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HUMAN RESPONSE TO VIBRATION

ABSTRACTS

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M. A. Lafortune, M. J. Lake and E. M. Hennig 1996 *Journal of Biomechanics*, **29**(12), 1531–1537. Differential shock transmission response of the human body to impact severity and lower limb posture. (7 pages, 3 figures, 2 tables, 28 references) (in English).
Authors' Abstract. The shocks imparted to the foot during locomotion may lead to joint-degenerative diseases and jeopardise the visual–vestibular functions. The body relies upon several mechanisms and structures that have unique viscoelastic properties for shock attenuation. The purpose of the present study was to determine whether impact severity and initial knee angle (IKA) could alter the shock transmission characteristics of the body. Impacts were administered to the right foot of 38 subjects with a human pendulum device. Combinations of velocities (0·9, 1·05, and 1·2 m s^{-1}) and surfaces (soft and hard foams) served to manipulate impact severity in the first experiment. Three IKA (0°, 20° and 40°) were examined in the second experiment. Transmission between shank and head was characterized by measuring the shock at these sites with miniature accelerometers. Velocity and surface had no effect on the frequency profile of shock transmission suggesting a consistent response of the body to impact severity. Shank shock power spectrum features accounted for the lower shock ratio (head/shank) measured under the hard surface condition. IKA flexion caused considerable reduction in effective axial stiffness of the body (EASB), 28·7–7·9 kN m^{-1}, which improved shock attenuation. The high correlation ($r = 0{\cdot}97$) between EASB and shock ratio underscored the importance EASB to shock attenuation. The present findings provide valuable information for the development of strategies aimed at protecting the joints, articular cartilage, spine and head against locomotor shock.
Topics: *Ambulation*; *Body posture*; *Transmissibility*.

V. K. Grigorova and L. N. Kornilova 1996 *Aviation, Space, and Environmental Medicine* **67**(10), 947–954. Microgravity effect on the vestibulo-ocular reflex is dependent on otolith and vision contributions. (8 pages, 2 figures, 4 tables, 24 references) (in English).
Authors' Abstract. Background: We studied whether microgravity influences horizontal and vertical vestibulo-ocular reflex (VOR), and what the otolith contributes to VOR in the absence of gravity, in six cosmonauts during and after space missions. Method: VOR was elicited by active yaw and roll head movement at a frequency of about 0.2 Hz. Results: The various individual quantitative changes (increase, decrease, and left–right asymmetry) found in the horizontal VOR evoked by yaw head movements during the adaptation period to microgravity suggested central reprogramming of mechanisms controlling VOR; i.e., a non-specific effect of microgravity on VOR. At the same time, horizontal and vertical VOR's were recorded during roll head movements, which were not obvious before flight. In the cosmonaut who participated in a long-term flight, the increased activity of vertical canals turned to unidirectional (downward) eye movements, independent of the head movement direction, lasting during the whole mission. These VOR changes probably

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resulted from the absent adequate otolith stimulation and reduced otolith influence upon semicircular canal function. Conclusion: Thus, a specific effect of microgravity on VOR was observed during roll head movements, when the interaction between semicircular canals and otoliths should be more pronounced, mainly in the vertical plane. The stability of the "space" pattern of interactions in the readaptation period depended on the time spent in microgravity. We suggest that in visual–vestibular interactions revealed in VOR evoked by head movements with open eyes, vision dominates when a conflict arises between "space" and "terrestrial" patterns of sensory interactions.
Topics: *Perceptual mechanisms* (*vestibular*).

H. Eyeson-Annan, C. Peterken, B. Brown and D. Atchison 1996 *Aviation*, *Space*, *and Environmental Medicine* **67**(10), 955–962. Visual and vestibular components of motion sickness (8 pages, 5 figures, 2 tables, 11 references) (in English).
Authors' Abstract. Background: The relative importance of visual and vestibular information in the etiology of motion sickness (MS) is not well understood, but these factors can be manipulated by inducing Coriolis and pseudo-Coriolis effects in experimental subjects. Hypothesis: We hypothesized that visual and vestibular information are equivalent in producting MS. The experiments reported here aim, in part, to examine the relative influence of Coriolis and pseudo-Coriolis effects in inducing MS. Methods: We induced MS symptoms by combinations of whole body rotation and tilt, and environment rotation and tilt, in 22 volunteer subjects. Subjects participated in all of the experiments with at least 2 d between each experiment to dissipate after-effect. We recorded MS signs and symptoms when only visual stimulation was applied, when only vistibular stimulation was applied, and when both visual and vestibular stimulation were applied under specific conditions of whole body and environmental tilt. Results: Visual stimuli produced more symptoms of MS than vestibular stimuli when only visual or vestibular stimuli were used (ANOVA: $F = 7{\cdot}94$, $df = 1$, 21 $p = 0{\cdot}1$), but there was no significant different in MS production when combined visual and vestibular stimulation were used to produce the Coriolis effect or pseudo-Coriolis effect (ANOVA: $F = 0{\cdot}40$, $df = 1$ $p = 0{\cdot}53$). This was further confirmed by examination of the order in which the symptoms occurred and the lack of a correlation between previous experience and visually induced MS. Conclusions: Visual information is more important than vestibular input in causing MS when these stimuli are presented in isolation. In conditions where both visual and vestibular information are present, cross-coupling appears to occur between the pseudo-Coriolis effect and the Coriolis effect, as these two conditions are not significantly different in producing MS symptoms.
Topics: *Motion sickness* (*causes of*); *Perceptual mechanisms* (*visual*, *vestibular*).

C. E. Egan, B. H. Espie, S. McGrann, K. McKenna and J. A. Allen 1996 *Occupational and Environmental Medicine* **53**, 663–669. Acute effects of vibration on peripheral blood flow in healthy subjects (7 pages, 5 figures, 3 tables, 11 references) (in English).
Authors' Abstract. Objectives—The main objective was to study the acute vascular effects in the hands of normal healthy subjects of a complex vibration spectrum similar to that generated by many industrial hand held tools. The effects of repeated bouts of vibration and alternations in the intensity of vibration were also studied. Methods—Blood flow was measured by venous occlusion plethysmography with strain gauges. Vibration across a frequency range of 0·4 to >4000 Hz was generated by a pneumatic chisel and applied to the right hand. Blood flow was measured in both middle fingers, both big toes, or both forearms before, during, and after a two minute period of vibration. Systolic pressure of a finger and heart rate were also measured. Results—Vibration was associated with a

significant bilateral reduction in finger and toe blood flow ($P < 0{\cdot}01$ and $P < 0{\cdot}03$) and a significant increase in heart rate ($P < 0{\cdot}05$) but had no effect on forearm blood flow. The finger response was not abolished by repeated bouts of the vibration but was initially most notable during the first minute of vibration. Increasing the intensity of vibration delayed recovery. Conclusions—Hand vibration causes a generalised increase in sympathetic tone in the heart and extremities. This may be a factor in the development of vasospastic disease in habitual users of hand held industrial vibrating tools.
Topics: *Vibration syndrome* (*vibration-induced white finger*); *Physiological effects* (*cardiovascular*).

J. C. Makous, R. M. Friedman and C. J. Vierck 1995 *The Journal of Neuroscience* **15**(4), 2802–2818. A critical band filter in touch (17 pages, 11 figures, 0 tables, 47 references) (in English).
Authors' Abstract. Separate mechanoreceptor systems in humans were isolated by varying the spectra of vibrotactile stimuli. First, a function relating threshold to frequency of a sinusoid was obtained on the fingertip for each of four subjects, and it was found to comprise two limbs: a Pacinian and a non-Pacinian limb. The peak sensitivity within the Pacinian limb (mediated by Pacinian corpuscles) was around 250 Hz and spanned the region from 65 to 400 Hz. The non-Pacinian limb showed no detectable change in sensitivity in the region between 10 and 65 Hz. These two limbs were then treated as psychophysical channels in experiments in which narrow band noise and individual sinusoids were used to excite one or both channels. In the second and third experiments, the noise stimuli varied in bandwidth from 8 to 70 Hz and varied in center frequency from 25 to 218 Hz. Masking functions were obtained on ON-frequency conditions (the sinusoidal test and noise masker occupied the same frequency region) and for OFF-frequency conditions (the test and masker occupied different frequency regions). The ON-frequency experiments were used to estimate the signal-to-noise ratio (S/N) of the Pacinian channel at threshold. The OFF-frequency masking experiments were used to infer the shape of the Pacinian channel at frequencies below 65 Hz, where threshold for Pacinian activation were above detection threshold. The results of these three experiments predicted the findings of a fourth masking experiment with a parameter free model that treated the Pacinian channel as a filter that integrates stimulus power. The results show that the Pacinian channel is analogous to a critical band in the auditory system.
Topics: *Perceptual mechanisms* (*touch*); *Vibration sense* (*sensory mechanisms*).

R. T. Verrillo, S. J. Bolanowksi, F. Baran and P. F. Smith 1996 *The Journal of the Acoustical Society of America* **100**(1), 651–658. Effects of underwater environmental conditions on vibrotactile thresholds (8 pages, 6 figures, 4 tables, 19 references) (in English).
Authors' Abstract. The effects of low-frequency, water-borne vibration upon the cutaneous surface of swimmers and divers are virtually unknown. It has been reported that divers can 'feel' underwater sound on various parts of their bodies. The current experiments were conducted in two parts as initial investigations of these reports. The first experiments were to determine if changes in barometric pressure and breathing mixture have an effect on vibrotactile thresholds measured in air. Vibrotactile thresholds at the thenar eminence were measured on eight divers during two saturation dives in a dry hyperbaric chamber. Measurements were made on four subjects before and after a 6-day saturation dive that simulated an excursion to 300 feet of seawater (fsw). Measurements on another four subjects were made at 1 atmosphere absolute (ATA) before and after an 8-day simulated 300-fsw dive, and 5, 7 and 10·1 ATA (300 fsw). The gas mixture in which the divers lived

was varied according to standard procedures to prevent adverse body reactions during compression and decompression. Vibrotactile thresholds were measured by standard psychophysical methods at 1, 10, 100 and 250 Hz. Results suggest that neither increased atmospheric pressure nor breathing gas has any effect on vibrotactile thresholds within any of the four mechanoreceptor channels that innervate normal skin. The second set of experiments was performed to assess the effect of complete seawater hydration of the skin upon vibrotactile threshold sensitivity measured at the thenar eminence and the volar surface of the forearm. In-air thresholds of three subjects were measured by standard psychophysical methods at 1, 10, 100 and 250 Hz. The measurements were repeated underwater after the forearm and hand were submerged for 20 min in a seawater solution. With the exception of 1 Hz, no statistically significant changes were found at either site when compared to threshold measured in air. At 1 Hz there appears to be an increase in sensitivity of approximately 3 dB when the skin is hydrated with seawater.
Topics: *Perceptual mechanisms* (*touch*); *Vibration sense* (*sensory mechanisms*).

M. Kanazuka, T. Shigekiyo, N. Toibana and S. Saito 1996 *Thrombosis Research* **82**(1), 51–56. Increase in plasma thrombomodulin level in patients with vibration syndrome (6 pages, 2 figures, 1 table, 15 references) (in English).
Authors' Abstract. To determine whether endothelial cells are injured in vibration syndrome, we measured plasma levels of thrombomodulin (TM) in 100 patients with this syndrome using one-step sandwich enzyme immunoassay. Plasma level of TM in patients with vibration syndrome was significantly higher than that in normal controls ($p < 0{\cdot}0001$). There was no significant difference in the plasma TM level between patients with vibration syndrome and those with collagen disease. Plasma TM concentration in chain-saw operators was significantly higher than that in rock-drill operators ($p < 0{\cdot}05$). Plasma TM value did not significantly differ between patients with vibration-induced white finger (VWF) and those without VWF. These results suggest that endothelial injury is present in patients with vibration syndrome, the degree of endothelial injury in patients with vibration syndrome equals that in patients with collagen disease, and the endothelial injury in chain-saw operators is greater than that in rock-drill operators. However, there was no difference in the degree of endothelial injury between patients with VWF and those without VWF.
Topics: *Vibration syndrome* (*vibration-induced white finger*, *nerve*).

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*Contributions to the Literature Collection are invited. They should be sent to Professor M. J. Griffin, Human Factors Research Unit, Institute of Sound and Vibration Research, University of Southampton, Southampton, SO*17 1*BJ, England.*