

*Full-Length Article*

## The Effect of Short-Term Vibroacoustic Treatment on Spasticity and Perceived Health Condition of Patients with Spinal Cord and Brain Injuries

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### Abstract

Vibroacoustic (VA) treatment was applied to patients with chronic spinal cord and brain injuries during rehabilitation. The study aimed to ascertain the suitability of short-term VA treatment for decreasing spasticity and pain, and improving health conditions within the rehabilitation program for patients with spinal cord and brain injuries. Hypotheses: 1) indicators of self-perceived spasticity and pain measured after VA treatment are lower than measurement results before treatment; 2) VA treatment can be used in rehabilitation programs to support the improvement of self-perceived health condition. 53 patients aged 20-72 participated in the study. VA treatment of 40 Hz was conducted once a day for 23 minutes over 4 or 5 days. Self-report numerical rating scales were used to measure patients' condition before and after VA treatment sessions. Research findings revealed significant change in the levels of spasticity, pain, physical discomfort, general health condition, fatigue, and anxiety after VA treatment sessions compared to the measurements before the sessions. Reduction in spasticity and physical discomfort was not statistically significantly different after 4 or 5 days of treatment, however a decrease in pain and an improvement in perceived health condition were significantly higher after 5 days than after 4 days of treatment.

**Keywords:** *vibroacoustic treatment, spinal cord and brain injuries, adults, spasticity, pain, self-perceived health condition.*

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### Introduction

#### *Vibroacoustic Method and Estonian Experiences*

Vibroacoustic (VA) therapy is defined as a treatment method based on low frequency sound vibrations and music [1, 2]. Depending on the choice of sound vibrations, the effect is either relaxing or stimulating, which allows using VA therapy for general relaxation and for the purpose of more specific physiotherapy and receptive music therapy [2, 3, 4]. In Estonia, mainly devices affecting the whole body are used: VA treatment beds produced in Estonia, vibroacoustic mattress (Multivib, Norway) (both utilizing Olav Skille's programs), and physioacoustic chair (Next Wave, Finland). Tallinn University has contributed to VA therapy practice and

research and the development of the equipment since the 1980s. The newest device, the prototype for which was launched by the Centre of Excellence in Health Promotion and Rehabilitation of Haapsalu College was introduced at the 1st International VIBRAC Conference in Lahti, Finland, in 2016.

In Estonian practice, mainly pulsating sinusoidal sound waves in the range of 30–88 Hz are used. Throughout the duration of the procedure, often music<sup>1</sup> and/or sounds of nature suitable to the purpose of the procedure are introduced in the therapy room as an auditory influence. If necessary, background music can mask everyday sounds and the audible component of low frequency sounds and provide musical support to the therapy goals. The most common length of sessions is 10 to 45 minutes [5]. In Estonian practice, the frequency of the sessions is 1-5 times a week (depending on therapy goals) and usually 10 sessions are recommended as optimal. The duration of a session is about 30 minutes, of which exposure to low frequency stimulation for 23 minutes (if music or nature sounds are used as a background, the session is slightly longer). Depending on the approach and health state, a combination with creative arts therapies is usually utilized, primarily in children.

PRODUCTION NOTES: Address correspondence to:

Eha Rüütel, Tallinn University, School of Natural Sciences and Health, E-mail: [eha@tlu.ee](mailto:eha@tlu.ee) | COI statement: The research was carried out in the frames of the project of Tallinn University Haapsalu College TA/112 "Health Promotion and Rehabilitation Centre (15.09.2011-31.08.2015)", and was funded by European Regional Development Fund, Tallinn University, Haapsalu Neurological Rehabilitation Centre and Haapsalu City Government. The authors have no conflict of interest to declare.

<sup>1</sup>Therapist-selected recorded music appropriate for the client. Therapists follow the music selection instructions given by Grocke and Wigram [1: 226-227].

According to Boyd-Brewer and McCaffrey [5], there have not been any reports of adverse effects of the VA method. Patrick [6] argues that there does not exist a condition in which a single VA stimulation could give a negative result. However, practitioners have observed that during or after the first sessions of VA therapy some negative side effects may occur – drowsiness, dizziness, and/or nausea. In such cases we have reduced the volume of the sound and moved the upper body of the patient in a more upright position (given the equipment allows this) or raised the height of the pillow. Based on their practical experience, Wigram [7] and Grocke, and Wigram [2, pp. 228-229] have listed contraindications to the use of the VA method: acute inflammations, pacemakers, psychoses, pregnancy (for the reason that there is a lack of any relevant empirical studies), acute physical states (first require consultation with their doctor), and hypotension (the method may further reduce blood pressure). We have also taken into consideration psychological factors [8] – e.g. excessive sensitivity to vibration or subjective aversion or fear of the given treatment may block the positive effect of VA therapy.

#### *The Findings of Earlier Research on the VA Method*

Studies on the VA method have shown a significant improvement in many somatic and functional disorders, e.g. reduction in pain [9-12], decrease in muscle tension and spasms [13, 1, 4, 14-16], reduction in the parameters of blood pressure, pulse rate and muscle oscillation [17]. In the treatment of Parkinson's disease, experiments with the method have produced an improvement in motor function [18, 19]. According to the practice-based evidence of VA treatment VA treatment, positive changes in indicators of the perceived health condition and emotional state [20] and an improvement of physical self-awareness [21,22] can be expected.

Relatively few studies have been conducted on influencing muscle tone and spasticity, but the received results are promising. Wigram's study [15] of physically disabled adults (n = 10) revealed a considerably higher muscle tension reduction and movement facilitating effect of VA stimulation compared to a session of sedative music<sup>2</sup>. In another of Wigram's [16] study (n = 27) VA stimulation produced an effect similar to motion physiotherapy. Katušić and Mejaški-Bošnjak [13] describe an improvement in the therapy outcomes after vibroacoustic stimulation had been added to physiotherapy. The researchers studied the effect of a 20-minute VA stimulation (40 Hz) on the spasticity and motor performance of children with cerebral paralysis (n = 13). The sessions took place once a week over a three-month period. The results showed a considerable improvement in body rotation, including keeping the body and head in an upright position, and in a variety of movements. Naghdi, Ahonen,

Macario & Bartel [23] investigated the impact of low frequency sound stimulation on patients with fibromyalgia (n = 19 females) and found that cervical muscle range of motion increased from 25% to 75% (p = 0.001), while muscle tone changed from hypertonic to normal (p = 0.0002) after 10 treatments (23 min) twice per week of low frequency sound stimulation (40 Hz).

Pain reduction through sound stimulation has been described by Chesky & Michel [24], who have described the technology of Music Vibration Table. In a randomised trial (n = 32), Burke [9] found that postoperative application of intensive VA stimulation could considerably reduce the perceived pain, anxiety, hostility and depression, and also the use of narcotic substances. Staud's research group [25] discovered that vibrotactile stimulation offered efficient pain management in chronic musculoskeletal pain, including fibromyalgia. Naghdi, Ahonen, Macario & Bartel [23] used 3 tools to measure the impact of pain: significantly reduced pain was measured on the Fibromyalgia Impact Questionnaire, 81%; a 49% before-after treatment reduction was measured on the Pain Disability Index; subjective assessment of pain showed decrease by 70% in median. Sleep is strongly affected by fibromyalgia. An improvement in sleep was 90% (p < 0.0001) on the Jenkins Sleep Scale. Fibromyalgia causes stiffness, and pain decreases the length of time individuals can stand or sit. The time of sitting and standing without pain incidence increased significantly (p < 0.0001).

Based on the findings of earlier studies and practical experience, in the planning stage of this study it was assumed that short-term VA treatment can have effect on spasticity, pain- and self-perceived health condition in patients with spinal cord and brain injuries. The study aimed to ascertain the suitability of short-term VA treatment in supporting the decrease in spasticity and pain and improvement in health condition in the rehabilitation program for patients with spinal cord and brain injuries.

Hypotheses: 1) indicators of self-perceived spasticity and pain measured after VA treatment are lower than the results of the measurement before the treatment; 2) VA treatment can be used in the rehabilitation program to support the improvement in self-perceived health condition.

#### *Material and Methods*

VA treatment was included in the rehabilitation program as a complementary intervention. This study can be viewed as a pilot study and was designed as intervention-outcome research comparing the results of the treatment with the indicators before treatment.

#### *Subjects*

Patients were referred to the study by the physicians of a rehabilitation center. The diagnostic criteria of the study were the following:

<sup>2</sup> The music used in both conditions was "Cristal Caverns" by Daniael Kobiialka [15: 60].

1. Lower limb spasticity as assessed by the rehabilitation physician;
2. Time elapsed since the beginning of the disease at least 1.5 years for spinal cord injury and at least six months for brain injury.

VA treatment took place during a 15 months on 17 randomly selected weeks from Monday to Friday. Patients meeting the diagnostic criteria, that were in rehabilitation on the weeks of the study and agreed to participate in the study, were referred to VA treatment. A total of 53 patients aged 20-72, including 34 men and 19 women participated in the study.

### Procedure

In this study, a vibroacoustic mattress *Multivib 10 Transducers Mattress* laid on top of a couch was used for VA treatment. During the procedure a patient was lying on the mattress in a position comfortable for him/her (patients mainly preferred lying on their back). For the duration of the session the therapist conducting the procedure left the therapy room to stay in the adjacent room. The original 23 minute *Multivib* program (composed by Olav Skille) recorded on a CD with basic frequency of 40 Hz was used for vibroacoustic stimulation. The choice of the frequency was based on the earlier observations by practitioners and previous studies, which had revealed the muscle tone and spasticity reducing effect of this frequency [13, 15]. Through headphones, patients heard relaxing music and/or sounds of nature (depending on their preference) during the session. Based on these preferences, patients could listen to relaxing music [25], relaxing music with nature sounds [26] or sounds of nature [27]. The reason for adding music or nature sounds was to mask procedure-related sounds coming from the adjacent rooms. The volume of the VA and auditory stimulation was regulated to suit the patient according to his/her subjective assessment.

The VA treatment sessions were planned on 5 consecutive days (from Monday to Friday) at more-or-less the same time between 9 am and 4 pm. As some of the subjects left the rehabilitation center a day earlier or on the morning of the fifth day, in 24 (55%) cases the process included five VA treatment sessions and in 20 (45%) cases four treatment sessions on consecutive days. Measurements of the patients' condition were carried out 3 times immediately before and after the treatment session.

Measurements were taken in a position most comfortable for the patient – depending on his/her condition, either sitting (both before and after the session) or in some cases lying on the VA mattress (before and after the session). Measuring was conducted in a lying position in case the change in body position – movement from the wheelchair onto the bed and after the session from the bed into the wheelchair – was inconvenient and would have significantly influenced the assessment of the perceived health condition. If a patient was not able to write, the VA therapist recorded the patient's

condition on the rating scales according to the patient's oral responses.

### Measurements

It was planned to measure the patients' condition through their subjective assessment of spasticity, pain, physical discomfort, and general health condition. Based on the additional changes mentioned by patients, within the course of the study, fatigue and anxiety were added to the indicators assessed. Numerical rating scales with 11 divisions were applied (0 – 10). Numerical rating scales are widely used to measure pain [29, 30] and are recommended for clinical studies [31]. Such numerical scales with 11 divisions have also been used to measure spasticity and a statistically significant correlation has been obtained with the rating scales used by physiotherapists (*Modified Ashworth Scale* and *Tardieu Scale*) [32]. Simple numerical rating scales are increasingly more frequently employed to measure subjectively assessed health indicators like pain, fatigue, depression, anxiety, sleep, physical and social functions, irrespective of health condition, age, or gender [33].

Measurements were conducted 3 times, before and after a VA treatment session – on the first, third and fifth day of the treatment; if a patient left the rehabilitation center on the fourth day of the treatment, the third (last) measurement was conducted on the fourth treatment day. In this study, it was also planned to use the Tardieu test simultaneously with numerical scales. Since it had been planned to conduct the study in the framework of a usual program of rehabilitation, carrying out the Tardieu test immediately before the first and after the last measurement of subjective condition by two physiotherapists, proved to be too time and work consuming. Therefore, the Tardieu test was abandoned after the trials conducted in the first weeks of the study.

### Data Analysis

Data were analyzed with statistical data processing program *Statistica for Windows 5.0* using repeated measures analysis of variance (ANOVA/MANOVA). Correlation analysis and multiple regression analysis were used for assessing relationship between spasticity and other indicators of health condition.

### Ethical Aspects

Consent to carry out the study was given by Tallinn Medical Research Ethics Committee. All patients gave their informed consent to participate in the study. Patients were informed that the suitability of VA treatment to their condition was researched. In the referral to the study, contraindications to VA treatment were taken into account and the treatment was immediately interrupted when a negative effect from VA stimulation occurred. In the research data, each participant was assigned a code and data analysis was conducted with coded data.

**Results**

Out of 53 patients, the data analysis included 44 participants, 30 men (average age 41, youngest 22, oldest 72) and 14 women (average age 54, youngest 20, oldest 72). Nine patients (17%) discontinued for the following reasons: spasticity increased in three patients (5%); two patients (4%) experienced discomfort in the heart area, which may have been related to the earlier occurring heart arrhythmia; one patient (2%) developed a pre-cramp feeling in one leg (which was not followed by a cramp); two patients (4%) reported feeling worse (one had a pain in the neck, the other discomfort in the back and a leg), which the patients did not link to the

conducted VA therapy; one patient (2%) left the rehabilitation centre for personal reasons immediately after referral to VA treatment.

Since there were no statistically significant gender differences in the indicators, the indicators for men and women have not been presented separately.

**1. General Effect of Changes in Condition**

Repeated measures ANOVA analyses (measurement x condition indicator) of three measurements (before and after VA treatment session) indicated the main effect of changes in patients' condition (Table 1).

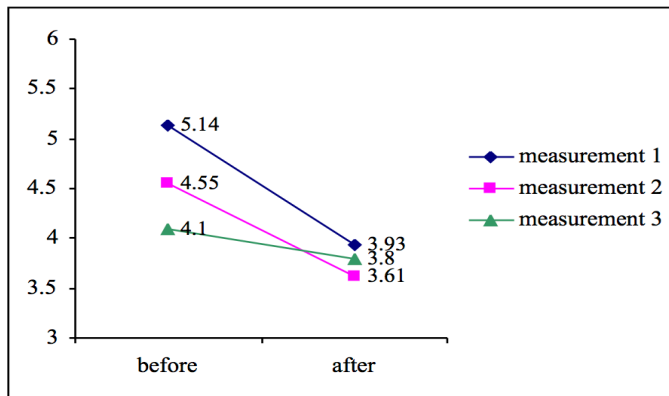
	Main effect <i>F</i>	Mean before treatment <i>M<sub>before</sub></i>	Standard deviation <i>SD</i>	Mean after treatment <i>M<sub>after</sub></i>	Standard deviation <i>SD</i>	Number of patients <i>N</i>
<i>F</i> (1, 126)						
Spasticity	18.73	4.60	2.75	3.78	2.72	44
Pain	7.15	1.95	2.60	1.57	2.38	44
Physical discomfort	20.77	2.91	2.61	1.93	2.24	44
General health condition	22.20	6.74	1.94	7.43	1.83	44
<i>F</i> (1, 42)						
Fatigue	11.70	4.36	2.85	3.18	2.86	15
Anxiety	9.52	1.84	2.50	1.04	1.51	15

Table 1. Changes in patients' condition during VA treatment session (scale from 0 to 10);  $p < 0.01$

VA treatment had the greatest effect on general health condition, physical discomfort and spasticity.

**2. Dynamics of Changes Before VA Sessions**

Figure 1 shows a change in spasticity over the three measurements. The dynamics indicates reduction in spasticity as measured before therapy sessions. The level of spasticity before the first (measurement 1) and before the third VA treatment sessions (measurement 2) differed significantly (Tukey HSD post hoc test,  $p < 0.05$ ).



Graph 1. Results of the three measurements of spasticity (scale from 0 to 10).

The decrease in pre-session level of physical discomfort showed main effect  $F(2, 126) = 5.82$ ;  $p < 0.01$  ( $M_1 = 3.93$ ,  $SD = 3.10$ ;  $M_2 = 2.57$ ,  $SD = 2.29$ ;  $M_3 = 2.17$ ,  $SD = 2.61$ ). In other measured indicators – pain, fatigue, anxiety, and general health condition – the measurements before VA sessions did not reveal significant changes.

**3. Relationship Between Treatment Days and Therapeutic Effect**

Of the patients participating in the study, 24 (55%) attended VA treatment on five consecutive days and 20 (45%) on four consecutive days. The effect of the number of treatment days (four or five days) on general health condition was significant:  $F(1, 42) = 4.44$ ;  $p < 0.05$  ( $M_{4d\_before} = 6.80$ ,  $SD = 2.12$ ;  $M_{4d\_after} = 7.25$ ,  $SD = 1.48$ ;  $M_{5d\_before} = 6.13$ ,  $SD = 1.92$ ;  $M_{5d\_after} = 7.67$ ,  $SD = 1.95$ ).

Number of treatment days had also significant effect on pain levels:  $F(1, 42) = 6.88$ ;  $p < 0.05$  ( $M_{4d\_before} = 1.05$ ,  $SD = 1.73$ ;  $M_{4d\_after} = 0.60$ ,  $SD = 1.46$ ;  $M_{5d\_before} = 3.17$ ,  $SD = 3.29$ ;  $M_{5d\_after} = 2.29$ ,  $SD = 2.87$ ).

The effect of the number of treatment days on spasticity, fatigue, anxiety, and physical discomfort was not statistically significant.

**4. Relationship Between Condition Indicators**

Pearson correlations between spasticity and other indicators were found to be statistically insignificant, correlation between the levels of spasticity before and after VA session showed a moderate relationship  $r = 0.69$  (compared to pain  $r = 0.80$ ;  $p < 0,001$ ). Thus the regression analysis was conducted to see whether the other changes in the patient’s condition during a VA treatment session could predict the change in spasticity. Self-reported spasticity level after a single VA treatment session was included into multiple regression analysis as a dependent variable. Pain, physical discomfort, and general health condition before and after VA session, and spasticity before VA session were included as independent variables. The indicators of fatigue and anxiety were left out of the analysis because of having too few measurements.

measurement results also includes the effect of rehabilitation program in general and refers to the total impact of different interventions. The music and/or sounds of nature used during the VA treatment sessions certainly had an effect as well. However, auditory music was necessary to mask the everyday and procedure-related sounds from rooms adjacent to the VA therapy room.

This study revealed a significant change in the subjectively assessed spasticity, pain, physical discomfort, general health condition, fatigue, and anxiety after VA therapy sessions compared to the measurement results before the sessions. The level of physical discomfort and spasticity measured before VA treatment diminished statistically during VA treatment days, which also reflects the broader impact of the rehabilitation program.

It might be assumed that spasticity is linked to physical discomfort. However, the correlation analysis did not show a significant relationship between these indicators and the correlation between the measurements before and after VA treatment session for spasticity was moderate. In this light the results of the regression analysis deserve some attention highlighting the accompanying role of physical discomfort before and after the VA session. The present study did not consider the components of physical discomfort, thus it would be interesting to explore further the moderating role of physical discomfort in the context of perceived level and changes of spasticity. The current results seem to refer to some similarities with the gate control theory of pain [34], which integrates peripheral stimuli with cortical variables in the perception of pain. The relationship between physical discomfort and spasticity also brings into focus the patient’s physical needs and the convenience of the procedure as a supporting factor for the treatment effect.

The study results indicate that in order to achieve a decrease in spasticity, 4 treatment sessions on consecutive days may be sufficient. However, to improve general health condition and reduce pain, the five-day intervention proved to be considerably more efficient, indicating that a longer intervention provides a better therapeutic effect. This is indirectly also confirmed by strong positive correlation between perceived pain level before and after VA treatment course.

Relying on research and relevant recommendations [31, 33], numerical scales subjectively rated by patients were used for measurement in this study. Beyond a doubt, numerical rating scales have certain limitations, since they reflect patients’ general assessment of spasticity and do not allow any interpretations of this assessment and analysis of specific changes in spasticity. On the other hand, simple numerical scales are timesaving, as they do not require large expenditure of time and energy and they are convenient to use. This had great relevance for the patients involved in this study. Firstly, taking into consideration the patients’ condition, in order not to cause inconvenience related to carrying out measurements

	BETA	Standard error of BETA	B	Standard error of B	T-statistic t(124)	P value
Intercept			2.05	0.79	2.58	0.011
Spasticity before	0.73	0.06	0.72	0.06	11.80	0.000
Physical discomfort before	-0.27	0.07	-0.29	0.07	-3.95	0.000
Physical discomfort after	0.18	0.07	0.22	0.08	2.61	0.010
General health condition after	-0.11	0.07	-0.16	0.09	-1.72	0.088

**Table 2.** Predictors of self-reported spasticity level after a single VA treatment session.  $R = 0.742$ ;  $R^2 = 0.55$ ; adjusted  $R^2 = 0.54$ ;  $F(4, 124) = 37.98$ ,  $p < 0.001$ , standard error: 1.85

Although the correlation analysis did not show a significant relationship between spasticity and physical discomfort, the results in the Table 2 draw attention to the negative relationship between physical discomfort and spasticity before VA treatment session and positive relationship after the session referring to the important role of physical discomfort in the context of perceived spasticity. The explanatory power of the regression model was 54%.

**Discussion and Conclusions**

In the conversations taking place after the VA sessions, patients highlighted the calming and muscle relaxing effect of VA treatment and the suitability of the procedure after physically active physiotherapy training. At the same time, changes in the patients’ condition cannot merely be viewed in the context of VA treatment, but the dynamics of the

(which may affect the results). Secondly, due to their treatment plan, patients' schedule is relatively tight in the rehabilitation center and rating scales that can be filled in quickly enable patients to keep up with the rhythm of consecutive procedures. Thereby, subjective rating of their condition attaches importance to patients' own assessment of therapeutic results and in a broader context allows better management of patients' condition, and potential service provider's behavior, enhancing communication between patient and service provider, and reflects a patient's health condition [35]. This study also confirmed that the measurement method used is suitable for observing patients' condition and receiving feedback from patients.

The outcomes of this pilot study revealed statistically significant changes during VA treatment, which suggests the suitability of short-term VA treatment in the rehabilitation program of patients with spinal cord and brain injuries.

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