Research Inventy: International Journal of Engineering And Science
Vol.6, Issue 8 (September 2016), PP -07-11
Issn (e): 2278-4721, Issn (p):2319-6483, www.researchinventy.com

The Acute Effects Of Vibroacoustically-Induced Microvibrations On EEG Activity In Rats

Olivera Stanojlović[1*], Dragan Hrnčić[1], Aleksandra Rašić – Marković[1], Duško Kornjača[2], Dušan Mladenović[3] and Dragan M. Djurić[1]

[1]*Institute of Medical Physiology "Richard Burian", Faculty of Medicine, University of Belgrade, Serbia*
[2]*FIP Komerc, Belgrade*
[3]*Institute of Pathophysiology "Ljubodrag Buba Mihailović", Faculty of Medicine, University of Belgrade, Serbia*

Abstract: *A 7-13 c/s mechanographic signal (amplitude 1-5μV) is detectable over relaxed limbs, phenomenon termed microvibration (MV). Exposure to mechanographic signals, low frequency noise, on other side, results in vibroacoustic disease. The aim of this study was to investigate the acute effects of vibroacoustically-induced MV in regio nuchae (vibroacoustic device Vitafon, St. Petersburg, Russian Federation) using four different modes of MV of specific amplitude (2.8 μm - 12.3 μm) and frequency (30 Hz – 18 kHz) on native undulating electrical CNS activity (EEG registration) in the adult rats. The experiments were performed on Wistar male rats and were divided into control and experimental groups. Rats subjected to the same experimental protocol, but with vibroacoustic treatment switched off, served as controls. EEG activity was registered during application of vibroacoustic MV and following was observed regardless of working regime: none of the graphoelements indicating hyperexcitability; there were no reduction in vigilance; beta rhythm and moderate transition alpha in beta rhythm were observed. Slightly override the beta waves in relation to alpha EEG band, under the stimulus of vibroacoustically-induced microvibration by Vitafon, suggests that mental alertness increased as well as focused attention, with no signs of hyperexcitability in rats.*

Keywords: *Vitafon, microvibrations, rats, EEG*

I. Introduction

Microvibrations (MV) are present in every living organism and represent Brownian motion in abiotic environment [1-3]. A 7-13 mechanographic signal in seconds with amplitude 1-5μV is detectable over relaxed limbs, phenomenon termed MV which continues during sleep, and should be changed during relaxation, exercise, disease or microgravity. The microvibration has also been termed the normal or minor tremor of the body surface which was firstly detected by Rohracher [l] in 1944. Rohracher [4] viewed the MV not as a reaction, but as a biological action of the organism, as Skille [5] wrote, the body receives an 'internal massage', the physical vibrations of both the music and the low frequency sine tone are felt in the body.

Unlike poikilothermic water-living and cold-blooded animals which do not manifest MV [6], the entire surface of the human or homeothermic animal body exhibits minute continuous MV due to muscular and cardiac activity, with aforementioned frequency like homeothermic mammal dolphin Tursiops truncates (13 Hz) [7].

Besides muscle contraction, the ballistocardiogram plays an important role in MV transmitted by osseous structures to soft tissues (relaxed muscle), mechanical coupling between bone and muscle tissue, and finally local resonance leads to the oscillations [3, 8-10], with strong influence of emotional changes as well as the hypothalamic stimulation [11].

The cerebral microvibration occurring on the dura mater was recorded from anesthetized cats and might represent the cerebral vasomotor tone maintained during the time [12]. The origin of spinal cord biosignal MV also involves the gamma motor system [13, 14]. Hippocampal seizure had no effect on minor tremor [12]. Micro-vibration with frequency spectrum 7-13 Hz in the physiological and psychiatric clinical application is considered corresponding to that of the EEG [2, 14].

Exposure to mechanographic (7-13 c/s) signals or low frequency noise on one side results in vibroacoustic disease [15, 16]. On the other hand, over the last 30 years vibroacoustic device that uses microvibration to affect the human body are noninvasive technology that transmits sound (involves a sinusoidal low frequency tones between 20 -70 Hz) as vibration to the body have developed in clinical treatment or vibroacoustic therapy [17- 20].

Accordingly, the aim of this study was to investigate the acute effects of vibroacoustically - induced microvibrations (vibroacoustic device *Vitafon, St. Petersburg, Russian Federation*) using four different modes of MV of specific amplitude (2.8 μm - 12.3 μm) and frequency (30 Hz – 18 KHz) on native undulating electrical CNS activity in the adult rats.

II. Material and methods

1.1. Animals

Adult male Wistar rats (180 – 220 g) were purchased from local certified supplier (The Military Medical Breeding Laboratories, Belgrade) and kept under controlled laboratory conditions (ambient temperature 21-23^{0}C, 55-65% humidity, 12/12 light/dark cycle, with light starting on 8 a.m.) during all experimental protocol. Free access to standard laboratory chow and tap water were allowed to all animals.

All experimental procedures were in full compliance with Directive of the European Parliament and of the Council (2010/63/EU). The Ethical Board of Belgrade University Faculty of Medicine and The Ethical Committee of the Republic of Serbia (Permission No 298/5-2) approved these experiments.

1.2. Surgical electrode implantation

For EEG recordings, rats were anesthetized with ketamine (100 mg/kg i.p.) and three gold-plated electrodes were implanted over

-frontal, (2 mm rostrally to bregma and 2 mm from the median line)

-parietal (2mm rostrally to lambda and 2 mm laterally to median line) and

-occipital (2 mm caudally to lambda) cortices by stereotaxic apparatus (David Kopf, USA). The animals were left to recover 7 days after the surgery.

2.3. Experimental groups

The parameters of a pulse sequence, such as the frequency, amplitude, duration, and number of pulses of the modulated can all be varied to produce different pulse sequences. Animals in experimental group (Exp, n=7) were subjected to vibroacoustic microvibrations in regio nuchae (*Vitafon, St. Petersburg, Russian Federation*) using 4 pre-defined working regimes in time series of 3 intervals of 5 min with pauses of 5 min among them. The ramp frequency range and amplitude for applied working regimes were as following regime:

- regime I: 30-60 Hz and 2.8 µm,
-regime II: 1200-4500 Hz and 6.0 µm,
- regime III: 200-1000 Hz and 5.4 µm,
-regime IV: 9000-18000 Hz and 12.3 µm.

Rats subjected to the same experimental protocol, but with vibroacoustic treatment switched off, served as controls (C, n=7).

2.4. EEG registration and analysis

For EEG registration, an 8-channel apparatus (RIZ, Zagreb, Croatia) was used with digital signal acquisition achieved by SCB-68 data acquisition card (National Instruments Co, Austin, TX, USA). Data acquisition and signal processing were performed using software based on LabVIEW platform (NeuroSciLaBG, Belgrade, Serbia). Sampling frequency was 512 Hz/channel, while the cut off frequencies were set at 0.3 and 100 Hz filters (high- and low-pass, respectively). Ambient noise was eliminated using 50 Hz notch filter.

The mean power spectra density, as a measure of the mean voltage of EEG waves, was calculated with a software by using fast Fourier transformation method and the integrated energy signals were expressed as μV^2/Hz.

III. Results

None of the epileptiform graphoelements was recorded in EEG of rats from *control group* while vibroacoustic treatment turns out. Recordings of bioelectrical brain activity in these rats showed baseline activity (Fig. 1A).

In EEG of rats from *experimental group*, none of the graphoelements indicating hyperexcitability and/or epilepsy was recorded during application of vibroacoustic microvibrations, regardless of working regime. Also, there were no reduction in vigilance and signs of EEG deceleration.

Visual inspection of EEG recordings obtained under the stimulus of vibroacoustically-induced microvibration by *Vitafon,* during the 15 minute regime (3 x 5 min), demonstrated beta rhythm (β frequency range from 15 to 30 Hz) accompanied with increased alertness in rat behavior followed with orienting reflex (Pavlov's *"What- is - it?"* reflex) (Fig. 1B). Slightly override the beta waves in relation to alpha EEG band, was seen.

In pauses between applied working regimes, during the break between the regime (3 x 5 min), waves of high amplitudes and low frequency were recorded indicating delta activity (δ frequency range from 0.5 to 4 Hz) denoting slow-wave-sleep (Fig. 1C), and normal behavior in treated animals.

IV. Discussion

In the healthy individuals, dominant pattern of microvibration is of 13 Hz frequency and remains constant if there is no change in room and body temperature, state of consciousness and the extent of fatigue of the individual [2-3, 21-22]. The mechanism of microvibration effect has not been definitely clarified, but ballistocardiographic and a muscular seems to be two major components [11], and nowadays there may be other opinions based on strengthening blood circulation, lymph flow, metabolic processes and stimulation neuropathic functions, decreasing edema in tissues [23]. Ozaki et al. [24] report that the reason for the existence of MV (with amplitude and frequency similar to muscle fiber movements) is heart beats or respiratory movements in addition to muscle contraction and musculoskeletal stiffness when even the lowest stiffness achieved the cardiac impact dominates.

MV has been used clinically as a simple test for the autonomic nervous system function in psychosomatic medicine [25]. Situational stress affects increase MV amplitude [4, 21], but after the person lies down (five min.), the amplitude of the MV becomes smaller showing a fairly constant pattern [12- 13].

Central stimulation on minor tremor was studied with unanesthetized rabbits, and there are some findings: hippocampal seizure had no effect on minor tremor, but acceleration of minor tremor was observed with stimulation of the motor cortex, thalamus and reticular formation [12].

Exposure to mechanographic signals or low frequency noise (7-13 c/s), on one side, results in vibroacoustic disease. It means a whole-body systemic pathology distinguished by depression, increased irritability and aggressiveness, a tendency for isolation, and decreased cognitive skills, moreover characterized by the abnormal proliferation of extra-cellular matrices in professionals (such as, aircraft technicians, military pilots and cabin crewmembers, ship machinists, restaurant workers, disk-jockeys etc.,) [15,16]. On the other side, we can discuss about vibracoustic therapy as a useful therapeutic treatment for many conditions (asthma, autism, cystic fibrosis, cerebral palsy, constipation, insomnia, pain and Parkinson's disease) [5,19]. For instance, vibroacoustic therapy using *Vitafon* that produced MV for patients with prostate gland hyperplasia, efficiencies and economically are favorable [17]. Vibroacoustic device that uses MV to affect the human body has been demonstrated in both human and animal models [15, 26].

Although this tremor (MV) of the human skin is similar and comparing to brain waves in EEG [11,14]. such that normal subjects show the highest 8-13Hz components as the α wave comparing with neurosis patients showing the highest 3-7 Hz components as the θ wave and schizophrenia patients showing the highest 14-40 Hz EEG (β wave), defined wave, respectively [2]. The spinal cord perpendicular MV time series changed its frequency spectrum increasing the θ-wave component with eyes closed. [11].

In our first results we observed changes in rat brain activity after application of *Vitafon* stimulation of different frequency range and amplitude for applied working regimes.

Visually observed changes were transition in EEG activity from alpha to beta frequency band. Alpha oscillations recorded by EEG correlated with an early decrease of alertness in the fronto-temporal regions [27], were typically during transition wake-to-drowsy and including event related synchronization/desynchronization [28] as soon as the eyes are open, alpha disappears and is replaced with the beta rhythm. It represents a change of the synchronized activity of neural elements [29], alpha block (desynchronization) and may be elicited by any form of sensory stimulation, also called arousal or alerting response.

After vibroacoustic therapy application, clinical observation shows significant decrease in irritation symptoms, reduction of muscle tones, increased range of motion, stress reduction and muscle and sensory stimulation for patients with severe disabilities [19]. The effect of vibroacoustic therapy on urination is maintained for the next 3-6 months [17], the same holds true with analgesic effectiveness of the vibro-acoustic method in musculoskeletal overload conditions [20]. Systolic and diastolic arterial pressure returned, almost completely to the initial value after the administration of the third and fourth regimens (*Vitafon*) in Wistar male rats [26].

A new sensitive measurement method for the human micro-vibration (for the spinal-cord, the heart beat, blood flow pulsation, and muscle tremors) obtained using a pico-Tesla resolution magneto-impedance sensor by touching a human skin position directly or indirectly via sensor head. The MV from spinal cord showed increased θ-wave component [2]. Reason for smooth muscle MV is Ca^{2+} oscillation [14].

V. Conclusion

Increased attention and vigilance that we got in an animal model using vibroacoustic device - *Vitafon*, that uses MV in all regimes for short time, provides very promising results. This possibly indicates that MV in a combination with modulators of other neurotransmitters could be applied as adjuvant therapeutical approach.

Acknowledgements

This study was supported by the Ministry of Science, Education and Environmental Protection of the Republic of Serbia, Grant #175032.

References

[1]. H. Rohracher, Schwingungen des menschlichen organismus, *Anzeigen der Wissenschaften*, *3*, 1946, 230.
[2]. H. Rohracher and K. Inanaga. Die Mikrovibration, *Verlag Huber*, Bern, 1969.
[3]. E. Gallasch, T. Kenner, and I. Kozlovskaya, Microvibration as a function of muscle tone studies in microgravity, *Naturwissenschaften*, *85(1)*, 1998, 28-30.
[4]. H. Rohracher, Permanent muscle activity and constancy of body temperature, *Perceptual and Motor Skills, 19*, 1964, 198.
[5]. O. Skille, A. Wigram, and L. Weekes, Vibroacoustic therapy: the therapeutic effect of low frequency sound on specific physical disorders and disabilities, *Journal of British Music Therapy*, *3(2)*, 1989, 6-10.
[6]. K. Fuziwara, Effects of adrenaline and noradrenaline upon the microvibration on the body surface, *Acta Medica Nagasakiensia*, *11(1)*, 1966, 72-83.
[7]. M. Haider and D. B. Lindsley, Microvibrations in man and dolphin, *Science, 146(3648)*, 1964, 1181-1183.
[8]. O. Toshiyuki, Y Minoru, and F. Katsuzo, On the relationship between minor tremor and ballistocardiogram in man, *Acta Medica Nagasakiensia, 9(3)*, 1965, 120-134.
[9]. H. Sugano and K. Inaxuoa, On the mechanism of minor tremor, *Brain Nerve 10*, 1958, 769.
[10]. K. Inanaga and T. Sato, Psychotropic drug and minor tremor, *Psychiat. Neural. Jap 61*, 1957.
[11]. N. Mishima, T. Oka, and H. Tanaka, Clinical application of micro-vibration to autonomic function test, *Nihon Rinsho*, *50(4)*, 1992, 768-772.
[12]. H. Sugano, Central effects on minor tremor, *Japanese Journal of Physiology, 13*, 1963, 492- 499.
[13]. K. Inanaga and H. Sugano, Microvibration of the brain, *Psychiatry and Clinical Neurosciences, 12(3)*, 1958, 198–206.
[14]. K. Mohri, Y. Nakamura, T. Uchiyama, Y. Mohri, Yu. Mohri, and Y. Inden, Sensing of human micro-vibration transmitted along solid using pico-Tesla magneto-impedance sensor (pT-MI Sensor), *PIERS Online*, *6(2)*, 2010, 161-164.
[15]. N.A. Branco and M. Alves-Pereira, Vibroacoustic disease, *Noise Health*, *6(23)*, 2004, 3-20.
[16]. R.J.M. Ferreira, A.R. Couto, N. Jalles-Tavares, M.S. Castelo Branco, and N.A. Castelo Branco, Airway flow limitation in patients with vibroacoustic disease, *Aviation, Space, and Environmental Medicine*, *70(3 Pt 2)*, 1999, 63-69.
[17]. S.B. Petrov, S.N Levkovsky, A.I Kurtov, and N.S Levkovsky, Research of the efficiency of vibroacoustic treatment method for the complex therapy for patients with prostate gland hyperplasia, *Complementary and Alternative medicine in since, 1*, 2013, 41-46.
[18]. M. Muche-Janota, Z. Sliwinski, R. Mucha, J. Budziosz, and A. Sieron, Evaluation of the effectivnes of combined magnetostimulation and vibroacustic therapy treatmentin low back pain and range of motion of the lumbar spine in professional drivers with low back pain, *Polish Journal of Sports Medicine, 29(3)*, 2013, 187-196.
[19]. C. Body-Brever, Vibroacoustic therapy: sound vibrations in medicine, *Alternative and Complementary therapies, 9(5)*, 2003, 257-263.
[20]. A. Łukasiak, M. Krystosiak, P. Widłak, and M. Woldańska-Okońska, Evaluation of the effectiveness of vibroacoustic therapy treatment of patients with so-called "heel spur" A preliminary report, *Ortopedia Traumatologia Rehabilitacja 15(1)*, 2013, 77-87.
[21]. H. Rohracher, Muscular micro-activity ("microvibration") as indicator of psychological tension, *Perceptual and Motor Skills, 8*, 1958, 150.
[22]. A. F. Pacela, Measurement of the body surface physiologic tremor or "micro vibration", *Behavior Research Methods & Instrumentation, 1(2)*, 1968, 60-70.
[23]. M. Muche-Janota, Z. Sliwinski, R. Mucha, J. Budziosz, and A. Sieron, Evaluation of the effectiveness of combined magnetostimulation and vibroacoustic therapy treatment in low back pain and range of motion of the lumbar spine in professional drivers with low back pain, *Polish Journal of Sports Medicine, 29(3)*, 2013, 187-196.
[24]. T. Ozaki, S. Sasaki, and T. Igarashi, Ballistocardiography simplified by recording microvibration of the skin surface of the head , The *Tohoku Journal of Experimental Medicine, 102(1)*, 1970, 99-100.
[25]. E. Gallash and T. Kenner, Microvibrations: an interrelation between heart beat, muscle tremor and resting muscle tone, *Scripta Medica (Brno), 71(4)*, 1998, 165-170.
[26]. D. Kornjaca, V. Zivkovic, N. Barudzic, V. Jakovljevic, and D. Djuric, The effects of vibroacoustically induced microvibrations on arterial blood pressure and oxidative stress in rats, *Serbian Journal of Experimental and Clinical Research*, *15(2)*, 2014, 83-88.
[27]. A. Kalauzi, A. Vuckovic, and T. Bojić, EEG alpha phase shifts during transition from wakefulness to drowsiness, *International Journal of Psychophysiology, 86(3)*, 2012, 195–205.
[28]. W. Klimesch, P. Sauseng, and S. Hanslmayr, EEG alpha oscillations: the inhibition-timing hypothesis, *Brain Research Reviews, 53(1)*, 2007, 63–88.
[29]. C. Kasprzak, Influence of infrasound on the alpha rhythm of EEG signal, *Acta Physica Polonica A, 121*, 2012, 61-63.

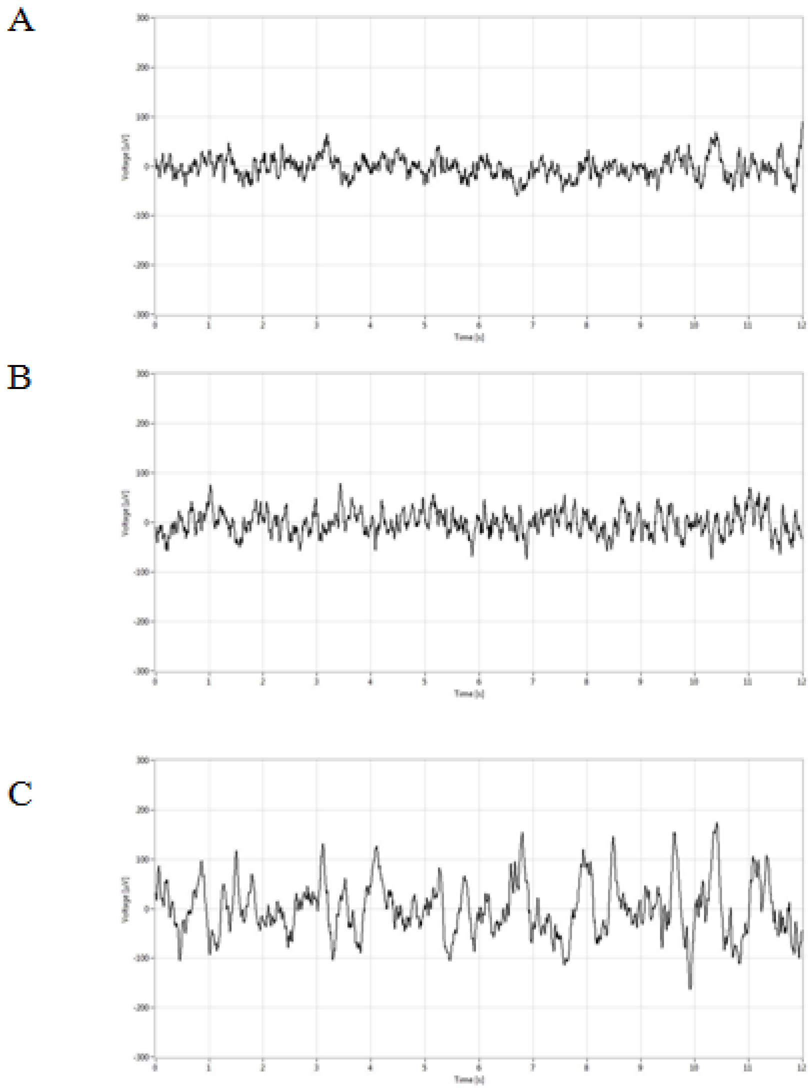

Figure 1. Representative EEG recordings:

(A) in control group of rats showing baseline activity
(B) during application of vibroacoustic microvibrations
(C) in pauses between applied working regimes.
Time calibration: 1s, amplitude calibration 100μV.
Lead: Right frontal- Left parietal cortex.