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Middle-ear Muscle Contraction Measurements Reveal No Anticipatory Activation Prior to Live Rifle Fire

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Repetitive exposure to high-level acoustic impulses, such as those from small arms fire and blast overpressure, increases the susceptibility for hearing loss. Currently, the United States Department of Defense acquisition standard (MIL-STD-1474E) mandates the U.S. Army use the Auditory Hazard Assessment Algorithm for Humans (AHAAH) for calculating impulse noise exposure limits of military systems. However, several concerns involving the appropriateness of including this model as a medical standard in an updated Damage Risk Criteria (DRC) have been raised, and thus there is still no such medical standard available in the Department of Defense. The current study addressed a concern raised about the middle-ear muscle contraction (MEMC) associated with the acoustic reflex that is assumed, and implemented, as a protective mechanism for certain instances in which a person is "warned" prior to the impulse. Accordingly, some Damage-Risk Criteria (DRC) for impulsive noise include MEMCs as a protective factor, either as acoustic reflexes or as an early MEMC engaged in anticipation of a known imminent exposure. DRC inclusion assumes that MEMCs are pervasive (> 95 % confidence of > 95% prevalence) within the population, and are of sufficient strength and duration to serve as a protective mechanism. For the purpose of a health hazard assessment, an inappropriate implementation of this assumption would result in an underestimation of auditory hazard and may incorrectly predict that some high-level exposures are safe. This assumption was addressed by attempting to condition an anticipatory MEMC in both laboratory and field environments. Five different training tasks were administered under laboratory-controlled conditions using both acoustic and non-acoustic elicitors. Results found the likelihood of observing an MEMC for short-duration acoustic stimuli was much lower than for non-acoustic stimuli, and that voluntary eye closure produced the greatest likelihood of an MEMC. Conditioned MEMC responses were far below the 0.95 criterion necessary to consider the responses pervasive. Interestingly, participant attention greatly influenced the likelihood of observing an early, conditioned MEMC. Field measurements were made in Soldiers firing military rifles for situations where they were instructed to fire and when they had no knowledge of when a second person was firing. Results indicate that MEMC do not reliably contract either in anticipation of, or in response to, an impulsive noise. Collectively, these studies indicate MEMCs should not be included as a protective factor in DRC for impulsive noise not should it be used as an acquisition standard without substantial revision.

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Tympanic Membrane Mechanics after Repeated Exposure to Loud Sound

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Intense impulsive sounds like those from blast or firearms can damage ear structures and produce both conductive and sensorineural hearing loss. Some studies have suggested that Tympanic Membrane (TM) perforation can be used as a biomarker to assess damage to the ear from blasts. However, TM mechanics after blast exposure has not been well studied. In some cases, the TM remains visually intact despite the presence of hearing loss. Although the blast-induced hearing impairment generally includes hair cell or nerve level damage, damage to the middle-ear conductive mechanism can also play a role. Several recent studies showed significant changes in the mechanical properties of the TM after exposure to blast waves, and such changes may significantly affect sound energy absorption by the TM – the first step in the hearing process. In this study, we systematically characterize TM full-field transient responses to moderate level impulsive sounds before, during and after exposing the cadaveric ear sample to a series of blasts of equivalent sound pressure greater than 150 dB SPL. Experimental modal analysis is applied to the stimulus normalized displacement at over 200,000 points that cover the entire TM surface. We compare TM mechanical indicators, such as TM shape, modal motion mode, natural frequency, and damping, before and after blast exposure to gain insight into the conductive mechanisms of hearing damage by loud sound.

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