatment programme with other frequencies targeting other areas of the body. As the client suffered from pain in specific areas such as the neck/shoulders, higher frequencies within the *general relaxation* treatment programme were deemed suitable. Further, this treatment programme was repeated so as to create a bridge between the procedures in the multidisciplinary rehabilitation unit in Article II and the clinical setting presented in Article III.

Interpretative Phenomenological Analysis was used to analyse the session transcriptions and VASs assessed pain, mood, anxiety, and relaxation. This study delved deeper into how qualitative documents can support the exploration of a quantitatively-recorded experience. The difficulty in accurately representing one's subjective experiences in numeric format (Chiarotto et al., 2018) is seen clearly within a clinical context. In a sense, translating the subjective experience to a more objective frame proved to be somewhat difficult because interpreting the meaning units related to positive – or negative – change is challenging for factors such as pain. The solution to this issue was to apply a standardised metric used to determine the smallest change that would be regarded as clinically relevant: the minimal clinically important difference (MCID) (Dworkin et al., 2008). Contextualising the scores was conducted by using interpretation cut-off points (Jensen, Chen, & Brugger, 2003). Combined, these indices allowed for gauging the severity of, e.g. pain, before and after the VA treatment, but also to judge whether the magnitude of change was clinically meaningful. It has been argued that applying the MCID – an approach based on comparison with patients' global ratings – is not relevant to the patient's perception of what is meaningful change, as it is the practitioner or investigator who assigns the chosen rating for satisfactory improvements within an individual's specific context (Beaton et al., 2001). Based on this, ten Klooster, Drossaers-Bakker, Taal, and van de Laar (2006) proposed that patient-perceived satisfactory improvement (PPSI) would be a more meaningful improvement indicant for individual outcomes assessment. Whilst this may be the case, this author feels that the quantitative outcomes could be considered as valuable estimates of [pain] perception. The MCID and PPSI are based on meaning units of change for individuals. In an individual clinical setting, the MCID can nonetheless be helpful in estimating the client's condition, then utilising the therapeutic interaction as a way to explore the indicators from the quantitative results in more detail. The MCID outlines the smallest change score that would likely be important either from a patient's or practitioner's perspective (Chiarotto et al., 2018); this change is hence not definitive but in its application here it served an

important purpose in guiding and supporting the qualitative data interpretation.

Investigating treatment response to an intervention is relevant for chronic pain, as the experience is influenced by several circumstances and is inherently an individual experience. In addition to this, the importance of an individual's treatment response, given their history/experiences, biological, social, psychological, and economic factors, is of importance in a clinical setting rather than the treatment response of a particular group of individuals sharing the same diagnosis. Single case experimental designs are particularly well suited to examining psychological and behavioural intervention outcomes (Smith, 2012). The reversal single case experimental design was chosen for this clinical setting. It is denoted commonly as an ABAB design, and involves repeatedly introducing and withdrawing the independent variable. This study's aim was to investigate the influence of music listening within the VA treatment triad of low frequency sound vibration, music listening, and practitioner support, and so during every second session the music listening portion was withdrawn, whilst all other variables remained the same. In this way, the effect of the music listening could be addressed.

In the issue of outcome measures, VAS reports related to experimental pain have shown that more severe pain is rated more consistently than moderate pain. Although the reason for this is unclear, Quiton and Greenspan (2008) suggested it could be due to the concept of the severe end of a VAS being more easily understood than the mild/no pain portion. Further, the authors posited that the strong correlation between across- and within-subject variation at low, moderate, and severe pain levels suggests that variability in VAS pain outcomes is intrinsically characteristic of the individual rating their own pain. Due to this within-person variability, the use of other sources of evidence (such as diaries or session transcriptions) would be important to support the interpretation of the variable VAS outcomes.

5.3.1 Interpretative Phenomenological Analysis

The qualitative documents used to support the VAS outcomes for this study consisted of transcripts of the practitioner-client session discussions before and after the VA treatment programme. The therapeutic process afforded by the practitioner supports processing of images, sensations, memories, and/or emotions which may arise during a session (Grocke & Wigram, 2007), phenomena which envelop a therapeutic process. Interpretative Phenomenological Analysis (IPA) was therefore used to analyse these transcripts. IPA considers and examines one's "personal lived experience, the meaning of experience to participants and how participants make sense of that experience" (Smith, 2011, p. 9). As pain and comorbid symptoms are an individual experience, the meaning one assigns to these symptoms and how they impact one's life is consequently an individual experience.

Complicating the analysis process is that a researcher analyses another person's experiences; in this way, it requires the researcher's engagement and

interpretation. Smith describes the researcher's interpretation of a participant's experiences whilst the participant attempts to make sense of their own experiences as a "double hermeneutic" (p. 10). There were several layers of interpretation ongoing throughout the therapeutic process in Article III; these layers were based on the multiple roles that both this author and the client filled. Firstly, this author was engaged in active interpretation of the client's experience during the sessions in the role of practitioner, and then revisiting these experiences later during the analysis and member check (see Section 5.3.2) stages as a researcher. The client was also participating on two levels, the first as client, the second as re-interpreter of her own experience during the member check interview conducted after the analysis was completed. These four layers of hermeneutics interacted throughout the whole process. The interpretation of the VAS outcomes therefore was a means to ground the interpretation of phenomenological experiences and guide the analysis process from an overall perspective as well as from a within-session perspective. When the qualitative and quantitative data were integrated as part of the mixed methods process, the quantitative outcomes were used to compare the effects within a VA treatment session as well as compare the overall similarities or differences visible in the music and non-music sessions. The qualitative findings were then used to explore her experiences of receiving VA treatment for the first time and the meaning she attributed to that experience, and investigate how she made sense of her own therapeutic process.

5.3.2 Validity check

The validity of the multi-layered hermeneutic interpretation procedure and outcomes were evaluated using a member check interview. The process includes the participant being provided relevant sections of a report and asked to comment on the accuracy, with a focus on their experiences, emotions, and thoughts, potentially also being asked to comment on the analysis. It may also be a way to equalise the relationship power dynamics between the researcher and participant, being a reflexive process for both parties. After a relatively substantial period of time has passed between data collection and member check interview, the participant may find it difficult to identify with the person they previously were. Rather than finding the report an inaccurate representation of themselves, the participant may find the interview illuminates how they have changed during that time (Koelsch, 2013). The IPA method supported this experiential discussion, and the member check was viewed in the present study as an elongation of the therapeutic and interpretative process.

5.3.3 Results and their relevance

VAS outcomes showed that VA-Music sessions were beneficial for pain, mood, anxiety, and relaxation. Although some improvement was reported in the VA-silence sessions, clinically important differences were seen for pain, anxiety, and relaxation only in the music sessions. Themes which emerged from the

qualitative analysis revealed that the client was trapped by her anxiety, yearned for control, and was undergoing a change in her self-reflection. The themes were interrelated such that she sought control because she felt trapped by her anxiety, and she began to see changes by using music as a different way of taking control. Initially in the treatment process, music served as a distraction from anxious thoughts. During the process, whether or not there was music listening became an important element for the participant as she made the conscious decision to listen to music during a planned VA-silence session. This marked a pivotal point in her using music listening as a means to listen to and act upon her own needs, and to self-regulate her anxiety.

This study delved into the role that music listening plays in managing chronic pain and anxiety in a clinical VA treatment session and process. Individual variance across symptoms and treatment responses is a consideration in any intervention, but the exploration of this issue as a single case shows that even within only ten sessions one's responses to the same treatment programme and the same music can vary markedly from one session to the next. This study opened the discussion further on how the music listening aspect of VA treatment may be used to enhance the relaxation response.

This article built upon three concerns that arose in Article II. Firstly, VAS outcomes were used in Article II to assess change after VA treatment. The interpretation of these changes was difficult, given the individual response variation, but the practitioner's clinical documents and the patient's comments supported the interpretation process. The use of the MCID and interpretation cut-off points applied to ground VAS interpretation in Article II was maintained in Article III, this time measuring the change scores from pre- and post-treatment.

Secondly, as the practitioner's clinical notes of participants' experiences is an indirect experience evaluation, a more substantial foundation for interpreting the session transcripts from Article III was needed. To solve this issue, the member check interview was used as a measure of validity. The importance of the member check interview was such that it afforded the participant the possibility to re-examine the therapeutic process and how she had changed in the time since the end of the treatment process. The dual roles played by both this author (as practitioner and researcher) and the participant (as client and experience re-interpreter) were integrated in the member check interview. These roles were also important as a means of exploring individual treatment responses often reported at the multidisciplinary rehabilitation unit introduced in Article II.

Thirdly, a single case experimental design was chosen to more closely examine the effect of music listening in VA sessions using an experimental design relevant for psychological interventions. This approach was deemed appropriate in this case because a VA treatment session in general may not necessarily always include music listening. This design allowed for assessing the client's response to both conditions, showing the between-session and within-session effects. Isolating the music listening was important for justifying its importance within VA treatment, exploring its role potentially ascribed by individual cli-

ents. This element therefore remained a part of the treatment protocol examined in Articles IV and V.

5.4 Article IV: Introducing self-care to multidisciplinary rehabilitation

The biopsychosocial model dictates that pain is a biological, psychological, and social issue. Given the interaction between these three elements in relation to pain intensity, using these connections advantageously, such as in multidisciplinary rehabilitation, may be beneficial for relieving symptoms associated with the chronic pain experience. Applying VA treatment, which works on both biological and psychological levels, may elevate mood and relieve pain in a dualistic and bi-directional manner. Healthcare providers believe self-care is the first step to pain management, with effects seen also for mood regulation, increased perceived control, and improved quality of life. This study explored participants' individual responses to the treatment conditions within multidisciplinary rehabilitation. Article IV reported on an empirical study carried out at Seinäjoki Central Hospital, implanted into a naturalistic setting. Compared to Article II which reported outcomes recorded following standard practices at this rehabilitation unit, Article IV reported on studies designed to build upon these previously established protocols.

Article IV introduced the concept of self-care to VA treatment. The design of this study was such that participants received eight bi-weekly VA treatments at the hospital followed by self-care sessions conducted by the participants themselves at their homes five times per week. After both of these conditions ended, participants continued to record outcomes during a washout period with no treatments. The self-care phase was added to hospital sessions to explore how long the positive effects of VA could be continued with treatments of less intensity but more frequent application. The washout period (a phase without treatments) was used to investigate the duration of the treatment effect after stimulus cessation.

The frequency programme used in the practitioner-led sessions was again the 37-minute *general relaxation* treatment programme from the Physioacoustic system presented in Article II. It was standardised across all participants to enable comparison, however the strength of the stimulus overall and according to each speaker in the Physioacoustic chair was adjusted according to each participant's needs. The overall strength of the programme was systematically reduced at the beginning of the practitioner-led phase and increased as treatment process continued and the participants became accustomed to the sensation. The same parameters (cf. Articles II and III) were applied in this case.

The self-care phase introduced in this study differed from the practitioner-led phase in that only 40 Hz (with cycles/pulsations lasting approximately 7 seconds) was delivered. The same principle of 40 Hz being the fundamental

frequency for eliciting a relaxation response was applied. As the aim was not to compare the effectiveness of the practitioner-led sessions to the self-care sessions or the contents of the treatment programmes per se, rather to explore the overall procedure, a simplified treatment programme with only one frequency was chosen for the self-care phase. An additional rationale for only using one frequency was that participants would be applying the stimulus to themselves without the direct guidance of the practitioner.

5.4.1 Mixed methods for multiple cases

As a mixed methods approach was considered appropriate for the previous study, this was repeated in Article IV. VASs for pain and mood were again utilised before and after each treatment within each session. Depression and anxiety were also self-assessed by participants using Beck's Depression Inventory (II) and the anxiety subscale of the Hospital Anxiety and Depression Scale respectively, but these were measured only at the beginning and end of each treatment phase. MCID and interpretation guidelines are also available for BDI-II and HADS-A, so these were integrated into the quantitative data analysis procedures.

This article used two qualitative data sources: the practitioner's clinical notes and the participants' evaluations of the protocol in an evaluation form. Qualitative content analysis (discussed in Section 5.1.2) was again applied following an inductive approach, mirroring the process reported in Article I but using the participants' experiences as a way to reinforce and validate the practitioner's observations. Relaying participants' experiences in the form of patient reported outcomes was an important element in the protocol development, as their perception of the feasibility and applicability of an added self-care phase was essential. As such, the participants' evaluations added another interpretative layer to the standard outcome assessment procedures conducted at this facility. The knowledge gained from the experiences reported in Article II informed the development of this protocol and the data collection methods used, as the emphasis gradually shifted to more systematically including patients' subjective treatment responses for assessing intervention effectiveness.

5.4.2 Results and their relevance

Participants reported pain relief, increased range of movement and relaxation, less stiffness and stress, as well as improved quality of sleep, a sense of empowerment, and remission of panic attacks. Improved energy levels were also noticed, as well as not needing to take analgesics during either treatment phase. The effects of self-care were reported as weaker than those of the VA treatments at the hospital; this was to be expected given the size difference in the devices. However, the benefits of self-care were noticed during the washout period, because symptoms returned during this time. Individual variation was high among participants, which supported the findings from Articles I and II. Results also indicated that the encouragement from the practitioner after the hos-

pital sessions end may be important for ensuring patients continue with self-care practice.

An important aspect explored further in this article was the relevance of the relaxation response in achieving the therapeutically-afforded, pre-defined clinical goals of VA treatment and the added self-care intervention. As initially proposed in Article II, the interpretation of individual treatment responses was supported by the exploration of how relaxation impacted patients' perception of pain, depression, and anxiety. It was suggested that relaxation may be an essential element in alleviating the symptoms of the chronic pain experience, given the incongruent reports between patients' pain evaluations (VAS) and their verbal reports of feeling relaxed after VA treatment sessions. This outcome was further discussed in Article IV, proposing the relaxation response as a potential precursor to pain relief, but that the effects may actually be mediated by the severity of a patient's mood disorder. For example, Participant 1 of Article IV was suffering from major depression, and reported weaker effects from VA treatment than those who did not have a clinical diagnosis for depression. In this way, the severity of one's mood disorder may inhibit the ability to experience greater relaxation as reported by others.

This study was integral to the model development, as self-care is one of the core elements thereof. The results indicate that the additional self-care phase – conducted immediately after the practitioner-led sessions at the hospital – may be beneficial for prolonging the effects of an intensive VA treatment process. As those with chronic illness report considerable usage of healthcare services, increasing patients' control over their own symptoms is desirable. Patients who receive VA treatment offered at Seinäjoki Central Hospital report symptom reduction, but the longevity of these treatment effects is short-lived – as seen in Article II. The self-care sessions helped to protract and maintain the symptom relief for participants of the study.

Three components from the single case experimental design study reported in Article III and standard procedures reported in Article II were developed in this study; (1) a more comprehensive tracking of quantitative outcomes, (2) reinforced qualitative findings with the addition of the participants' evaluations; and (3) aiming to prolong the treatment outcomes from VA sessions. Item (1) was addressed by asking participants to complete pre- and post-treatment VASs for both the hospital and self-care sessions, as well as during the washout period when the treatments had ended. In this way, their progress could be tracked within both phases as well as within individual sessions. Showing the magnitude of change within sessions was of interest, especially since the published research on this treatment modality is relatively sparse. Item (2) was addressed by participants completing evaluation forms of the overall process; this supplemented their VAS outcomes and gave an overview of their individual impressions of the protocol. As seen in Article II, the treatment effects – evidenced by patients returning for second treatment periods at the hospital – did not last particularly long. Item (3) was therefore addressed by adding a self-care phase to the standard treatment protocol. Given that passive coping strategies –

giving responsibility to others for pain management or allowing the pain to adversely affect other areas of one's life - have been shown to be a strong risk factor in the development of disabling pain (Mercado, Carroll, Cassidy, & Côté, 2005), another function of self-care was to increase proactive health behaviours and engage patients more keenly in their rehabilitation.

5.5 Article V: Establishing the role of self-care in multidisciplinary rehabilitation

This manuscript dealt with VA treatment and an additional self-care phase to improve functioning and ability to work as important aspects of the chronic pain experience, and was therefore a further exploration of self-care's role in the multidisciplinary rehabilitation context. This article shifted focus slightly to how the chronic pain experience impacted patients' lives, viewing chronic pain from a more comprehensive and integrated perspective of its influence on one's daily activities. Musculoskeletal pain conditions are prevalent worldwide and are the second-most common contributor to disability. Low functioning and comorbid mood disorders are also connected to increased disability and work absenteeism. Experiences of four single cases with musculoskeletal pain were presented based on a mixed methods approach of quantitative questionnaires/scales, qualitative reports from participant diaries, and exploratory physiological measures. The self-care phase in this study took place after a washout period in which participants had no treatments, i.e., the self-care did not occur directly after the hospital sessions, as reported in Article IV. This altered protocol aimed to explore the duration of treatment effect from both conditions. As each treatment condition was followed by a phase without treatments, each participant served as their own control.

Article V built upon similar concepts to those of Article IV. The protocol was amended to include a washout period directly after the practitioner-led VA treatments at Seinäjoki Central Hospital because Article IV only addressed the cumulative effects of both practitioner-led VA treatments and participants' self-care sessions at home. The self-care phase in Article V therefore began after the first washout period. Participants in Article IV compared the effectiveness of the self-care device to the Next Wave Physioacoustic chair used at the rehabilitation unit. This – although not an aim of the previous protocol – was an issue, because the effectiveness of the self-care phase itself was not as closely considered as a result. The first washout period after the practitioner-led sessions therefore aimed to dispel or reduce the potential for comparison.

The practitioner-led sessions reported in Article IV were rather strictly controlled, such that all participants received the same VA treatment programme, but the volume/intensity thereof was adjusted for each participant and increased throughout the eight sessions as participants became accustomed to the sensation. In Article V, the practitioner conducted ten sessions according

to his standard approach, altering the frequencies and treatment programmes used throughout the phase according to the participant's individual needs. In this way, the effectiveness of the treatment could be assessed on how the participant responded to their individually-tailored VA sessions within the naturalistic paradigm. The treatment programme parameters from the practitioner-led sessions were the same as in Articles II, III, and IV, but the treatment programmes and the range of frequencies within each programme were this time individualised to each participant. Regardless of the specific programme, they were delivered at reduced intensity at the beginning of each participant's process, building up the vibration strength over time. As the process continued, the practitioner developed and augmented the treatment programmes, frequencies, and intensity based on the participants responses to the stimulus.

During the practitioner-led sessions, participants began with a Physioacoustic treatment programme entitled *insomnia.* This programme ranges from 31–42 Hz (28–48 Hz with the scanning function, averaging at 38 Hz). The strength is mild and therefore suitable as a programme with which to begin a VA treatment process. After the clients became accustomed to the sensation, Physioacoustic system programmes such as *leg cramp, general relaxation,* and *intensive shoulder massage* or a customised version of their combination were delivered. As their names suggest, *leg cramp* focuses on the lower half of the body, whilst *intensive shoulder massage* has greater intensity in the neck area. The former ranges from 27–50 Hz (with scanning, 27–58 Hz, averaging at 43 Hz), with the strongest intensity in the thigh and calf speakers. The latter ranges from 40–86 Hz (with scanning 39–93 Hz, averaging at 66 Hz), with the greatest strength in the neck area and lower intensity in the legs. The programme delivered was based on the client's individual needs rather than focusing only on eliciting a general relaxation response. Treatment programmes targeting specific areas of the body (e.g.) neck tend to focus on higher frequencies in the 20–120 Hz range based on the principles of sympathetic resonance discussed in Section 3.3, and in this case, the *intensive shoulder massage* programme targets smaller muscles resonating with frequencies around 60 Hz (Section 3.2.1).

The first washout period then served to explore how long the treatment effects lasted and to try and avoid a direct comparison between participants' experiences of the Next Wave Physioacoustic chair used in the practitioner-led sessions and the Taikofon device used for self-care.

The self-care phase for this study was also amended. Instead of conducting five sessions per week for one month, participants conducted self-care four times per week for five weeks. The self-care phase treatment programme was the same as in Article IV, and applied under the same rationale (discussed in Section 5.4).

The washout period after this second treatment condition served the same purpose as the first washout.

The copious amount of outcome measures completed for Article IV was reduced to avoid participant fatigue. Evaluating the treatment effects before and after each practitioner-led and self-care session was irritating to the partici-

pants, so it was altered so outcomes were measured only at the beginning and end of each phase. Trying to integrate the assessment more seamlessly into the unit's practices, central to the possibility of continuing the protocol, was deemed more important at that point than elucidating the magnitude of improvement within and between each treatment session.

Washout periods in between treatment conditions showed that practitioner-led and self-care sessions were beneficial for improving functioning, relieving pain and mood symptoms, and increasing relaxation. They became aware of the effects when they were no longer receiving VA. The immediate effects of both practitioner-led and self-care sessions are reported in participants' diaries, as well as participants becoming aware of new sensations in their body and how this changed over time.

Physiological outcomes showed that, despite the subjective reports at times indicating participants did not experience as significant pain relief from self-care compared to practitioner-led sessions, participants relaxed during both treatment conditions. Increased vagal tone, a marker of parasympathetic activity (Porges, 1992) (RMSSD; heart rate variability), for example, was associated with higher pain in one participant. When pain decreased, so did vagal tone; this was supported by previous literature (e.g. Koenig et al., 2014). There were greater effects during the practitioner-led sessions, possibly due to the whole-body effect from the device used in Seinäjoki, but self-care may be a valuable addition to the rehabilitation process there, especially as the waiting lists for treatment are relatively long and the fact that the duration of treatment effects is relatively short, seen in Article II. The disparity between the physiological outcomes, VASs, and verbal reports may be partly explained by the effects of the combined sound vibration and the music listening; that is, the research-based physiological effects of music listening may influence the effects of preference and the confounding relaxation induced by the VA treatment programme used.

The results of this study showed the importance of participants' knowledge of self-care approaches individual to them, such as participation and social interaction. Self-care is described as an essential and inherent aspect of health behaviours; the positive outcomes from self-care practice were displayed, as well as the potential barriers patients may face in carrying out this mode of care. It explored the individual variation that may occur with patients that have a similar type of pain but varied severity of mood issues and levels of daily functioning. A link between pain and mood (and the subsequent effect on functioning) was seen in this study, which supports the biopsychosocial approach to symptom management using interventions such as VA treatment. The washout period directly after the practitioner-led sessions was relevant for investigating how long the treatment effect lasted and whether self-care could achieve similar outcomes to the practitioner-led sessions, important in understanding whether the self-care phase would be a suitable supplementary intervention in the treatment model.

Although there were fewer VAS measurement points, several novel aspects were added to the protocol for this study. First, as the focus was this time on functioning and ability to work, and how they are influenced by pain and mood, a scale to evaluate functioning (World Health Organization's Disability Assessment Schedule, [WHODAS] 2.0) and a VAS for ability to work were added to the battery of tests. In addition to this, participants were asked to keep diaries of their experiences. In this way, their subjective experiences could be explored in more detail, honing in on how their pain affected their functioning and how the chronic pain experience manifested in their daily lives. Finally, physiological responses were exploratively measured. This approach of adding self-care to standard VA treatment protocol at Seinäjoki Central Hospital was therefore examined on three levels; first, self-complete questionnaires and scales; second, participants' personal experiences of the treatment conditions and washout phases; and finally, the physiological outcomes. The progression of the project from Article I to V can be delineated by the progression of methods throughout the work. An overview of all five studies' methods is therefore presently discussed.

5.6 Relationship between the articles

After the context had been established in Article I, each successive article built upon the knowledge gained from the preceding work. The overall objective of the project was to develop an operational model based on the application of VA treatment in a multidisciplinary rehabilitation setting with an added self-care component. Each article's function was to support this model development in terms of materials used and methods applied. The findings from Article I laid foundation to the directions in which the clinical practice and research of VA may go; Article II explored how VA treatment is currently applied in a multidisciplinary rehabilitation setting, specifically for patients with chronic pain and comorbid symptoms, which was important for developing a model to support this issue within this particular setting; Article III examined a single case's experiences and perception of the role of music within VA treatment delivered in a clinical context, the results of which – in addition to previous clinical experience and research – supported the application of music listening for increasing relaxation, a pivotal aspect of managing the chronic pain experience (as discussed in Section 3.3); Articles IV and V investigated self-care as a concept in the same multidisciplinary rehabilitation setting introduced in Article II, building up the picture of how individualised healthcare may be afforded in a hospital unit supported by a rehabilitation team, working towards increasing the self-efficacy of patients with persistent pain and comorbid mood disorders.

The materials used to work towards building up the operational model (presented in Section 6.2) were explored throughout the project (see Figure 5). Beginning in Article II with a presentation of how VA treatment is delivered according to standard protocol at the multidisciplinary rehabilitation unit, an

overview of the Physioacoustic system in practice and the parameters involved in such treatment programmes was presented. One of the most commonly delivered treatment programmes (*general relaxation*) was described as an example. Thereafter, this same treatment programme was selected and applied in a clinical setting (Article III) throughout a whole treatment process. The aim of the work was not to delineate which frequencies in particular – nor the device used to deliver the stimulation – was the catalyst for potential change. Therefore, the treatment protocol for the single case study (Article III) followed principles of multidisciplinary care adhered to by Seinäjoki Central Hospital (Article II). The treatment programme used in Article IV was the same selected treatment programme as in Articles II and III and was standardised across all participants; this was to enable possible comparison of treatment outcomes without focusing on one specific frequency, rather on the general effect from such a treatment programme. The self-care treatment programme, however, differed from the practitioner-led treatment programmes. A single frequency was applied as this was a novel aspect of the work and avoiding complications or side-effects was important. For this reason, the same stimulus was used for the self-care sessions in Article V. Finally, the practitioner-led treatment programmes in Article V were individualised for each participant, taking a client-centred approach to VA treatment during this phase, and as such followed standard protocol of VA treatment practice at this unit, mirroring the approach taken in Article II. This was supported thereafter by self-care. The final article was a way of further exploring how a simple self-care treatment programme could supplement the nuanced practitioner-led treatment process in which various combinations of treatment programmes and frequencies are regularly used.

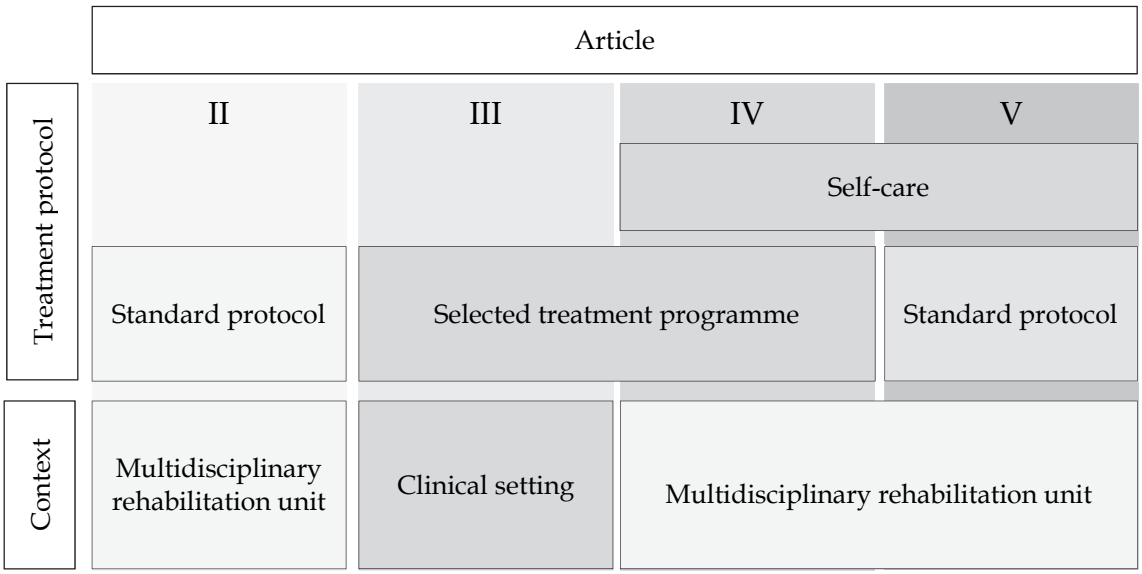

FIGURE 5. Development of applied treatment programmes and interventions used in each research context.

The ways in which each article built upon the previous can be delineated in terms of this layered approach to research methods (see Figure 6) used to develop the operational model (presented in Section 6.2). The work as a whole is built upon subjective experiences, beginning with Olav Skille as a primary source of how VA developed over time, describing the state-of-the-art, and highlighting the starting point for exploration. From there, the application of this treatment modality is described in a healthcare setting, underscoring that patient reported outcomes may be reinforced when interpretation guidelines are used. Article III makes a diversion to a more precise examination of the inner workings of VA treatment in a clinical setting using a single case experimental design. Gradually building up the picture, the methods used for Article III examined the phenomenon of chronic pain and comorbid anxiety, and how an individual may respond to VA treatment with and without music, with pre- and post-treatment outcomes for each session, again interpreted using established guidelines. A similar approach to Article III was taken in Article IV, with pre- and post-treatment measurement points and interpretation guidelines. Additional depression and anxiety scales were also implemented. The pre- and post-treatment scores provided more information on the symptom fluctuations within- and between-VA treatment and self-care sessions. The foundation of the work still rested on the participants' subjective experiences of VA and self-care; the addition of a participant evaluation form at the end of the pilot study (Article IV) augmented the participants' reporting outlets. More subjective reports – participant diaries – were incorporated into Article V, in addition to more objective measures explored with physiological outcomes. Due to the highly subjective nature of the chronic pain experience, participants' subjective responses to the treatment conditions were viewed as fundamentally important to the development of the operational model, but the physiological outcome measures were used to support the interpretation of participants' subjective experiences.

FIGURE 6. Progressively adding more objective assessment tools to the subjective assessment methods commonly used to report on the chronic pain experience.

The continuous act of examining and refining the data collection, research, and analysis methods took the importance of a person's subjective chronic pain experience into account whilst addressing its real-world consequences in terms of functioning, and exploring how the personal manifestation of chronic pain may be viewed in a more objective manner. The struggle to show effectiveness and/or efficacy of this treatment method for both individuals and those sharing similar diagnoses may be attenuated by incorporating more objective measures to support patient reported outcomes (subjective reports). A patient's subjective experiences and personal clinical relevance of a treatment method are, however, fundamental to how pain and its comorbidities may be perceived. As a result, they are crucial for informing how, or whether, a treatment method may be developed within a larger context amidst other applied interventions such as the multidisciplinary rehabilitation unit presented in this project. In the following chapter, the main findings of the project are outlined, leading to a presentation of the proposed operational model, followed by a general discussion of the limitations of the work, the reliability and validity of the project, the implications for research and clinical practice of VA treatment, and future areas of research.

6 DISCUSSION

The primary aim of this project was to develop an operational model of vibroacoustic treatment for chronic pain management within a multidisciplinary rehabilitation setting. Each article added to the knowledge gained from the previous, building up towards the operational model presented in this chapter. A primary objective in working towards this operational model was in exploring how patients with chronic pain and comorbid mood disorders respond to VA treatment as a means of symptom management. A secondary objective was to investigate the impact of self-care on prolonging the outcomes from the practitioner-led VA treatment sessions delivered at Seinäjoki Central Hospital, an augmented and developed application of this treatment previously explored within the same setting (Ala-Ruona, 1999; 2003). To illustrate the findings of the empirical studies and delineate the proposed model, VA treatment was first contextualised in relation to the associated fields, followed by a presentation of the chronic pain experience and the ramifications thereof, and a rationale for VA treatment as a biopsychosocial approach to manage chronic pain. This chapter outlines the main findings, limitations, and implications of the research.

6.1 Main findings

Multifaceted interventions are those addressing several aspects of a disease and illness (as seen in Section 3.5) such as VA treatment. Healthcare service research has shown that "multifaceted interventions are more effective than simpler ones" (Kennedy, Rogers, & Bower, 2007, p. 968). Complex interventions comprising several components acting independently or interdependently can be difficult to evaluate, as it may be hard to judge if the mechanisms and processes are not sufficiently described (Campbell et al., 2007). Effects of complex interventions are not only produced by the intervention, but are strongly connected to the context within which they occur (Tarquinio, Kivits,

Minary, Coste, & Alla, 2015). VA treatment as a biopsychosocial approach was explored in both clinical and rehabilitation settings – naturalistic settings - with the latter investigating the effects of an adjunct self-care intervention. The main findings in relation to the individual elements of VA treatment are presently discussed.

6.1.1 Low frequency sound vibration

The mechanical waves – the low frequency sound vibration – element of VA treatment is that which is most clearly experienced through taction. As a result, the effects most commonly reported relate to experiences such as pain relief or relaxation. The principle findings from this project support previous applications of VA for pain relief (e.g. Braun Janzen et al., 2019; Chesky & Michel, 1996; Chesky et al., 1997; Naghdi et al., 2015; Patrick, 1999; Rüütel et al., 2017), as well as reports of increased range of movement (Katušić & Mejaški-Bošnjak, 2011; Rüütel et al., 2017), and body awareness and muscle tension (Rüütel, Ratnik, Tamm, & Zilensk, 2004).

Participants in Articles IV and V reported noticing sensations of which they had previously not been aware (pain areas, lack of feeling on one side of the body); this may be related to the phenomenon of sympathetic resonance. Based on Wigram's work (1996), it is known that people tend to feel the same vibration in similar body parts, with the general rule being that the lower the frequency within the VA treatment range, the larger the muscle that responds and the closer to one's feet it is perceived. The physical sensation of tactile vibration was therefore reported as a way one may enhance one's perception of one's own body. A participant in Article IV, however, also wrote that she perceived VA treatment more on a psychological than physical level, highlighting the array of individual treatment responses. Her report further emphasises that, despite the prevalent physical sensation, VA may be subjectively perceived as more beneficial for mental health.

6.1.2 Music listening

The importance of music listening to distract oneself from worries and anxieties (Article III) and to help relax is supported by previous literature on the influences of music. As a stand-alone intervention, music listening (music medicine) has been beneficial for reducing medication intake (Guétin et al., 2012; Lee, 2016), for imagery recall, and have a calming influence on the listener in VA treatment contexts (Rüütel et al., 2004) as well as creating feelings of relaxation and safety (Grocke & Wigram, 2007; Punkanen & Ala-Ruona, 2012). The relaxation response – as is commonly reported after VA treatment (Campbell et al., 2017) – may be induced by the repetitive nature of the pulsed vibration, as well as the affective aspect of a patient's preferred music. Music works on a sensory, cognitive, affective, and behavioural levels (Guétin et al., 2012) and as such is a comprehensive approach to symptom management (see Section 2.3). Music listening alone for chronic pain relief is attributed to dis-

traction from the pain sensation, with preference being an influential factor (Mitchell & MacDonald, 2006), as well as relaxation (Mitchell, MacDonald, Knussen, & Serpell, 2007). The findings from the articles included in this project are in line with previous research including reduced analgesic consumption (Article IV), relaxation/calming response (Articles III, IV, and V), pain relief (Articles III, IV, and V), and distraction from adverse affective feelings (Article III).

The knowledge gained from VA in a clinical setting supports the importance of music listening for these purposes, but also highlights that the client's preference and ability to choose whether or not to listen to music should be taken into account. Self-confidence attrition and a sense of helplessness can be detrimental to medication adherence and ability to self-manage symptoms, resulting in suboptimal symptom management and increased dependence on social systems (Barrie, 2011). Empowered patients make decisions about their own care, taking responsibility for their actions. Although healthcare professionals are responsible for assisting the patient by offering clear and accurate information, the decision of what is ultimately best for the patient rests with the patient themselves (ibid.). The single case as the primary informant on her own experiences (Article III) is reflective of a patient's need to be actively involved in their own health management. Given that "medical ownership" plays a significant role in the concept of disease, in that it belongs to the doctor as s/he who has the responsibility of diagnosing, prognosing, and treating the disease, and the psychological stresses and willingness to avoid responsibility for unexplained symptoms, the role of the patient in their own healthcare has become more prominent (Salmon & Hall, 2003). Salmon and Hall argue that the biopsychosocial model allows for an expansion – and therefore dissipation – of responsibility, with ethical implications related to the amount of personal information that is relayed by the patient to their doctor. This author would argue, however, that the combination of (1) the subjective nature of pain and comorbid mood disorders, (2) the need for self-efficacy and patient agency in symptom management, (3) and the suggested underlying source of chronic pain being affect suppression could be reason enough to advocate for such divulsion of private (psychosocial-related) information.

Another skill inherent in symptom self-management is decision making (Lorig & Holman, 2003); in this sense, the client in Article III was working towards making decisions for herself which supported her own wellbeing (music listening) in the moment, taking control of her own health situation.

6.1.3 Practitioner support

Within the VA treatment sessions, the supportive role of the practitioner was an important element in helping clients to process their experiences. The social environment comprising family, friends, one's workplace, and the healthcare system all play important roles in supporting (or alternatively impeding) self-care and improvement of chronic illness behaviours. In addition to this, monitoring and responding to the changes in disease and illness (such as the bio-

logical symptoms of pain and the related issues of coping and affective responses) is important in patients' ability to adapt to illness (Von Korff, Gruman, Schaefer, Curry, & Wagner, 1997). When healthcare providers and patients work together to achieve health-related goals, interventions supporting these principles show improved medical, affective, and functioning outcomes. Furthermore, Von Korff and colleagues (1997) explicated that patients' ability to care for themselves is augmented when the necessary skills to carry out medical regimens or healthy behaviour change are taught and emotional support is provided.

The role of the VA treatment practitioner in enhancing patients' self-care outcomes may be understood in four steps. First, the patient learns about and experiences VA treatment in the hospital; second, the practitioner supports their experiential processing within each session; third, the practitioner works towards eliciting behaviour change by educating patients on their ability to manage symptoms at home with the self-care intervention; finally, the practitioner acts as a focal point of support, so that the patient can have a check-up on their self-care progress, reporting outcomes of that experience to the practitioner.

Within self-care practice, the role of the healthcare provider is important in ensuring patients conduct self-care and improve treatment outcomes (Von Korff et al., 1997). Self-care practices are supported by a positive relationship between patient and healthcare provider (Lorig & Holman, 2003). Participant involvement and support (see Article IV) was fostered by the practitioner's check-ups conducted during the self-care phase. This was integral to the participant's initiation of self-care practice during this protocol phase. The need for support from the practitioner and practitioner-client interaction was further highlighted by one participant missing this element during self-care when she could no longer meet with a professional (VA practitioner) twice a week at the hospital (Article V). Bair and colleagues (2009) delineated the barriers and facilitators of self-management of musculoskeletal pain and comorbid depression, finding that aspects thereof were related to lack of support within one's social circle, lack of tailored approaches specific to their needs, not being able to maintain the use of the self-care approach after the study had ended, and a difficult relationship between patient and their physician. Encouragement from healthcare providers (e.g. nurses) is a main facilitator to supporting patients' self-care practice, supported by Article IV.

6.1.4 Adjunct self-care

The main findings regarding the self-care adjunct intervention were that patients found their symptoms or need for analgesics returned as soon as the treatments stopped; this supports the idea that self-care, despite the device being comparatively weaker, was capable of prolonging the outcomes of the practitioner-led sessions. Individualised, coordinated, and integrated multidisciplinary care incorporating self-care which is responsive to an individual client's needs and tracks the patient's progress is important in managing

chronic diseases (Pulvirenti, McMillan, & Lawn, 2011). Given the commonly reported under-treatment of pain (Glajchen, 2001), supplementary and supporting interventions designed to prolong and augment positive treatment effects from one-on-one sessions were hypothesised to be beneficial for patients with persistent pain.

Prolonging the treatment effects into one's daily life raises issues of where the responsibility lies in one's pain management. The increase in chronic illness and comorbid symptoms led to a responsibility shift from the caregivers to the patient, however the question has arisen of whether the increase of self-care interventions is resultant of a faulty healthcare system or a genuine effort to improve and support the patient-healthcare giver relationship to incite better health outcomes (Vadiee, 2012). The adoption of a self-care phase as an adjunct to standard VA treatment protocol at Seinäjoki Central Hospital was not designed to shift responsibility from the healthcare system and reduce the practitioner's responsibility, rather to first provide a foundation (practitioner-led sessions) upon which the patient could later build (self-care). The continued support from the practitioner (Articles IV and V) was recognised as an important element of the self-care process, especially given the relatively short VA treatment process possible at the rehabilitation unit. The availability of wider services (e.g. at polyclinics), in which self-care is an inherent aspect, may support the integrated approach to chronic illness management (Kennedy et al., 2007). The self-care phase reported here was framed as a continuation, rather than the abandonment, of the clients' personalised pain management rehabilitative process.

6.1.4.1 Translating treatment effects into daily life

The rationale for listening to the same music in- and outside the practitioner-led VA treatments is that of using the music as a bridge between the therapeutic setting and one's daily life (Ala-Ruona, 1999). This also reflects the rationale for adding self-care to the standard VA protocol as a way of continuing and promoting the treatment effects at home. Although the inflexibility of this within the research paradigm led to a certain level of boredom and frustration, the client's choice contributes on the level of music preference and also in relation to the possibility to choose music based on their daily fluctuating needs outside of a research context. In this sense, the active choice-making process described in Article III informs the relevance of music within the treatment, and is therefore also relevant to one's self-care practices and how one may build up the self-care framework based on their own needs.

A further rationale for listening to the same music outside the treatment session is based on the concept of "homework". Although, to this author's knowledge, there is only one publication describing music-related interventions of re-listening or re-experiencing therapeutic context-related music outside the session (Erkkilä et al., 2019), the concept of homework within the Cognitive Behavioural Therapy tradition is well known. In the case of chronic

pain, less activity/physical exercise is associated with greater disability (Von Korff, Katon, et al., 2005); activating and fear-reducing interventions for people with chronic pain have reduced patient fears, limitations in common activities related to back pain, and the number of days of being incapable to carry out usual activities because of pain (Von Korff, Balderson, et al., 2005). Therefore, increasing patients' independence and activity is beneficial in managing chronic pain, rather than applying passive coping techniques usually beneficial for managing acute pain (e.g. resting).

A major contributor to relapse in chronic pain patients is the inability to maintain outcomes after treatment cessation or generalise health behaviours learned during the treatment to the outside environment (Johnson, 2007). Johnson argues that there is a lack of firm evidence supporting homework in psychological treatment for chronic pain, but the most significant components of learned techniques such as relaxation or home practice, which follow instruction within the session, are *themselves* the treatment. That is, the techniques one practices in a therapy session under the guidance of the therapist are utilised outside the session where the therapeutic change occurs. Therefore, listening to the same music outside of a session based on the therapist's/practitioner's recommendations could be termed as homework. "The encouragement and awareness of strategies to maximize the prospect of patients maintaining treatment activities is an essential part of the effective treatment" (Johnson, 2007, p. 264). Nelson, Castonguay, and Barwick (2007) stated that given the evidence based on the application of homework for between-session activities, it may "be time to add homework to the list of so-called 'common factors', which are viewed as active therapeutic ingredients cutting across theoretical orientations" (p. 425). Since homework enhances therapy outcomes (Kazantis, Whittington, & Dattilio, 2010), self-care may be viewed in such terms because it is an extension of VA treatment outside of the VA treatment session in which therapeutic change may also occur, and is therefore an essential part of the effective treatment. Furthermore, utilising music re-listening as an inherent element of the homework activity can also be viewed with the potential to translate the effects from VA treatment sessions to the patient's daily life.

6.1.4.2 Self-efficacy and empowerment

Another outcome of VA treatment in general was a sense of empowerment (Article IV). Person-centred approaches to treatment place the person or client at the centre, whereas empowerment approaches enable and promote the patient's health, giving "centrality to the social environment the individual lives within" (Pulvirenti et al., 2014, p. 307). The strong support for VA treatment as both a physiological and psychological intervention effecting change through improving patients' abilities to participate in social/environmental activities, self-care as an adjunct intervention may also support the empowerment of a patient with chronic pain. In essence, people suffering from chronic conditions are eternally self-managing outside of the direct patient-caregiver relationship

to varying degrees (ibid). Thus, building up patients' experiences of feeling empowered and having the ability to effect change and optimise their health is supported in the literature on homework for enhancing therapy outcomes, as well as the participants' experiences in the empirical studies of this project.

6.1.4.3 Enhancing health and limiting illness through self-care

Although the terms self-management and self-care are often used interchangeably (Grady and Gough, 2014), self-management is the day-to-day management of chronic conditions whilst self-care activities are those in which healthy people engage at home to prevent illness. However, given the continuum upon which health and illness, and the intersect of functioning and disability, are situated, self-management and self-care may often overlap. Indeed, Richard and Shea (2011) found that there are more commonalities among the terms self-care, self-management, and self-monitoring than there are differences. Furthermore, the World Health Organization defines self-care as "the activities individuals, families and communities undertake with the intention of enhancing health, preventing disease, limiting illness, and restoring health" (World Health Organization, Health Education Service, 1984, p. 2). This underscores the importance of not only the individual themselves, but also their social environment, and focuses not only on maintaining one's current state of health but also limiting illness (the subjective effects of a disease on one's life). The daily fluctuation in chronic pain manifests in WHO's definition of self-care, as the need for either enhancing health or limiting illness may change from one day to the next. In this context, because the symptoms have been alleviated by the practitioner-led VA treatment sessions, the self-care intervention is applied to prolong these effects, and in that case may adhere more keenly to the definition of health enhancement. On the other hand, on occasions in which symptoms flare up, the focus of self-care may be on "limiting illness". The difference between disease and illness (Gatchel, 2004) – with disease being the objective phenomenon and illness being the subjective response and effects the disease has on one's life – relates to the physiological sensation of pain and the psychological consequences of that disease.

Interventions in the home facilitate increased functioning by optimising health and working towards maintaining more independent lives (Grady & Gough, 2014). The addition of self-care to VA treatment therefore is a flexible intervention which adheres and responds to one's individual needs – an important strategy in healthcare (Pulvirenti et al., 2011).

Based on previous research and the results and findings from the articles of this dissertation, the proposed operational model is outlined in the following section.

6.2 Operational model of vibroacoustic treatment and self-care

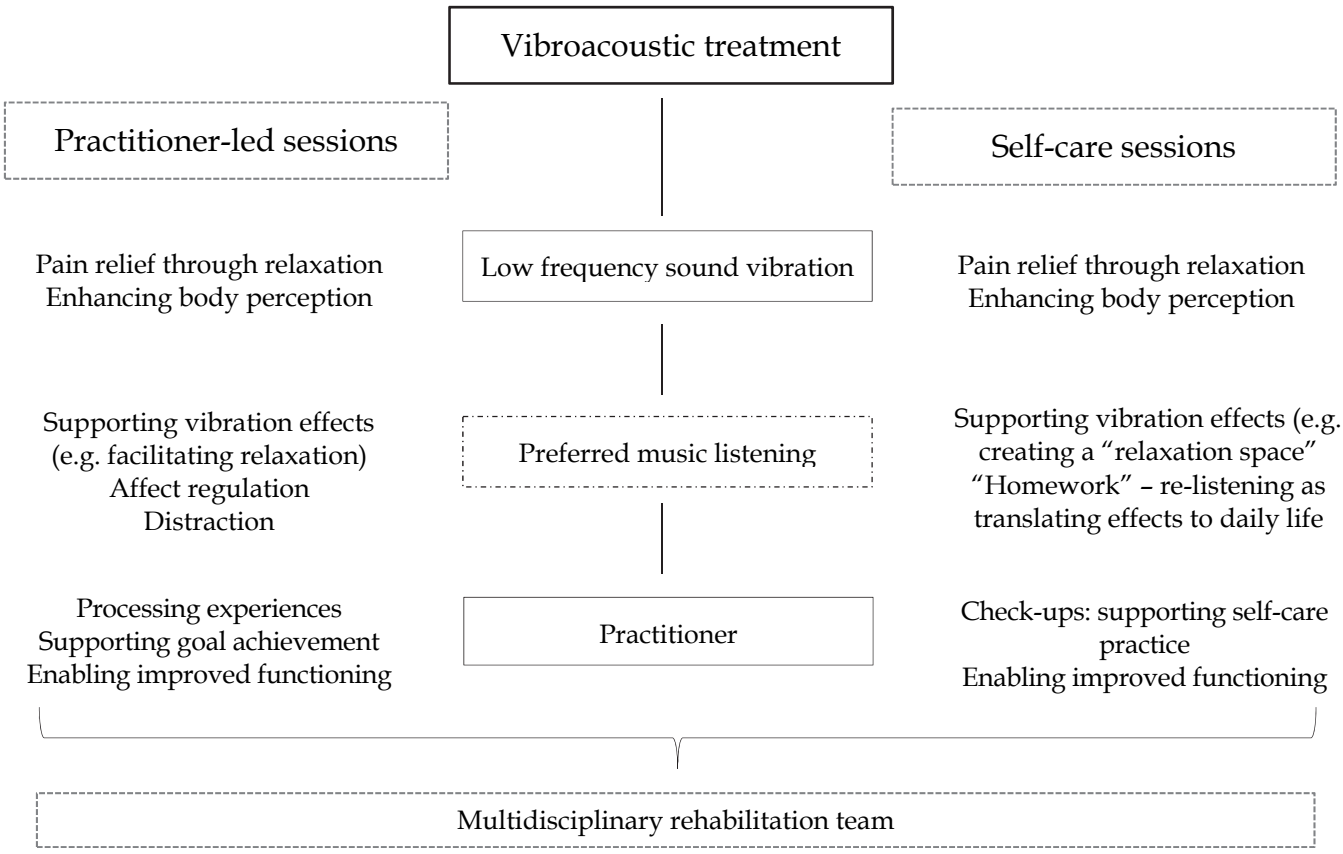

FIGURE 7. Operational model of vibroacoustic treatment and self-care, showing the role of each element for the practitioner-led and self-care sessions, supported by the multidisciplinary rehabilitation team.

This model shown in Figure 7 delineates the two proposed mutually supportive branches of vibroacoustic treatment. The practitioner-led sessions should always precede the first iteration of self-care sessions, because the safe application of VA stimuli is of priority in ensuring positive outcomes for the patient/client. However, the format in which self-care may be conducted is flexible. It may support the practitioner-led sessions during the treatment process by having self-care sessions between contact sessions with the practitioner, or could be used after the practitioner-led process has ended, and as an interim or supporting intervallic intervention between practitioner-led treatment phases. The self-care could also be used as a means of bridging the gap between treatment and waiting list duration; if a patient receives one or two practitioner-led VA sessions, self-care could be conducted directly after this whilst waiting to engage in the full-length practitioner-led treatment phase. The role of each element of VA treatment according to each branch is also explained as to how it supports the overall therapeutic goals of a treatment process.

In both branches, the low frequency sound vibration is applied to manage chronic pain through eliciting the relaxation response. It may also be beneficial to increase patients' body perception, such as becoming aware of body sensations or other areas of pain. Research suggests that an inability to identify feelings and differentiate between them is elevated in those with chronic pain, and that deficits in emotional awareness are related to amplification of somatosensory perception (Lumley et al., 2011). As participants also reported the psychological benefits of the treatment, emotional and somatosensory awareness may be increased through the vibration.

The preferred music listening branch of VA treatment is encased in a dashed outline; this is because the music listening element should be included based on the client's needs which may vary from session to session. The practitioner's role is to support the client's empowerment in decision-making based on their [client's] needs, gradually increasing the self-efficacy skills of the client with chronic pain. The music listening can play the role of enabling and augmenting the relaxation response elicited through the vibrations; however, this is both client- and session-dependent. For the self-care branch, the music can function as a means of creating a "relaxation space" in the client's home, supporting the effects of the vibration, and may also be used as a form of "homework", suggested or assigned by the practitioner to translate the session effects into the client's daily life.

The practitioner also serves a dual purpose. In the practitioner-led branch, s/he supports the client's experiential processing, working towards the predefined clinical goals of the treatment process. S/he also guides the client towards self-care, which is important for continuing the effects if there is a break in the practitioner-led process or it has ended. The supportive role of the practitioner is also important in helping the client to improve their functioning in daily life, becoming aware of how they may alter their activities to suit their level of disability. During the self-care phase, check-ups from the practitioner are an important element in ensuring the client continues with the self-care practice. Self-care is an inherent part of rehabilitation and our daily lives (Orem, 1985) but the mood-related disorders usually comorbid of chronic pain may demotivate patients to continue the practice. The practitioner could help in this regard. Continued practice is a means of maintaining or continuing to improve functioning in those suffering from chronic pain and comorbid mood disorders.

Finally, the multidisciplinary rehabilitation team plays an important role in the overall rehabilitation process. Supporting a patient's rehabilitation process has been shown to ensure better outcomes (see Chapter 4); this was also found to be the case in Article IV and V of this project. Therefore, despite the project's aim to increase patients' self-efficacy and independent healthcare practices, the supportive team tailoring individual rehabilitation processes to each patient's needs allows for (1) the added self-care to be built upon a stronger foundation of health practices, and (2) more favourable outcomes overall.

6.3 Limitations

Some limitations of the included articles are to be noted. First, as Kvam (1997) wrote: "Vibroacoustic treatment will not benefit everyone" (p. 295). This is a testament to the individual responses reported from this treatment modality. Just as an individual's experience of chronic pain differs greatly to that of another, so too may one person's response to VA treatment differ from another's. Although one limitation is related to generalisability across participants, this could also be seen as a positive aspect. The studies reporting on the use of VA treatment in a rehabilitation setting are explorations thereof within a naturalistic setting; they are effectiveness (rather than efficacy) studies, and are reports of individuals' responses to VA treatment in relation to other therapies they receive. In this sense, the individual treatment responses are important to be delineated, as these single case, or *n*-of-1, studies are needed in order to substantiate whether larger, controlled studies are feasible (Barlow et al., 2002). Another rationale for non-controlled studies is that pain management is essentially an individualised endeavour and the comparison across participants was not the objective of the studies. The experience of pain is subjective, and the outcomes were based on subjective assessment methods (see Section 5.6). The inter-individual treatment responses may be seen as enriching the field, rather than detracting from its credibility. Indeed, Kvam (ibid.) proposed that if physiotherapists were to have access to a VA device, it would be the optimum possibility to develop individualised treatments for patients. This supports this work as an examination of individual treatment responses to VA treatment as part of individualised, multidisciplinary care.

6.3.1 Restrictive protocol

The protocol was rather restrictive when developing the model; in both Articles IV and V, participants naturally felt that having to conduct self-care on specific days with repetition of their preferred music choices was not desirable. As pain and mood (as well as schedules) can be influenced by a plethora of variables, VA self-care should be seamlessly integrated into a person's general self-care practices. Flexibility in the self-care treatment programmes, such as individually-tailored self-care treatment programmes designed by the certified practitioner, would offer more promising results. Self-care is an iterative process; variation in how one conducts it could be integral to continuation of the practice. Furthermore, the same treatment programme was used for all participants in Article IV, only the intensity of the stimulus was tailored to each patient. This was a restriction of the standard protocol in an attempt to generalise across participants, however this was not employed in Article V.

6.3.2 Duration of effect

As seen in Article II, the duration of treatment effects is rather limited. This was seen in the symptom return reported in Articles IV and V after the interventions had stopped. Kvam (1997) also reported that when beneficial effects were recorded, they were short-term. Daily treatments were therefore proposed as a means of obtaining the maximum effect. The rather short duration of effects was also a driving force for initiating the self-care addition to the protocol; apart from increasing patients' independence in their own pain management, prolonging the treatment outcomes was a desired outcome and Kvam's (ibid.) observation supports the need for more frequent VA treatment applications.

Additionally, the concept of learned treatment response may be one way of understanding the short-term effects of VA treatment. Clinical practice dictates that low intensity vibration is first used so the client can become accustomed to the sensation before greater volume is used. If a client can become used to the sensation, and the duration of effects does not last considerably after a treatment process ends, one must wonder if the cumulative effect would at one point suffice or if the body requires the stimulation to be constantly increased as soon as one has become used to it, eventually leading to a plateau effect. This specific issue should be addressed in future studies.

6.3.3 Incongruent outcome measures

One issue related to outcome measures was the difficulty in interpreting (1) the subjective VAS outcomes compared to the verbal reports from patients to the practitioner, and (2) these compared to the physiological outcomes. This is somewhat confusing, given the subjective nature of both the VAS and verbal reports. However, it has been previously reported at this multidisciplinary unit that patients receiving VA treatment often verbally reported the effects more positively than were suggested in the VAS outcomes (Ala-Ruona, 1999; 2003). More severe pain, however, is more easily discernible from moderate or mild pain, possibly explaining the incongruent reports. Ahearn (1997) found that patients rate their symptoms more severely using VAS than would be reported based on a clinician's assessment. Yet, a clinician's assessment of a client's pain as less severe does not necessarily mean the pain is any less severe for the client.

Based on the knowledge that pain fluctuates, it was thought that increased data points for pain measurement (VAS) would help to clarify the direct outcomes of the treatments. Too few data points may not afford an authentic depiction of chronic pain (Punkanen & Ala-Ruona, 2012). However, participant fatigue from completing VAS outcomes before and after each VA treatment and self-care session (a total of 71 measurement points in Article IV) was evident. Simply measuring pain at the beginning and end of a treatment process may be sufficient, as it may offer the client a means of self-reflection, as was reported by Rüütel et al. (2004): "This continuous filling in of the tests

helped to analyse my feelings … I could analyse very quickly the moods I had" (p. 40).

6.3.4 Exploratory outcomes

As these studies were not efficacy studies, rather assessing the effectiveness of a complex intervention in a naturalistic setting, linking the treatment effects directly to the objective physiological outcomes is not possible. The PNS and SNS outcomes were therefore somewhat difficult to interpret, but highlighted the individual responses to the treatment. Confounding factors to relaxation and pain relief, such as wearing the measurement equipment during the treatment sessions are to be considered. However, to some degree the reports of PNS activity increasing with relaxation and decreasing with activation were supported by the subjective outcome measures, pointing towards the potential for tracking stress responses to objectively evaluate the effectiveness of an intervention. On a final note related to this, it may also be worth considering whether the addition of objective measures is supported in relation to such an intensely personal experience as chronic pain and comorbidities. Although it may give more scientific credence to intervention impact, the subjective experience is still of utmost importance to the patient, who should remain as the focal point of any individualised, biopsychosocial approach.

6.3.5 Shortcomings of self-care

Several caveats exist for self-care, despite being an integral part of an individual's healthcare practices and an important element in patients' rehabilitation process (as discussed in Section 4.3). Firstly, as the interaction between practitioner and client is an important element of VA treatment, this missing element from the self-care practice may be problematic if the patient does not receive at least intermittent support and check-ups after practitioner-led sessions have ended and/or there is no follow-up from the rehabilitation team. Secondly, moving from intensive sessions with the practitioner to conducting self-care at home may also be difficult for some. This is possibly due to the high reliance on healthcare use of those with pain-related disability (Blyth, March, Brnabic, & cousins, 2004), as well as our innate need to express ourselves (Bunt, 1994). Furthermore, the differences in device from practitioner-led to self-care sessions was noted by participants in Articles IV and V, as they had become accustomed to the whole-body tactile sensation from the practitioner-led sessions; comparatively, the self-care device did not meet their expectations of such a comprehensive relaxation response. Thirdly, the importance of the practitioner is not only in affording a therapeutic relationship, but also of ensuring the patient or client does not experience side-effects, such as numbness. Although the stimulation used with the self-care devices in this project was much weaker than the whole-body effects, contraindications are still vital to be considered. Finally, technical issues are also a consideration with this approach. The self-care device may be considered difficult to use, especially in instances where battery life may not be

as long as expected, with patients only realising so when initiating a self-care session. Despite these shortcomings, self-care is nonetheless an important avenue for future clinical work and research.

6.4 Reliability and validity of the project

The decisions made during the project planning stage in relation to materials and methods utilised for exploring this topic are also to be discussed. This relates both to the devices and treatment programmes used in the practitioner-led (Articles II-V) and self-care sessions (Articles IV-V) as well as the role this author played in conducting the research.

The setting and aims of the project – to develop an operational model building upon standard practices at a multidisciplinary rehabilitation unit – dictated the devices and, to a certain extent, the treatment programmes that could be used for the practitioner-led phases. The work explored the procedures used to manage chronic pain and comorbid mood disorders, rather than the influence of one specific frequency delivered by only one device. This author placed more importance on exploring the potential effectiveness of an intervention in a naturalistic setting with typical patients rather than on exploring the efficacy of a specific frequency and device in a controlled paradigm. Understanding a phenomenon as complex as chronic pain and comorbid mood disorders supports the use of a naturalistic setting over a controlled one; how one responds to an intervention outside their usual experience (i.e. in a controlled paradigm) may not be clinically relevant (Golafshani, 2003). Therefore, this project did not compare and contrast the effects of one frequency to another, one device to another, or whether the multiple frequencies within the practitioner-led treatment programmes were superior to the single-frequency programme used in the self-care sessions. The question of which frequencies would be most beneficial for specific target groups therefore remains open and as a consideration for future research. The same device was used in the practitioner-led sessions reported in Articles II-V (Next Wave Physioacoustic chair) and the same Taikofon FeelSound Player used for the self-care interventions in Articles IV and V. Although a different device was used for the self-care and practitioner-led sessions, this was for practical reasons. Furthermore, the aim was not to compare the effectiveness of the self-care device/treatment programmes to the device and treatment programmes used in the practitioner-led sessions.

In Articles II-V, measures were taken to support intervention development within a naturalistic setting whilst trying to avoid falling victim to bias due to the absence of control groups. In Article I, this author was not present for the interview reported. This means that her exploration of how VA treatment came to be what it is, through the dialogue between the interviewee (Olav Skille) and two interviewers (EA-R and MP) and the supporting literature, was that of an outsider (as discussed in Section 5.1.1), and arguably more objective as a result.

In Article II, this author's position as an outside observer and interpreter of the standard procedures within the multidisciplinary rehabilitation unit at Seinäjoki Central Hospital meant that questions arising about protocol, choices made related to treatment programmes, their contents and duration, and the general structure of VA treatment sessions could be highlighted and were important to be discussed in the project planning phase. The other authors' (EA-R and JH) roles and experiences in the unit served to support this questioning process from an insider's perspective. As Article II explored the standard procedures of the rehabilitation unit, comparison or control groups were impossible. Typical procedures followed in the naturalistic setting could then also be viewed from the perspective of how current practices serve typical patients within the unit and how patients typically respond to the intervention.

In Article III, the authors and client filled various roles throughout the process – as practitioner, researcher, client, re-observer of lived experiences – meaning that each role built upon the previous to formulate a more coherent picture of the process. The employed data analysis method (Interpretative Phenomenological Analysis) was also chosen to support the exploration of the client's phenomenological experiences. As a further means of analysis and interpretation verification, a member check interview (Section 5.3.2) was conducted to discuss the findings of the data analysis.

This author's role in Articles III-V role was more prominent from the outset as the study design, data collection, analysis and interpretation, and manuscript draft writing were executed by her. This enabled her to oversee the process but also switch between roles such as from study planner to data analyst and interpreter. This may be seen as a strength of the process, as "qualitative researchers have come to embrace their involvement and role within the research", compared to quantitative researchers who may wish to disassociate themselves as much as possible from the research process (Golafshani, 2003, p. 600). The integral role of this author as practitioner and researcher (Article III) may support the trustworthiness of the data interpretation, as the researcher in qualitative work "is the [research] instrument" (Patton, 2001, p.14, cited in Golafshani, 2003, p.600). Planning and overseeing the empirical studies from genesis to execution meant that this author was a consistent observer of the work; all data were therefore seen through the same lens.

Conversely, filling several roles could also be seen as a confounding factor in data collection, analysis, and interpretation. In order to substantiate the findings and interpretation, mixed methods were used. The qualitative data were used to contextualise and inspect the experiences recorded in the quantitative scales. Triangulation of (mixed methods) data sources is used to study the same issue from multiple perspectives, affording a more complete portrayal of a person's lived experiences (O'Cathain, Murphy, & Nicholl, 2010). The qualitative documents were an important source for understanding how participants perceived their symptoms. Furthermore, they could help to illuminate the oftentimes ambiguous or misleading outcomes from the VASs (Sandahl & Wilberg, 2006). Triangulation was a common thread used in Articles II-V as a way

of supporting the trustworthiness of the qualitative findings and the reliability of the quantitative results.

The progression of research methods used (see Figure 6) throughout the work supports the overall aims of the project. Exploring the effectiveness of VA treatment within a multidisciplinary rehabilitation unit by examining patients' responses to the standard procedures and the influence of an adjunct self-care treatment phase was founded upon patients' subjective responses using subjective reports. Objective measures were used to bolster the interpretation of these subjective experiences. It was not possible to examine the efficacy of the Physioacoustic chair compared to other VA devices commonly used (e.g. mattresses) nor is it possible to explicate which element(s) of the procedures were the specific catalyst for change. In the context of this work, all three elements of the VA treatment triad play important roles in working towards clinical goals.

6.5 Implications of the project outcomes

The implications of this project are presented from the perspective of both clinical practice and research. From a clinical practice perspective, the importance of individually-tailoring the treatments and developing interventions responsive to clients' changing needs is supported in this project; however, the need for promoting clarity regarding self-management and its integration into practice in general is increasing (Grady & Gough, 2014). Implications of this work for future applications and development could be on the translation of the best-suited treatment programmes from the practitioner-led sessions to practitioner-designed self-care treatment programmes. Instead of applying only one treatment programme, the client could have a selection to choose from based on their experiences of fluctuation and inter-session variability in treatment response. The freedom to choose to which music to listen under the same criteria would also be an important element to explore, yet generalisable results across similarly diagnosed patients may be important for the conceptual validity of VA treatment and self-care for chronic pain management. Further explorations of the effects of combined or successive VA treatment and physiotherapy should also be carried out, investigating the valuable contribution VA treatment could have in improving physiotherapy outcomes, but self-care may be a valuable addition to the overall rehabilitation process there, especially as the waiting lists for treatment are relatively long.

In terms of research implications, several areas could be of interest. The relaxation response commonly reported by patients/clients could be explored further in relation to sympathetic resonance. Given the relatively rudimentary understanding of sympathetic resonance in VA treatment, future studies could explore the effects of applied tactile vibration more keenly in relation to specific body areas or whole-body treatment. The music listening aspect of VA treatment should also be further examined. This relies heavily on the individual person receiving VA treatment, but the interaction between music listening

(whether it is the client's preferred music, the practitioner's research-based music choice, or no music listening at all) and the tactile vibration should be explored in more detail. VA treatment as a complex multidisciplinary biopsychosocial intervention may give insight into how chronic pain can be managed, but the effects of each branch may be mediated by several elements within the pain experience, as well as the daily fluctuation of symptom severity in chronic pain. Finally, the practitioner's role in supporting the VA treatment sessions and the client's experiences therein, as well as the adjunct self-care phase, deserve further exploration for patients suffering from chronic pain. As described in Section 3.2.3, the interaction between practitioner/therapist and client is important for eliciting therapeutic change, and the definitive role a VA treatment practitioner may play in the operational model should be more clearly delineated.

6.6 Conclusion

In sum, this project has explored the use of VA treatment in both a clinical and multidisciplinary rehabilitation setting. The combination of low frequency sound vibration, preferred music listening, and practitioner support following a biopsychosocial approach to chronic pain and comorbid mood disorder management was investigated. The proposed operational model comprises practitioner-led sessions which lay the foundation for increasing patient self-efficacy and empowerment to continue health-promoting self-care practice as a supportive, adjunct intervention. The knowledge gained by the patient during the practitioner-led sessions supports them in safely applying the low frequency mechanical vibration with needs-based, translational, client-preferred music listening, cumulatively facilitated by the practitioner. The multidisciplinary rehabilitation setting is also an important element in ensuring positive outcomes, working towards increased physical, psychological, and social functioning.

This project has explored VA treatment as a way to help us to "feel more human" (Bunt, 1994), as it incorporates music experiences and human interaction, as well as a relaxation-inducing tactile sensation. Supporting this exploration of humanness – as it is an essential part of our daily activities (Orem, 1985) – is adjunct self-care. This work proposes that expressing oneself through musical experiences and practitioner-client interaction, afforded by an efficient multidisciplinary rehabilitation team, may allow patients with chronic pain to reverse and re-organise their faulty neurosignature, thereby developing a healthier perception of changed functioning, and moving towards unmuting the depressive state proposed to lead one to a state of chronic pain (cf. Chapter 1). VA treatment with self-care is an exciting and complex area of clinical practice and research, perhaps limited only by untapped ingenuity. The outcomes of this project are a small step towards the important objective of alleviating and managing the experience of chronic pain.

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ORIGINAL PAPERS

I

VIBROACOUSTIC THERAPY: CONCEPTION, DEVELOPMENT, AND FUTURE DIRECTIONS

by

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ARTICLE

VIBROACOUSTIC THERAPY: CONCEPTION, DEVELOPMENT, AND FUTURE DIRECTIONS

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Introduction

Some of the earliest explorations into the therapeutic use and applications of music and vibration were undertaken by Teirich in the late 1950s (Hooper, 2001). Teirich's initial inquiries into the sensations felt by Sutermeister, a deaf mute, when he 'listened' to music was one of the first sources upon which Olav Skille, a pioneer in vibroacoustic therapy research and development, based his own work (Skille, Interview, 2014). Since then, innumerable case studies and anecdotal evidence, as well as the recent emergence of controlled trials (e.g. Naghdi, Ahonen, Macario, & Bartel, (2015) reporting on the efficacy of sound vibration as a treatment for physiological and psychological issues, have arisen. Although its theoretical conception began in the late 1960s, much is still unknown about the methods and mechanisms. This paper aims to cast light on the inconsistencies in knowledge on conception, current evidence, and future directions of vibroacoustic therapy (VAT) based on an interview of Olav Skille conducted in 2014. The interview data are supported by examples reporting on the efficacy of VAT in various populations. This culmination of sources highlights the gaps in knowledge, thereby showing how research of and in VAT could continue.

Background

Vibroacoustic therapy (VAT) is 'a combination of low-frequency sound vibration, [and] music listening combined with therapeutic interaction' (Punkanen & Ala-Ruona, 2012, p. 128). The notion itself was first conceptualised after a conversation between Olav Skille, a therapist and educator from Norway, and Juliette Alvin, a French musician and pioneer music therapist, on the absolutes of music (Skille, Interview, 2014). The process itself involves the client lying in a supine position on a mattress, or sitting on a recliner chair, with in-built loudspeakers. Sound waves are thus transferred directly to the body and in this way the body 'vibrates in sympathetic resonance with the sound waves used' (Wigram, 1997, p. 12). VAT is based on the premise that pure vibrations, or pure tones, activate masses that resonate specifically to a given frequency, and complex tones will induce sympathetic resonance with multiple areas simultaneously (Fernandez, 1997). Therefore, by using frequencies in a targeted manner, the application area can become activated by the agency of the applied force.

Although the application of VAT, known in Finland as Physioacoustic therapy (PA), has become more widespread, the actual mechanisms behind its efficacy are not completely understood. This article discusses the beginnings of VAT as described in the Skille interview, his observations and ruminations on early experimentation, examples of current research and a presentation of the current knowledge of the field, and suggestions for future study and implementation of VAT. The aim of the report is to clarify and connect that which is known about sound vibration use, aided by comparison to mechanical vibration applications, and from there present a clear path forward in the research thereof.

Application

VAT has been used in the treatment of pain, Rett syndrome, muscular overuse, multiple sclerosis, Fibromyalgia Syndrome, cerebral palsy, and pulmonary disorders such as cystic fibrosis, in post-operative care, for blood pressure, insomnia, anxiety, self-harm, autism, depression, and stress management among others (Skille, 1997). Much of the sound vibration research has been in case study format or anecdotal in nature. The need for a systematic approach is clear, as will be discussed later. However, although there is a need for evidence, the application of sound vibration has become more common since the increased availability of commercial systems (e.g. Multivib, Norway; NextWave, Finland; Somatron, Sound Oasis, NexNeuro, USA;

Soundchair/bed/box, UK). It has developed from several fields including music therapy, music in medicine, and vibration and low-frequency sound research (Wigram, 1997).

VAT was originally designed and developed to reduce spasticity in children with cerebral palsy and reduce muscle tone (Skille, 1997), however, since the gradual emergence of evidence, it is clear that the effects lie on a much broader spectrum than was originally intended or expected. Experiments have been conducted to ascertain the effects of music on physiological responses (Burrai, Micheluzzi, & Bugani, 2014; Ebneshahidi & Mohseni, 2008; Fredenburg & Silverman, 2014; and Ikonomidou, Rehnström, & Naesh, 2004). Mannes (2011) described a scenario in which Dr. Jeffrey Thompson at the Center for Neuroacoustic Research used low frequency vibrations to create sympathetic vibration in the body. Furthermore, he discovered that specific body parts are receptive only to their specific frequency, for example the back muscles will respond to vibrations between 45 and 55Hz, but not the lower body. Dr. Concetta Tomaino (personal communication with Mannes, 2011, p. 299) explains this concept further:

> *'What happens is you feel like this vibration is going through your body in waves, but actually while the vibrations are presented to the whole body, only part of your body is vibrating at that specific frequency. You can feel the effects right away'.*

We can deduce from Tomaino's and Fernandez's explanations, that although the vibration is applied to the body as a whole, it is felt in waves and only those muscular areas which resonate to the applied vibration will respond. In this way, if a muscle group is targeted with a specific frequency with which it resonates, the remaining muscle groups should be neither positively nor negatively affected.

Method

The interview of Olav Skille, recorded in 2014 in Jyväskylä, Finland, was undertaken to clarify how vibroacoustic therapy was developed, to discuss the possible mechanisms underlying its efficacy, the knowledge currently driving the research and application of VAT, and how it can be developed and cultivated. The interview was unstructured; however there were clear aims as to the topics that should be discussed in order to ascertain the foundations upon which VAT currently stands. The interviewers, Dr. Esa Ala-Ruona (EAR) and Dr. Marko Punkanen (MP), engaged Skille in dialogue about VAT, resulting in a gathering and pooling of

information based on clinical experiences of all three vibroacoustic practitioners. No specific questions were formulated pre-interview, rather the communication method was open, and the loose guidelines as to the topics to be covered were used only to be sure all relevant evidence would be gathered and discussed. This information is laid upon the foundation of evidence within various target groups for the application of VAT.

Data analysis

The audio-recorded interview was transcribed and analysed using Qualitative Content Analysis (as described in Titscher, Meyer, Wodak, and Vetter, 2000). The steps of Qualitative Content Analysis consist of summarising the material in such a way that the essential content is retained but the abstractions are condensed. Next, the data are explicated and clarified, followed by narrow content analysis whereby the original material is simultaneously incorporated with contextually grounded knowledge.

The analysis took place in several stages. Initially, the text was read several times and summarised whilst attempting to retain the factual information. This summarisation was generalised according to the predominant themes that emerged from the dialogue. The themes were visible mainly in the narrative-like answers provided by Skille, and the interviewers' questions led the discussion in a fluid manner. The text was analysed first as narrow content analysis, which was closely linked to the text itself, followed by a broader analysis, giving additional meaning to the themes, which had arisen from the narrow content analysis. The results of the analysis were formulated in a table, which is presented below (Table 1).

Results

Table 1 below shows the three themes, sub-themes, a description thereof, and a quote outlining the source of the theme.

Table 1. Main and sub-themes with descriptions and illustrative quotes

Main themes	Sub-themes	Description	Illustrative quote
Conception and early experimentation	Early conceptualisation	The early ideas of VAT stemmed from a conversation with Juliette Alvin on the absolutes of music.	'Ok, we relax to music but we have to go a long way from the ear to the muscles. What will happen if we transfer sound directly to the muscles instead of going via the ear?' (Skille).
	Early issues	Problems with sound pollution, over stimulation (e.g. asthma symptoms) were some of the early issues in experimentation.	'And one of the most difficult problems when we made the first equipment and so on was to reduce the sound from the back-side of the loudspeakers...' (Skille).
	Duration	The duration was chosen based on research which had been reported in *Musik in der Medizin* (1958) in which responses were reported to occur until 15 minutes and after this there was no change.	'They said that the effect on the autonomic nervous system, blood pressure and pulse and so on, is increasing until 15 minutes […] so I used Teirich ['s research] as a model and then added some more just to be certain...' (Skille).
Current knowledge	Frequencies	The most commonly implemented frequency used in VAT is 40 Hz and is referred to by Skille as the 'life frequency'.	'[40 Hz is] the basic frequency for life, of somehow putting balance, order, and optimism into the body' (Skille).
	Mechanisms	Possible mechanisms were explored in the interview. This came about by Skille hypothesising what could happen if sound were transferred directly to the body.	'What will happen if we transfer sound directly to the muscles instead of going via the ear?' (Skille)
		Speculation on the possible mechanisms are discussed.	'…it seems that the first thing that happens is that the autonomic nervous system calms, calms down' (MP).
	Breathing	The pulsations in VAT occur in 6.8 second cycles as it was found that this duration did not interfere with breathing- nor heart rate.	'This leads you to normal breathing' (MP).
	Target groups	(1) Menstruation (2) Chronic stress patients	Muscular overuse: '…he wasn't almost able to move, he had

		(3) Insomnia (4) Muscular overuse (5) Large and small muscle targeting	terrible pains' (Skille).
	Programmes	Skille developed many programmes, one of which is the maintenance programme lasting 79 minutes descending from 68 Hz to 40 Hz.	'…and you have 68 Hz which is changing slowly during this 79 minutes down to 40. And then it collides with the 60 and the 52 on the way, so you get also some changes during the whole system [felt in your whole body]' (Skille).
	Training	Training must be completed before VAT can be practiced. Such training takes place at the VIBRAC Skille-Lehikoinen Centre for Vibroacoustic Training and Research, based in Jyväskylä, Finland.	'…we need trainings for people [so] that they can do it [VAT] in the best possible way' (MP).
Future research directions	Experimentation	Case studies are plentiful but individual variation is high. Concrete measurements must be taken to outline physiological effects.	'[the] problem usually is that, that as we all know – [individual variation] is always quite high' (EAR).
	Measurements and reporting	Heart rate variability and hormonal testing are discussed as potentially useful in deciphering the physiological effects of VAT.	'And I think heart rate variability would be a good thing [to measure] because it's now [the] most [commonly] used way to measure [the] autonomic nervous system' (EAR).
	Collaboration	Collaboration is needed to further develop VAT; e.g. with educational institutions and hospitals.	'…so we can go into the universities where they are educating doctors and so on and come in as lecturers [in their basic studies] … then we will be almost [sharing a common understanding]' (Skille).

The themes that emerged from the analysis are discussed in more detail below. These themes were as follows:

(1) Conception and early experimentation
(2) Current knowledge
(3) Future research directions.

The sub-theme *Mechanisms* was categorised as part of the main theme *Current knowledge*. However, this could also be a segment of *Future research directions*, as the exact workings and mechanisms behind vibroacoustic therapy are unknown. The interview, although not tightly structured, centred on the past, present, and future of vibroacoustic therapy, and the data are supplemented with examples and other reports in order to clearly outline that which is already known about the application of sound vibration for various target groups.

Theme one: Conception and early experimentation

Sub-theme one: Early conceptualisation

In Olav Skille's early reflections on the effects of music on the body, the concept of the universality of music was discussed. For Skille, the connection between vibroacoustics and music is inescapable but the connection between music and the body can be difficult to define regardless of cultural background. Music can elicit several reactions in the body such as an emotional, physiological, or biochemical responses, e.g. happiness or sadness, increasing or decreasing muscular energy, heart rate, breathing, fatigue, and endocrine function. (Skille & Wigram, 1995.) Furthermore, Skille wrote: '*There must be elements in music which have effects on human beings that are independent of cultural differences in expression*' (1997, p. 235). One possible explanation for this is a study reported by Mannes (2011). She described experimentation conducted to observe how music can change heart rate and blood pressure. It seemed the rhythm of the heartbeat was syncing with that of the music; the faster the tempo of the music, the faster the heart would beat. This occurred no matter the genre, thus implying that it may not be the emotional connection to music per se, rather a connection to the speed, which elicits the physiological response.

From the early experimentation with low-frequency sound vibration, Skille explained that three elements can be empirically observed; relaxation is elicited through low frequencies, rhythmical music stimulates the body, and aggression results from loud music (Skille & Wigram, 1995). Skille pointed out (Interview, 2014) that, from his initial research, his

own body reacted the most significantly at frequencies 60 and 80Hz (Interview, 2014)[3]. Skille grounded this by drawing on the example of harmony and the Pythagorean scale in which 40Hz is one octave lower than 80Hz, and 60Hz a fifth above 40Hz. After much experimentation and practical work, he found that 40Hz was most useful for eliciting a massage-like effect and could be considered the basic frequency.

During these early musings on the effects elicited from various applications of different frequencies, Skille posited during the interview that if 40Hz is to be considered the body's basic general frequency, while 60 and 80Hz are also beneficial but in a localised manner, the concepts of harmony and the Pythagorean scale could explain why these particular frequencies are useful; the harmonic relationship between 40, 60, and 80Hz could help to define what seems to be a somewhat random assortment of frequencies. These speculations have been important for directing later research into the possible mechanism of VAT; Skille's early thoughts, through collaboration and discussions with other VAT practitioners and researchers, have helped to develop the empirical evidence into what is now known about the physical reactions the body has under VAT application.

Sub-theme two: Early issues

One of the early issues in VAT was noise pollution. In Skille's experimentation, the devices were crude, and restricted the amount of people that could be availing of the therapy at a given time (Interview, 2014). Thus the sound damping mechanisms were added. Although this is available in the Multivib - the Norwegian VAT system - and other vibroacoustic devices, the Physioacoustic system has not yet advanced to this point.

Another issue that was highlighted was the onset of asthma in subjects after being exposed to constant frequencies. (Contraindications are discussed later in more detail.) This led to the development of the ebb and flow, the swell, or the pulsations in the stimulus. This not only reduced the side effects, but the pulsations allowed the loudspeakers to last longer, as constant low-frequency stimulation had previously led to their destruction (Skille, Interview, 2014).

Skille experimented with various time intervals between each pulsation. 6.8 seconds was chosen because it neither interfered with breathing nor heart rates. He posited that this may lead to an increased feeling of safety and a higher possibility to relax and 'somehow feel life is streaming through your body'

[3] He later explained that 80Hz was irritating in an auditory sense and therefore his earlier focus turned to 60 and 40Hz (Personal communication, November 12, 2015).

(Skille, Interview, 2014). Skille connected the level of relaxation to our reptilian brains and basic survival skills. By relaxing and diminishing the fear of attack, we are able to allow changes to occur in the autonomic nervous system (Skille, Interview, 2014):

> *'When you are used to the frequency and the* [pulsation]*, you will not be surprised by anything. You can let your reptile brain take over because the reptile brain is somehow making changes in the autonomic nervous system if there is a danger coming, and dangers* […] *are sudden, but if we don't have the sudden things - just have it - we can relax...'*

The concept of *neuroception* (as coined by Porges, 2004) explains how our neural circuits determine how safe, or dangerous, a situation may be. These mechanisms are engaged regardless of whether we are cognitively aware of them or not, and so too, as a result, are our bodies' attempts to facilitate defensive mechanisms, i.e. fight, flight, or freeze. Porges furthermore explained that the nervous system is constantly activated in risk assessment (Porges, p. 20):

> *'Faulty neuroception - that is, an inaccurate assessment of the safety or danger of a situation - might contribute to the maladaptive physiological reactivity and the expression of defensive behaviors associated with specific psychiatric disorders'.*

In other words, if our nervous systems react to a safe environment by preparing for danger, the resultant responses will be counterproductive to the situation. Therefore, the application of sound vibration as a means of aiding in functional *neuroception*, the body can be more relaxed.

The term 'silent jogging' arose during the interview. Dr. Ralph Spintge, an MD, tested stress hormone reactions to VAT with pain patients and found that the hormone levels had risen during or after the VAT treatment. Although there were immediate or consequential effects, it seemed that the relaxation effect came a while after the stimulation had ceased. First came activation, then the body stabilised, and the effects were visible after a certain amount of time. 'silent jogging' refers to this delayed reaction. Other early results showed that heart rate and blood pressure reduced; people were able to relax and their anxiety was reduced. 'So after stimulation, relaxation comes. You don't have relaxation first'. (Skille, Interview, 2014.)

Sub-theme three: Duration

The duration of the treatment was based on the work of Pontwick and Teirich in their book *Musik in der Medizin* from 1958 (Skille, Interview, 2014). It served as an important information source for Skille during the early conceptualisation of VAT. These MDs had developed a music pillow and found that positive effects were achieved at 15 mins into the treatment, and after this time the effects ceased to increase.

Due to this, Skille chose to implement VAT for 23 mins in the early sessions, allowing some time each side of the treatment for discussion between client and practitioner. The treatment programmes nowadays, when implemented by certified vibroacoustic therapy practitioners, can be tailored to suit the client's particular needs and therefore vary in length, with a maintenance programme, for example, lasting 79 mins.

MP also suggested that the minimum duration of treatment should be 20 mins, but preferably 30 mins: *'Yeah, I think based on the clinical experience I say that 20 minutes is minimum. If there is a very stress-symptom patient I think 30 minutes would be better'* (MP, Interview, 2014).

Theme two: Current knowledge

Discussing the mechanisms of pain reduction as influenced by sound vibration raises the inescapable connection of vibration to music. Pain theories are inadequate to explain the influence that music has physiologically on the body and how this influence results in pain relief (Naghdi, Ahonen, Macario, and Bartel, 2015), however, Melzack (ibid. p. e22) suggested that the effects of music on the body were related to the 'brain mechanism-based body-self neuromatrix (NM)'. His earlier gate control theory somehow attempts to define the implications of music for pain relief in that stimulation of the 'nerve origin region of pain will serve to "close the gate" to the transmission of pain' and the stimulation of the mechano-receptors via low frequency sound vibration could be a way to block pain transmission (ibid.). Thus Naghdi and colleagues (2015) argue that by applying vibration directly to the body rather than through the auditory canals with music listening, the body is simulated and regulates the disrupted oscillatory network between the thalamus and cortex, a condition, which is characteristic of chronic pain conditions.

Direct application of low-frequency sound vibration has been shown to be effective for a wide variety of conditions (Skille, 1997) and the neuromatrix theory may explain how the vibrations affect the brain, for example, for pain management and relief. Further theories and speculations as to the efficacy of VAT relate to (1) the relaxation response, (2) neural inhibition, and (3) cellular cleansing (Punkanen & Ala-Ruona, 2012). The relaxation response relates to the targeted application of vibration to elicit relaxation, i.e. when a specific frequency is used for a particular body part, this muscle or muscle group will resonate with the frequency. This connects to Fernandez's (1997) description of sympathetic resonance. Neural inhibition, or the stimulation of Pacinian corpuscles, is induced by vibrations of 60Hz and higher via tactile stimulation, resulting in the pain messages to the brain being interrupted. This is based on Melzack and Wall's gate control theory (1965), leading towards the neuromatrix theory described earlier. Finally, another theory as to the efficacy of VAT is cellular cleansing. This effect, the Jindrak Postulate, is normally connected to effects of vibration on the brain, however could apply to all cells of the body experiencing the cleansing effect (Skille & Wigram, 1995). Deduced from this, the vibration could elicit a causal sequence of positive effects in the brain filtering to the rest of the body.

The postulations made on the functional mechanisms eliciting bodily effects are somewhat inconclusive; however by further delving into specific target groups and outcomes specific to certain symptoms, the evidence could point towards a source theory. The current knowledge - as described by Skille (Interview, 2014) - on vibroacoustics is also explained under several subthemes extrapolated from the interview. These are

(1) Frequencies
(2) Mechanisms
(3) Entrainment
(4) Target groups
(5) Programmes
(6) Training.

Sub-theme one: Frequencies

Most of the current anecdotal evidence on the efficacy of vibroacoustic therapy for various illnesses centres around 40 - 60Hz, with specific applications of 68Hz for brain-related issues, and neck/shoulder pains, and 40Hz being most effective for the bigger muscles. Skille pointed out that 40Hz could be considered the *'life frequency'* as it seems to be the basic frequency for creating balance and optimising bodily functions, acting in the same manner as a 'reset button'. He explained that

40Hz is '*the basic frequency for life, of somehow putting balance, order, and optimism into the body*' (Skille, Interview, 2014). Furthermore, frequencies lower than 40Hz are also connected with relaxation and general wellbeing. The interviewee expressed that 40Hz would be the frequency with which one could begin basic research. Returning the body to a state of homeostasis (as discussed by Benson, 1978) could perhaps explain the efficacy of VAT for patient groups such as Parkinson's disease (King, Almeida & Ahonen, 2009).

As is described above, vibroacoustic therapy is the therapeutic use of sound vibration. Understanding the mechanisms behind VAT may be possible through the juxtaposition of sound vibration with mechanical vibration applications. One such example is Whole Body Vibration (WBV), a type of mechanical vibration, which is 'low-amplitude (<10 mm) and low-frequency (<65Hz) mechanical stimulation of the human body for short durations (<30 min) to attain an effective and safe way to exercise musculoskeletal systems' (Albasini, 2010, p. 2). Albasini, Krause, and Rembitzki furthermore discussed the use of whole body vibration in relation to applications in physical therapy and sports rehabilitation. Skille described early experimentation with Petri Lehikoinen using 40Hz on the physioacoustic chair to treat an ice hockey player's symptoms of muscular overuse (as is presented later in sub-theme section *Target groups*). Although the player had been quite incapacitated, after the treatment he was able to return to training the next day (Skille, Interview, 2014). Explorations into the connection or disconnect between VAT/PA and WBV should be explored as the frequencies applied in WBV are close to the 40Hz 'life frequency' commonly used in VAT.

Sub-theme two: Mechanisms

Propositions as to the elicitation of physiological and emotional response from sound have been explored. Landreth and Landreth (1974) suggested that physiological reactions might be induced from changes in sound wave frequencies, amplitudes, and timbre, which are affected by our Central Nervous System. Alternatively the music may affect brain functions first, become involved in emotion centres and thought processes, later affecting physiology. A third proposition is that both these mechanisms work symbiotically. Watkins developed these propositions by saying that, because the locus ceruleus triggers the release of norepinephrine from our nerves and epinephrine from the adrenal medulla, thereby increasing anxiety, heart rate, and blood pressure, impulses triggered by music

may help to mediate these physiological elements (cited in Watkins, 1997).

As Mannes discussed (2011), some experiments conducted at the Cleveland Clinic measuring changes in heart rate and blood pressure found that these changes were relative to the music tempo, i.e. that the heart rate became faster and slower according to the tempo of the music. Others showed that the heart rate increases regardless of the genre. Succinctly, 'the interaction between music and our bodies is complicated and we're just beginning to understand how it works' (p. 21).

In a conversation between Bobby McFerrin and Brian Greene (as reported by Mannes, 2011), McFerrin queried whether music has the capability to get into your pores, in the same manner as it gets into your ears. This is a crucial concept in the field of music vibration and could explain the connection between music and vibroacoustic therapy, which has been so difficult to define. Skille, in his early conceptualisations of VAT, based his theories on the direct transferral of music to the body, rather like skipping the middleman, in an attempt to treat symptoms in a more direct manner. If music affects us physiologically, and since music is vibration and all objects vibrate according to the laws of physics, then the vibrations felt during VAT may be a much more direct and effective way to encourage physiological change: *'What will happen if we transfer sound directly to the muscles instead of going via the ear?'* (Skille, Interview, 2014).

Several other explanations have been posited as to the efficacy and mechanisms behind VAT, such as were discussed in the interview. These were not based on previous research, rather were Skille's theorisations or speculations based on clinical experiences.

As was described above, these have afforded further research and exploration into the mechanisms, and these theories have been much developed since the early self-experimentation conducted by Skille in the 1980s. These included the vibration working on the autonomic nervous system (ANS), activating the body's natural and innate healing mechanisms, the placebo effect, activation of the endocrine system, or hypothalamic effects. MP posited that the vibration could affect the ANS due to the relaxation response (Benson, 1978). In states of chronic stress or insomnia, the ANS is hyper-aroused and [MP] *'it seems that the first thing that happens is that the autonomic nervous system calms... calms down'* leading to cumulative physiological and emotional effects, such as improved mood and quality of sleep. Furthermore, in the interview, the ANS was suggested to be the first area for future basic research.

Skille also suggested that the effect from the vibration might be generated from the placebo effect. However, if sound vibration is more than 80% effective, he believes that the chance of the mechanism being related to the expectation of effectiveness is low. He suspects that there is a tangible explanation for this; testing hormone levels and the effect that vibration has on the endocrine system may give some additional pointers (Skille, Interview, 2014). Due to the lack of comprehensive basic knowledge on the efficacy of VAT, researching the phenomenon in relation to similar fields may give some indication as to where to begin testing.

Stress hormones ACTH, adrenaline, and cortisol are essential for survival by their role in the flight-or-fight mechanism; evidence suggests that the immune and neuroendocrine systems work to regulate themselves synchronously (Zoli et al., 2002). Not only do they affect our organs but also increase blood flow to the muscles and increase blood pressure. These hormones cause stress in the body, and music – or vibration – could be one way this effect can be reversed (Mannes, 2011). Furthermore, the effects of WBV are discussed in relation to hormones. In his doctoral dissertation, Cardinale (2002) showed that testosterone increased by 7%, growth hormones by 460%, and cortisol was reduced by 32% (cited by Albasini, Krause, & Rembitzki, 2010) after WBV had been applied.

Constant exposure to vibration during Skille's early experimentation led to negative results such as the development of asthma-like symptoms after prolonged constant exposure to singular frequencies; this was one reason for the addition of pulsation effect – his earlier experimentation showed that constant vibration is neither technologically feasible nor feels good for the body. These contraindications are discussed later in this article. Although the dosage for WBV and low-frequency sound vibration is different, the pulsation action may be a solution for the ill effects sometimes experienced after WBV (as was discussed by Albasini et al. 2010).

Sub-theme three: Entrainment

Entrainment, as was discussed in the interview (Skille, Interview, 2014), is one possible mechanism used by the body during VAT in order to reach a state of homeostasis and deep relaxation. During VAT, a pulsation mechanism is in place; the vibrations during VAT work in phases, meaning that there is a wave-like feeling in 6.8 second cycles. During the therapy, if one is in a state of hyper-arousal, or one is hyperventilating, the body seems to sync with these pulsations to the point of becoming relaxed; one noticeable

reaction is the regulation of breathing via syncing or entraining with the rhythm of the pulsation: *'this leads you to normal breathing'* [MP]. Often times, the argument as to the efficacy of music for relaxation or pain relief is that the listener uses the music as a method of distraction (as is discussed by Mitchell, MacDonald, & Brodie, 2006). The same could be explored in relation to VAT; by focusing on the rhythms of the pulsation, it may be that the body relaxes due to attention redirection.

Sub-theme four: Target groups

Target groups discussed during the interview were patients with (1) menstruation/menopausal symptoms, (2) chronic stress, (3) insomnia, (4) muscular overuse, and (5) large and small muscle targeting. Also mentioned, although these have not been tested, were work-related stress and exhaustion, and myalgic encephalomyelitis (Skille, EAR, & MP, Interview, 2014). Although it is unknown why VAT is effective for these, the case study results discussed in the dialogue show that, at least on an individual basis, the therapy can produce efficient results. In relation to menstruation symptoms, it seems that the bleeding is much more severe after VAT usage, but subsides much more quickly than without the treatment (MP, Interview, 2014).

Skille (Interview, 2014) stressed the importance of communication with the patients regardless of their specific reason for referral, as individual differences and variation in application should be considered; *'[…] and talk with the patients, and try to find some way of doing [the therapy]'*. This, too, connects to the need for proper training discussed later.

Muscular overuse, and the use of VAT to ease related symptoms, was mentioned in the interview regarding early experimentation conducted with Petri Lehikoinen, Skille's contemporary in sound vibration development. An ice hockey player was experiencing severe muscular pains, *'he wasn't almost able to move; he had terrible pains'* (Skille, Interview, 2014). After one treatment session, he was able to return to training the next day.

Much research is currently being conducted in Canada into the effects of VAT for various target groups, and results from earlier studies on Parkinson's disease (King, Almeida, & Ahonen, 2009), and fibromyalgia (Naghdi, Ahonen, Macario, & Bartel, 2015) have shown positive results relating to VAT application. It was also suggested that future research should look towards work-related stress, exhaustion, and myalgic encephalomyelitis (EAR, Interview, 2014).

One example of contraindications that arose was the appearance of asthma symptoms after longer exposure to constant vibration. Skille (Interview, 2014) described this in relation to the prolonged use of sound vibration without the pulsation effect; the patients will begin to feel undesirable counter-effects. Another such contra-indication was discussed in terms of inexperienced practitioners being unable to provide the correct amount of sound vibration suitable for each particular client. It was proposed that proper training is needed in order for the practitioner to be aware of possible contraindications and negative symptoms arising from prolonged stimulation or stimulation that is too strong. (The training required to become a VAT practitioner is outlined under *Sub-theme 6*).

Sub-theme five: Programmes

Skille developed many programmes of varying intensity and duration. One such programme discussed in the interview is that which he has named the *Maintenance programme.* It lasts 79 mins and begins at 68Hz, gradually lowering to 40Hz over the entire programme duration. Skille (Interview, 2014) spoke of the calming effect that is felt from the downward glissando, as the transitioning from the highest frequency to the lowest, is slow-paced. The body adapts to this slow frequency de-cent and relaxes over time. The opposite seems to be true based on anecdotal evidence; an upward glissando acts as a stressor for the body.

Additionally, other frequencies are experienced by the body in addition to 68 and 40Hz due to this glissando effect *'…So it crosses all the other frequencies on its way down'* (Skille, Interview, 2014); in this way, if one has multiple issues such as neck pain (68Hz), lower back pain (52Hz) and is in need of general relaxation (40Hz), all of these can be targeted in one treatment. Skille, EAR, and MP discussed that specialisation training, as can be completed at the VIBRAC Skille-Lehikoinen Centre for Vibroacoustic Therapy and Research in Jyväskylä as described below, is highly important (Interview, 2014).

Once a practitioner has completed this training and has become certified, it is possible to alter the programmes to suit the needs of a particular client, however sufficient training must be completed before one can begin to use VAT in practice.

Sub-theme six: Training

Training for the practice of VAT is needed. Currently, training to become a VAT practitioner is offered in the VIBRAC Skille-Lehikoinen Centre for Vibroacoustic Therapy and Research, administrated by the Eino Roiha Foundation in Jyväskylä, Finland. The training consists of three levels. These are outlined in the Table 2 below.

Table 2. Training levels and VAT practitioner certification

	Level 1	**Level 2**	**Level 2**	**Level 2**	**Bridge**	**Level 3**
Level breakdown	*Introduction*	*Practitioner I*	*Practitioner II*	*Practitioner III*		*Advanced practitioner*
Duration	2 days 14 contact hrs, 14 independent hrs	4 days, 28 contact hrs	3 months, 56 hrs	4 days, 28 contact hrs + 56 independent study hrs	Independent clinical practice	4 days, 28 contact hrs + 56 independent study hrs
Mode	Lectures Demos Discussions	Lectures Demos Exercises Discussions	Independent studies & exercises with peer partner; Clinical practice 10 VAT sessions with a client	Lectures Demos Exercises Discussions Case consultation		Lectures Demos Exercises Discussions Case consultation
Supplements		Reading package	Study diary & reflective report	Internship under supervision, case report	Clinical practice (minimum 4 cases, 10 sessions each)	Reading package and assignments
Outcome	Basic theoretical knowledge			Certified VIBRAC practitioner	Requirement for level 3	Certified Advanced VIBRAC practitioner

From VIBRAC Skille-Lehikoinen Centre for Vibroacoustic Therapy and Research orientation lecture (2014).

As can be seen above, participants in the training courses are certified practitioners after having completed Level II. Until this point, the training Levels II and III have taken place in Finnish; however the first international VAT training in Level II is planned to take place in 2016. Skille, EAR, and MP raised several concerns in relation to VAT application and practice. Individual variation is quite high in terms of how people react physiologically to the stimulus; therefore is it essential that the practitioner has completed the training modules and is equipped to deal with these variations. At times the effects can be immediately positive; others experience negative reactions at first, which gradually mature into positive outcomes, which has been discussed earlier. In these instances, the practitioner should have experience in and knowledge of the basic effects of VAT.

Theme three: Future research directions

Sub-theme one: Experimentation

Currently, the research into VAT, as has been discussed earlier, has been mostly in the form of case studies. This is valuable information for creating a foundation upon which further studies can be based. However, due to the high levels of individual variation in anecdotal results, more concrete measurements must be taken in order to ascertain the type of effects felt by particular target groups, whether these are generalisable, and duration of effect.

Specific target groups for further research as discussed by Skille, EAR, and MP included those suffering from work-related stress, exhaustion, and myalgic encephalomyelitis. Musculoskeletal pain costs amount to €1.1 billion annually in Finland (Mäntyselkä et al., 2011) and work related upper limb musculoskeletal disorders (WURLDs), i.e. neck and shoulder pain, is estimated to cost between 0.5% and 2% of Gross National Product in the Nordic Countries and the Netherlands (Buckle & Devereux, 1999). Using the Disability Adjusted Life Years (DALYs) measurement, in which 1 measure relates to the loss of 1 'healthy' year, countries such as Finland and Luxembourg have a higher average number of DALYs due to falls relating to osteoarthritis, and for these countries, including those such as Austria, Croatia, Denmark, France, Germany, Ireland, and others, musculoskeletal diseases are the 'third largest cause of disability from non-communicable diseases' (*Musculoskeletal Health in Europe, Report v5.0,* p. 58). Furthermore, in Finland the prevalence of musculoskeletal pain in adolescents is related to longer periods of sedentary behaviours, and emotional and behavioural problems (Jussila et al., 2014). Due to

the prevalence of musculoskeletal issues based on statistics from the Finnish Institute of Occupational Health, the discussion in the interview centred on VAT being targeted towards those statistically likely to suffer from neck/shoulder pain, e.g. office workers. This, it was posited, would have a high societal impact, socially and economically, e.g. in terms of ability to return to work (EAR, Interview, 2014).

This sort of pre-emptive treatment, or preventive care, was further discussed in relation to menstruation pains. Skille explained that building a treatment plan tailored specifically to a woman based on her own cycle would improve general life quality. Indeed, consultation and collaboration with MDs, specifically gynaecologists, would aid in designing the procedure. Essentially, this shows the great need for collaboration with those knowledgeable in various fields in order to work under best practice principles. (Skille, Interview, 2014).

Sub-theme two: Measurements and reporting

One such measurement, which could be used, as was discussed in the interview, is heart rate variability (HRV). This measurement is used to measure autonomic influence on the cardiovascular system and functions as a 'predictor of risk or warning sign of cardiovascular diseases [...] hypertension, development of diabetic neuropathy, cerebrovascular disease, congestive heart failure, and lethal arrhythmic complications after an acute myocardial infaction' (Terathongkum & Pickler, 2004, p. 78). Skille suggested that the measuring of the patient before and after the session and the following of a set protocol would be a good start. The perk of measuring HRV is the linear nature thereof; it is an on-going measurement, continuously capturing data (EAR, Interview, 2014). Furthermore, MP explained (Interview, 2014) that HRV is now commonly used for measuring the autonomic nervous system. Additionally, collecting and collating data from practitioners worldwide would aid in the systematic understanding and reporting of how VAT affects the body.

The most crucial issue, which arose in the discussion on future research and application of VAT, is the need to begin with simple measurements (i.e. HRV, blood pressure, pulse) and with a basic frequency (i.e. 40Hz, the 'life frequency'). Skille told that he had been experimenting with many frequencies, layering, and complicating the data; by returning to more basic structures, e.g. applying only one frequency – 40Hz – it was possible to understand how the body reacts to only one stimulus. A clearer picture of the applications can result from this sort of basic

practice and the application of only one frequency (again, 40Hz) has been shown to be beneficial for fibromyalgia patients (Naghdi et al., 2015). This highlights the importance of simplicity in exploration rather than over-complication of the procedure (Skille, Interview, 2014).

Sub-theme three: Collaboration

Skille, EAR, and MP discussed the collaborative possibilities linked to vibroacoustic therapy and medical education institutes. Although a strong emphasis was made on the progress that has been made through case studies and the gathering of anecdotal and empirical evidence, Skille (Interview, 2014) stressed the importance of collaboration with novice doctors. By entering medical teaching institutes, spreading knowledge as to the efficacy of VAT for a plethora of target groups, and connecting the already available anecdotal evidence to physiological test results, the research into and application of low-frequency sound vibration would grow. Skille and the interviewers posited that this would be an important step forward in the promotion of vibroacoustic therapy as a treatment within medical settings (Skille, EAR, & MP, Interview, 2014).

This has been successful in some cases, such as can be seen through the open communication between the vibroacoustic therapist, pain specialising psychologist, and MDs at Seinäjoki Hospital, South Ostrobothnia. This relationship has been fostered through collaboration leading to the accumulation of many case studies on target groups such as depression, pain, physical rehabilitation, and insomnia. The use of pre-existing professional connections is discussed as being a useful method for developing the educational foundation of MDs interested in the effects of vibration for health outcomes. By presenting VAT at educational institutions, basic information could easily be transmitted thereby planting seeds for later collaboration.

The referral system functions well in Seinäjoki, meaning that the metaphorical gates are open between therapists and MDs. Distributing information at an earlier stage is presented as a way to open connections between the university and hospital; Skille suggested that these ties could be made by holding workshops at universities, thereby spreading information systematically. The collaboration possibilities will furthermore be developed at the 1st International VIBRAC Conference to take place in Lahti, Finland, in October 2016. Since the foundation of the VIBRAC Skille-Lehikoinen Centre for Vibroacoustic Therapy and Research in 2012, the possibilities of VAT application have been growing. This is a promising development, as Skille

explained that collaboration is an integral part in the furthering of VAT application and understanding (Interview, 2014).

When questioned as to his thoughts on the future of VAT in five or ten years, Skille answered that he hoped VAT would be a part of the basic referral repertory of MDs and physiotherapists. Again, the importance of collaboration for the development of vibroacoustic therapy was addressed. Skille explained that his meeting Petri Lehikoinen – the Finnish forerunner of sound vibration research and application – in Jyväskylä helped to develop ideas and education and refine the methods and tools, something which he 'could never have done alone' (Interview, 2014). Skille described the current situation of vibroacoustic therapy as a half-reality; in his work and collaboration with Lehikoinen (and others such as Tony Wigram) VAT moved from a dream into its current state, however, in order to further progress the field, VAT must be systematically available to and used by various healthcare professionals. 'Intellectual capital' is currently in our possession, said Skille (Interview, 2014). This needs to be honed with other professionals in order to further the research and practice of VAT.

Discussion and conclusion

The development of VAT since its conception has been in some areas swift and in others lacking. Until recently, the vast amount of evidence available on the efficacy of VAT for various target groups has been in the format of case studies, rather than of high quality randomised controlled trials in which the effects of the treatment can be quantified and presented systematically. Although case studies are valuable sources of information on the individuals or small group's reaction to the treatment, various forms of evidence should be presented. This has begun to change with the emergence of articles discussing the use of sound vibration for Parkinson's Disease, depression, Fibromyalgia Syndrome, blood circulation, bone metabolism, and functional capacity (King, Almeida, & Ahonen, 2009; Koike, Hoshitani, Tabata, Seki, Nishimura, & Kano, 2012; Naghdi, Ahonen, Macario, & Bartel, 2015; and Zheng et al., 2009) and with this emergence of new evidence, the foundations upon which future research can rest will be much more secure. Although case studies offer an interesting insight into the small-scale effects and individual variation known to emerge after VAT treatment, generalisability is somewhat lacking and in order to increase

probability of collaboration possibilities in medical settings, effect sizes should be presented.

It is clear that more evidence is needed to broaden the understanding into the mechanisms behind sound vibration, in order to comprehend on a deeper level how the body is affected by various frequencies and how these results can apply to a larger amount of clients. As it stands, knowledge on VAT has been fed from many different fields and the gaps in the understanding show that collaboration with healthcare professionals is necessary.

Future studies should focus on the applicability and efficacy of sound vibration for target groups such as musculoskeletal pain patients, work-related stress, insomnia, and chronic fatigue syndrome/myalgic encephalomyelitis patients, as was discussed by Skille, EAR, and MP in the interview. These should be conducted by assessing the outcomes from basic frequency application (e.g. 40Hz) in order to ascertain efficacy and duration of effects. These studies should also attempt to provide evidence on both physiological and emotional outcomes, as VAT is often referred to as being a therapeutic approach with the focus being on the client as a whole, rather than being a unilateral treatment.

Conflicting information also exists, i.e. the variance in effect felt by patients undergoing WBV treatment in which frequencies such as 30Hz have been reported to be ineffective, compared to the reported efficacy of frequencies ranging from 40 - 29Hz which are continuously implemented by VAT practitioners in Norway in descending glissando maintenance programmes (Skille, Interview, 2014). These discrepancies could lead to misunderstanding as to the effect VAT can have and therefore it is crucial to address these issues in future research.

In conclusion, although much is known as to the physiological and psychological effects of VAT, more research into the mechanisms behind its efficacy is needed, in addition to building fruitful and constructive collaborative relationships with practitioners and professionals from the medical field.

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II

VIBROACOUSTIC TREATMENT FOR CHRONIC PAIN AND MOOD DISORDERS IN A SPECIALISED HEALTHCARE SETTING

by

Elsa A. Campbell, Jouko Hynynen, & Esa Ala-Ruona, 2017

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Vibroacoustic Treatment for Chronic Pain and Mood Disorders in a Specialized Healthcare Setting

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Abstract

Much of what we know about vibroacoustic (VA) treatment and its efficacy has been published in case reports. Recent clinical trials have increased awareness of this treatment for target groups such as those with Parkinson's Disease and Fibromyalgia Syndrome. Protocols for using VA treatment have not been concreticized although there has been a focus on using 40Hz. Seinäjoki Central Hospital has used VA treatment for more than two decades, with patient reports on Visual Analogue Scales being systematically recorded and showing positive outcomes on several measures including pain and mood. This treatment is offered on the rehabilitation unit as part of specialized heathcare in the South Ostrobothnia healthcare district in Finland. This paper describes VA treatment utilized within this unit, with a focus on pain and mood outcomes as reported by subjective patient reports, and practitioner and patient comments.

Keywords: ***vibroacoustic treatment, chronic pain, mood, music listening*** multilingual abstract | **mmd.iammonline.com**

Introduction

According to the World Health Organization, 1 in every 15 Europeans suffers from major depression, whilst anxiety affects nearly 4 out of 15 people, with rates in women significantly higher than in men [1]. Furthermore, musculoskeletal pain is prevalent, with one fifth of adult populations reporting widespread pain, one third experiencing shoulder pain, and up to one half suffering from lower back pain [2]. Musculoskeletal conditions are the most common reason for chronic pain and disability in the EU and lead to significant healthcare and social costs. Interest in using music interventions within medical settings has been growing in the past decades. Vibroacoustic treatment is an example of such an intervention, yet an exploration of this used within a multidisciplinary team has been sparsely reported.

Vibroacoustic (VA) treatment – otherwise known as Vibroacoustic Therapy (VAT), Physioacoustic Therapy (PAT), and Rhythmic Sensory Stimulation (RSS) – is low frequency (30–120Hz) sound vibration, with music listening, applied for therapeutic purposes [3]. It has been shown to increase pressure-to-pain thresholds [4], to increase ability to work, improve quality of sleep, and help in reducing or discontinuing analgesic consumption [5] in people with fibromyalgia. VA treatment has also been shown to improve cognition in Alzheimer's patients [6], and decrease pain [7] and improve functional capacity, and increase blood circulation in the elderly [8]. Improved passive range of motion during physical therapy [9], and improved mood, coping skills, and concentration have also been reported [10], among others. The range of applications indicates VA treatment could be a useful addition to multidisciplinary healthcare practice.

Mechanisms

Pain mechanisms are not well understood. Continued nociception can lead to dysfunction in the messages conveyed to the central nervous system. These changes indicate plasticity in the nervous system, perhaps leading to neural sensitization. The Neuromatrix Theory proposes the importance of learned responses to persistent pain. It is suggested that pain may be suppressed by sensory and evaluative processes, as well as by the activation of our endogenous opioid system [11]. The cumulative negative effects of stress are argued to account for individuality in pain responses, thereby highlighting a person's personal pain history as a factor in their present-day pain responses.

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Chronic pain has been shown to alter thalamocortical connections resulting in disrupted thalamic neuronal behavior [12]. VA treatment may drive neural rhythmic oscillatory activity, thereby resetting this dysrhythmia [5]. Relaxation is one of the effects reported by patients and is described as resonant oscillation achieved by the targeted area's specific frequency matching that of the low frequency sound [13]. Increasing relaxation and decreasing stress may help to regulate or reset pain responses that have been learned over time.

Rehabilitation within Specialized Healthcare at Seinäjoki Central Hospital

VA treatment is offered as part of specialized healthcare at the rehabilitation unit of Seinäjoki Central Hospital in Ostrobothnia, Finland, by a full-time VIBRAC-practitioner.[1] (Although the general protocol for these patients will be discussed in this paper, further information on the treatment protocol used at this facility can be found in a clinical report on pages 184-186 of this issue.) This multi-modal treatment setting is used to treat either in- or outpatients whose multiple symptoms have been especially difficult to treat. These patients may have received previous treatments, yet their symptoms persisted. Patients referred to this unit suffer from various physical, psychological, and emotional symptoms. Multidisciplinary rehabilitation programmes are beneficial in addressing sensory, physiological, emotional, and social issues, and can be a catalyst for patients' discharge after intensive multidisciplinary rehabilitation [14]. Such outcomes work towards increasing patient autonomy; Bettger and Stineman [ibid.] also explained that measures of depression, anxiety, or stress could be important elements to consider in understanding how patients react to an intervention.

This paper presents the use of VA treatment for pain and mood disorders within the specialized healthcare rehabilitation unit at Seinäjoki Central Hospital. These cases are extracted from a naturalistic setting, meaning there was no control group for comparison. These rich data afford a unique opportunity to examine VA treatment use within a medical setting.

2. Method and Materials

Case reports and VAS measurements from 29 chronic musculoskeletal pain patients with comorbidities of mood disorders treated within specialised rehabilitation during 2014-2015 were selected. As per standard protocol, the patients' pre- and post-treatment outcomes were recorded using Visual Analogue Scales (VAS) assessing general arousal, vitality, mood, relaxation, pain, sleep quality, range of movement, limb temperature, and quality of life. A VAS is a single-item continuous scale consisting of a horizontal 100-millimeter line, which is anchored by two descriptors. These scales are self-administered, with patients asked to mark a perpendicular line at the point that best represents their current state. This is then measured with a ruler to determine the numerical value [15].

The anchors for the pain VAS were *unbearable pain* and *no pain*, and *depressed* and *happy* for mood. The pre- and post-treatment measurements were recorded as part of standard hospital protocol, as such that the patient does not see the pre-treatment measurement when completing the post-treatment scale. In addition to these VAS outcomes, the VIBRAC-practitioner took general notes on the patients' state and recorded their statements/reactions to the treatment (see Table 4).

2.1. Treatment Protocol

Patients typically receive 10 weekly sessions. This varies depending on the patients' individual needs however and they may initially receive treatment twice a week. The patient receives the treatment in a Physioacoustic chair (Next Wave), a recliner with in-built loudspeakers located at the neck, back, thighs, and calves. The low frequency sound waves are computer-generated and controlled, and are transmitted through loudspeakers built into the chair. The stimulation software used at this healthcare unit is Sonus Health Editor v3.26c. In this system, the frequencies range from 27.13–113.22 Hz. The device is approved by the Food and Drug Administration (FDA) in the USA, the Canadian Standards Association (CSA), and the British Standards Institution (BSI), and is classified as class-II, low risk, and non-invasive. Three claims are permissible: muscle relaxation, stress and pain reduction, and increased blood and lymphatic circulation.

The program parameters include time, frequency, scan, speed, cycle (or pulsation), strength, and action (direction). The programme is divided into phases of various lengths measured in minutes. The frequencies are measured in Hertz (Hz) and range from 29.15–61.04 Hz. Scan refers to the range of frequencies above and below the fundamental frequencies in each phase, which is done so as to avoid numbness. For example, in phase 1 of this programme, the fundamental frequency was 40.27 Hz and the scanning action moved from 39.26–41.34 Hz. Speed refers to how fast the frequencies in this scanning action change. Here, the frequencies modulated every 16 seconds. Cycle is the speed of the pulsation (volume change). This varies from silence (amplitude = 0 dB) to the set maximum ($n > 0$ dB), then returning to silence. The length of this pulsation cycle was an average of 11.09 seconds (range 7.76–16.25 seconds). The strength of the program is set for each speaker location. These values are presented as dBC (decibels relative to the carrier) and were 53.6–103.1 dBC,

[1] The VIBRAC-practitioner has been trained by the VIBRAC Skille-Lehikoinen Centre for Vibroacoustic Therapy and Research.

52.6–103.9 dBC, 56.5–108.2 dBC, and 59.7–103.5 dBC for the neck/shoulders, back, thighs, and calves respectively. Finally, action refers to whether the sound moves from head to toe, or vice versa. The direction varied almost every second phase, except for the last phase in which there was no directional movement. The speed of the direction is also influenced by the cycle: the faster the cycle, the faster the directional movement.

Music listening is often part of the treatment and patients listen either by headphones or via speakers. They were asked what kind of music they would like to listen to and instructed to choose music that relaxes them. If they did not have anything in particular in mind, the practitioner offered suggestions. Usually they decided to listen to instrumental/classical music, however client preference also meant that patients chose to listen to more rhythmic music such as heavy/symphonic metal. All patients presented here listened to music during their treatment sessions; the full discography of music choices is shown in Appendix A presented according to genre.

Music is used in addition to the low frequency sound to encourage relaxation and as a means of offering a multi-modal treatment experience. As described by Chesky and Michel [4], this combination takes a "two-pronged" approach to pain management, with the music listening working on a psychological level, and the physiology being affected by the transcutaneous- applied sound vibration. The low frequency sound vibration works on its own, however the experience is enriched when music listening is also a part of the treatment. Patients have the choice whether they would like to listen to music or not and it may occur that clients wish to listen to music through the speakers whilst talking with the practitioner about their illness/situation throughout the treatment program.

A session typically begins with a discussion between the VIBRAC-practitioner and the patient, followed by the VA treatment with music listening, and again ending with a discussion on the potential sensations, experiences, and/or emotions evoked during the treatment. The choice of program and frequencies administered is also based on the patients' diagnoses, but the strength of the program can be varied during the treatment program if a patient feels the stimulation to be either too much or too little. The most commonly used programme is *General Relaxation*, which centers around 40 Hz, lasting usually between 20–40 minutes. The program used with these patients ranged from 27.13–61.04 Hz and lasted 36 minutes. This programme is most often used at this facility as it tends to elicit a strong relaxation response, and clinical practice has shown patients tend to respond better to frequencies within the lower frequencies of the 27.17–133.22 Hz range. If a patient responds especially well to a particular frequency, this part may be lengthened. The program is usually started at a lower intensity when a client begins these sessions to avoid possible side effects and so the client becomes accustomed to the sensation.

The VAS outcomes, the practitioner's clinical observations, patients' comments, and the music listening choices are recorded in an electronic medical record system. In interpreting these VAS outcomes, the minimal clinically important difference (MCID) was selected. MCIDs are scores that reflect changes that are meaningful for a patient. Although caution should be used when applying this principle to group scores, these may nevertheless show a general trend. Accepted changes in numerical rating scales for pain intensity are 10mm reduction corresponding to a minimally important change, and 20–27mm reduction associated with fewer requests for medication and relating to "much" or "some" improvement [16]. As there is no way to determine group differences in these data (because there is no control condition), the MCID is applied here only as a means of attempting to contextualize the outcomes reported.

Results

Data on 29 patients treated during 2014–2015 are presented. They received treatment for chronic musculoskeletal pain, depression, anxiety, or a combination. The demographic data are shown in Table 1. As this was part of multidisciplinary rehabilitation, some patients underwent other treatments simultaneously, which does not allow for efficacy assessment, rather gives a picture of VA treatment protocol within a specialized healthcare unit. All patients presented in this study listened to music during their treatments.

Table 1. *Demographic data, other treatments, and medication intake*

Characteristics of n=29 patients	
Age [Mean (SD)]	49.67(10.92)
Gender [n (%)]	
Female	19 (65.52)
Male	10 (34.48)
Weight in kilograms [Mean (SD)]	86.55 (23.09)
n (%) undergoing other treatments:	21 (72.41)
Physiotherapy	11 (37.93)
Psychotherapy	4 (13.79)
Intermittent massage	1 (3.45)
Discussions with/support from a psychiatric nurse	4 (13.79)
n (%) taking medication	26 (89.66)
n (%) of these taking:	
Analgesics & mood regulators	11 (42.31)
Analgesics alone	4 (17.39)
Mood regulators alone (anti-depressants, anti-psychotics, anti-anxiety)	5 (21.74)
Other (hypertension, insomnia, muscle relaxants)	8 (34.78)

89.66% of patients were taking medication in addition to VA treatment, with 42% of these patients taking a combination of analgesics and mood regulators. 72.41% of patients also received other treatments before, during, or after VA treatment. For patients in need of psychotherapy, the waiting list is quite long and is separately organised and coordinated by the Finnish Social Insurance Institution, Kela. Data are not available if the patient was undergoing psychotherapy elsewhere. As discussed earlier, all patients listened to music during their sessions, with these choices ranging from heavy metal to ambient/easy listening. Table 2 outlines these patients' psychological and physical symptoms. Some VIBRAC-practitioner clinical observations and patients' comments are presented in Table 4.

Table 2. *Most common symptoms*

Symptom category	Descriptor
Psychological symptoms	Depression, social anxiety disorder, panic attacks, somatic symptom disorder, Obsessive Compulsive Disorder, trauma-related symptoms
Physical symptoms	Rheumatoid arthritis, spondylitis, osteoarthritis, neck tension, neck/shoulder pain, upper arm pain, Degenerative Disc Disease, neck tension, fibromyalgia, chronic pain syndrome, whiplash

Of the 29 patients presented, 23 received VA treatment in one phase (monophasic), whilst 6 patients returned for a second series of VA treatment sessions after a pause (biphasic). After preliminary analysis, in order to better understand the patients' outcomes – and because post-treatment relaxation is reported by most patients – the relaxation VAS pre- and post-treatment measures were also extracted. Table 3 shows the mean improvement (in mm) and standard deviations from baseline to the final pain, mood, and relaxation assessments for patients who received treatment in both one and two phases.

Table 3. *Average VAS improvements in mm*

Groups	Mean (SD)		
	Pain	Mood	Relaxation
Monophasic patients' scores (n=23)	18.96 (25.37)	16 (16.45)	34.22 (26.42)
Biphasic patients' scores (n=6)			
Phase 1	16.83 (13.41)	21.5 (18.81)	37.83 (21.57)
Phase 2	10.67 (17.87)	0.67 (8.40)	29.33 (14.99)

Monophasic patients' data are presented as VAS pre- and post-treatment scores for pain (Figure 1), mood (Figure 2), and relaxation (Figure 3).

Monophasic patients

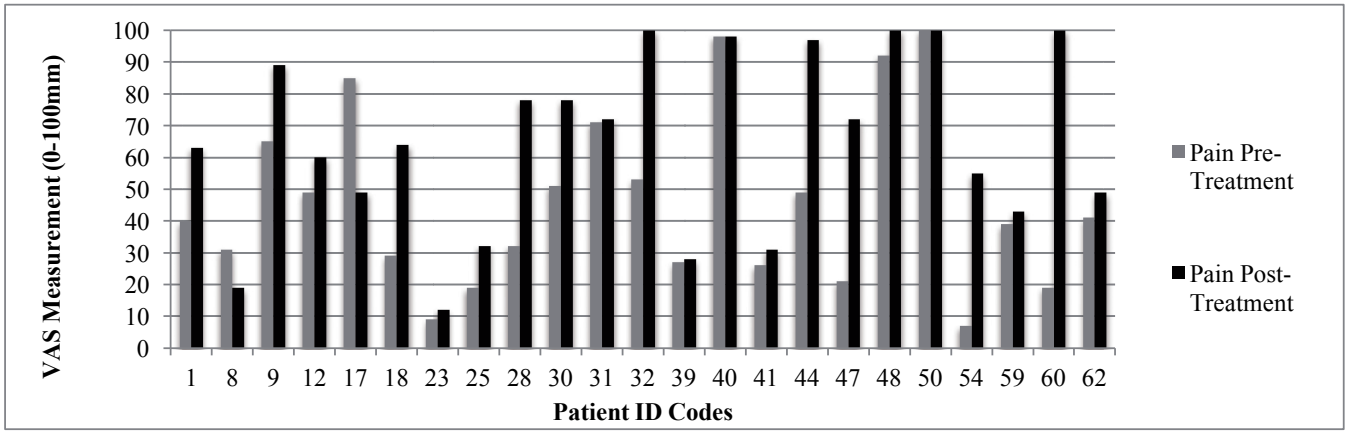

Figure 1. *Monophasic patients' (n=23) pain levels pre- and post-treatment*

The majority of patients (n=23) received treatment in one phase, with a mean mm improvement (and standard deviation) of 18.96 (25.37) in pain, and 16 (16.45) in mood, corresponding to a minimal–moderate MCID. Some patients reported quite drastic pain improvements, with similar improvements in relaxation (Figure 3), as shown by, for

example, patient 60. Others presented a worsening in pain levels (e.g. patient 17) but an improvement in mood (Figure 2) and relaxation (Figure 3).

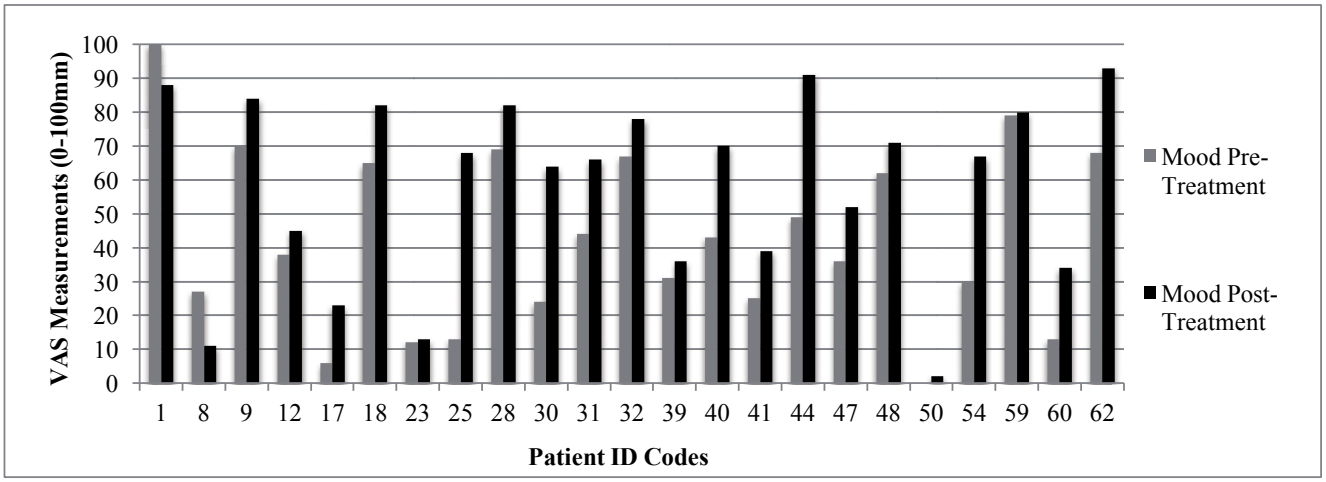

Figure 2. *Monophasic patients' (n=23) mood levels pre- and post-treatment.*

Although patient 23 reported barely any improvement in pain or mood, her relaxation score had very much improved after the treatment. As with many of these patients, it is clear that relaxation is a relevant factor. The small sample size prevents any in-depth or subgroup analyses.

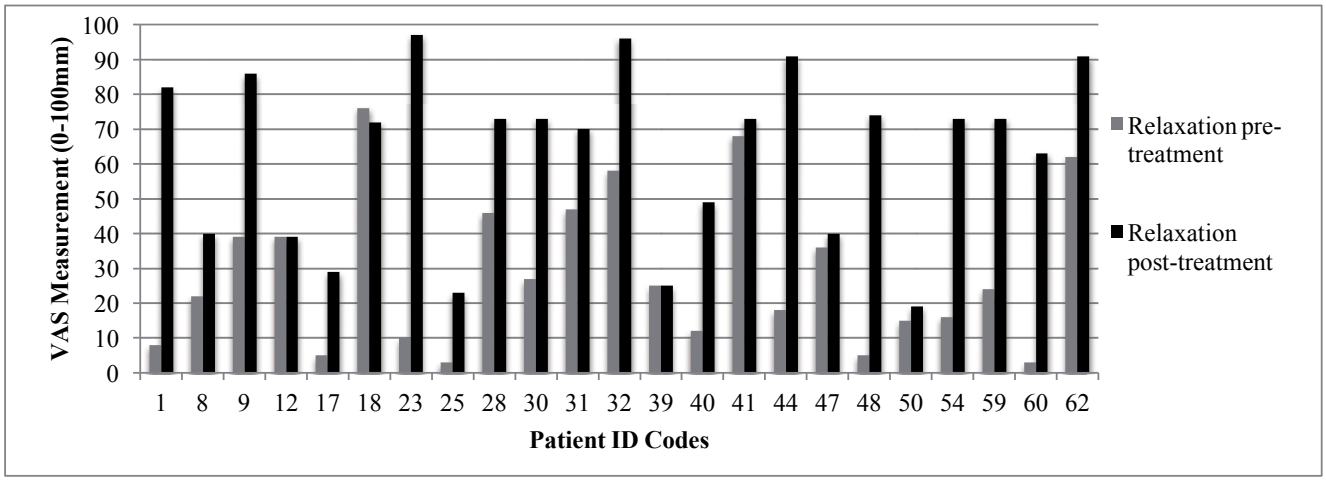

Figure 3. *Monophasic patients' (n=23) relaxation levels pre- and post-treatment.*

Biphasic patients

For patients who received treatment in two phases (n=6), the results are presented according to the pre- and post-treatment pain (Figure 4), mood (Figure 5), and relaxation (Figure 6) outcomes for the first and second treatment periods. Each

grouping of four columns represents one individual patient's outcomes.

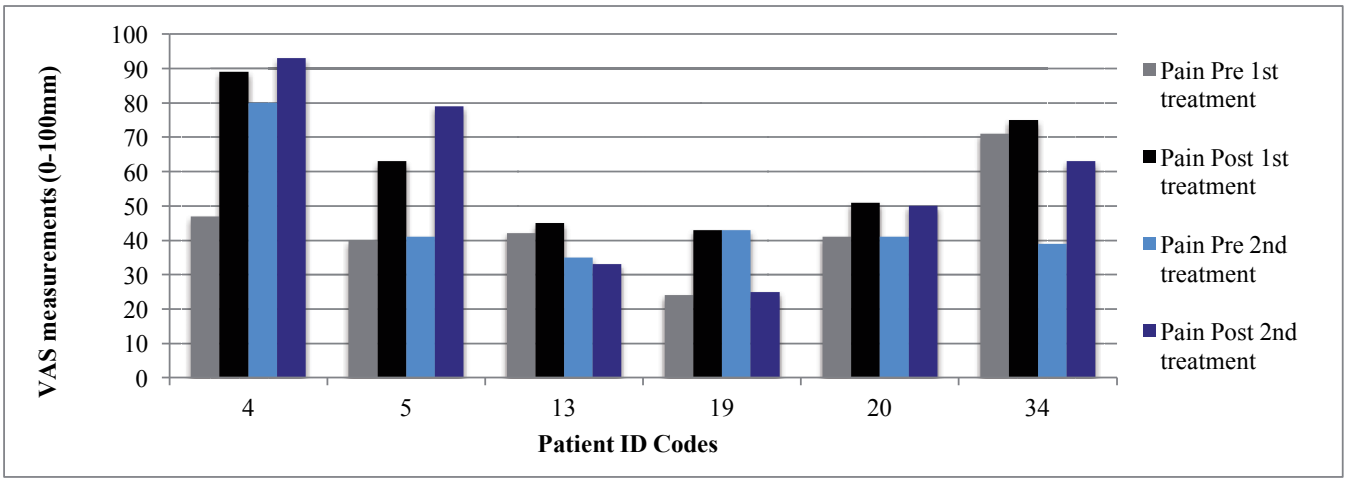

Figure 4. *Biphasic patients' (n=6) pain levels pre- and post- treatment*

Again, the scores showed – to some degree – improvement in pain scores, however, these remain somewhat difficult to interpret conclusively. Patient 19 shows improved pain post-phase 1, which then returns to baseline post-phase 2. A slight decrease is also reported in mood scores. Contextualizing the pain and mood outcomes within those of relaxation help to give a clearer picture. This patient appeared much more relaxed after both phases 1 and 2, leaning towards a positive outcome for this individual.

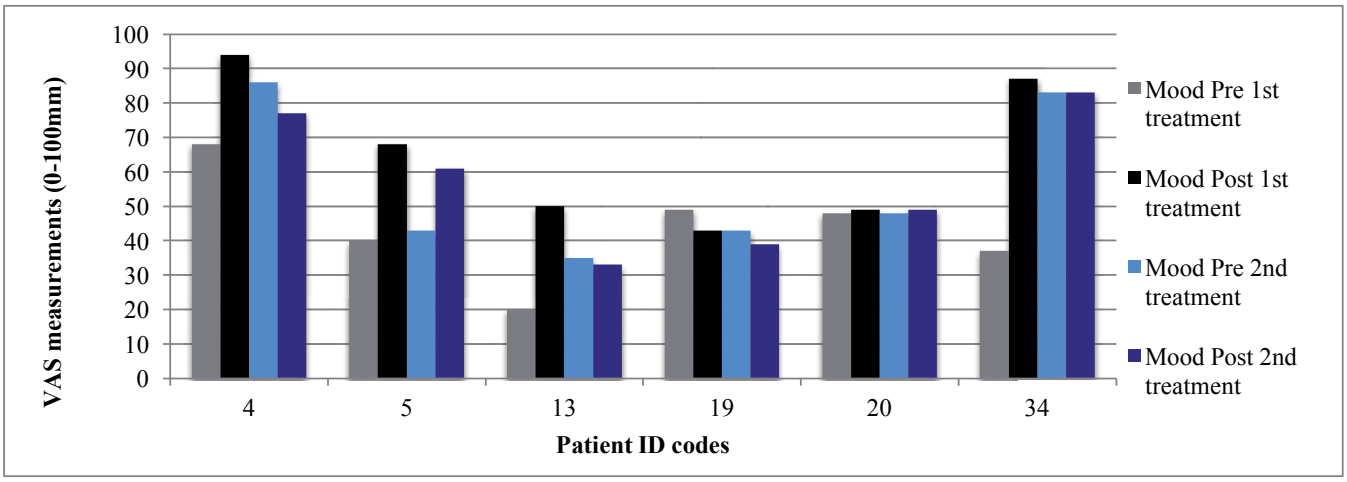

Figure 5. *Biphasic patients' (n=6) mood levels pre- and post- treatment*

Again, patient 20 shows that the relaxation outcomes reflect another dimension to the pain symptoms and mood disorder, thereby highlighting the importance of appreciating the patient's pain story in its entirety.

However, the relaxation outcomes did not consistently clarify the pain or mood outcomes. Patient 13 reported deterioration in pain and mood, but relaxation remained somewhat similar after both phases. This patient presented with fibromyalgia and comorbid depression; the difficulty in treating this syndrome is highlighted by this patient's VAS scores. She reported feeling much better afterwards, especially the day of and day after receiving the low frequency sound stimulation. This improvement, the practitioner noted, was not reflected in the VAS reports.

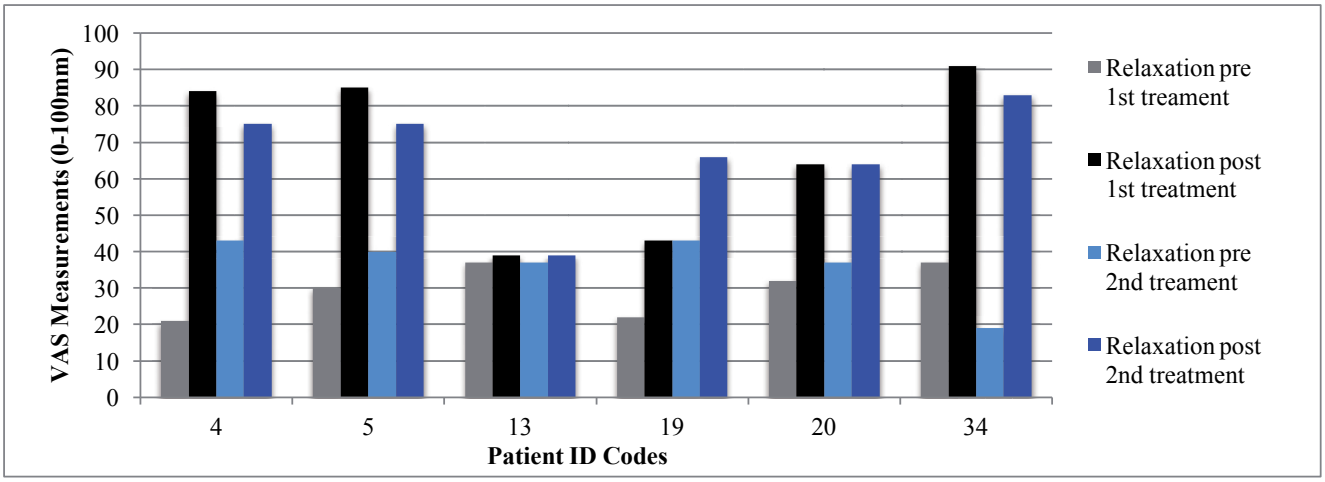

Figure 6. *Biphasic patients' (n=6) relaxation levels pre- and post- treatment*

The pain, mood, and relaxation scores across all patients (n=29) show quite a lot of individual variation. VAS and verbal reports made by the same patient were sometimes antagonistic; even if the VAS outcomes showed very little improvement, the patients verbally expressed feeling better after the treatment. Some of these verbal reports are presented in Table 4.

Table 4. *Patient responses and practitioner notes on the treatment.*

Pain relief
Significant improvement in the situation; easier to undergo physiotherapy in the absence of pain.
Relaxation
Easier to fall asleep; surprised at the ability to relax; improved mood; improvement in neck/shoulder tension.
Reduction in medication
Reduction in Mirzapin – from 30mg to 15mg after only one month of treatment.
Quality of sleep
"I fell asleep faster and listened to the same music at home when going to sleep; the treatment forced me to relax."
Duration of effects
He slept for 15 minutes in the first session. Slept without needing medication that night, slept through until morning. After the treatment, his anxiety melted away and stayed away for a few days. After the third visit, he didn't need relaxation medication for three days (normally only one day).

Discussion

The implementation of VA treatment at a rehabilitation unit as part of specialized healthcare has been presented. Decreased pain, improved mood and sleep, reduction in analgesic intake, and increased relaxation are among the effects often reported after VA treatment [4,6,8,10]. These effects have also been shown in the 29 patients presented here, although interpreting results within a multidisciplinary setting is complex.

Zisapel and Nir [17] showed that a statistically significant change of 10mm in VAS scores is clinically significant for both pain and mood, corresponding to patient ratings of "a little better". Furthermore, a 20-27mm increase corresponds to ratings of "much" or "some" change [16]. Large improvements can be seen here in individual patients' pain, mood, and relaxation scores, particularly in monophasic patients. However, Katz, Paillard, and Ekman [18] caution that relying on the MCID as a determinant of clinical decisions may not be the best approach; the changes in pain scores do not tell the whole story. The patient may report clinically relevant changes in other measures, such as relaxation, as was shown here. Exploration of the whole patient's experience is essential; by focusing only on one aspect of the pain experience, only a part of the outcomes are understood. This also recapitulates the complexity of the data presented here.

Patient comments

An interesting observation of these patients' experiences is the incongruent responses between the subjective verbal comments and the VAS outcomes. Patient 19 reported sleeping much better after the treatment even though this was not reflected in the VAS outcomes – rather her condition appeared to have deteriorated. This discrepancy between

subjective verbal reports and VAS outcomes has also been reported earlier [19]. Although the VAS outcomes did not support the comments this patient made on the process, it is prudent to remember that pain experiences are unique to the individual. Practitioners treating a patient with chronic pain cannot define or understand the subjective experience, further stressing the importance of multiple outcome measures. The catalyst for improved wellbeing may be the combination of factors addressing sensory, physiological, and emotional needs. Chronic pain is a multi-layered phenomenon, affecting the patient in many facets of their lives, and the aim should be to address all of these aspects.

Interpreting outcomes

Relaxation is often an after-effect of VA treatment and the pre- and post-treatment scores presented here support this. Increased relaxation may help to reset the learned response of dysfunctional pain processing associated with the cumulative negative effects of chronic pain, anxiety, and depression. If stress is accountable for individual differences in pain perception – and thereby an agent of chronicity – increasing relaxation so as to decrease stress may aid in regulating and resetting learned pain responses. However, as neither the underlying mechanisms of chronic pain nor those of low frequency sound stimulation are fully understood, further research is needed to delve into the multifaceted nature of chronic pain and comorbid mood-related phenomena and the effects VA treatment exerts thereafter.

One limitation of the data presented here may be that only pre- and post-treatment process VAS measurements were taken. Punkanen and Ala-Ruona [2012] explained that in recording only the two measurement points, we might not see the range of a client's experiences of a process. This indeed may be the case, as the measurements are simply recorded on the first and last day of the treatment, rather than throughout the entire experience. Although patients give a subjective account of how they perceived VA treatment, this does not show as much detail as would weekly measurements. Taking a patient's final measurements on a day they experience especially high pain levels, for example, may potentially skew an effective measurement of the process.

Conclusion

The positive outcomes of the patients at Seinäjoki Central Hospital support current knowledge on the effective application of VA treatment and music listening for both chronic pain and mood disorders. Most patients were undergoing or had received other treatments around the same period, such as physiotherapy. Objective markers, such as cortisol levels, should also be explored in future research. Although pain is a subjective experience, interpreting patient experiences according to standardized frames - such as the minimal clinically important difference – increases validity and generalizability in experiential reports.

These data were collected as part of standard hospital protocol and represent the application of this treatment in a naturalistic setting. Therefore, it is not possible to ascertain which treatments – or whether it was their combination – were the catalysts for change due to the lack of a control group. However, the narrative presented shows that VA treatment can be beneficial when used within a multidisciplinary unit, and that the subjective differences presented by patients are moderately clinically relevant. This account affords an interesting insight into the workings of a multidisciplinary treatment process.

VA treatment is growing but the evidence supporting its efficacy is relatively sparse. Non-controlled studies cannot report on the efficacy of a treatment, yet reporting protocols followed in a naturalistic setting provides information on how a treatment may function within a larger context. A plurality of methods and reports is necessary for the future of VA research. Randomized controlled trials are indeed needed to discuss the efficacy of the stimulation, yet these should not detract from qualitative reports of patient experiences.

Acknowledgements

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bone metabolism in frail old men and women. Clin Rehabil. 2009; 23: 897–908.
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Appendix A

Discography

Classical
Johansson L. Bach for Meditation. [Album]. Naxos. 2004.
Johansson L. Beethoven for Meditation. [Album]. Naxos. 2003.
Johansson L. Mozart for Meditation. [Album]. Naxos. 2004.

Easy Listening/Ambient
Clayderman R. All by myself [Album]. Recall (UK). 2000.
Enya. A day without rain [Album]. WEA. 2000.
Enya. The magic of Enya. [Róisín and Celtic Spirit. Album] Newsound. 2000.
Enya, Ryan R. The very best of Enya. [Enya]. Reprise. 2009.
Gregorian. Masters of Chant. Edel America Records. 1999.
Oldfield M. Voyager [Album]. Voyager. 1996.
Vinkel I. Meri Panga Panga All [The sea below the cliff of Panga]. [Album]. Orbital Vox Records. 1999.

Electronic
Jarre MJ. Chronologie [Album]. Polydor. 1993.

Folk/Country/World
Passenger. All the little lights [Album]. Embassy of Music. 2012.

Metal
Aaltonen R, Häkkinen C, Järvinen A. Get on. Love Records. 1974
Aaltonen R, Järvinen A, Maijanen P. Bourbon Street. Polar studios. 1980.
Bell R, Downey B. Whiskey in the Jar. Karussell. 1996.
Bon Jovi J, Sambora R, Child D. You give love a bad name. Mercury. 1986.
Bon Jovi J, Sambora R. It's my life. Island. 2000.
Blackmore R. Gillian I, Glover R, Lord J, Paice I. Highway star. EMI. 1972.
Blackmore R, Dio JD. A light in the black. Polydor. 1976.
Blackmore R, Glover R. Lost in Hollywood. Polydor. 1979.
Blackmore R, Coverdale D. Stormbringer. Purple. 1974.
Blackmore R, Lynn Turner J. Street of Dreams. Polydor. 1983.
Blackmore R, Gillan I, Glover R. Perfect Strangers. Polydor. 1984.
Blackmore R, Gillan I, Glover R. Wasted sunsets. Polydor. 1984.
Brvant B. Love Hurts. Warner Bros. 1961.
Cartellone M, Chase C, Medlocke R, Rossington G, Thomasson H, Van Zant J. Still Unbroken. Nashville, Tennessee: The All Blacks. 2009.
Cooper A, Child D, McCurry J. Poison. Epic. 1989.
Cooper A, Child D, Bon Jovi J, Sambora R. Hell is living without you. Epic. 1989.
Coverdale D. We wish you well. United Artists. 1979.
Coverdale D, Marsden B. Here I go again. Geffen. 1987.
Coverdale D, Aldrich D. Best years. SPV/Steamhammer. 2008.
Dio RJ. Don't talk to Strangers. Warner Bros. 1983.
Dio RJ. Holy diver. Warner Bros. 1983.
Fogerty J. Lookin' out my back door. Fantasy. 1970.
Gillan I, Glover R, Lord J, Morse S, Paice I. Don't make me happy. EMI Switzerland. 1998.
Gillan I, Towns C. Sleeping on the Jon. Virgin. 1980.
Gillan I, Glover R, Morse S, Airey D, Paice I. Things I never said. Eagle Records. 2005.
Harburg EY, Brooker G, Arlen H, Reid K. Weisselklenenacht [The signature]. Eagle Records. 2003.
Henley D, Leadon B. Witchy Woman. Asylum. 1972.
Hensley K. Easy livin'. Bronze. 1972.

Hetfield J, Hammett K, Ulrich L. The unforgiven. Elektra. 1991.
Holopainen T. Nemo. Nuclear Blast. 2004.
Lynott P. The boys are back in town. Vertigo. 1976.
Mercury F, Deacon J. Friends will be friends. EMI. 1986.
Meine K. Wind of Change. Vertigo. 1991.
Osbourne I, Rhoads R, Daisley B. Mr. Crowley. Epic. 1980. Osbourne O, Frederiksen M, Jones M. Dreamer. Sony. 2001.
Page J, Plant R. Stairway to heaven. Atlantic. 1971.
Perry J, Tyler S. Love in an Elevator. Geffen. 1989.
Tyler S. Dream on. Columbia. 1973.
Tyler S, Supa R. Amazing [Orchestral Version]. Geffen. 1993.
Van Halen E, Van Halen A, Roth DV, Anthony M. Ain't talkin' 'bout love. Sunset Sound Recorders. 1978.
Walsh J, Grey G, Henley D. Life in the fast lane. Asylum. 1977.
Warwick R, Johnson D, Gorham, S, Mendoza, M, Wharton D. All hell breaks loose. Los Angeles: Nuclear Blast. 2013.
Waters R. Hey you. Harvest. 1979.
Waters R. Another brick in the wall, pt 2. Harvest. 1979.
Westerholt R, den Adel S, Spierenburg M. Memories. Roadrunner. 2005.

New Age
Levantis. Stress Release. Dynamic Entertainment Ltd. 2001.

Popular
Clayderman, R. Memories [Album]. Telefunken. 1979.
Il Divo. Il Divo [Album]. Syco Music. 2005.
The Shadows. 20 golden greats. EMI. 1977.
Vartiainen J. Terra [Album]. WEA. 2013.

Rock/Hard Rock/Pop Rock
AC/DC. Highway to hell [Album]. Atlantic. 1979.
Agents & Jorma Kääriäinen. Agents is more ! [Album]. Parlophone. 1997.
Knopfler M. Sultans of Swing. Vertigo Records. 1977.
Sonata Arctica. Silence [Album]. Spinefarm Records. 2001.
Neljä Ruusua. Poplaulajan Vapaapäivä. 20 suurinta hittiä [Album]. Ratas Music Group. 2013.

III

A SINGLE CASE, MIXED METHODS STUDY INVESTIGATING THE ROLE OF MUSIC LISTENING IN VIBROACOUSTIC TREATMENT

by

Elsa A. Campbell, Birgitta Burger, & Esa Ala-Ruona

Accepted for publication.

A single-case, mixed methods study investigating the role of music listening in vibroacoustic treatment

Chronic pain is a widespread issue accompanied commonly by depression and anxiety. Chronic pain has been shown to alter brain processing within the emotional and reward circuits, pointing towards a possible link between pain and comorbid mood disorders. Pain relief may be achieved by alleviating depressive and anxious symptoms. Relaxation is important for pain relief and eliciting relaxation through music listening is shown to relieve pain, depression, anxiety, and discomfort among others. In addition to auditory stimuli, Vibroacoustic treatment – the tactile application of low frequency sinusoidal sound vibration, plus music listening and therapeutic interaction – has been shown to be beneficial for relieving these symptoms. Although the combination of music listening and low frequencies has been previously explored, the role of the music listening within the vibroacoustic treatment context is unknown. A single case, mixed method crossover study was conducted with a client suffering from chronic pain and comorbid mood disorders, four sessions with music listening, and four sessions without. Quantitative outcomes showed the client was more relaxed, less anxious, and had less pain after the music sessions. Qualitative findings showed that the client at first could not relax without the music listening because of her severe anxiety, later learned to use music as a distractor from her thoughts to relax, but also that silence was equally important for her; these hinged on her making the choice based on her needs, which had previously been difficult for her.

Keywords: *music listening, vibroacoustic treatment, pain, anxiety, depression*

Introduction

One in ten adults report chronic widespread pain (Mansfield, Sim, Jordan, & Jordan, 2016). Furthermore, depression and anxiety are prevalent in individuals with chronic pain, with these mood disorders longitudinally predicting chronic pain and pain-related disability (Lerman, Rudich, Brill, Shalev, & Shahar, 2015). Chronic pain patients may experience maladaptive anxiety and harbour a tendency towards hypervigilance or catastrophising their symptoms, often being focused on the negative meaning or potential consequences of their pain (Symreng & Fishman, 2004). Chronic pain has also been shown to alter brain processing, being observed in the emotional and reward circuits, showing a possible link between chronic pain and comorbid mood disorders (Navratilova, Morimura, Xie, Atcherley, Ossipov, & Porreca, 2016). Indeed, improving depression, anxiety, and pain catastrophising is found to relieve pain, and reduce pain-specific disability days and likelihood of disability (Scott, Kroenke, Wu, & Yu, 2016). Due to this interrelation between pain and anxiety, discerning the principle factor may be difficult; however, this overlap is fortuitous in treatment as approaches for treating one can be beneficial in simultaneously managing the other (Symreng & Fishman, 2004).

Music interventions for relieving pain and mood

Non-pharmacological interventions that have been beneficial for managing both pain and anxiety include those such as paced breathing techniques, muscle relaxation, or attention diversion

(Symreng & Fishman, 2004). Indeed, relaxation has been shown to be an important element in relieving pain (Ezenwa et al, 2018) and anxiety (Nelson, Adamek, & Kleiber, 2017) and as musical experiences (e.g. music making such as singing or listening to pre-recorded music) elicit and evoke emotional responses in us, they are often used to regulate emotions (Lonsdale & North, 2011) but also for the purpose of pain relief (Tamplin & Clark, 2016).

Music interventions have been shown to be efficacious at relieving anxiety, depression, (Lai, Li, and Lee, 2012), pain, and inducing a state of relaxation (Liu & Petrini, 2018). It is proposed music may act as a distractor from patients' psychological and physiological sensations as well as reducing patients' experiences of discomfort (Nilsson, 2008) by serving as an audioanalgesic, audioanxiolytic, or audiorelaxant, as well as music listening having an effect on hospital patients' stress responses (Nilsson, 2009). A systematic review (Bradt, Dileo, and Shim, 2013) found that music listening may be beneficial for reducing anxiety in people with myocardial infarction, also indicating that music listening may reduce pain. Although music as a distractor is an important mechanism in anxiolytic responses (Nilsson, 2008), Bradt et al. (2013) argue that music also affords an aesthetic experience, able to offer comfort, and creative engagement in music may result in an increase in perceived control. In a surgical setting, Wu, Huang, Lee, Wang, and Shih (2017) reported significantly reduced anxiety for patients undergoing an awake craniotomy after listening to their preferred music. Although Gillen, Biley, and Allen (2008) found that anxiety reduction from music listening seems to be more strongly reflected in the psychological parameters (e.g. STAI) rather than physiological markers of anxiety and stress (e.g. HR), the aforementioned overlap between the physiological and psychological aspects of pain and anxiety/depression points towards a cumulative intervention effect. This may be important in designing interventions for patients suffering from these psychological and physical symptoms. Results seem to generally suggest consistently positive and significant reduction in anxiety and pain due to music intervention, as well as increased relaxation and decreased depression.

Vibroacoustic treatment for eliciting psychophysiological changes

Music interventions can also be delivered in a tactile manner such as with pulsed, sinusoidal, low frequencies between 20–120 Hz through a recliner chair or mattress combined with music listening and therapeutic interaction. When applied by a trained practitioner, these combined elements (see Figure 1) are referred to as Vibroacoustic (VA) treatment (Campbell, Hynynen, & Ala-Ruona, 2017). Low frequencies may also be delivered without music listening, based on the client's needs and preferences, e.g. music may evoke memories or sensations which the client is not yet ready to address. The rationale for listening to music is therefore based on whether the music listening may enhance the experience for the client. For those who enjoy music, it may more readily enable relaxation and offer a source of comfort.

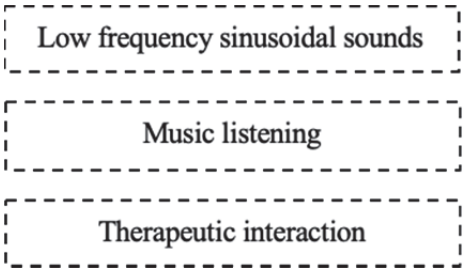

Figure 1. Elements of VA treatment

As is often the case for music listening, relaxation is one of the most commonly reported outcomes of VA treatment (Ala-Ruona, Punkanen, & Campbell, 2015; Campbell, Hynynen, & Ala-Ruona, 2017). The relaxation response, a relaxed but alert state elicited through repeated and focused meditative practices (Benson, 1975), is posited to be one possible explanation for the positive outcomes associated with this treatment modality (Punkanen & Ala-Ruona, 2012). Recent studies focusing only on the pulsed sinusoidal low frequency sound vibration, i.e. without music listening or therapeutic interaction, have shown that low frequencies are beneficial for pain relief and mood regulation (Braun Janzen, Paneduro, Picard, Gordon, & Bartel, 2019; Naghdi, Ahonen, Macario, & Bartel, 2015), anxiety reduction (Rüütel, Ratnik, Tamm, & Zilensk, 2004), spasticity in those with spinal cord and brain injuries (Rüütel, Vinkel, & Eelmäe, 2017), and can be beneficial for decreasing both pain and stress, and increasing emotional enrichment, concentration, and physical and emotional relaxation (Ahonen, Deek, & Kroeker, 2012) as well as reducing anxiety and affording relaxation in those with Alzheimer's disease (Clements-Cortés, Ahonen, Freedman, & Bartel, 2017). Campbell, Hynynen, and Ala-Ruona (2017) showed improvements in pain, mood, and relaxation for those receiving the combined treatment of low frequencies and music listening with therapeutic interaction. Skille and Wigram (1995) compared the effects of music plus vibroacoustic stimulation (40 and 55 Hz) to music alone for those with multiple physical disabilities, finding that vibroacoustics is beneficial in reducing muscle tone and increasing range of motion. Wigram (1996) compared new age music listening, vibroacoustics (40 Hz), and lying in silence with non-clinical participants and found reduced arousal in the vibroacoustic group compared to both the music and control group. Both vibroacoustics and music groups had reduced heart rate compared to the silence group. Rüütel (2002) also examined the effects of music, vibroacoustics, and silence on healthy people, finding that one or two sessions of vibroacoustics can be beneficial for reducing fatigue or stress for healthy people in everyday life.

These studies have examined the effects of low frequencies alone, the combination of all three VA treatment elements, as well as comparing the effects of low frequencies with and without music. However, the role that music listening plays in the treatment session with therapeutic interaction has not been explored. As discussed, music listening has been shown to be efficacious at inducing a relaxed state, and relieving pain, anxiety, and depression. Low frequency vibration has also been shown to do so, as has the combination of music listening, low frequencies, and therapeutic interaction. Given that both music and vibration can be beneficial for symptom relief, the aim of this study was to explore in more detail the role that the music listening element within a practitioner-supported VA treatment setting may have with a client suffering from chronic pain, anxiety, and depression. Furthermore, this study investigates whether the client's perception and experience of her symptoms - and the influence VA treatment has thereon - are enhanced by music listening.

Method

Study design

A mixed method, n-of-1 crossover design was used to explore the role of music in VA treatment, integrating quantitative and qualitative data to triangulate the results and findings to gain a greater understanding of these subjective physical and psychological phenomena. Although quantitative methods are helpful when addressing the relationship between specific variables, they are not suitable for answering process-oriented questions which can be addressed using qualitative approaches (Leech & Onwuegbuzie, 2007). Triangulation of mixed methods is used to describe an issue (e.g. pain) from several perspectives to gain a more complete impression of the phenomenon (O'Cathain, Murphy, & Nicholl, 2010). In case studies, the quantitative data can shed light on a patient's change (e.g. potential improvement) during the therapeutic process, whilst the qualitative

data may be used to understand the sudden fluctuations on the symptoms represented in the quantitative scales (Sandahl & Wilberg, 2006).

Participant

Jane was a 34-year-old mother of two living with her partner who was on disability sick leave. She first took leave in 2008 due to burnout and then due to surgery for a herniated disc in 2012 after a brief return to work. She had moderate depression, panic disorder and anxiety, difficulty relaxing and sleeping, stress, and tension headaches, migraines, and shoulder pain, although there was no organic reason for these symptoms. The lack of discernible medical explanation for her collection of symptoms may be grouped under the term Medically Unexplained Symptoms (MUS). This includes musculoskeletal pain and 'pseudoneurology' – tiredness, sleeping issues, fatigue, and mood changes (Eriksen & Ursin, 2004). Although unexplained, these symptoms have, in addition to headaches, high blood pressure, and emotions such as anger, anxiety, and panic, been linked to negative stress (Yehuda & Seckl, 2011) such as from shock. She explained she would like to move forward with her life but was feeling stuck. Once or twice per month, Jane visited her local healthcare centre and spoke with the psychiatric nurse. She did not take any medication, except for analgesics when migraines were particularly severe. She had applied to participate in music therapy as part of clinical training at [facility] and, due to the severity and collection of symptoms, was approached by Author 1 regarding her willingness to participate in VA treatment instead of music therapy for managing pain and comorbid symptoms. The research was conducted at [clinic] and therefore followed the general principles and rules of therapeutic work at healthcare units. She gave informed consent to have weekly sessions.

Procedure

Vibroacoustic (VA) treatment consists of three elements: pulsed sinusoidal low frequency sound vibration (20-120Hz), (client preferred) music listening, and therapeutic interaction between client and practitioner (Campbell, Hynynen, & Ala-Ruona, 2017; Ala-Ruona & Punkanen, 2017). The music listening and low frequency sound vibration are received simultaneously. The sound vibration is transmitted through devices such as chairs, cushions, or mattresses whilst the music listening is typically delivered through headphones. In general, the procedure is conducted in several stages: preparation for the session (setting up the equipment), introducing the client to the treatment modality, beginning the combined sound vibration and music listening, monitoring the client's reception, ending the stimulus, and post-stimulus work (e.g. processing) (Grocke & Wigram, 2007). The therapeutic relationship between the client and practitioner may take the form of verbal interaction between the client and practitioner, usually before and after the low frequency sound vibration and music listening. However, in some cases, the client may wish to interact with the practitioner during the stimulation. A client may fall asleep during the stimulus and the practitioner's role thereafter is to reassure and guide the client back to the present moment. Before and after the stimulus, the practitioner plays an important role in experiential processing. This may take the form of offering comfort and helping the client to process and reflect on experiences and sensations.

The VA treatment procedure in this study was as follows: ten VA treatment sessions were planned with the client (hereafter referred to as 'Jane') to take place once per week in a single case crossover design of Vibroacoustic sessions with (VA-Music) and without (VA-Silence) music listening. Jane wore headphones in all sessions, but no music was played during VA-Silence sessions. Before the first session, the practitioner asked Jane to send a list of her preferred music listening choices. Jane suggested some artists to which she sometimes listened and the practitioner made a playlist based on these suggestions. The VA sessions took place in a music therapy clinic equipped with a Next Wave Physioacoustic recliner chair (Next Wave, n.d.). The client lay in a supine position on this chair with a blanket during all sessions and the lights were dimmed during

the low frequency stimulation. The same 20-minute low frequency programme (ranging from 29—61 Hz) was used in all sessions; this frequency range has been beneficial for managing physical and psychological disorders and inducing relaxation (Campbell, Hynynen, & Ala-Ruona, 2017).

The client received eight sessions in total; two sessions were cancelled due to illness. Four sessions (S1, S3, S5, S6) comprised usual protocol for VA treatment; low frequency sound vibration, music listening, and therapeutic interaction (VA-Music). Four sessions (S2, S4, S7, S8) comprised all of these elements minus music listening (VA-Silence). It was planned that every second session would be VA-Silence, however this change in scheduling was made for therapeutic reasons (discussed in sections *Control through choice* and *Music as a translational mechanism*).

Sessions 1 and 2 focused on preparing Jane for the procedure and becoming accustomed to the sensation of low frequencies and discussing her difficulty with relaxation in general. Sessions 3-5 focused on how Jane could become more aware of her physical sensations as a way to anchor herself in the present moment. She was also paying attention to the effects of the treatment, and beginning to integrate these changes into her daily life. Sessions 6 and 7 was about making choices for herself regarding self-care (e.g. taking medication, receiving massage) and noticing other changes outside the sessions. The final session further explored making choices and how the effects of the sessions may be translated into daily life, and expressing a willingness to continue to try and help herself.

Outcomes assessment

The data for this study consisted of both qualitative and quantitative measures. The qualitative data were transcribed discussions between Jane and Practitioner whilst the quantitative data comprised Visual Analogue Scales (VASs). A VAS is a unidimensional self-complete scale composed of a horizontal 100mm line with two verbal descriptors on either end (Hawker et al., 2011). The scales used in the present study assessed pain (VAS-P), mood (VAS-M), anxiety (VAS-A), and relaxation (VAS-R) and were completed by Jane before and after each 20-minute treatment programme in each session. The anchors for these scales were '0=worst pain imaginable – 100=no pain'; '0=depressed – 100=happy'; '0=very anxious – 100=no anxiety'; and '0=tense – 100=relaxed' respectively. At all VAS measurement points, Jane was asked to mark each scale to represent her current state at that moment, thereby enabling an assessment of both within- and between-session change. Visual Analogue Scales are widely implemented in diverse populations due to low respondent burden and ease of administration (Hawker, Mian, Kendzerska, & French 2011).

Quantitative data analysis

The pre- and post-treatment VAS outcomes were analysed using SPSS (IBM SPSS Statistics, Version 24). Both an overview of the process as well as a comparison between each condition are presented. The pre-treatment score in Session 1 and the post-treatment score in Session 8 for each variable are used to give an overview of the between-session therapeutic process. Additionally, the mean (and standard deviation) pre- and post-treatment pain, mood, anxiety, and relaxation scores for both VA-Music and VA-Silence conditions are presented to show within-session change. Guidelines for interpreting quantitative outcomes such as VASs are beneficial to understand patients' responses to interventions. Jensen and colleagues (2003)[1] recommend cut-off interpretation points for VAS-P of 0-4mm (severe pain), 5-44mm (moderate pain), 45-74mm (mild pain), and 75-100mm (no pain). Further, clinically relevant change is also necessary in intervention evaluation; this is referred to as the Minimal Clinically Important Difference (MCID) and for VAS-P has been defined as 10-20% as MCID, >30% as moderate improvement, >50% as substantial improvement (Dworkin et al., 2008). These interpretation guidelines are employed here to evaluate all VAS data.

[1] These values are inverted.

Qualitative data analysis

Patients' experiences and the corresponding disability or *ill*-being resultant of chronic pain are important in further delineating the efficacy of chronic pain management treatment methods. Understanding how a client engages in meaning-making and the elements of a subjective experience which they consider important give insight into the experience of suffering and alleviation thereof. To this end, Interpretative Phenomenological Analysis (IPA) allows researchers to gain insight into what is important to participants, then exploring what this *means* to them (Smith & Osborn, 2007). Situating and understanding a participant's experiences and meaning making can help to interpret findings from quantitative outcomes (Larkin & Thompson, 2011). Thus, IPA was used in this study to gain greater insight into the meaning of music within her VA treatment process.

The analytic process was as follows. The transcripts from all sessions were read and re-read several times to obtain a sense of the participant's experiences. Several coding methods were used. The first coding round consisted of Descriptive Coding, in addition to Emotion Coding, Process Coding, Conditional Coding, and Evaluation Coding. Descriptive Coding highlighted Jane's experiences throughout the process, whilst Process Coding showed what happened to the participant throughout this process; Emotion Coding highlighted all emotion words used by the participant; Conditional Coding was applied to structures such as 'if…then', to find connections between conditions and actions/outcomes, and finally Evaluation Coding was applied to see how the participant evaluated each condition/intervention. These codes were primarily organised into themes and then explored for interrelationships (Saldaña, 2009), with a focus on Jane's overall response to the VA treatment sessions and then paying attention to how she responded to the VA-Music and VA-Silence sessions separately. Themes that clustered together were grouped as superordinate themes (Smith & Osborn, 2007; Osborn & Smith, 1998). The emergent themes were organised such that a consistent and meaningful representation of Jane's experiences were presented, representing the essence of her responses to the treatment and the factors potentially influencing this response. The analysis thus followed an inductive rather than deductive approach, establishing themes from the data rather than from pre-determined constructs.

Integration

After both qualitative and quantitative outcomes were analysed separately by Author 1, the results and findings of each were co-explored and are presented narratively and visually, highlighting the quantitative responses to each treatment modality and discussing the qualitative findings supporting these outcomes. The role of the VASs was to gain insight into the potential influence of VA sessions with and without music listening on pain, mood, anxiety, and relaxation, however as these are subjective phenomena, the participant's subjective experiences of the treatment – as well as her state in between sessions – was important in bringing greater understanding to how the treatment process affected her. The verbal processing within the treatment sessions, and later in the member check interview, afforded her the possibility to explore and share her own experiences (Bradt et al., 2015).

Member check

To assess the validity of the analysis, a member check interview – otherwise referred to as a validation interview – was conducted with Jane to discuss the emergent themes and their genesis based on the transcripts, and to 'confirm, substantiate, verify or correct researchers' findings'

(Buchbinder, 2011), i.e. to discuss whether the themes presented accurately represented the discussions and her experiences during the treatment process. In the interview, Author 3 presented both quantitative results and the qualitative findings to assess if these were accurate representations of her experience during the process or not, whether she wished to add something to the outcomes which she felt was important, or whether there were aspects she wished to correct in the results and findings to better portray the sessions. (Author 1's role in this process is discussed in the subsequent section.) Conducting the member check interview – termed as descriptive triangulation – in which the researcher(s) show the findings or interpretations to the participants in order to assess accuracy, was a means of increasing trustworthiness of the qualitative findings (Leech & Onwuegbuzie, 2007).

Roles of the researchers / practitioner

The authors played various roles in the therapeutic process as well as the data collection and analysis phases. During the treatment process, Author 1 filled the roles of both practitioner and researcher. Author 1 met with the client to discuss the procedure of the sessions, acquired informed consent from Jane, and collected the data at the beginning and end of each session. In the practitioner role, Author 1 facilitated the therapeutic process, delivering the music and tactile interventions at each session. A number of clinical researchers subscribe to the idea that research in itself, as well as follow-up interviews, has a therapeutic effect (Sandahl & Wilberg, 2006). From this perspective, the interacting and overlapping roles of a practitioner and researcher may involve complementary processes.

Both Author 1 and 3 conducted the member check interview. Although it was initially planned that only Author 3 would conduct the member check, Jane requested that Author 1 also be present in the meeting. Author 1's role was passive in the member check interview unless clarification was needed and requested from the participant.

Results

Quantitative results

When viewing the overall process, clinically relevant pain decrease and relaxation increase were recorded by Jane when only the pre- treatment score from Session 1 and the post-treatment score from Session 1 are presented (i.e. both VA-Music and VA-Silence sessions). At the end of the process, her pain corresponded to *no pain* and relaxation corresponded to *mild tension* when following the interpretation guidelines (Jensen et al., 2003). Mood and anxiety deteriorated during this time to a minimal clinically relevant degree (see Table 1). Both mood and anxiety were *moderate* at the end of the treatment process.

When comparing the mean VAS outcomes between the music and silence sessions, VAS-M, VAS-A, and VAS-R showed improvement; VAS-P change was negatively clinically relevant change in the silence sessions, but showed improvement in the music sessions, indicating that music was at least somewhat beneficial for pain. VAS-M improvement was clinically relevant in the music sessions, but VAS-A and VAS-R were substantially clinically relevant in both conditions according to the MCID (see Table 1). These results indicate that the VA-Music sessions were more beneficial for anxiety and relaxation than for pain or mood.

Table 1. Pre-treatment Session 1 and post-treatment Session 8 scores for all variables showing progression over time, and mean (and standard deviation) of all pre- and post-treatment scores for each variable comparing VA-Music and VA-Silence sessions.

	VAS-Pain		**VAS-Mood**		**VAS-Anxiety**		**VAS-Relaxation**	
Overall treatment process (0-100mm; higher score indicates better outcome)								
Whole process	*Session 1*	*Session 8*	*Session 1*	*Session 8*	*Session 1*	*Session 8*	*Session 1*	*Session 8*
	69	93*	51	43	64	52	5	71*
Comparing VA-Music and VA-Silence sessions (0-100mm; higher score indicates better outcome)								
	Pre-treatment	*Post- treatment*	*Pre- treatment*	*Post- treatment*	*Pre- treatment*	*Post- treatment*	*Pre- treatment*	*Post-treatment*
VA-Music	60.82(*17.86*)	65.25(*12.19*)	43.39(*7.46*)	52.75(*5.31*)*	34.79(*17.98*)	54.5(*13.28*)***	21.54(*14.54*)	51(*12.75*)***
VA-Silence	85.75(*5.26*)	73.75(*11.65*)	47.75(*8.13*)	50.5(*13.46*)	35.5(*8.20*)	45.25(*12.70*)*	30.75(*16.16*)	54.75(*13.94*)***

Note: All Visual Analogue Scales range from 0-100mm; a higher score represents a more favourable outcome; *Indicates the Minimal Clinically Important Difference (MCID); **Indicates moderate change; ***Indicates substantial change

Pain

VA-Silence pre-treatment scores were generally better compared to VA-Music, as the mean pre-treatment score for VA-Silence was in the *minimal* category and for VA-Music was in the *mild* category. From an individual session perspective (see Figure 2), substantial improvement was recorded in Sessions 3 (VA-Music), with MCID in Session 5 (VA-Music). MCID negative improvement was reported in Sessions 1 and 6 (VA-Music) and Sessions 2, 4, and 7 (VA-Silence). There was relatively high variation between the conditions; however, when the pre-treatment score was the worst (Session 3), the improvement was also the most substantial.

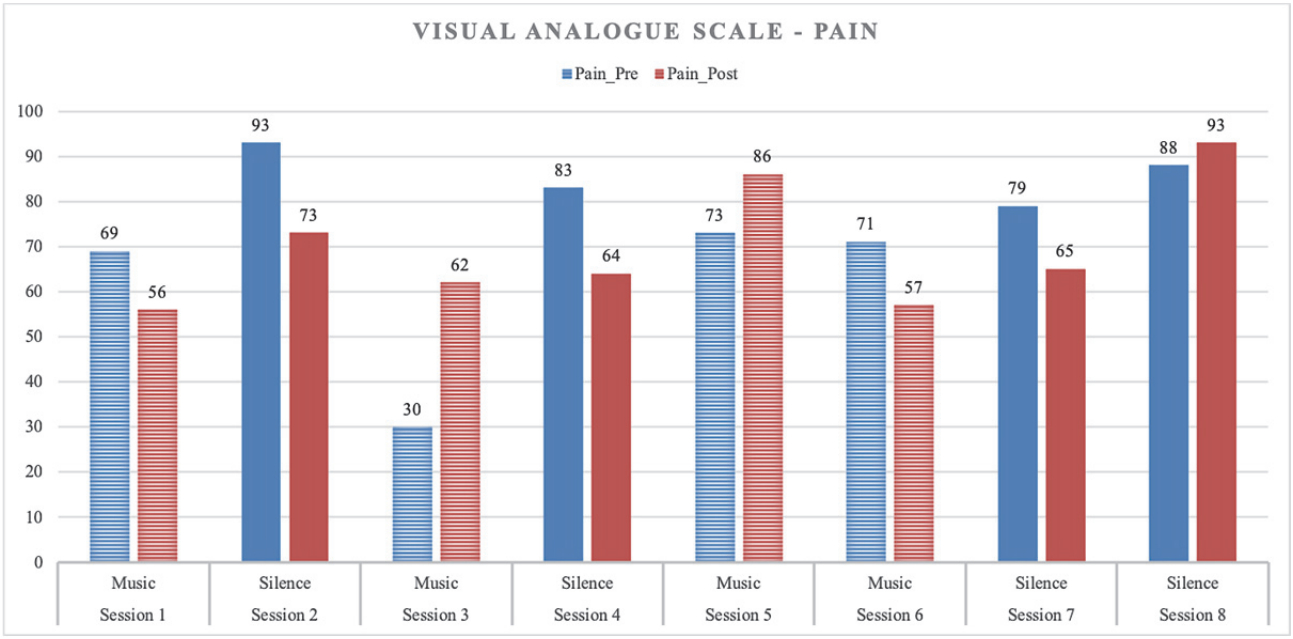

Figure 2. Pre- and post-treatment scores for pain completed before and after each treatment in all sessions. Solid colours represent VA-Silence sessions. Visual Analogue Scales range from 0=worst pain imaginable; 100=no pain. Point increase (+) relates to less pain.

Mood

Mean mood scores for pre-treatment VA-Music sessions was in the *moderate* category and VA-Silence in the *mild* category. Again, Session 3 (VA-Music) showed substantial improvement (see Figure 3), whilst Sessions 1 and 6 were also clinically relevant. For VA-Silence sessions, moderate improvement was reported in Session 4, clinically relevant improvement in Session 7 but negative clinically important change in Sessions 2 and 8. Therefore, although the final score at the end of the process was worse than the beginning of the process, the mean change over time was nevertheless towards improvement, although only clinically relevant for the VA-Music sessions.

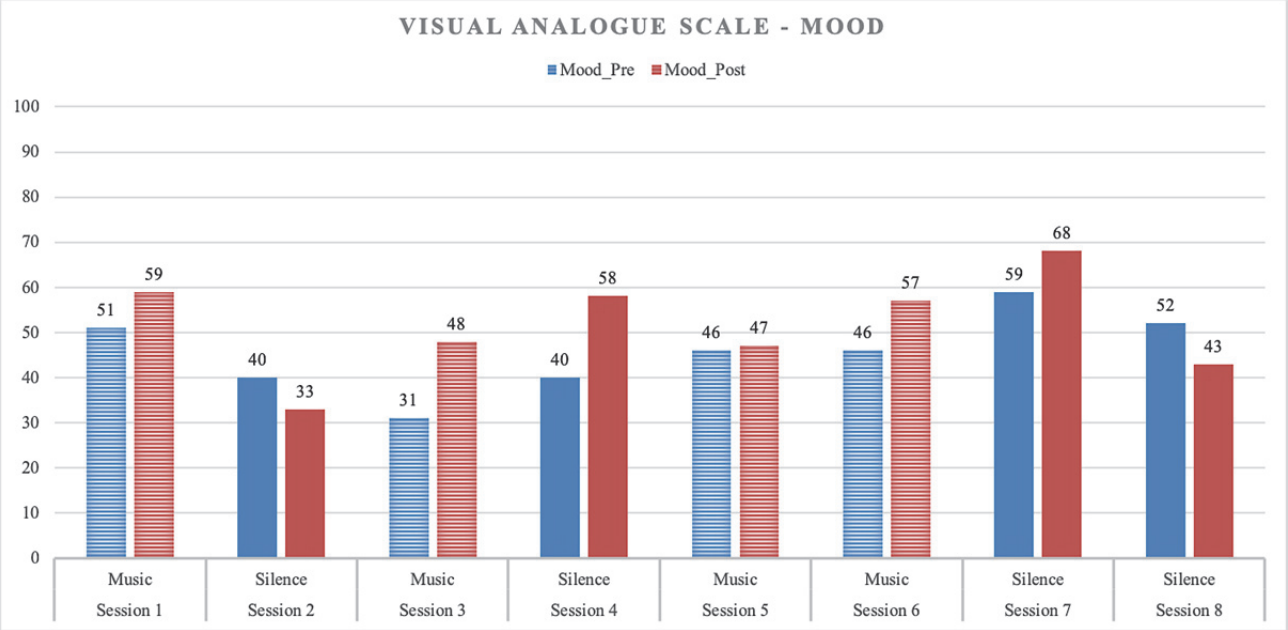

Figure 3. Pre- and post-treatment scores for mood completed before and after each treatment in all sessions. Solid colours represent VA-Silence sessions. Visual Analogue Scales range from 0=depressed; 100=happy. Point increase (+) relates to better mood.

Anxiety

Pre-treatment scores in both conditions on average were *moderate* and post-treatment scores were *mild* for both conditions, suggesting that both were beneficial for anxiety relief. There was greater relief recorded for the music sessions, however. Minimal clinically important change was reported in Sessions 1 and 7, with moderate improvement in Sessions 4 and 8, and substantial improvement in Sessions 3 and 6. As seen in Figure 4, on days when anxiety was the worst, Jane reported the greatest improvement (Session 3, 143%; Session 6, 184%).

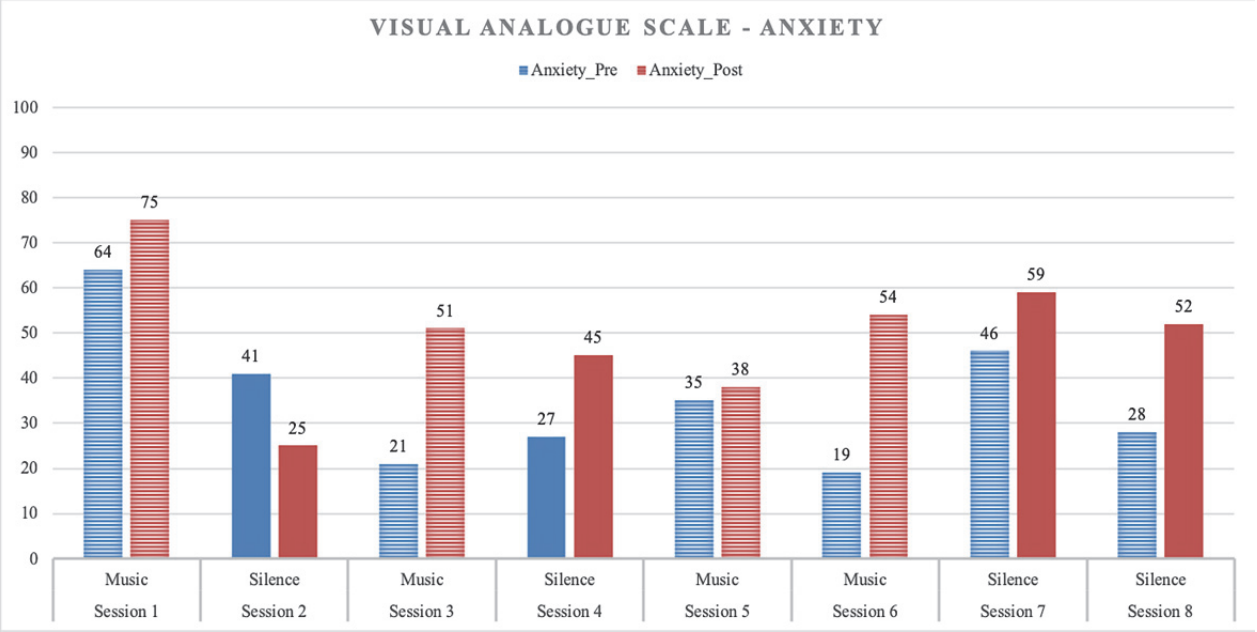

Figure 4. Pre- and post-treatment scores for anxiety completed before and after each treatment in all sessions. Solid colours represent VA-Silence sessions. Visual Analogue Scales range from 0=very anxious; 100=no anxiety. Point increase (+) relates to less anxiety.

Relaxation

The greatest improvements overall were recorded for relaxation (see Figure 5). Pre-treatment scores for both conditions were *moderate,* changing to *mild* post-intervention. MCID was recorded in Session 5, moderate improvement in Session 6, and substantial improvement in Sessions 1, 3, 4, 7, and 8. Again, Jane experienced the greatest increase in relaxation in those sessions with relatively higher tension pre-treatment.

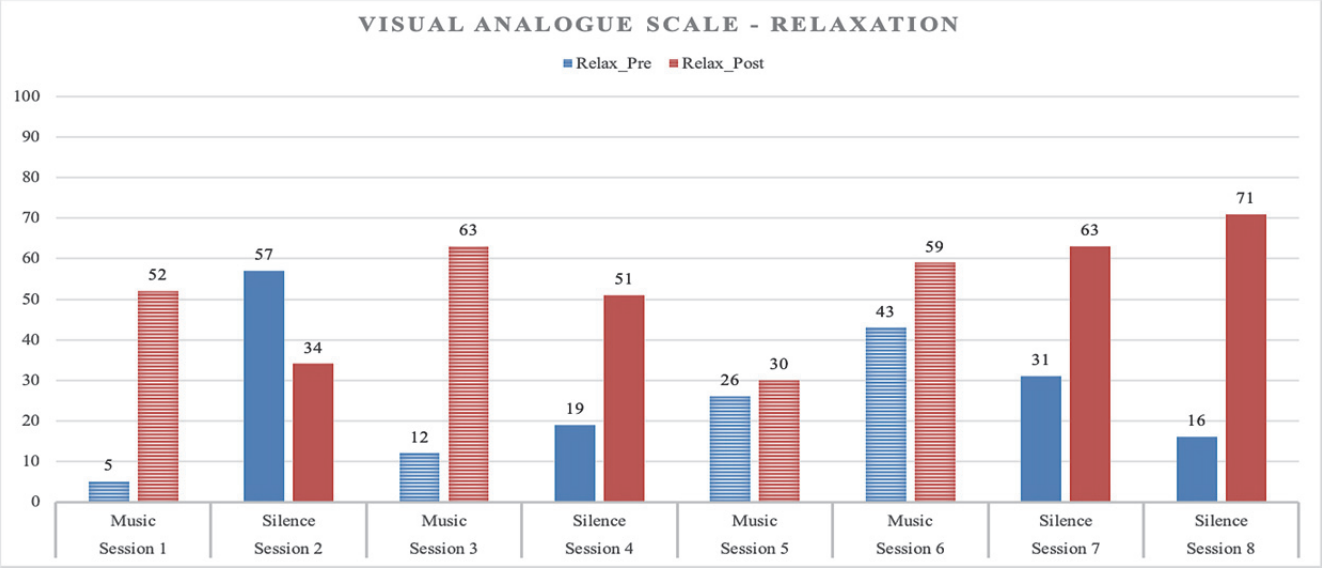

Figure 5. Pre- and post-treatment scores for relaxation completed before and after each treatment in all sessions. Solid colours represent VA-Silence sessions. Visual Analogue Scales range from 0=tense; 100=relaxed. Point increase (+) relates to greater relaxation.

Qualitative findings

Jane's experiences of VA treatment and the role that music played in this process were explored in the interaction between her and the practitioner during the eight VA sessions. Three superordinate themes emerged from the analysis: *Trapped by her anxiety, Control,* and *A changing self-reflection*; the interrelationships of these themes are shown *in Figure 6*. Each superordinate theme had subthemes, which are presented narratively with exemplative quotations. The first two superordinate themes were interconnected – Jane sought control as she was trapped by her own anxiety – and the second and third superordinate theme were interconnected – Jane began to see changes by using music listening as a means to take control in a different way. The interrelationships of these themes are represented in the figure such that Jane's anxiety and need for control were pervasive and connected to each other. Being *Trapped by her anxiety* overlapped with her need to control all situations, yet her anxiety and need for control were starting points in the process and are therefore stacked rather than linear as both themes were equally prevalent. The superordinate theme *A changing self-reflection* is justified to the right as it signifies the process of moving forward, rather than the stagnation of being trapped by one's emotions. It overlaps with *Control* because Jane was nonetheless struggling to make this change, but was able to try with the help of the VA treatment sessions.

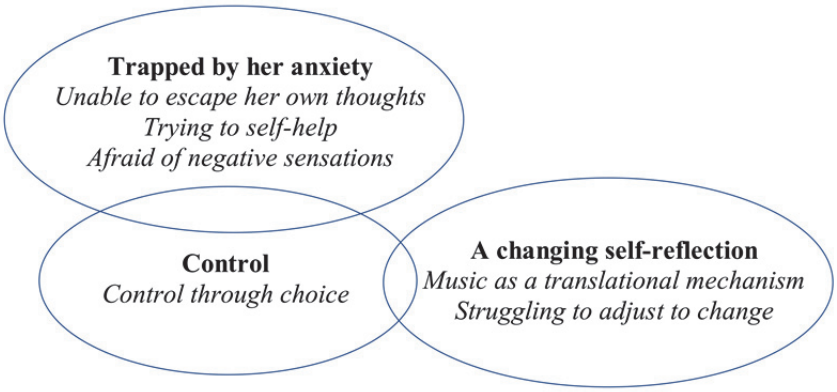

Figure 6. Interrelationships of the three superordinate themes

Trapped by her anxiety

Jane was unable to relax at home – she sometimes found solace wandering the shops and could relax there because she was alone and it was quiet; she described her attempts to relax at home as '*chaos'*. She equated this chaotic feeling with the inability to relax during her first VA-Silence session: '*But it is the same if I'm at home and I try to relax and I have that same kind of feeling as now without the music*'. She felt trapped in feelings from which she could not escape, her health situation, and being so sensitive to each sensation she felt caused her great distress: '*It's too distressing…I feel as though I am in a box and I can't get out of it*'.

Unable to escape her own thoughts

She tried to consciously avoid thinking about situations which gave her anxiety – such as her daughter wishing to move in with her biological father – and admitted that this in turn increased the sensation: '*If I don't think about those things consciously, about my daughter and my health, then they just circulate in my mind and I think about them in the evening and I get that kind of feeling…and I think it's exacerbated by that*'. Jane found in Session 2 (VA-Silence), that she had no distraction from her thoughts in the absence of music: '*Somehow I wasn't able to relax; I was thinking the whole time, and there was nothing else*'. She found her thoughts were initially much more relaxed with music than without (Session 3): '*My mind was much more peaceful than without music, even though I wasn't necessarily listening to the lyrics, but still somehow…it was relaxing!*'

In addition to this, Jane had no resources to alleviate her anxiety. This led to her suppressing her emotions even further, creating a space in which she had no escape from her anxiety: '*I don't have the resources to take the anxiety away or reduce it. Maybe it would be better if I just spoke about it, but who can I talk to? Talking to yourself isn't fun!*' She recognised her need to talk as a means to understand and process her situation, yet this was problematic. She was alone in her suffering; she had only one friend, whom she seldom met. This meant that she could not offload and it caused her to spiral into unhealthy patterns of rumination. She was highly aware of this fact: '*If I can't speak to someone about it then I don't think rationally and there's uncertainty*'.

Trying to self-help

When attempting to rectify this and speak to a friend to relieve her anxiety, she was unable to prioritise her own feelings, again trapping herself in this anxious space; after making plans to meet during the day and then to watch a film together in the evening, Jane received a message from her friend cancelling the earlier meeting: '*I was disappointed that we couldn't meet during the day because then we can't talk'*. When asked whether she could have told her friend that it was important, it became clear that her own feelings were not a priority: '*I could have written that it's very important, but what can I do if she's feeling really bad and she just can't make it to meet during the day?*' Additionally, Jane expressed that she had expected such a cancellation message; it was almost a self-fulfilling prophecy in not expressing this to her friend. Instead, she suppressed rather than expressed her anger.

Although she was trapped in her anxiety, Jane was also seeking out ways to help herself. She did not find the visits with the psychiatric nurse beneficial and did not want to take mood regulators as '*it kills something* [inside you] *when you take that…I don't like taking medications*'. Despite gaining no use from the visits, she still went once per month; she was afraid to give these up, having a strong desire to improve her situation. She felt desperate with her own emotions and sought out methods to help herself, including complementary medicine, avoiding interventions with which she had previously had negative experiences i.e. pharmacological mood regulators.

Afraid of negative sensations

In addition to being in an almost constant state of emotional upheaval, she was also acutely and constantly aware of physical sensations in her body, having pain and tension every day, immediately attributing new sensations to a new health concern: '*Now, I'm always afraid of what it* [new pain] *is*'.

Control

She admitted that she found it difficult to be out of control of a situation: '*I'm that kind of person that needs to always know what is happening next*'. This stemmed from the sudden need for surgery after a herniated disc and as a result being afraid of each sensation she felt, anxious that it may lead to something more serious: '*I worry about what's coming. It's pretty hard*'. She also felt unable to control her own thoughts and incapable of calming herself down. During the process, she was awaiting a phone call from her doctor with results from a scan. She explained that she felt extremely anxious the night before the expected phone call and was unable to relax. Nevertheless, she felt that she was lucky that she had not been worrying the whole week, suggesting that she felt her anxiety was out of her control: '*Luckily I didn't worry before*'.

Control through choice

Although Jane expressed that she felt the need to constantly be aware of what was coming and be in control, she also seemed to fear this control. This manifested in her difficulty to make choices for herself. During a scheduled VA-Silence session, Jane asked to listen to music, asserting her need for distraction. This moment of choice was important, as asking for something she needed was difficult for Jane; it showed she could control her affect regulation when really needed. As this choice had been important, the practitioner asked Jane in a later session whether she wished to listen to music or not, offering her the choice based on her needs; although she was eventually able

to make the decision (deciding on silence), and afterwards felt it was good there was no music, she found it hard to make the choice.

A changing self-reflection

After the first session (VA-Music), Jane felt '*just wonderful*' and spent six to seven hours shopping after the treatment; thereafter, she noticed how tired she was. She was surprised by her ability to relax during the first session of trying something new: '*This mode worked surprisingly...for the first time…surprisingly well*', but she was not able to pace herself after the session and was fatigued after spending hours walking around the shop. Interestingly, although she felt physically relaxed afterwards, her mind was still very active throughout the stimulation; she was quite anxious, spending the entirety of the treatment programme counting the songs to figure out how long was left: '*Always thinking about what song is next – calculating now three minutes, and one song is almost four minutes and now it's been eight minutes*'.

Initially, she responded poorly to the VA-Silence sessions. She found her mind was much more restless without music as she had nothing with which to distract herself: '*My mind was much more agitated without music. ... The thoughts lasted the whole time, it was terrible, it wasn't good, no, no, just terrible*'. She found it difficult to be in the sessions without music and was overwhelmed by it. She felt that, even if she does not listen to the lyrics of the songs, she could choose when to listen to the music and when to let her mind wander and this relaxed her: '*At the same time I can think and then I can listen again to the singing*'. This became a technique for her during VA-Music sessions; selective listening became a way for her to self-regulate her anxious thoughts.

Struggling to adjust to change

Jane's symptoms were relieved from the treatment, she found that she was able to think more clearly, and expressed having a '*free feeling*' after leaving each session. This improvement, however, also sparked anxiety. She feared what would happen in the Autumn when the darkness would return and she would no longer have VA treatment sessions, again alone in her suffering. She expected to feel worse again and for the improvements to be only fleeting. Unable to enjoy the improvement, she hampered the sensation, instead worrying about the future. She was not able to adjust to the positive change, instead stuck in the feeling that her symptoms would not remain away. Despite this worry about the future, she remarked in Session 7 that she had not had pain or tension in the previous two weeks and she also felt that her frame of mind was better: '*Sometimes I think I* think *better*'. Although struggling to adjust to the change, she also acknowledged that she was experiencing relief and she was beginning to pay attention to the positive rather than worrying about negative feelings she experienced.

Music as a translational mechanism

Music changed the way Jane perceived the treatments; the sensation of the VA treatment programme was different depending on whether she was listening to music or not. The music distracted her both from her own thoughts but also translated the sensation of the vibrations so they felt less intense, although the same frequency series was used each time. She felt that the treatment programme went by more quickly with music and that the vibrations moved up and down her body differently, sensing them in different parts of her body when she listened to music (moving from legs towards chest) compared to no music (chest area, no movement).

Music also translated the way Jane felt about silence. Although she was at first afraid of the sessions without music, she later found that the silence was an important element for her, too, and that actually she needed the silence when she was in a highly aroused state. She was anxious and upset about her daughter wishing to move in with her biological father; Jane recognised that her previously having used music as a way to distract herself from her anxiety did not apply at this point and, music was not something she needed at this time. She did not desire an escape from her anxiety and felt that listening to music would be too overwhelming for her. Although she did not feel relaxed after the session, she felt that '*it was good there was no music*'. This was a stark contrast to her initial fear of silence. Her choice to not listen was an important step in her process and made her realise that she did not need to have music to distract her all the time, rather could selectively use it when she felt she needed support, feeling in control of her fear of silence: '*I think I beat my fear*'. This mirrored what she did during the VA-Music sessions, during which she chose to selectively listen to the music and channel it when she felt the need.

Integrated results

Both quantitative and qualitative outcomes of this study showed that Jane was in a state of suffering. Throughout Jane's process, it was possible to see her move through an isolated and anxious state of suffering towards the hopeful understanding of the possibilities that music offered her in symptom management and in showing her that it is possible to relieve her anxiety. She displayed how one may struggle to cope but also how VA treatment can be used to help retrain one's focus from negative sensations towards developing a sense of self-efficacy, making choices based on her own needs.

The findings revealed that anxiety had control over Jane's ability to engage in daily activities, which was sometimes overwhelming; her need for control in general was magnified when she felt out of control of her own thoughts. She began to take small steps towards discovering and enacting her own needs and this was highlighted at the pivotal stage of choosing to first have music in Session 6 and then not in Session 8. *Control* was overlapping both her struggles with anxiety and her *changing self-reflection*, and the means of taking control for her was to utilise the music listening to regulate her anxiety within music sessions when needed, but also to choose when not to listen to music. Music affected her during the process by enabling her to make this choice and increase her sense of control. Bradt, Dileo, and Shim (2013) also found that engaging in music can increase the perception of control. During the first VA-Silence session (Session 2), pain, mood, anxiety, and relaxation got worse; this negative reaction was supported by her verbal processing of the experience ('*My mind was much more agitated without music. … The thoughts lasted the whole time, it was terrible, it wasn't good, no, no, just terrible*'). In the next session (VA-Music), Jane reported substantial improvements in pain, anxiety, and relaxation, and moderate improvement in mood with the VASs, and also verbally reported as such ('*My mind was much more peaceful than without music, even though I wasn't necessarily listening to the lyrics, but still somehow…it was relaxing!*'). Jane's perception of being calmer during VA-Music sessions is also represented in the mean outcomes per condition (i.e. VA-Music vs VA-Silence), as mean improvement for anxiety was substantial in VA-Music sessions, yet substantial improvement was clear for relaxation in both VA-Music and VA-Silence sessions. The VA treatment thematic interrelationships with control as a catalyst for this positive development are shown in Figure 4 and presently individually discussed.

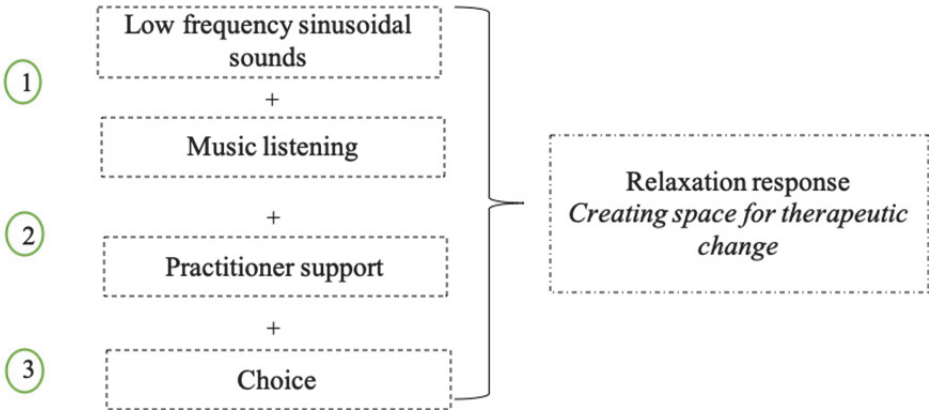

Figure 7. Interrelated elements of (1) low frequency sinusoidal sounds and music listening, (2) practitioner support, and (3) choice, together creating space for therapeutic change through the relaxation response within the VA treatment setting.

Low frequencies and music listening

The first interconnected elements were the low frequency sound vibrations and the music listening. Relaxation was pivotal for eliciting change, which for Jane was at first only possible with the additional music listening element. This is evidenced by the negative response to VA treatment in Session 2 (VA-Silence). The ability to relax was a crucial aspect for her in reducing stress and anxiety and building up the therapeutic space. This was also visible in the VAS-A scores, as anxiety improvement (and worsening) mirrored that of the VAS-R scores. Relaxation was something that Jane reported had previously been quite impossible, however within the context of VA sessions she learned how to do so. The low frequencies allowed her to experience positive bodily sensations, rather than always expecting and experiencing pain. The music listening gave her a means to relax and distract herself from her own thoughts without feeling the stress and frustration of trying and failing to do so in silence. Music was thus a key element in the sessions and process overall, first to help her relax, then as a way to selectively listen and use the music as a distractor as needed within music sessions, and finally to make the choice based on her needs, i.e. choosing to not listen to music.

This is supported by the quantitative outcomes; Jane was unable to relax without music in Session 2 and her relaxation decreased by 40% (VAS-R), her anxiety increased by 39% (VAS-A), her pain got worse by 22% (VAS-P), and her mood also deteriorated by 18% (VAS-M), all clinically relevant changes. It can also be seen that the worsening in pain during VA-Silence sessions represented clinically relevant change, compared to only minimal and non-clinically relevant worsening in VA-Music sessions. Elicitation of a relaxation response seems to have an important role to play in VA sessions, but interestingly an increase in pain levels apparently did not affect her ability to relax nor reduce her anxiety, suggesting that her overall state of suffering was more related to her anxiety than was affected by her pain. Indeed, severe anxiety seems to have taken precedence over her physical symptoms.

Support from the practitioner

Secondly, the interaction with and supportive role of the practitioner was important, especially at a time when she felt isolated in her suffering. The VA sessions were a place where Jane could express herself when seemingly no one else was listening. The hope and expectations that Jane had for the sessions, coupled with experiences of self-efficacy from successful relaxation experiences within

the session, founded on the supportive role of the practitioner, are indicative of some elements necessary to elicit therapeutic change.

Choice

Thirdly, increasing Jane's empowerment and self-efficacy was possible through affording her the control and choice of whether to listen to music or not during the sessions. She initially began this choosing process during VA-Music sessions, when she chose to use music as a distraction from her thoughts – weaving in and out of active and passive listening, using music as a way to self-regulate. Music and choice were the factors which opened the process of needs-based and client-centred decision making; although the choice of whether to listen to music was a struggle, she chose based on her needs and wants in that moment. In Session 6 when Jane made the pertinent decision to listen to music although it was intended to be a VA-Silence session, it was clear from the quantitative outcomes that she was making this decision from a state of acute anxiety; she experienced the greatest anxiety relief (184%, substantial improvement) in this session, suggesting that the combination of control from her choice, music listening with the low frequency stimulus, and the encouragement from the practitioner were all part of the effect.

The interrelationships between the superordinate themes coupled with the VAS outcomes highlights the complexity of these interconnected symptoms and the ways in which they interact and influence each other.

Descriptive triangulation through a member check interview

In the member check interview, Jane confirmed that she felt less pain and anxiety, was in a better mood, and was more relaxed after the VA-Music sessions, and that VA treatment was a '*good model*' for managing her pain and anxiety. She also felt that, although there was a lot of variation and disruption in her quality of sleep, the relaxation and '*maybe a little more of a tired feeling*' after VA-music meant she did not ruminate as much before bed, attributing this to her better sleep.

She confirmed that although her pain was not severe during the process, it was persistent and interconnected with her anxiety and mood and that her MD had confirmed there was no detectable cause for her symptoms. Her experience of music or no music was contradictory, '*sometimes it was good, sometimes not*'. This, she explained, was dependent on her level of coping at the time. Jane noticed she was hypersensitive to sensory stimuli. If feeling low or stressed, she could tolerate only soft/quiet music. When she did listen to music, however, she found that it was difficult for her to focus on herself; during the VA-music sessions she was able to become immersed in the experience and felt like '*being on top of waves, and the waves just carried me*', but found this was a way she could also avoid working on her issues. She also told she was able to gain different perspectives on her issues through the discussions with the practitioner, experiencing a clarity of mind - '*basically somehow lighter*'.

She confirmed that her experience of the treatment was both a physical and mental one: '*when the chair was vibrating*, *I could feel it in my body, but when I was quiet and concentrated on just that, again it affected my mind'*. She told that during the process she learned to concentrate on herself and learned that the anxiety would not overwhelm her; if she could become quiet, she was then able to enjoy '*a sort of...peaceful moment*'. Initially, the non-music sessions were difficult for Jane because she had to '*tolerate myself*'. She was constantly aware of things happening in her surroundings, which was burdensome. She also commented if she noticed a new pain, she immediately categorised it as the worst possible pain – '*I'm very sensitive to that*'.

Jane acknowledged the themes from the qualitative analysis were representative of her experience and agreed that control is a major part of her personality. She also explained that her pain and anxiety were very tightly intertwined and that they usually co-existed. She confirmed that she felt trapped by her anxiety, that she struggled to remain in control of all aspects of her life, and that she began to change the way she thought about and approached situations because of the VA treatments: '*I noticed that I have pain even if I did nothing and I learned to just live with it a bit better and then it was easier'*. She felt that it was '*always a kind of holiday feeling or something quite exciting* [going to the sessions] ... *I could cope somehow better… my head was a bit emptier'*, but initially the sessions were frightening for her because she did not feel in control of the situation. When not in control, '*I'm terribly anxious*' and she found schedule changes very difficult: '*If something surprising happens, I feel that the whole meeting is gone to pieces*.'

Jane agreed with the finding of her changing self-reflection during this process. She began to teach herself how to approach things differently: '*maybe that kind of more relaxed view, way of being'*. Through attending the sessions, she felt that '*my head got a bit of a break*'; this clarity of mind was a contrast to the '*lump*' on her chest that she described as her anxiety. Finally, she told she was encouraged by the fact that the findings from the analysis were relevant to her and that it was '*really nice for me that they are really my things and I felt I also got something from these results* [discussed in the member check interview]*'*.

Discussion

This single case study explored the influence of music listening within VA treatment and the triad of its components: low frequency sounds, music listening, and therapeutic interaction. The quantitative results showed that Jane left the VA sessions feeling much more relaxed, which was also corroborated by the qualitative findings and the member check interview, and that there were more consistent positive effects in the VA-Music condition. This, in addition to improvements in the remaining variables, may point towards lower levels of stress, as was reported by Rüütel (2002). Relaxation is one of the most commonly reported effects of VA treatment (Campbell, Hynynen, & & Ala-Ruona, 2017; Punkanen & Ala-Ruona, 2012) and eliciting the relaxation response is beneficial for relieving stress (Esch, Fricchione, & Stefano, 2003). The relaxation response (Benson, 1975) results in reduced stress response and sympathetic nervous system arousal and may explain the effects of VA treatment (Punkanen & Ala-Ruona, 2012), perhaps due to the repetitive, pulsed nature of the frequency cycles in the treatment programmes and the sympathetic resonance between the body and the applied frequencies, as well as the transporting effect of listening to one's preferred music.

Suffering and sensitisation

The findings showed that Jane was struggling to cope with her unpredictable symptoms as well as uncertainty within her family structure, which contributed to an overall sense of suffering. Suffering is characterised as a state of distress instigated by threat and loss of wholeness, an individualised and subjective experience that includes assigning negative meaning to an event or perceived threat (Cassel, 1997; in Deal, 2011). After the surgery in 2012 she reported as unexpected, Jane was constantly afraid of various pains or sensations she felt, fearing they would result in more medical procedures. She was under continuing psychological threat to her subjective wellbeing. Medically unexplained symptoms (Eriksen & Ursin, 2004) are highly representative of Jane's suffering. The lack of identifiable cause also may have added to hyperawareness of her symptoms. Although the lack of discernible disease source for her physical pain was confirmed by a scan during the process, she was suffering from the psychological stress and anxiety associated with her fear of new pain and what implications it may have. Attentional (hypervigilance) biases in interpretation are strongly

related to anxiety (van Diest et al., 2005). The theory of cognitive sensitisation for medically unexplained complaints (Brosschot, 2002) outlines that those who have an extreme concern about somatic disease will develop a cognitive bias for information related thereto. This bias appears in an activated cognitive network, meaning that signals related to, for example, pain are more closely observed and noticed by us. As a result, one would over-report, misattribute, or over-interpret these somatic sensations based on their own fears or illness beliefs. Jane was highly sensitised to all sensations – both somatic and psychological – and had developed a continued level of anxious suffering because of this cognitive sensitisation to her medically unexplained symptoms. As she explained in the member check interview, she was trying to re-train this response.

Four themes related to suffering are noted by Reed (2003, in Deal, 2011): isolation, hopelessness, vulnerability, and loss. Essential to alleviating suffering is a sense of hope, with a focus on a realistic future. Our perceived reality becomes clouded when one loses hope, as it results in a lack of desire to survive the experience (Rolley, Chang & Johnson, 2014). Jane's experiences can be categorised under these themes of suffering such that she was alone in her suffering and initially felt hopeless and helpless, struggling for control, leading her to a feeling of vulnerability. She greatly disliked being out of control in all situations and since her sudden health issues, she had lost the life she had once led and was lost in her own sphere of anxiety, trapped in her own thoughts.

Yet, Hart (2018) discussed two types of suffering: one in which one feels worried, hopeless, miserable, angry, and worthless with the 'stressful anxiety of loss and responsibility' (p. 142), and the other in which one glimpses hope, learning to see things optimistically and gratefully. The act and experience of suffering is not only a solitary state but also one in which one learns to see the way forward; it is both dissonance and consonance. Music listening - and the choice to listen or not – was a marker of both of these types of suffering for Jane. First, having sessions without music listening were impossible in this worried, hopeless, and miserable state, but later, in choosing to *not* listen to music in Session 8 - thereby listening to her own needs - she was able to see things optimistically, leaving the sessions with a '*free feeling*' and getting over her fear of silence ('*I think I beat my fear*'). Music is widely used to increase one's sense of wellbeing and act as a distractor from thoughts and feelings, improve mood and reduce anxiety, and decrease pain (Kemper & Danhauer, 2005; Nilsson, 2008), which was certainly the case for Jane. Hanser (2014) describes the role of music in framing the experience of pain as 'an ever-changing phenomenon that rises and falls as the music changes in synchrony. As these dimensions shift, the perceptual path of pain ebbs and flows, and it is possible for pain to dissipate in the mind of the listener' (para. 15). This was also the case for Jane and her anxiety; as the music played, the perceptual path of her anxiety ebbed and flowed so that it dissipated and she was able to relax, reducing her bodily tension and pain.

Listening

Due to Jane's isolated suffering, she lamented having no one to whom to talk and thus resorted to suppressing her emotions, spurring more anxiety. One's attempts to understand and endure one's suffering are eased by the sharing of this experience with others, so a listener is an important aspect of any therapeutic process (Deal, 2011). Listening to and conveying that the client has been heard and understood are important elements in building up a supportive environment (Pinto et al., 2012). In the case of VA treatment, the practitioner takes on a supportive role for the client's self-exploration in a client-centred approach by providing the client the opportunity to make choices supporting their own healthcare. Patient empowerment and self-efficacy are essential for eliciting change and clients taking control of their own lives and wellbeing; further, there has been increased emphasis on the identification of patients' healthcare wishes and an increase in patient autonomy (Laugharne & Priebe, 2006). One way in which practitioners can support patient empowerment is to

assume a guiding or coaching role (Chamberlin, 1997). In Jane's case, this involved affording her the possibility to make the choice to listen to music through listening to her own needs. Jane listened to and expressed her own needs, which the practitioner heard and acknowledged. Choice has been shown to have positive consequences in e.g. educational, workplace, and health contexts (Patall, Cooper, & Robinson, 2008), leading to a sense of personal control (Taylor, 1989 cited in ibid.). When a choice has important implications (i.e. eliciting relaxation for anxiety reduction), it may be more difficult to make (e.g. choosing whether to listen to music or not), particularly when the options are equally attractive; individuals experience increased motivation, perseverance, performance, and production when they assert their autonomy through choice-making (Patall, Cooper, & Robinson, 2008). Choice has also been suggested to influence patients' commitment and motivation for attending therapy (Rokke, Tomhave, & Jocic, 1999). In the case of providing choice of music to which patients could listen for managing pain, their preference was important as there was ultimately no difference in the pain outcomes between patients choosing Taiwanese or American music (Huang, Good, & Zauszniewski, 2010). The authors wrote that preference is integral when one employs music listening on a long-term basis for pain management. Jane's choice was a pivotal moment in her treatment process, as it opened the door towards exploring the meaning and use that she could herself attribute to the music listening.

Implications for practitioners

The results and findings from this study suggest VA treatment in general may be beneficial for improving pain, mood, anxiety, and relaxation for a client with medically unexplained symptoms. As such, when comparing the influence of music within the treatment protocol, an important finding of this research is that the client's preference for listening to music should supersede the theoretical understanding of the physiological and psychological effects music has on us (discussed in the section *Music interventions for relieving pain and mood*). The practitioner's role within the treatment sessions to support a client's therapeutic process and safely deliver VA treatment also means the practitioner should help the client to make an informed decision on whether music listening could be used; this would be based on the needs and goals of the overall process as well as a single treatment session. Therefore, this study supports the use of goal-directed music listening rather than delivering music listening solely based on research evidence.

Limitations of the research

The study design employed here, the single case experimental design, was chosen to evaluate how one client receiving VA treatment sessions would respond to both the presence and absence of the music listening element. Therefore, carryover to other patients – even those with a similar configuration of symptoms – is problematic (Charness, Gneezy, & Kuhn, 2012). In general, the disadvantages of exposing one participant to multiple treatments relate to the confounding elements inherent in an individual's experience, especially in a more naturalistic setting (ibid.). As such, the results presented here are to be interpreted with caution, as the treatment process over time – regardless of the specific condition of each session per se – influenced the overall effects of the music listening element. AB designs as such can be useful in exploring the feasibility of an intervention, but do not provide definitive indications of the effectiveness of a treatment (Manolov, Gast, Perdices, & Evans, 2014). On the other hand, the varied treatment responses also highlight the difficulty in managing medically unexplained symptoms and the many external factors influencing a therapeutic process.

Another potential limitation of this study is the fact that Author 1 filled two roles, one as the VA treatment practitioner and the other as a researcher. Author 1 collected all data in the role of

practitioner and also conducted all data analysis and interpretation; despite the qualitative and quantitative data being analysed separately in their entirety before the integrated analysis, this process could not be completely separate as a result of this role overlap. This nevertheless may also be seen as advantageous, as Author 1 had a complete picture of the process from a practitioner's perspective from the sessions to the member check interview as a result of the dual roles (as discussed in section *Roles of the researchers / practitioner*).

Finally, Visual Analogue Scales may have been too simplistic a measurement tool to assess Jane's nuanced experiences. The verbal processing / qualitative data were therefore extremely important in supporting the quantitative results. The broader topics of discussion between the client and practitioner during the sessions allowed for a more complex examination of Jane's contextual therapeutic experiences, but the integration of diverse data sources – the quantitative as specific and qualitative as more general explorations – was more complicated as a result. Although it may have potentially been beneficial to conduct more formalised interviews of her experiences pertaining directly to the variables under examination, this would have compromised the integrity of the therapeutic context. The research process and outcomes of this study therefore support the use of mixed methods as a means of exploring how a client may respond to a therapeutic intervention when having diverse symptoms of no discernible medical source, despite the potential pitfalls of single case research in general.

Areas for further exploration

The client's specific connection to their preferred music may be important in sensation perception. Having a clearer idea of how an individual responds to certain music would be an important step in further understanding the interaction of the VA treatment elements. This supports the necessity of the therapeutic and supportive role of the practitioner in planning and executing the therapy process, with the client sharing the responsibility in how their treatment progresses. Understanding more closely the individual benefits and cumulative effects of each arm of the VA treatment triad works towards more effective and safe utilisation of VA. More research is also needed to explore how the VA treatment elements work together for various target groups such as patients with complex and interacting symptoms.

Conclusion

Music listening with low frequency sound vibration and therapeutic interaction was beneficial for reducing anxiety, improving mood, and reducing pain with potential implications for improving quality of sleep for a client with medically unexplained symptoms. Low frequency sinusoidal sound vibration and therapeutic interaction with and without music listening was beneficial for relaxation. Music ultimately became an opportunity for Jane to learn how to both actively and passively self-regulate her anxiety, and the choice to not listen to music was equally important as it enabled her to address and engage with her own needs. Choosing to listen to music or not was supported and reinforced by the practitioner, as the choice was based on Jane's current needs and served to empower Jane, important for therapeutic change. Although more research is needed, music in this case was an important pivotal point of change in the therapeutic process, enabling the participant to make positive choices for her own wellbeing. The choice of whether to listen to music or not, or indeed the music to which one listens, within VA treatment can play an important role in the effect music listening may have within a process.

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IV

EXPLORING THE USE OF VIBROACOUSTIC TREATMENT FOR MANAGING CHRONIC PAIN AND COMORBID MOOD DISORDERS: A MIXED METHODS STUDY

by

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Exploring the use of Vibroacoustic Treatment for managing chronic pain and comorbid mood disorders: A mixed methods study

Introduction: Chronic pain is a worldwide issue with common comorbidities of depression and anxiety, altogether inhibiting one's personal relationships and capability to work. Music has long been used as a means to improve pain and mood, and the tactile application of music has shown promising and beneficial results for the treatment of both psychological and physical symptoms. VA treatment uses low frequency sinusoidal sound vibration (20-120Hz) supported by client-preferred music listening and therapeutic interaction. **Methods:** Using mixed methods, this study addresses the addition of a self-care VA intervention to maintain the effects of practitioner-led VA treatments and to increase patients' independence in managing their symptoms. After baseline measurements, VA treatment was delivered to 5 patients at a rehabilitation unit by a trained VA practitioner, followed by self-care at home and a washout phase with no treatments. Quantitative outcome measures included Visual Analogue Scales for pain and mood, and Beck's Depression Inventory and the anxiety subscale of Hospital Anxiety and Depression Scale. Qualitative data comprised practitioner clinical notes and participant evaluation forms. **Results:** Quantitative outcomes suggest VA treatment is beneficial for pain and mood relief and that a self-care intervention has the potential to prolong positive outcomes. Qualitative findings suggest that patients found the sessions at the hospital useful and empowering but the self-care treatments comparatively weak. **Discussion:** Future studies may address the difficulty in conducting self-care and the importance of the client-practitioner relationship in supporting this activity for those suffering from chronic pain and comorbid mood disorders.

Keywords: vibroacoustic; chronic pain; depression; anxiety; self-care

Introduction

Access to pain management is a fundamental human right (Declaration of Montréal, 2011). There is inadequate knowledge regarding both the underlying mechanisms of chronic pain and suitable and tenable approaches to its management. As a psychophysiological phenomenon (Garland, 2012), chronic pain presents with

comorbidities such as depression, anxiety, social phobia, and panic disorder (Castro et al., 2009; Gureje, 2008; Scott et al., 2007). Pain may act as a catalyst towards disease severity by aggravating depressive symptoms, thereby increasing disability and social isolation, indicating a bi-directional relationship (Kiecolt-Glaser, McGuire, Robles, & Glaser, 2002; Woo, 2010). Combined anxiety and depression are more common in those suffering from chronic pain than pain with either mood disorder alone (Scott et al., 2007) and addressing these interconnected symptoms is heightened by their subjective nature. Furthermore, negative pain-related emotions materialise as biobehavioural processes, influencing how pain is perceived, thus begetting further suffering. These interconnected physiological, psychological / emotional, and behavioural aspects are critical issues in pain management. As mood disturbances and nociception (sensory response to pain) share pathways and neurotransmitters in the brain, a precedent exists for treating these concurrently using approaches addressing both (Scott et al., 2007).

Music listening for chronic pain relief

Music listening has been proffered for pain relief due to the ease of delivery, low provisional cost, and absence of side-effects. The effects of music intervention may be based on neurophysiological responses specific to pain and music, working on sensory, cognitive, affective, and behavioural components (Guétin et al., 2012). Music medicine – music listening offered by a healthcare professional (Bradt et al., 2015) – was shown to be effective for reducing analgesic use (Lee, 2016). Lee states that music medicine is used to distract, reduce tension, and promote relaxation. Music listening has significantly improved chronic pain, anxiety, and depression and reduced medication consumption (Guétin et al., 2012). Linnemann and colleagues (2015) found music listening in daily life may lead to successful pain management as activation and relaxation predicted an increase in participants' sense of control over their pain. Garza-

Villarreal et al. (2014) found patients' pain was significantly reduced when listening to their preferred music.

Music listeners who have chronic pain describe music as having the possibility to increase energy and lift one's spirits; further, sad music can help release negative feelings or support altering pain perception and enhancing physical relaxation (Gold & Clare, 2012). Alleviating mood and increasing relaxation significantly relieves pain, highlighting again the pain-mood relationship. The authors posit that using music to provide "positive emotional experiences" (p. 559) could offer a meaningful mode of coping with chronic pain.

Vibroacoustic Treatment - a tactile and auditory music intervention

Although most studies focus on auditory music reception, music may also be tactually experienced. Vibroacoustic (VA) treatment is comprised of three elements: low frequency sound vibration (20-120Hz), music listening, and therapeutic interaction (Campbell, Hynynen, & Ala-Ruona, 2017). This intervention is often used within music therapy practice (Ala-Ruona & Punkanen, 2017). The low frequency stimulation is delivered through specially designed recliner chairs, mattresses, or smaller portable devices. The sensation felt when receiving the stimulus may be compared to a wave-like sensation or a massage. Experimentation (Wigram, 1996) showed people consistently feel the same frequencies in similar places on their bodies, for example, 40 Hz is felt strongest in the calves/thighs. This response of the body to particular frequencies in particular areas has been referred to as *resonance*.

In music listening interventions, client preference is important; however, the intention of using music in VA treatment is to support physical and psychological relaxation (Grocke & Wigram, 2007), so further factors may be considered. Grocke and

Wigram note that music without unpredictable changes in volume, tempo, or harmony may elicit a relaxation response.

Finally, the interaction/support from the practitioner is an essential element to VA treatment. Adequate client preparation and application of the intervention, and effective closure of potential responses to treatment (e.g., physical sensations, mental imagery) is required to ensure goal-oriented therapeutic outcomes (Grocke & Wigram, 2007).

Oscillation and dysfunction with chronic pain

A resonant frequency – the frequency at which a system responds to applied oscillation by resonating or entraining with said frequency – manifests as a complex and dynamic response due to the high damping effect from the body (Griffin, 2004). The effects of vibroacoustics relate to direct oscillation or resonance of the body when frequencies are applied (Punkanen & Ala-Ruona, 2012). Resonance is linked not only to this physical resonance in the body but is posited to stem from oscillation within the brain (Llinás, 2003; Bartel et al., 2017). The symptoms and comorbidities of chronic pain points towards oscillation dysfunction playing a significant role in developing and maintaining chronic pain (Ploner, Sorg, & Gross, 2016). Thalamocortical dysfunction – disrupted gamma oscillations around 40 Hz – may be amended by applying tactile vibration such as in VA treatment (Bartel et al., 2017). VA research has been conducted on frequencies around 40 Hz under the hypothesis that it may act as a driving force for rhythmic (re)entrainment of this disrupted thalamocortical loop (Bartel et al., 2017).

VA treatment for pain

The relatively limited research conducted on VA for chronic pain relief has reported clinically relevant outcomes for various types of pain. Fibromyalgia patients

showed statistical and clinical improvement in pain (Naghdi, Ahonen, Macario, & Bartel, 2015) after 10 low frequency treatments (23 minutes at 40 Hz). Patients with chronic pain (e.g., chronic pain syndrome) and comorbid psychological issues (e.g., depression) showed clinically relevant improvements in pain, mood, and relaxation after 10 sessions (approx. 37 minutes each) with 40 Hz-centric treatment programmes, patient-preferred music listening, and therapeutic interaction (Campbell et al., 2017). In adults with spinal cord and brain injuries, symptoms including spasticity, pain, physical discomfort, and anxiety were significantly improved after four to five 40 Hz VA treatment sessions lasting 23 minutes (Rüütel, Vinkel, & Eelmäe, 2017). Except in one study (Campbell et al., 2017), follow-up has not been conducted, but results suggest effects may fade after time.

Self-care for pain management

Although pain prevalence is acknowledged, patients report inadequate treatment (Breivik et al., 2006). Obstacles include patients' reluctance to seek treatment, and perceived patient-practitioner communication barriers; chronic pain self-care programmes supplementary to therapeutic interventions are being developed to counteract this (Ruelman, Karoly, & Enders, 2012). Self-care allows for an individualised approach, as patients may be best suited to assessing the procedures most beneficial for themselves. Patients' belief that something is helpful may also be important. Healthcare providers believe self-care is the first step in pain management (Kovačević et al., 2018). Reported outcomes include significant reductions in pain intensity, and depressive and anxious symptoms (Mehlsen, Heegaard, & Frostholm, 2015), increased perceived control (Ruelman et al., 2012), and improved mental health and quality of life (Miaskowski et al., 2004). Healthcare personnel play an integral role in supporting (e.g. giving advice, encouragement) the process (Mann, Fort &

VanDenKerhof, 2013). Without this, chronically ill patients abandon their practices when overwhelmed by their symptoms or if feeling unsupported (Godfrey et al., 2010).

Rationale

Music – including tactile – interventions have both physiological and psychological effects on us, situated within a biopsychosocial framework. VA treatment includes: (1) the music listening experience, shown to be effective for pain, depression, and anxiety relief, (2) the tactile stimulus, beneficial for both physical and psychological symptoms, and (3) support from the practitioner, important in ensuring processing (of potentially evoked sensations, emotions, memories, or images) and in helping to achieve therapeutic outcomes defined by the patient and practitioner. Acknowledging these combinative roles and self-care's potential to reduce pain and improve mental health, the rationale to explore the combination of VA treatment and a self-care phase applied to manage chronic pain and comorbid symptoms exists.

Aim

The aims of this study were to measure patients' pain and mood outcomes after VA treatment within a naturalistic medical setting followed by self-care practice conducted at home, and to assess individual responses to the treatment conditions. To address this aim, the following research questions were posed:

RQ 1: Does VA treatment alleviate chronic pain, depression, and anxiety, and does self-care maintain these potential effects?

RQ2: What were the individuals' responses to the treatments?

RQ3: How do the themes which emerged from the qualitative analysis inform the interpretation of the quantitative pain and mood scores reported in each phase?

We sought to answer RQ1 with self-report quantitative scales and to answer RQ2 exploring participants responses to the treatments recorded in the practitioner's clinical notes and in the patients' evaluations of the treatments and procedure of the pilot study (evaluation form). RQ3 was addressed in the integration of the quantitative and qualitative outcomes.

Methods

We employed a mixed methods approach with quantitative and qualitative data collected in a convergent-parallel design (Bradt, Burns, & Creswell, 2013). The quantitative (self-report scales for pain, depression, and anxiety) and qualitative (practitioner's clinical notes and participant evaluation forms) data allowed us to utilise the strengths of both, with integration for comparing and contrasting outcomes.

Upon receiving ethics approval (ETL: R16078), patients with chronic pain at [blinded] referred by their physician for VA treatment were approached by the practitioner and informed about the pilot study's design, treatments, and aims. The practitioner assessed patients' eligibility according to the inclusion criteria of suffering from chronic pain and potential depressive/anxious symptoms. Individuals who were pregnant, had inflammation, or were suffering from severe psychological issues (e.g., psychosis) were not included. This sample was representative of the patients treated at this unit and followed a purposive sampling method. Potential participants diagnosed with various types of chronic pain were screened for comorbid mood disorders using Beck's Depression Inventory-II (BDI-II), a widely accepted tool for assessing intensity of depression in psychiatric and normal populations and the Hospital Anxiety and Depression-Anxiety subscale (HADS-A), widely used in both medical and psychiatric contexts (Smarr & Keefer, 2011).

Participants

Six participants partook in this study. One participant was excluded from analysis because his pain-related symptoms were minimal. The mean age of the remaining two females and three males was 44.8(±8.08) years (range 33-55). Demographics are summarised in Table 1.

Table 1. Participant demographics

Demographics	Participants (n=5)
Age (years)	
Mean(*SD*)	44.8(*8.08*)
Range	33–55
Sex	2 females, 3 males
Diagnoses	
P1	M51.3 Intervertebral disc degeneration M79.0 Rheumatism, unspecified F33 Recurrent depressive disorder F40.1 Social phobia
P2	M47.2 spondylosis with myelopathy F41 Scoliosis J44.8 Chronic Obstructive Pulmonary Disease (COPD) J45.9 (Asthma) M79.7 Fibromyalgia
P3	G71.11 Myotonic disorders (muscular dystrophy, type II) R52.2 Chronic pain
P4	F32.3 Severe depressive episode without psychotic symptoms M75.1 Rotary Cuff Syndrome
P5	M51.3 Intervertebral disc degeneration M79.0 Rheumatism, unspecified

Devices

Two devices were used to deliver the low frequency sound vibration stimuli: a Next Wave Physioacoustic Chair (see *Picture 1* in the supplementary web material) and a Taikofon FeelSound Player, a small portable cushion (see *Picture 2* in the supplementary web material).

Physioacoustic chair

Sonus Health Editor v3.26c computer software is used to play the treatment programmes through the loudspeakers located in the neck, back, thigh, and calf regions of the chair. The seatback and leg rests of this recliner chair can be adjusted by remote control. The frequency range is 27.13–113.22 Hz. The chair is designated as a low-risk, non-invasive treatment and is approved by the Food and Drug Administration (FDA) in the USA, the Canadian Standards Association (CSA), and the British Standards Institution (BDI) with permissible claims of pain and stress relief, muscle relaxation, and improved blood and lymphatic circulation.

Taikofon

The Taikofon FeelSound Player, a cushion-like device, has built-in speakers and sound vibration or music can be played via audio cable or Bluetooth. The frequency range is 20–20,000 Hz. To play the stimulus, participants were given an android mobile phone (Huawei Y5) with one VA treatment programme installed. Due to the size of this cushion, it can easily be placed anywhere on the body, for instance, the lower back.

Stimuli

A 37-minute programme was used with the Physioacoustic chair played through Sonus Health Editor v3.26c computer software and a 23-minute programme with the Taikofon played through the Huawei device. Both programmes were the same for all participants, however the intensity of the programme through the Physioacoustic chair was adjusted according to each patient's needs and participants could individually adjust the volume of the self-care programme at home.

The VA treatment programme parameters delivered through the Physioacoustic

chair using are *time*, *frequency*, *scan*, *speed*, *cycle*, *strength*, and *action*. The 37-minute programme has several phases lasting from two to three minutes focusing on 40 Hz but ranging from 29.15–61.04 Hz. This programme was used because 40 Hz has been shown to be useful for pain relief (Naghdi et al., 2015), with the potential to act as a driving force for thalamocortical oscillatory regulation (Bartel et al., 2017). Practice-based evidence also shows it is useful in managing pain and mood disorders (Campbell, et al., 2017). The massage-like sensation is simultaneously afforded by several elements; *scan* refers to the constant frequency changes around the fundamental of each phase. This helps reduce potential side effects, as high levels of low frequency sound can be associated with nausea and panic (Wigram, 1997, p.11). *Cycle* is also referred to as *pulsation*; it corresponds to the speed of the amplitude change, that is, the time taken to complete a full cycle from silence to the designated peak volume. In this programme, each cycle lasted an average of 11.09 seconds. In practice, a longer cycle relaxes, whilst a shorter cycle energises. The *strength* can be globally adjusted or specific to each speaker; a particular body part, for instance, the lower back, may be targeted in this way. Treatment programme strength is generally lower when a process begins so the patient can become accustomed to the sensation. *Action* is the directional movement; the programme either moves from head-to-toe, vice-versa, or remains fixed. The speed of this *action* is also dictated by *cycle*: the faster the cycle, the faster the directional movement.

With Taikofon, a 23-minute 40 Hz programme was used with all participants. As this is a smaller, portable device, the parameters of the treatment programme pertain only to the *strength*, that is, the volume, which could be individually adjusted, and *cycle*, approximately seven seconds long. The mobile phone through which the programme is played is used to adjust the volume.

Procedure

The protocol (see *Figure 1*) consisted of four phases. Phase I was a one-week baseline measurement phase. There were no VA treatments during this time. Phase II comprised VA treatment sessions offered by a trained practitioner using the Physioacoustic chair. The practitioner, with a background in occupational healthcare, has been trained by the Vibrac Skille-Lehikoinen Centre for Vibroacoustic Therapy and Research. Participants received eight VA treatment sessions delivered bi-weekly for one month. In Phase III participants conducted five self-care VA treatments per week for one month in their homes. They were instructed to conduct self-care from Mondays–Fridays at the same time each day, to position themselves comfortably (e.g. sitting or lying down), and to listen to the same music as during Phase II, making a note of where they positioned the Taikofon device on their body during self-care. Finally, Phase IV was a month-long washout period; participants did not receive VA treatments.

Assessment

Quantitative outcomes

The quantitative outcomes were Visual Analogue Scales for both pain (VAS-P) and mood (VAS-M), Beck's Depression Inventory-II (BDI-II), to assess depression, and the anxiety subscale of the Hospital Anxiety and Depression Scale (HADS-A) for anxiety.

A Visual Analogue Scale (VAS) is a 10cm horizontal line with anchors on either end. The anchors in this study for pain were 0=worst pain imaginable and 100=no pain; for mood, these were 0=depressed and 100=happy. The VAS is widely implemented due to ease of use (Younger, McCue, & Mackey, 2009). Test-retest reliability is reported as r = 0.94 for pain (Hawker et al., 2011) and r= 0.82 for mood (Ahearn &

Carroll, 1996). The patient was asked to mark these lines to represent their current pain intensity and mood.

Beck's Depression Inventory-II (BDI-II) is a self-complete, 21-item self-report psychometric test measuring severity of depressive symptoms (Smarr & Keefer, 2011). Items are rated on a four-point scale from 0 (e.g., "I do not feel like a failure") to 3 (e.g., "I feel I am a total failure as a person"). Depression severity is represented by the sum of the scores across items. The scale used is validated in Finnish (Suija et al., 2012) and can be used to measure both baseline severity and responsiveness to treatment. Cronbach's α, an objective measure of a scale's internal consistency or reliability, was reported as 0.92 for outpatients and 0.93 for college students (Smarr & Keefer, 2011).

The anxiety subscale of the Hospital Anxiety and Depression Scale (HADS-A) is a self-complete scale to assess the non-somatic cognitive and emotional aspects of anxiety in general medical populations. It has seven items that are rated on a four-point scale (e.g., "I feel 'wound up'" ranging from 0=not at all to 3=most of the time). The reliability of HADS-A ranges from α=0.78–0.93 (Smarr & Keefer, 2011).

VAS-P and VAS-M, BDI-II, and HADS-A were taken at intake in Phase I and at the end of Phases II, III, and IV. VAS-P and VAS-M were also assessed two more times during baseline (Phase I total: 3), before and after each VA treatment (Phase II total: 16), before and after each self-care treatment (Phase III total: 40) and three times per week during washout (Phase IV total: 12). Each participant completed 71 VAS-P and VAS-M and four BDI-II and HADS-A. As this was an exploratory study, we wished to garner as much information as possible on the variability of the patients' pain and mood during the process, especially since few studies have been conducted on this topic and that self-care was a novel addition to VA treatment. Pre- and post-treatment VAS-P and VAS-M outcomes were thus collected in both treatment phases.

Qualitative outcomes

The qualitative outcome measures included the practitioner's clinical observations/notes (including participants' verbal reports recorded by the practitioner throughout the process) and participants' process evaluation. The practitioner made notes after each session with a client, reporting on patients' self-assessments, an important element in the communication between healthcare professionals in this multidisciplinary team. All verbal interaction between the client and practitioner pertaining to their treatment response was recorded but no formal template was used because patients' responses can be variable and freedom to report all types of responses is desired. These notes, sent to the primary physician after the process had ended, included recommendations for future treatment phases. In the evaluation form, participants were asked to opine on (a) each treatment phase, (b) the devices used in the study, and (c) to express whether their symptoms returned, remained the same, or improved during the washout period.

Data analysis

Quantitative data

Due to the difficulty in assessing and meta-analysing pain management intervention outcomes, the Initiative on Methods, Measurement, and Pain Assessment in Clinical Trials (IMMPACT) outlined a standard set of measures to foster meaningful comparison. The consensus statement (Dworkin et al., 2008) recommends margins for the smallest clinically relevant change in patient outcomes called the Minimal Clinically Important Difference (MCID). The following benchmarks for minimal, moderate, and substantial clinical change for pain relief are suggested: a 10-20% reduction on the VAS corresponds to the MCID in patient reported outcomes; ≥30% reflects at least a

moderate change, and ≥50% reflects substantial improvement. Additionally, Jensen, Chen, and Brugger (2003) recommended interpretation cut-off points[1]: 0-24mm (severe pain); 25-55mm (moderate pain); 56-95mm (mild pain); 96–100 (no pain).

BDI-II scores can be interpreted as follows: 0–13 minimal depression; 14–19 mild depression; 20–28 moderate depression; 29–63 severe depression. Dworkin et al. (2008)'s category change (e.g., from *moderate* to *mild* depression) and 5-point reduction benchmarks are used here.

HADS-A scores can be interpreted as: 0–7 normal; 8–10 borderline, and 11–21 abnormal anxiety. The MCID for the anxiety sub-scale in HADS-A is suggested as a decrease of 1.57 points (Puhan, Frey, Büchi, & Schünemann, 2008).

Data were analysed using SPSS (IBM SPSS Statistics for Macintosh, Version 24.0). Means and standard deviations were calculated per phase per participant; these were used to see possible individual change within phases, using Dworkin and colleagues' (2008) interpretation guidelines for assessment of change, and Jensen and colleagues' (2003) interpretation guidelines for contextualisation of pain and mood changes.

Qualitative data

Qualitative content analysis was used to analyse all qualitative data (Elo & Kyngäs, 2008). Raw data were prepared in a common document and analysed by Author 1, with a member check completed by Practitioner. An inductive approach of

[1] Jensen and colleagues' recommendations for VAS were based on the anchors the 0=no pain; 100=worst pain imaginable. As this study implemented the opposite (i.e. 0=worst pain imaginable) as is standard protocol at this facility, the guidelines presented here are inverted.

deriving categories was used so as to stay as close as possible to the experiences of the participants, allowing the findings to emerge from the raw data (Thomas, 2006). The coding process was guided by the research question "*What were the individuals' responses to the treatments?"*, providing a focus for the analysis rather than expectations regarding specific findings. The documents were read through to make sense of them as a whole. The first round consisted of open coding. A code assigns interpreted meaning to data to locate patterns and develop categories (Saldaña, 2016) and are the bones of the analysis from which one constructs the skeleton (Charmaz, 2006). Next, a general description of the subject was abstracted and formulated, each lower-level category derived from several readings of this raw data and the upper-level (main) categories founded on the evaluation aim. These were identified by marked text sections translating into emerging categories. Several readings and revisions of these categories were conducted to identify (non)common elements, so that common elements would be grouped under the same category when meanings were similar. To convey the emerged lower- and upper-level categories, illustrative quotes were selected based on the initial marked sections to display the core of each category.

Integrated data

After the separate analysis of the quantitative and qualitative data, these were compared and (non)congruent findings contrasted, with a joint display of these participants' experiences after VA treatment and self-care. As the mixed methods design pertained to a parallel-convergent design, in which both data sets were collected simultaneously for answering questions pertaining to the same phenomenon, the qualitative data supported the quantitative in exploring the participants' responses to the treatment. The quantitative pain and mood data were merged with the qualitative descriptions of the participants' experiences such that when a participant reported on

pain, the same instance was explored in the qualitative themes. Experiences expressed in the qualitative themes were compared and contrasted with the quantitative changes reported by each participant.

Results

Quantitative results

The quantitative data were used to answer RQ1: *Does VA treatment alleviate chronic pain, depression, and anxiety, and does self-care maintain these potential effects?* Mean pain and mood scores for each individual participant per phase are shown in Table 2 marked with Dworkin and colleagues' (2008) MCID guidelines. BDI-II and HADS-A scores are also shown in Table 2. Due to participant heterogeneity and small sample size, mean scores across all participants are not presented, however Jensen et al.'s (2003) interpretation guidelines are presented per phase to discuss all participants' change throughout the process. Participants completed (P1) 72%, (P2) 77%, (P3) 85%, (P4) 100%, and (P5) 97% of VAS outcomes measures and all but P1 and P2 completed 100% of BDI-II and HADS-A outcomes.

Table 2. Means (and *standard deviations*) of all outcome measures for pain, mood, depression, and anxiety for each participant in the respective phases.

	Baseline	Hospital sessions		Self-care sessions		Washout
	Phase I	Phase IIa	Phase IIb	Phase IIIa	Phase IIIb	Phase IV
	Visual Analogue Scale – Pain (0-100mm; higher score denotes less pain)					
P1	53*	59.88(*7.90*)	69.63(*6.61*)°,°	45.09(*5.31*)	43.27(*4.26*)	47.67(*5.35*)°
P2	42 (7.87)	54.14(*24.19*)	85.29(*10.01*)†,§	57.64(*18.60*)	71.77(*15.96*)†,°	58.08(*10.20*)§
P3	37(10.03)	40.88(*21.52*)	68.25(*14.00*)†,†	33.05(*17.72*)	42.90(*15.63*)°,°	75.00(*8.64*)†
P4	24.67(1.70)	72(*13.82*)	69(*19.72*)†	37.3(*12.66*)	42(*12.72*)†,°	33.75(*6.04*)§
P5	67.33(9.53)	71.88(*8.62*)	80.38(*17.59*)°,°	66.75(*16.72*)	71.65(*17.59*)	75.50(*5.30*)°

Visual Analogue Scale – Mood (0-100mm; higher score denotes better mood)						
P1	39*	59.63(*8.43*)	72.5(*7.19*) †,°	23.65(*21.81*)	26.25(*24.27*)-§,°	51.58(*4.46*)°
P2	52.67(*20.17*)	79.14(*8.06*)	91.86(*6.40*)°	80.29(*12.37*)	86.92(*6.97*)	67.17(*11.89*)
P3	75.00(*8.64*)	67(*10.70*)	74.88(*7.70*)°	58.4(*13.32*)	59.8(*13.28*)	71.00*°
P4	50(*13.74*)	81.5(*2.96*)	70.25(*9.09*)°	54.9(*14.42*)	49.7(*8.61*)	45.58(*13.23*)
P5	28.00(*4.32*)	36.63(*6.84*)	43.75(*6.46*)°	33.8(*8.47*)	36.9(*10.76*)	39.58(*3.77*)
Beck's Depression Inventory-II (0-63; lower score denotes fewer depressive symptoms)						
P1	30	-	-	-	30	29
P2	15	-	-	-	0°	9°
P3	23	-	24	-	25	27
P4	42	-	36°	-	41	43
P5	26	-	4°	-	5°	2°
Hospital Anxiety & Depression Scale – Anxiety subscale (0-21; lower score denotes fewer anxious symptoms)						
P1	7	-	-	-	9	9
P2	8	-	-	-	3°	3°
P3	7	-	9	-	5°	7
P4	11	-	10	-	11	14
P5	12	-	5°	-	5°	3°

*Denotes only one measurement.
VAS improvements are denoted by the following symbols: °Minimal Clinically Important Difference (MCID); ° Moderate improvement; †Substantial improvement; if two symbols are presented, then the first symbol denotes improvement from baseline, and the second denotes improvement from pre- to post-treatment scores within one phase (e.g., from Phase IIa to Phase IIb). A minus symbol additionally refers to a negative change, i.e. -§ refers to moderate worsening.

Pain

All participants apart from P5 presented with *moderate* pain at baseline and their pain was *mild* in Phase II post-treatment. P1, P3, and P4 returned to *moderate* pain during Phase III, however P3 had *mild* pain during Phase IV. P2 remained in the *mild* category for the remainder of the process and P5 had *mild* pain throughout.

When participants' pain remained in the same category (e.g., P5), the change within the phases could be seen through the MCID interpretations. From Phase I to IIb, all participants recorded at least MCID; P2, P3, and P4 reported *substantial*

improvement. From Phase IIa to IIb, P1 and P5 reported MCID, P2 reported *moderate* improvement, and P3 reported *substantial* improvement. From Phase I to IIIb, P2 and P4 reported *substantial* improvement and P3 reached the MCID. From Phase IIIa to IIIb, P2, P3, and P4 reported the MCID. Improvements from Phase I to IV for P1 and P5 were MCID, *moderate* for P2 and P4, and *substantial* for P3.

Mood

All participants apart from P3 were *moderate* at baseline. P3 remained in the *mild* category throughout whilst P5 remained *moderate.* P1, P2, and P4 changed to *mild* in Phase II. P2 remained *mild* until the end, P4 was *moderate* from Phase III onwards, and P1 was *severe* in Phase IIIa but *moderate* from Phase IIIb until the end.

From Phase I to IIb, all participants reported MCID, with P1 reporting substantial improvement. Within Phase II, only P1 recorded MCID. From Phase I to IIIb, P1 reported *substantial* worsening, but positive MCID from Phase IIIa to IIIb. P1 and P3 had MCID from Phase I to IV. P3, although only in the *mild* category throughout, reached the MCID in Phase II and reported improvement also in Phases III and IV. P5 – persistently *moderate* – also reported improvement in each phase, reaching MCID in Phase II. P4 reported worsening mood in all phases, yet within Phase II was *mild* and the worsening scores were only marginal from Phase IIIa to IV.

Depression

In Phase I, P1 and P4 had *severe* depression, P3 and P5 had *moderate* depression, and P2 had *mild* depression (see *Figure 2*). Minimal clinically important change was recorded by P2, P5, and P4. Although P4 remained in the same category (*severe*) throughout the study, clinically important change was still achieved, represented by a 6-point decrease in Phase II. P5 changed two categories, from

moderate to *minimal*, and P2 improved from *mild* to *minimal*. P1 and P4 remained in the *severe* category and P3 remained in the *moderate* category throughout. P1 and P2 did not complete the BDI-II or HADS-A at the end of Phase II.

Anxiety

P1 and P3 were in the *normal* category at baseline (Phase I), P2 was *borderline*, and P4 and P5 were in the *abnormal* category as measured by their HADS-A scores (see *Figure 3*). P2 and P5 reported clinically important changes in category and reduced their score by 5 and 9 points respectively. P1's anxiety increased by 2 points during washout. P3 had more anxiety in Phase II, showed clinical improvement in Phase III, and returned to baseline score in Phase IV, although this was still within the *normal* range. Finally, P4 temporarily changed to the *borderline* category (Phase II) but was more anxious in Phase IV than in the other three phases.

Qualitative results

The qualitative data were used to answer RQ2: *What were the individuals' responses to the treatments?* Four main categories – *Relief*, *Recurrence*, *Evaluation*, and *Proactive Involvement* (see *Table 3*) – with nine categories – *Improved Symptoms, Medication Changes, Retained Effects, Returning Symptoms, Positive Experience, Challenges in Self-care, Less Rigid Design, Seeking Relief,* and *Self-care Activities* – emerged from analysis. Category descriptions and illustrative quotes are presented to support the generated categories.

Table 3. Qualitative Content Analysis of practitioner's clinical notes and participant evaluation forms

Main category	**Category**	**Illustrative quote**	
		Practitioner notes	**Participant evaluation form**
Relief	Improved symptoms	<u>Practitioner notes</u> "In the 1st session the client had neck pain that was gone after the treatment" (P3) "It was easier to move his head whilst driving […] and following the traffic" (P1) "Things don't stress her as much, she is more relaxed and peaceful; her partner wondered whether she was taking new medication" (P2) "Energetic, more cheerful (spouse noticed and mentioned this)" (P2) "The client could relax and remain so during the treatment time, which is usually very difficult for him" (Practitioner on P1) "She experienced that the treatment works more on a psychological level than a physical one; It makes her thoughts very calm; she has never before been able to relax as well as with this method" (P5)	"Neck isn't as stiff as it was before the treatment" (P1) "Treatment helped in several ways" (P5) "This helped me a lot; Many thanks!" (P5)
	Medication changes	"She told in the 5th session that she has not needed any analgesics since the treatment started" (P5) "Told that after May 10th [end of Phase III], stopped taking amlodipine [for hypertension]. After he stopped taking the medication, the pains in his hands and ribs/sides were slightly better. The mediations caused ambiguous pains" P4)	
	Retained effects	"Always slept well 2-3 nights after the treatment" (P4)	"Mood remained more or less the same [during Phase IV]" (P3)
Recurrence	Returning symptoms during Phase IV	"Panic attacks returned (wakes up at night); hot flushes returned – many times per day; Not sleeping well" (P2); "She felt that her health got much worse during the washout-phase, which can be see [from the VAS outcomes]" (P5);	"The pains got worse and the symptoms [hot flushes] returned" (P2) "For some reason, the amount of sweating increased during this time" (P3) "Sleeping deteriorated after the treatments [Phase II] ended" (P5)
Evaluation	Positive experience	"She felt that through the years, nothing she tried worked and now her has found a treatment that affects her overall state" (P5); "I would rate the [VA] chair as 10+" (P2);	"Positively empowering" (P2) "Nice – no anxiety" (P1) "Good practitioner" (P5)
	Challenges in self-care	"He found the cushion strength slightly weak, and the effects weren't near	"A bit awkward – couldn't find the right place to

		what they were with the chair. Sleeping started to deteriorate after the VA sessions [Phase II]. The Taikofon didn't have good results for sleep in this case. The pains returned to baseline scores and the same with sleeping and then as a result, level of activation also became worse" (P4)	put the cushion" (P1)
		"Using the cushion felt like he was forced to do so and the effects weren't close at all to the effects of the chair" (P3)	"Compulsory commitment" (P3)
		"Some benefits from the Taikofon; … The shoulder blades are not as stiff" (P5)	"Clear instructions – the wires/flexes could be longer" (P2)
		"Now she notices that the 8x contact sessions were very good. The Taikofon was somewhat useful (noticed this during the washout period). Now back to the poorer condition. When nothing else had helped, the VA treatments relieved her symptoms in several areas" (P5)	
	Less rigid design	"I recommend that the client returns for a new phase of contact sessions, where he can be treated with a more intensive and massage-like program and which can be better adjusted for the client" (Practitioner on P3)	"It would be good if it would be possible to have different options for treatment programs" (P5)
Proactive involvement	Seeking relief	"Before, she had had massages once or twice a month and she got relief in her lower body for several days; now she was receiving the same effect but during the treatment phase [Phase II] the effects have been enduring" (P5).	"Interesting experiment. I try to receive all the help I can" (P3)
	Self-care activities	Physiotherapy once per month; psychiatric nurse visits 2-3 per week (P3) Physiotherapy; acupuncture; massage (P5)	"Stopped smoking 3 weeks ago [during Phase IV]; using mouth spray" (P1) "3.5 months without smoking" (P3; at intake)

Relief

Improved symptoms

Pain relief, increased range of movement and relaxation, reduced stiffness and stress, and improvement in quality of sleep were reported by participants during Phase II. Immediate pain relief after the VA sessions positively affected functioning, for instance, greater range of movement in the neck whilst driving after the sessions. The practitioner observed that participants could relax well during the Phase II treatments; occasionally falling asleep during the treatments. P5 told that she felt increasingly relaxed as Phase II progressed and that it calmed her mind, working more on a psychological than physical level. P2 showed such an energy and mood increase that her spouse wondered whether she had started new medication. The practitioner noted P5 was grateful for the experience and reflected on the overall process, having noticed the deterioration during the washout phase: "This helped me a lot; many thanks!"

Medication changes

P5 reported she had not needed analgesics at all in Phases II or III. P4 also reported a change in medication; he had noted that the VA treatment [Phase II] had "found pains" in his wrists, ankles, knees, hips, and shoulders. After he stopped taking hypertension medication, these pains were reduced. Although the treatment brought out these pains, he also felt that he had been "completely treated" – comparing the sensation to a strong massage – and felt it was a positive experience.

Retained effects

During Phase II, effects after the sessions were reported as improved quality of

sleep lasting two or three nights afterwards, but also that symptoms remained similar to Phase III when all treatments had stopped (mood, P1, P3, & P4). P4 wrote that his pain reduced and mood improved during Phase IV and was sleeping better.

Recurrence

Two participants (P3 and P5) reported their pain got noticeably worse during Phase IV. Quality of sleep also deteriorated after Phases II (P4) and IV ended (P2). P3 expressed difficulty in managing his pain after Phase II had ended: "The pains did not stay away". Symptoms such as sweating increased during self-care for P3; P5's menopause symptoms and panic attacks returned during Phase IV.

Evaluation

Positive experience

Participants found the experience positive, "empowering" (P2), an "interesting experiment" (P3), that the practitioner was good (P5), and that the sessions relieved panic (P1). P5 tried for years to find a method of symptom relief; VA treatment was effective when nothing else was.

Self-care challenges

There were some challenges in self-care. Participants placed the cushion at their lower back (P3, P4), upper back (P5), or neck/shoulder area (P1, P2), but found it hard to place it so as to most efficiently feel the vibrations (P1, P3). More choice of treatment programme was also desired (P5).

All participants felt the Taikofon's effects were not close to those of the VA chair. However, P5 found some benefit in the Taikofon as her neck/shoulders were not

as stiff during Phase III as during either Phase I or IV. During Phase IV, she noticed how beneficial both Phase II and III were, as she returned to a poor condition during washout. P1 found the outcome measures bothersome and tedious, and P3 reported the self-care as a "compulsory commitment".

P1 did not initially engage in self-care at all. The practitioner called him on the telephone to check on his progress and only after reassurance and further instruction from the practitioner did P1 begin to conduct the self-care sessions. Without the input of Practitioner, P1 would have lacked the motivation to use the self-care device.

Less rigid design

The practitioner recommended a new treatment phase at the facility for P1, P2, P3, and P4 with a more intensive, massage-like programme. P5 commented that different treatment programmes could also be used. She was also recommended more treatments, however, the senior physician suggested she try different approaches due to the long waiting lists at the facility.

Proactive involvement

Seeking relief

P3 found the experiment interesting; he tries to receive all the help he can in managing with his diagnosis. P5 gets bi-monthly massages to ease her symptoms, from which she has relief for several days. With VA treatment, the same effect lasted longer.

Self-care activities

P1 stopped smoking three weeks before the end of the study, and P4 stopped 3.5 months before starting the study, taking proactive steps towards improving his general

health. P3 and P5 attended monthly physiotherapy, P3 also visiting the psychiatric nurse several times per month for extra support. These proactive approaches to self-care suggest a positive change in the participants' mentality towards improving their own health status.

Integrated results

The two data sets were merged to answer RQ3: *How do the qualitative themes inform the interpretation of the quantitative pain and mood scores reported in each phase?* These are narratively presented according to physical, psychological, and other symptoms reported by the participants and a joint display is presented in *Table 4*.

Physical symptoms

Phase II showed participants' pain improved from pre- to post-treatment measures, except for P4 who presented a non-clinically relevant deterioration. This was also seen in the qualitative findings; participants reported feeling immediate pain relief and the practitioner also noticed they were increasingly able to relax during Phase II. P4's worsening VAS-P was explained in the qualitative findings, in which he reported the treatment "finding pains"; he began to notice new pains in his body, a similar experience to that of a full-body massage. He also fell, injuring himself during this phase. P5 improved in both Phase II and III (VAS-P); her qualitative reports support this. She did not need to take analgesics at all during either of these phases. She also reported that VA felt like a massage, but the effects of VA lasted longer. All participants (apart from P1) recorded improved pain levels from Phase IIIa to IIIb. Quantitative results from P3 and P5 are, however, not supported by the qualitative reports. Both participants had less pain (VAS-P) in Phase IV than Phase IIIb (although

not compared to Phase I), but both reported that they noticed their pain getting noticeably worse during washout.

Psychological symptoms

All participants – except P4 – recorded mood improvement in Phases II and III with VAS-M. The worsening in pain for P4 was also seen in his worsening mood recorded with VAS-M. His depressive symptoms (BDI-II) worsened in Phases III and IV although he reported his mood improved during the washout. The psychological effects of the treatment were in fact reported as more prominent for P5 than were the physical, and this were represented also by her BDI-II and HADS-A outcomes. Her depressive and anxious symptoms had vastly improved during the Phase II sessions and remained so, although not seen in VAS-M. In contrast to Phase IV quantitative outcomes, the qualitative findings showed that her panic attacks returned during this time. P2 reported improvement in Phase II and III and her Phase IV scores were better than those at baseline, seen in VAS-M, BDI-II, and HADS-A. This was further supported by the qualitative findings; her mood had improved so noticeably that her spouse commented on it.

[Insert Table 4 here]

Other symptoms

Participants reported changes in other symptoms throughout the process, which were recorded in the practitioner's clinical notes. These included better quality of sleep, feeling empowered and less stressed, increased range of movement, and improvement in menopause symptoms beginning in Phase II. They reported their poor sleep, panic, and menopause symptoms returning during washout.

In answer to RQ1, the VAS-P, VAS-M, BDI-II, and HADS-A outcomes suggest that patients experience pain, depression, and anxiety relief from VA treatment. They also experienced some relief from self-care even though the stimulus itself was localised to a smaller area and it felt much weaker than the chair at the facility. In answer to RQ2, qualitative findings indicate individuals experienced increased relaxation and improved quality of sleep, had no panic attacks, and felt empowered and mentally calmer in addition to the pain and mood relief from VA treatment. The self-care may have helped to maintain the effects from the VA treatment because participants reported symptoms returning during the washout phase, seen in both qualitative and quantitative reports. The most beneficial effects were recorded during Phase II, representative of the multiple speakers and whole-body sensation elicited from the chair compared to the relatively smaller size of the self-care cushion. Finally, in answer to RQ3, the qualitative findings were beneficial for providing further context to the quantitative outcomes that can be difficult to interpret, especially due to the subjective nature of pain. Although there was some inconsistency among the quantitative outcomes, the qualitative findings imply that participants felt benefit from both VA treatments at the facility with results suggestive of the potential of self-care.

Discussion

The aim of this mixed methods study was to explore whether patients with chronic pain and mood disorders experienced relief from VA treatment and if an additional self-care intervention would maintain these potential effects, as well as to explore variability in patient responses to this treatment modality and to the overall procedure. We combined quantitative scales assessing pain and mood (VAS-P, VAS-M,

BDI-II, and HADS-A) with the qualitative documents from the process (practitioner's clinical notes and participant evaluation forms).

Our findings seem to be congruent with previous research that VA treatment positively impacts chronic pain, depression, and anxiety (Campbell et al., 2017; Naghdi et al., 2015; Rüütel et al., 2017). They are also in line with previous findings that music interventions reduce the need for medication (Guétin et al., 2012). We found the supportive role of the practitioner may be an important element in participants' adherence to the protocol exemplified by P1's delayed self-care initiation; contact with healthcare providers has been shown to improve patient outcomes, and telephone contact has proven particularly effective (Von Korff, Gruman, Schaefer, Curry, & Wagner, 1997). The role of the healthcare provider has been found to be that of a teacher or partner as well as a supervisor and that building up a partnership with the healthcare provider is an important element in self-care practices (Lorig & Holman, 2003). Although nuances exist between quantitative and qualitative data, our findings suggest self-care may be useful in maintaining the effects of VA treatment.

Quantitative results

Whilst there were minimal changes in the VAS-M scores, the BDI-II outcomes showed significant improvements for P2 and P5 and similar significant improvements for P2 and P5 in HADS-A outcomes. Although VAS-M has shown satisfactory evidence of reliability and validity, with high correlations (r = 0.82) comparing clinician VAS ratings to patients' BDI-II and VAS ratings (Ahearn & Carroll, 1996), patients may feel that the VAS does not represent the experience strongly enough, tending to rate oneself more severely than would clinicians (Ahearn, 1997).

Qualitative findings

Relaxation, exemplified in observations of reduced facial tension and falling asleep, is the most commonly reported treatment effect at this facility. This suggests that the whole-body relaxation effect, comparable to the effects of a deep massage (e.g., P5), may be key in promoting muscle relaxation and reducing tension thereby reducing pain. Evidence suggests eliciting a relaxation response through music listening (e.g., Gold & Clare, 2012; Guétin et al., 2012) or VA treatment (Campbell et al., 2017) can be beneficial for reducing pain, increasing mobility, and reducing analgesic consumption. The importance of support for those with chronic illness is also reinforced. Chronically ill patients are forced to face their own vulnerability and reduced functionality; experiencing their body as a hindrance, struggling to understand their illness, searching for normalcy, and dealing with the loneliness of suffering are aspects of the experience, but independence and self-management alleviate these (Öhman, Söderberg, & Lundman, 2003).

Multiple chronic conditions are difficult to manage, as the symptoms of one may aggravate those of another; social and emotional support is therefore necessary in self-care promotion (Bayliss, Steiner, Fernald, Crane, & Main, 2003). The balance between support from healthcare providers and sufficient independence to conduct self-care may be the goal of chronic illness treatment and management. In this case, the practitioner's role in supporting participants' adherence to the self-care protocol was important.

Additional self-care

The prepatent benefit of self-care as an addition to standard protocol of VA treatment for managing chronic pain may be seen firstly in the quantitative outcomes: participants reported increased pain during washout, possibly indicating the self-care intervention helped to maintain the effects of the Phase II sessions. Secondly, the

qualitative findings show that pain returned during washout; other symptoms such as panic attacks that were under control during both Phases II and III also returned during Phase IV.

However, the qualitative findings simultaneously present nuanced experiences of the self-care intervention. The participants compared the effects of the Taikofon to those of the Physioacoustic chair – which, due to its relatively small size could not produce the same whole-body effects one feels from the multiple loudspeakers in the recliner. Participants' self-care reports compared this stimulus to the Physioacoustic chair and could thus be interpreted as ineffective. Yet, the VAS outcomes suggest a potential benefit of the self-care sessions. Further, all participants used the audio cable to play the treatment programme; it transpired that played this way the stimulus was noticeably weaker at full volume compared to Bluetooth at half-volume, meaning the stimulus the participants received was not as intense as it could have been. This complicates the interpretation of the self-care phase effects; however, from the qualitative reports we know that there was some degree of benefit, even at this low volume. The importance of the self-care phase was not to compare the treatment conditions to each other, rather to explore whether positive outcomes from Phase II could be maintained with self-care.

Limitations to self-care practice

Physical or logistical limitations of conducting self-care were responses to the self-care phase and is a common element preventing patients with multiple chronic disease from engaging in self-care practices (Bayliss, Steiner, Fernald, Crane, & Main, 2003). Participants in this study did report this difficulty, suggesting that more support may be needed in these instances.

The challenges were also associated with the feeling of obligation; there was a copious amount of VAS-P and VAS-M to complete during this time, which may have negatively impacted participants' commitment and motivation, as well as their general perception of the effects. Self-care practices may be more beneficial when the impetus to carry them out and create one's own "relaxation space" comes from the patient themselves which may still be aided by practitioner support.

The role of the practitioner

An important aspect of VA treatment in general is the practitioner-client relationship. Under the assumption that participants would have pain and mood relief from Phase II supported by the practitioner, participants may ideally improve to the point of being able to continue and maintain these gains with less external support. Yet, this may be dependent on the severity of the depression/anxiety, as was the case for P1 and P4. They had severe depression throughout the study, which may have been a factor hindering progress due to low motivation associated with depression. Healthcare personnel (e.g., nurses) are strong sources of support, affecting patients in getting "[them] back on track" and providing "positive reinforcement" (Bair et al., 2009, p. 1286). Managing depression is a highly relevant way to self-manage pain, so that with relieving depressive symptoms, one has a greater desire and motivation to do things, which "makes pain more manageable" (p. 1285). P1 was reluctant at first to engage in self-care at all. At the half-way point in Phase III, P1 was motivated by Practitioner to start self-care, highlighting the potential importance of the practitioner-patient relationship and intermittent check-ups in self-care promotion. This has previously been found to be an important facet of self-care practice (Mann, Fort, & VanDenKerhof, 2013).

Limitations

As this was an uncontrolled study with a small sample size, the effects of confounding variables cannot be dismissed. The study looked at the individual responses of patients in this naturalistic setting and thus a randomised controlled trial was deemed inappropriate. Those treated at this facility also receive concurrent treatments, so the effects are cumulative to other treatments the participants may have received (e.g., physiotherapy). The results give an impression of how this additional self-care intervention may be useful in multidisciplinary healthcare.

The reduced stimulation from the self-care device is also an interpretative limitation; future applications of this device should ensure that participants play the stimulus using Bluetooth for greater volume potential.

Conclusion

The present study explored the novel addition of self-care to VA treatment within a rehabilitation setting. Results suggest participants experienced reduced pain, anxiety, and depression, increased relaxation, improved quality of sleep, and empowerment from the treatment, but also highlighted the potential role that self-motivation plays in self-care and the need for support during this. The difficulty in managing chronic pain as a phenomenon is seen in the discrepancies between the quantitative and qualitative reports of self-care. The qualitative data were beneficial in exploring what quantitative outcomes mean in practice for patients with persistent pain and comorbid symptoms. Future studies may also address how more individualised treatment programmes would be clinically important for chronic pain patients, especially in congruence with other treatments such as physiotherapy. More detailed qualitative reports (e.g., diaries) would offer a valuable addition to single-case study explorations of this topic and may be especially beneficial for chronic pain patients due

to individual variation. As the results suggest the importance of the practitioner's role in supporting therapeutic outcomes, future work should also address this aspect of the VA treatment triad more closely.

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V

VIBROACOUSTIC TREATMENT TO IMPROVE FUNCTIONING AND ABILITY TO WORK: A MULTIDISCIPLINARY APPROACH TO CHRONIC PAIN REHABILITATION

by

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Vibroacoustic treatment to improve functioning and ability to work: A multidisciplinary approach to chronic pain rehabilitation

Purpose: To study the use of Vibroacoustic treatment and an added self-care intervention for improving the functioning and ability to work of patients with chronic pain and potential comorbid depressive and anxious symptoms. **Materials and Methods**: A mixed methods study with four single cases. Participants received bi-weekly Vibroacoustic practitioner-led treatment sessions for five weeks, followed by a one-month washout period without treatments. Then, participants conducted four self-care vibroacoustic sessions per week for five weeks, followed by another month-long washout period. Participants kept diaries of their experiences during this time. Quantitative scales included the World Health Organization Disability Assessment Schedule 2.0, Visual Analogue Scales (pain, mood, relaxation, anxiety, and ability to work), Beck's Depression Inventory-II, and Hospital Anxiety and Depression Scale (Anxiety only). The use of physiological markers was also explored. **Results**: The greatest improvement was from the practitioner-led sessions, but self-care was beneficial for pain relief and relaxation. Participants became more aware of sensations in their own bodies, and during washout periods noticed more clearly the treatment effects when symptoms returned. An added self-care phase to standard Vibroacoustic treatment could be beneficial for maintaining the effects from the more intensive Vibroacoustic treatment as part of multidisciplinary rehabilitation.

Keywords: vibration, music, rehabilitation, chronic pain, mood disorders

Introduction

Painful musculoskeletal conditions affect 20-33% of the world's population [1]. They are the second greatest contributor to disability and, in addition to mobility restrictions, are linked to depression, early retirement, and a reduced ability to socially participate [2][3]. Chronic pain is subject to not only genetic factors, but is also influenced by our past experiences of pain and the context in which it occurs [4]. Our emotional state, anxiety, memories, and attention / distraction are all factors which augment or diminish our experience of pain [5] and therefore factors which also influence our ability to function.

The biopsychosocial model outlines that physical illnesses such as pain are a result of the interaction between physiological, psychological, and social factors, and mediated by socioeconomic factors, which may exacerbate the presentation of pain [6][4]. Interactions between emotional disorders, maladaptive cognition (e.g. poor coping skills), disability, physical deconditioning (due to decreased physical activity), disrupted social functioning, and nociceptive dysregulation suggests that approaches to chronic pain management should focus on more than simply the pain sensation.

Multidisciplinary rehabilitation for symptom management

The goal of rehabilitation is to achieve optimal functioning. Building up one's resources supports this process by providing a facilitating environment, developing one's performance in interacting with their environment [7], regulating inappropriate adaptive stress responses posited to cause disorders such as depression and chronic fatigue syndrome [8], and reducing the calamitous impact poorly managed symptoms can have on healthcare systems [9]. Multidisciplinary approaches to pain management yield significant improvement in pain, physical and perceived functioning, emotional distress, pain acceptance and coping, and in the decreased use of maladaptive and passive coping

strategies [10][11]. Coordinated interdisciplinary approaches offer the best clinical care for patients with chronic pain and is also the most cost-effective approach [12].

Vibroacoustic treatment in multidisciplinary rehabilitation

Vibroacoustic treatment is one example of a multi-modal approach to pain management. At [facility], Vibroacoustic treatment is delivered as part of multidisciplinary rehabilitation. It consists of three elements: low frequency sinusoidal sound vibration between 20–120 Hz, clients' preferred music, and practitioner support [13]. Described as a "two-pronged approach", the tactile sinusoidal vibration elicits a relaxation response whilst the music listening element is beneficial for psychological symptoms [14]. Previous research has shown it is beneficial for eliciting a relaxation response, pain relief [14][15] and comorbid depression, anxiety, and insomnia [13], muscle tension and spasms [16], physical discomfort, fatigue, anxiety, and perceived general health [17], as well as being a suitable intervention to facilitate better outcomes in physiotherapy [18][13].

Applied within multidisciplinary care, Vibroacoustic treatment is part of an individually-tailored combination of standard pharmacological interventions as well as physiotherapy, (music) psychotherapy, and occupational therapy. The team coordinates and develops the treatment plan based on a patient's needs, working towards improving patients' quality of working life or to work towards evaluation points assessing patients' capability of returning to work. Given the impact of chronic pain and comorbid mood-related symptoms on functioning, interventions applied to improve these symptoms could aid in improving one's functioning and ability to (return to) work.

Underlying mechanisms of Vibroacoustic treatment

Although the underlying mechanisms of Vibroacoustic treatment are unknown, some theories exist. Stimulation of subcutaneous sensory mechanoreceptors (Pacinian corpuscles) sensitive to vibration and deep pressure [19] serves to potentially block afferent pain transmission [20][14]. Another theory relates to the relaxation response [21] and the concept of *sympathetic resonance.* Wigram [22] showed that applied vibrations are systematically felt in the same areas of the body (e.g. 40 Hz is commonly felt most strongly in the thigh muscles). Our bodies have natural resonant frequencies (e.g. each muscle) which may be activated or entrained through vibrotactile stimuli at the same frequency [23]. The vibration can stimulate sympathetic resonance through this matched oscillation, acting as a driving force [20]. In general, the higher the frequency within the low frequency range, the smaller the muscle and the closer to the head the frequency is perceived; i.e. 40 Hz is felt in the thighs, 60 Hz is felt in the chest [22]. Oscillatory dysfunction is suggested to play a significant role in developing and maintaining chronic pain [24], with disruption on the gamma band (around 40 Hz) related to thalamocortical dysregulation. This, in addition to clinical evidence and previous studies [15], supports the application of 40 Hz to act as a driving force for resolving this disrupted frequency band [20].

The second element of Vibroacoustic treatment – music listening – is also beneficial for pain relief, as well as reducing analgesic consumption [25] and physiological arousal, and is known to affect physiological parameters such as heart rate, respiration, and stress hormones [26]. It can be a directed approach to facilitating therapeutic change by manipulating or selecting music based on characteristics which will

influence these variables, such as a tempo. Music perception is also influenced by our past experiences [27] and can elicit memories and images [28]. As pain perception is also influenced by past experiences thereof, music listening has the potential to influence how we perceive pain, altering our perception thereof through emotional responses.

Combined, the low frequency sound vibration and the music listening can work towards altering the client's perception of pain, facilitated by the practitioner and the practitioner-client relationship.

Self-care as an element of rehabilitation

Orem [29] describes self-care as "an essential human regulatory function" [p. 33] and as it is inherent in one's daily activities, it should be viewed as an integral part of rehabilitation. The concept of self-care comprises an individual's responsibility towards healthy behaviours required for functioning, as well as those needed to manage chronic health conditions [9]. Barriers to conducting self-care are mostly related to having comorbidities, and include logistics of carrying out the practice, need for support, compound effects of conditions and medications, the emotional effects of the disease, and the physical limitations of conducting it [30]. The outcomes of self-care activities, on the other hand, include decreased pain, disability, and depressive symptoms [31], and improved cognitive symptom management, energy, fatigue, and self-rated health [32]. Although applications of low frequency sound vibration and music listening are generally afforded by a practitioner or therapist, Picard and colleagues [33] reported on a self-care approach to vibroacoustic treatment. Participants conducted sessions of combined music and pulsed vibration to manage their widespread pain and tenderness. Results showed improved indices of pain interference, relaxation, muscle tension, and energy levels [33].

As suggested by previous research of practitioner-led Vibroacoustic treatment, it can be effective for relieving both psychological and physiological symptoms. The aim of this study was to assess the impact of Vibroacoustic treatment with a self-care element on functioning, chronic pain, and possible comorbid symptoms, implemented within a multidisciplinary rehabilitation context.

Materials and methods

The study was in ABA^1B^1 form. In Phase I, participants received bi-weekly Vibroacoustic practitioner-led treatment sessions for five weeks at a specialised rehabilitation unit at [facility] followed by a month-long washout period (Phase II) without treatment. Thereafter, participants conducted four self-care Vibroacoustic sessions per week for five weeks at home (Phase III), followed by a second month-long washout period (Phase IV). The purpose of the washout periods was to assess the duration of treatment effect. Each participant served as his/her own control. As per standard practice at this unit, patients engage in various treatments (such as physiotherapy, [music] psychotherapy, and/or pharmacotherapy) concurrently or consecutively and this study took place within this naturalistic setting. [Location] University Hospital ethical committee granted ethics approval to conduct this study (ETL: R18007).

Phase I: Practitioner-led Vibroacoustic treatment sessions

A Next Wave Physioacoustic chair is used at this facility (see figure 1). Sonus Health

Editor v3.26c software is used to play the low frequency treatment programme through loudspeakers located in the neck, back, thigh, and calf areas of the chair; the frequency range of this software is 27–113 Hz. Participants received their bi-weekly practitioner-led sessions in this chair, with their preferred music playing through headphones, and interacting / discussing sensations and observations with [Practitioner] before and after the treatment programme.

Figure 1. Physioacoustic recliner chair used in Phase I (practitioner-led) sessions. Dimensions 184cm long, 78.5cm wide, 120cm high. Image reproduced with kind permission from the copyright holder: Next Wave Oy.

At this facility, a typical treatment programme used for enabling relaxation and pain relief centres around 40 Hz, based on clinical experience and previous reports of this frequency discussed in section *Underlying mechanisms of Vibroacoustic treatment.* [Practitioner] tailored the treatment programmes to suit the participants' individual needs, gradually increasing the volume as they became accustomed to the sensation. A treatment programme contains several steps and parameters such as *scan*, *cycle*, *strength*, *action*, and *time*. *Scan* modulates around the fundamental frequency, e.g. 31 Hz, by moving from this to a higher and lower frequency, e.g. 29–34 Hz, much akin to a radar, so that several scans of the fundamental frequency are completed during a two- to three-minute phase. *Cycle* or *pulsation* refers to the speed of the amplitude change – the time taken from silence to designated peak volume, e.g. 11 seconds. In practice, the longer the cycle and the wider the scanning range, the greater the relaxation effect. The wave-like sensation elicited through this pulsation may be compared to that of a massage chair. The *strength* of the programme can be adjusted both globally across all speakers and locally at individual speakers so that the programme strength can be increased and specific areas of the body can also be targeted. *Action* refers to the directional movement; either head-to-toe, vice versa, or no movement. The faster the *cycle*, the faster the *action* movement.

Phase III: Self-care sessions

Participants conducted their self-care sessions using a Taikofon FeelSound Player (see figure 2), a small, cushion-like device with an in-built transducer, an audio cable, and Bluetooth function. The frequency range of Taikofon is 20-20,000 Hz. Participants used an android phone (Huawei Y5) to play the pre-installed Vibroacoustic treatment programme. The participants were free to place the cushion anywhere on their body, thereby offering targeted stimulation to e.g. the lower back.

Figure 2. Taikofon FeelSound Player used in Phase III (self-care sessions). Dimensions: 48cm long, 12 cm wide, 35cm high. Image reproduced with kind permission from the copyright holder: Flexound Systems Oy.

All participants used the same 23-minute, 40 Hz self-care treatment programme for each self-care session. The duration of the *cycle* or *pulsation* was 6.8 seconds. They could adjust the programme *volume* / *strength* using the phone's volume control.

Participants

Participants were recruited following a purposive sampling method. Patients with chronic pain were contacted by [Practitioner] regarding study participation; four patients gave informed consent. The mean age of the three females and one male was 43.25 (±11.03) years (see table 1 for an overview of demographics).

Data collection

A mixed methods approach was taken consisting of participant diaries, questionnaires / scales, and physiological data. The data were collected in a concurrent-parallel design [34] such that each would support the others in exploring individual responses to both treatment conditions and the washout periods. The quantitative results comprise primary (functioning and ability to work), secondary (pain, mood, anxiety, and relaxation), and exploratory outcomes (physiological measures: [para-]sympathetic nervous system activity, galvanic skin response, and respiration rate). Participants wrote their diaries beginning at Phase I until the end of Phase IV. Quantitative outcomes were assessed at five measurement points. Measurement points 1 and 2 were the beginning and end of practitioner-led sessions in Phase I; Measurement Points 3 and 4 were the beginning and end of the self-care sessions in Phase III; Measurement Point 5 was follow-up, at the end of the second washout period in Phase IV. All quantitative scales / questionnaires and physiological measurements were completed at these time-points.

Qualitative data collection and analysis

Each participant wrote a diary to reflect their responses to the treatment conditions and washout periods, also reflecting on what they perceived to positively or negatively influence their symptoms. The instructions were rather open-ended to afford as rich and organic a description as possible. Each participant's diary was separately fully analysed with Qualitative Content Analysis [35] following an inductive approach. Inductive analysis allows findings to emerge from the raw data without pre-defined assumptions, theories, or hypotheses, but is still guided by evaluation objectives or research questions [36]. The diary transcripts for Participant 1 were first read through several times, based

Table 1. Participant demographics showing ICD-10* classifications and medications

Participant	Sex	Age	Type of pain	Diagnoses (ICD-10)	Medications
1	Female	33	Musculoskeletal and neuropathic	M54.5 lower back pain; M54.6 Pain in thoracic spine; R29.8 Other unspecified symptoms and signs involving nervous and musculoskeletal systems; muscle weakness	Paracetamol; gabapentin; venlafaxine; amitriptyline; tramadol; tramadol including paracetamol
2	Female	37	Musculoskeletal and neuropathic	S13.4 Sprain and strain of the cervical spine; S44.3 Injury of axillary nerve; Nerve damage in right hand; Depression; neck/shoulder/back pain	Escitalopram; gabapentin; paracetamol
3	Female	58	Musculoskeletal	M79.7 Fibromyalgia; M47.8 Other spondylosis; lumbosacral spondylosis L4 - L5	Buprenorphine; esomeprazole; paracetamol; pregabalin; amitriptyline
4	Male	45	Musculoskeletal	M79.7 Fibromyalgia; sleep apnea	Tramadol; paracetamol; amitriptyline; pregabalin; pantoprazole

*ICD-10 refers to the International Statistical Classification of Diseases and Related Health Problem

on which a coding frame was developed. The frame comprised the code label describing the code meaning, a description of this meaning, and illustrative text examples. Analytic memos were also written during the analysis process, which were used in developing the categories and themes. If new codes subsequently emerged from other participants' data, the coding frame was adjusted accordingly and applied to all data. Through this process, categories emerged developing into broader main themes and sub-themes. Similarities and differences between participants were explored and findings are tabulated according to the phase in which they were recorded by the participant.

Quantitative data collection and analysis

All quantitative data are presented as single cases, showing individual scores for each outcome at each measurement point. Interpretation guidelines for individual outcomes, as suggested by Dworkin and colleagues [37], referring to the smallest clinically relevant change in individual patients' outcomes, the Minimum Clinically Important Difference (MCID), were used where available for data analysis. Additionally, interpretation cut-off points for VAS outcomes that are available for pain [38] were also used. As these benchmarks for other VASs are unavailable, the pain cut-off points have been applied to all VAS outcomes as general indicators of each variable's current status. The interpretation guidelines are discussed for each scale separately.

World Health Organisation Disability Assessment Schedule (WHODAS)

The World Health Organization Disability Assessment Schedule 2.0 (WHODAS) is a 12-item self-complete scale used to standardise assessment of health and disability across all diseases with applications in both clinical and general populations. Cronbach's α was reported as ranging from .83–.92 [39]. The MCID for WHODAS has not been established.

Visual Analogue Scales

Pain, mood, relaxation, anxiety, and ability to work were measured using Visual Analogue Scales (VAS). These scales are 100mm horizontal lines with anchors on either end; the anchors in this case were 0mm = unbearable pain, 100mm = no pain, 0mm = depressed, 100mm = happy; 0mm = tense, 100mm = relaxed; 0mm = anxious, 100mm = no anxiety; and 0mm = completely unable to work; 100mm = best working ability. The polarities of these scales are used in this direction at this facility and, in order to retain coherence in their standard protocols, this formulation of the VAS was retained despite the usual format being, for example, 0 = no pain, 100 = unbearable pain. Participants were asked to mark the line to represent how they were feeling at that time. Test-retest reliability for pain was reported as r = .94 [40], r = 0.82 for mood [41], and r = .59 for anxiety [42]. For VAS for pain, the MCID is suggested as 10–20% reduction for minimal improvement, ≥30% for moderate improvement, and ≥50% corresponding to substantial improvement [37]. Interpretation VAS pain cut-off points applied to all VAS outcomes are 0–4mm = severe [pain], 5–44mm = moderate [pain], 45–74mm = mild [pain], and 75–100mm = no [pain] [38].

Beck's Depression Inventory-II

Beck's Depression Inventory-II (BDI-II) is a self-report, 21-item scale used to assess the severity of depressive symptoms. Scores range from 0–63 points and items are rated on a four-point scale from 0 (e.g., "I do not feel like a failure") to 3 (e.g., "I feel I am a total failure as a person"). Scores can be interpreted as 0–13pts = minimal; 14–19pts

= mild depression; 20–28pts = moderate depression; 29–63pts = severe depression. Cronbach's α was reported as .92 for outpatients and .93 for college students [43]. A category change (e.g. from *moderate* to *mild* depression) and a 5-point reduction are used as MCID benchmarks here [37].

Hospital Anxiety and Depression Scale – Anxiety subscale

The anxiety subscale of the Hospital Anxiety and Depression Scale (HADS-A) is a seven-item, self-complete scale used to assess the non-somatic cognitive and emotional aspects of anxiety in general medical populations. It is a four-point scale ranging from 0–3, (e.g., "I feel 'wound up'", 0=not at all, 3=most of the time). Scores can be interpreted as 0–7pts = normal; 8–10pts = borderline anxious; and 11–21pts = abnormal anxiety. Cronbach's α ranges from .78–.93 [43]. The MCID corresponds to a 1.57-point decrease in the HADS anxiety subscale [44].

Physiological data

Raw ECG signal, respiration, and galvanic skin response (GSR) data were recorded using the NeXus-10 physiological monitoring and biofeedback platform. BioTrace+ software was used to analyse the respiration rate and pain-related arousal respectively, and Kubios software was used to analyse the raw heart rate data recorded with ECG. All measurements were taken in the same soundproof treatment room with an ambient temperature of 22°C; the first and last self-care sessions were conducted at the facility to control for the measurement environment.

ECG / [para-]sympathetic nervous system activity. The NX1-EXG2-Snap cable was used to detect heart rate data via ECG signal. ECG data pre-processing and analysis were performed using Kubios, version 3.1.0.1. The threshold-based method was used to remove artefacts. These are detected by comparing each beat-to-beat interval against a local average interval; if an interval differs more than a specified threshold from the local average, it is marked as an artefact. Kubios also adjusts these thresholds with mean heart rate. The minimum thresholds were selected to remove the artefacts without affecting the remaining data. The raw signals were de-trended using the smoothness priors method before analysis. Kubios analysis software provides indexes for autonomic nervous system assessment. Parasympathetic nervous system (PNS) activity, such as during resting or recovered states, decreases heart rate and increases heart rate variability. When we are stressed and the sympathetic nervous system (SNS) is activated, our heart rate increases and heart rate variability decreases [45]. The PNS index reflects Mean RR (mean of time interval between successive R-waves), RMSSD (root mean square of successive RR interval differences), and S1 (%), whilst for SNS these are Mean HR, Stress index, and SD2 (%). These indexes were used to evaluate participants' stress responses at the five measurement points as an objective measure of pain [46]. A PNS / SNS value of zero refers to the mean population values, e.g. non-zero PNS values show how many standard deviations below (negative integers) or above (positive integers) the parameters are relative to normal population averages and vice-versa for SNS values.

The Taskforce of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology [47] recommends five-minute recordings for short-term HRV assessment. Five-minute segments were extracted from the beginning and end of the first and last practitioner-led sessions (Measurement Points 1and 2) and the first and last self-care sessions (Measurement Points 3 and 4), and a five-minute

measurement was taken as follow-up (Measurement Point 5) at the end of the second washout period.

Galvanic skin response and respiration rate

The galvanic skin response sensor measures arousal through tracking sweat gland activity; expressed in microsiemens (μS), the value increases with the level of arousal, and normally decreases during relaxation. Ag-AgCI finger electrodes measure relative changes in skin responses [48]. The electrodes were placed on the distal phalanx of the digitus secundus and digitus medius of the participants' left hands. The respiration sensor, consisting of an elastic belt worn around the navel, measures relative expansion of the abdomen during inhalation and exhalation. Mean galvanic skin response and respiration data values from the same five-minute segments as the ECG data were extracted for analysis using BioTrace+ software (V2017A).

Data integration

After both qualitative and quantitative data were separately analysed, these were integrated for each participant by exploring the qualitative findings' parallel manifestations in the quantitative data. For example, changes in functioning described in participants' diaries were compared and contrasted with WHODAS outcomes. Experiences of both qualitative and quantitative aspects were explored to ascertain whether the objective and subjective reports were congruent. Due to the parallel-convergent design of the data collection, the experiences participants reported either in their diaries or by completing the scales were recorded within the same timeframe (rather than successively) and may therefore afford a richer description of their overall experiences. The qualitative data also provided richer contextual information about how participants responded to the treatment sessions in between measurement points.

Presentation of results and findings

An overview of results and findings is first provided to give an impression of the general outcomes across all participants. However, the main focus is on the individual participants' treatment responses and therefore an in-depth, integrated qualitative and quantitative presentation of each participant follows the general overview.

To simplify the quantitative data presentation and discussion, only the post-treatment data are shown (figures 1-4), signifying the general change in variables over the course of the protocol (between sessions), rather than a detailed description of the within-session changes through the pre-/post-treatment outcomes. The quantitative results are narratively discussed using MCID [37] and interpretation guidelines [38] for interpretation purposes.

Results

Overall quantitative results

Primary outcomes

Participants 2, 3, and 4 showed an improvement in functioning during both treatment conditions. After the first washout period, Participants 2 and 4 reported worse functioning (Measurement Point 3) and all participants had worse functioning after the second washout period. For Participant 1, functioning appeared to have deteriorated

throughout the process. The same was seen for participants' ability to work; whilst this tended to improve during the treatment conditions and deteriorate during the washout phases for Participants 2, 3, and 4, neither practitioner-led nor self-care sessions seemed to impact Participant 1's ability to work.

Secondary outcomes

Relaxation was the outcome which improved most substantially during both treatment conditions for each participant. The clearest effects were generally seen from Measurement Points 1-2, the practitioner-led sessions, and although the improvements from Measurement Points 3-4 were also substantial, the scores at the beginning of this self-care phase were also worse from not having received treatments for one month (e.g. Participant 3, Measurement Point 3). The effect of the Phase I and III sessions for BDI-II outcomes appear to have been generally worse after the second washout. Neither treatment condition seems to have had a strong impact on HADS-A outcomes; however, only Participant 3 recorded *abnormal anxiety* at the beginning of the study, and the effect was as a result greater for her compared to those beginning with *normal* or *borderline* level anxiety.

Exploratory outcomes

For all participants, physiological outcomes seem to indicate that the PNS activity increase and GSR decrease were associated with pain relief. Respiration rate, however, seems to contradict the expectation that slower respiration would be associated with a greater relaxation response. These exploratory outcomes, therefore, did not always support the other quantitative outcomes, as discussed later.

Overall qualitative findings

Four main themes, (1) *Pain as a barrier,* (2) *Adjusting to the new status quo,* (3) *Approaches to symptom management,* and (4) *Symptom nexus* emerged from the analysis of all four participants' diaries. Five sub-themes traversed all participants' experiences (see table 2 for overview of overlapping main- and sub-themes). These – under the main theme titles – are displayed presently. Individual participants' qualitative findings are presented in more detail in tables 3-6.

[Insert table 2 about here]

Main theme 1: Pain as a barrier

Only one sub-theme, *Pain inhibits relief*, was individual to Participant 2, whilst *Pain inhibits functioning* was common to all participants. Pain as an inhibitor to functioning was seen in activities such as lowered capacity to do housework / drive. Pain was a hindrance, also, in how Participants 2-4 were able to rest, e.g. waking up because of pain.

Main theme 2: Adjusting to the new status quo

Throughout the process, all participants became more aware of changes in their bodies or functioning by tracking progress whilst they actively engaged in the rehabilitation process. Although the level of functioning varied across participants, they became aware of sensations such as how long they could carry out activities before they started to feel pain. The experience of having better and worse days during the rehabilitation process was also evident for all participants.

Table 2. Overlap of the qualitative main themes with sub-themes across all participants

Participant	**Theme**						
	Theme 1: Pain as a barrier				**Theme 2: Adjusting to the new status quo**		
	Pain inhibits functioning	Pain inhibits mood	Pain inhibits relief	Pain as a barrier to rest & recovery	Changes in level of functioning	Recognising needs / limitations / sensations	Rehabilitation as a dynamic process
1	✓	✓				✓	✓
2	✓	✓	✓	✓	✓	✓	✓
3	✓			✓	✓	✓	✓
4	✓			✓	✓	✓	✓
	Theme 3: Approaches to symptom management				**Theme 4: Symptom nexus**		
	Participation to manage symptoms	Analgesic intervention	Relaxation to improve pain	Process of integrating and adjusting self-care practices	Intertwined relationship between symptoms	Success-dependent mood	Symptom genesis meaning-making
1		✓	✓	✓			
2	✓	✓	✓	✓	✓	✓	
3		✓	✓	✓	✓	✓	✓
4			✓	✓			

Main theme 3: Approaches to symptom management

In addition to this awareness, actively trying to integrate the self-care practice during Phase III into their daily lives was a sub-theme for all participants, adjusting it to suit their own needs and schedules (e.g. changing its placement on the body when symptoms, for example, in the lower body were stronger, or conducting the practice in the mornings rather than the evenings). Relaxation was also a tool and outcome of the Vibroacoustic treatment sessions. It appeared for all stages that inducing a relaxation response afforded pain relief.

Main theme 4: Symptom nexus

This final main theme was manifest for only Participants 2 and 3, those with greater mood issues. They struggled with disability and the frustration they felt associated with this change in level of functioning. This was underlined in the emerging of the relationship between their symptoms (functioning, pain, and mood), and the sense of accomplishment and positive mood they associated with managing their pain. Possibly due to having an ambiguous diagnosis (fibromyalgia), meaning-making was important for Participant 3.

Integrated individual results and findings

Integrated outcomes for Participant 1

Participant 1's low ability to work was interestingly not reflected in her WHODAS scores (see figure 3), however it was seen in her diary entries (see table 3), exemplified by entries such as "*Came home, wasn't able to go for a walk (100m)"* (Main theme: *Adjusting to the new status quo).* This related to her being aware of her needs and engaging in health behaviours, such as resting when needed. She recorded her daily activities according to distances walked (usually ~1km), whether she did aerobics / swam that day, resting periods, and additional analgesics she took to manage her pain. For Participant 1, the sub-theme *Pain inhibits functioning* manifested in her pain-related physical limitations, *"I could only do small bits* [of aerobics] *because of the pain".* Her mood was rarely affected by lower functioning; her HADS-A scores improved by MCID during practitioner-led sessions, though generally her depression and anxiety scores were minimal.

Table 3. Qualitative findings for Participant 1 showing protocol phase and illustrative quote.

Main theme	**Sub-theme**	**Phase**	**Illustrative quote**
Pain as a barrier	Pain inhibits functioning	II	Evening aerobics; I could only do small bits because of the pain.
	Pain inhibits mood	I	Until Friday, mood very high-spirited but the pain started to erode away at that on Friday.
Adjusting to the new status quo	Recognising limitations / needs / sensations	I	Came home, wasn't able to go for a walk (100m).
	Rehabilitation as a dynamic process	I	Reduced [analgesic] in the morning – 300mg (from 600mg). Experience: noticed the lower dose in my back.
Approaches to symptom management	Analgesic intervention	II	From Wednesday-Saturday I was travelling and in pain and took extra medication. Immediately when I'm up for longer, it requires extra medication.
	Relaxation to improve pain	I	12:00 Vibroacoustic treatment "basic treatment". Relaxed a lot. Best experience, evening pains less.
	Process of integrating and adjusting self-care practices	III	Vibroacoustic treatment [self-care] on the legs, because they are so sore. [Next day] Vibroacoustic treatment from Friday helped a lot with the legs.

Phase I = Practitioner-led sessions; Phase II = Washout 1; Phase III = Self-care phase; Phase IV = Washout

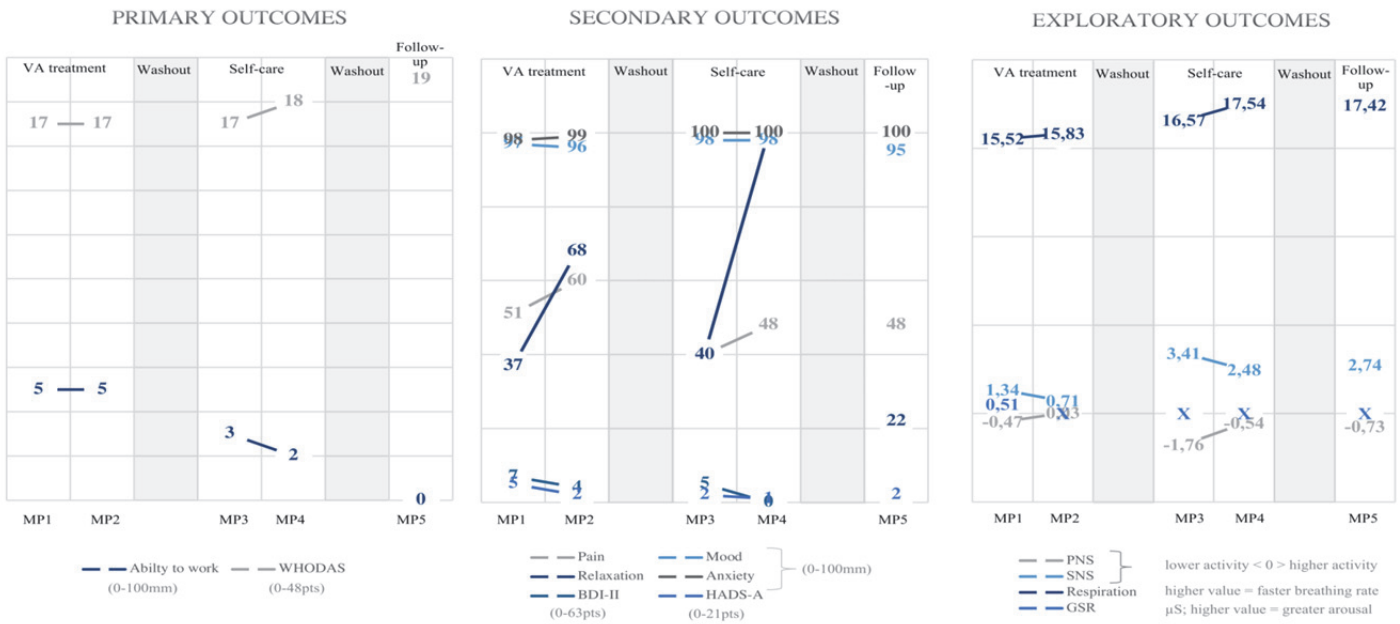

Figure 3. Primary, secondary, and exploratory quantitative outcomes for Participant 1 at Measurement Points 1-5.

Pain and relaxation scores varied from *mild* to *severe* but she recorded *moderate-substantial* improvements in both during Phases I and III; she also reported about this relaxation response from a practitioner-led session in her diary; "*Relaxed a lot. Best experience, evening pains were less"* (Main theme: *Approaches to symptom management*). Relaxation was *moderate* at Measurement Point 1 and *mild* Measurement Point 2, and from *moderate* to *relaxed* from Measurement Point 3 to Measurement Point 4, suggesting there was a greater impact on level of relaxation during the self-care sessions. Pain improved from *moderate* (Measurement Point 1) to *mild* (Measurement Point 2) during practitioner-led sessions, but remained in the same category during the self-care phase. Contrary to the stable self-care scores, she noted in her diary that applying the self-care device to her legs helped the pain and at times she fell asleep. The general trend in SNS outcomes from Measurement Points 1-2 (Phase I) and Measurement Points 3-4 (Phase III) support the increased relaxation she experienced during both treatment periods.

She engaged in several approaches to symptom management – mostly analgesics, but also receiving other therapies such as physiotherapy – and she recognised that when she was more active than usual, she needed to take extra analgesics (Main theme: *Approaches to symptom management*). She wrote, however, that she "*did not really notice the effects of the* [self-care] *treatment"* and that she "*did not relax as well as in the* [Physioacoustic] *chair"*.

Integrated outcomes for Participant 2

Participant 2 had a *moderate* ability to work (see figure 4) throughout the study, however within this category her ability decreased by 50% from Measurement Points 3-4, the self-care phase, which corresponds to *substantial* change with the MCID [37] whereas there had been no change during the practitioner-led sessions. She reported improved functioning with WHODAS in both treatment conditions; despite a greater improvement during the self-care phase, the overall scores during Phase I were nonetheless better than during Phase III.

The immediate effects of the Phase I sessions are seen in the diary entries, also (see table 4). Before the first Vibroacoustic session, she had difficulty driving because of her swollen and painful hands (Main theme: *Pain as a barrier;* "*The pain – mostly burning and neuralgia – was strong. It was very difficult to hold on to the steering wheel"*). The treatment relieved her pain and driving home was easier (Main theme: *Approaches to symptom management;* "*A wonderful feeling! Driving home was much better"*) indicating immediate positive results from the practitioner-led sessions.

During the self-care phase, she noted she was able to do more gardening than in previous years, indicating an increase in functioning, but also that she was in more pain because of this increased activity (Main theme: *Adjusting to the new status quo*; "*I nevertheless did more physical, heavier work outside in the garden and inside the house. Maybe my legs are reacting to this changing situation"*). WHODAS outcomes show that the improvement during Phase III was greater than during Phase I and that during the first washout period her functioning decreased, evidenced by the increased WHODAS score at Measurement Point 3. The VAS for pain and WHODAS outcomes support the increase in pain and improvement in functioning during the self-care phase. VAS for ability to work, however, highlights a lesser ability to work during the self-care phase, which could be related to the increased pain as a result of having greater functioning.

Table 4. Qualitative findings for Participant 2 showing protocol phase and illustrative quote.

Main theme	Sub-theme	Phase	Illustrative quote
Pain as a barrier	Pain inhibits functioning	I	The pain – mostly burning and neuralgia – was strong. It was very difficult to hold on to the steering wheel
	Pain inhibits mood	II	I have finally resigned as the secretary of the shooting club, which wasn't possible because of my physical state … It wasn't possible to write because of the pain. And 'failing' always affected my mood
	Pain as a barrier to relief	III	Today I didn't do Taikofon. The pain meant I didn't have enough patience
	Pain as a barrier to rest & recovery	IV	I can't sleep any longer. Face is sore. I was tossing in bed in vain!
Adjusting to the new status quo	Changes in level of functioning	II	The first big drop into the ravine was having to stop playing the 5-row accordion, which I'd played since I was 7. Playing released feelings and endorphins ☺ … It's difficult to change your activities/actions to become a listener
		III	I nevertheless did more physical, heavier work outside in the garden and inside the house. Maybe my legs [pain] are reacting to this changing situation
	Recognising limitations / needs / sensations	I	A new observation about my own body, is that the vibration treatment doesn't feel the same on both sides of my body. The program was changed slightly during the phase to be slightly stronger, i.e. more massage-like. The right side of my body doesn't function in the same way as the left. It feels missing
	Rehabilitation as a dynamic process	II	Hands are again swollen. I decided not to be afraid of the pains. I already started to get pissed off with this illness, pain, low mood, and that nothing can be done. ☺☹☺☹☺
Approaches to symptom management	Participation to manage symptoms	I	Mood was nevertheless positive and expectant. Research intrigued me. When I can be part of something, doing things with adults etc., everything feels good, when I don't have those possibilities now through working life
	Analgesic intervention	II	The trip to [location] was successful. Great! ☺ I managed the pains with analgesics. I tried to break up the standing, sitting, movement, so that my body wouldn't react to the pain. It was fairly successful
	Relaxation to improve pain	I	I was able to deeply relax, at least in the second half of the program. Relaxation clearly reduced the burning feeling in the neck/shoulder (from 75-35mm). A wonderful feeling!
	Process of integrating and adjusting self-care practices	III	I carried it out lying on the bed, because there was no other peaceful place on offer. … It's hard to find a quiet time in the evenings here
			Taikofon doesn't give the same relaxation as Vibroacoustics. Legs feel tense. Vibroacoustics also helped my legs. Taikofon doesn't. … Taikofon helps with lighter relaxation, but when your whole body is shouting with tension and pain, the cushion isn't enough for that

Symptom nexus	Intertwined relationship between symptoms	III	Mind was somehow restless and relaxation didn't quite happen. The pain usually affects me like that. I get a restless feeling, even though I don't have big worries or the like
	Success-dependent mood	II	Mood somehow good. It's probably because I was able to manage the pain and participate in the journey ☺
		IV	This week I've been feeling quite blue, because the pains have been continuous and doing everything slowly and it still affects the pains

Phase I = Practitioner-led sessions; Phase II = Washout 1; Phase III = Self-care phase; Phase IV = Washout 2

Figure 4. Primary, secondary, and exploratory quantitative outcomes for Participant 2 at Measurement Points 1-5.

Figure 4. Primary, secondary, and exploratory quantitative outcomes for Participant 2 at Measurement Points 1-5.

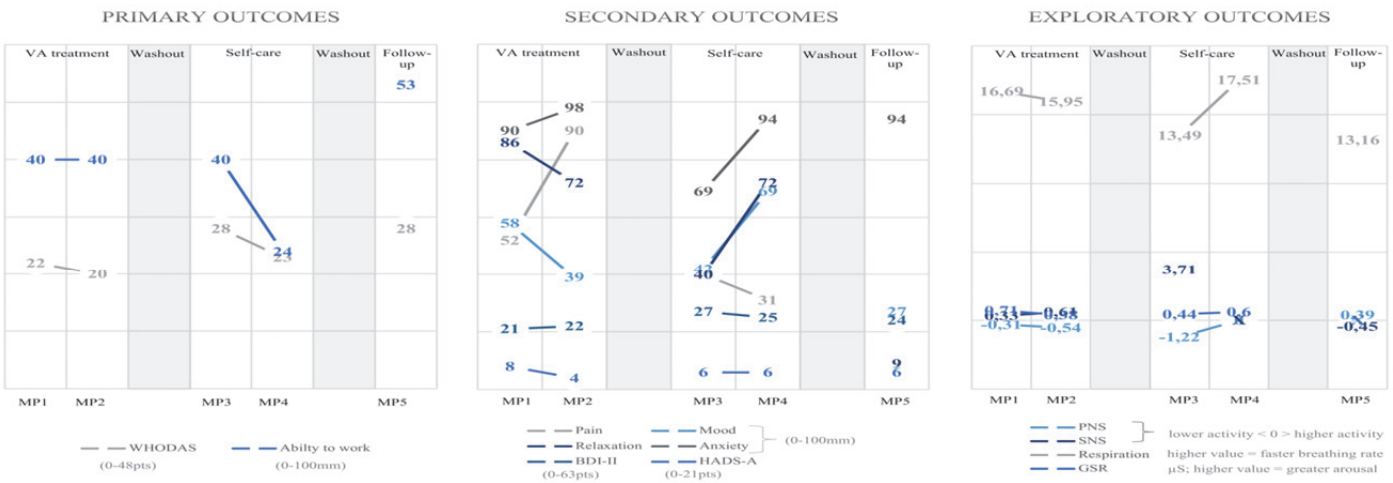

Figure 4. Primary, secondary, and exploratory quantitative outcomes for Participant 2 at Measurement Points 1-5.

Participant 2 explained that relaxation reduced the burning sensation in her neck/shoulder (sub-theme: *Relaxation to improve pain*). She also reported this relaxation response during the first self-care sessions, suggesting that pain relief was an auxiliary outcome to relaxation. The VAS outcomes for pain improved from *moderate* to *mild* during Phase I, and remained *moderate* during self-care, suggesting the practitioner-led sessions were more beneficial. Although relaxation improved from *moderate* to *mild* from Measurement Points 3-4, the post-treatment scores during the practitioner-led scores were nonetheless consistently *mild.* The respiration rate outcomes further support her subjective response to the practitioner-led sessions, with decreased respiration rate from Measurement Points 1-2, however PNS activity increased and SNS activity decreased only during the self-care phase, suggesting less alert / stressed state during this time. Respiration rate also increased at Measurement Points 3-4. Arousal (GSR), pain, mood, depression, anxiety, and relaxation changes paralleled each other, on the other hand.

The reduced ability to work coincided with an increase in depression and anxiety, and linked to her adjusting to her lower level of functioning since the car accident: "*Anxious, angry, tired feeling which was somehow eased after psychotherapy. It again became overwhelming. Will I ever learn that my functioning will never again be 100% after the accident?"* (Main theme: *Adjusting to the new status quo*). Being unable to work also made her feel lonely: "*I miss adult company*", suggesting that her lower functioning intertwined with her mood. After the first washout period, functioning, depression, and anxiety scores were also worse; the deterioration in BDI-II and HADS-A scores were also clinically relevant, implying that her overall situation had become worse after the practitioner-led treatments stopped.

Her ability to manage her symptoms was important for her, because it allowed her to participate and function in social events, which she noted was another means of symptom management: "*When I can be a part of something, doing things with adults etc., everything feels good*" (Sub-theme: *Participation to manage symptoms*). She was aware of both the connection between her pain and mood, and between being able to participate and her mood. When she was successful with pain management and participation, her mood was positive: "*The trip to* [club event] *was successful. Great! ☺ I managed the pains with analgesics. I tried to break up the standing, sitting, movement, so that my body wouldn't react to the pain. It was fairly successful*" (Main theme: *Approaches to symptom management*).

Integrated outcomes for Participant 3

Although she recorded only a *mild* inability to work with VAS (see figure 5), P3's functioning according to WHODAS was relatively poor. Pain was a barrier (see table 4) to functioning and working ability, evidenced by having to leave work because of headaches (Sub-theme: *Pain inhibits functioning;* "*pain continued during the night and next day, had to take migraine meds as well as leave work*"). When she felt less pain, she felt better and could manage to carry out more activities such as housework. A lesser ability to work paralleled worse pain, mood, relaxation, and anxiety levels, and she highlighted the pain-mood connection: "*Mood is good when I don't have any pain"* (Main theme: *Symptom nexus*). This is seen in the clinically relevant VAS (pain and mood), BDI-II, and HADS-A improvements. Her condition affected her mood when she felt despondent about the future: "*Mind a bit glum, I just feel that* healthy *days aren't coming or even a relatively good day"* (Sub-theme: *Success-dependent mood*), but she also

Table 5. Qualitative findings for Participant 3 showing protocol phase and illustrative quote.

Main theme	Sub-theme	Phase	Illustrative quote
Pain as a barrier	Pain inhibits functioning	I	A heavy headache started the previous night, took several [analgesics], pain continued during the night and next day, had to take migraine meds as well as leave work.
		III	Pains reduced noticeably as well as the numbness, feeling better → mood better → can manage to do more
	Pain as a barrier to rest & recovery	I	4.30 I got up to take a [analgesic]. Getting up at 7.00 somewhat helped the headache.
Adjusting to the new status quo	Changes in level of functioning	IV	The 'chair treatment' in the hospital was just wonderful; I was able to relax, not that much that I would fall asleep, pains disappeared, in the beginning this was for a few hours, then at the end they started to come back only the next day … With the cushion I didn't experience big changes, maybe more from the music which helped to relax, but sure the vibrations felt wonderful on my back. … Overall the pains are in my opinion less and changed a lot and are more tolerable, normally I don't notice them anymore, I just notice them if I want to go and do something e.g. housework, 1h is my limit after which the pain starts.
	Recognising limitations / needs / sensations	I	This week I had a new symptom when I sit or lie on the sofa, I get tingling in my legs (normally it's numbness). I didn't have this for a few years.
	Rehabilitation as a dynamic process	III	Already when I think about this whole cushion phase the cushion + music somehow helped the pain, sometimes not, but there was a big effect on mood and also to concentration e.g. in the evening the last time I think I was able to concentrate on breathing and my thoughts didn't wander so much, afterwards I felt relaxed, calm and the pain was gone. I think sometimes I noticed if I were to get my own cushion the bad days would come just now and then. … Certainly, doing the exercises which I do about 3 times a week, walking to work every day and in the evening little walks have also helped the pain and the physio, to which I've gone every week.
Approaches to symptom management	Analgesic intervention	I	Backpain … Had to take analgesics at work for the pain and in [Location] for the neuralgia.
	Relaxation to improve pain	I	Treatment was wonderful, few times almost fell asleep, good day, like before the pain, about 2 ½ years ago.
	Process of integrating and adjusting self-care practices	III	Cushion under calves, neuralgia in right calf, full volume Feeling wonderfully relaxed, tried to concentrate on breathing, no pain in calves, left toes were numb during the day, little pain in back, feeling also tired but still glum.

Symptom nexus	Intertwined relationship between symptoms	II	Mood is good when I don't have any pain.
	Success-dependent mood	III	Mind a bit glum, just feel that healthy days aren't coming or even a relatively good day, even though on the other hand there have been and gradually, like I've improved really slowly
	Symptom genesis meaning making	I	Tired in the morning, pains changing position and numbness, weather +1°, windy, cloudy, does the weather affect it?

Phase I = Practitioner-led sessions; Phase II = Washout 1; Phase III = Self-care phase; Phase IV = Wash

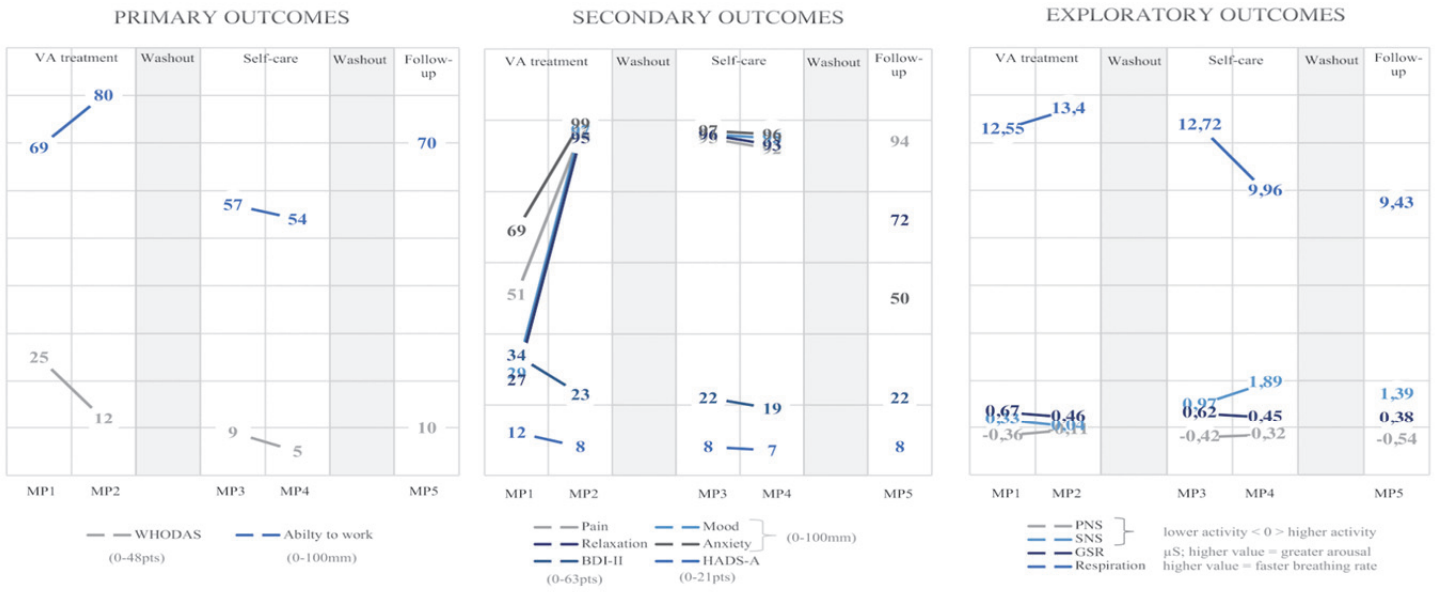

Figure 5. Primary, secondary, and exploratory quantitative outcomes for Participant 3 at Measurement Points 1-5.

acknowledged that her symptoms were gradually improving: *"even though, on the other hand, there have been* [good days] *and gradually, like, I've improved really slowly"* (Sub-theme: *Success-dependent mood*). The self-evaluated success of the rehabilitation process for her appeared to be related to having more healthy days and when she felt as though she did not have many, her mood was subsequently low. According to the VAS outcomes (see figure 5), pain, mood, relaxation, and anxiety all improved after Measurement Point 1, the first three remaining in the *mild* category and anxiety as *no anxiety* until the end of the self-care phase.

The immediate effects of the practitioner-led and self-care sessions are seen in this participant's diary entries (see table 5). The relaxation response she felt during the practitioner-led sessions reminded her of a time before the pain started ("*Treatment was wonderful, few times almost fell asleep, good day, like before the pain, about 2 ½ years ago*", Main theme: *Approaches to symptom management*). The physiological outcomes also show an increase in relaxation response from Measurement Points 1-2 (practitioner-led sessions) with increased PNS and decreased SNS activity as well as decreased arousal (GSR) and increased PNS activity also at Measurement Points 3–4. PNS activity increased and GSR decreased to a greater degree during the practitioner-led sessions, suggesting that the self-care sessions were not as relaxing as the practitioner-led sessions. Contrary to this, respiration rate decreased much more during the self-care phase. Although there appeared to be a negative trend in the physiological outcomes, she wrote: "*Already when I think about this whole cushion phase, the cushion and music somehow helped the pain, sometimes not, but there was a big effect on mood and also concentration*" (Main theme: *Adjusting to the new status quo*), highlighting that although she did not experience pain relief during self-care sessions comparable to that of practitioner-led treatments, she experienced other positive effects. She marked improvement for the concentration item of WHODAS, as she found concentration *slightly difficult* at the beginning of the study and *not at all difficult* at the end, also supported by the qualitative findings that she was less distracted: "*I think I was able to concentrate on breathing and my thoughts didn't wander so much"* (Sub-theme: *Rehabilitation as a dynamic process*).

Throughout the process, she became conscious of new sensations, or those that had returned after years of absence: "*This week I had a new symptom when I sit or lie on the sofa, I get tingling in my legs (normally it's numbness). I didn't have this for a few years*" (Sub-theme: *Recognising limitations / needs / sensations*). In comparing the practitioner-led and self-care sessions, she noted that her pain stayed away longer as Phase I continued ("*I was able to relax, not that much that I would fall asleep, pain disappeared; in the beginning this was for a few hours, then at the end it* [pain] *started to come back only the next day*", sub-theme: *Changes in level of functioning*). She noticed that her pain was generally less frequent as the process continued ("*Overall the pain is, in my opinion, less, and it changed a lot and is more tolerable, normally I don't notice it anymore, I just notice it if I want to go and do something e.g. housework, one hour is my limit after which the pain starts*", Sub-theme: *Changes in level of functioning*). Ability to work VAS scores improved too during the self-care sessions and at the end of the process she discussed increasing her working hours with her MD – further supporting her ability to work had improved.

Integrated outcomes for Participant 4

Participant 4's positive response to the practitioner-led treatment sessions (see figure 6) was most clearly seen in improved functioning, pain, relaxation, and mood. During the first session, he experienced pain relief (nerve pain in his head), however it returned as soon as he left the treatment room (see table 6). It was a large adjustment for him, as the difference between the pain and no-pain was so noticeable: "*I felt quite anxious then* [when the pain came back] *because the contrast was so big*" (Sub-theme: *Changes in level of functioning*). However, as this phase continued, he noticed the pain stayed away for longer: "*It helped my legs a lot!! They were lighter and I was painless for many days*" (Sub-theme: *Rehabilitation as a dynamic process*). He also noticed other changes. He usually applied cooling gel to reduce night-time leg pain, but could reduce the amount of gel he applied during Phase I (Main theme: *Adjusting to the new status quo*). Although the general trend of respiration rate and PNS / SNS activity suggest he was less relaxed from Measurement Points 1–2 and Measurement Points 3–4, arousal (GSR) was greatly reduced during the practitioner-led sessions. Relaxation (VAS) showed a slight decrease from Measurement Points 1–2, however the score still fell within the *mild* tension category at Measurement Point 2. BDI-II improvement during Phase I was clinically relevant, as was the improvement in the HADS-A score during Phase III.

Participant 4 did not notice a great change in his pain when conducting the self-care sessions, however his pain was in the *mild* category at all Measurement Points. He reported in his diary that he was able to relax using the self-care device, noticing some pain relief (Theme: *Approaches to symptom management*). This can also be seen in the VAS pain outcomes, with improved pain from Measurement Points 3–4.

The quantitative results show that all outcomes were worse after the treatments stopped, at Measurement Point 5. He noted: "*After the treatments stopped, I had a lot more pain. Nerve pain in my head and legs has returned. I have been sleeping worse"* (Sub-theme: *Process of integrating and adjusting self-care practices*). Although Phase III improvement margins were comparatively narrower than during Phase I sessions, his condition during self-care was also better than before the study began. He more easily noticed the benefit of the self-care sessions after the treatments had ended, because his symptoms deteriorated at that point; this is also supported by the quantitative Measurement Point 5 scores.

Table 6. Qualitative findings for Participant 4 showing protocol phase and illustrative quote.

Main theme	Sub-theme	Phase	Illustrative quote
Pain as a barrier	Pain inhibits functioning	I	I was in more pain than usual. I wasn't able to do anything in the evening. I felt as though I had a heavy cold and I was frozen solid under a blanket. I woke to a heavy cramp in my leg during the night.
	Pain as a barrier to rest & recovery	II	I've had a lot of pain. Sleeping poorly at night and back and legs have been painful. I'm constantly getting electric shock in my legs.
Adjusting to the new status quo	Changes in level of functioning	I	The pains returned quite quickly. I felt quite anxious then because the contrast was so big.
		I	Relaxed again really well [during the treatment]. I was able to put less creams on my legs when I go to bed (cooling gel etc).
	Recognising limitations / needs / sensations	I	I relaxed again much deeper. If I relax properly, I'm in more pain in the evening. The night was again rather good.
	Rehabilitation as a dynamic process	I	It helped my legs a lot!! They were lighter and painless for many days. It's terrible that it's stopping almost like in the middle of the treatment, now that it's beginning to help the pain!!!
Approaches to symptom management	Relaxation to improve pain	I	I relaxed well again. After the treatment, my strength was rather gone, but returned quickly. Nerve pain in my head was less.
	Process of integrating and adjusting self-care practices	III	It has worked with varying success. I intermittently put it on my neck when going to sleep. Relaxed quite well and I'm able to fall asleep better. The same music is already starting to be irritating.
			I have tried to use the cushion religiously. If I use it too late, the only effect is tiredness. I don't notice great changes to the pain. Able to manage to relax.

Phase I = Practitioner-led sessions; Phase II = Washout 1; Phase III = Self-care phase; Phase IV = Washout

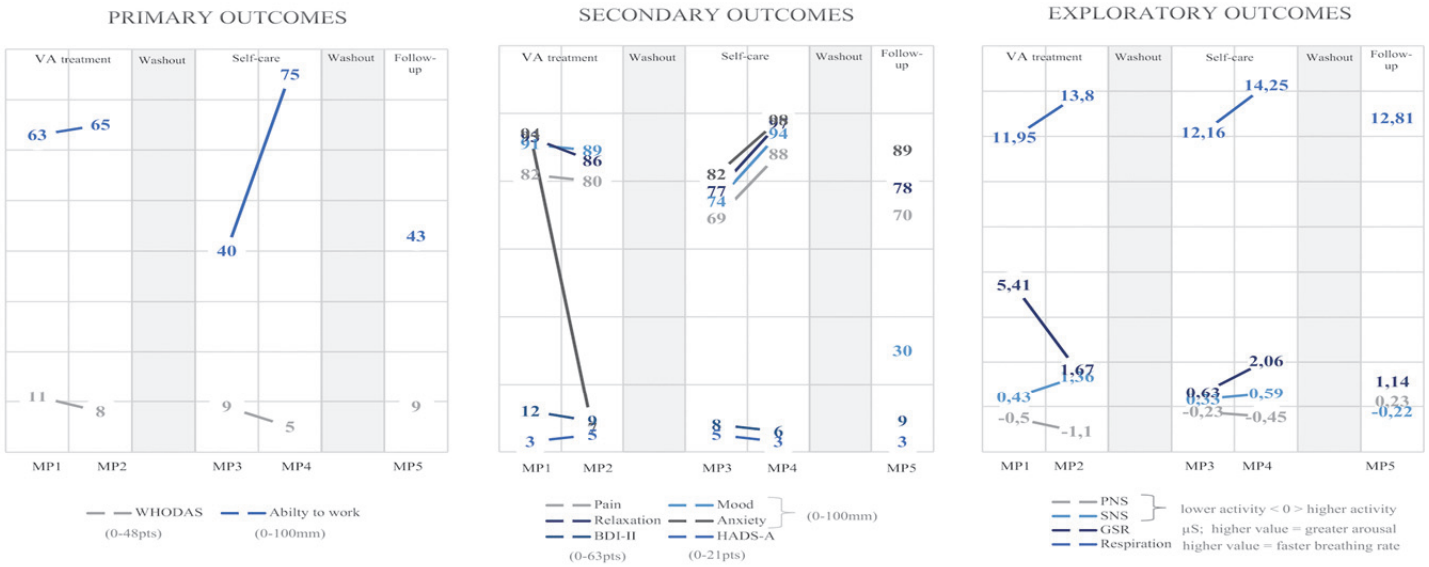

Figure 6. Primary, secondary, and exploratory quantitative outcomes for Participant 4 at Measurement Points 1-5.

Discussion

This study aimed to assess the impact of practitioner-led Vibroacoustic treatment sessions and self-care on functioning, chronic pain, and possible comorbid mood disorders within a multidisciplinary rehabilitation setting. As self-care is a part of regulatory function inherent in one's daily activities and to be viewed as an integral part of rehabilitation [29], the self-care phase was introduced to the Vibroacoustic treatment protocol, as a means of protracting patients' rehabilitation processes. As in previous research of Vibroacoustic treatment [13][14][15][17], participants in this study experienced pain, mood, and insomnia relief. The outcomes from the limited applications of Vibroacoustic as a self-care intervention [33] support these participants' experiences of increased energy and relaxation. The comparatively greater improvement in relaxation scores by participants in this study are also in line with previous research [13-15]. Patients receiving Vibroacoustic treatment within multidisciplinary care, as with the participants in this study, also reported relaxation as the variable of greatest improvement, even by those previously unable to reach a state of relaxation using other methods [49].

Self-care as an integral part of a rehabilitation process

Self-care as a concept adheres to several principles: attributes, such as one's ability to perform self-care, and decision-making; antecedents, such as social support, perceived and actual physical and psychological health condition, prior experiences, and self-efficacy; and outcomes, including improved functioning, coping, and physiological and psychological symptoms [29]. These elements can be seen in the participants' experiences presented here. As self-care is intrinsically involved in rehabilitation and one's daily health behaviours, the emerging self-care-related behaviours were noted already during the practitioner-led phase, laying the foundation for these to become fully realised during the self-care phase.

Awareness of change

Improved symptoms noticed by participants (such as concentration) contributed to how they perceived improved functioning and their increased ability to work, evidenced by Participant 3's gradual increase in working hours. Awareness, as one of the attributes of self-care described by Orem [29], was also exhibited by other participants. As perceived disability and emotional distress negatively influence one's ability to work [50], Participant 3's awareness of her improved symptoms could have been a boost towards affording her a sense of self-efficacy and control over her symptoms. Participant 3 also noticed improvement in cognitive functioning, a reported effect of self-care practices [32]. The quantitative outcomes support the improvement in mood which could have afforded this positive change.

A similar situation occurred for Participant 2; in becoming aware of the gradual increase in sensation in her right leg during the practitioner-led sessions, although she was not yet at the stage where she could return to work, she only noticed this asymmetrical sensation during Vibroacoustic treatment, and it became a way of tracking treatment progress.

Participant 4 noticed how beneficial self-care had been when symptoms returned during the second washout period. Although the effects were subtler than the

comparatively greater effects he felt from the practitioner-led sessions, he exhibited awareness of the changes from the treatments, and then as a result of their absence.

With greater awareness, one potentially begins to recognise potential barriers. All participants noticed some barriers to functioning and self-care, including influence from comorbidities such as mood, also shown elsewhere [30]. Improvements recorded during self-care included decreased pain and depression, and improved functioning, which were also previously reported [31].

Mourning one's past identity

Patients with persistent pain are also commonly emotionally impacted by the chronic illness (as seen with Participants 2 and 3) and the link between pain and poor mental wellbeing, sometimes mourning the loss of their former selves [51]. Frustration with poor functioning, loneliness, inadequacy resultant of the new experience of low functioning, and embarrassment due to non-working status are all aspects of this emotional impact. Participant 3 felt that Vibroacoustic treatment reminded her of a time before her pain; her mood was low, fearing that she would not return to this former self. Patients often feel disappointed when they realise that they must settle for symptom reduction rather than a cure [51]. This supports Participant 2's struggle to accept that her functioning would never again be at 100%. Patients with chronic pain also often believe that a change in functioning corresponds to a complete loss of functioning, as was the case for Participants 2 and 3 [52]. They at times struggled to accept the new level of functioning as they had been accustomed to more activity, social functioning, and participation before the onset of their pain.

Social functioning

Participant 2 understood the importance of socialising to her rehabilitation process, noticing improvement in her pain and mood when she was able to participate in social events. In contrast, Participant 1 may have not felt the need to return to work because of her support system outside the workplace which was lacking for Participant 2 whilst on disability leave. One's ability to participate is influenced by one's biological functioning, which refers to the general physical functioning and the extent to which this limits one's activities [54]. Social functioning is an important element predicting pain self-efficacy and pain severity [54], with lower social functioning and biological functioning predicting higher pain severity. The importance of being able to retain or regain one's social functioning is underscored by Participant 2's experiences and need for socialising. The fact the self-care was at home, without the same level of professional support, was an issue for her. Despite the intensive rehabilitation offered at the hospital, she wished for a longer Vibroacoustic treatment period, having found the bi-weekly sessions beneficial from the social point-of-view as well as the physical treatments. When psychological symptoms were greater (e.g. feeling low because of disability), participants' feelings of control over their symptoms was impacted. Prior experiences of greater functioning resulted in frustration with the current level, as described in previous research [52]. Their negative responses to pain or inability to conduct day-to-day activities affected their health-related behaviours (e.g. skipping self-care sessions) and disability negatively impacted their social interactions (inability to attend birthday parties / club events).

Comparing objective and subjective reports

The differences between the qualitative and quantitative data were seen in instances where, for example, Participant 4 reported the self-care intervention was ineffective for pain relief, but the VAS for pain indicated otherwise. The improvement in pain during self-care was clinically relevant, however he felt the effects were much weaker than the practitioner-led sessions in which there was no clinically important difference. His pain at Measurement Point 4 was objectively better than Measurement Point 1, but he only noticed the deterioration in symptoms after the self-care had ended. The effects from self-care were perceived as subtler than those of the practitioner-led sessions. The physiological outcomes were mixed. He reported decreased PNS and SNS activity, however increased arousal (GSR), during the practitioner-led phase. During the self-care sessions, SNS activity increased, supporting his claims that these sessions were not as relaxing as the previous treatment condition. Higher RMSSD (vagal tone) scores are associated with higher pain intensity in those with chronic pain compared to controls without chronic pain [54]. This was also seen, for example, at Measurement Point 4 for Participant 4; his RMSSD score at the beginning of the treatment phase was 28.5ms (VAS pain 69mm), and 26.6ms (VAS pain 88mm) at the end of the treatment phase. Patients with fibromyalgia, such as Participant 4, have been shown to exhibit decreased PNS activity and increased SNS activity compared to controls [55]. This could explain Participant 4's increased SNS level at Measurement Point 1 when his pain was *mild* and the decreasing PNS during the practitioner-led sessions when his VAS pain score was worse. From a within-session perspective, although not the focus of this present study, those entering a relaxation response have been shown to exhibit increased heart rate and decreased respiration whilst meditating [56]. Participant 4's physiological outcomes showed an increase in heart rate from 69 to 71 beats per minute and a decrease in respiration rate from 15 to 13 breaths per minute at Measurement Point 2. He also marked *relaxed* on the VAS for relaxation. Arousal also reduced from 2.08-1.67μS during this session. The within-session changes may indicate a general trend over time such that the decreased respiration rate from 3–4 and increased SNS activity (including heart rate) may represent a relaxation response over time. Galvanic skin response (GSR), as a physiological measure of arousal and mental / emotional states, has been shown to reduce with meditation and music listening as so-called stress-relieving methods, but may also indicate the level of concentration; if one is disturbed when engaging in these activities, GSR peaks [57]. This could account for higher mean GSR levels (e.g. Measurement Point 4, Participant 4), possibly resulting in difficulty reaching a more relaxed state during the comparatively short self-care treatment time.

Anxiety is potentially another confounding variable. It has been shown that the relationship between pain and anxiety is not always unidirectional, in that when anxiety is not related to experimental pain, the pain is perceived as less intense compared to when anxiety is associated with the pain source [58]. The music, despite being participant-chosen, may have influenced physiological responses. Music chosen by participants has been shown to arouse autonomic nervous system responses (e.g. heart rate, muscle tension) even though participants reported reduced anxiety and an increase in relaxation [59]. This could partly explain the disparity between the physiological, VAS, and verbal reports.

Similarly, in assessing subjective and objective reports of activity in patients with chronic lower back pain [60], self-report measures did not correlate with the objective measurement of physical activity. There were strong correlations, however,

between objective and subjective reports in controls who were asymptomatic. Comparison with asymptomatic controls is not possible in the present study; however, symptoms such as pain (as suggested by van Weering and colleagues [60]) may account for the disparity in subjective and objective records.

These conflicting reports emphasise the complex interactions between physiological responses and perceptual experiences of the multi-modal experience of chronic pain and multidisciplinary approaches to its management.

Limitations

As this study took place within a naturalistic setting, participants were receiving various other interventions either concurrently or successively. To some degree, the qualitative findings show some pre- and post-treatment changes, however the overall effect of both treatment conditions is compounded by additional therapy regimens. This has both positive and negative attributes. The efficacy of the interventions cannot be assessed using this approach. However, as Vibroacoustic treatment is delivered to difficult-to-treat patients with various diagnoses receiving various treatments at this unit, adding this self-care intervention to the naturalistic setting gives a more accurate representation of how it would work in practice, therefore assessing effectiveness. Effectiveness studies look at clinical practice and the real-life circumstances. The "ideal" scale for measuring pain is the VAS, because it is independent of language, however, a mix of subjective and objective reports should be used given the disparity in what a patient or researcher / healthcare giver may evaluate as a successful intervention [61]. As perceived functioning and chronic pain are subjective to each individual patient, their experiences of this approach - relative to their standard care - is, in essence, the most important tool for intervention evaluation. In addition to the other treatment participants were receiving, medication changes were also a compounding variable for Participant 1 because she changed medication dosage during the protocol. Although it is also a part of one's rehabilitation process, this influences her pain and may account for the relatively little pain reported with VAS.

In relation to the study design, although comparison across individual cases is not possible, the outline aimed to give impressions of how participants with various levels of functioning may respond to Vibroacoustic treatment with added self-care. Barlow and colleagues [62] expressed the necessity of non-RCT studies in evaluating processes, as such studies are required to explore whether the resources needed to conduct larger, randomised studies are justified. The present study serves as a way of exploring the potential responses of a highly varied target group, and whether chronic pain patients with possibly comorbid mood disorders may benefit from this "two-pronged" approach. As the field is still small, these more in-depth studies are needed before larger studies can be considered. This was, however, an issue for outcome measures, as the small sample meant quantitative analyses could not be conducted. On the other hand, the mixed methods design highlighted the complexity of the individual chronic pain experience. As Morgan and Morgan [63] succinctly wrote: "No amount of research in the nomothetic tradition can effectively reveal the likelihood of successful treatment in an individual case" (p. 185).

The comparatively lower intensity of the Phase III sessions compared to the Phase I sessions was also discussed by participants. Although the self-care device is indeed much smaller than the Physioacoustic chair, the aim of this study was not to

compare efficacy of one approach to the other, rather to explore whether a self-care phase could be useful as an additional intervention for patients at home.

Conclusion

Outcomes from a self-care phase added to standard Vibroacoustic treatment protocol at the multidisciplinary rehabilitation unit at [facility] indicate that both interventions may be beneficial for improving functioning, pain, mood, and relaxation. Participants found the effects from the practitioner-led sessions were more distinctly manifested by the end of that phase; the self-care sessions appear to have been beneficial for less severe pain and related symptoms. This self-care approach could be applied directly after practitioner-led sessions to prolong the effects, or as an intervallic or intermediate intervention applied between intensive practitioner-led phases. The mentality and skills developed during a rehabilitation process may support prolonged relief, potentially helping to avoid relapse. As previous research has supported the combination of Vibroacoustic treatment and physiotherapy [13][17], the self-care device could be implemented as a way to improve physiotherapy outcomes when conducting exercises at home.

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Notes on figures

MP1-5: Measurement Points 1-5

Primary outcomes

WHODAS scores (raw 0-48pts); 0 = no impaired functioning; Ability to work Visual Analogue Scale (0-100mm): 0=completely unable to work, 100=best working ability

Secondary outcomes

Visual Analogue Scales (0-100mm); Pain, mood, relaxation, anxiety; e.g. 0mm = unbearable pain; 100mm = no pain

Beck's Depression Inventory-II (0-63pts); 0 = minimal depression

Hospital Anxiety and Depression Scale - Anxiety subscale only (0-21pts); 0 = no anxiety

Exploratory outcomes

Parasympathetic nervous system; lower PNS activity < 0 > higher PNS activity

Sympathetic nervous system index; lower SNS activity < 0 > higher SNS activity

Galvanic skin response (arousal); microsiemens (μS); higher score = greater arousal (X = no reading)

Respiration rate; higher score = faster breathing rate