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ADVANCED AUDIOLOGICAL TOOLS FOR NON-INVASIVE MONITOR OF INTRACRANIAL PRESSURE IN MICROGRAVITY

Abstract

Otoacoustic emissions (OAEs) are known to provide a non-invasive indirect indicator of intracranial pressure (ICP) changes. Indeed, the OAE phase is sensitive to the middle ear transmission, which depends on ICP due to the its connection with the intracochlear pressure. Increaed middle ear stiffness is associated with increased OAE phase. Advanced OAE acquisition procedures based on the equalization of the forward pressure level (FPL) of the stimuli add independent information about the middle ear transmission function that may complement and validate the OAE phase measurements. FPL techniques require preliminary evaluation of the Thevenin parameters (pressure and impedance) of the sound sources. When the Thevenin calibrated otoacoustic probe is inserted in the ear canal, a direct estimate of the load impedance of the ear canal (essentially dependent on the middle ear transmission) is obtained. A decrease of the imaginary part of the load impedance in the low-frequency range is the unambiguous signature of the increased middle ear stiffness that is assumed to generate also the OAE phase change when ICP increases. Thus, the simultaneous occurrence of the two phenomema (increased OAE phase and decreased imaginary part of the impedance) validates the diagnostic interpretation of OAE changes as due to ICP changes. Acoustic Diagnostics is an Italian Space Agency experiment operating on the International Space Station 2019-2022. Five ISS astronauts were audiologically tested, measuring distortion product OAEs (DPOAEs) pre-, in-, and post-flight, to detect changes in their hearing properties associated with long term exposure to microgravity conditions. The payload measured DPOAE level and phase using FPL calibration, and Thevenin calibrated sound sources. Therefore, the data obtained in the FPL calibration phase of the measurement may be used to independently estimate changes of the middle ear impedance. The same instrument was also used in a ground experiment to detect ICP changes associated with body-tilt in normal-hearing subjects. Experimental data from both experiments are shown to discuss strengths and weaknesses of the proposed combined method.