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THE EFFECT OF SHORT-TERM VIBRATION ON SOMATOSENSORY TEMPORAL DISCRIMINATION THRESHOLD

KISA SÜRELİ VİBRASYON UYGULAMASININ SOMATOSENSORİYEL TEMPORAL DİSKRİMİNASYON EŞİĞİ ÜZERİNE ETKİSİ

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ABSTRACT

Objective: This study will evaluate the changes in the somatosensory temporal discrimination threshold (STDT) after focal muscle vibration. The hypothesis was that the STDT, which is related to the functions of basal ganglia and somatosensory cortex, would deteriorate during application of peripheral muscle vibration if it had indirect central effects.

Materials and Methods: A total of fifteen healthy subjects (mean age 24.3±5.6;18-60) years) were prospectively included in the study. The researchers performed recordings of sensory threshold and the STDT on the second finger before, during, and after vibration in all subjects. A 100 Hz vibration was applied on the forearm flexor muscles for two minutes. The recordings were repeated four times: during, immediately after, one minute after, and three minutes after vibration.

Results: The mean STDT was 95.0±30.0 ms in recordings before vibration. During vibration, the STDT was significantly longer (146.9±52.6 ms) as compared to previbration recordings. However, the STDT value reduced immediately after the vibration and returned to previbration levels at one minute recordings (p=0.001, Friedman test).

Conclusion: The STDT value was longer during vibration. The longer STDT values during vibration suggest that the central effects of vibration can occur either directly or indirectly.

Keywords: Somatosensory temporal discrimination threshold, vibration, central effects

ÖZET

Amaç: Çalışmamızın amacı, fokal kas vibrasyonu sonrası somatosensoriyel temporal diskriminasyon eşiğindeki (STDT) değişiklikleri değerlendirmektir. Hipotezimiz, vibrasyonun dolaylı santral etkileri olması durumunda bazal ganglionlar ve somatosensoriyel korteks fonksiyonları ile ilgili olan STDT'nin, periferik kas vibrasyonu uygulaması sırasında STDT'de değişiklikler oluşabileceğiydi.

Gereç ve Yöntem: Çalışmaya prospektif olarak toplam on beş sağlıklı birey (ortalama yaş 24,3±5,6 years; 18-60 years) dahil edildi. Tüm deneklerde vibrasyon öncesinde, sırasında ve hemen sonrasında işaret parmağında önce duyusal eşik ve sonrasında STDT ölçümleri gerçekleştirildi. Önkol fleksör kaslarına 100 Hz'den iki dakika süreyle vibrasyon uygulandı. Kayıtlar, vibrasyon sırasında, hemen sonrasında, bir dakika sonra ve üç dakika sonra olmak üzere dört kez tekrarlandı.

Bulgular: Ortalama STDT değeri vibrasyon uygulanmadan önce 95,0±30,0 ms idi. Vibrasyon sırasında, STDT önceki kayıtlara kıyasla anlamlı olarak daha uzun olarak bulundu (146,9±52,6 ms). Ancak, vibrasyondan hemen sonra STDT değeri önemli ölçüde azaldı ve bir dakikalık kayıtta vibrasyon uygulanmadan önceki seviyelerine düştüğü gözlemlendi (p=0,001, Friedman testi).

Sonuç: Çalışmamızda, STDT değeri vibrasyon sırasında daha uzun olarak bulunmuştur. Daha uzun süre olan STDT değeri, vibrasyon etkisi altında, doğrudan veya dolaylı olarak titreşim duyusunun merkezi etkisi olabileceğini düşündürmüştür.

Anahtar Kelimeler: Somatosensoriyel temporal diskriminasyon eşiği, vibrasyon, merkezi etkileri

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INTRODUCTION

Vibration is best known to activate group Ia afferent fibers. Direct vibration stimulation on a muscle or tendon enhances muscle spindle activity leading to an excitatory response being known as tonic vibration reflex (TVR) (1, 2). The effect of vibration is not only on sensory nerve endings, but also provides increased neuromuscular activity (3). During high-frequency vibration, numerous skin afferents and interneurons are occupied and inhibition or facilitation on motoneuron are hypothesized to occur indirectly (4).

The effects of vibration have been studied using different electrophysiological parameters and have shown to indirectly affect various levels in the nervous system. When applied on the same muscle, vibration has a strong suppressive effect on H reflex amplitude and excitability (5-7). Vibration caused minor shortening of the cutaneous silent period end latency and duration of second inhibitory phase (8). Vibration also inhibits short interval intracortical inhibition or increases the amplitude of motor evoked potentials (9) whereas no effect was shown on the magnitudes of somatosensory evoked potentials (10). The effects on short interval intracortical inhibition or motor evoked potentials were attributed to the central effects.

This study evaluated the changes in somatosensory temporal discrimination threshold (STDT) after focal muscle vibration. The hypothesis was that STDT, which is related to the functions of the basal ganglia and somatosensory cortex, would deteriorate during application of peripheral muscle vibration if it had indirect central effects.

MATERIALS AND METHODS

The prospective study included fifteen healthy subjects (mean age of the subjects 24.3±5.6 years; age range 18-60 years; 9 men, 6 women). None of the subjects had a history of any neurological or systemic diseases or any medication use. Individuals who have contraindications in terms of electrophysiological studies or diseases that may affect the results such as peripheral nervous system disorders, movement disorders, or use of medications were excluded from the study.

The STDT was recorded in a quiet, low-light laboratory, using a Nihon Kohden 5504 (Japan) device, and commercially available standard bipolar stimulating electrode while subjects were seated.

We first determined the sensory threshold increasing the amplitude from 1mA in steps of 0.5mA. The sensory threshold was defined for each subject by delivering a series of stimuli to the index finger as the minimal intensity perceived by the subject in 5 of 5 consecutive stimuli. In the second step, the STDT was studied by delivering paired stimuli to the index finger that started with an inter-stimulus interval (ISI) of 10 ms and dramatically increasing the ISIs (in 10 ms steps) over experimental procedures already used in previous research (11, 12). The subjects were asked if they could distinguish a single stimulus or two separate stimuli by saying "one" or "two" after each stimulation. The first-time interval in which the subject perceived consecutive stimuli to be two different stimuli was the STDT value. After that, the average STDT value was calculated by taking two more measurements and averaging three measurements.

A 100Hz vibration was applied on the forearm flexor muscles for two minutes. The STDT values were measured again during vibration. We used high-frequency (100 Hz) vibration because higher frequency vibration (~100 Hz) generates a strong illusion of movement with a velocity related to the frequency of vibration. The vibration, 100 Hz in frequency and 1 mm in amplitude, was applied using the Beurer Hand Held Massager (M70, Ulm, Germany).

The recordings of STDT were repeated immediately after, one minute after and three minutes after the application of vibration. The timing of recordings was adapted from previous studies (8, 10).

Data analyses were performed using the SPSS 20 software statistical package (SPSS Inc., Chicago, IL, USA). First, we identified the normality of distribution using the Shapiro-Wilk test. Because the data was non-normally distributed, the STDT values before, during, and after the focal muscle vibration application were compared with the Friedman test and the Wilcoxon test was used for Post-hoc analysis. A p value ≤0.05 was deemed significant.

This study was approved by the Ethical Committee of Istanbul University Cerrahpasa- Cerrahpasa Faculty of Medicine (Date:11.06.2019, No: 86733). All participants gave informed consent.

RESULTS

The mean sensory threshold was 2.3±0.3mA. The mean STDT was 95.0±30.0ms in recordings before vibration. During vibration, the STDT was significantly longer (146.9±52.6ms) compared to the previbration recordings (p=0.001, Friedman test, Table 1). However, the STDT value was reduced immediately after the termination of vibration, and it returned to the previbration levels at one minute and three minute recordings (Tables 1, 2). Figure 1 shows boxplots of the STDT values before, during, and after the vibration.

Table 1: The change of mean STDT values before, during, immediately after, 1 minute after and 3 minutes after the application of vibration (mean±SD)

Parameter	Before	During	Immediately after	1 minute after	3 minutes after	p
STDT (ms)	95.0±30.0	146.9±52.6*	103.1±28.4	95.6±29.6	95.0±27.8	0.001*

*: Friedman test, STDT: somatosensory temporal discrimination threshold, SD: Standard deviation, ms: millisecond

Table 2: The p values of Wilcoxon Signed Ranks test between before vibration and each condition

STDT	p
During	0.00096*
Immediately after	0.284
1 minutes after	0.284
3 minutes after	1

*: Wilcoxon Signed Ranks test, between before vibration and during vibration p<0.001, STDT: Somatosensory temporal discrimination threshold

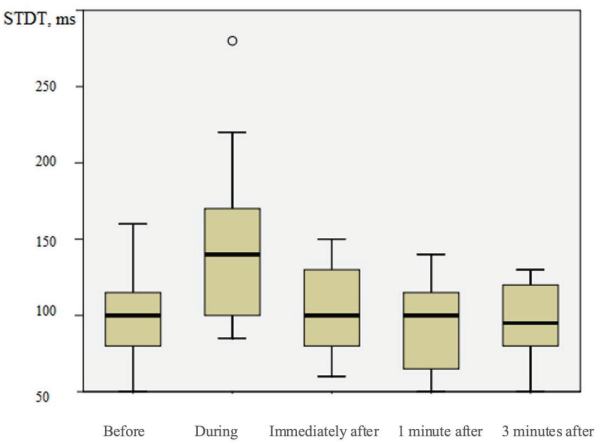

Figure 1: Boxplots of STDT values before, during, immediately after, and immediately, 1 minute after and 3 minutes after the application of vibration.

ms: millisecond

As seen in Figure 1, there was an outlier during vibration recordings. When we repeated the statistics excluding this subject, we obtained the same results.

DISCUSSION

The major finding in this study is that STDT is longer during vibration and the effect of vibration is lost immediately after vibration. Vibration is a powerful stimulator of group Ia afferent fibers. Nevertheless, the effect of the vibration is non-discriminatory and can activate mechanoreceptors other than primary spindle endings (13).

When the skin was vibrated around its resting level, the slowly adapting afferents displayed the same response characteristics as the rapidly adapting and Pacinian afferents. This suggests that the mechanisms underlying the responses of all three mechanoreceptors are similar (14).

The Group Ia afferent of the muscle spindles are activated by the implementation of high-frequency vibration on muscle and tendon directly, this implementation also affects in a smaller degree, the secondary afferents and Golgi tendon organ (15). Cortical areas of the brain receive and operate proprioceptive information when the high-frequency vibration is applied directly, which produces evoked cortical potentials (16). The amplitude of the auditory startle reflex was most likely reduced by the application of continuous high-frequency vibration on the dominant hand (17). But, the latter effect was attributed to the sensory filtering at the brainstem, prepulse inhibition. The activated areas in the brain after muscle vibration are associated with motor function and are responsible for voluntary motor command and sensorimotor integration such as the posterior parietal cortex (18, 19).

In temporal discrimination, there is a role of interaction between the cortical structures, cerebellum, and subcortical structures such as basal ganglia. The important cortical structures are assumed to be the primary somatosensory cortex and pre-supplementary motor area, which focuses attention during the task. Subcortical structures engaged in this task are putamen, superior colliculus, and substantia nigra (20). Keeping in mind that vibration has indirect central effects and the STDT is a function of central structures, this study suggests that vibration may induce longer STDT through its central suprasegmental effects.

However, there are other mechanisms that could have an impact on these results such as habituation, surround inhibition (SI) or collision. For example, the second response is reduced when the two closely timed stimuli are given in a rapid sequence (21). The SI occurs at more than one level of the somatosensory system. In healthy individuals, the sum of the two individual peripherals input is bigger than the size of a dual input. SI is the suppression of the excitability of the area surrounding the active neural network. Through the SI, the motor system facil-

itates the activation of the muscles responsible for the implementation of selected motor programs and inhibits the activation of muscle antagonists that are not targeted (22, 23). In physics, a collision is the abrupt and forceful coming together of two objects through direct contact. When two objects collide, the sum of their momentum before the impact is equal to the sum of their momentum after the impact. In electrophysiology, two distinct types of stimuli may collide, and the result will change the ultimate behavior (24).

There were certain limitations in this study. The STDT was recorded only on the vibrated extremity. The number of subjects included in the study was small. The study findings were not correlated with other electrophysiological measures such as somatosensory evoked potentials or high-frequency oscillations.

In conclusion, vibration might cause longer STDT values through its central suprasegmental effects.

Informed Consent: Written consent was obtained from the participants.

Ethics Committee Approval: This study was approved by the Cerrahpaşa Faculty of Medicine Clinical Research Ethics Committee (Date: 12.06.2019, No: 86733).

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