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Retrospective Observational Study

INTEGRATED APPROACH IN CHRONIC PAIN FROM MUSCULOSKELETAL STIFFNESS: MUSIC THERAPY AND VIBRO-ACOUSTIC PLATFORM

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ABSTRACT

Music Therapy (MT) can be used in the presence of many pathologies. It has the ability to stimulate the organism both through the acoustic vibrations transmitted by the auditory system and through the mechanical vibrations picked up by the somatic mechanoreceptors. Therefore, we observed data relating to 20 patients (average age 69.6±10.8 years) suffering from painful musculoskeletal rigidity subjected to a treatment session consisting of the administration of 6 relaxing songs through a specific Vibroacoustic Therapy (VT) platform. Half of the patients (n=10) carried out the session with music + vibrations (Intervention, INT) while the other half (n=10) of the sample carried out the session with music only (Control, CONT). Patients were evaluated before and after the session using Digital Algometry (ALG) at the lumbar paravertebral level and evaluation of Heart Rate (HR) and Blood Oxygen Saturation (SpO2) with digital pulse-oximeter. At the end of the session, it was observed that the ALG value detected tended to rise in INT patients, with more mixed results for CONT. As regards the HR, INT highlighted a lower reduction in the value compared to the CONT. Regarding SpO2, INT showed a slight increase in the value, in contrast to the slight reduction highlighted in CONT. Therefore, it is possible to state that MT has modulation effects on pain and basic vital parameters both when administered in the form of music alone and when administered as a combination of music and contact vibration.

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INTRODUCTION

Vibroacoustic Therapy (VT), as a branch of Music Therapy (MT), represents a relatively new method in the rehabilitation and occupational area since its foundations were laid in the second half of the 20th century. It uses low-frequency sound (generally in the range between 30 and 120 Hz) in the audible range to produce mechanical vibrations, unlike methods that use only infrasonic frequencies (below 20 Hz), which are inaudible to the human ear (1-3). These vibrations are then transmitted to the body of the person undergoing treatment by direct contact with a platform equipped with speakers. This system ensures that therapeutic music is not only perceived by the auditory system as a sound vibration but also as a tactile vibration by many somatic mechanoreceptors due to the direct contact with the transduction platform itself.

The distinctive feature of VT is the use of low-frequency vibrations in conjunction with listening to music, similar to Whole-Body Vibrations (WBVs), which are typically applied while standing on an oscillating platform that moves the individual and alters the gravitational forces acting on the body to produce a modification of muscle tone-tropism (4). Similar effects can be observed for Focused Mechano-Acoustic Vibrations (FMAVs) therapy, which applies localized vibrations at the muscular level produced by air pressure variations inside cups positioned on the patient's body and connected to a turbine (5).

In the field of MT, it is possible to differentiate low-frequency selective music from full-frequency music. Low-frequency music uses specific frequencies for vibroacoustic stimulation, such as that produced by Skille's equipment (6), while full-frequency music uses a single sound source and plays music using a wide range of frequencies, as is the case with the musical vibration platform by Chesky (7).

Regarding selective low-frequency stimulations, an important issue is related to the selection of suitable frequencies. Although Skille formulated a set of seven frequencies, this set is simply based on practical experiences and lacks theoretical support (6, 8). However, it has been shown that this therapeutic combination has positive effects on muscle tone and pain (6).

Music is a therapeutic means capable of determining a series of effects in a multitude of pathological contexts, ranging from the improvement of cardiovascular parameters (9) and the quality of sleep (10) to the reduction of muscle hypertonicity (11).

These therapeutic properties of music could be very useful in some pathologies, particularly in the presence of muscle hypertonicity and musculoskeletal stiffness associated with chronic widespread pain. On several occasions, music therapy has proven effective in reducing muscle tension and pain perceived by some types of patients (12-14), as has been achieved by vibratory treatments.

It is assumed that VT can determine its therapeutic effects through different mechanisms. First of all, vibratory stimulation is received in the body by specific mechanoreceptors, in particular the Pacinian Corpuscles, which have pain modulation properties and tactile/vibratory perception activity and are sensitive to a wide frequency range, between 60 and 600 Hz (15). Furthermore, the combination of music and tactile vibration as a therapeutic stimulus would seem to have a strong suppression effect on afferent and efferent neuronal pain activation, as well as an action on pain perception at the level of the Central Nervous System (15), presumably due to a phenomenon of synchronization of neuronal activity with the vibrational frequencies of the treatment.

Given the potential therapeutic properties of MT and VT, in this study, we wanted to observe how they could modulate pain and some basic vital parameters in patients suffering from widespread musculoskeletal stiffness associated with pain.

MATERIALS AND METHODS

This retrospective observational study was conducted in the period from May to October 2021 at Ce.Fi.R.R. (Center for Physiotherapy, Rehabilitation, and Re-education), located in the headquarters of the “G. d'Annunzio" University of Chieti-Pescara.

Data were collected from 20 patients aged between 51 and 82 years (mean 69.6±10.8 years) who had received a medical diagnosis of diffuse musculoskeletal stiffness associated with chronic musculoskeletal pain.

The rehabilitation protocol to which the patients were subjected is safe; it is accessible to all patients who do not highlight specific contraindications to the initial clinical evaluation necessary for all patients who access the facility where the study is carried out; furthermore, the protocol does not constitute an experimental practice, as it is the same therapeutic protocol used for all patients who do not present the aforementioned contraindications. The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Written informed consent was obtained at enrolment from willing and able participants; alternatively, informed consent was obtained from caregivers. Because of all these

considerations and the lack of incontrovertible national legislation regarding the need to submit retrospective and/or non-pharmacological observational studies to an ethics committee, the normal ethics committee clearance was not required (16).

People with active cancer, pacemakers, and atrial fibrillation were excluded from the study. Furthermore, all subjects who were affected by deafness, cardiovascular disorders, recent stroke, convulsions, shock, and treatment with drugs that modify cardiac autonomic regulation were also excluded from the research.

Of the 20 patients observed, 10 underwent an MT session without vibrations (Control, CONT), and 10 underwent a VT session (Intervention, INT). Given the observational nature of the study, there was no randomization of patients; we simply proceeded with the data analysis once an equivalent number of patients who received an MT or VT prescription had been reached. The evaluation tools used before (T0) and after the therapeutic session (T1) were:

- pressure Algometer (ALG) (F-Meter, Storz Medical AG, Tägerwilen, Switzerland): it was used to detect the pressure-pain threshold of the patient for specific assessment points (17). The device was pointed locally and bilaterally at the level of the lumbar paraspinal muscles, approximately at the point between the L3 and L4 vertebrae. After that, the therapist applied progressive pressure with the tip of the device until the patient reported a pain sensation. The level of pain reached was then read on the display and marked as a pressure-pain threshold for that patient at that point, with each unit of pressure consisting of about 200g of applied weight. The algometer has proven useful for evaluating muscle tenderness in patients affected by painful chronic tone abnormalities, such as in the case of fibromyalgia and other myofascial syndromes (18, 19);
- digital Pulse-oximeter: (YK-81CEU, Braun GmbH, Kronberg, Germany). It is an indirect and non-invasive method that allows to measure oxygen saturation of the hemoglobin present in the arterial blood (SpO2) as well as additional data on other vital parameters of the patient, such as the heart rate (HR), the plethysmographic curve and the perfusion index. In particular, to monitor changes in vital parameters of observed patients after the treatment, SpO2 (%) and HR (Beats per minute, Bpm) data were collected (20). The evaluation of basic vital parameters, such as SpO2 and HR, are considered indicators of the state of psycho-emotional and, consequently, musculoskeletal relaxation in humans (21, 22) and have often been used in the field of VT for monitoring the effects of relaxation possibly induced by the treatment (23, 24).

The therapeutic session was carried out in both groups and observed using the Music Vibration Platform (MVP). This instrument, which was positioned in a specific acoustically isolated room within the premises of the study, is composed of an audio system, a hollow wooden platform (dimensions: 125x200x54 cm), a computerized system for processing the transmitted vibrations, and a vibrating membrane. The platform was explicitly handcrafted to meet the operational needs of the center where the study was carried out.

The MVP can modulate the emission of vibratory stimuli in terms of intensity through a feedback mechanism based on detecting the patient's weight and its distribution once lying on the platform itself. The precision of the setting is guaranteed by an automatic calibration carried out with sensors, which can be performed at each treatment session to compensate for differences in weight and general positioning between subjects lying on the platform.

The vibrating membrane comprises 3 components, which are located respectively under the back, under the thighs, and the legs of the patient. The membranes transmit contact vibrations determined by the low frequencies of the musical pieces played to the body of the patient. Instead, the auditory perception of the songs played is entrusted to a set of over-ear headphones. The vibrational system and the headphones are connected to the same musical source. They can be separated to work simultaneously (true VT), only with headphones (pure MT), or only with vibrations (almost WBVs).

Given that individual physiological responses to musical stimuli vary due to the unique physiological and psychological reactivity systems of each person, it was necessary to use a musical selection chosen by the experimenters, which did not have an influence on the emotionality of the patient (i.e., songs that are fundamentally recognized as relaxing but unknown to him) to obtain an unconditioned physiological response. The songs selected for the treatment sessions were the following both for CONT and INT:

1. “Nuvole Bianche” by Ludovico Einaudi (Duration: 6’05”, Peak Frequency: 103 Hz)
2. “People Help the People” by Birdy (Duration: 4’18”, Peak Frequency: 92 Hz)
3. “Caribbean Blue” by Enya (Duration: 3’57”, Peak Frequency: 110 Hz)
4. “Midnight” by Coldplay (Duration: 5’07”, Peak Frequency: 46 Hz)
5. “Weightless” by Marconi Union (Duration: 8’09”, Peak Frequency: 110 Hz)
6. “Remember Me” by Thomas Bergensen (Duration: 4’29”, Peak Frequency: 54 Hz)

The selected pieces were chosen based on their coherence with the definition of "relaxing or sedative music" generally accepted in literature, which defines it as music characterized by slow tempo, repetitive rhythm, gentle contours, and, eventually, strings (25, 26).

By starting playback of the audio sequence on the device, it is transmitted to the mixer, which sends the signal directly to the membranes in the Music Vibration Table and to the relative headphones.

To perform the treatment, the patient was made to lie down on the platform, in the center of it, in a supine and comfortable position. The patient was given 1-2 minutes of settling time on the platform and was then subjected to listening to the musical selection in the form of music + vibrations in the INT group and music only in the CONT group.

At the end of the session, the patient was asked to stand up calmly after 1 or 2 minutes from the end of the last song. The same therapist assigned to the role carried out all the accommodation procedures, treatment set-ups, and session monitoring.

Excel software (Microsoft, Redmond, Washington, U.S.A.) was used to analyze the data. The means of the observed values and the T-Test statistical significance were calculated for data obtained with the Algometer and the Pulse-oximeter. The corresponding *p-value* represents the possibility of observing a quantity different from the one observed; if the *p-value* is extremely small (≤0.05), the variation of the parameter under examination between T0 and T1 is assumed to be significant.

RESULTS

Pressure algometer (ALG)

In the INT group, the pain threshold (ALG) increased in the right hemisome by 5.8% in a non-statistically significant manner (from 15.4 ± 12.6 to 16.3 ± 13.2 points, p=0.722); in the left hemisome, it increased significantly by 26.4% (from 12.5 ± 10 to 15.8 ± 10.3 points, p=0.001).

In the CONT group, however, the ALG value decreased in the right hemisome by 13.8% in a non-statistically significant manner (from 9.4 ± 10.1 to 8.1 ± 7.7 points, p=0.519). In the left hemisome, however, the ALG value increased by 12.7% in a non-statistically significant manner (from 6.3 ± 4.7 to 7.1 ± 5.7 points, p=0.23).

Heart rate (HR)

In the INT group, the HR value decreased by 4.4% (from 76.4 ± 18.7 to 73 ± 13.2 Bpm) in a non-statistically significant manner (p=0.24). In the CONT group, the HR significantly decreased by 9.6% (from 77.9 ± 11.1 to 70.4 ± 13.4 Bpm, p=0.004).

Oxygen saturation (SpO2)

The SpO2 value in the INT group increased by 0.2% (from 96 ± 1.8 to 96.2 ± 4.6 percent) in a non-statistically significant manner (p=0.891). In the CONT group, SpO2 decreased by 0.1% (from 96.8 ± 0.9 to 96.7 ± 1.1 percent) in a non-statistically significant manner (p=0.853).

DISCUSSION

The present study demonstrates how both MT (CONT) and VT (INT) are able, through a single treatment session, to produce changes in pressure pain (ALG) and vital parameters (HR and SpO2) in patients with musculoskeletal stiffness and chronic pain. These effects, however, reach a different magnitude between the two types of neuro-sensory stimulations, and, in general, the effect of a single session produced significant variations only in 2 cases: in the raising of the pressure pain threshold of the left lumbar paravertebral point in INT patients and the decrease in HR in CONT patients.

The greater increase in ALG values in INT patients appears to be consistent with a summation effect of the analgesic properties of music and the vibrations produced by the appropriate treatment platform. A potential analgesic effect induced by music has already been described in the literature, especially if generally identifiable as relaxing (12), probably based on psycho-emotional factors connected to a possible involvement of the limbic system as a moderator of abnormal pain stimuli (12). Furthermore, therapeutic vibrations have also often been associated with analgesic effects; this phenomenon could have both a direct nature due to phenomena of perceptive overlap between pain and vibration (27) in accordance with the "gate control theory" (28) and an indirect nature due to the ability to modulate muscle tone: in fact, the increase of muscular tone over time tends to be associated with forms of chronic musculoskeletal pain (29).

Regarding basic vital parameters, a greater reduction in HR was observed in CONT compared to INT (10% vs 3%). Current literature would seem to suggest that low-frequency vibrations should induce parasympathetic adaptations capable of reducing HR in humans (30). However, in our case, CONT, not subjected to contact vibrations, showed a greater reduction in the HR value, albeit remaining within a clinical normal range. It could be hypothesized that since

our patients had a relatively high mean age (69.6±10.8 years), the sample observed could have presented an alteration in tactile and vibratory sensitivity due to aging factors (31,32).

Finally, regarding SpO2 values, a slight reduction in the value was observed in CONT, in contrast to a slight increase in the same in INT. This difference, even if clinically irrelevant, could be due to a potential improvement of the oxygenation of the blood circulation induced by the vibrations applied using a vibroacoustic platform in INT (33,34). The particularities of the results obtained from the observed sample could be traced back to the existence of a state of inflammaging (35). This condition includes a chronic onset of low-grade inflammation and a decline in metabolic function (36) in the whole organism (37). Inflammaging plays a key role in the pathogenesis of age-related diseases and is accompanied by a "2-fold-to-4-fold" increase in plasma levels of pro-inflammatory mediators in healthy elderly people compared to the healthy adult population.

Accepting the definition of pain as an unpleasant sensory and emotional experience associated with actual or potential tissue damage and described in terms of such damage, as defined by the International Association for the Study of Pain, and recognizing the difference between pain-symptom, danger signal for the organism, and pain-illness, that is non-finalistic and disengaged from the primary cause (38), this study aims to bring new results obtained from customized treatment based on rigorous patient data framed in a holistic rehabilitation approach. We also took into account the original experiences of Maffei and his School (39,40), using elastic and/or mechanical waves (acoustic and tactile stimulation) as an endogenous pharmacotherapy.

The possibility of finding and applying new therapeutic approaches that are minimally invasive, easy to carry out, and relatively cheap is particularly important in the context of pathologies connected to chronic musculoskeletal pain and muscle and joint stiffness, which in severe cases may lead to non-musculoskeletal symptoms such as depression and kinesiophobia (41) and, sometimes, may require interventions based on more invasive approach such as surgery or infiltrative therapy (42).

Since the present study is characterized by an observational design and was carried out for a limited number of sessions, it is necessary to point out how the small and non-homogeneous sample observed, in relation to the single treatment session evaluated, could have influenced the significance of the results. However, given the apparent consistency of what was observed with what is currently known in the literature, it is appropriate to underline that the present study represents a new step in the perspective of studying interesting rehabilitation techniques such as MT and VT in the context of chronic pain from musculoskeletal stiffness.

CONCLUSIONS

The study highlighted how both MT and VT administered with a Music Vibration Platform are able to induce, in the short term, positive, although not always significant, changes in the health status of patients suffering from chronic pain resulting from musculoskeletal stiffness. However, given the limitations of this research project, it would be important to conduct further studies on the subject, possibly in an RCT-type setting with a larger and more homogeneous sample and the presence of a control group and a follow-up, to better clarify the medium-long term effectiveness of the treatment methods observed.

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