

# **A Comprehensive Critique of Vibroacoustic Therapy for Physical and Mental Ailments**

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## **Abstract**

Vibroacoustic therapy (VAT) is a nonpharmacologic and noninvasive form of music therapy that uses furniture-like devices, such as physioacoustic chairs, to transmit low-frequency sound waves to the body. The vibrations are thought to regenerate cellular function of aging, injured, or stressed cells. In addition, music usually complements this form of treatment. However, there is much controversy regarding how VAT works. This paper is a critique of the existing literature published on VAT's theories and experiments on specific patient populations, such as those with Parkinson's Disease, to assess VAT's role in improving muscle function and tone, reducing chronic pain, and alleviating depressive symptoms. The goal is to analyze the various research on VAT to discover ways to improve and encourage future studies in this area. It is likely that VAT has the potential to be a cost-effective supplement to medical treatment, but without the evidence, these conclusions cannot be made. This critique revealed several gaps in the literature and areas worthy of future research investment. Major limitations were found in published studies, but there is a high demand for greater longitudinal and controlled experiments.

## **Key Words:**

Vibroacoustic therapy, VAT, music therapy, psychology, music psychology

From providing therapeutic pain relief post-surgeries to alleviating high stress levels during extended hospital stays, music therapy is a class of treatments that provides physical and mental benefits through something people love (Peterson Family Foundation 2016). While the science of music therapy is expansive, some researchers are particularly interested in a new, yet controversial, form of music therapy known as vibroacoustic therapy (VAT). Vibroacoustic therapy is a nonpharmacologic and non-invasive form of music therapy that utilizes low-frequency sound waves to transmit vibrations to targeted body areas with the use of furniture-like devices. The therapy is typically accompanied by relaxing music.

Currently, there is much debate in the scientific community regarding the benefits of VAT due to the lack of extensive research and generalizable results. For example, there is not a widely accepted theory on how VAT mechanistically works on the body to

alleviate physical or mental ailments. Scientists have various hypotheses to explain how this therapy works. The most common theory involves a combination of low-frequency sounds (between 20 and 100 Hz) and music to produce resonance in the body that matches the natural frequency of a specific body part (Punkanen and Ala-Ruona 2012). These vibrations are predicted to restore function in aging or injured cells. While this theory of vibrations regenerating cellular function seems convincing, there is no conclusive data or scientific imaging collected to fully support this theory.

At the cellular level, the science behind this theory states that micro-vibrations are constantly created in the body when cells utilize energy to move or undergo chemical reactions (Dervil 2015). At the tissue level, cells combine to form skeletal muscle that resonates at certain frequencies during twitch and tetanic contractions, and these mechanical frequencies naturally produce sound waves (Barry and Cole 1990). Twitch contractions are typically

short, jerky contractions from slowly delivered stimuli (e.g., movements in facial muscle) and tetanic contractions are larger, smoother contractions from rapidly delivered stimuli (e.g., holding an arm up) (Baghmanli et al. 2013). After injury, chronic stress, or aging, cells' ability to move or utilize energy slowly declines and these essential micro-vibrations decrease (Dervil 2015). It is thought that transmitting low-frequency vibrations to specific body parts will restore the natural frequency of aging or injured cells and improve their cellular functions. Nevertheless, many researchers are highly skeptical of this theory because VAT lacks "systemically lead reviews on its research (Kantor et al. 2019). Regarding the implementation of VAT into practice, many physicians are hesitant to adopt this form of non-invasive therapy because it lacks evidence-based medical research (Kantor et al. 2019). Some of the most convincing research that exists on VAT in the form of narrative research and patient case studies (Ellis 2004).

While the mechanism behind VAT remains unclear, there are known advantages of this form of therapy, including its nonpharmacologic and non-invasive methods (Boyd-Brewer 2003). Specific patient populations that suffer from side effects of medications or are vulnerable to the effects of post-surgery could benefit from VAT therapy for symptomatic control. Two countries that are utilizing VAT as supplemental methods for treatments (e.g., chronic pain and Parkinson's disease) are Norway and Finland (Boyd-Brewer 2003). The Norwegian Multivib (mattress, cushion) and the Finish Nextwave (physioacoustic chair; see <http://vibroacoustic.org/> for an example) are popular furniture-like devices used to help with sound transmission to the body (Boyd-Brewer 2003). Unfortunately, most hospitals in Norway and Finland using VAT technology have not conducted many trials to quantify the effectiveness of VAT on their patients.

This vibration-generating technology could be a promising treatment for those with physical and mental ailments if more longitudinal, randomized studies found supporting evidence. Only a handful of researchers in the past century have attempted to analyze VAT's effects, and most of the existing literature is on patients with Parkinson's Disease,

people with chronic pain, and adults with sub-clinical depression. Parkinson's Disease is a neurodegenerative disorder that targets muscular function, resulting in resting tremors (uncontrollable shaking of a finger or limb at rest), rigid muscles, and slowed movement (Mayo Clinic Staff 2018). Seinäjoki Central Hospital in Norway, which has been giving VAT for over 20 years on their patients with Parkinson's Disease, has recently begun conducting clinical trials to demonstrate the effectiveness of their VAT program (Campbell and Ala-Ruona 2018). The physicians at Central Hospital hope to find clinical evidence that VAT improves muscle function and reduces resting tremors (Campbell and Ala-Ruona 2018). Furthermore, some studies have also tested the effectiveness of VAT for those with chronic pain and sub-clinical depression. Chronic pain is defined as experiencing pain every day for the preceding three months (National Center for Complementary and Integrative Health 2015). One study by Brewer and Coope (2003) found a 60% reduction in chronic pain in their 40 cancer patients after controlled pre- and post- evaluations. On the other hand, Yoshihisa et al. (2012) found that depressiveness and sadness symptoms, temperature, and pulse reduced in 15 elderly adults with sub-clinical depression. Sub-clinical depression is a condition in which people have depressive symptoms, but the symptoms are not severe enough to be declared as clinical depression (Ji 2012). This population is at high-risk of developing clinical depression and would benefit from preventative care, like VAT (Ji 2012). However, most studies that tested VAT's effects on sub-clinical depression, chronic pain, and Parkinson's Disease had significant limitations (lack of control groups and small sample sizes), which reduced the validity of the positive results.

Muscle function, pain perception, and depression are all integrated at the central nervous system. The vibrations of neurons in the brain, especially the thalamus, have been scientifically proven to affect different functions in the mammalian body (Kantor et al. 2019). For example, thalamic neurons vibrate normally around 40 Hz, and vibrational stimulation of these neurons directly activate other areas of the brain, such as the frontal cortex, sensorimotor cortex, and striatum (Liu et al. 2015; Ala-Ruona and Punkanen 2015). The striatum plays a role in

voluntary muscle function and tone, the sensorimotor cortex modifies pain perception, and the fronto-limbic cortex affects mood (related to depression) (Kravitz and Kreitzer 2014; Maihöfner et al. 2010; Canbeyli 2013). However, if there is decreased activity due to weakened neuronal connections or muscular cells, adding mechanical vibrations of the correct frequency can be beneficial in partially restoring function for these patients (Liu et al. 2015). This scientific basis is a possible explanation for why most vibration-technology research has been conducted on patient populations in one of these three areas. For these reasons, this critique focuses primarily on patient populations with muscle dysfunction, chronic pain, and sub-clinical or clinical depression.

It is further theorized that VAT-related research could be a cost-effective supplement to traditional medical treatment. Current treatments for muscular disorders, chronic pain, and depression are significantly expensive and not entirely successful (Naghdi et al. 2015). Many of these illnesses also have no cure; therefore, management of symptoms is critical for these patients to maintain a certain quality of life (Naghdi et al. 2015). Medications are one of the most common forms of symptom management. For example, an average Parkinson's patient in the United States spends about \$2,500 per year on medications, but these medications often become less effective after prolonged usage and are associated with side effects, such as nausea and dizziness (Parkinson's Disease 2018; Institute for Quality and Efficiency in Health Care 2015). Apart from muscular disorders, average medication costs for chronic pain disorders, such as rheumatoid arthritis, can be as high as \$30,000 annually (Freeman 2018). Treatment costs for depressive disorders are also rising substantially, ranking them as the sixth-most-costly illness (Winerman 2017). On the other hand, existing vibroacoustic therapy clinics charge patients from approximately \$55 for 15-minute sessions to \$300 for 75-minute sessions (Tournesol Wellness 2018). This non-invasive and non-pharmacologic therapy adds no side effects, and sessions can be personalized to a certain length or vibration to meet patient's needs (Ala-Ruona and Punkanen 2015). Dr. Lee Bartel also advocates for an at-home vibroacoustic therapy system (VTS-1000) that is available for \$500, though patients can

receive at-home 60 VAT sessions designed by doctors in support of VAT (Sound Oasis; Bartel 2017). The system includes diverse pre-made sessions that range in different frequencies and sounds, depending on the symptoms needing improvement. While many online reviews and case studies support the usage of VAT, more cost-benefit analyses would help quantify the effectiveness of VAT as a therapeutic add-on.

It is extremely important for the scientific community to invest in further VAT research, including controlled, longitudinal studies with large, randomized samples, before hospitals and medical clinics implement VAT technology to treat patients. This paper is a narrative critique of the existing literature published on VAT's theories and experiments on specific populations, such as those with Parkinson's Disease and arthritis, to assess VAT's role in improving muscle function, reducing chronic pain, and alleviating depressive symptoms. This investigative search identified approximately 183 VAT research papers from four scholarly databases. From the papers identified, twelve research studies were relevant and reviewed in this critique. Four studies focus on muscle function, three studies focus on chronic pain, and five studies focus on depression. Studies selected had either an experimental design or a pre-post intervention design. Some studies utilized full-body vibration therapy, while other studies targeted a specific area for vibrations. The goal was to analyze the various research on VAT to discover ways to improve and encourage future studies in this area. With greater evidence-based research, VAT could be a cost-effective and therapeutic supplement to traditional allopathic medical treatments.

### **VAT Improves Muscle Function and Tone**

As mentioned briefly in the introduction, the common theory for how VAT improves muscle function and tone states that vibrations can stimulate cells back to their optimum frequencies (Dervil 2015). For example, one can transmit low-frequency sounds to match the natural frequency in an injured thigh muscle. This method is thought to release muscle tension, improve blood circulation, and increase metabolism (Punkanen and Ala-Ruona 2012). During VAT, music is typically added with

the sound vibrations for therapeutic effects. Playing the patient's favorite music helps with increased relaxation and activation of positive emotions and memories that may benefit the overall effect of VAT (Punkanen and Ala-Ruona 2012).

There are several challenges in this theory. First, no biological evidence exists to show that blood circulation and metabolism are improving with VAT. Neuroimaging techniques may help gather more evidence on the physical frequencies at which muscles vibrate and see the effects of VAT. Furthermore, while music is known to improve mood and stimulate positive memories, no studies conducted show that VAT combined with music demonstrates better results for muscle improvement than music alone does. The theory on VAT for muscle functional and tonal improvement also does not specify whether vibrations need to be applied to the entire body or just to a targeted region experiencing muscular limitations.

Although scientific data showing how VAT physically works on muscle are limited, some studies have shown positive results for symptomatic improvement in Parkinson's Disease patients. King et al. (2009) examined the effects of VAT on patients (n=40) with Parkinson's Disease. The researchers used a physioacoustic chair - a chair that contained six speakers to transmit low-frequency sound waves to the body - to deliver vibrations to the patients' whole bodies. Vibrations were delivered for one minute, followed by one minute of rest; this occurred for 5 trials. This was the first experiment to quantitatively measure changes (utilized Unified Parkinson's Disease Rating Scale (UPDRS), quantitative gait assessments, and a grooved pegboard) in motor symptoms and provide whole-body vibrations uniformly (King et al. 2009). The researchers found that tremor and rigidity decreased significantly, according to the UPDRS. In addition, step length significantly increased in patients with tremor-dominant symptoms. Another study by Macerollo et al. (2018) examined vibration therapy in healthy adults (n=54) and patients with Parkinson's Disease (n=10). This study also supports the evidence found in the study by King et al. (2009). With the application of 80 Hz peripheral vibration to the right wrist for 30 seconds, the participants

significantly improved in different and randomized motor control tasks (Macerollo et al. 2018).

While both studies found positive results of VAT on their Parkinson's patients, they have three major limitations that are common in most VAT-related studies. Both studies have a small sample size, a short testing period, and no control groups. These two studies also differ in their two methods. King et al. (2009) performed full-body vibrations, whereas Macerollo et al. (2018) conducted peripheral vibrations. Due to the non-standardized methods for testing VAT's effectiveness, it is unclear which of these two methods is more beneficial for Parkinson's disease patients.

Nevertheless, further research of VAT's effects on Parkinson's disease patients could be useful and cost-effective to the medical community. There are about 60,000 people diagnosed with Parkinson's Disease every year, and the combined costs of Parkinson's Disease in the United States is approximately \$25 billion dollars per year (Parkinson's Foundation 2018). Currently, medication and deep-brain stimulation are the two most common treatment methods for resting tremors; However, medication typically fails, and deep-brain stimulation is an invasive, surgical procedure with associated risks (American Parkinson's Disease Association 2018). In addition, these treatment options are extremely costly. A Parkinson's patient spends an average of \$2,500 per year on medications, and surgery costs about \$100,000 per patient (Parkinson's Foundation 2018). On the other hand, vibroacoustic therapy equipment is nonpharmacological and non-invasive. Its prices range from approximately \$2000 for a therapy mat to \$5000 for a physioacoustic chair (Inner Solutions 2018). This is about 20 times cheaper than the average surgery costs for just one patient. If more conclusive data are collected on how VAT physically benefits Parkinson's disease patients, this therapy could potentially revolutionize treatment for these individuals. It is difficult to implement VAT in medical treatment for Parkinson's Disease, without first understanding whether the therapy has any positive effects.

Apart from Parkinson's disease patients, a few studies have also assessed the effects of vibrations on

patients with other muscle limitations, such as restless leg syndrome in dialysis patients. Patients with end-stage-renal-disease must undergo regular dialysis to cleanse their blood of toxins and wastes. However, this treatment typically leads to the development of restless leg syndrome (pain, tingling, and numbness in feet and impaired sleep and stress) and decreased ability to perform everyday tasks. Hosseini et al. (2017) conducted a study on 80 hemodialysis patients with restless leg syndrome (RLS) to test for changes in symptoms after simple vibration therapy. After applying vibrations for four weeks, patients reported significantly less severity in their RLS symptoms (Hosseini et al. 2017). One strength of this study is that the data collection utilized a questionnaire to quantify RLS severity based on international standards. The reliability of this method was stated to be 97%. In addition, the subjects were asked to complete the questionnaire pre- and post- vibrations and measured the changes in responses over time. While the positive results of this study are encouraging, the study also has two limitations. The researchers did not disclose the kind of vibrations applied or include the addition of music. It would be interesting to learn whether a control group (music alone), control group (VAT alone like this study), and experimental group (VAT combined with music) demonstrate significant differences in the patients' severity of RLS. If VAT alone produces greater reduction in severity than music alone, then this would highly support Hosseini et al.'s (2017) study.

A common weakness in several studies testing VAT's effectiveness on muscle function is the lack of a control group. While many of the current studies have published positive results of VAT's effect on either tremors or muscle rigidity, the researchers have not included a control group to compare the results to another group. Instead, they are just measuring significance changes in a sample population over time. This is not enough when trying to prove the benefits of a treatment. On the other hand, some studies have used control groups but with inaccurate methods. For example, one study in Finland by Zheng et al. (2009) conducted a single-blind, randomized controlled experiment, which included a control group. The study consisted of 49 elderly participants (14 males, 35 females) with 12 different diseases at senior care centers in Finland.

There were no significant differences in diseases or medications taken between the experimental group (VAT intervention) and control group (no intervention). Spanning six months, the study found evidence for VAT's effect on increasing mobility in the elderly. Those who received VAT on average increased their time walking outdoors and stated decreased mobility difficulties, compared to those in the control group. The main issue with this experiment is that the control group received no intervention rather than a placebo intervention. It is hard to conclude whether the patients in the experimental group stated increased mobility due to VAT's effects or placebo effects. It is acceptable that this study included a control group that received no intervention; however, they should have also added a second control group that received a placebo intervention to account for placebo effects. While the results of this study are slightly convincing, this study also had some strengths, such as single-blind methods and randomization, that lacked in previous studies.

After a comprehensive analysis of the existing literature on VAT's effects on muscle function and tone, it can be concluded that a significant amount of research must be conducted before physicians and therapists can utilize this therapy actively in neurological clinics, dialysis centers, or senior nursing homes. Currently, VAT is not accepted by most private healthcare insurance companies and Medicare/Medicaid programs in the U.S. because this form of alternative treatment does not have enough evidence published in medical literature (Aetna 2018). Insurance companies have stated that more long-term randomized studies need to be conducted to support the effectiveness of VAT as an alternative medical intervention (Aetna 2018).

### **VAT Reduces Chronic Pain**

In terms of using VAT for chronic pain (defined as experiencing pain every day for preceding 3 months) (National Center for Complementary and Integrative Health 2015), the current theories are similar to those on muscle function and tone. Supporters of VAT for chronic pain believe that the transmission of sound vibrations to mechanoreceptors and pain receptors, such as the Pacinian Corpuscle (large mechanoreceptors in skin and connective tissues

around organs and joints) can reduce chronic pain in patients and regenerate those cells (Chesky and Michel 1991). More basic research on these mechanisms needs to be conducted before these theories are accepted broadly. Furthermore, music is thought to play a greater role with VAT for reducing chronic pain. Previously, it was stated that music is accompanied with VAT to enhance the patient's enjoyability of the experience. For patients with chronic pain, however, the role of music is proposed to be more complex. Brown et al. (1991) explains that music has two dimensions for pain reduction. One is the attention-distraction dimension, and the other is the affect dimension (Brown et al. 1991). The attention-distraction dimension claims that music can help engage a patient's attention and distract the focus from the painful experience (Brown et al. 1991). This may help speed up the patient's perception of time and reduce the suffering involved with the painful treatment or condition, if not the physical pain itself. Furthermore, the affect dimension states that music can arouse positive emotional experiences and alter a patient's mood by reminding them of happy memories associated with certain music (Brown et al. 1991).

Many researchers question whether vibroacoustic treatment is necessary as part of music therapy for pain reduction. To prove this distinction, control groups in experiments are essential to compare results and isolate the effects of VAT on patients. One study by Chesky and Michel (1991) utilized appropriate methods and found convincing evidence for VAT's physical function in chronic pain. They demonstrated that subjects with rheumatoid arthritis experienced reduced perception of pain when a Music Vibration Table (using a frequency range of 60Hz to 600Hz) transmitted different frequencies of vibrations on pain receptors (Chesky and Michel 1991). In addition, Chesky and Michel found that pain relief in rheumatoid arthritis patients was significantly greater when music was combined with VAT than when music was used alone (Chesky and Michel 1991). There was a 64% reduction in pain perception in VAT and music combined, 24% reduction with music only, and 2% reduction with the placebo treatment (Chesky and Michel 1991). These results indicate that VAT's effects are enhanced with the addition of music. This is a critical finding that deserves more attention and further

research because the current treatment options for chronic pain are largely ineffective.

There are about 25.3 million adults (11.2 percent) in the United States that experience chronic pain and about 50 million who experience severe pain (NCCIH 2015). Pain medication and physical therapy are used to treat chronic pain; however, these treatments are costly. It is estimated that about \$560 to \$635 billion dollars were spent in 2010 on treatments for chronic pain management in the United States (Darrell et al. 2011). Therefore, there is high demand for better treatment options for managing and curing chronic pain. Ailioaie et al. (2011) studied the effects of physical therapy and VAT on 68 young patients with juvenile idiopathic arthritis. The researchers divided the children into two groups: Group 1 with VAT, physical therapy, and medication and Group 2 with only physical therapy and medication (VAT in placebo mode). After a 12-week experiment, administering VAT consecutively for 10 days and then once a week for 20 minutes, Ailioaie et al. (2011) quantified the results using the Simplified Disease Activity Index (SDAI). They found astonishing results. Based on the SDAI scores, Group 1 experienced a significant decrease from severe to moderate pain levels after 12 weeks. In addition, Group 1 experienced a significant reduction in the number of swollen and tender joints, anxiety, chronic fatigability, and depressive tendencies when compared to Group 2 (Ailioaie et al. 2011). Researchers of this study believe that VAT can revolutionize chronic pain treatment for children and adults. The results of this study are convincing because the researchers included an appropriate control group that tested for placebo effects. Future efforts to replicate these results and determine effective treatment length and plan would be the next step to gather more support for VAT.

Some hospitals in Europe, particularly in Nordic countries, have already incorporated VAT into their pain management programs to help specialized patient groups. However, they have not conducted clinical trials to provide statistical evidence of VAT's effectiveness on their patients. Understanding how medical centers are implementing VAT into their treatment plans can help researchers conduct similar studies in U.S. hospitals. Hoping to gather more clinical data,

Seinajoki Central Hospital has recently begun 13-week clinical trials to gather experimental evidence on the effectiveness of VAT (Campbell and Ala-Ruona 2018). This hospital in Finland has been utilizing VAT for patients with chronic pain from musculoskeletal diseases and fibromyalgia for over two decades (Campbell and Ala-Ruona 2018).

In comparison to European nations, only a handful of clinical trials testing VAT in American hospitals have occurred. In 1999, Dr. Richard Patrick pioneered the research for VAT in hospitals (Brewer and Coope 2003). As the Chief of Recreation Therapy at the Clinical Medical Center at the National Institutes of Health, Dr. Patrick conducted an experiment on 272 patients at the center with a variety of chronic diseases and found a 49% to 61% reduction in pain with VAT (Brewer and Coope 2003). However, this study had several limitations, such as the sample population having a large variety in diagnoses possibly creating confounding variables in this experiment testing the effectiveness of VAT. Therefore, in 2003, Brewer and Coope repeated a clinical experiment similar to Dr. Patrick's design (Brewer and Cooper 2003). Brewer and Coope (2003) conducted a 6-week trial, in which nurses collected patient data from over 40 cancer patients with controlled pre- and post- evaluations. The results showed an approximate 60% reduction in pain with 30-minute VAT sessions. Coope, who is the Nursing Director at Ella Milbanks Foshay Cancer Center at Jupiter Medical Center in Florida, was so impressed by these results that she implemented the model used in her previous experiment at the cancer center. She has now established a comprehensive VAT and pain management program at the Foshay Cancer Center, which has already invested in 6 infusion stations (Brewer and Coope 2003). This is a rare example of a clinical trial transforming into a VAT program administered at a hospital. While Brewer and Coope (2003) found positive results, the methods of the study could have been improved significantly to increase validity. One weakness is that there was no control group. The researchers assessed the same sample population before and after the intervention by using surveys. This methodology is vulnerable to placebo effects and/or expectancy effects. The patients could have rated reduced pain symptoms because they expected the intervention, VAT, to have a positive effect. If more

comprehensive and controlled studies are conducted in this field, scientists will be able to better understand the benefits of VAT on chronic pain reduction. This could potentially lead to more VAT programs in hospitals, such as Foshay Cancer Center, to manage chronic pain symptoms.

### **VAT Alleviates Depressive Symptoms**

While the previous sections have focused on VAT for physical impairments, such as muscle rigidity and chronic pain, this section digs deeper into VAT's role in treating mental illnesses. The existing literature on VAT for mental illnesses is extremely limited. Moreover, the theory behind how VAT alleviates depressive symptoms or anxiety is barely understood. Some researchers claim that VAT increases parasympathetic responses (e.g., reduced heart rate) and improves sleep cycles, correlating with decreased depressive symptoms (Dervil 2015). Other theories, such as Brown et al's (1991) theory on the affect dimension of music (explained in the previous section on chronic pain), emphasize the benefits of combining VAT with music for those with depression. Brown et al. (1991) hypothesized that combining VAT with music stimulates positive moods by reminding patients of happy experiences associated with certain music (Wilgram 1995). This may lead to a reduction in depressive or anxiety symptoms in patients, but more research testing this theory is necessary.

Substantial evidence shows that music alone helps patients with mental illnesses increase their positive emotional states. Some hospitals already administer music therapy (e.g., classical music in operating rooms) for anxious or depressed patients undergoing surgery or invasive medical treatment (Kahloul et al. 2016). It is possible that VAT could similarly be incorporated into hospitals to help patients with psychological disorders receiving surgery or treatment. For instance, a randomized study by Burke (1997) showed that using VAT after surgery in gynecological patients significantly reduced not only surgery-related pain but also depressive emotions when compared to patients who did not receive VAT. One area that demands attention is the interaction between VAT and music therapy. VAT is usually accompanied with music, but no controlled experiments have shown that VAT combined with

music produces significantly better results in depressed patients than using music alone (Wilgram 1995).

An experiment designed by Sandler et al. (2017) demonstrated that VAT was not significantly more effective than just relaxing CD music alone in patients with psychosomatic disorders. This controlled study tested individuals with a variety of psychosomatic disorders, including anxiety, depression, and somatoform disorders. All participants received both interventions in succession; however, the order in which the interventions were presented was randomized. Some participants listened to CD music only first and received VAT second. Other participants received VAT first and listened to CD music only second. The Berlin Mood Questionnaire was used after each intervention to record subject responses. Interestingly, the results showed that patients experienced significantly increased positive moods and decreased depressiveness (e.g., elevated mood, decreased anxious depressiveness, decreased anger, decreased listlessness) regardless of whether they listened only to the CD music first or received VAT first. This indicates that VAT is just as effective at reducing depressive symptoms as music alone is. According to the data and graphs, responses were actually better for those who had VAT first than music first, but this difference was not significant. One major strength in this experiment is that Sandler et al. (2017) also utilized physiological methods to support their psychological data. They employed two forms of physiological measures: skin conductance levels and salivary cortisol levels. In response to the physiological tests, Sandler et al. (2017) surprisingly found that salivary cortisol levels increased in both groups, which is the opposite from what they were expecting. Reduced salivary cortisol levels were expected since the relaxing music and the vibrations were proposed to decrease stress. On the other hand, Sandler et al. (2017) saw an increase in both groups for skin conductance levels, which was in support of their hypothesis and indicated increased relaxation. This study found no significant psychological or physiological differences between the treatment groups. However, it may benefit researchers in knowing that VAT is just as effective as reducing depressive symptoms as relaxing music is for psychosomatic patients.

While this study may discourage researchers from pursuing further research on VAT's role in alleviating depression, it is important to point out a few major limitations with this study. When testing for improvements in psychological symptoms, Sandler et al. (2017) state in their study's limitations section that salivary cortisol levels may not have been an effective way to measure physiological responses to the interventions. The increased cortisol levels were possibly due to the stress from participating in the study or altered stress systems in psychosomatic patients, shadowing the effect of relaxing music. In addition, there was only a 10-minute break between the two interventions. This most likely was not enough time to see differences in physiological or psychological effects between the two interventions. It may have been more effective to randomize two separate intervention groups so patients were not experiencing both treatments in a short time. Lastly, VAT is usually accompanied with music, so comparing VAT combined with music to music alone would have been a better indicator of its success. It is possible that the effects of VAT are enhanced with the accompanying music. Recommendations to improve future research in this area include using an effective combination of psychological and physiological measures (visual analogues, neuroimaging), having separate intervention groups (VAT with music v. music alone), and testing for longer periods of time to appropriately measure responses.

Looking at physiological responses from VAT is important in understanding how the therapy works on the body and brain. Understanding the physiological effects will in turn help researchers predict the psychological effects. For instance, Sandler et al. (2017) utilized physiological measures, such as salivary cortisol and skin conductance levels. He predicted a reduction in salivary cortisol and increase in skin conductance levels would be indicative of decreased sympathetic activity and increased parasympathetic activity, leading to reduced depressive symptoms. However, there are other ways to measure physiological reactions to VAT. Yoshihisa et al. (2012) measured changes in body temperature, pulse, and sleeping patterns, along with the Dementia Mood Assessment Scale (DMAS), to test the effects of VAT on elderly nursing home patients with depressive symptoms.

For 10 consecutive days (two weeks, excluding Saturdays and Sundays), 15 patients were given 30 minutes of VAT treatment using a mattress-type vibroacoustic device (the Symphony device). In addition, classical music accompanied the VAT sessions. From Week 1 to Week 2 of treatment, the study found that depression and sadness symptoms improved significantly, temperature and pulse decreased significantly, and mean sleeping hours decreased significantly. This study showed similar results to Sandler et al. (2017). Not only did the subjects state a decrease in depressive symptoms, but also the physiological responses indicated increases in parasympathetic activity. The link between parasympathetic activity and reduced depressiveness is recognized in the studies by Sandler et al. (2017) and Yoshihisa et al. (2012). However, Yoshihisa et al.'s (2012) experiment has one major limitation - the lack of a control group. The elderly adults are vulnerable to expectancy effects or placebo effects. In addition, it is difficult to state whether the treatment of VAT accompanied by classical music would be more effective than simply using classical music alone. A similarly replicated experiment that includes a placebo group and/or control group would help confirm the results from Yoshihisa et al.'s (2012) study.

While Sandler et al. (2017) and Yoshihisa et al. (2012) analyzed the effectiveness of VAT with music, another group of researchers took VAT research a step further. Seeking to improve the current psychotherapy treatments, Rogers et al. (2007) attempted to integrate VAT with cognitive-behavior therapy and electrotherapy. Cognitive-behavior therapy (CBT) is one of the most common forms of psychotherapy treatment, but success rates for this therapy are not very high (National Institute of Mental Health 2018). Rogers et al. (2007) conducted a pilot study that proposes a potential model for introducing VAT into depression treatment plans using CBT. Unlike Sandler et al.'s (2017) study, this study found results in favor of VAT. In Rogers et al.'s (2007) study, the researchers designed a multi-component approach to CBT with the addition of VAT and cranial electrotherapy stimulation. They observed that after assessing differences in the pre-treatment and post-treatment, patients with depression and/or anxiety experienced significant decreases in depressive and anxious

symptoms. Based on these positive results, Rogers et al. (2007) suggest that hospitals and clinics offering depression and anxiety treatments should complement their management approaches with VAT and electrotherapy.

While the positive results in this study are promising for VAT, the lack of control groups makes it difficult to infer whether VAT or electrotherapy contributed to the decrease in psychological symptoms. Nevertheless, an increasingly number of researchers are supporting the addition of low frequency vibroacoustic technology as a complement therapy to traditional depression treatment. A newly published study by Sigurdardóttir et al. (2019) supports the results by Rogers et al. (2007). Sigurdardóttir et al. (2019) conducted an open randomized controlled study that utilized vibroacoustic therapy in a specialized form known as High Amplitude Low-Frequency-Music Impulse Stimulation of the Vagus Nerve (HALF-MIS). The experimental group received eight additional vibration therapy sessions for about a month, and the control group only received standard depression treatment. Implementing the Hamilton Depression Rating Scale, Sigurdardóttir et al. (2019) found that the experimental group had a significant decrease in symptoms compared to the control group, supporting the addition of vibration therapy to traditional depression treatment. While this experiment did have a small sample size ( $n=38$ ), the inclusion of a control group, randomization, and the appropriate implementation of VAT increase the validity of this study's results.

Each of the vibroacoustic studies in this critique was evaluated for major strengths, weaknesses, and key findings that support the further investigation of VAT research in the fields of muscle function, chronic pain, and depression. Table 1 (Appendix) outlines the concise findings and individual study analysis for all 12 studies, which were discussed in further detail in the paper.

## Limitations

Several common limitations were found among the current studies published on VAT. One of the most important limitations was the lack of appropriate control groups. Some studies, such as Zheng et al. (2009), had control groups that included no intervention. However, these poorly designed control groups allow for placebo effects or expectancy effects. Participants may declare positive improvement in symptoms because they expected the treatment to benefit them. On the other hand, studies, such as Yoshihisa et al. (2012), did not separate the effects of VAT and music. VAT was accompanied by relaxing CD music or by classical music for many treatments, but it was impossible to determine whether the improvement in physical or mental symptoms was due to music alone or the combination of VAT and music.

Another challenge with most studies was the small sample sizes. Some experiments had as few as 15 patients. The disease-specific populations make it difficult for studies to find a large sample size. For example, it is challenging to find a large sample of patients with Parkinson's Disease to test the effects of VAT on resting tremor. Enough subjects are needed though to randomly split patients between experimental and control groups and conclusive data.

In addition, more research behind the physiological mechanisms of VAT is needed. How exactly does VAT improve blood circulation, increase skeletal muscle strength, reduce pain, or decrease depressiveness? Chesky and Michel (1991) demonstrated that low-frequency vibrations (20 Hz to 100 Hz) can target pain receptors and mechanoreceptors (e.g., Pacinian Corpuscles) to reduce pain perception. However, Punkanen and Ala-Ruona's (2012) theory that vibrations increase blood flow and resonant muscles to release tension requires more data supported by visual analogues, chemical testing, or neuroimaging. Regarding VAT's effects on depression, Sandler et al. (2017) and Yoshihisa et al. (2012) revealed few results indicating the connection between increased parasympathetic activity and reduced depressiveness in patients. These studies' results also need to be supported with further scientific research.

Clearly understanding how VAT impacts the human body is essential for this form of music therapy to be

approved by insurance companies and medical professionals. Currently, it is extremely unclear how long the effects of VAT last. How long should one VAT session be? How many sessions of VAT are necessary? Are the effects of VAT long-lasting or permanent? The answers to these questions most probably depend on the severity and type of medical condition. Nevertheless, each study presented in this critique had a different method in terms of the low-frequency sounds used, overall testing period, number of sessions administered, length of one session, and time breaks between sessions. In addition to the wide range of methods, the researchers did not follow-up of their patients several months or years after the experiment. Following-up on patients who demonstrated positive results from VAT would help researchers understand whether VAT has long-lasting or short-term effects. This information is important in the creation of standardized treatment plans necessary for clinical use in hospitals, clinics, or nursing homes.

### Discussion

Analyzing current studies on VAT for muscle function and tone, chronic pain, and sub-clinical depression revealed several gaps in the literature and areas worthy of future research. This comprehensive critique pointed out strengths and weaknesses in previously conducted studies. The major limitations, such as lack of control groups and small sample sizes, found in some of the studies reduced the validity of the positive results. While VAT equipment has advantages of being non-invasive, non-pharmacologic, and cost-effective, the implementation of this therapy is useless unless experimentally controlled data demonstrate VAT's benefits for physical and mental ailments. It is crucial that supporters of this therapy conduct more research on its biological mechanisms to develop an evidence-based theory behind VAT's functioning. In addition, larger, controlled, and double-blind experiments are needed to gather conclusive data on VAT's effects on different populations.

Future studies would allow researchers to compare results to previous experiments and develop a better

understanding of whether VAT is useful. Further research may also highlight other physical and mental ailments, apart from the ones discussed in this critique, which could benefit from VAT. It is possible that significantly positive results from well-conducted studies on VAT could revolutionize physical and mental medical treatments and help specific populations, such as patients with Parkinson's disease or those with sub-clinical depression.

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