HOSPITAL UNIVERSITÁRIO
HUPE
PEDRO ERNESTO

Artigo de revisão

Human cutaneous mechanoreceptive afferents response after Whole Body Vibration: a literature review

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Abstract

Introduction: High levels of sensory information are part of the sensory feedback system that provides balance and are related to motor task accuracy and postural regulation in humans. Considering whole body vibration (WBV) affects in part the sensorial receptors, it is important to understand this relation. The goal of this study was to review the literature of the effects of whole body vibration on cutaneous sensitivity for vibration and touch-pressure.

Materials and Methods: A review of identified papers on studies that used WBV and measured its effects on cutaneous receptors to address the following question: WBV affects vibration and touch-pressure receptors?

Results and Discussion: The acute effects of WBV on vibration and touch-pressure receptors show that the vibration impairs their function temporarily in a significant way. The duration of changes of WBV (recovery time) is about 1h for touch-pressure and about 2.5h for vibration receptors. Long term effects of WBV still need to be investigated.

Keywords: Mechanoreceptors; Whole body vibration; Cutaneous sensitivity; Vibro-receptors.

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Revista HUPE, Rio de Janeiro, 2018;17(1):35-38
doi: 10.12957/rhupe.2018.39290
Recebido em 22/04/2018. Aprovado em 26/10/2018.

Resumo

Resposta dos aferentes mecanorreceptivos humanos após Vibração de Corpo Inteiro: uma revisão de literatura

Introdução: Altos níveis de informação sensorial fazem parte do sistema de feedback sensorial que proporciona o equilíbrio e está relacionado à precisão de tarefas motoras e à regulação postural em seres humanos. Considerando que a vibração do corpo inteiro afeta em parte os receptores sensoriais, é importante entender essa relação. O objetivo deste estudo foi revisar a literatura sobre os efeitos da vibração de corpo inteiro (VCI) na sensibilidade cutânea vibratória e de toque-pressão.

Materiais e Métodos: Uma revisão de artigos identificados que utilizaram VCI e mediram seus efeitos sobre receptores cutâneos vibratórios e/ou de toque-pressão para abordar a seguinte questão: A VCI afeta os receptores de vibração e sensibilidade ao toque-pressão? Resultados e Discussão: Os efeitos agudos da VCI em vibração e receptores de pressão de toque mostram que a vibração prejudica sua função temporariamente de forma significativa. A duração das mudanças da VCI (tempo de recuperação) é de cerca de 1h para pressão de toque e cerca de 2,5h para receptores de vibração. Efeitos da VCI no longo prazo ainda precisam ser investigados.

Descritores: Mecanorreceptores; Vibração de corpo inteiro; Sensibilidade cutânea; Vibro-receptores.

Resumen

Perfil clinico de las internaciones por herpes zoster en un hospital universitario

Introducción: altos niveles de información sensorial son parte del sistema de retroalimentación sensorial que proporciona equilibrio y están relacionados con la precisión de la tarea motora y la regulación postural en humanos. Considerando que las vibraciones de cuerpo completo (WBV) afectan en parte a los receptores sensoriales, es importante entender esta relación. El objetivo de este estudio fue revisar la literatura sobre los efectos de vibraciones de cuerpo completo sobre la sensibilidad cutánea a la vibración y la presión táctil.

Materiales y métodos: una revisión de los documentos identificados que usaron WBV y midieron sus efectos sobre los receptores cutáneos para abordar la siguiente pregunta: WBV afecta los receptores de vibración y presión de táctil?

Resultados y Discusión: Los efectos agudos de WBV sobre la vibración y los receptores de presión táctil muestran que la vibración afecta su función temporalmente de una manera significativa. La duración de los cambios de WBV (tiempo de recuperación) es de aproximadamente 1 h para la presión táctil y de aproximadamente 2,5 h para los receptores de vibración. Los efectos a largo plazo de WBV todavía tienen que ser investigados.

Palabras clave: Mecanorreceptores; Vibraciones de cuerpo completo; Sensibilidad cutánea; Vibro-receptores.

Introduction

The mechanoreceptors nerve impulse conduction occurs along Aα/Aβ sensory fibers that are large diameter afferents. They are classified as slow (SA) or fast (FA) adapting receptors. The SA receptors produce sustained responses to static stimulation.[1,2] The FA receptors are sensitive to the rapid application and release of a stimulus (1) and these receptors are particularly sensitive to mechanical vibrations.[2] FA mechanoreceptors can be divided into Meissner corpuscles and Pacinian corpuscles, being the first one related to low (30 Hz) and the later one to high (200 Hz) vibration frequencies.

Exposure to vibration affects the human body. Occupational medicine has extensively studied the effects of vibration. Cardinale and Pope (2003)[3] understood that vibration affects not only muscles, joints, and bones, but the neurosmuscular system and its receptors as well. In whole body vibration the skin is the first tissue that receives the vibration stimulus,[4] thus mechanoreceptors, slow or fast adapting, will be influenced by this mechanical stimulus. It can be expected as well that chronic exposure to vibration becomes deleterious.[3,5]

Vibration stimulation can be used to reduce the perception of pain.[2,6-8] Some interesting findings in mammalians show that Meissner corpuscles are multiafferented mechanoreceptors with nociceptive immunohistochemical properties.[9] It is well reported[10,11] that activity in large-diameter afferents may alter transmission in the central pathways that convey the messages ultimately experienced as pain and can attenuate it. Such interaction is thought to occur in the dorsal horn of the spinal cord and the thalamus.[12] The effects of an intervention on pain perception are of particular interest in therapeutic interventions because there is no drug involved. However, a reduced sensitivity in the mechanoreceptors might increase the risk of falls.

The influence of WBV in large diameter fibers has been shown directly after WBV for touch-pressure[4,13,14] and vibration perception threshold (VPT)[4,15-17] with sensitivity reduction. However, presumable beneficial effects of WBV to a long term intervention based on its interaction are not clearly documented. Therefore, the purpose of this study was to review the effects of WBV on human tactile sensitivity.

Materials and methods

A search in Medline/Pubmed, Scielo, Lilacs and PEDro databases was performed in march 2018. All papers containing the terms "whole body vibration" "mechanoreceptors", "touch-pressure sensitivity", "vibration sensitivity", "Paccini corpuscles", "Meissner corpuscles", "vibrotactile" in the title or abstract were identified.

The abstracts of these studies (n=11) were then inspected to ascertain whether they contained the information of interest. The author then reviewed the studies and 6 relevant papers were selected. Abstracts not related to the topic were excluded and the duplicates were verified.

Results

Most studies on WBV in the selected articles have been done on samples of health individuals considering specific measures of touch pressure and vibration sensitivity.

The effects of WBV on touch-pressure and vibration sensitivity were documented in 6 papers, as showed in Table 1.

Touch-pressure sensitivity

A significant loss of sensation was observed immediately after WBV for different platform settings and time of exposure for all considered studies.[4,13,14] An increase in force is equal to a loss of touch pressure sensitivity. Studies shows that immediately after 5,[13] 10[4] and 15[14] minutes of WBV exposure and different settings a decrease in touch-pressure sensitivity in all tested regions was observed. A study from Sonza et al. (2013) shows that one hour after WBV exposure, in four tested regions of the foot sensitivity remained significantly lower than at baseline. Two and three hours after WBV exposure, only the sensitivity of the heel remained significantly lower than at baseline.

Vibration sensitivity

The VPT is defined as the amplitude of a vibration stimulus that is perceptible to a subject. Above this amplitude threshold the subject is able to perceive the vibration and the optimal response of Vater-Pacini corpuscles to frequencies occurs between 200 and 250 Hz,[18] peaking at a frequency of 20-50 Hz for Meissner corpuscles.[19] One study(4) showed a significant change in vibration, with a decrease in sensitivity directly after WBV exposure in all the measured regions of the foot at both tested vibration frequencies, 30 Hz and 200 Hz. Other studies[15,17] showed the same results for 200 Hz and other vibration frequencies.[16]

The study from Sonza et al. (2013)[4] showed the slow adapting receptors (30Hz) recover before the fast adapting receptors (200Hz). No region of the foot showed significant differences in vibration sensitivity 3 h after exposure to WBV for 30 Hz. However, significant differences were found for 200 Hz in two from the 5 measured regions of the foot. A randomized clinical

trial[17] measuring healthy young adults found as a short-term response on WBV (3 sessions, with 48 hours interval) an improvement on vibration sensitivity.

Discussion

A study from Ribot-Ciscar, et al.[20] indicated that 10 min of local vibration affected the cutaneous mechanoreceptive afferents leading to impaired perceptual and sensorimotor process for several minutes post stimulus. The presented studies[4,13-17] that evaluated WBV and mechanoreceptors for touch-pressure and vibration sensitivity (fast and slow adaptors) corroborate this information on the acute effect of WBV on these receptors.

The vibration sensitivity at 30Hz and 200Hz evaluate the response of two different tactile sensory end-organs. The vibration frequency at 30 Hz is closely related to the activation of the Meissner corpuscles. The vibration frequency at 200 Hz is closely related to the activation of the Paccini corpuscles.[4,18] In order for the vibration to be perceived, lower amplitude was necessary for the 200Hz vibration than for the 30 Hz vibration, which corroborates findings reported in the literature.[18] The study from Sonza et al. (2012)[4] showed an increase in the amplitude of about 5 times for receptors sensitive at 200 Hz, and about 4 times for receptors sensitive at 30 Hz.

A vibration stimulus presented to the vibration receptors activates the receptors synchronously, resulting in a series of repeating events leading to a simultaneous action potential of the individual sensors.[10]

The touch pressure and vibration sensitivity nerve fibers are similar to muscle spindle single afferent Aα/Aβ fibers.[21] Activity, such as vibration stimuli, in the large-diameter fiber systems not only modifies the perception of pain, but also attenuates it.[10] Therefore,

Table 1. Studies whose main outcomes include touch pressure and vibration perception thresholds (VPT) after whole body vibration

Authors	Descriptive data from subjects	Outcomes	WBV parameters settings	Instruments	Conclusion on sensitivity
Pollock et al 2011[13]	Eighteen adults (24.3 ± 1.5 years, 15 females)	Balance Touch-pressure sensitivity threshold Joint position sense	five 1 min bouts, 30 Hz, 4 and 8 mm peak to peak	cutaneous sensation: pressure aesthesiometry	WBV impaired touch-pressure sensitivity
Schlee et al. 2012[15]	30 young healthy subjects of both genders (25.3 ± 3.0 years; 176.1±9.0 cm; 69.7±11.2kg)	Balance Vibro-tactile threshold, foot was measured	single session of a 4-min WBV training (27Hz, 2mm horizontal amplitude	VPT for 200 Hz, were measured using a modified Tira Vibration Exciter(model TV51075,Schalkau, Germany)	WBV impaired vibration sensitivity
Sonza et al. 2013[4]	Twenty adults (25.3±2.6 years, 10 males)	Vibro-tactile and touch-pressure sensitivity thresholds, foot was measured Recovery time	10-min WBV session, at a frequency of 42 Hz with 2 mm amplitude in a spiral mode	Von Frey monofilaments. VPT for 30 and 200 Hz were measured using a custom built neurothesiometer.	WBV impaired vibration and touch-pressure sensitivity. Tactile sensitivity recovery time was between 2 and 3 h
Kowalski and Zając 2012[16]	Ten healthy male adults, (aged between 25 and 50).	Vibro-tactile threshold on hand-arm vibration (HAV) and WBV, index finger was measured	Frequencies of 4, 20, 31.5, 100 and 125 Hz, 0.7m/s2 acceleration; exposure to both kinds of vibration lasted 5 min (±3 s). Seated exposure to vertical vibrations.	Custom built designed VPT	The increase in vibration thresholds, for all stimulus frequencies, was higher than after HAV or WBV combined than alone
Sonza et al. 2015[14]	Twenty-four healthy adults, 12 male (25.3 ± 2.6 years)	Balance Touch-pressure sensitivity threshold, foot was measured Lower limbs temperature	15 minutes, vertical mode at four different frequencies (31, 35, 40, and 44 Hz) with 1 mm of amplitude.	Von Frey monofilaments	WBV impaired touch-pressure sensitivity
Hernandez et al. 2016[17]	Twenty-three healthy adults, 24 male (aged between 18 and 40). Placebo (n-11) and WBV group (n=12),	Vibro-tactile threshold, foot was measured	Three sessions (48h between them) of 4min, 18 Hz frequency, 4 mm amplitude.	VPT, Vibration II (Sensortek, Inc. Clifton, NJ, EE. UU.)	WBV impaired vibration sensitivity as an acute response, however, 48 hours later the sensitivity increased

it is possible to speculate that vibration stimulation could be used to reduce the perception of pain[8,20] in a similar manner that transcutaneous electrical nerve stimulation (TENS) is used for pain reduction.[22] A possible explanation for the pain reduction that is found to occur with vibration could be that large numbers of Aα/Aβ fibers are activated synchronously and therefore stimulate the dorsal column.[10]

A study with rats submitted to a musculoskeletal chronic pain model treated with WBV and low intensity exercise shows a decrease in touch-pressure sensitivity after all WBV sessions and pain after the third session[23] from ten applied sessions. Hernandez et al. (2016)[17] shows a vibration sensitivity increase after the third WBV session, and an immediate decrease after the WBV stimuli. The authors speculate about the possible long term effects of the WBV.

In conclusion, it seems that, regardless of the parameter settings of the platforms, WBV seems to alter the discharge of slow and fast adapting vibration receptors and the ones responsible for touch-pressure sensation immediately after the vibration stimulation. Long term effects still need to be investigated in normal and disease conditions.

As a limitation of this study, only articles in English were added to this review, however, the main worldwide scientific information is written in English language.

Conflict of interest

There are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

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