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Vibration Effects on Performance and Health

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14. ABSTRACT

The study of human response to whole-body vibration (WBV) is concerned with establishing relationships between various effects (e.g., comfort, performance, health) and their causes. This document introduces the topic of human tolerance to WBV and the current state of knowledge regarding health and performance effects.

15. SUBJECT TERMS

WBV, Whole-body vibration, human response, performance, health

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Background

There is concern that aircrew and passengers in current and future Army aircraft (i.e., future vertical lift) may encounter levels of vibration that could adversely affect their health and performance. While it is known that long-term whole-body vibration (WBV) exposure in frequency ranges that include operating frequencies of military rotary-wing aircraft is linked with musculoskeletal injury disorder, detailed information on how specific frequencies result in physiological or performance decrements, and the extent of these decrements, to aircrew and aviation passengers remains unknown. The level of vibration (i.e., exposure characteristics) that initiates an operationally relevant decrease in aviator performance is not known. The current state of information only allows for an estimation of performance effects due to expected symptoms resulting from WBV exposure. General guidelines for measuring and quantifying human exposure to WBV have been presented in both international (ISO-2631: Part 1, 1997; ISO-2631: Part 5, 2018) and military (MIL-STD-810H, 2019; MIL-STD-1472G_CHG-1, 2019) standards; however, these standards do not set simple vibration and exposure limits, making it difficult to incorporate vibration limits in aircraft design specifications.

Discussion

The foundational and most common approach to study and assess human response to whole-body vibration (WBV) is based on the investigation of cause and effect relationships (Griffin, 1990). For example, comfort, performance, and/or health effects due to varying factors or characteristics of vibration exposure may be evaluated (Griffin, 1990). Magnitude of acceleration, direction of acceleration, frequency content, and exposure time have all been identified as exposure characteristics that contribute to biomechanical and physiologic responses. The U.S. Army Aeromedical Research Laboratory (USAARL) Injury Biomechanics and Protection Group (IBPG) has experience evaluating human response and performance effects during mounted (ground and air) military operational exposures. Previous and current aviation-based vibration research at USAARL has primarily focused on measuring and understanding WBV signature patterns, investigating various WBV effects of aircraft and military vehicle equipment in transmitting mechanical WBV to military personnel (aircrew and patients), and assessing human biomechanical and/or physiologic response. USAARL IBPG developed and maintains a graphical user interface (GUI) tool that implements the complete WBV methodology (ISO-2631: Part 1, 1997; ISO-2631: Part 5, 2004; Alem et al., 2004). The tool computes key parameters for WBV and multiple shock and automatically assigns severity categories based on these parameters. Although originally developed to investigate the applicability of existing WBV standards to tactical ground vehicles for Health Hazard Assessments, the software can also be used to analyze aircraft exposure characteristics. Updates are currently underway to incorporate the most recent version of ISO-2631: Part 5 (2018) into the tool.

Conclusion

Specific vibration dose thresholds that cause adverse health effects or degraded performance are not known, and therefore absolute limits are not available for use in vehicle (air or ground) acquisition programs. Available references can serve as interim guidance. The companion technical report (Ballard, Madison, & Chancey, 2020) provides a brief summary of the current state of knowledge regarding the biomechanical and physiological effects of WBV exposure. Additionally, the report provides an overview of effects most relevant to aviation-based WBV exposure and the direction of current and proposed USAARL research.

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